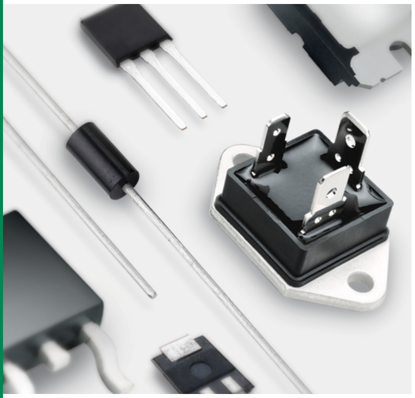
Littelfuse®

Expertise Applied | Answers Delivered



PRODUCT
CATALOG
& DESIGN
GUIDE

THYRISTOR

Power Switching Semiconductor Products

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$I_{T(RMS)}$	V_{DRM}/V_{RRM}	$I_{GT\ (Q1)}$	Series			Through-Hole							Surface Mount			
			Sensitive	Standard	Alternistor	TO-92	TO-251	TO-220 Isl	TO-220 Non-Isl	TO-218 Isl	TO-218X Isl	TO-3	Compak	SOT-223	TO-252	TO-263
Triacs																
0.8A	400-600V	3-25mA	LxX8Ex LxXx	QxX8Ex QxXx		•							•			
0.8A	400-600V	3-5mA	LX8			•								•		
1.0A	400-600V	3-25mA	Lx01Ex,LxNx	Qx01Ex,QxNx		•							•			
1.0A	400-800V	3-10mA	L01			•								•		
4.0A	400-1000V	3-25mA	Lxx04xx	Qxx04xx			•	•	•						•	
6.0A	400-1000V	5-50mA	Lxx06xx	Qxx06xx	Qxx06xHx		•	•	•						•	•
8.0A	400-1000V	5-50mA	Lxx08xx	Qxx08xx	Qxx08xHx		•	•	•						•	•
	600V	10mA			Q6008LH1LED			•								
10.0A	400-1000V	25-50mA		Qxx10xx	Qxx10xHx			•	•							•
12.0A	400-1000V	10-50mA			Qxx12xHx			•	•							•
	600V	10mA			Q6012LH1LED			•								
15.0A & 16.0A	400-1000V	10-80mA		Qxx15xx	Qxx16xHx			•	•							•
25.0A	400-1000V	50-80mA		Qxx25xx	Qxx25xHx			•	•	•	•	•				•
25.0A	600V	50mA			HQ6025xH5			•	•	•						•
30.0A & 35.0A	400-800V	50mA		Qxx35xx	Qxx35xHx			•	•			•				•
40.0A	400-1000V	50-100mA			Qxx40xx					•	•					
Quadracs																
4 / 6 / 8 / 10 / 15.0 A	400-600V			QxxxxLT	QxxxxLTH											
8.0A	600V				Q6008LTH1LED											
12.0A	600V				Q6012LTH1LED											

$I_{T(RMS)}$	V_{DRM}/V_{RRM}	$I_{GT\ (Q1)}$	Series		Through-Hole								Surface Mount				
			Sensitive	Standard	TO-92	TO-251	TO-220 Isl	TO-220 Non-Isl	TO-218AC Isl	TO-218AC Non-Isl	TO-218X Isl	TO-218X Non-Isl	Compak	SOT-89	SOT-223	TO-252	TO-263
SCRs																	
0.8A	400-600V	12 - 500µA	EC103xx SxSx		•								•				
0.8A	400-800V	5 - 200µA	SxX8xSx		•									•	•		
1.0A	400-600V	10mA		Sx01E SxN1	•								•				
1.5A		200µA	TCR22-x		•												
1.5A		200µA	Sx02xS		•										•		
4.0A		50- 500µA	Sxx04xSx			•										•	
6.0A	400-1000V	0.2-15mA	Sxx06xSx	Sxx06x		•	•	•								•	
8.0A		0.2-15mA	Sxx08xSx	Sxx08x		•	•	•								•	
10.0A		0.2-15mA	Sxx10xSx	Sxx10x		•	•	•								•	
12.0A		20mA		Sxx12x		•	•	•								•	
15.0A & 16.0A		30mA		Sxx15x Sxx16x			•	•									•
20.0A & 25.0A		30-35mA		Sxx20x Sxx25x			•	•									•
35.0A		40mA		Sxx35x					•		•						
40.0A		40mA		Sxx40x				•									•
55.0A		40mA		Sxx55x				•		•		•					•
65.0A		50mA		Sxx65x					•		•						
70.0A	400-800V	50mA		Sxx70x								•					

Series			Through Hole	Surface Mount	Switching V_{BO}	I_H	I_{TSM}	static dv/dt	di/dt	T_J
Standard	High Energy	Multipulse								
SIDACs										
Kxxxzy			DO-15, TO-92	DO-214AA	79-330V	150mA	20A	1500V/µs	150A/µs	-40 to +125 °C
	Kxxx0yH		DO-15, TO-92	DO-214AA	190-280V	150mA	20A		150A/µs	-40 to +125 °C
	K2xx0GHU		DO-15	DO-214AA	190-260V	60mA			220A/µs	-40 to +125 °C
		Kxxx1G	DO-15		200-380V	120mA			150A/µs	-40 to +125 °C
		Kxxx1GL	DO-15		200-265V	30mA			150A/µs	-40 to +125 °C

Series	Through Hole	$I_{F(RMS)}$	$I_{F(AV)}$	I_{FSM}		I^2t	T_{stg}	T_J		
		RMS forward current	Average forward current	Peak non-repetitive surge current		I^2t Value for fusing	Storage temperature range			
Rectifiers										
Dxx15L Dxx20L Dxx25L	TO-220 Isl.	15 - 25A	9.5 to15.9A	single half cycle; f = 50Hz; TJ (initial) = 25°C 188 - 300A	single half cycle; f = 60Hz; TJ (initial) = 25°C 225 - 350A	210 - 508 A^2s	-40 to +150 °C	-40 to +125 °C		

Thyristor Product Descriptions

Thyristors

A Thyristor is any semiconductor switch with a bi-stable action depending on p-n-p-n regenerative feedback. Thyristors are normally two- or three-terminal devices for either unidirectional or bi-directional circuit configurations. Thyristors can have many forms, but they have certain commonalities. All Thyristors are solid state switches that are normally open circuits (very high impedance), capable of withstanding rated blocking/off-state voltage until triggered to on state. When triggered to on state, Thyristors become a low-impedance current path until principle current either stops or drops below a minimum holding level. After a Thyristor is triggered to on-state condition, the trigger current can be removed without turning off the device. Thyristors are used to control the flow of electrical currents in applications including:

- Home appliances (lighting, heating, temperature control, alarm activation, fan speed)
- Electrical tools (for controlled actions such as motor speed, stapling event, battery charging)
- Outdoor equipment (water sprinklers, gas engine ignition, electronic displays, area lighting, sports equipment, physical fitness)

Sensitive Triacs

Littelfuse's sensitive gate Triacs are AC bidirectional silicon switches that provide guaranteed gate trigger current levels in Quadrants I, II, III, and IV. Interfacing to microprocessors or other equipment with single polarity gate triggering is made possible with sensitive gate Triacs. Gate triggering currents of 3 mA, 5 mA, 10 mA, or 20 mA may be specified.

Sensitive gate Triacs are capable of controlling AC load currents from 0.8 A to 8 A rms and can withstand operating voltages from 400 V to 600 V.

Standard Triacs

Littelfuse's products are bidirectional AC switches, capable of controlling loads from 0.8 A to 35 A rms with 10 mA, 25 mA, and 50 mA I_{GT} in operating Quadrants I, II and III.

Triacs are useful in full-wave AC applications to control AC power either through full-cycle switching or phase control of current to the load element. These Triacs are rated to block voltage in the "OFF" condition from 400 V minimum with selected products capable of 1000 V operation. Typical applications include motor speed controls, heater controls, and incandescent light controls.

Quadrac

Quadrac devices, originally developed by Littelfuse, are Triacs and Alternistor Triacs with a DIAC trigger mounted inside the same package. These devices save the user the expense and assembly time of buying a discrete DIAC and assembling in conjunction with a gated Triac.

The Quadrac is offered in capacities from 4 A to 15 A rms and voltages from 400 V to 600 V.

Alternistor Triacs

The Alternistor Triac is specifically designed for applications required to switch highly inductive loads. The design of this special bidirectional chip effectively offers the same performance as two Thyristors (SCRs) wired inverse parallel (back-to-back).

This new chip construction provides the equivalent of two electrically-separate SCR structures, providing enhanced dv/dt characteristics while retaining the advantages of a single-chip device.

Littelfuse manufactures 6 A to 40 A Alternistor Triac with blocking voltage rating from 400 V to 1000 V. Alternistor Triacs are offered in TO-220, TO-251, TO-252, TO-218, and TO-218X packages with isolated and non-isolated versions.

Sensitive SCRs

Littelfuse's sensitive gate SCRs are unidirectional Silicon-Controlled Rectifiers representing the best in design, performance, and packaging techniques for low- and medium-current applications.

Anode currents of 0.8 A to 10 A rms can be controlled by sensitive gate SCRs with gate drive currents ranging from 5 μA to 500 μA. Sensitive gate SCRs are ideally suited for interfacing to integrated circuits or in applications where high current load requirements and limited gate drive current capabilities exist. Examples include ignition circuits, motor controls, and DC latching for alarms in smoke detectors. Sensitive gate SCRs are available in voltage ratings to 600 V.

SCRs

Littelfuse's SCR products are half-wave, Silicon-Controlled Rectifiers that represent the state of the art in design and performance.

Load current capabilities range from 1 A to 70 A rms, and voltages from 400 V to 1000 V may be specified to meet a variety of application needs.

Thyristor Product Descriptions (continued)

Because of its unidirectional switching capability, the SCR is used in circuits where high surge currents or latching action is required. It may also be used for half-wave-type circuits where gate-controlled rectification action is required. Applications include crowbars in power supplies, camera flash units, smoke alarms, motor controls, battery chargers, and engine ignition.

Surge current ratings are available from 30 A in the TO-92 packaging to 950 A in the TO-218X package.

Rectifiers

Littelfuse manufactures 15 A to 25 A rms Rectifiers with voltages rated from 400 V to 1000 V. Due to the electrically isolated TO-220 package, these Rectifiers may be used in common anode or common cathode circuits using only one part type, thereby simplifying stock requirements.

DIACs

DIACs are trigger devices used in phase control circuits to provide gate pulses to a Triac. They are voltage-triggered bidirectional silicon devices. DIAC voltage provide trigger pulses closely matched in symmetry at the positive and negative breakover points to minimize DC component in the load circuit.

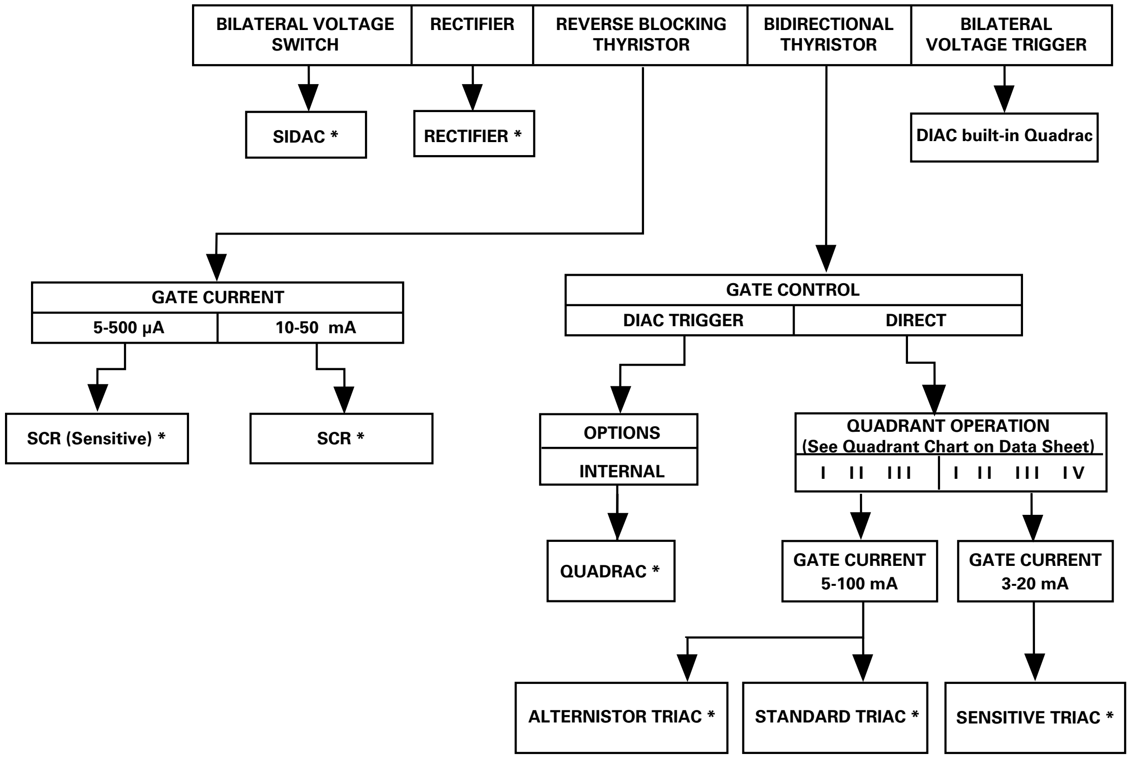
Some applications include gate triggers for light controls, dimmers, power pulse circuits, voltage references in AC power circuits, and motor speed controls.

SIDACs

SIDACs represent a unique set of Thyristor qualities. The SIDAC is a bidirectional or unidirectional voltage triggered switch. Some characteristics of this device include a normal 95 V to 330 V switching point, negative resistance range, latching characteristics at turn-on, and a low on-state voltage drop.

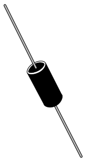
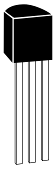
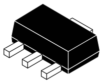
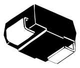
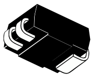
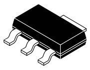
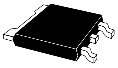
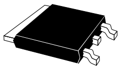
One-cycle surge current capability up to 20 A makes the SIDAC an ideal product for dumping charged capacitors through an inductor in order to generate high-voltage pulses. Applications include light controls, high-pressure sodium lamp starters, metal halide lamp ignition power oscillators, and high-voltage power supplies.

Circuit Requirement Diagram

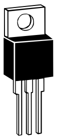
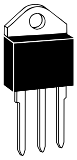
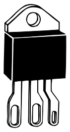
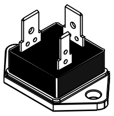
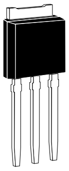
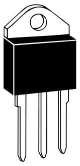
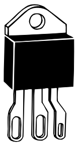
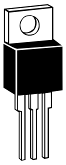


* For detailed information, see specific data sheet in product catalog.

Product Packages

Package Code		G	E	B	S	C	T	D	N
									
Product Type	Current (Amps)	DO-15	TO-92	SOT-89	DO-214	Compak	SOT-223	TO-252 D-Pak	TO-263 D^{2}Pak
Sensitive Triac	0.8		X			X	X		
	1		X			X	X		
	4							X	
	6							X	
	8							X	
Standard Triac	0.8		X			X			
	1		X			X			
	4							X	
	6								X
	8								X
	10								X
	15								X
	25								X
	35								
Alternistor	6							X	X
	8							X	X
	10								X
	12								X
	16								X
	25								X
	30								
	35								X
	40								
Quadrac	4								
	6								
	8								
	10								
	12								
	15								
Sensitive SCR	0.8		X	X		X	X		
	1.5		X				X		
	4							X	
	6							X	
	8							X	
	10							X	
SCR	1		X			X			
	6							X	
	8							X	
	10							X	
	12							X	
	15								
	16								X
	20								
	25								X
	35								
	40								X
	55								X
	65								
	70								
Rectifier	15								
	20								
	25								
SIDAC		X	X		X				

Product Packages (continued)

Isolated Mounting Tab				Non-isolated Mounting Tab				Package Code	
L	K	J	P	V	M	W	R		
 TO-220	 TO-218	 TO-218X	 TO-3 Fastpak	 TO-251 V-Pak	 TO-218	 TO-218X	 TO-220	Current (Amps)	Product Type
								0.8	**Sensitive Triac**
								1	
X				**X**				4	
X				**X**				6	
X				**X**				8	
								0.8	**Standard Triac**
								1	
X				**X**				4	
X							**X**	6	
X							**X**	8	
X							**X**	10	
X							**X**	15	
			X				**X**	25	
			X					35	
X				**X**			**X**	6	**Alternistor**
X				**X**			**X**	8	
X							**X**	10	
X							**X**	12	
X							**X**	16	
X	**X**	**X**					**X**	25	
X								30	
							X	35	
	X	**X**						40	
X								4	**Quadrac**
X								6	
X								8	
X								10	
X								12	
X								15	
								0.8	**Sensitive SCR**
								1.5	
				X				4	
X				**X**				6	
X				**X**				8	
X				**X**				10	
								1	**SCR**
X				**X**				6	
X				**X**			**X**	8	
X				**X**			**X**	10	
				X			**X**	12	
X								15	
							X	16	
X								20	
X							**X**	25	
	X	**X**						35	
							X	40	
					X	**X**	**X**	55	
	X	**X**						65	
						X		70	
X								15	**Rectifier**
X								20	
X								25	
								SIDAC	

Revised: 12/14/14

Quality and Reliability Assurance

Littelfuse Quality Policy

Littelfuse is committed to being sensitive to customer expectations and providing quality products and services at a competitive price. In support of this commitment, Littelfuse will:

- **Encourage** quality awareness and quality performance in all associates at all levels of the company through management leadership;
- **Promote** the participation of all associates in making individual contributions to the quality improvement process;
- **Support** continuous quality improvements by providing our associates with necessary training, tools and information feedback to enable enhancement of the quality of our products and services;
- **Develop** relationships with suppliers who consistently demonstrate their ability to fulfill quality, price and delivery objectives that are mutually beneficial; and;
- **Build** quality into our products and services, striving for zero defects in everything we do, thereby reducing cost and increasing **Total Customer Satisfaction**.

Quality Management Principles

The Littelfuse, Inc. Management Team understand and concur with the following eight management principles:

- **Customer focus:** Littelfuse depends on its customers and makes every effort to understand their current and future needs. Littelfuse strives to meet customer requirements and to exceed customer expectations.
- **Leadership:** Leaders establish unity of purpose and direction for the Littelfuse organization. Our leaders should create and maintain the internal environment inch our associates can become fully involved in achieving the Littelfuse objectives.
- **Involvement of people:** Littelfuse associates at all levels are the essence of Littelfuse. Their full involvement enables their abilities to be used for the benefit of Littelfuse.
- **Process approach:** The results desired by Littelfuse are achieved more efficiently when activities and related resources are managed as a process.
- **System approach to management:** Identifying, understanding and managing interrelated processes as a system contributes to effectiveness and efficiency in achieving Littelfuse objectives.
- **Continual improvement:** Continual improvement of the overall performance should be a permanent objective of Littelfuse.
- **Factual approach to decision making:** Effective decisions are based on the analysis of data and information at Littelfuse.
- **Mutually beneficial supplier relationships:** Littelfuse and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

Quality Assurance

Incoming Material Quality

Littelfuse “Vendor Analysis” programs provide stringent requirements before components are delivered to Littelfuse. In addition, purchased materials are tested rigidly at incoming inspection for specification compliance prior to acceptance for use.

Process Controls

From silicon slice input through final testing, we use statistical methods to control all critical processes. Process audits and lot inspections are performed routinely at all stages of the manufacturing cycle.

Parametric Testing

All devices are 100% computer tested for specific electrical characteristics at critical processing points.

Final Inspection

Each completed manufacturing lot is sampled and tested for compliance with electrical and mechanical requirements.

Reliability Testing

Random samples are taken from various product families for ongoing reliability testing.

Finished Goods Inspection

Product assurance inspection is performed immediately prior to shipping.

Design Assurance

The design and production of Littelfuse devices is a demanding and challenging task. Disciplined skills coupled with advanced computer-aided design, production techniques, and test equipment are essential elements in Littelfuse’s ability to meet your demands for the very highest levels of quality.

All products must first undergo rigid quality design reviews and pass extensive environmental life testing. Littelfuse uses Statistical Process Control (SPC) with associated control charts throughout to monitor the manufacturing processes.

Quality and Reliability Assurance (continued)

Only those products which pass tests designed to assure Littelfuse's high quality and reliability standards, while economically satisfying customer requirements, are approved for shipment. All new products and materials must receive approval of QRA prior to being released to production.

The combination of reliability testing, process controls, and lot tracking assures the quality and reliability of Littelfuse's devices. Since even the best control systems cannot overcome measurement limitations, Littelfuse designs and manufactures its own computerized test equipment.

Littelfuse's Reliability Engineering Group conducts ongoing product reliability testing to further confirm the design and manufacturing parameters.

Reliability Stress Tests

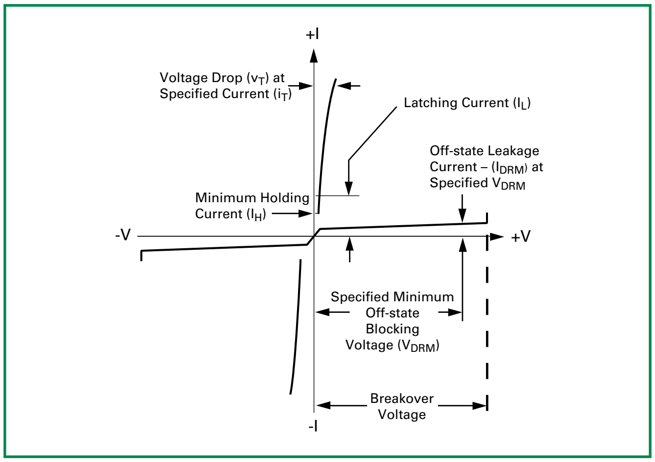
The following table contains brief descriptions of the reliability tests commonly used in evaluating Littelfuse product reliability on a periodic basis. These tests are applied across product lines depending on product availability and test equipment capacities. Other tests may be performed when appropriate.

Test Type	Typical Conditions	Test Description	Standards
High Temperature AC Blocking	Rated V_{DRM} (VAC-peak), 110°C up to 125°C, 1008 hours	Evaluation of the reliability of product under bias conditions and elevated temperature	MIL-STD-750 (Method 1040)
High Temperature Storage Life	150°C, 1008 hours	Evaluation of the effects on devices after long periods of storage at high temperature	MIL-STD-750 (Method 1031)
Biased Temperature & Humidity	160V_{DC}, 85°C, 85%RH, 168 up to 1008 hours	Evaluation of the reliability of non-hermetic packaged devices in humid environments	EIA/JEDEC, JESD22-A101
Temperature Cycle [Air to Air]	-65°C to 150°C, 15-minute dwell, 10 up to 500 cycles	Evaluation of the device's ability to withstand the exposure to extreme temperatures and the forces of TCE during transitions between temperatures	MIL-STD-750 (Method 1051), EIA/JEDEC, JESD22-A104
Thermal Shock [Liquid to Liquid]	0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles	Evaluation of the device's ability to withstand the sudden changes in temperature and exposure to extreme temperatures	MIL-STD-750 (Method 1056)
Autoclave (PCT)	121°C, 100%RH, 2atm, 24 up to 168 hours	Accelerated environmental test to evaluate the moisture resistance of plastic packages	EIA/JEDEC, JESD22-A102
Resistance to Solder Heat	260°C, 10 seconds	Evaluation of the device's ability to withstand the temperatures as seen in wave soldering operations	MIL-STD-750 (Method 2031)
Solderability	Steam Aging (1 to 8 hrs) 245°C Solder Temperature	Evaluation of the solderability of device terminals after simulated aging	ANSI J-STD-002
Lead Bend	225g weight, three 90° bends	Evaluation of resistance of device leads to metal fatigue	MIL-STD-750 (Method 2036)
Moisture Sensitivity Level	85%RH, 85°C, 168hrs 3 reflow cycles (260C peak)	Evaluation to determine device immunity to moisture	JEDEC J-STD-020 Level 1
ESD	HBM, 8kV CDM, 15kV	Evaluation to determine device immunity to electro-static discharge	JESD22-A114, MIL-STD-883D 3015.7, JESD22-C101

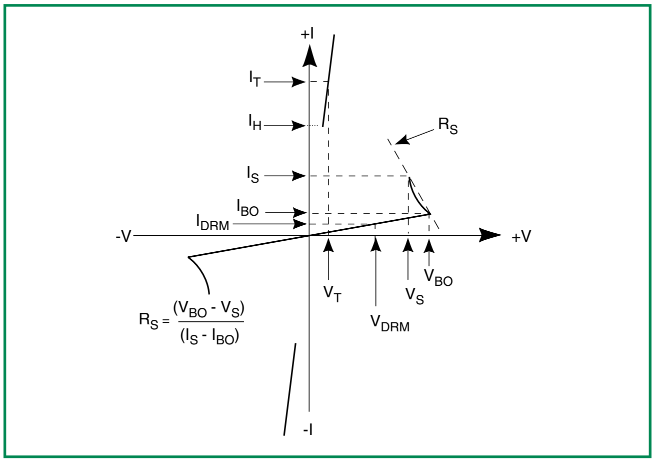
Flammability Test

For the UL 94V0 flammability test, all epoxies used in Littelfuse encapsulated devices are recognized by Underwriters Laboratories.

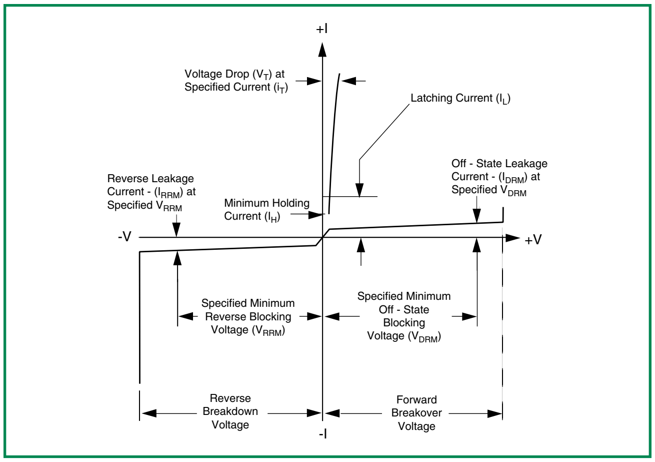
V-I Characteristics of Thyristor Devices



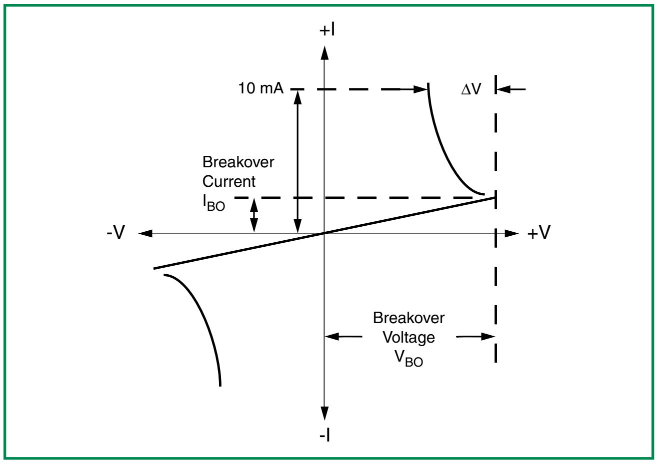
V-I Characteristics of Triac Device



V-I Characteristics of SIDAC Device with Negative Resistance



V-I Characteristics of SCR Device



V-I Characteristics of Bilateral Trigger DIAC

Electrical Parameter Terminology

Diode Rectifiers

di/dt (Critical Rate-of-rise of On-state Current) - Maximum value of the rate-of-rise of on-state current which a Thyristor can withstand without deleterious effect.

dv/dt (Critical Rate-of-rise of Off-state Voltage or Static dv/dt) - Minimum value of the rate-of-rise of principal voltage which will cause switching from the off state to the on state.

dv/dt(c) Critical Rate-of-rise of Commutation Voltage of a Triac (Commutating dv/dt) - Minimum value of the rate-of-rise of principal voltage which will cause switching from the off state to the on state immediately following on-state current conduction in the opposite quadrant.

I^2t (RMS Surge (Non-repetitive) On-state Fusing Current)- Measure of let-through energy in terms of current and time for fusing purposes.

I_{BO}(Breakover Current) - Principal current at the breakover point.

I_{DRM}(Repetitive Peak Off-state Current) - Maximum leakage current that may occur under the conditions of V_{DRM}.

I_{GT}(Gate Trigger Current) - Minimum gate current required to switch a Thyristor from the off state to the on state.

I_H (Holding Current) - Minimum principal current required to maintain the Thyristor in the on state.

I_{PP} (Peak Pulse Current) - Peak pulse current at a short time duration and specified waveshape.

I_{RRM} (Repetitive Peak Reverse Current) - Maximum leakage current that may occur under the conditions of V_{RRM}.

I_S (Switching Current) - Current at V_S when a SIDAC switches from the clamping state to on state.

$I_{T(RMS)}$ (On-state Current) - Anode cathode principal current that may be allowed under stated conditions, usually the full-cycle RMS current.

I_{TSM} (Surge (Non-repetitive) On-state Current) - Peak single cycle AC current pulse allowed.

$P_{G(AV)}$ (Average Gate Power Dissipation) - Value of gate power which may be dissipated between the gate and main terminal 1 (or cathode) average over a full cycle.

P_{GM} (Peak Gate Power Dissipation) - Maximum power which may be dissipated between the gate and main terminal 1 (or cathode) for a specified time duration.

$R_{\theta JA}$ (Thermal Resistance, Junction-to-Ambient) - Temperature difference between the Thyristor junction and ambient divided by the power dissipation causing the temperature difference under conditions of thermal equilibrium.

Note: Ambient is defined as the point where temperature does not change as a result of the dissipation.

$R_{\theta JC}$ (Thermal Resistance, Junction-to-case) - Temperature difference between the Thyristor junction and the Thyristor case divided by the power dissipation causing the temperature difference under conditions of thermal equilibrium.

t_{gt} (Gate-controlled Turn-on Time) - Time interval between the 10% rise of the gate pulse and the 90% rise of the principal current pulse during switching of a Thyristor from the off state to the on state.

t_q (Circuit-commutated Turn-off Time) - Time interval between the instant when the principal current has decreased to zero after external switching of the principal voltage circuit and the instant when the SCR is capable of supporting a specified principal voltage without turning on.

V_{BO} (Breakover Voltage) - Principal voltage at the breakover point.

V_{DRM} (Repetitive Peak Off-state Voltage) - Maximum allowable instantaneous value of repetitive off-state voltage that may be applied across a bidirectional Thyristor (forward or reverse direction) or SCR (forward direction only).

V_{GT} (Gate Trigger Voltage) - Minimum gate voltage required to produce the gate trigger current.

V_{RRM} (Repetitive Peak Reverse Voltage) - Maximum allowable instantaneous value of a repetitive reverse voltage that may be applied across an SCR without causing reverse current avalanche.

V_S (Switching Voltage) - Voltage point after V_{BO} when a SIDAC switches from a clamping state to on state.

V_T (On-state Voltage) - Principal voltage when the Thyristor is in the on state.

Diode Rectifiers

$I_{F(AV)}$ (Average Forward Current) - Average forward conduction current.

I_{RM} (Maximum (Peak) Reverse Current) - Maximum reverse leakage current that may occur at rated V_{RRM}.

$I_{(RMS)}$ (RMS Forward Current) - RMS forward conduction current.

I_{FSM} (Maximum (Peak) Forward (Non-repetitive) Surge Current) - Maximum (peak) forward single cycle AC surge current allowed for specified duration.

V_{FM} (Maximum (Peak) Forward Voltage Drop) - Maximum (peak) forward voltage drop from the anode to cathode at stated conditions.

V_R (Reverse Blocking Voltage) - Maximum allowable DC reverse blocking voltage that may be applied to the rectifier.

V_{RRM} (Maximum (Peak) Repetitive Reverse Voltage) - Maximum peak allowable value of a repetitive reverse voltage that may be applied to the rectifier.

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Lead Form Dimensions

The TO-218, TO-220AB, and TO-92 package configurations, because of their unique design, can be mounted in a variety of methods, depending upon heat sink requirements and circuit packaging methods. Any of the derived types shown in this section are available as standard parts direct from the factory. Custom package variations are available. Consult the factory for more information.

To designate lead form options, simply indicate the type number at the end of the Teccor standard part number.

Example: Q4008L465 (Signifies Type 65)

See "Description of Part Numbers" in the Product Selection Guide of this catalog for a complete description of Teccor part numbers.

Lead Bending Specifications

Leads may be bent easily and may be bent to any desired angle, provided that the bend is made at a minimum 0.063" (0.1 for TO-218) away from the package body with a minimum radius of 0.032". DO-15 device leads may be bent with a minimum radius of 0.050", and DO-35 device leads may be bent with a minimum radius of 0.028". Leads should be held firmly between the package body and the bend, so that strain on the leads is not transmitted to the package body.

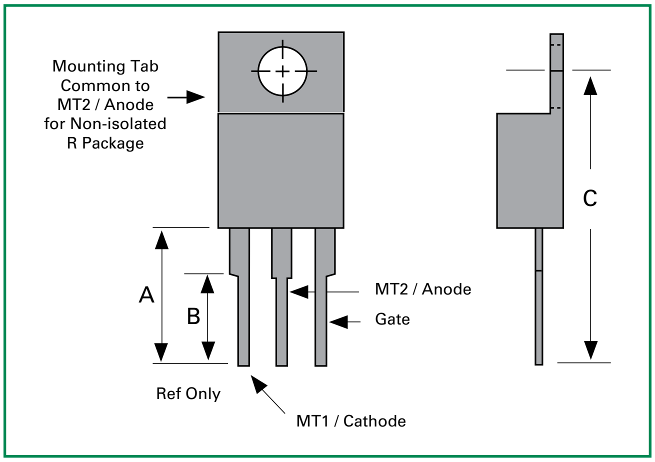
When bending leads in the plane of the leads (spreading), bend only the narrow part.

Sharp angle bends should be done only once, as repetitive bending will fatigue and break the leads.

Lead Form Dimensions (continued)

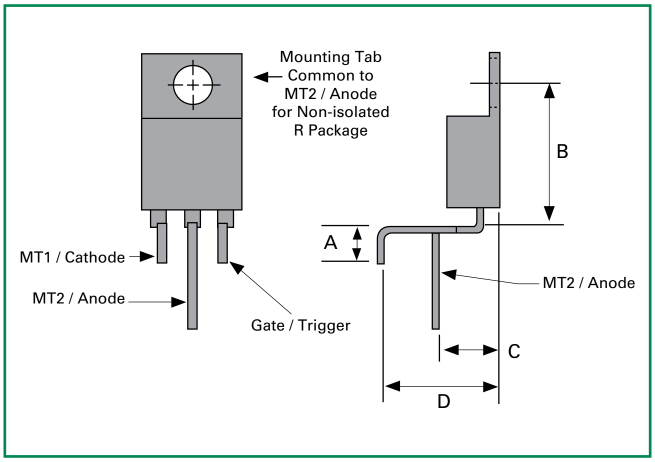
TO-220 Type 51 — R or L Package

Replaces RCA 6249



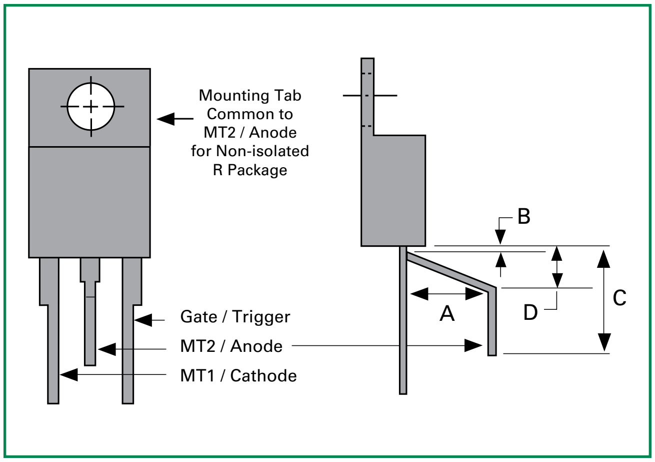
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.320	0.340	8.13	8.64
B	0.190		4.83	
C	0.795	0.850	20.19	21.59

TO-220 Type 53 — R or L Package



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.175		4.45	
B	0.542	0.582	13.77	14.78
C	0.167	0.207	4.24	5.26
D	0.355	0.395	9.02	10.03

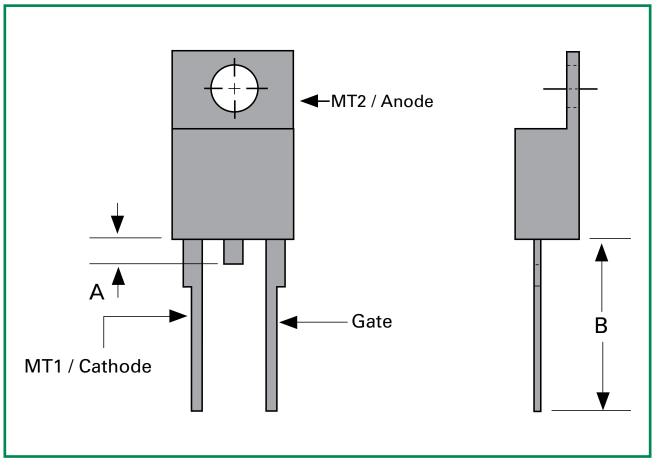
TO-220 Type 52 — R or L Package



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.169	0.189	4.29	4.80
B	0.040	0.060	1.02	1.52
C	0.250		6.35	
D	0.110	0.170	2.79	4.32

TO-220 Type 54 — R Package

Replaces Motorola Form 4, G.E. Type 4, RCA 6206

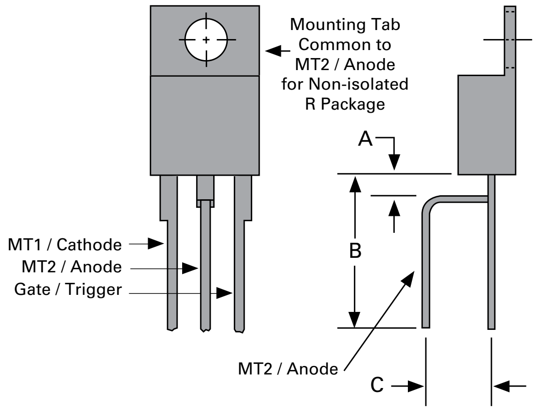


Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.040	0.070	1.02	1.78
B	0.500		12.70	

Lead Form Dimensions (continued)

TO-220 Type 55 — R or L Package

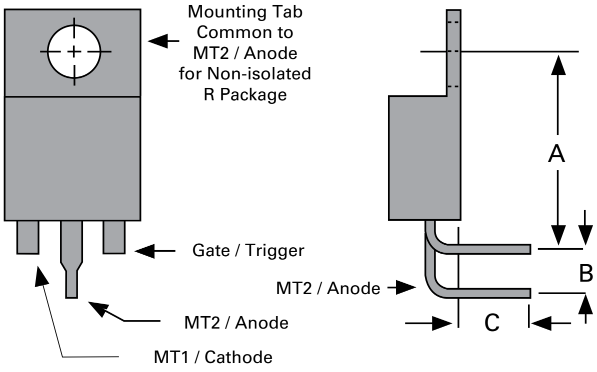
Replaces G.E. Type 5



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.065	0.095	1.65	2.41
B	0.353	0.433	8.97	11.00
C	0.115	0.130	2.92	3.30

TO-220 Type 56 — R or L Package

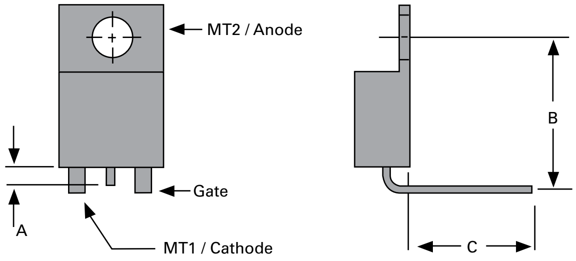
Replaces G.E. Type 6, Motorola Lead Form 3, RCA 6221



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.570	0.590	14.48	14.99
B	0.120	0.130	3.05	3.30
C	0.172	0.202	4.37	5.13

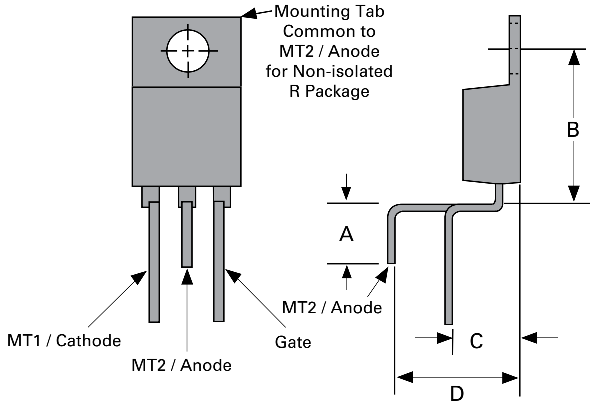
TO-220 Type 57 — R Package

Similar to TO-66, Gate-Cathode Reversed



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.040	0.070	1.02	1.78
B	0.570	0.590	14.48	14.99
C	0.340	0.422	8.64	10.72

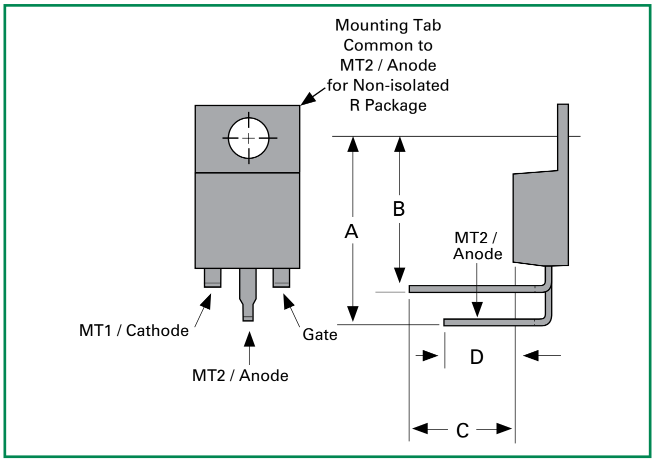
TO-220 Type 58 — R or L Package



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.175		4.45	
B	0.542	0.582	13.77	14.78
C	0.167	0.207	4.24	5.26
D	0.355	0.395	9.02	10.03

Lead Form Dimensions (continued)

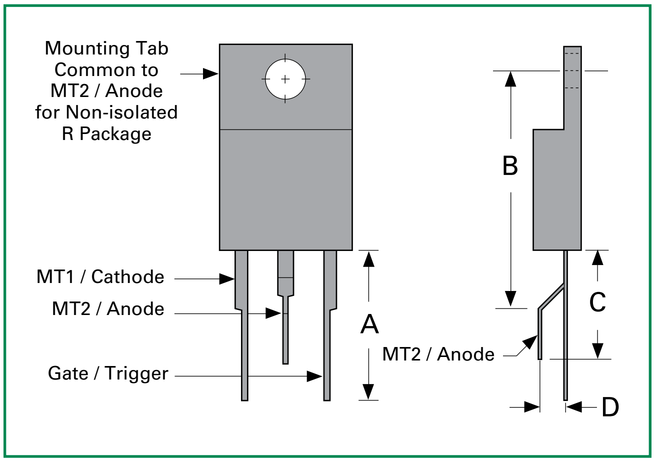
TO-220 Type 59 — R or L Package



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.685	0.725	17.40	18.42
B	0.558	0.598	14.17	15.19
C	0.375		9.53	
D	0.250		6.35	

TO-220 Type 65 — R or L Package

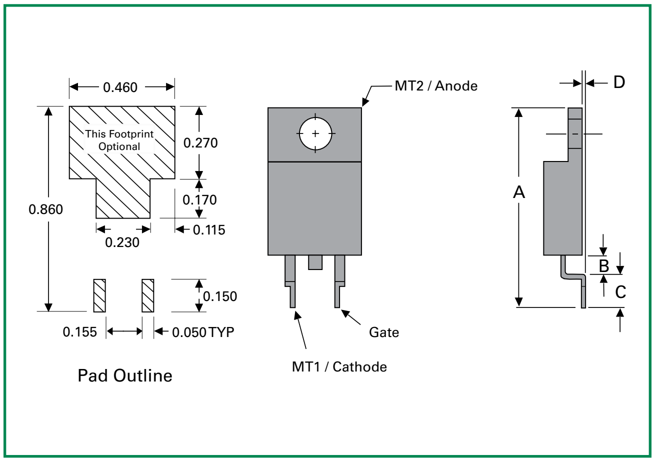
Replaces RCA 6210



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.500	0.562	12.70	14.27
B	0.580	0.620	14.73	15.75
C	0.300		7.62	
D	0.080	0.120	2.03	3.05

TO-220 Type 67 — R Package

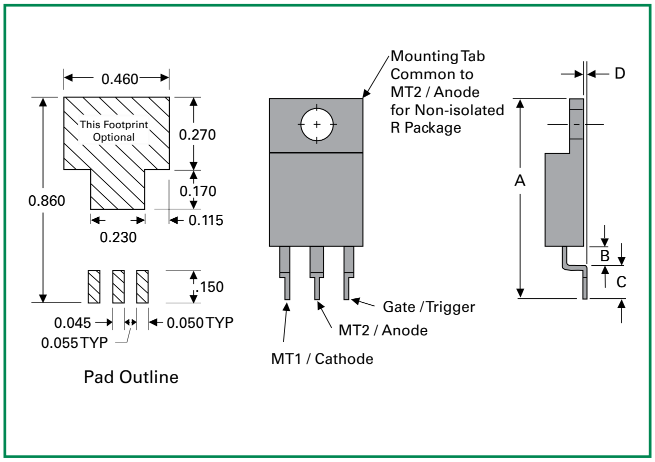
Surface Mount



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.780	0.850	19.05	21.59
B	0.080	0.100	2.03	2.54
C	0.110	0.130	2.79	3.30
D		0.013		0.33

TO-220 Type 68 — R or L Package

Surface Mount

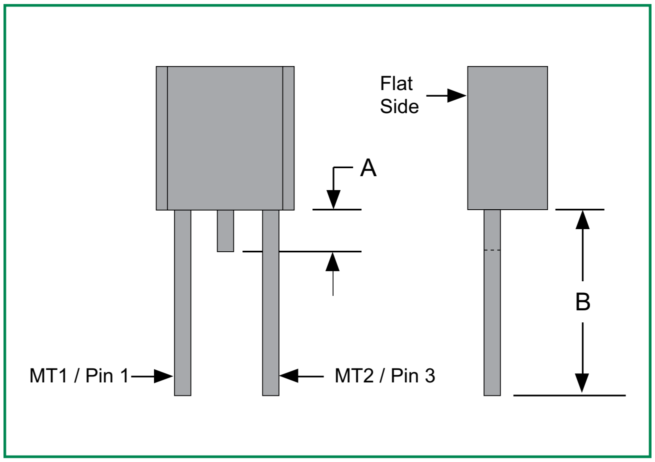


Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.780	0.850	19.05	21.59
B	0.080	0.100	2.03	2.54
C	0.110	0.130	2.79	3.30
D		0.013		0.33

Lead Form Dimensions (continued)

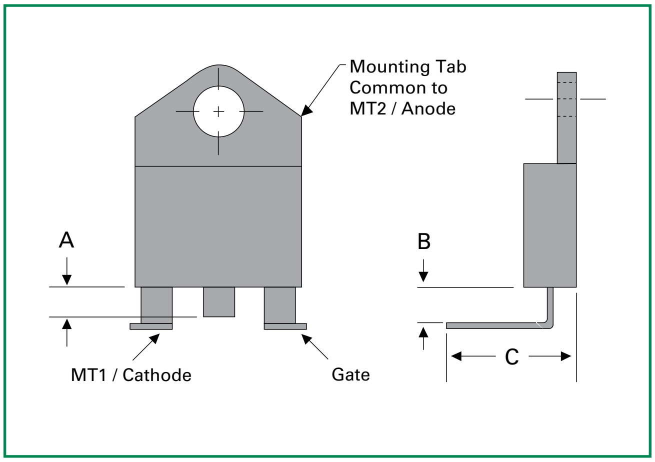
TO-92 Type 70 — E Package

SIDAC Only



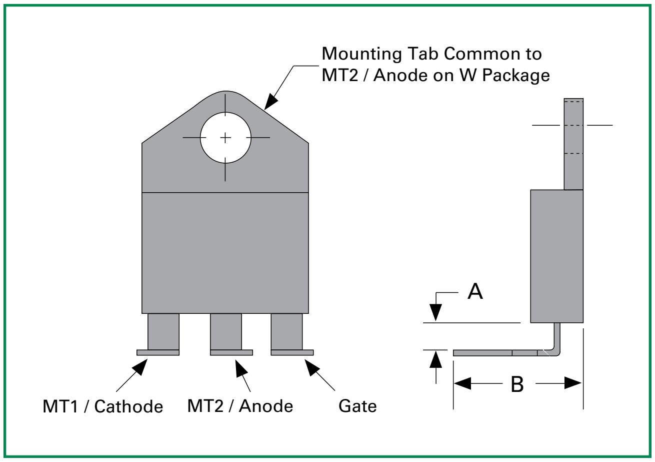
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A		0.060		1.52
B	0.50		12.7	

TO-218 Type 82 — M and W Packages



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A		0.095		2.41
B	0.080	0.120	2.03	3.05
C	0.580	0.640	14.73	16.26

TO-218 Type 81 — K, M, J, or W Packages



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.080	0.120	2.03	3.05
B	0.580	0.640	14.73	16.26

Fundamental Characteristics of Thyristors

Introduction

The Thyristor family of semiconductors consists of several very useful devices. The most widely used of this family are silicon controlled rectifiers (SCRs), Triacs, SIDACs, and DIACs. In many applications these devices perform key functions and are real assets in meeting environmental, speed, and reliability specifications which their electro-mechanical counterparts cannot fulfill.

This application note presents the basic fundamentals of SCR, Triac, SIDAC, and DIAC Thyristors so the user understands how they differ in characteristics and parameters from their electro-mechanical counterparts. Also, Thyristor terminology is defined.

SCR

Basic Operation

Figure AN1001.1 shows the simple block construction of an SCR.

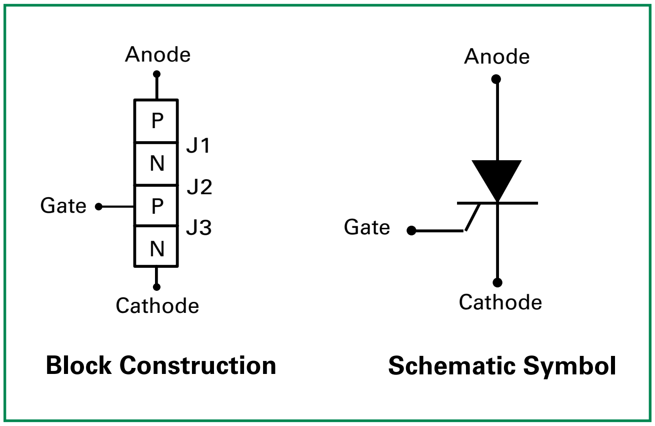


Figure AN1001.1 SCR Block Construction

The operation of a PNPN device can best be visualized as a specially coupled pair of transistors as shown in Figure AN1001.2.

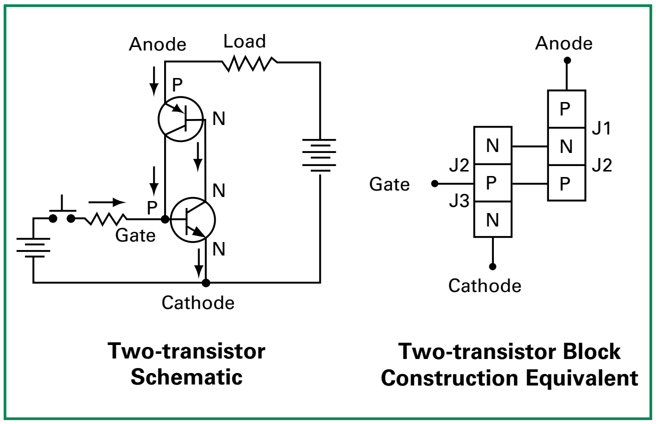


Figure AN1001.2 Coupled Pair of Transistors as a SCR

The connections between the two transistors trigger the occurrence of regenerative action when a proper gate signal is applied to the base of the NPN transistor. Normal leakage current is so low that the combined h_{FE} of the specially coupled two-transistor feedback amplifier is less than unity, thus keeping the circuit in an off-state condition. A momentary positive pulse applied to the gate biases the NPN transistor into conduction which, in turn, biases the PNP transistor into conduction. The effective h_{FE} momentarily becomes greater than unity so that the specially coupled transistors saturate. Once saturated, current through the transistors is enough to keep the combined h_{FE} greater than unity. The circuit remains "on" until it is "turned off" by reducing the anode-to-cathode current (I_T) so that the combined h_{FE} is less than unity and regeneration ceases. This threshold anode current is the holding current of the SCR.

Geometric Construction

Figure AN1001.3 shows cross-sectional views of an SCR chip and illustrations of current flow and junction biasing in both the blocking and triggering modes.

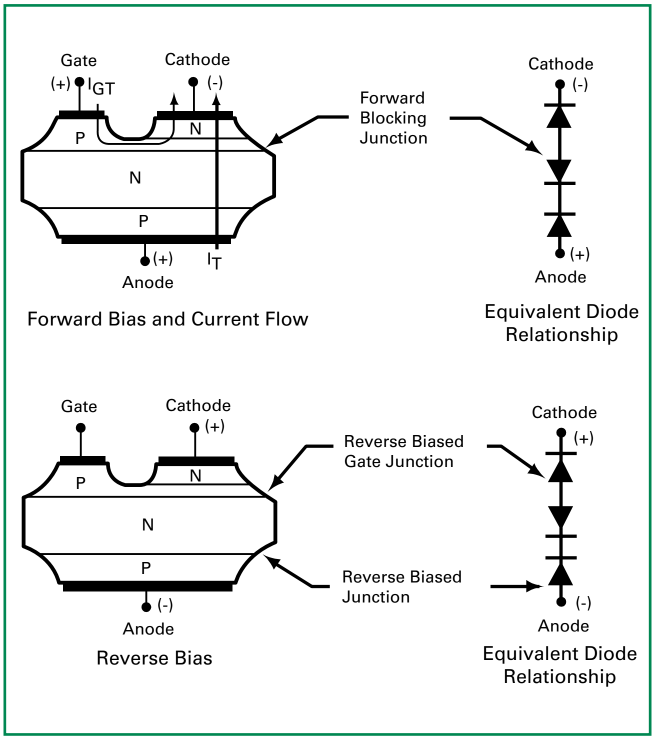


Figure AN1001.3 Cross-sectional View of SCR Chip

Triac

Basic Operation

Figure AN1001.4 shows the simple block construction of a Triac. Its primary function is to control power bilaterally in an AC circuit.

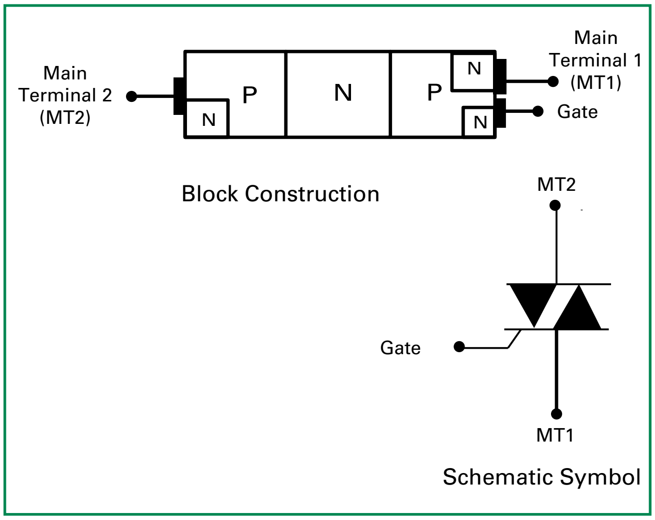


Figure AN1001.4 Triac Block Construction

Operation of a Triac can be related to two SCRs connected in parallel in opposite directions as shown in Figure AN1001.5.

Although the gates are shown separately for each SCR, a Triac has a single gate and can be triggered by either polarity.

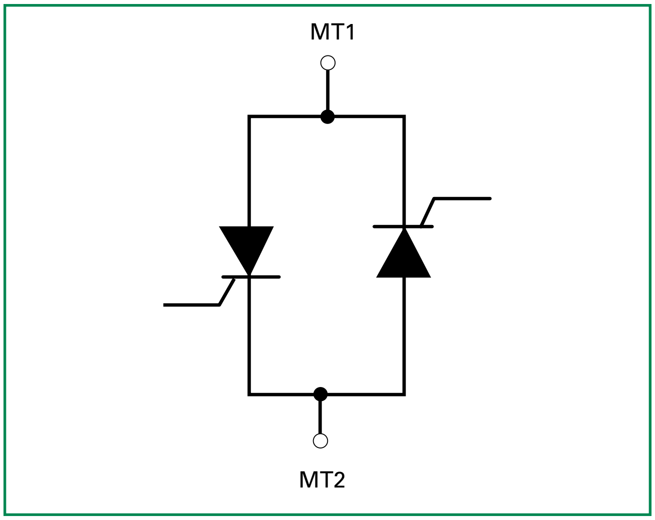


Figure AN1001.5 SCRs Connected as a Triac

Since a Triac operates in both directions, it behaves essentially the same in either direction as an SCR would behave in the forward direction (blocking or operating).

Geometric Construction

Figure AN1001.6 show simplified cross-sectional views of a Triac chip in various gating quadrants and blocking modes.

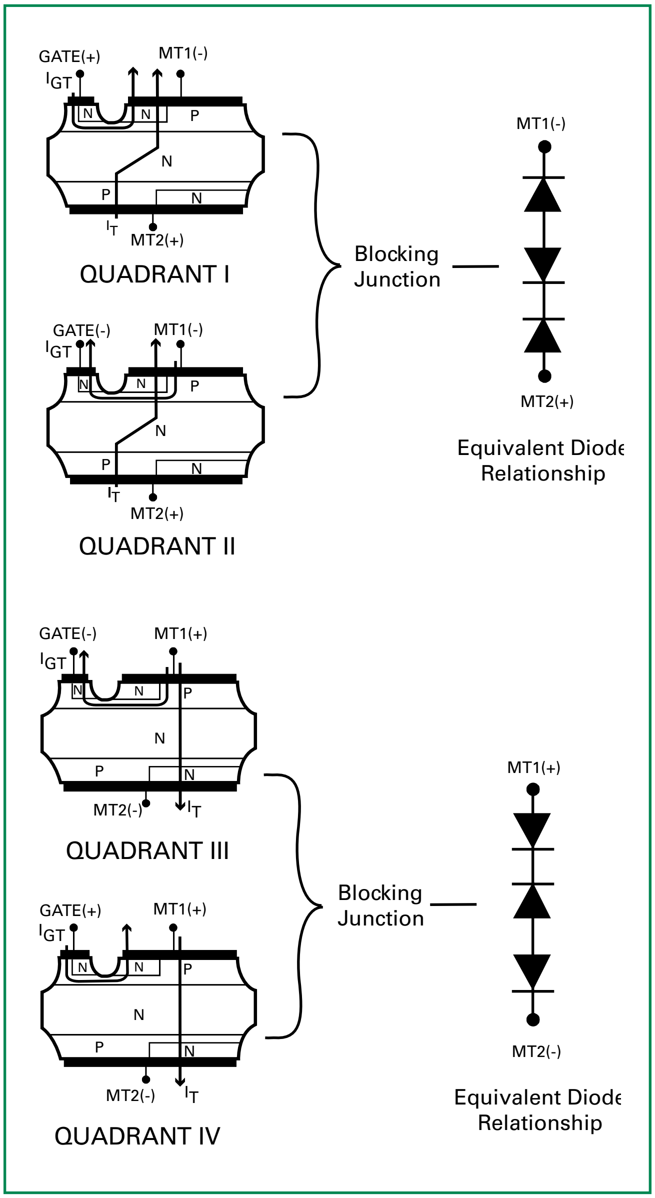


Figure AN1001.6 Simplified Cross-sectional of Triac Chip

Fundamental Characteristics of Thyristors (continued)

SIDAC

Basic Operation

The SIDAC is a multi-layer silicon semiconductor switch. Figure AN1001.7 illustrates its equivalent block construction using two Shockley diodes connected inverse parallel. Figure AN1001.7 also shows the schematic symbol for the SIDAC.

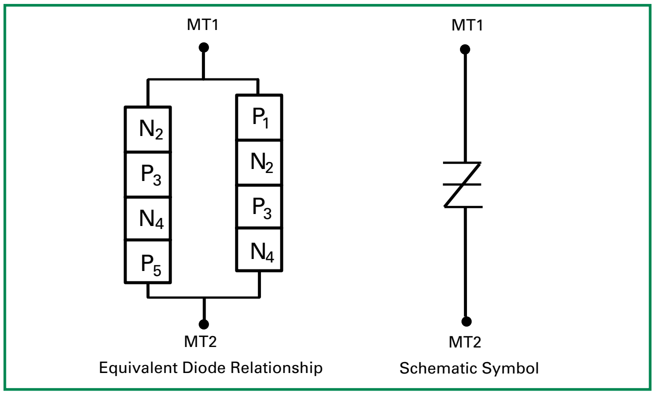


Figure AN1001.7 SIDAC Block Construction

The SIDAC operates as a bidirectional switch activated by voltage. In the off state, the SIDAC exhibits leakage currents (I_{DRM}) less than 5 µA. As applied voltage exceeds the SIDAC V_{BO}, the device begins to enter a negative resistance switching mode with characteristics similar to an avalanche diode. When supplied with enough current (I_S), the SIDAC switches to an on state, allowing high current to flow. When it switches to on state, the voltage across the device drops to less than 5 V, depending on magnitude of the current flow. When the SIDAC switches on and drops into regeneration, it remains on as long as holding current is less than maximum value (150 mA, typical value of 30 mA to 65 mA). The switching current (I_S) is very near the holding current (I_H) value. When the SIDAC switches, currents of 10 A to 100 A are easily developed by discharging small capacitor into primary or small, very high-voltage transformers for 10 µs to 20 µs.

The main application for SIDACs is ignition circuits or inexpensive high voltage power supplies.

Geometric Construction

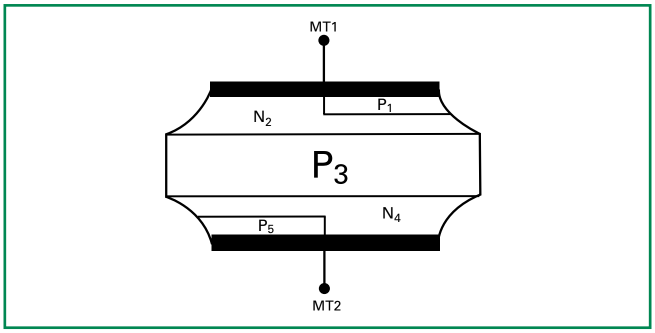


Figure AN1001.8 Cross-sectional View of a Bidirectional SIDAC Chip with Multi-layer Construction

DIAC

Basic Operation

The construction of a DIAC is similar to an open base NPN transistor. Figure AN1001.9 shows a simple block construction of a DIAC and its schematic symbol.

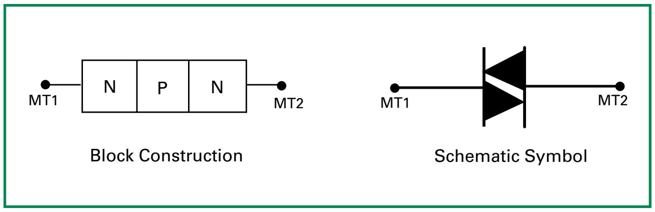


Figure AN1001.9 DIAC Block Construction

The bidirectional transistor-like structure exhibits a high-impedance blocking state up to a voltage breakover point (V_{BO}) above which the device enters a negative-resistance region. These basic DIAC characteristics produce a bidirectional pulsing oscillator in a resistor-capacitor AC circuit. Since the DIAC is a bidirectional device, it makes a good economical trigger for firing Triacs in phase control circuits such as light dimmers and motor speed controls. Figure AN1001.10 shows a simplified AC circuit using a DIAC and a Triac in a phase control application.

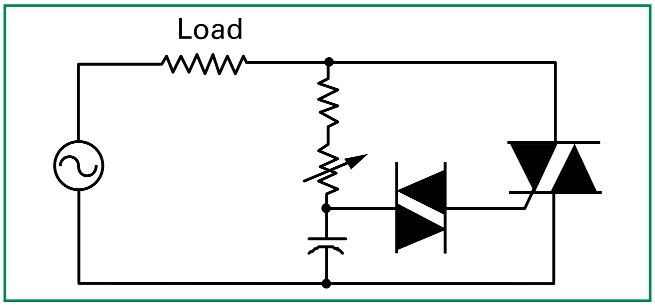


Figure AN1001.10 AC Phase Control Circuit

Geometric Construction

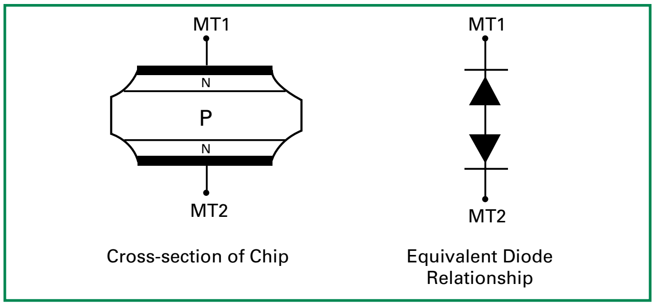


Figure AN1001.11 Cross-sectional View of DIAC Chip

Fundamental Characteristics of Thyristors (continued)

Electrical Characteristic Curves of Thyristors

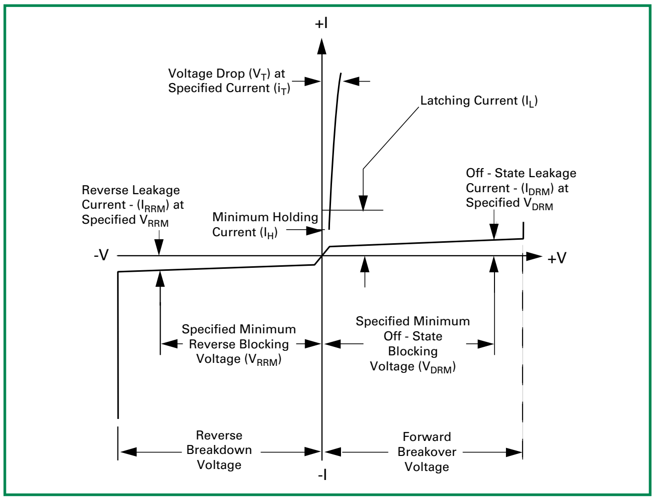


Figure AN1001.12 V-I Characteristics of SCR Device

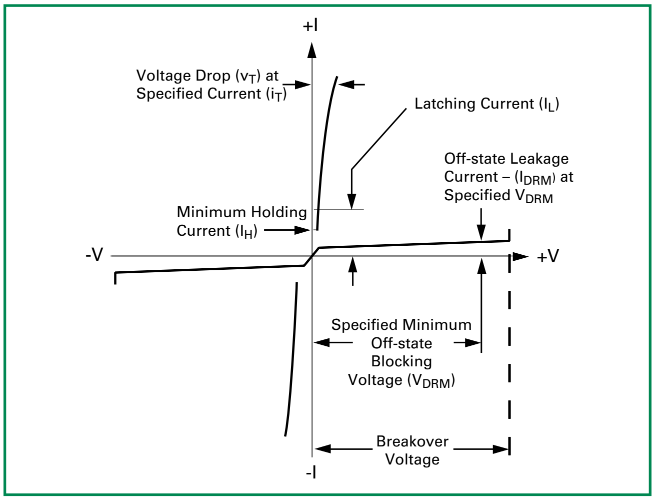


Figure AN1001.13 V-I Characteristics of Triac Device

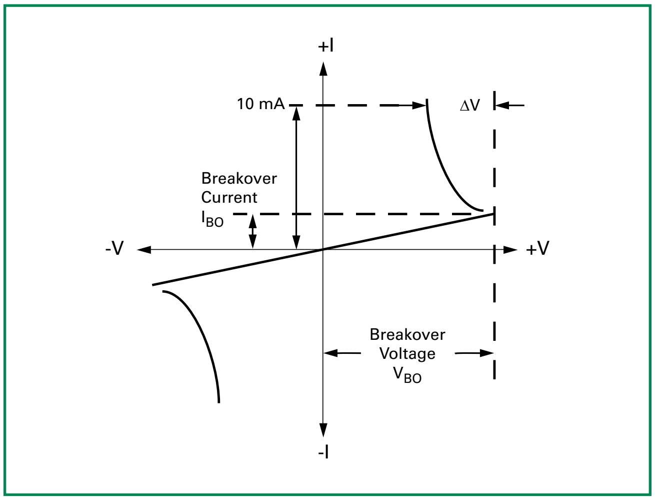


Figure AN1001.14 V-I Characteristics of Bilateral Trigger DIAC

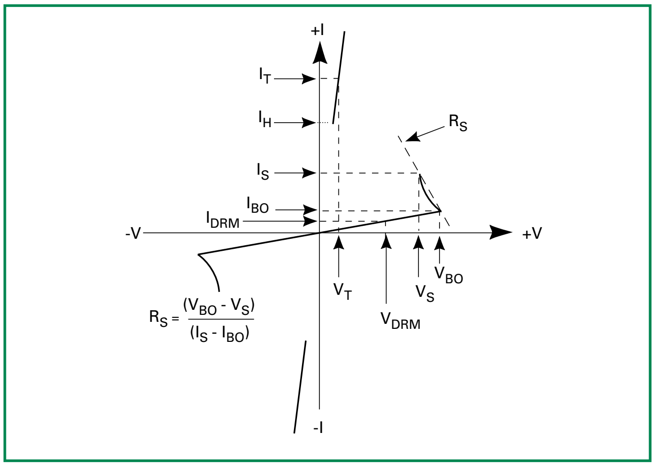


Figure AN1001.15 V-I Characteristics of a SIDAC Chip

Methods of Switching on Thyristors

Three general methods are available for switching Thyristors to on-state condition:

- Application of gate signal
- Static dv/dt turn-on
- Voltage breakover turn-on

Application Of Gate Signal

Gate signal must exceed I_{GT} and V_{GT} requirements of the Thyristor used. For an SCR (unilateral device), this signal must be positive with respect to the cathode polarity. A Triac (bilateral device) can be turned on with gate signal of either polarity; however, different polarities have different requirements of I_{GT} and V_{GT} which must be satisfied. Since DIACs and SIDACs do not have a gate, this method of turn-on is not applicable. In fact, the single major application of DIACs is to switch on Triacs.

Static dv/dt Turn-on

Static dv/dt turn-on comes from a fast-rising voltage applied across the anode and cathode terminals of an SCR or the main terminals of a Triac. Due to the nature of Thyristor construction, a small junction capacitor is formed across each PN junction. Figure AN1001.16 shows how typical internal capacitors are linked in gated Thyristors.

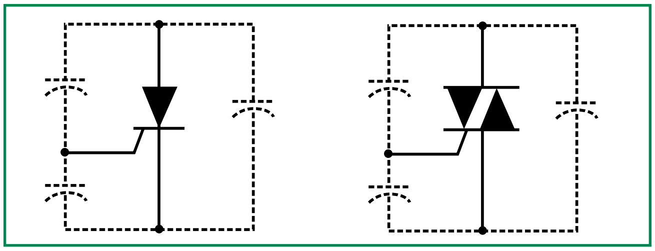


Figure AN1001.16 Internal Capacitors Linked in Gated Thyristors

When voltage is impressed suddenly across a PN junction, a charging current flows, equal to:

$$i = C\left(\frac{dv}{dt}\right)$$

When $C\left(\frac{dv}{dt}\right)$ becomes greater or equal to Thyristor I_{GT}, the Thyristor switches on. Normally, this type of turn-on does not damage the device, providing the surge current is limited.

Generally, Thyristor application circuits are designed with static dv/dt snubber networks if fast-rising voltages are anticipated.

Voltage Breakover Turn-on

This method is used to switch on SIDACs and DIACs. However, exceeding voltage breakover of SCRs and Triacs is definitely not recommended as a turn-on method.

In the case of SCRs and Triacs, leakage current increases until it exceeds the gate current required to turn on these gated Thyristors in a small localized point. When turn-on occurs by this method, localized heating in a small area may melt the silicon or damage the device if di/dt of the increasing current is not sufficiently limited.

DIACs used in typical phase control circuits are basically protected against excessive current at breakover as long as the firing capacitor is not excessively large. When DIACs are used in a zener function, current limiting is necessary.

SIDACs are typically pulse-firing, high-voltage transformers and are current limited by the transformer primary. The SIDAC should be operated so peak current amplitude, current duration, and di/dt limits are not exceeded.

Triac Gating Modes Of Operation

Triacs can be gated in four basic gating modes as shown in Figure AN1001.17.

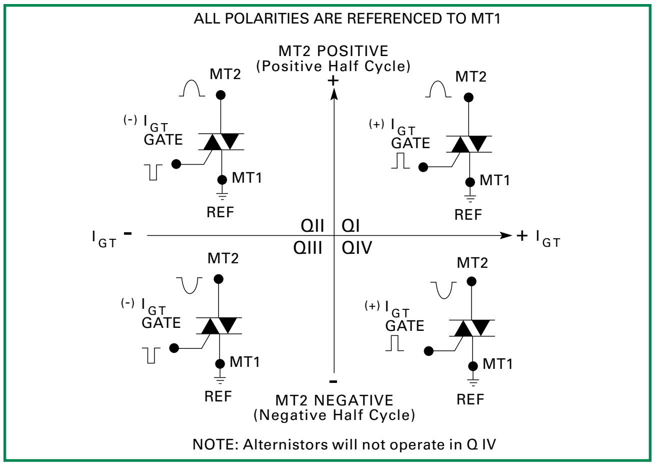


Figure AN1001.17 Gating Modes

The most common quadrants for Triac gating-on are Quadrants I and III, where the gate supply is synchronized with the main terminal supply (gate positive -- MT2 positive, gate negative -- MT2 negative). Gate sensitivity of Triacs is most optimum in Quadrants I and III due to the inherent Thyristor chip construction. If Quadrants I and III cannot be used, the next best operating modes are Quadrants II and III where the gate has a negative polarity supply with an AC main terminal supply. Typically, Quadrant II is approximately equal in gate sensitivity to Quadrant I; however, latching current sensitivity in Quadrant II is lowest. Therefore, it is difficult for Triacs to latch on in Quadrant II when the main terminal current supply is very low in value.

Special consideration should be given to gating circuit design when Quadrants I and IV are used in actual application, because Quadrant IV has the lowest gate sensitivity of all four operating quadrants.

General Terminology

The following definitions of the most widely-used Thyristor terms, symbols, and definitions conform to existing EIA-JEDEC standards:

Breakover Point – Any point on the principal voltage-current characteristic for which the differential resistance is zero and where the principal voltage reaches a maximum value

Principal Current – Generic term for the current through the collector junction (the current through main terminal 1 and main terminal 2 of a Triac or anode and cathode of an SCR)

Principal Voltage – Voltage between the main terminals:

(1) In the case of reverse blocking Thyristors, the principal voltage is called positive when the anode potential is higher than the cathode potential and negative when the anode potential is lower than the cathode potential.

(2) For bidirectional Thyristors, the principal voltage is called positive when the potential of main terminal 2 is higher than the potential of main terminal 1.

Off State – Condition of the Thyristor corresponding to the high-resistance, low-current portion of the principal voltage-current characteristic between the origin and the breakover point(s) in the switching quadrant(s)

On State – Condition of the Thyristor corresponding to the low-resistance, low-voltage portion of the principal voltage-current characteristic in the switching quadrant(s).

Fundamental Characteristics of Thyristors (continued)

Specific Terminology

Average Gate Power Dissipation [$P_{G(AV)}$] – Value of gate power which may be dissipated between the gate and main terminal 1 (or cathode) averaged over a full cycle

Breakover Current (I_{BO}) – Principal current at the breakover point

Breakover Voltage (V_{BO}) – Principal voltage at the breakover point

Circuit-commutated Turn-off Time (t_q) – Time interval between the instant when the principal current has decreased to zero after external switching of the principal voltage circuit and the instant when the Thyristor is capable of supporting a specified principal voltage without turning on

Critical Rate-of-rise of Commutation Voltage of a Triac (Commutating dv/dt) – Minimum value of the rate-of-rise of principal voltage which will cause switching from the off state to the on state immediately following on-state current conduction in the opposite quadrant

Critical Rate-of-rise of Off-state Voltage or Static dv/dt (dv/dt) – Minimum value of the rate-of-rise of principal voltage which will cause switching from the off state to the on state

Critical Rate-of-rise of On-state Current (di/dt) – Maximum value of the rate-of-rise of on-state current that a Thyristor can withstand without harmful effect

Gate-controlled Turn-on Time (t_{gt}) – Time interval between a specified point at the beginning of the gate pulse and the instant when the principal voltage (current) has dropped to a specified low value (or risen to a specified high value) during switching of a Thyristor from off state to the on state by a gate pulse.

Gate Trigger Current (I_{GT}) – Minimum gate current required to maintain the Thyristor in the on state

Gate Trigger Voltage (V_{GT}) – Gate voltage required to produce the gate trigger current

Holding Current (I_H) – Minimum principal current required to maintain the Thyristor in the on state

Latching Current (I_L) – Minimum principal current required to maintain the Thyristor in the on state immediately after the switching from off state to on state has occurred and the triggering signal has been removed

On-state Current (I_T) – Principal current when the Thyristor is in the on state

On-state Voltage (V_T) – Principal voltage when the Thyristor is in the on state

Peak Gate Power Dissipation (P_{GM}) – Maximum power which may be dissipated between the gate and main terminal 1 (or cathode) for a specified time duration

Repetitive Peak Off-state Current (I_{DRM}) – Maximum instantaneous value of the off-state current that results from the application of repetitive peak off-state voltage

Repetitive Peak Off-state Voltage (V_{DRM}) – Maximum instantaneous value of the off-state voltage which occurs across a Thyristor, including all repetitive transient voltages and excluding all non-repetitive transient voltages

Repetitive Peak Reverse Current of an SCR (I_{RRM}) – Maximum instantaneous value of the reverse current resulting from the application of repetitive peak reverse voltage

Repetitive Peak Reverse Voltage of an SCR (V_{RRM})– Maximum instantaneous value of the reverse voltage which occurs across the Thyristor, including all repetitive transient voltages and excluding all non-repetitive transient voltages

Surge (Non-repetitive) On-state Current (I_{TSM}) – On-state current of short-time duration and specified waveshape

Thermal Resistance, Junction to Ambient ($R_{\theta JA}$)– Temperature difference between the Thyristor junction and ambient divided by the power dissipation causing the temperature difference under conditions of thermal equilibrium

Note: Ambient is the point at which temperature does not change as the result of dissipation.

Thermal Resistance, Junction to Case ($R_{\theta JC}$) – Temperature difference between the Thyristor junction and the Thyristor case divided by the power dissipation causing the temperature difference under conditions of thermal equilibrium

Gating, Latching, and Holding of SCRs and Triacs

Introduction

Gating, latching, and holding currents of Thyristors are some of the most important parameters. These parameters and their interrelationship determine whether the SCRs and Triacs will function properly in various circuit applications.

This application note describes how the SCR and Triac parameters are related. This knowledge helps users select best operating modes for various circuit applications.

Gating of SCRs and Triacs

Three general methods are available to switch Thyristors to on-state condition:

- Applying proper gate signal
- Exceeding Thyristor static dv/dt characteristics
- Exceeding voltage breakover point

This application note examines only the application of proper gate signal. Gate signal must exceed the I_{GT} and V_{GT} requirements of the Thyristor being used. I_{GT} (gate trigger current) is the minimum gate current required to switch a Thyristor from the off state to the on state. V_{GT} (gate trigger voltage) is the voltage required to produce the gate trigger current.

SCRs (unilateral devices) require a positive gate signal with respect to the cathode polarity. Figure AN1002.1 shows the current flow in a cross-sectional view of the SCR chip.

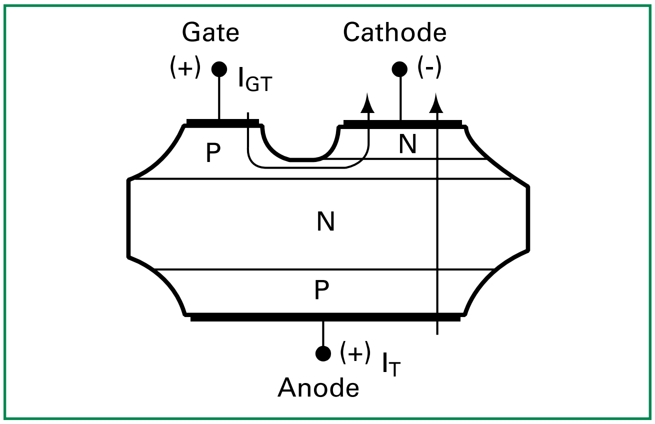


Figure AN1002.1 SCR Current Flow

In order for the SCR to latch on, the anode-to-cathode current (I_T) must exceed the latching current (I_L) requirement. Once latched on, the SCR remains on until it is turned off when anode-to-cathode current drops below holding current (I_H) requirement.

Triacs (bilateral devices) can be gated on with a gate signal of either polarity with respect to the MT1 terminal; however, different polarities have different requirements of I_{GT} and V_{GT}. Figure AN1002.2 illustrates current flow through the Triac chip in various gating modes.

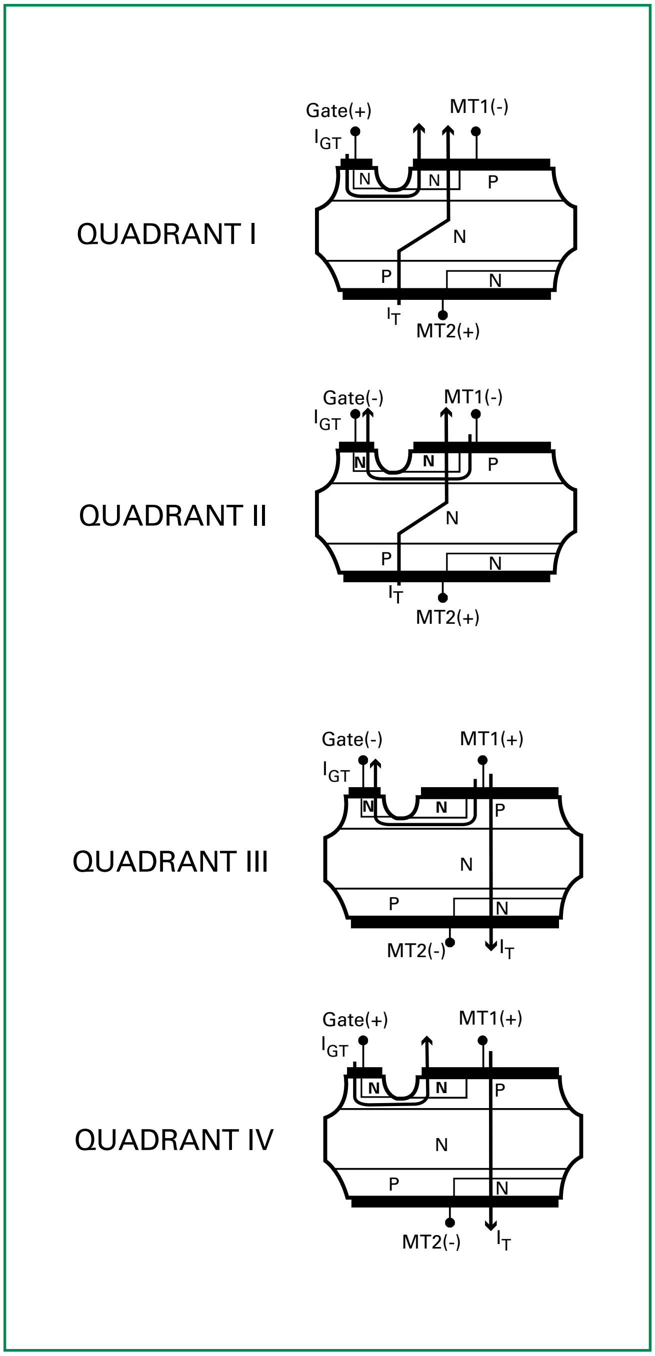


Figure AN1002.2 Triac Current Flow (Four Operating Modes)

Triacs can be gated on in one of four basic gating modes as shown in Figure AN1002.3. The most common quadrants for gating on Triacs are Quadrants I and III, where the gate supply is synchronized with the main terminal supply (gate positive -- MT2 positive, gate negative -- MT2 negative). Optimum Triac gate sensitivity is achieved when operating in Quadrants I and III due to the inherent Thyristor chip construction. If Quadrants I and III cannot be used, the next best operating modes are Quadrants II and III where the gate supply has a negative polarity with an AC main terminal supply. Typically, Quadrant II is approximately equal in gate sensitivity to Quadrant I; however, latching current sensitivity in Quadrant II is lowest. Therefore, it is difficult for Triacs to latch on in Quadrant II when the main terminal current supply is very low in value.

Special consideration should be given to gating circuit design when Quadrants I and IV are used in actual application, because Quadrant IV has the lowest gate sensitivity of all four operating quadrants.

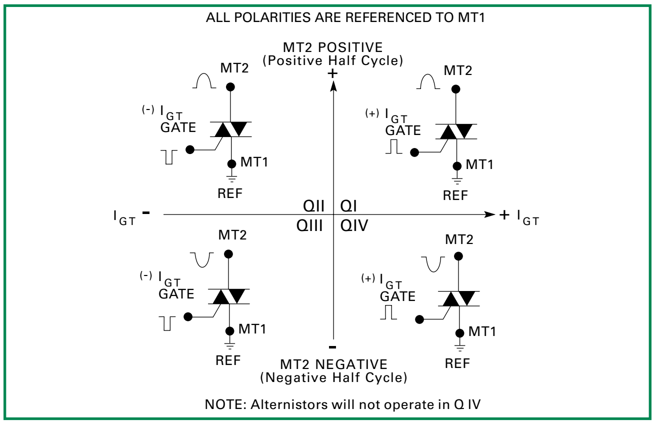


Figure AN1002.3 Definition of Operating Quadrants in Triacs

The following table shows the relationships between different gating modes in current required to gate on Triacs.

Typical Ratio of $\frac{I_{GT}\text{(in given Quadrant)}}{I_{GT}\text{(Quadrant 1)}}$ at 25°C				
Type	Operating Mode			
	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
4 A Triac	1	1.6	2.5	2.7
10 A Triac	1	1.5	1.4	3.1

Example of 4 A Triac:

If I_{GT}(I) = 10 mA, then

I_{GT}(II) = 16 mA

I_{GT}(III) = 25 mA

I_{GT}(IV) = 27 mA

Gate trigger current is temperature-dependent as shown in Figure AN1002.4. Thyristors become less sensitive with decreasing temperature and more sensitive with increasing temperature.

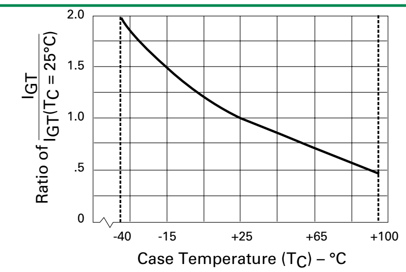


Figure AN1002.4 Typical DC Gate Trigger Current versus Case Temperature

For applications where low temperatures are expected, gate current supply should be increased to at least two to eight times the gate trigger current requirements at 25 °C. The actual factor varies by Thyristor type and the environmental temperature.

Example of a 10 A Triac:

If I_{GT}(I) = 10 mA at 25 °C, then

I_{GT}(I) = 20 mA at -40 °C

In applications where high di/dt, high surge, and fast turn-on are expected, gate drive current should be steep rising (1 µs rise time) and at least twice rated I_{GT} or higher with minimum 3 µs pulse duration. However, if gate drive current magnitude is very high, then duration may have to be limited to keep from overstressing (exceeding the power dissipation limit of) gate junction.

Latching Current of SCRs and Triacs

Latching current (I_L) is the minimum principal current required to maintain the Thyristor in the on state immediately after the switching from off state to on state has occurred and the triggering signal has been removed. Latching current can best be understood by relating to the "pick-up" or "pull-in" level of a mechanical relay. Figure AN1002.5 and Figure AN1002.6 illustrate typical Thyristor latching phenomenon.

In the illustrations in Figure AN1002.5, the Thyristor does not stay on after gate drive is removed due to insufficient available principal current (which is lower than the latching current requirement).

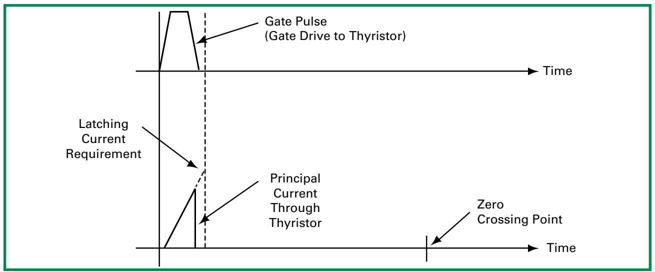


Figure AN1002.5 Latching Characteristic of Thyristor (Device Not Latched)

In the illustration in Figure AN1002.6 the device stays on for the remainder of the half cycle until the principal current falls below the holding current level. Figure AN1002.5 shows the characteristics of the same device if gate drive is removed or shortened before latching current requirement has been met.

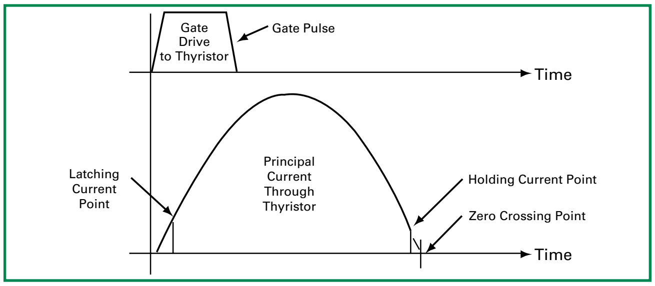


Figure AN1002.6 Latching and Holding Characteristics of Thyristor

Similar to gating, latching current requirements for Triacs are different for each operating mode (quadrant). Definitions of latching modes (quadrants) are the same as gating modes. Therefore, definitions shown in Figure AN1002.2 and Figure AN1002.3 can be used to describe latching modes (quadrants) as well. The following table shows how different latching modes (quadrants) relate to each other. As previously stated, Quadrant II has the lowest latching current sensitivity of all four operating quadrants.

Typical Ratio of $\frac{I_L\text{(in given Quadrant)}}{I_L\text{(Quadrant 1)}}$ at 25°C				
Type	Operating Mode			
	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
4 A Triac	1	4	1.2	1.1
10 A Triac	1	4	1.1	1

Example of a 4 Amp Triac:

If I_L(I) = 10 mA, then

I_L(II) = 40 mA

I_L(III) = 12 mA

I_L(IV) = 11 mA

Latching current has even somewhat greater temperature dependence compared to the DC gate trigger current. Applications with low temperature requirements should have sufficient principal current (anode current) available to ensure Thyristor latch-on.

Two key test conditions on latching current specifications are gate drive and available principal (anode) current durations. Shortening the gate drive duration can result in higher latching current values.

Holding Current of SCRs and Triacs

Holding current (I_H) is the minimum principal current required to maintain the Thyristor in the on state. Holding current can best be understood by relating it to the "drop-out" or "must release" level of a mechanical relay. Figure AN1002.6 shows the sequences of gate, latching, and holding currents. Holding current will always be less than latching. However, the more sensitive the device, the closer the holding current value approaches its latching current value.

Holding current is independent of gating and latching, but the device must be fully latched on before a holding current limit can be determined. Holding current modes of the Thyristor are strictly related to the voltage polarity across the main terminals. The following table illustrates how the positive and negative holding current modes of Triacs relate to each other.

Typical Triac Holding Current Ratio		
Type	Operating Mode	
	I_H(+)	I_H(–)
4 A Triac	1	1.1
10 A Triac	1	1.3

Example of a 10 A Triac:

If I_H(+) = 10 mA, then

I_H(-) = 13 mA

Holding current is also temperature-dependent like gating and latching shown in Figure AN1002.7. The initial on-state current is 200 mA to ensure that the Thyristor is fully latched on prior to holding current measurement. Again, applications with low temperature requirements should have sufficient principal (anode) current available to maintain the Thyristor in the on-state condition.

Both minimum and maximum holding current specifications may be important, depending on application. Maximum holding current must be considered if the Thyristor is to stay in conduction at low principal (anode) current; the minimum holding current must be considered if the device is expected to turn off at a low principal (anode) current.

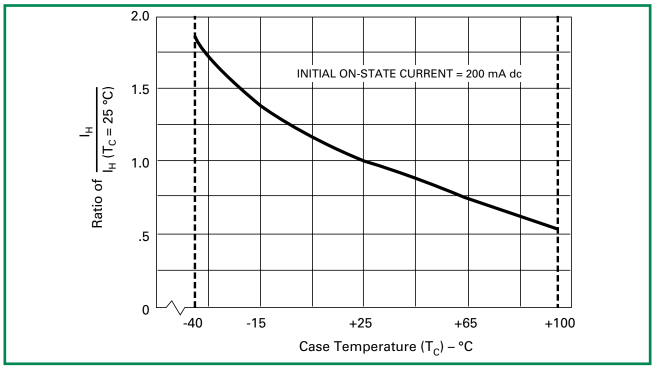


Figure AN1002.7 Typical DC Holding Current vs Case Temperatures

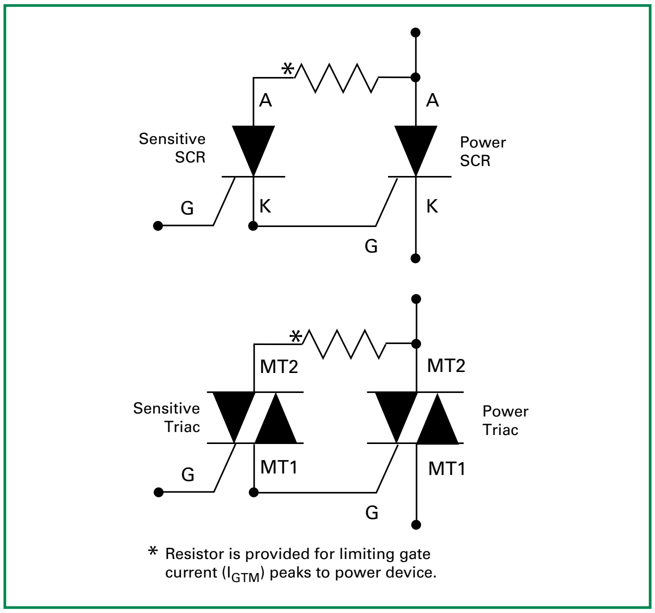
Example of a 10 A Triac:

If I_H(+) = 10 mA at 25 °C, then

I_H(+) ≈ 7.5 mA at 65 °C

Relationship of Gating, Latching, and Holding Currents

Although gating, latching, and holding currents are independent of each other in some ways, the parameter values are related. If gating is very sensitive, latching and holding will also be very sensitive and vice versa. One way to obtain a sensitive gate and not-so-sensitive latching-holding characteristic is to have an "amplified gate" as shown in Figure AN1002.8.



* Resistor is provided for limiting gate current (I_{GTM}) peaks to power device.

Figure AN1002.8 "Amplified Gate" Thyristor Circuit

The following table and Figure AN1002.9 show the relationship of gating, latching, and holding of a 4 A device.

Typical 4 A Triac Gating, Latching, and Holding Relationship				
Parameter	Quadrants or Operating Mode			
	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
I_{GT} (mA)	10	17	18	27
I_L (mA)	12	48	12	13
I_H (mA)	10	10	12	12

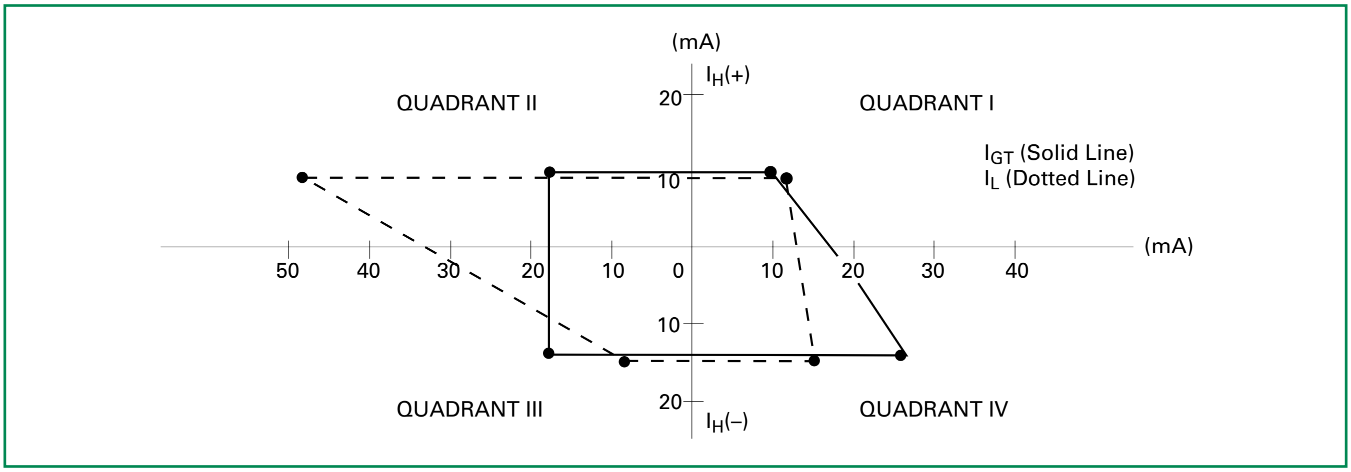


Figure AN1002.9 Typical Gating, Latching, and Holding Relationships of 4 A Triac at 25 °C

The relationships of gating, latching, and holding for several device types are shown in the following table. For convenience all ratios are referenced to Quadrant I gating.

Typical Ratio of Gating, Latching, and Holding Current at 25 °C									
Devices	Ratio								
	$\frac{I_{GT}(II)}{I_{GT}(I)}$	$\frac{I_{GT}(III)}{I_{GT}(I)}$	$\frac{I_{GT}(IV)}{I_{GT}(I)}$	$\frac{I_L(I)}{I_{GT}(I)}$	$\frac{I_L(II)}{I_{GT}(I)}$	$\frac{I_L(III)}{I_{GT}(I)}$	$\frac{I_L(IV)}{I_{GT}(I)}$	$\frac{I_H(+)}{I_{GT}(I)}$	$\frac{I_H(-)}{I_{GT}(I)}$
4A Triac	1.6	2.5	2.7	1.2	4.8	1.2	1.3	1.0	1.2
10A Triac	1.5	1.4	3.1	1.6	4.0	1.8	2.0	1.1	1.6
15A Alternistor	1.5	1.8	–	2.4	7.0	2.1	–	2.2	1.9
1A Sensitive SCR	–	–	–	25	–	–	–	25	–
6A SCR	–	–	–	3.2	–	–	–	2.6	–

Gating, Latching, and Holding of SCRs and Triacs (continued)

Examples of a 10 A Triac:

If I_{GT}(I) = 10 mA, then
I_{GT}(II) = 15 mA
I_{GT}(III) = 14 mA
I_{GT}(IV) = 31 mA

If I_L(I) = 16 mA, then
I_L(II) = 40 mA
I_L(III) = 18 mA
I_L(IV) = 20 mA

If I_H(+) = 11 mA at 25 °C, then
I_H(+) = 16 mA

Summary

Gating, latching, and holding current characteristics of Thyristors are quite important yet predictable (once a single parameter value is known). Their interrelationships (ratios) can also be used to help designers in both initial circuit application design as well as device selection.

Phase Control Using Thyristors

Introduction

Due to high-volume production techniques, Thyristors are now priced so that almost any electrical product can benefit from electronic control. A look at the fundamentals of SCR and Triac phase controls shows how this is possible.

Output Power Characteristics

Phase control is the most common form of Thyristor power control. The Thyristor is held in the off condition -- that is, all current flow in the circuit is blocked by the Thyristor except a minute leakage current. Then the Thyristor is triggered into an "on" condition by the control circuitry.

For full-wave AC control, a single Triac or two SCRs connected in inverse parallel may be used. One of two methods may be used for full-wave DC control -- a bridge rectifier formed by two SCRs or an SCR placed in series with a diode bridge as shown in Figure AN1003.1.

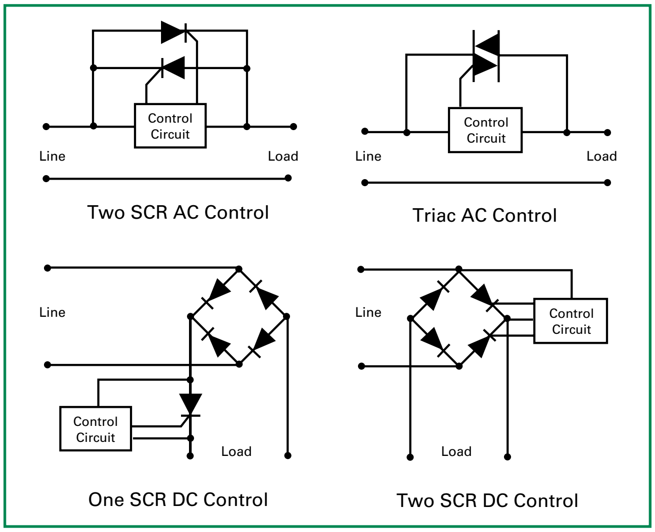


Figure AN1003.1 SCR/Triac Connections for Various Methods of Phase Control

Figure AN1003.2 illustrates voltage waveform and shows common terms used to describe Thyristor operation. Delay angle is the time during which the Thyristor blocks the line voltage. The conduction angle is the time during which the Thyristor is on.

It is important to note that the circuit current is determined by the load and power source. For simplification, assume the load is resistive; that is, both the voltage and current waveforms are identical.

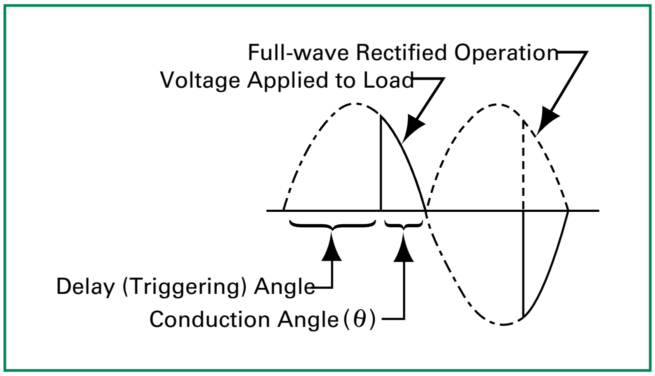


Figure AN1003.2 Sine Wave Showing Principles of Phase Control

Different loads respond to different characteristics of the AC waveform. For example, some are sensitive to average voltage, some to RMS voltage, and others to peak voltage. Various voltage characteristics are plotted against conduction angle for half- and full-wave phase control circuits in Figure AN1003.3 and Figure AN1003.4.

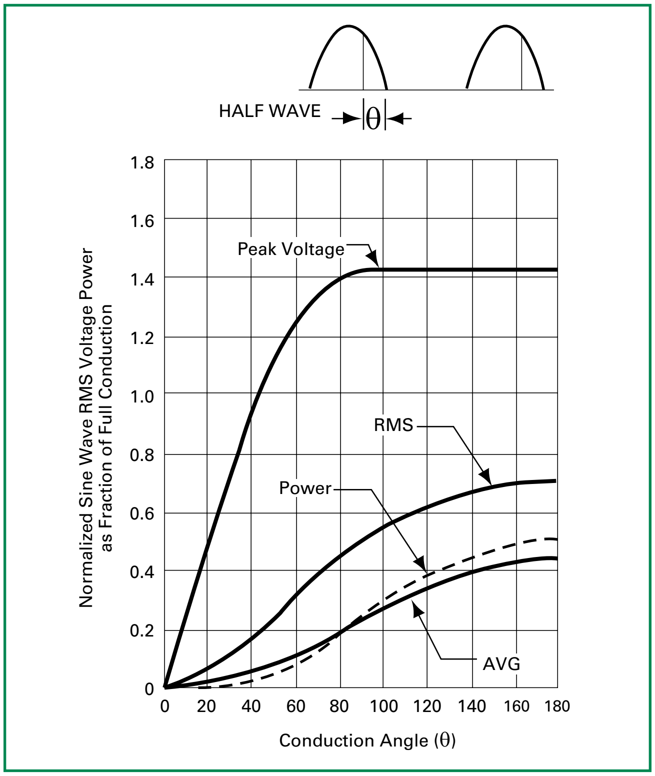


Figure AN1003.3 Half-Wave Phase Control (Sinusoidal)

Phase Control Using Thyristors (continued)

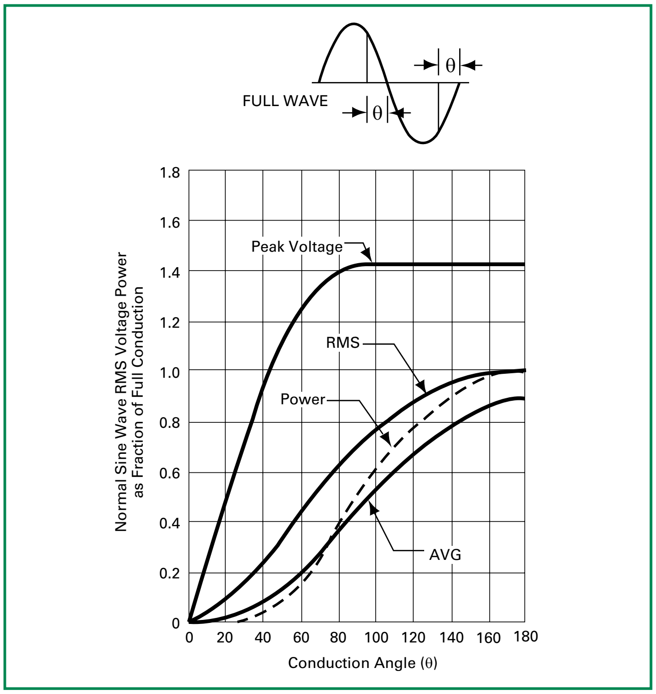


Figure AN1003.4 Symmetrical Full-Wave Phase Control (Sinusoidal)

Figure AN1003.3 and Figure AN1003.4 also show the relative power curve for constant impedance loads such as heaters. Because the relative impedance of incandescent lamps and motors change with applied voltage, they do not follow this curve precisely. To use the curves, find the full-wave rated power of the load, and then multiply by the ratio associated with the specific phase angle. Thus, a 180° conduction angle in a half-wave circuit provides 0.5 x full-wave conduction power.

In a full-wave circuit, a conduction angle of 150° provides 97% full power while a conduction angle of 30° provides only 3% of full power control. Therefore, it is usually pointless to obtain conduction angles less than 30° or greater than 150°.

Figure AN1003.5 and Figure AN1003.6 give convenient direct output voltage readings for 115 V/230 V input voltage. These curves also apply to current in a resistive circuit.

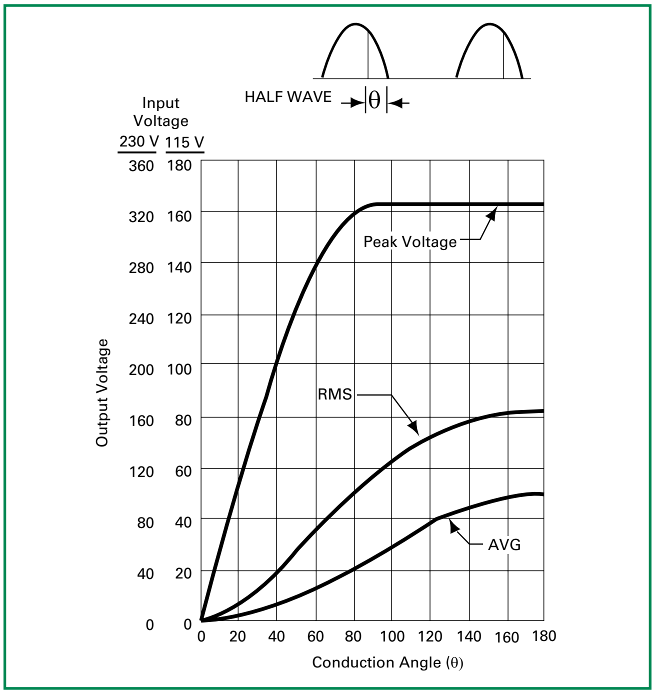


Figure AN1003.5 Output Voltage of Half-wave Phase

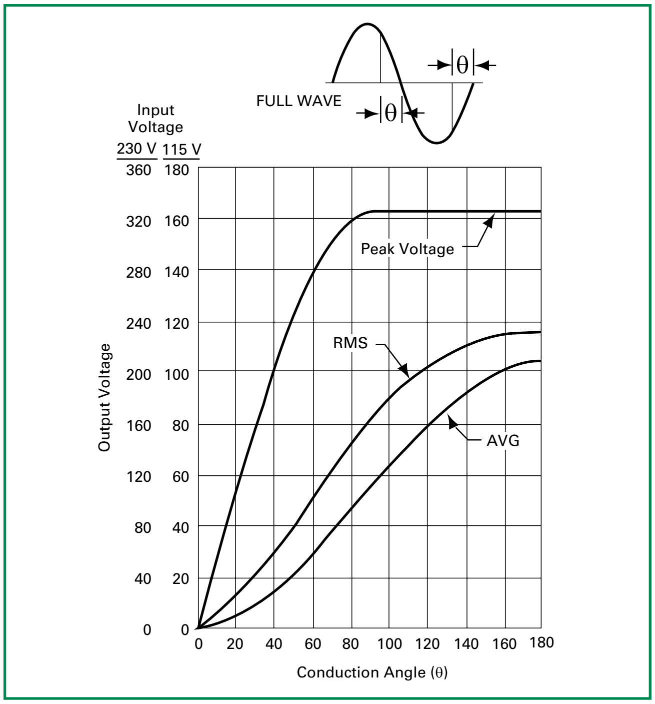


Figure AN1003.6 Output Voltage of Full-wave Phase Control

Phase Control Using Thyristors (continued)

Control Characteristics

A relaxation oscillator is the simplest and most common control circuit for phase control. Figure AN1003.7 illustrates this circuit as it would be used with a Thyristor. Turn-on of the Thyristor occurs when the capacitor is charged through the resistor from a voltage or current source until the breakover voltage of the switching device is reached. Then, the switching device changes to its on state, and the capacitor is discharged through the Thyristor gate. Trigger devices used are neon bulbs, unijunction transistors, and three-, four-, or five-layer semiconductor trigger devices. Phase control of the output waveform is obtained by varying the RC time constant of the charging circuit so the trigger device breakdown occurs at different phase angles within the controlled half or full cycle.

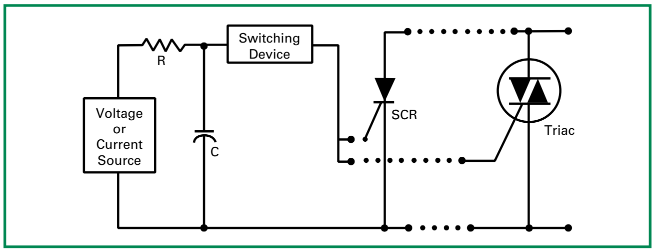


Figure AN1003.7 Relaxation Oscillator Thyristor Trigger Circuit

Figure AN1003.8 shows the capacitor voltage-time characteristic if the relaxation oscillator is to be operated from a pure DC source.

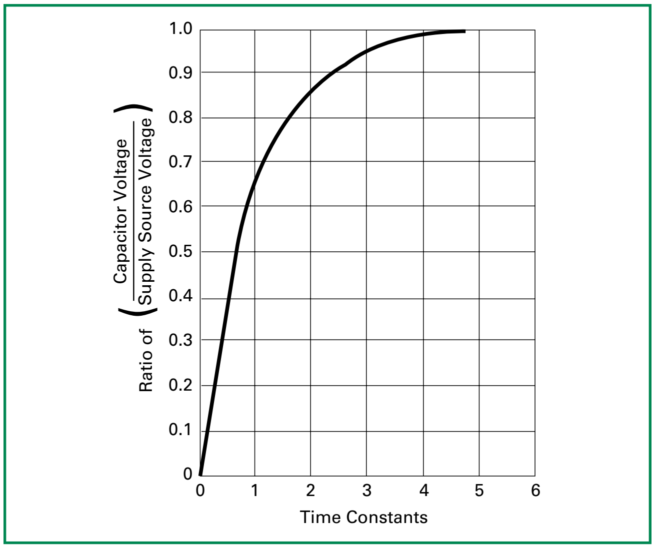


Figure AN1003.8 Capacitor Charging from DC Source

Usually, the design starting point is the selection of a capacitance value which will reliably trigger the Thyristor when the capacitance is discharged. Trigger devices and Thyristor gate triggering characteristics play a part in the selection. All the device characteristics are not always completely specified in applications, so experimental determination is sometimes needed.

Upon final selection of the capacitor, the curve shown in Figure AN1003.8 can be used in determining the charging resistance needed to obtain the desired control characteristics.

Many circuits begin each half-cycle with the capacitor voltage at or near zero. However, most circuits leave a relatively large residual voltage on the capacitor after discharge. Therefore, the charging resistor must be determined on the basis of additional charge necessary to raise the capacitor to trigger potential.

For example, assume that we want to trigger an S2010L SCR with a 32 V trigger DIAC. A 0.1 µF capacitor will supply the necessary SCR gate current with the trigger DIAC. Assume a 50 V dc power supply, 30° minimum conduction angle, and 150° maximum conduction angle with a 60 Hz input power source. At approximately 32 V, the DIAC triggers leaving 0.66 V_{BO} of DIAC voltage on the capacitor. In order for DIAC to trigger, 22 V must be added to the capacitor potential, and 40 V additional (50-10) are available. The capacitor must be charged to 22/40 or 0.55 of the available charging voltage in the desired time. Looking at Figure AN1003.8, 0.55 of charging voltage represents 0.8 time constant. The 30° conduction angle required that the firing pulse be delayed 150° or 6.92 ms. (The period of 1/2 cycle at 60 Hz is 8.33 ms.) To obtain this time delay:

$$6.92 \text{ ms} = 0.8\ RC$$

$$RC = 8.68 \text{ ms}$$

$$\text{if } C = 0.10\ \mu\text{F}$$

$$\text{then, } R = \frac{8.68 \times 10^{-3}}{0.1 \times 10^{-6}} = 86{,}000\ \Omega$$

To obtain the minimum R (150° conduction angle), the delay is 30° or

$$(30/180) \times 8.33 = 1.39 \text{ ms}$$

$$1.39 \text{ ms} = 0.8\ RC$$

$$RC = 1.74 \text{ ms}$$

$$R = \frac{1.74 \times 10^{-3}}{0.1 \times 10^{-6}} = 17{,}400\ \Omega$$

Using practical values, a 100 k potentiometer with up to 17 k minimum (residual) resistance should be used. Similar calculations using conduction angles between the maximum and minimum values will give control resistance versus power characteristic of this circuit.

Triac Phase Control

The basic full-wave Triac phase control circuit shown in Figure AN1003.9 requires only four components. Adjustable resistor R_1 and C_1 are a single-element phase-shift network. When the voltage across C_1 reaches breakover voltage (V_{BO}) of the DIAC, C_1 is partially discharged by the DIAC into the Triac gate. The Triac is then triggered into the conduction mode for the remainder of that half-cycle. In this circuit, triggering is in Quadrants I and III. The unique simplicity of this circuit makes it suitable for applications with small control range.

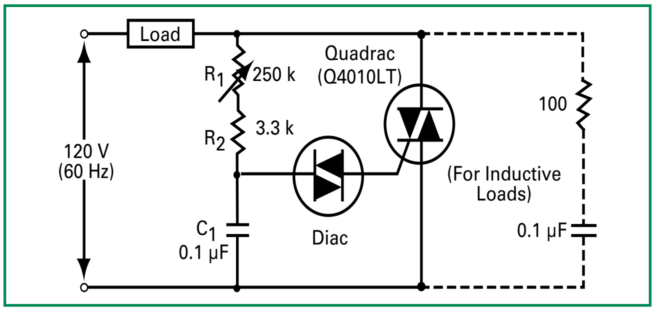


Figure AN1003.9 Basic DIAC-Quadrac Phase Control

The hysteresis (snap back) effect is somewhat similar to the action of a kerosene lantern. That is, when the control knob is first rotated from the off condition, the lamp can be lit only at some intermediate level of brightness, similar to turning up the wick to light the lantern. Brightness can then be turned down until it finally reaches the extinguishing point. If this occurs, the lamp can only be relit by turning up the control knob again to the intermediate level. Figure AN1003.10 illustrates the hysteresis effect in capacitor-DIAC triggering. As R_1 is brought down from its maximum resistance, the voltage across the capacitor increases until the DIAC first fires at point A, at the end of a half-cycle (conduction angle θi). After the gate pulse, however, the capacitor voltage drops suddenly to about half the triggering voltage, giving the capacitor a different initial condition. The capacitor charges to the DIAC, triggering voltage at point B in the next half-cycle and giving a steady-state conduction angle shown as θ for the Triac.

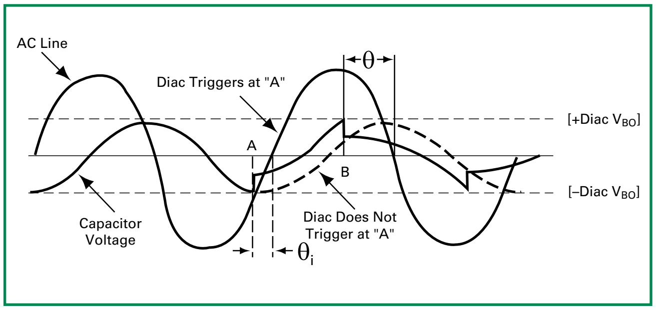


Figure AN1003.10 Relationship of AC Line Voltage and Triggering Voltage

In the Figure AN1003.11 illustration, the addition of a second RC phase-shift network extends the range on control and reduces the hysteresis effect to a negligible region. This circuit will control from 5% to 95% of full load power, but is subject to supply voltage variations. When R_1 is large, C_1 is charged primarily through R_3 from the phase-shifted voltage appearing across C_2. This action provides additional range of phase-shift across C_1 and enables C_2 to partially recharge C_1 after the DIAC has triggered, thus reducing hysteresis. R_3 should be adjusted so that the circuit just drops out of conduction when R_1 is brought to maximum resistance.

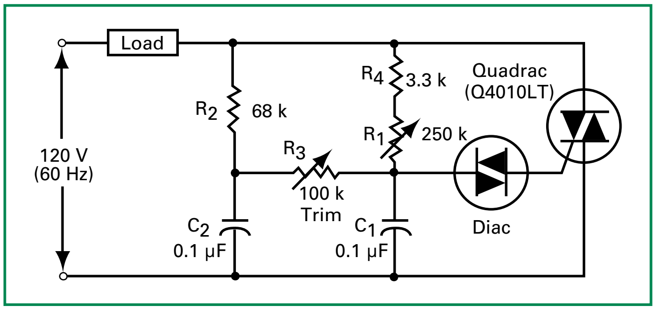


Figure AN1003.11 Extended Range Full-wave Phase Control

By using one of the circuits shown in Figure AN1003.12, the hysteresis effect can be eliminated entirely. The circuit (a) resets the timing capacitor to the same level after each positive half-cycle, providing a uniform initial condition for the timing capacitor. This circuit is useful only for resistive loads since the firing angle is not symmetrical throughout the range. If symmetrical firing is required, use the circuit (b) shown in Figure AN1003.12.

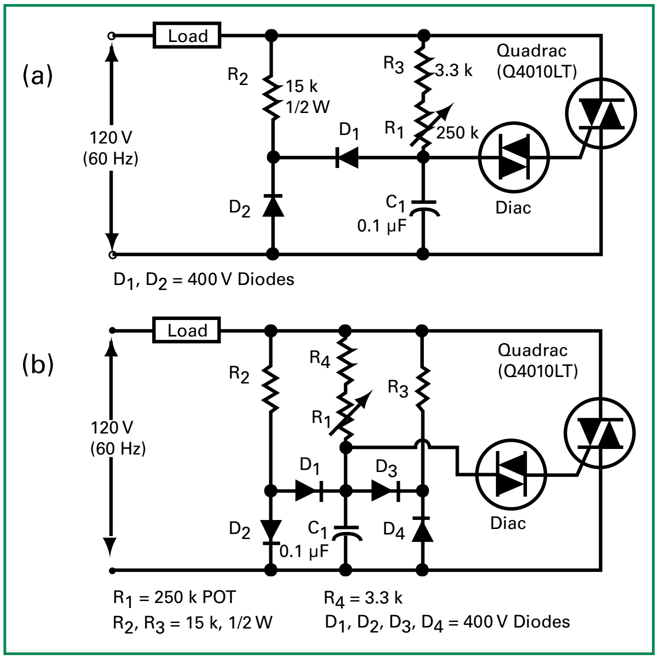
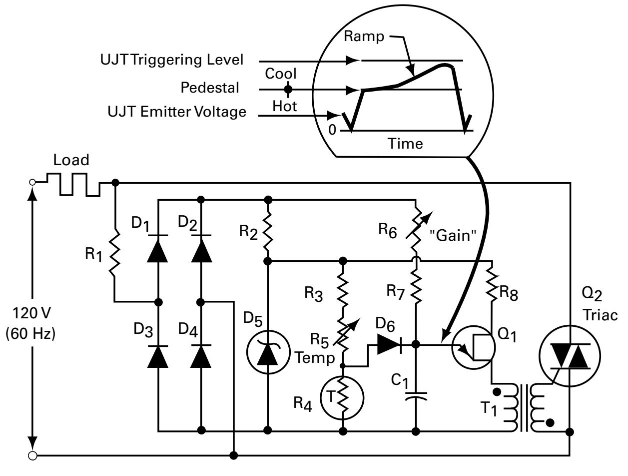


Figure AN1003.12 Wide-range Hysteresis Free Phase Control

For more complex control functions, particularly closed loop controls, the unijunction transistor may be used for the triggering device in a ramp and pedestal type of firing circuit as shown in Figure AN1003.13.

Phase Control Using Thyristors (continued)



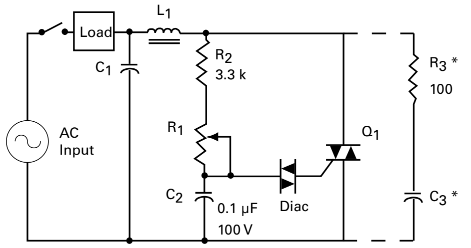
R_1, R_2 = 2.2 k, 2 W
R_3 = 2.2 k, 1/2 W
R_4 = Thermistor, approx. 5 k at operating temperature
R_5 = 10 k Potentiometer
R_6 = 5 M Potentiometer
R_7 = 100 k, 1/2 W
R_8 = 1 k, 1/2 W

Q_1 = 2N2646
Q_2 = Q4010L5
T_1 = Dale PT 10-101 or equivalent
D_{1-4} = 200 V Diode
D_5 = 20 V Zener
D_6 = 100 V Diode
C_1 = 0.1 µF, 30 V

Figure AN1003.13 Precision Proportional Temperature Control

Several speed control and light dimming (phase) control circuits have been presented that give details for a complete 120 V application circuit but none for 240 V. Figure AN1003.14 and Figure AN1003.15 show some standard phase control circuits for 240 V, 60 Hz/50 Hz operation along with 120 V values for comparison. Even though there is very little difference, there are a few key things that must be remembered. First, capacitors and Triacs connected across the 240 V line must be rated at 400 V. Secondly, the potentiometer (variable resistor) value must change considerably to obtain the proper timing or triggering for 180° in each half-cycle.

Figure AN1003.14 shows a simple single-time-constant light dimmer (phase control) circuit, giving values for both 120 V and 240 V operation.



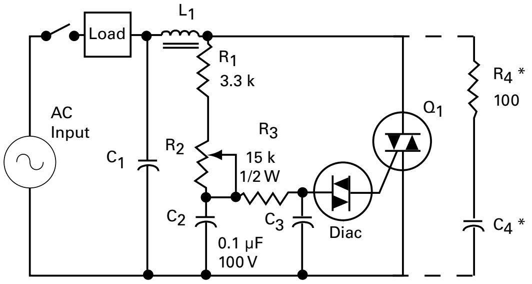
Note: L_1 and C_1 form an RFI filter that may be eliminated

* dv/dt snubber network when required

AC Input Voltage	AC Load Current	R_1	C_1, C_3	L_1	Q_1
120 V ac 60 Hz	12 A	250 k	0.1 µF 200 V	100 µH	Q4010LTH
240 V ac 50/60 Hz	3 A	500 k	0.1 µF 400 V	200 µH	Q6006LTH

Figure AN1003.14 Single-time-constant Circuit for Incandescent Light Dimming, Heat Control, and Motor Speed Control

The circuit shown in Figure AN1003.15 is a double-time-constant circuit which has improved performance compared to the circuit shown in Figure AN1003.14. This circuit uses an additional RC network to extend the phase angle so that the Triac can be triggered at small conduction angles. The additional RC network also minimizes any hysteresis effect explained and illustrated in Figure AN1003.10 and Figure AN1003.11.



Note: L_1 and C_1 form an RFI filter that may be eliminated

* dv/dt snubber network when required

AC Input Voltage	AC Load Current	R_2	C_1, C_2, C_4	L_1	Q_1
120 V ac 60 Hz	8 A	250 k	0.1 µF 200 V	100 µH	Q4010LTH
240 V ac 50 Hz	6 A	500 k	0.1 µF 400 V	200 µH	Q6008LTH
240 V ac 60 Hz	6 A	500 k	0.1 µF 400 V	200 µH	Q6008LTH

Figure AN1003.15 Double-time-constant Circuit for Incandescent Light Dimming, Heat Control, and Motor Speed Control

Permanent Magnet Motor Control

Figure AN1003.16 illustrates a circuit for phase controlling a permanent magnet (PM) motor. Since PM motors are also generators, they have characteristics that make them difficult for a standard Triac to commutate properly. Control of a PM motor is easily accomplished by using an alternistor Triac with enhanced commutating characteristics.

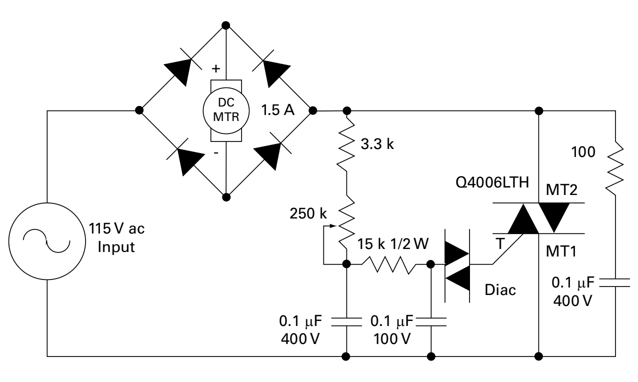
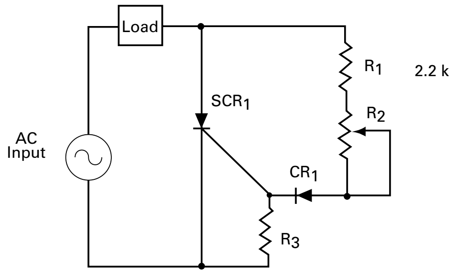


Figure AN1003.16 Circuit for Phase Controlling a Permanent Magnet Motor

PM motors normally require full-wave DC rectification. Therefore, the alternistor Triac controller should be connected in series with the AC input side of the rectifier bridge. The possible alternative of putting an SCR controller in series with the motor on the DC side of the rectifier bridge can be a challenge when it comes to timing and delayed turn-on near the end of the half cycle. The alternistor Triac controller shown in Figure AN1003.16 offers a wide range control so that the alternistror Triac can be triggered at a small conduction angle or low motor speed; the rectifiers and alternistors should have similar voltage ratings, with all based on line voltage and actual motor load requirements.

SCR Phase Control

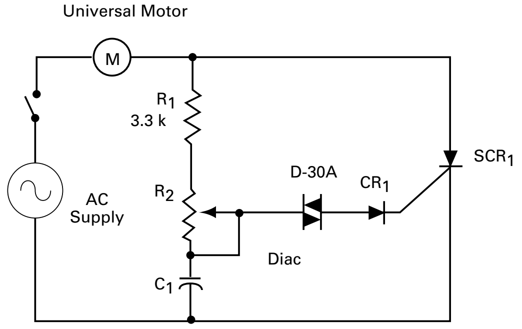
Figure AN1003.17 shows a very simple variable resistance half-wave circuit. It provides phase retard from essentially zero (SCR full on) to 90 electrical degrees of the anode voltage wave (SCR half on). Diode CR_1 blocks reverse gate voltage on the negative half-cycle of anode supply voltage. This protects the reverse gate junction of sensitive SCRs and keeps power dissipation low for gate resistors on the negative half cycle. The diode is rated to block at least the peak value of the AC supply voltage. The retard angle cannot be extended beyond the 90-degree point because the trigger circuit supply voltage and the trigger voltage producing the gate current to fire are in phase. At the peak of the AC supply voltage, the SCR can still be triggered with the maximum value of resistance between anode and gate. Since the SCR will trigger and latch into conduction the first time I_{GT} is reached, its conduction cannot be delayed beyond 90 electrical degrees with this circuit.



AC Input Voltage	AC Load Current	R_2	CR_1	SCR_1	R_3
120 V ac 60 Hz	0.8 A	500 k	IN4003	EC103D	1 k
120 V ac 60 Hz	8.5 A	100 k	IN4003	S4010R	Not Required
240 V ac 60 Hz	0.8 A	1 M	IN4004	EC103D	1 k
240 V ac 60 Hz	8.5 A	250 k	IN4004	S6010R	Not Required
240 V ac 50Hz	2.5 A	1 M	IN4004	T106M1	1 k

Figure AN1003.17 Half-wave Control, 0° to 90° Conduction

Figure AN1003.18 shows a half-wave phase control circuit using an SCR to control a universal motor. This circuit is better than simple resistance firing circuits because the phase-shifting characteristics of the RC network permit the firing of the SCR beyond the peak of the impressed voltage, resulting in small conduction angles and very slow speed.



AC Input Voltage	AC Load Current	R_2	CR_1	SCR_1	C_1
120 V ac 60 Hz	8 A	150 k	IN4003	S6008L	0.1µF 200 V
240 V ac 60 Hz	6.5 A	200 k	IN4004	S4015L	0.1µF 400 V
240 V ac 50 Hz	6.5 A	200 k	IN4004	S6008L	0.1µF 400 V

Figure AN1003.18 Half-wave Motor Control

Phase Control Using Thyristors (continued)

Phase Control from Logic (DC) Inputs

Triacs can also be phase-controlled from pulsed DC unidirectional inputs such as those produced by a digital logic control system. Therefore, a microprocessor can be interfaced to AC load by using a sensitive gate Triac to control a lamp's intensity or a motor's speed.

There are two ways to interface the unidirectional logic pulse to control a Triac. Figure AN1003.19 illustrates one easy way if load current is approximately 5 A or less. The sensitive gate Triac serves as a direct power switch controlled by HTL, TTL, CMOS, or integrated circuit operational amplifier. A timed pulse from the system's logic can activate the Triac anywhere in the AC sinewave producing a phase-controlled load.

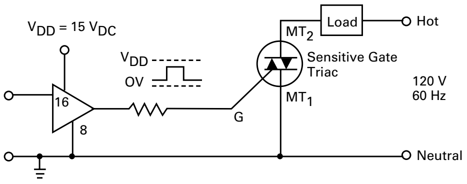
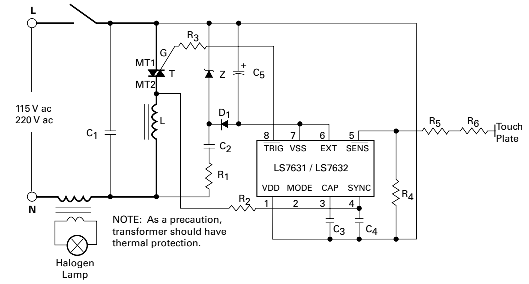


Figure AN1003.19 Sensitive Gate Triac Operating in Quadrants I and IV

The key to DC pulse control is correct grounding for DC and AC supply. As shown in Figure AN1003.19, **DC ground and AC ground/neutral must be common plus MT1 must be connected to common ground.** MT1 of the Triac is the return for both main terminal junctions as well as the gate junction.

Figure AN1003.20 shows an example of a unidirectional (all negative) pulse furnished from a special I.C. that is available from LSI Computer Systems in Melville, New York. Even though the circuit and load is shown to control a Halogen lamp, it could be applied to a common incandescent lamp for touch-controlled dimming.



NOTE: As a precaution, transformer should have thermal protection.

115 V ac

C_1 = 0.15 µF, 200 V
C_2 = 0.22 µF, 200 V
C_3 = 0.02 µF, 12 V
C_4 = 0.002 µF, 12 V
C_5 = 100 µF, 12 V
R_1 = 270, ¼ W
R_2 = 680 k, ¼ W
R_3 = 62, ¼ W
R_4 = 1 M to 5 M, ¼ W (Selected for sensitivity)
R_5, R_6 = 4.7 M, ¼ W
D_1 = 1N4148
Z = 5.6 V, 1 W Zener
T = Q4006LH4 Alternistor
L = 100 µH (RFI Filter)

220 V ac

C_1 = 0.15 µF, 400 V
C_2 = 0.1 µF, 400 V
C_3 = 0.02 µF, 12 V
C_4 = 0.002 µF, 12 V
C_5 = 100 µF, 12 V
R_1 = 1 k, ¼ W
R_2 = 1.5 M, ¼ W
R_3 = 62, ¼ W
R_4 = 1 M to 5 M, ¼ W (Selected for sensitivity)
R_5, R_6 = 4.7 M, ¼ W
D_1 = 1N4148
Z = 5.6 V, 1 W Zener
T = Q6006LH4 Alternistor
L = 200 µH (RFI Filter)

Figure AN1003.20 Typical Touch Plate Halogen Lamp Dimmer

For a circuit to control a heavy-duty inductive load where an alternistor is not compatible or available, two SCRs can be driven by an inexpensive TO-92 Triac to make a very high current Triac or alternistor equivalent, as shown in Figure AN1003.21. See "Relationship of IAV, IRMS, and IPK' in AN1009 for design calculations.

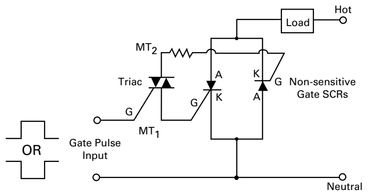


Figure AN1003.21 Triac Driving Two Inverse Parallel Non-Sensitive Gate SCRs

Figure AN1003.22 shows another way to interface a unidirectional pulse signal and activate AC loads at various points in the AC sine wave. This circuit has an electrically-isolated input which allows load placement to be flexible with respect to AC line. In other words, connection between DC ground and AC neutral is not required.

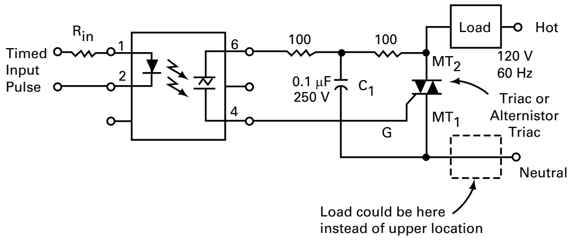


Figure AN1003.22 Opto-isolator Driving a Triac or Alternistor Triac

Microcontroller Phase Control

Traditionally, microcontrollers were too large and expensive to be used in small consumer applications such as a light dimmer. Microchip Technology Inc. of Chandler, Arizona has developed a line of 8-pin microcontrollers without sacrificing the functionality of their larger counterparts. These devices do not provide high drive outputs, but when combined with a sensitive Triac can be used in a cost-effective light dimmer.

Figure AN1003.23 illustrates a simple circuit using a transformerless power supply, PIC 12C508 microcontroller, and a sensitive Triac configured to provide a light dimmer control. R_3 is connected to the hot lead of the AC power line and to pin GP_4. The ESD protection diodes of the input structure allow this connection without damage. When the voltage on the AC power line is positive, the protection diode form the input to V_{DD} is forward biased, and the input buffer will see approximately V_{DD} + 0.7 V. The software will read this pin as high. When the voltage on the line is negative, the protection diode from V_{SS} to the input pin is forward biased, and the input buffer sees approximately V_{SS} - 0.7 V. The software will read the pin as low. By polling GP_4 for a change in state, the software can detect zero crossing.

Phase Control Using Thyristors (continued)

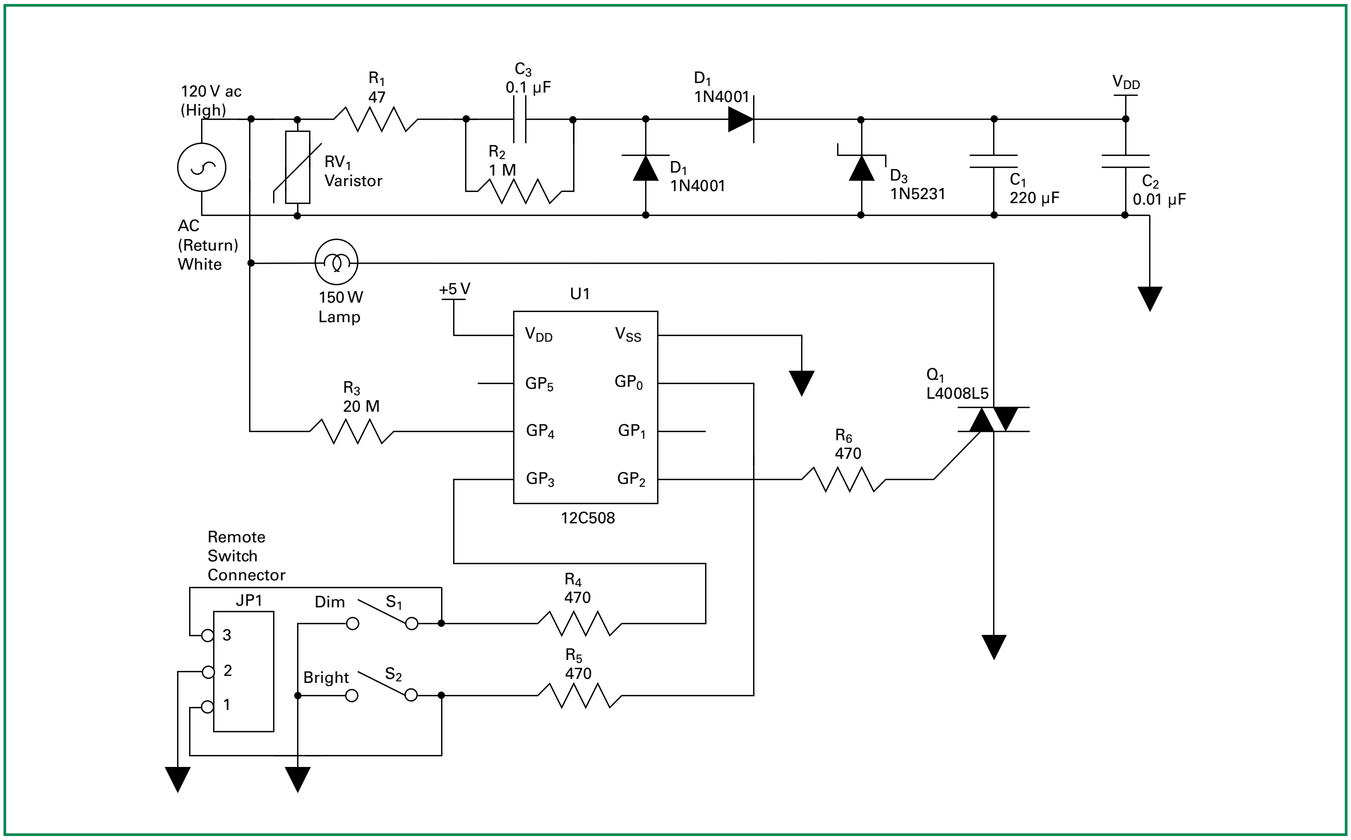


Figure AN1003.23 Microcontroller Light Dimmer Control

With a zero crossing state detected, software can be written to turn on the Triac by going from tri-state to a logic high on the gate and be synchronized with the AC phase cycles (Quadrants I and IV). Using pull-down switches connected to the microcontoller inputs, the user can signal the software to adjust the duty cycle of the Triac.

For higher amperage loads, a small 0.8 A, TO-92 Triac (operating in Quadrants I and IV) can be used to drive a 25 A alternistor Triac (operating in Quadrants I and III) as shown in the heater control illustration in Figure AN1003.24.

For a complete listing of the software used to control this circuit, see the Microchip application note PICREF-4. This application note can be downloaded from Microchip's Web site at www.microchip.com.

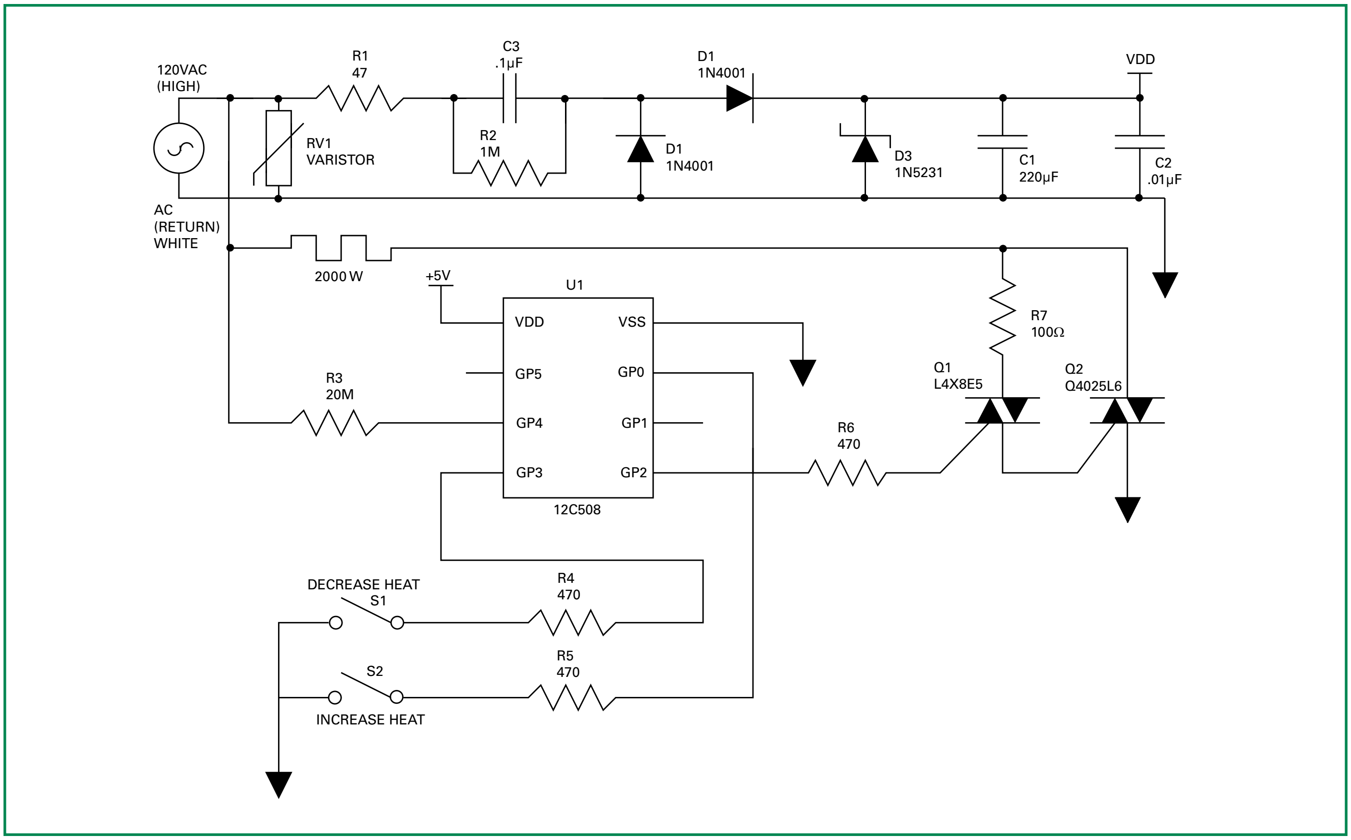


Figure AN1003.24 Microcontroller Heater Control

Summary

The load currents chosen for the examples in this application note were strictly arbitrary, and the component values will be the same regardless of load current except for the power Triac or SCR. The voltage rating of the power Thyristor devices must be a minimum of 200 V for 120 V input voltage and 400 V for 240 V input voltage.

The use of alternistors instead of Triacs may be much more acceptable in higher current applications and may eliminate the need for any dv/dt snubber network.

For many electrical products in the consumer market, competitive Thyristor prices and simplified circuits make automatic control a possibility. These simple circuits give the designer a good feel for the nature of Thyristor circuits and their design. More sophistication, such as speed and temperature feedback, can be developed as the control techniques become more familiar. A remarkable phenomenon is the degree of control obtainable with very simple circuits using Thyristors. As a result, industrial and consumer products will greatly benefit both in usability and marketability.

Mounting and Handling of Semiconductor Devices

Introduction

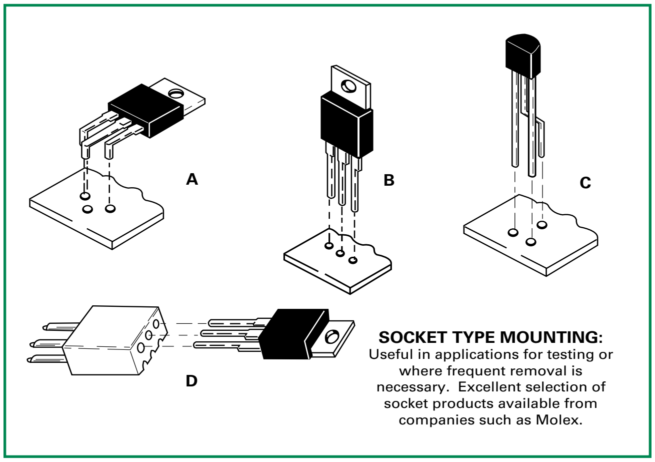
Proper mounting and handling of semiconductor devices, particularly those used in power applications, is an important, yet sometimes overlooked, consideration in the assembly of electronic systems. Power devices need adequate heat dissipation to increase operating life and reliability and allow the device to operate within manufacturers' specifications. Also, in order to avoid damage to the semiconductor chip or internal assembly, the devices should not be abused during assembly. Very often, device failures can be attributed directly to a heat sinking or assembly damage problem.

The information in this application note guides the semiconductor user in the proper use of Littelfuse devices, particularly the popular and versatile TO-220 and TO-218 epoxy packages.

Contact the Littelfuse Applications Engineering Group for further details or suggestions on use of Littelfuse devices.

Lead Forming — Typical Configurations

A variety of mounting configurations are possible with Littelfuse power semiconductor TO-92, DO-15, and TO- 220 packages, depending upon such factors as power requirements, heat sinking, available space, and cost considerations. Figure AN1004.1 shows typical examples and basic design rules.



SOCKET TYPE MOUNTING:
Useful in applications for testing or where frequent removal is necessary. Excellent selection of socket products available from companies such as Molex.

Figure AN1004.1 Component Mounting

These are suitable only for vibration-free environments and low-power, free-air applications. For best results, the device should be in a vertical position for maximum heat dissipation from convection currents.

Standard Lead Forms

Littelfuse encourages users to allow factory production of all lead and tab form options. Littelfuse has the automated machinery and expertise to produce pre-formed parts at minimum risk to the device and with greater convenience for the consumer. See the "Lead Form Dimensions" section of this catalog for a complete list of readily available lead form options. Contact Littelfuse for information regarding custom lead form designs.

Lead Bending Method

Leads may be bent easily and to any desired angle, provided that the bend is made at a minimum 0.063" (0.1" for TO-218 package) away from the package body with a minimum radius of 0.032" (0.040" for TO-218 package) or 1.5 times lead thickness rule. DO-15 device leads may be bent with a minimum radius of 0.050", and DO-35 device leads may be bent with a minimum radius of 0.028". Leads should be held firmly between the package body and the bend so that strain on the leads is not transmitted to the package body, as shown in Figure AN1004.2. Also, leads should be held firmly when trimming length.

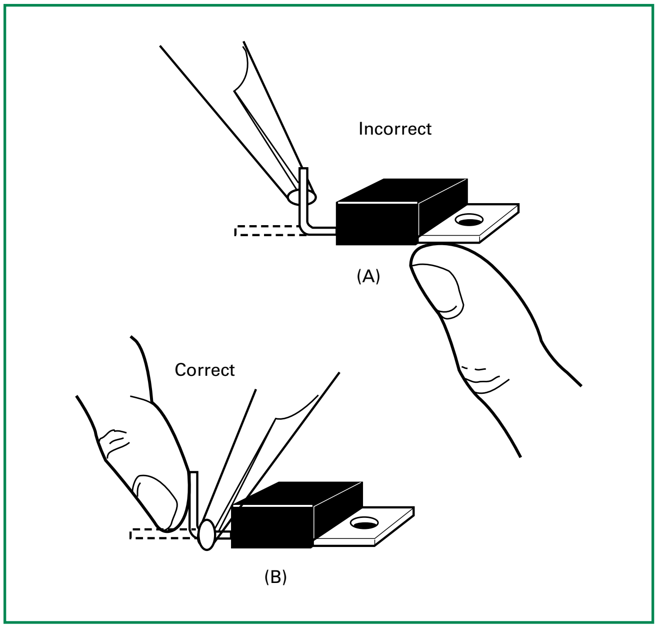


Figure AN1004.2 Lead Bending Method

When bending leads in the plane of the leads (spreading), bend only the narrow part. Sharp angle bends should be done only once as repetitive bending will fatigue and break the leads.

Heat Sinking

Use of the largest, most efficient heat sink as is practical and cost effective extends device life and increases reliability. In the illustration shown in Figure AN1004.3, each device is electrically isolated.

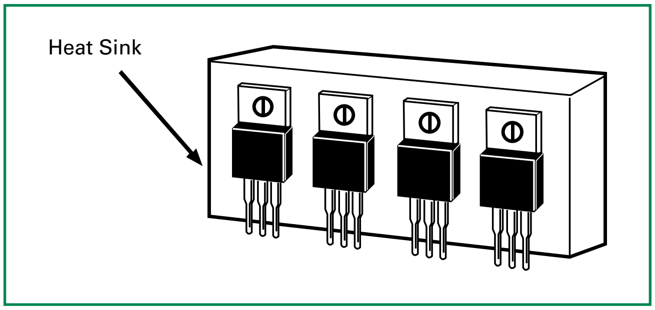


Figure AN1004.3 Several Isolated TO-220 Devices Mounted to a Common Heat Sink

Many power device failures are a direct result of improper heat dissipation. Heat sinks with a mating area smaller than the metal tab of the device are unacceptable. Heat sinking material should be at least 0.062" thick to be effective and efficient.

Note that in all applications the maximum case temperature (T_C) rating of the device must not be exceeded. Refer to the individual device data sheet rating curves (T_C versus I_T) as well as the individual device outline drawings for correct T_C measurement point.

Figure AN1004.4 through Figure AN1004.6 show additional examples of acceptable heat sinks.

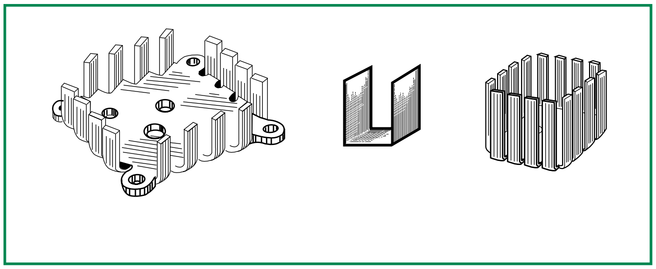


Figure AN1004.4 Examples of PC Board Mounts

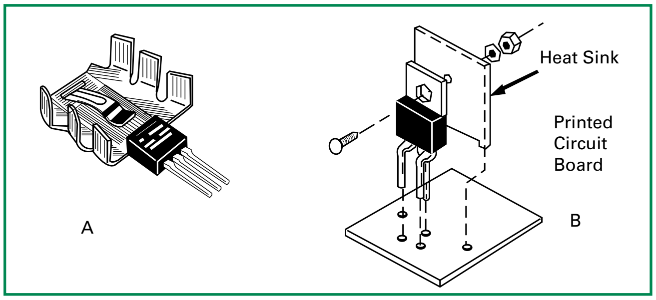


Figure AN1004.5 Vertical Mount Heat Sink

Several types of vertical mount heat sinks are available. Keep heat sink vertical for maximum convection.

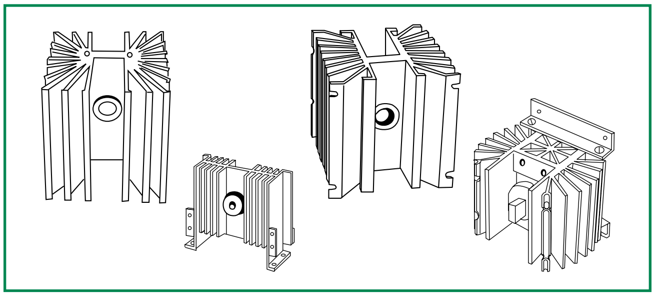


Figure AN1004.6 Examples of Extruded Aluminum

When coupled with fans, extruded aluminum mounts have the highest efficiency.

Heat Sinking Notes

Care should be taken not to mount heat sinks near other heat-producing elements such as power resistors, because black anodized heat sinks may absorb more heat than they dissipate.

Some heat sinks can hold several power devices. Make sure that if they are in electrical contact to the heat sink, the devices do not short-circuit the desired functions. Isolate the devices electrically or move to another location. Recall that the mounting tab of Littelfuse isolated TO-220 devices is electrically isolated so that several devices may be mounted on the same heat sink without extra insulating components. If using an external insulator such as mica, with a thickness of 0.004", an additional thermal resistance of 0.8° C/W for TO-220 or 0.5° C/W for TO-218 devices is added to the $R_{\theta JC}$ device rating.

Allow for adequate ventilation. If possible, route heat sinks to outside of assembly for maximum airflow.

Mounting Surface Selection

Proper mounting surface selection is essential to efficient transfer of heat from the semiconductor device to the heat sink and from the heat sink to the ambient. The most popular heat sinks are flat aluminum plates or finned extruded aluminum heat sinks.

The mounting surface should be clean and free from burrs or scratches. It should be flat within 0.002 inch per inch, and a surface finish of 30 to 60 microinches is acceptable. Surfaces with a higher degree of polish do not produce better thermal conductivity.

Many aluminum heat sinks are black anodized to improve thermal emissivity and prevent corrosion. Anodizing results in high electrical but negligible thermal insulation. This is an excellent choice for isolated TO-220 devices. For applications of non-isolated TO-220 devices where electrical connection to the common anode tab is required, the anodization

Mounting and Handling of Semiconductor Devices (continued)

should be removed. Iridite or chromate acid dip finish offers low electrical and thermal resistance. Either TO-218, Fastpak or TO-220 devices may be mounted directly to this surface, regardless of application. Both finishes should be cleaned prior to use to remove manufacturing oils and films. Some of the more economical heat sinks are painted black. Due to the high thermal resistance of paint, the paint should be removed in the area where the semiconductor is attached.

Bare aluminum should be buffed with #000 steel wool and followed with an acetone or alcohol rinse. Immediately, thermal grease should be applied to the surface and the device mounted down to prevent dust or metal particles from lodging in the critical interface area.

For good thermal contact, the use of thermal grease is essential to fill the air pockets between the semiconductor and the mounting surface. This decreases the thermal resistance by 20%. For example, a typical TO-220 with $R_{\theta JC}$ of 1.2 °C/W may be lowered to 1 °C/W by using thermal grease.

Littelfuse recommends Dow-Corning 340 as a proven effective thermal grease. Fibrous applicators are not recommended as they may tend to leave lint or dust in the interface area. Ensure that the grease is spread adequately across the device mounting surface, and torque down the device to specification.

Contact Littelfuse Applications Engineering for assistance in choosing and using the proper heat sink for specific application.

Hardware And Methods

TO-220

The mounting hole for the Teccor TO-220 devices should not exceed 0.140” (6/32) clearance. (Figure AN1004.7) No insulating bushings are needed for the L Package (isolated) devices as the tab is electrically isolated from the semiconductor chip. 6/32 mounting hardware, especially round head or Fillister machine screws, is recommended and should be torqued to a value of 6 inch-lbs.

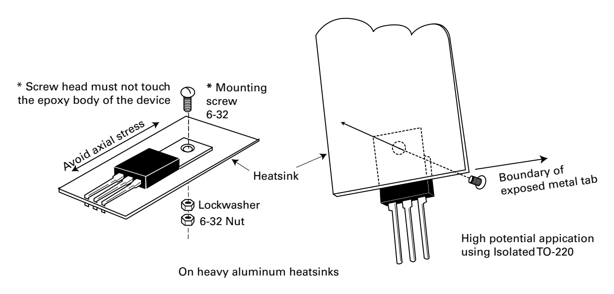


Figure AN1004.7 TO-220 Mounting

Punched holes are not acceptable due to cratering around the hole which can cause the device to be pulled into the crater by the fastener or can leave a significant portion of the device out of contact with the heat sink. The first effect may cause immediate damage to the package and early failure, while the second can create higher operating temperatures which will shorten operating life. Punched holes are quite acceptable in thin metal plates where fine-edge blanking or sheared-through holes are employed.

Drilled holes must have a properly prepared surface. Excessive chamfering is not acceptable as it may create a crater effect. Edges must be deburred to promote good contact and avoid puncturing isolation materials.

For high-voltage applications, it is recommended that only the metal portion of the TO-220 package (as viewed from the bottom of the package) be in contact with the heat sink. This will provide maximum oversurface distance and prevent a high voltage path over the plastic case to a grounded heat sink.

TO-218

The mounting hole for the TO-218 device should not exceed 0.164” (8/32) clearance. Isolated versions of TO-218 do not require any insulating material since mounting tab is electrically isolated from the semiconductor chip. Round lead or Fillister machine screws are recommended. Maximum torque to be applied to mounting tab should not exceed 8 inch-lbs.

The same precautions given for the TO-220 package concerning punched holes, drilled holes, and proper prepared heat sink mounting surface apply to the TO-218 package. Also for high-voltage applications, it is recommended that only the metal portion of the mounting surface of the TO-218 package be in contact with heat sink. This achieves maximum oversurface distance to prevent a high-voltage path over the device body to grounded heat sink.

General Mounting Notes

Care must be taken on TO-220 & TO-218 packages at all times to avoid strain to the mounting tab or leads. For easy insertion of the part onto the board or heat sink, avoid axial strain on the leads. Carefully measure holes for the mounting tab and the leads, and do any forming of the tab or leads before mounting. Refer to the “Lead Form Dimensions” section of this catalog before attempting lead form operations.

Rivets may be used for less demanding and more economical applications. 1/8” all-aluminum pop rivets can be used on both TO-220 and TO-218 packages. Use a 0.129”-0.133” (#30) drill for the hole and insert the rivet from the top side, as shown in Figure AN1004.9. An insertion tool, similar to a “USM” PRG 430 hand riveter, is recommended. A wide selection of grip ranges

Mounting and Handling of Semiconductor Devices (continued)

is available, depending upon the thickness of the heat sink material. Use an appropriate grip range to securely anchor the device, yet not deform the mounting tab. The recommended rivet tool has a protruding nipple that will allow easy insertion of the rivet and keep the tool clear of the plastic case of the device.

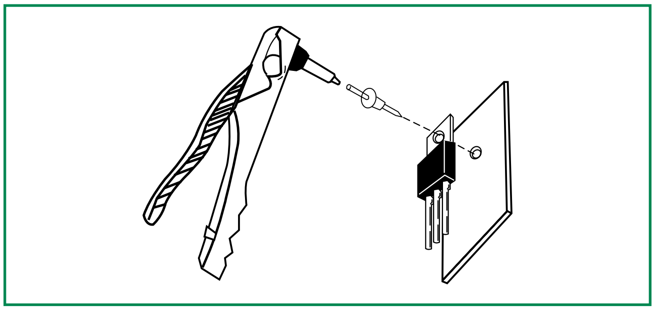


Figure AN1004.9 Pop Riveting Technique

A Milford #511 (Milford Group, Milford, CT) semi-tubular steel rivet set into a 0.129" receiving hole with a riveting machine similar to a Milford S256 is also acceptable. Contact the rivet machine manufacturer for exact details on application and set-up for optimum results.

Pneumatic or other impact riveting devices are not recommended due to the shock they may apply to the device.

Under no circumstance should any tool or hardware come into contact with the case. The case should not be used as a brace for any rotation or shearing force during mounting or in use. Non-standard size screws, nuts, and rivets are easily obtainable to avoid clearance problems.

Always use an accurate torque wrench to mount devices. No gain is achieved by overtorquing devices. In fact, overtorquing may cause the tab and case to deform or rupture, seriously damaging the device. The curve shown in Figure AN1004.10 illustrates the effect of proper torque.

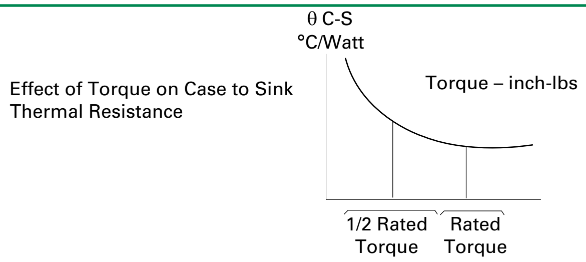


Figure AN1004.10 Effect of Torque to Sink Thermal Resistance

With proper care, the mounting tab of a device can be soldered to a surface. However, the heat required to accomplish this operation can damage or destroy the semiconductor chip or internal assembly. See "Surface Mount Soldering Recommendations" (AN1005) in this catalog.

Spring-steel clips can be used to replace torqued hardware in assembling Thyristors to heat sinks. Clips snap into heat sink slots to hold the device in place for PC board insertion. Clips are available in several sizes for various heat sink thicknesses and Thyristor case styles from *Aavid Thermalloy* in Concord, New Hampshire. A typical heatsink is shown in Figure AN1004.11

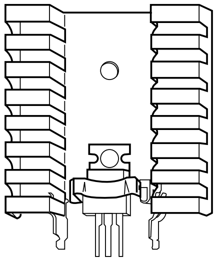


Figure AN1004.11 Typical Heat Sink Using Clips

Soldering Of Leads

A prime consideration in soldering leads is the soldering of device leads into PC boards, heat sinks, and so on. Significant damage can be done to the device through improper soldering. In any soldering process, do not exceed the data sheet lead solder temperature of +280 °C for 10 seconds, maximum, ≥1/16" from the case.

This application note presents details about the following three types of soldering:

- Hand soldering
- Wave soldering
- Dip soldering

Hand Soldering

This method is mostly used in prototype breadboarding applications and production of small modules. It has the greatest potential for misuse. The following recommendations apply to Littelfuse TO-92, TO-220, and TO-218 packages.

Select a small- to medium-duty electric soldering iron of 25 W to 45 W designed for electrical assembly application. Tip temperature should be rated from 600 °F to 800 °F (300 °C to 425 °C). The iron should have sufficient heat capacity to heat the joint quickly and efficiently in order to minimize contact time to the part. Pencil tip probes work very well. Neither heavy-duty electrical irons of greater than 45 W nor flame-heated irons and large heavy tips are recommended, as the tip temperatures are far too high and uncontrollable and can easily exceed the time-temperature limit of the part.

Littelfuse Fastpak devices require a different soldering technique. Circuit connection can be done by either quick-connect terminals or solder.

Mounting and Handling of Semiconductor Devices (continued)

Since most quick-connect 0.250" female terminals have a maximum rating of 30 A, connection to terminals should be made by soldering wires instead of quick-connects.

Recommended wire is 10 AWG stranded wire for use with MT1 and MT2 for load currents above 30 A. Solderingshould be performed with a 100-watt soldering iron. The iron should not remain in contact with the wire and terminal longer than 40 seconds so the Fastpak Triac is not damaged.

For the Littelfuse TO-218X package, the basic rules for hand soldering apply; however, a larger iron may be required to apply sufficient heat to the larger leads to efficiently solder the joint.

Remember not to exceed the lead solder temperatures of +280 °C for 10 seconds, maximum, ≥1/16" (1.59mm) from the case.

A 60/40 or 63/37 Sn/Pb solder is acceptable. This low melting-point solder, used in conjunction with a mildly activated rosin flux, is recommended.

Insert the device into the PC board and, if required, attach the device to the heat sink before soldering. Each lead should be individually heat sinked as it is soldered. Commercially available heat sink clips are excellent for this use. Hemostats may also be used if available. Needle-nose pliers are a good heat sink choice; however, they are not as handy as stand-alone type clips.

In any case, the lead should be clipped or grasped between the solder joint and the case, as near to the joint as possible. Avoid straining or twisting the lead in any way.

Use a clean pre-tinned iron, and solder the joint as quickly as possible. Avoid overheating the joint or bringing the iron or solder into contact with other leads that are not heat sinked.

Wave Solder

Wave soldering is one of the most efficient methods of soldering large numbers of PC boards quickly and effectively. Guidelines for soldering by this method are supplied by equipment manufacturers. The boards should be pre-heated to avoid thermal shock to semiconductor components, and the time-temperature cycle in the solder wave should be regulated to avoid heating the device beyond the recommended temperature rating. A mildly activated resin flux is recommended. Figures AN1004.12 and .13 show typical heat and time conditions.

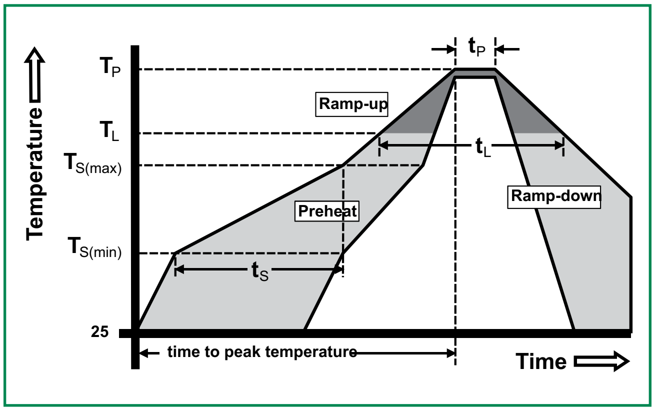


Figure AN1004.12 Reflow Soldering with Pre-heating

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp (T_L) to peak		5°C/second max

$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5º}$ C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C

Figure AN1004.13 Heat and Time Table

Dip Soldering

Dip soldering is very similar to wave soldering, but it is a hand operation. Follow the same considerations as for wave soldering, particularly the time-temperature cycle which may become operator dependent because of the wide process variations that may occur. This method is not recommended.

Board or device clean-up is left to the discretion of the customer. Littelfuse devices are tolerant of a wide variety of solvents, and they conform to MIL-STD 202E method 215 "Resistance to Solvents."

Surface Mount Soldering Recommendations

Introduction

The most important consideration in reliability is achieving a good solder bond between surface mount device (SMD) and substrate since the solder provides the thermal path from the chip. A good bond is less subject to thermal fatiguing and will result in improved device reliability.

The most economic method of soldering is a process in which all different components are soldered simultaneously, such as DO-214, Compak, TO-252 devices, capacitors, and resistors.

Reflow Of Soldering

The preferred technique for mounting microminiature components on hybrid thick- and thin-film is reflow soldering.

The DO-214 is designed to be mounted directly to or on thick-film metallization which has been screened and fired on a substrate. The recommended substrates are Alumina or P.C. Board material.

Recommended metallization is silver palladium or molymanganese (plated with nickel or other elements to enhance solderability). For more information, consult Du Pont's Thick-Film handbook or the factory.

It is best to prepare the substrate by either dipping it in a solder bath or by screen printing a solder paste.

After the substrate is prepared, devices are put in place with vacuum pencils. The device may be laid in place without special alignment procedures since it is self-aligning during the solder reflow process and will be held in place by surface tension.

For reliable connections, keep the following in mind:

(1) Maximum temperature of the leads or tab during the soldering cycle does not exceed 280 °C.

(2) Flux must affect neither components nor connectors.

(3) Residue of the flux must be easy to remove.

Good flux or solder paste with these properties is available on the market. A recommended flux is Alpha 5003 diluted with benzyl alcohol. Dilution used will vary with application and must be determined empirically.

Having first been fluxed, all components are positioned on the substrate. The slight adhesive force of the flux is sufficient to keep the components in place.

Because solder paste contains a flux, it has good inherent adhesive properties which eases positioning of the components. Allow flux to dry at room temperature or in a 70 °C oven. Flux should be dry to the touch. Time required will depend on flux used.

With the components in position, the substrate is heated to a point where the solder begins to flow. This can be done on a heating plate, on a conveyor belt running through an infrared tunnel, or by using vapor phase soldering.

In the vapor phase soldering process, the entire PC board is uniformly heated within a vapor phase zone at a temperature of approximately 215 °C. The saturated vapor phase zone is obtained by heating an inert (inactive) fluid to the boiling point. The vapor phase is locked in place by a secondary vapor. (Figure AN1005.1) Vapor phase soldering provides uniform heating and prevents overheating.

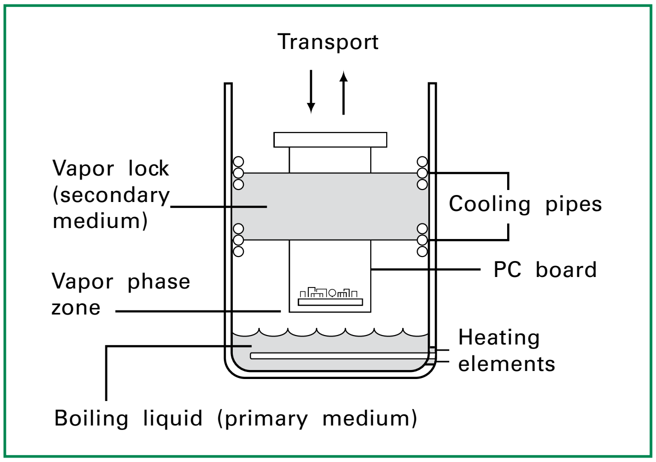


Figure AN1005.1 Principle of Vapor Phase Soldering

No matter which method of heating is used, the maximum allowed temperature of the plastic body must not exceed 250 °C during the soldering process. For additional information on temperature behavior during the soldering process, see Figure AN1005.2 and Figure AN1005.3.

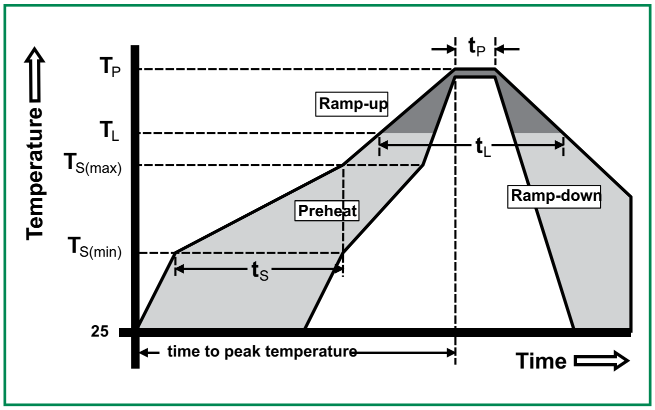


Figure AN1005.2 Reflow Soldering Profile

Surface Mount Soldering Recommendations (continued)

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C

Reflow Soldering Zones

Zone 1: Initial Pre-heating Stage (25 °C to 150 °C)

- Excess solvent is driven off.
- PCB and Components are gradually heated up.
- Temperature gradient shall be <2.5 °C/Sec.

Zone 2: Soak Stage (150 °C to 180 °C)

- Flux components start activation and begin to reduce the oxides on component leads and PCB pads.
- PCB components are brought nearer to the temperature at which solder bonding can occur.
- Soak allows different mass components to reach the same temperature.
- Activated flux keeps metal surfaces from re-oxidizing.

Zone 3: Reflow Stage (180 °C to 235 °C)

- Paste is brought to the alloy's melting point.
- Activated flux reduces surface tension at the metal interface so metallurgical bonding occurs.

Zone 4: Cool-down Stage (180 °C to 25 °C)

Assembly is cooled evenly so thermal shock to the components or PCB is reduced.

The surface tension of the liquid solder tends to draw the leads of the device towards the center of the soldering area and so has a correcting effect on slight mispositionings. However, if the layout is not optimized, the same effect can result in undesirable shifts, particularly if the soldering areas on the substrate and the components are not concentrically arranged. This problem can be solved by using a standard contact pattern which leaves sufficient scope for the self-positioning effect (Figure AN1005.3 and Figure AN1005.4) Figure AN1005.5 shows the reflow soldering procedure.

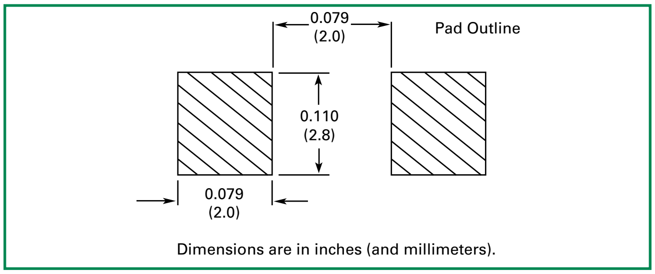


Figure AN1005.3 Minimum Required Dimensions of Metal Connection of Typical DO-214 Pads on Hybrid Thick- and Thin-film Substrates

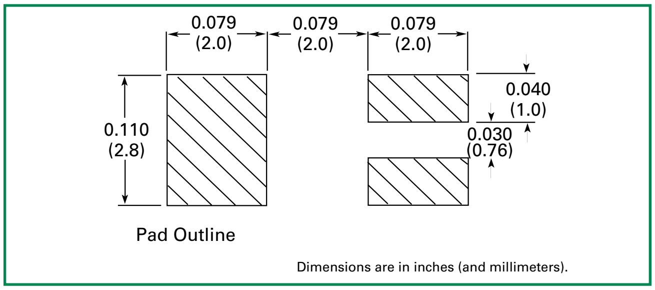


Figure AN1005.4 Modified DO-214 Compak — Three-leaded Surface Mount Package

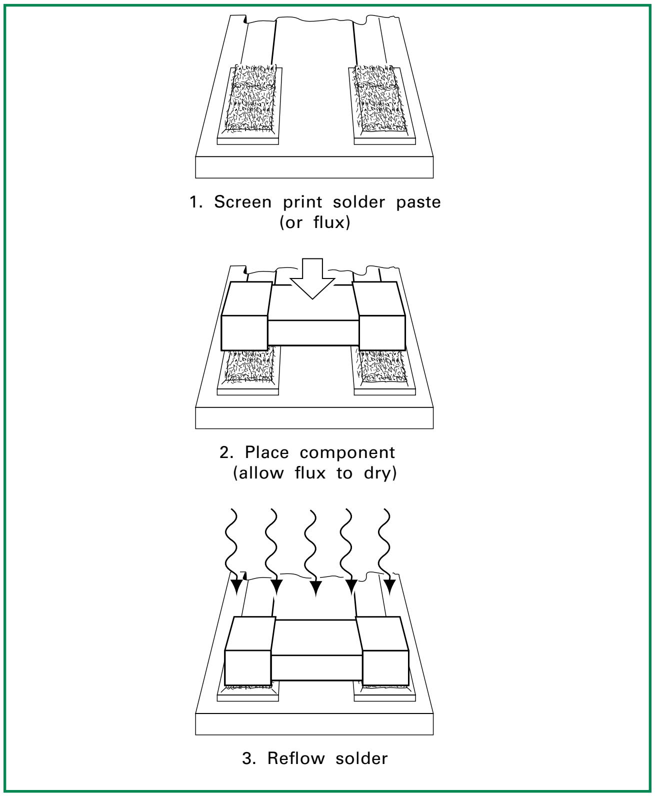


Figure AN1005.5 Reflow Soldering Procedure

After the solder is set and cooled, visually inspect the connections and, where necessary, correct with a soldering iron. Finally, the remnants of the flux must be removed carefully.

Use vapor degrease with an azeotrope solvent or equivalent to remove flux. Allow to dry.

After the drying procedure is complete, the assembly is ready for testing and/or further processing.

Wave Soldering

Wave soldering is the most commonly used method for soldering components in PCB assemblies. As with other soldering processes, a flux is applied before soldering. After the flux is applied, the surface mount devices are glued into place on a PC board. The board is then placed in contact with a molten wave of solder at a temperature between 240 °C and 260 °C, which affixes the component to the board.

Dual wave solder baths are also in use. This procedure is the same as mentioned above except a second wave of solder removes excess solder.

Although wave soldering is the most popular method of PCB assembly, drawbacks exist. The negative features include solder bridging and shadows (pads and leads not completely wetted) as board density increases. Also, this method has the sharpest thermal gradient. To prevent thermal shock, some sort of pre-heating device must be used. Figure AN1005.6 shows the procedure for wave soldering PCBs with surface mount devices only. Figure AN1005.7 shows the procedure for wave soldering PCBs with both surface mount and leaded components.

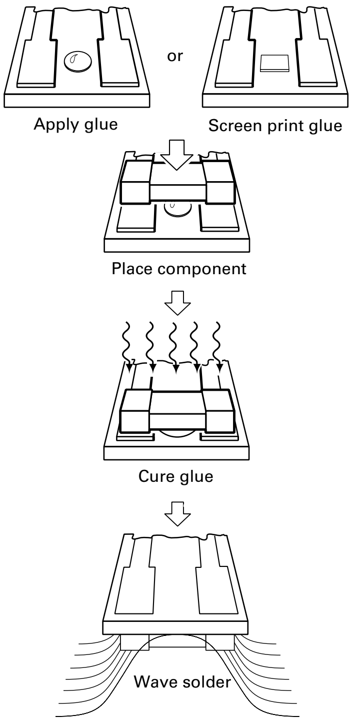


Figure AN1005.6 Wave Soldering PCBs With Surface Mount Devices Only

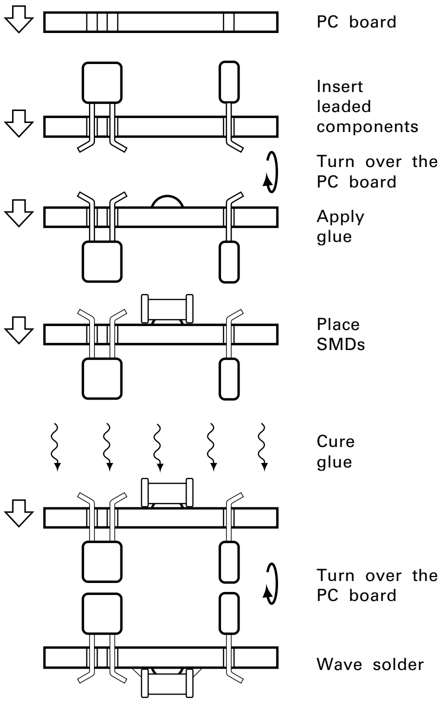


Figure AN1005.7 Wave Soldering PCBs With Both Surface Mount and Leaded Components

Immersion Soldering

Maximum allowed temperature of the soldering bath is 235 °C. Maximum duration of soldering cycle is five seconds, and forced cooling must be applied.

Hand Soldering

It is possible to solder the DO-214, Compak, and TO-252 devices with a miniature hand-held soldering iron, but this method has particular drawbacks and should be restricted to laboratory use and/or incidental repairs on production circuits.

Recommended Metal-alloy

(1) 63/37 Sn/Pb - non - RoHS

(2) (SAC 305) 96.5/3/0.5 Sn/Ag/Cu - RoHS

Pre-Heating

Pre-heating is recommended for good soldering and to avoid damage to the DO-214, Compak, TO-252 devices, other components, and the substrate. Maximum pre-heating temperature is 165 °C while the maximum pre-heating duration may be 10 seconds. However, atmospheric pre-heating is permissible for several minutes provided temperature does not exceed 125 °C.

Surface Mount Soldering Recommendations (continued)

Gluing Recommendations

Prior to wave soldering, surface mount devices (SMDs) must be fixed to the PCB or substrate by means of an appropriate adhesive. The adhesive (in most cases a multicomponent adhesive) has to fulfill the following demands:

- Uniform viscosity to ensure easy coating
- No chemical reactions upon hardening in order not to deteriorate component and PC board
- Straightforward exchange of components in case of repair

Low-temperature Solder for Reducing PC Board Damage

In testing and troubleshooting surface-mounted components, changing parts can be time consuming. Moreover, desoldering and soldering cycles can loosen and damage circuit-board pads. Use low-temperature solder to minimize damage to the PC board and to quickly remove a component. One low-temperature alloy is indium-tin, in a 50/50 mixture. It melts between 118 °C and 125 °C, and tin-lead melts at 183 °C. If a component needs replacement, holding the board upside down and heating the area with a heat gun will cause the component to fall off. Performing the operation quickly minimizes damage to the board and component.

Proper surface preparation is necessary for the In-Sn alloy to wet the surface of the copper. The copper must be clean, and you must add flux to allow the alloy to flow freely. You can use rosin dissolved in alcohol. Perform the following steps:

(1) Cut a small piece of solder and flow it onto one of the pads.

(2) Place the surface-mount component on the pad and melt the soldered pad to its pin while aligning the part. (This operation places all the pins flat onto their pads.)

(3) Cut small pieces of the alloy solder and flow each piece onto each of the other legs of the component.

Indium-tin solder is available from ACI Alloys, San Jose, CA and Indium Corporation of America, Utica, NY.

Multi-use Footprint

Package soldering footprints can be designed to accommodate more than one package. Figure AN1005.8 shows a footprint design for using both the Compak and an SOT-223. Using the dual pad outline makes it possible to use more than one supplier source.

Cleaning Recommendations

Using solvents for PC board or substrate cleaning is permitted from approximately 70 °C to 80 °C.

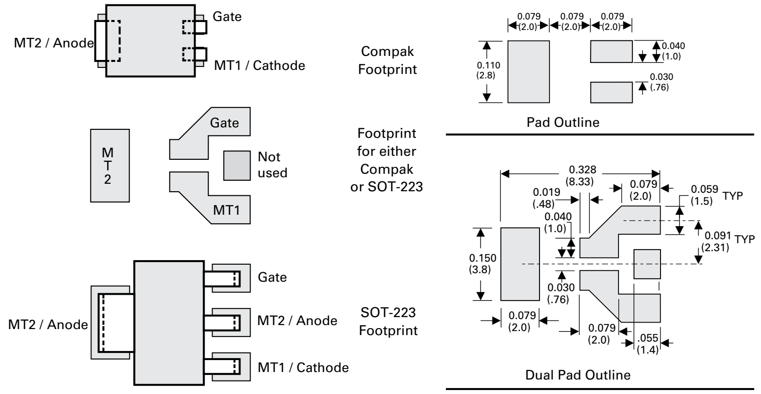
The soldered parts should be cleaned with azeotrope solvent followed by a solvent such as methol, ethyl, or isopropyl alcohol.

Ultrasonic cleaning of surface mount components on PCBs or substrates is possible.

The following guidelines are recommended when using ultrasonic cleaning:

- Cleaning agent: Isopropanol
- Bath temperature: approximately 30 °C
- Duration of cleaning: MAX 30 seconds
- Ultrasonic frequency: 40 kHz
- Ultrasonic changing pressure: approximately 0.5 bar

Cleaning of the parts is best accomplished using an ultrasonic cleaner which has approximately 20 W of output per one liter of solvent. Replace the solvent on a regular basis.



Dimensions are in inches (and millimeters).

Figure AN10058 Dual Footprint for Compak Package

Thyristor and Rectifier Testing Using Curve Tracers

Introduction

One of the most useful and versatile instruments for testing semiconductor devices is the curve tracer (CT). Tektronix is the best known manufacturer of curve tracers and produces four basic models: 575, 576, 577 and 370. These instruments are specially adapted CRT display screens with associated electronics such as power supplies, amplifiers, and variable input and output functions that allow the user to display the operating characteristics of a device in an easy-to-read, standard graph form. Operation of Tektronix CTs is simple and straightforward and easily taught to non-technical personnel. Although widely used by semiconductor manufacturers for design and analytical work, the device consumer will find many uses for the curve tracer, such as incoming quality control, failure analysis, and supplier comparison. Curve tracers may be easily adapted for go-no go production testing. Tektronix also supplies optional accessories for specific applications along with other useful hardware.

Tektronix Equipment

Although Tektronix no longer produces curve tracer model 575, many of the units are still operating in the field, and it is still an extremely useful instrument. The 576, 577 and 370 are current curve tracer models and are more streamlined in their appearance and operation. The 577 is a less elaborate version of the 576, yet retains all necessary test functions.

The following basic functions are common to all curve tracers:

- **Power supply** supplies positive DC voltage, negative DC voltage, or AC voltage to bias the device. Available power is varied by limiting resistors.
- **Step generator** supplies current or voltage in precise steps to control the electrode of the device. The number, polarity, and frequency of steps are selectable.
- **Horizontal amplifier** displays power supply voltage as applied to the device. Scale calibration is selectable.
- **Vertical amplifier** displays current drawn from the supply by the device. Scale calibration is selectable.

Curve tracer controls for beam position, calibration, pulse operation, and other functions vary from model to model. The basic theory of operation is that for each curve one terminal is driven with a constant voltage or current and the other one is swept with a half sinewave of voltage. The driving voltage is stepped through several values, and a different trace is drawn on each sweep to generate a family of curves.

Limitations, Accuracy, and Correlation

Although the curve tracer is a highly versatile device, it is not capable of every test that one may wish to perform on semiconductor devices such as dv/dt, secondary reverse breakdown, switching speeds, and others. Also, tests at very high currents and/or voltages are difficult to conduct accurately and without damaging the devices. A special high-current test fixture available from Tektronix can extend operation to 200 A pulsed peak. Kelvin contacts available on the 576 and 577 eliminate inaccuracy in voltage measured at high current (V_{TM}) by sensing voltage drop due to contact resistance and subtracting from the reading.

Accuracy of the unit is within the published manufacturer's specification. Allow the curve tracer to warm up and stabilize before testing begins. Always expand the horizontal or vertical scale as far as possible to increase the resolution. Be judicious in recording data from the screen, as the trace line width and scale resolution factor somewhat limit the accuracy of what may be read. Regular calibration checks of the instrument are recommended. Some users keep a selection of calibrated devices on hand to verify instrument operation when in doubt. Re-calibration or adjustment should be performed only by qualified personnel.

Often discrepancies exist between measurements taken on different types of instrument. In particular, most semiconductor manufacturers use high-speed, computerized test equipment to test devices. They test using very short pulses. If a borderline unit is then measured on a curve tracer, it may appear to be out of specification. The most common culprit here is heat. When a semiconductor device increases in temperature due to current flow, certain characteristics may change, notably gate characteristics on SCRs, gain on transistors, leakage, and so on. It is very difficult to operate the curve tracer in such a way as to eliminate the heating effect. Pulsed or single-trace operation helps reduce this problem, but care should be taken in comparing curve tracer measurements to computer tests. Other factors such as stray capacitances, impedance matching, noise, and device oscillation also may create differences.

Safety (Cautions and Warnings)

Adhere rigidly to Tektronix safety rules supplied with each curve tracer. No attempt should be made to defeat any of the safety interlocks on the device as the curve tracer can produce a lethal shock. Also, older 575 models do not have the safety interlocks as do the new models. Take care never to touch any device or open the terminal while energized.

WARNING: Devices on the curve tracer may be easily damaged from electrical overstress.

Thyristor and Rectifier Testing Using Curve Tracers (continued)

Follow these rules to avoid destroying devices:

- Familiarize yourself with the expected maximum limits of the device.
- Limit the current with the variable resistor to the minimum necessary to conduct the test.
- Increase power slowly to the specified limit.
- Watch for device "runaway" due to heating.
- Apply and increase gate or base drive slowly and in small steps.
- Conduct tests in the minimum time required.

General Test Procedures

Read all manuals before operating a curve tracer.

Perform the following manufacturer's equipment check:

1. Turn on and warm up curve tracer, but turn off, or down, all power supplies.
2. Correctly identify terminals of the device to be tested. Refer to the manufacturer's guide if necessary.
3. Insert the device into the test fixture, matching the device and test terminals.
4. Remove hands from the device and/or close interlock cover.
5. Apply required bias and/or drive.
6. Record results as required.
7. Disconnect all power to the device before removing.

Model 576 Curve Tracer Procedures

The following test procedures are written for use with the model 576 curve tracer. (Figure AN1006.1)

See "Model 370 Curve Tracer Procedure Notes" on page AN1006-16 and "Model 577 Curve Tracer Procedure Notes" on page AN1006-18 for setting adjustments required when using model 370 and 577 curve tracers.

The standard 575 model lacks AC mode, voltage greater than 200 V, pulse operations, DC mode, and step offset controls. The 575 MOD122C does allow voltage up to 400 V, including 1500 V in an AC mode. Remember that at the time of design, the 575 was built to test only transistors and diodes. Some ingenuity, experience, and external hardware may be required to test other types of devices.

For further information or assistance in device testing on Tektronix curve tracers, contact the Littelfuse Applications Engineering group.

Thyristor and Rectifier Testing Using Curve Tracers (continued)

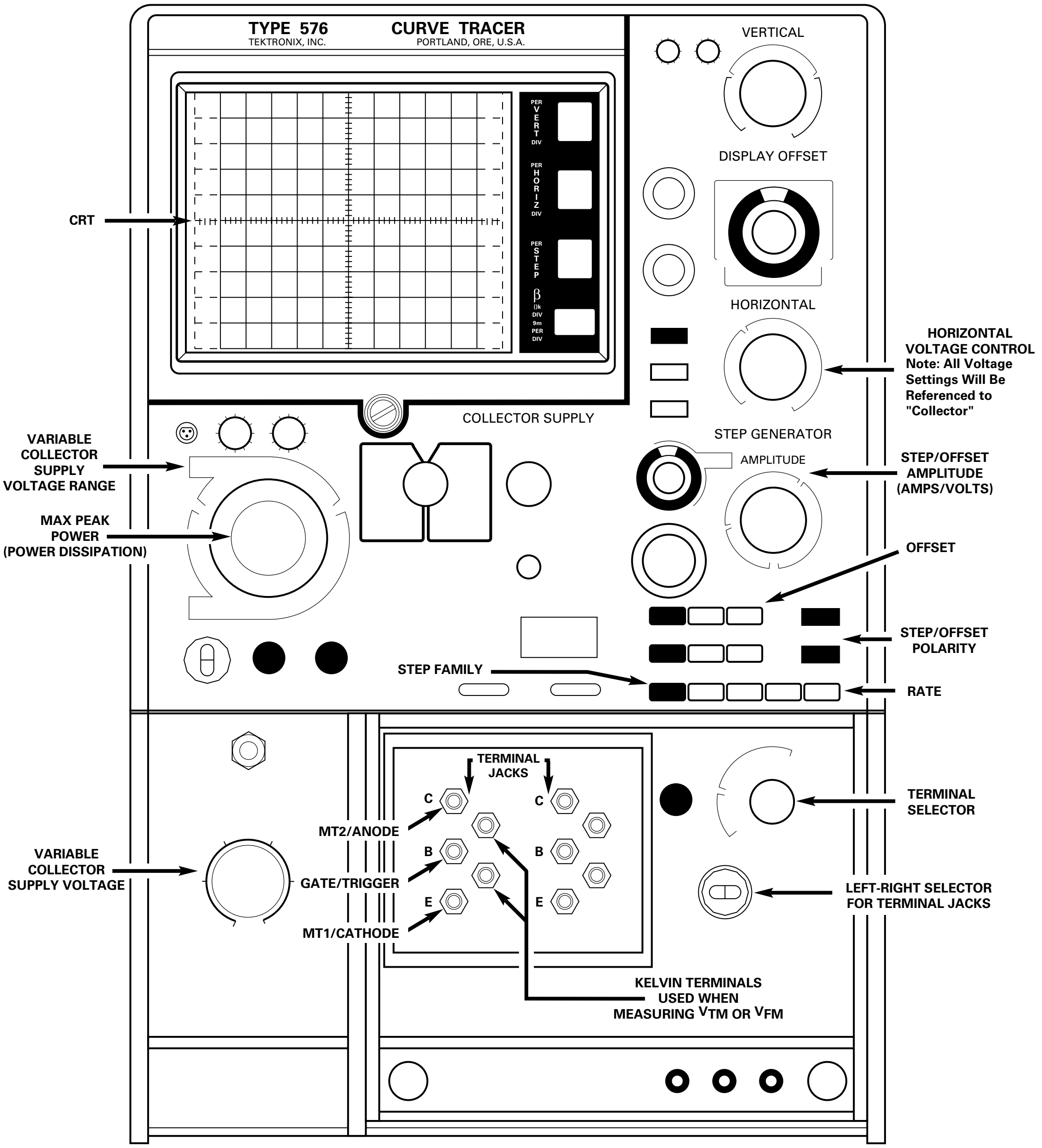


Figure AN1006.1 Tektronix Model 576 Curve Tracer

Power Rectifiers

The rectifier is a unidirectional device which conducts when forward voltage (above 0.7 V) is applied.

To connect the rectifier:

1. Connect *Anode to Collector Terminal (C).*
2. Connect *Cathode to Emitter Terminal (E).*

To begin testing, perform the following procedures.

Procedure 1: V_{RRM} and I_{RM}

To measure the V_{RRM} and I_{RM} parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 V.*(*2000 V on 370*)
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level (*100 V/DIV* for 400 V and 600 V devices and *50 V/DIV for 200 V devices*).
3. Set **Mode** to *Leakage.*
4. Set **Vertical** knob to *100 µA/DIV.* (Due to leakage setting, the CRT readout will be 100 nA per division.)
5. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
6. Set **Polarity** to (-).
7. Set **Power Dissipation** to *2.2 W.* (*2 W* on 370)
8. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
9. Increase **Variable Collector Supply Voltage** to the rated V_{RRM} of the device and observe the dot on the CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.2)

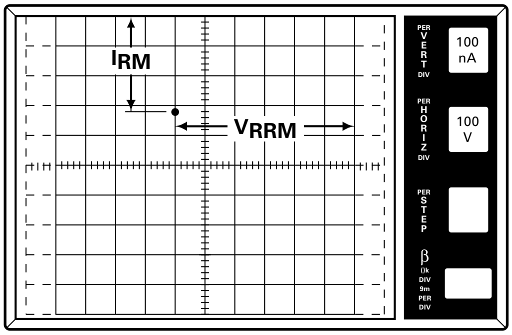


Figure AN1006.2 I_{RM} = 340 nA at V_{RRM} = 600 V

Procedure 2: V_{FM}

Before testing, note the following:

- A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of VFM will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connections.
- Due to the current limitations of standard curve tracer model 576, V_{FM} cannot be tested at rated current without a Tektronix model 176 high-current module. The procedure below is done at $I_{T(RMS)}$ = 10 A (20 A_{PK}). This test parameter allows the use of a standard curve tracer and still provides an estimate of whether V_{FM} is within specification.

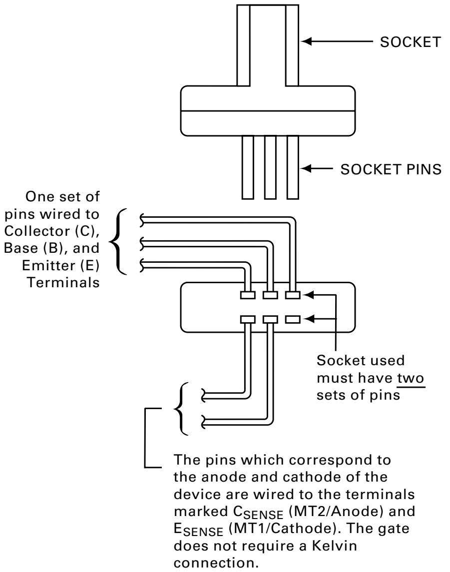


Figure AN1006.3 Instructions for Wiring Kelvin Socket

To measure the V_{FM} parameter:

1. Set **Variable Collector Supply Voltage Range** to *15 Max Peak Volts.* (*16 V on 370*)
2. Set **Horizontal** knob to *0.5 V/DIV.*
3. Set **Mode** to *Norm.*
4. Set **Vertical** knob to *2 A/DIV.*
5. Set **Power Dissipation** to *220 W* (*100 W on 577*).
6. Set **Polarity** to (+).
7. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
8. Increase **Variable Collector Supply Voltage** until current reaches 20 A.

WARNING: Limit test time to 15 seconds maximum.

To measure V_{FM}, follow along horizontal scale to the point where the trace crosses the 20 A axis. The distance from the left-hand side of scale to the crossing point is the V_{FM} value. (Figure AN1006.4)

Note: Model 370 current is limited to 10 A.

Thyristor and Rectifier Testing Using Curve Tracers (continued)

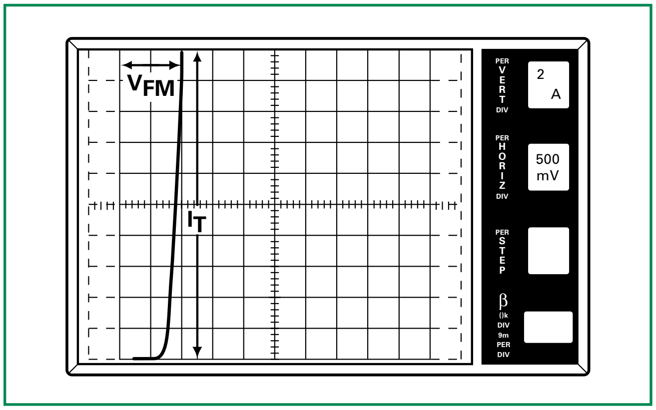


Figure AN1006.4 V_{FM} = 1 V at I_{PK} = 20 A

SCRs

SCRs are half-wave unidirectional rectifiers turned on when current is supplied to the gate terminal. If the current supplied to the gate is to be in the range of 12 µA and 500 µA, then a sensitive SCR is required; if the gate current is between 1 mA and 50 mA, then a non-sensitive SCR is required.

To connect the rectifier:

1. Connect *Anode to Collector Terminal (C).*
2. Connect *Cathode to Emitter Terminal (E).*

Note: When sensitive SCRs are being tested, a 1 kΩ resistor must be connected between the gate and the cathode, except when testing I_{GT}.

To begin testing, perform the following procedures.

Procedure 1:V_{DRM} / V_{RRM} / I_{DRM} / I_{RRM}

To measure the V_{DRM} / V_{RRM} / I_{DRM}, and I_{RRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to appropriate *Max Peak Volts* for device under test. (Value selected should be equal to or greater than the device's V_{DRM} rating.)
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level. (The *100 V/DIV* scale should be used for testing devices having a V_{DRM} value of 600 V or greater; the *50 V/DIV* scale for testing parts rated from 300 V to 500 V, and so on.)
3. Set **Mode** to *Leakage*.
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *0.5 W*.(*0.4 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base*.
7. Set **Vertical** knob to approximately ten times the maximum leakage current (I_{DRM}, I_{RRM}) specified for the device. (For sensitive SCRs, set to *50 µA*.)

Note: The CRT screen readout should show 1% of the maximum leakage current if the vertical scale is divided by 1,000 when leakage current mode is used.

Procedure 2:V_{DRM} / I_{DRM}

To measure the V_{DRM} and I_{DRM} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
2. Set **Variable Collector Supply Voltage** to the rated V_{DRM} of the device and observe the dot on CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.5)

WARNING: Do NOT exceed V_{DRM}/V_{RRM} rating of SCRs, Triacs, or Quadracs. These devices can be damaged.

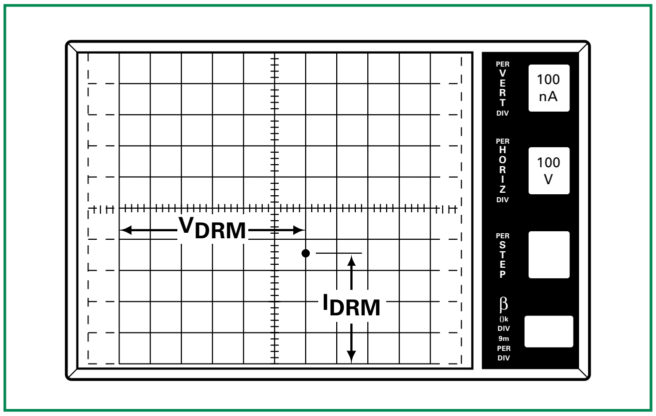


Figure AN1006.5 I_{DRM} = 350 nA at V_{DRM} = 600 V

Procedure 3: V_{RRM} / I_{RRM}

To measure the V_{RRM} and I_{RRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Steps 1 and 2 (V_{DRM}, I_{DRM}) except substitute V_{RRM} value for V_{DRM}. (Figure AN1006.6)

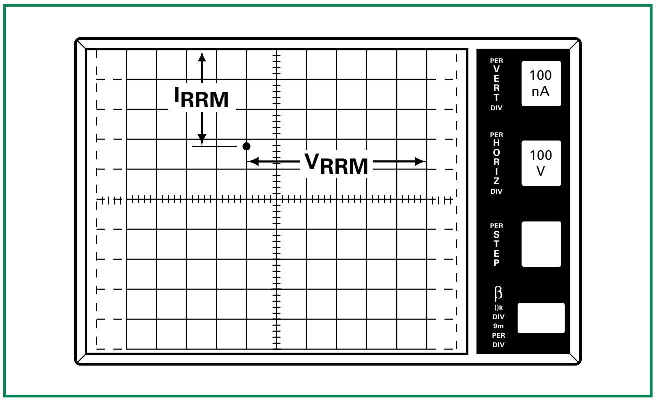


Figure AN1006.6 I_{RRM} = 340 nA at V_{RRM} = 600 V

Procedure 4: V_{TM}

To measure the V_{TM} parameter:

1. Set **Terminal Selector** to *Step Generator-Emitter Grounded.*
2. Set **Polarity** to *(+).*
3. Set **Step/Offset Amplitude** to twice the maximum I_{GT} rating of the device (to ensure the device turns on). For sensitive SCRs, set to *2 mA.*
4. Set **Max Peak Volts** to *15 V.* (*16 V* on 370)
5. Set **Offset** by depressing *0* (zero).
6. Set **Rate** by depressing *Norm.*
7. Set **Step Family** by depressing *Rep* (repetitive).
8. Set **Mode** to *DC.*
9. Set **Horizontal** knob to *0.5 V/DIV.*
10. Set **Power Dissipation** to *220 W* (*100 W on 577*).
11. Set **Number of Steps** to *1*. (Set steps to 0 (zero) on 370.)
12. Set **Vertical** knob to a sufficient setting to allow the viewing of 2 times the $I_{T(RMS)}$ rating of the device ($I_{T(peak)}$) on CRT.

    Before continuing with testing, note the following:

    (1) Due to the excessive amount of power that can be generated in this test, only parts with an $I_{T(RMS)}$ rating of 6 A or less should be tested on standard curve tracer. If testing devices above 6 A, a Tektronix model 176 high-current module is required.

    (2) A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in the fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connectors.
13. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
14. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$, which is twice the $I_{T(RMS)}$ rating of theSCR under test.

Note: Model 370 current is limited to 10 A.

WARNING: Limit test time to 15 seconds maximum after the Variable Collector Supply has been set to $I_{T(peak)}$. After the Variable Collector Supply Voltage has been set to $I_{T(peak)}$, the test time can automatically be shortened by changing Step Family from repetitive to single by depressing the Single button.

To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. The distance from the left-hand side of scale to the intersection point is the V_{TM} value. (Figure AN1006.7)

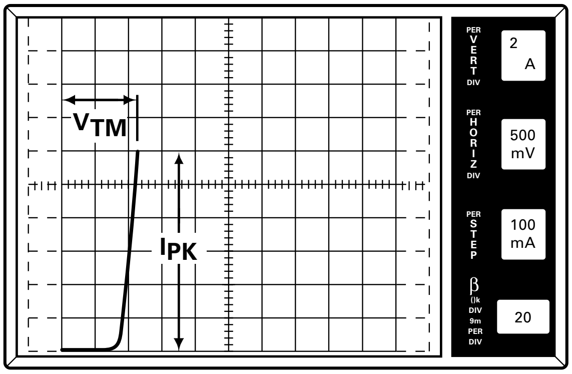


Figure AN1006.7 V_{TM} = 1.15 V at $I_{T(peak)}$ = 12 A

Procedure 5: I_H

To measure the I_H parameter:

1. Set **Polarity** to (+).
2. Set **Power Dissipation** to *2.2 W.* (*2 W* on 370)
3. Set **Max Peak Volts** to *75 V.* (80 V on 370)
4. Set **Mode** to *DC.*
5. Set **Horizontal** knob to *Step Generator.*
6. Set **Vertical** knob to approximately 10 percent of the maximum I_H specified.

Note: Due to large variation of holding current values, the scale may have to be adjusted to observe holding current.

7. Set **Number of Steps** to *1.*
8. Set **Offset** by depressing *0*(zero). (Press *Aid* and Oppose at the same time on 370.)
9. Set **Step/Offset Amplitude** to twice the maximum I_{GT} of the device.
10. Set **Terminal Selector** to *Step Generator-Emitter Grounded.*
11. Set **Step Family** by depressing *Single.*
12. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
13. Increase **Variable Collector Supply Voltage** to maximum position (*100*).
14. Set **Step Family** by depressing *Single*. (This could possibly cause the dot on CRT to disappear, depending on the vertical scale selected.)
15. Change **Terminal Selector** from *Step Generator-Emitter Grounded* to *Open Base-Emitter Grounded.*
16. Decrease **Variable Collector Supply Voltage** to the point where the line on the CRT changes to a dot. The position of the beginning point of the line, just before the line becomes a dot, represents the holding current value. (Figure AN1006.8)

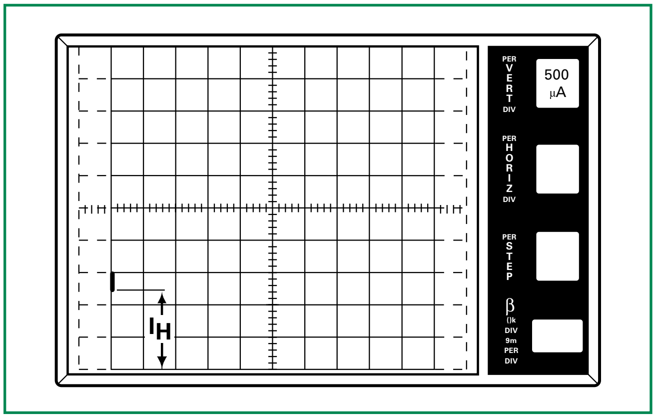


Figure AN1006.8 I_H = 1.2 mA

Procedure 6: I_{GT} and V_{GT}

To measure the I_{GT} and V_{GT} parameter:

1. Set **Polarity** to (+).
2. Set **Number of Steps** to 1.
3. Set **Offset** by depressing *Aid.*
4. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and *Oppose* at the same time on 370.)
5. Set *Terminal Selector* to *Step Generator-Emitter Grounded.*
6. Set **Mode** to *Norm.*
7. Set **Max Peak Volts** to *15 V.* (*16 V* on 370)
8. Set **Power Dissipation** to *2.2 W.* (*2 W* on 370) For sensitive SCRs, set at 0.5 W. (*0.4 W* on 370)
9. Set **Horizontal** knob to *2 V/DIV.*
10. Set **Vertical** knob to *50 mA/DIV.*
11. Increase **Variable Collector Supply Voltage** until voltage reaches 12 V on CRT.
12. After 12 V setting is completed, change **Horizontal** knob to *Step Generator.*

Procedure 7: I_{GT}

To measure the I_{GT} parameter:

1. Set **Step/Offset Amplitude** to 20% of maximum rated I_{GT}.

   Note: R_{GK} should be removed when testing I_{GT}
2. Set **Left-Right Terminal Jack Selector** to correspond with location of the test fixture.
3. Gradually increase **Offset Multiplier** until device reaches the conduction point. (Figure AN1006.9) Measure I_{GT} by following horizontal axis to the point where the vertical line crosses axis. This measured value is I_{GT}. (On 370, I_{GT} will be numerically displayed on screen under offset value.)

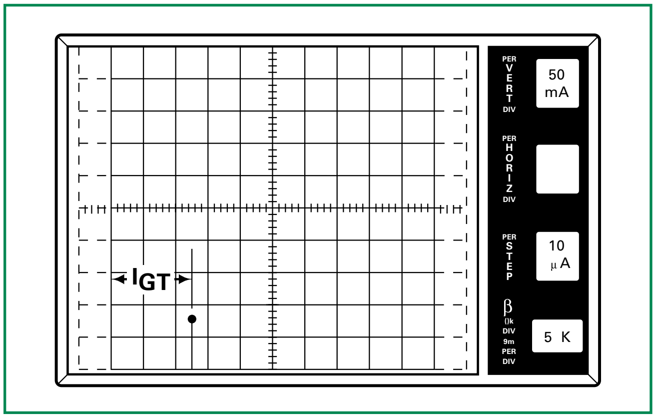


Figure AN1006.9 I_{GT} = 25 µA

Procedure 8: V_{GT}

To measure the V_{GT} parameter:

1. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and *Oppose* at the same time on 370.)
2. Set **Step Offset Amplitude** to 20% rated V_{GT}.
3. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
4. Gradually increase **Offset Multiplier** until device reaches the conduction point. (Figure AN1006.10) Measure V_{GT} by following horizontal axis to the point where the vertical line crosses axis. This measured value is V_{GT}. (On 370, V_{GT} will be numerically displayed on screen, under offset value.)

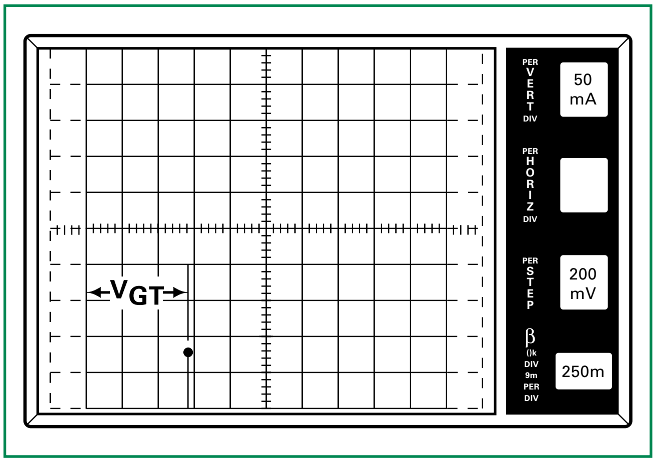


Figure AN1006.10 V_{GT} = 580 mV

Thyristor and Rectifier Testing Using Curve Tracers (continued)

Triacs

Triacs are full-wave bidirectional AC switches turned on when current is supplied to the gate terminal of the device. If gate control in all four quadrants is required, then a sensitive gate Triac is needed, whereas a standard Triac can be used if gate control is only required in Quadrants I through III.

To connect the Triac:

1. Connect the *Gate* to the *Base Terminal* (B).
2. Connect *MT1* to the *Emitter Terminal* (E).
3. Connect *MT2* to the *Collector Terminal* (C).

To begin testing, perform the following procedures.

Procedure 1: (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, (-)I_{DRM}

Note: The (+) and (-) symbols are used to designate the polarity MT2 with reference to MT1.

To measure the (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, and (-)I_{DRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to appropriate *Max Peak Volts* for device under test. (Value selected should be equal to the device's V_{DRM} rating.)

   WARNING: DO NOT exceed V_{DRM}/V_{RRM} rating of SCRs, Triacs, or Quadracs. These devices can be damaged.
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level. (The *100 V/DIV* scale should be used for testing devices having a V_{DRM} rating of 600 V or greater; the *50 V/DIV* scale for testing parts rated from 30 V to 500 V, and so on.)
3. Set **Mode** to *Leakage.*
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *0.5 W.* (*0.4 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
7. Set **Vertical** knob to ten times the maximum leakage current (I_{DRM}) specified for the device.

Note: The CRT screen readout should show 1% of the maximum leakage current. The vertical scale is divided by 1,000 when leakage mode is used.

Procedure 2: (+)V_{DRM}, (+)I_{DRM}

To measure the (+)V_{DRM} and (+)I_{DRM} parameter:

1. Set Left-Right Terminal Jack Selector to correspond with location of the test fixture.
2. Increase Variable Collector Supply Voltage to the rated V_{DRM} of the device and observe the dot on the CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.11)

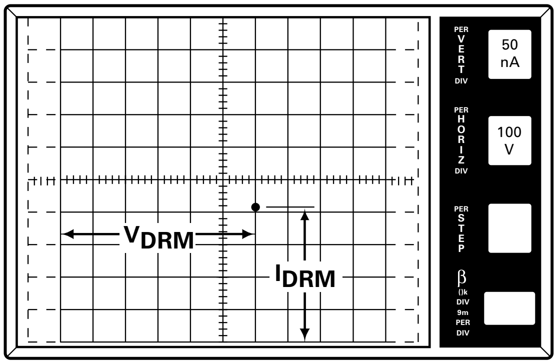


Figure AN1006.11 (+)I_{DRM} = 205 nA at (+)V_{DRM} = 600 V

Procedure 3: (-)V_{DRM}, (-)I_{DRM}

To measure the (-)V_{DRM} and (-)I_{DRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Procedures 1 and 2. (Read measurements from upper right corner of the screen.)

Procedure 4: $V_{TM \text{ (Forward and Reverse)}}$

To measure the $V_{TM \text{ (Forward and Reverse)}}$ parameter:

1. Set **Terminal Selector** to Step Generator-Emitter Grounded.
2. Set **Step/Offset Amplitude** to twice the maximum I_{GT} rating of the device (to insure the device turns on).
3. Set **Variable Collector Supply Voltage Range** to *15 V Max Peak volts.* (*16 V* on 370)
4. Set **Offset** by depressing *0* (zero).
5. Set **Rate** by depressing *Norm.*
6. Set **Step Family** by depressing *Rep* (Repetitive).
7. Set **Mode** to *Norm.*
8. Set **Horizontal** knob to *0.5 V/DIV.*
9. Set **Power Dissipation** to *220 W* (*100 W* on 577).
10. Set **Number of Steps** to *1.*
11. Set **Step/Offset Polarity** to non-inverted (button extended; on 577 button depressed).
12. Set **Vertical** knob to a sufficient setting to allow the viewing of 1.4 times the $I_{T(RMS)}$ rating of the device [$I_{T(peak)}$ on CRT].

Note the following:

- Due to the excessive amount of power that can be generated in this test, only parts with an $I_{T(RMS)}$ rating of

8 A or less should be tested on standard curve tracer. If testing devices above 8 A, a Tektronix model 176 high-current module is required.

- A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connections.

Procedure 5: $V_{TM\ (Forward)}$

To measure the $V_{TM\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$, which is 1.4 times $I_{T(RMS)}$ rating of the Triac under test.

   Note: Model 370 current is limited to 10 A.

WARNING: Limit test time to 15 seconds maximum. After the Variable Collector Supply Voltage has been set to $I_{T(peak)}$, the test time can automatically be set to a short test time by changing Step Family from repetitive to single by depressing the Single button.

To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. The distance from the left-hand side of scale to the crossing point is the V_{TM} value. (Figure AN1006.12)

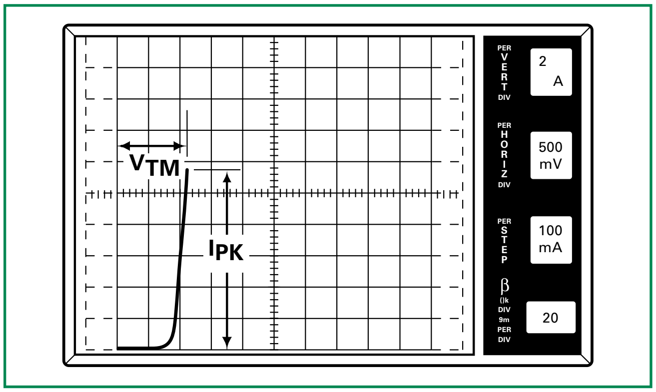


Figure AN1006.12 $V_{TM\ (forward)}$ = 1.1 V at I_{PK} = 11.3 A (8 A rms)

Procedure 6: $V_{TM\ (Reverse)}$

To measure the $V_{TM\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$.
4. Measure $V_{TM(Reverse)}$ similar to Figure AN1006.12, except from upper right hand corner of screen.

Procedure 7: $I_{H(Forward\ and\ Reverse)}$

To measure the $I_{H\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Step/Offset Amplitude** to twice the I_{GT} rating of the device.
2. Set **Power Dissipation** to *10 W*.
3. Set **Max Peak Volts** to *75 V*. (*80 V* on 370)
4. Set **Mode** to *DC*.
5. Set **Horizontal** knob to *Step Generator*.
6. Set **Vertical** knob to approximately 10% of the maximum I_H specified.

   Note: Due to large variation of holding current values, the scale may have to be adjusted to observe holding current.
7. Set **Number of Steps** to *1*.
8. Set **Step/Offset Polarity** to non-inverted (button extended, on 577 button depressed).
9. Set **Offset** by depressing *0* (zero). (Press *Aid* and *Oppose* at same time on 370.)
10. Set **Terminal Selector** to *Step Generator-Emitter Grounded*.

Procedure 8: $I_{H(Forward)}$

To measure the $I_{H\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Increase **Variable Collector Supply Voltage** to maximum position (*100*).
4. Set **Step Family** by depressing *Single*.

   This could possibly cause the dot on the CRT to disappear, depending on the vertical scale selected).
5. Decrease **Variable Collector Supply Voltage** to the point where the line on the CRT changes to a dot. The position of the beginning point of the line, just before the line becomes a dot, represents the holding current value. (Figure AN1006.13)

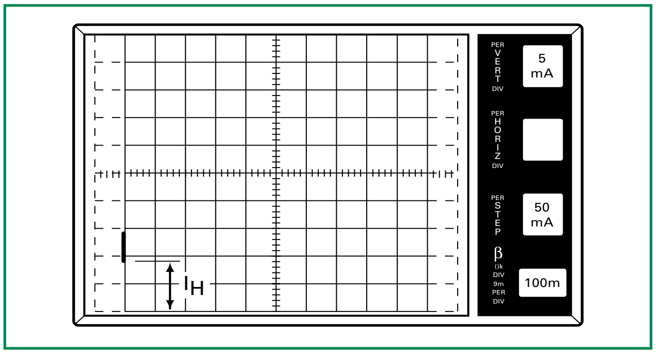


Figure AN1006.13 $I_{H\ (Forward)}$ = 8.2 mA

Thyristor and Rectifier Testing Using Curve Tracers (continued)

Procedure 9: $I_{H(Reverse)}$

To measure the $I_{H\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Repeat Procedure 7 measuring $I_{H(Reverse)}$. (Read measurements from upper right corner of the screen.)

Procedure 10: I_{GT}

To measure the I_{GT} parameter:

1. Set **Polarity** to (+).
2. Set **Number of Steps**to *1.* (Set number of steps to *0* (zero) on 370.)
3. Set **Offset** by depressing *Aid.* (On 577, also set **Zero** button to *Offset.* Button is extended.)
4. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and Oppose at same time on 370.)
5. Set **Terminal Selector** to *Step Generator-Emitter Grounded.*
6. Set **Mode** to **Norm.**
7. Set **Max Peak Volts** to *15 V.* (*16 V* on 370)
8. Set **Power Dissipation** to *10 W.*
9. Set **Step Family** by depressing *Single.*
10. Set **Horizontal** knob to *2 V/DIV.*
11. Set **Vertical** knob to *50 mA/DIV.*
12. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
13. Set **Variable Collector Supply Voltage** until voltage reaches 12 V on CRT.
14. After 12 V setting is completed, change **Horizontal** knob to *Step Generator.*

Procedure 11: I_{GT} - Quadrant I [MT2 (+) Gate (+)]

To measure the I_{GT} - Quadrant I parameter:

1. Set **Step/Offset Amplitude** to approximately 10% of rated I_{GT}.
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Gradually increase **Offset Multiplier** until device reaches conduction point. (Figure AN1006.14) Measure I_{GT} by following horizontal axis to the point where the vertical line passes through the axis. This measured value is I_{GT}. (On 370, I_{GT} is numerically displayed on screen under offset value.)

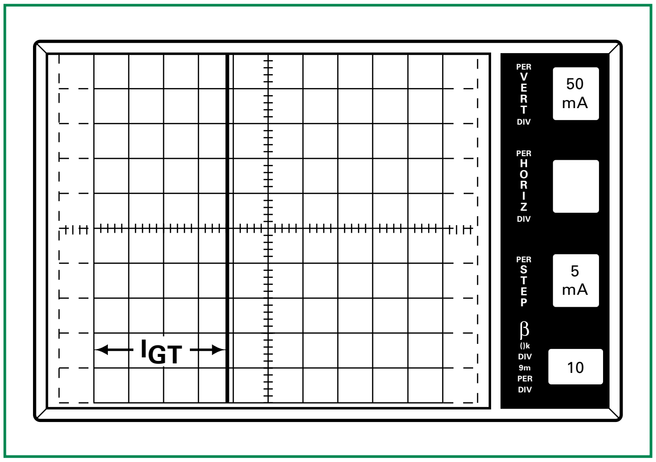


Figure AN1006.14 I_{GT} in Quadrant I = 18.8 mA

Procedure 12: I_{GT} - Quadrant II [MT2 (+) Gate (-)]

To measure the I_{GT} - Quadrant II parameter:

1. Set **Step/Offside Polarity** by depressing Invert (release button on 577).
2. Set **Polarity** to (+).
3. Set observed dot to bottom right corner of CRT grid by turning the horizontal position knob. When Quadrant II testing is complete, return dot to original position.
4. Repeat Procedure 11.

Procedure 13: I_{GT} - Quadrant III [MT2 (-) Gate (-)]

To measure the I_{GT} - Quadrant III parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
3. Repeat Procedure 11. (Figure AN1006.15)

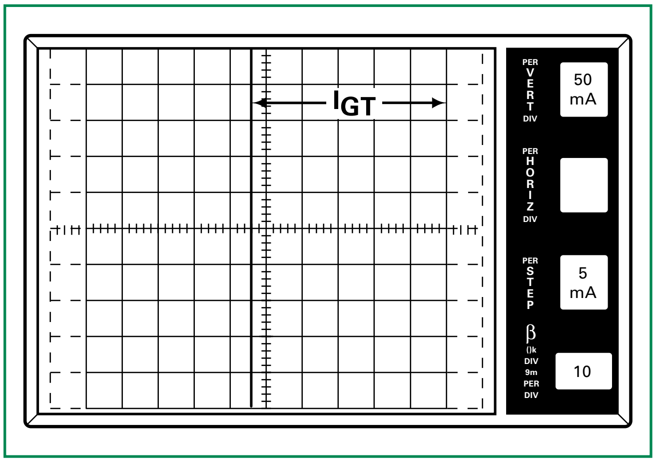


Figure AN1006.15 I_{GT} in Quadrant III = 27 mA

Thyristor and Rectifier Testing Using Curve Tracers (continued)

Procedure 14: I_{GT} - Quadrant IV [MT2 (-) Gate (+)]

To measure the I_{GT} - Quadrant IV parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** by depressing *Invert* (release button on 577).
3. Set observed dot to top left corner of CRT grid by turning the **Horizontal** position knob. When Quadrant IV testing is complete, return dot to original position.
4. Repeat Procedure 11.

Procedure 15: V_{GT}

To measure the V_{GT} parameter:

1. Set **Polarity** to (+).
2. Set **Number of Steps** to *1*. (Set steps to *0* (zero) on 370.)
3. Set **Offset** by depressing *Aid*. (On 577, also set *0* (zero) button to *Offset*. Button is extended.)
4. Set **Offset Multiplier** to *0* (zero). (Press *Aid* and *Oppose* at same time on 370.)
5. Set **Terminal Selector** to *Step Generator-Emitter Grounded.*
6. Set **Mode** to *Norm.*
7. Set **Max Peak Volts** to *15 V*. (*16 V* on 370)
8. Set **Power Dissipation** to *10 W.*
9. Set **Step Family** by depressing *Single.*
10. Set **Horizontal** knob to *2 V/DIV.*
11. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
12. Set **Current Limit** to 500 mA (not available on 577).
13. Increase **Variable Collector Supply Voltage** until voltage reaches 12 V on CRT.
14. After 12 V setting is complete, change **Horizontal** knob to *Step Generator.*

Procedure 16: V_{GT} - Quadrant I [MT2 (+) Gate (+)]

To measure the V_{GT} - Quadrant I parameter:

1. Set **Step/Offset Amplitude** to 20% of rated V_{GT}.
2. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.
3. Gradually increase **Offset Multiplier** until device reaches conduction point. (Figure AN1006.16) Measure V_{GT} by following horizontal axis to the point where the vertical line passes through the axis. This measured value will be V_{GT}. (On 370, V_{GT} will be numerically displayed on screen under offset value.)

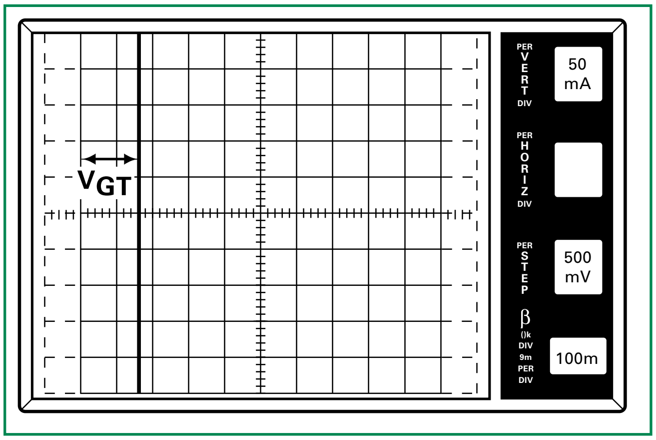


Figure AN1006.16 V_{GT} in Quadrant I = 780 mV

Procedure 17: V_{GT} - Quadrant II [MT2 (+) Gate (-)]

To measure the V_{GT} - Quadrant II parameter:

1. Set **Step/Offset Polarity** by depressing *Invert* (release button on 577).
2. Set **Polarity** to (+).
3. Set observed dot to bottom right corner of CRT grid by turning the **Horizontal** position knob. When Quadrant II testing is complete, return dot to original position.
4. Repeat Procedure 16.

Procedure 18: V_{GT} - Quadrant III [MT2 (-) Gate (-)]

To measure the V_{GT} - Quadrant III parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** to non-inverted position (button extended, on 577 button depressed).
3. Repeat Procedure 16. (Figure AN1006.17)

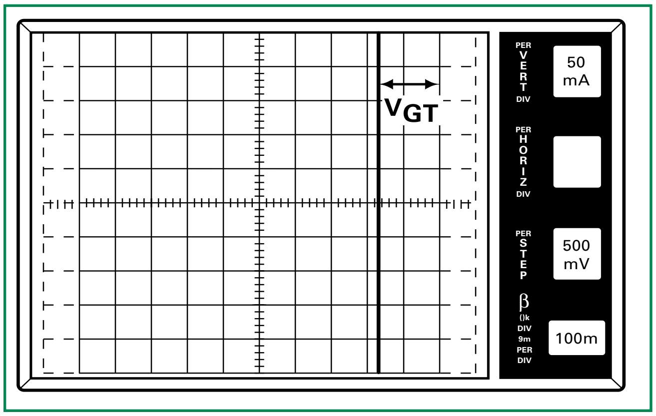


Figure AN1006.17 V_{GT} in Quadrant III = 820 mV

Procedure 19: V_{GT} - Quadrant IV [MT2 (-) Gate (+)]

To measure the V_{GT} - Quadrant IV parameter:

1. Set **Polarity** to (-).
2. Set **Step/Offset Polarity** by depressing *Invert* (release button on 577).

3. Set observed dot to top left corner of CRT grid by turning the **Horizontal** position knob. When testing is complete in Quadrant IV, return dot to original position.
4. Repeat Procedure 16.

Quadracs

Quadracs are simply Triacs with an internally-mounted DIAC. As with Triacs, Quadracs are bidirectional AC switches which are gate controlled for either polarity of main terminal voltage.

To connect the Quadrac*:*

1. Connect *Trigger* to *Base Terminal* (B).
2. Connect *MT1* to *Emitter Terminal* (E).
3. Connect *MT2* to *Collector Terminal* (C).

To begin testing, perform the following procedures.

Procedure 1: (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, (-)I_{DRM}

Note: The (+) and (-) symbols are used to designate the polarity of MT2 with reference to MT1.

To measure the (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, and (-)I_{DRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to appropriate *Max Peak Volts* for device under test. (Value selected should be equal to or greater than the device's V_{DRM} rating).
2. Set **Horizontal** knob to sufficient scale to allow *viewing of trace at the required voltage level. (The* 100 V/DIV scale should be used for testing devices having a V_{DRM} rating of 600 V or greater; the *50 V/DIV* scale for testing parts rated from 300 V to 500 V, and so on).
3. Set **Mode** to Leakage.
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *0.5 W.* (*0.4 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
7. Set **Vertical** knob to ten times the maximum leakage current (I_{DRM}) specified for the device.

   Note: The CRT readout should show 1% of the maximum leakage current. The vertical scale is divided by 1,000 when the leakage mode is used.

Procedure 2: (+)V_{DRM} and (+)I_{DRM}

To measure the (+)V_{DRM} and (+)I_{DRM} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Increase **Variable Collector Supply Voltage** to the rated V_{DRM} of the device and observe the dot on the CRT. (Read across horizontally from the dot to the vertical current scale.) This measured value is the leakage current. (Figure AN1006.18)

WARNING: Do NOT exceed V_{DRM}/V_{RRM} rating of SCRs, Triacs, or Quadracs. These devices can be damaged.

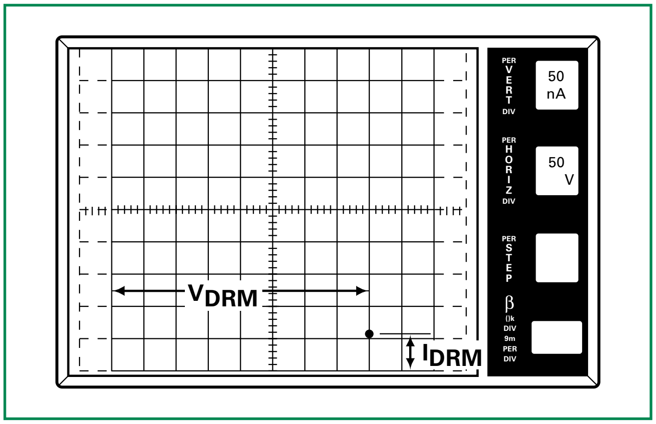


Figure AN1006.18 (+)I_{DRM} = 51 nA at (+)V_{DRM} = 400 V

Procedure 3: (-)V_{DRM} and (-)I_{DRM}

To measure the (-)V_{DRM} and (-)I_{DRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Procedures 1 and 2. (Read measurements from upper right corner of screen).

Procedure 4: V_{BO}, I_{BO}, V_{BO}

(Quadrac Trigger DIAC or Discrete DIAC)

To connect the Quadrac:

1. Connect *MT1 to Emitter Terminal* (E).
2. Connect *MT2 to Collector Terminal* (C).
3. Connect *Trigger Terminal* to *MT2 Terminal* through a 10 Ω resistor.

To measure the V_{BO}, I_{BO}, and ΔV_{BO} parameter:

1. Set **Variable Collector Supply Voltage Range** to *75 Max Peak Volts.*(*80 V* on 370)
2. Set **Horizontal** knob to *10 V/DIV.*
3. Set **Vertical** knob to *50 μA/DIV.*
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *0.5 W.* (*0.4 W* on 370)
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*

Procedure 5: V_{BO} (Positive and Negative)

To measure the $V_{BO \text{ (Positive and Negative)}}$ parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Set **Variable Collector Supply Voltage** to *55 V* (*65 V* on 370) and apply voltage to the device under test (D.U.T.) using the **Left Hand Selector Switch**. The peak voltage at which current begins to flow is the V_{BO} value. (Figure AN1006.19)

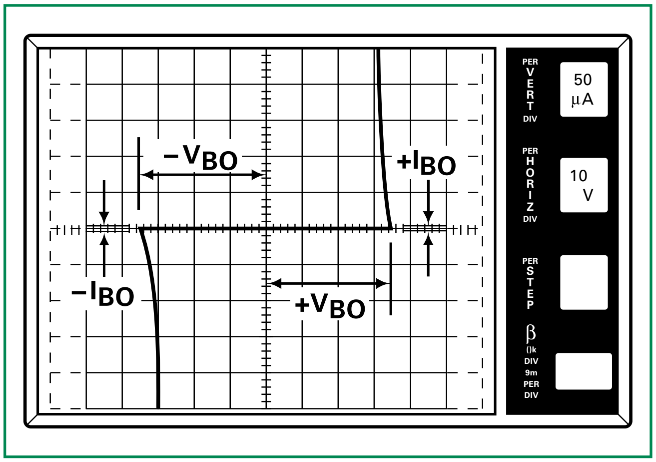


Figure AN1006.19 (+)V_{BO} = 35 V; (-)V_{BO} = 36 V; (±)I_{BO} < 10 A

Procedure 6: I_{BO} (Positive and Negative)

To measure the $I_{BO \text{ (Positive and Negative)}}$ parameter, at the V_{BO} point, measure the amount of device current just before the device reaches the breakover point. The measured current at this point is the I_{BO} value.

Note: If I_{BO} is less than 10 µA, the current cannot readily be seen on curve tracer.

Procedure 7: $\Delta V_{BO \text{ (Voltage Breakover Symmetry)}}$

To measure the $\Delta V_{BO \text{ (Voltage Breakover Symmetry)}}$ parameter:

1. Measure positive and negative V_{BO} values per Procedure 5.
2. Subtract the absolute value of V_{BO} (-) from V_{BO} (+).

   The absolute value of the result is:

   $\Delta V_{BO} = [\ |+V_{BO}| - |-V_{BO}|\ ]$

Procedure 8: $V_{TM \text{ (Forward and Reverse)}}$

To test V_{TM}, the Quadrac must be connected the same as when testing V_{BO}, I_{BO}, and ΔV_{BO}.

To connect the Quadrac:

1. Connect *MT1* to *Emitter Terminal* (E).
2. Connect *MT2* to *Collector Terminal* (C).
3. Connect *Trigger Terminal* to *MT2 Terminal* through a 10 Ω resistor.

Note the following:

> Due to the excessive amount of power that can be generated in this test, only parts with an $I_{T(RMS)}$ rating of 8 A or less should be tested on standard curve tracer. If testing devices above 8 A, a Tektronix model 176 high-current module is required.
>
> A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin connections.

To measure the $V_{TM \text{ (Forward and Reverse)}}$ parameter:

1. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
2. Set **Max Peak Volts** to *75 V.* (*80 V* on 370)
3. Set **Mode** to *Norm.*
4. Set **Horizontal** knob to *0.5 V/DIV.*
5. Set **Power Dissipation** to *220 watts* (*100 watts* on a 577).
6. Set **Vertical** knob to a sufficient setting to allow the viewing of 1.4 times the $I_{T(RMS)}$ rating of the device $I_{T(peak)}$ on the CRT.

Procedure 9: $V_{TM(Forward)}$

To measure the $V_{TM \text{ (Forward)}}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable** Collector **Supply Voltage** until current reaches rated $I_{T(peak)}$, which is 1.4 times the $I_{T(RMS)}$ rating of the Triac under test.

   Note: Model 370 current is limited to 10 A.

   WARNING: Limit test time to 15 seconds maximum.
4. To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. This horizontal distance is the V_{TM} value. (Figure AN1006.20)

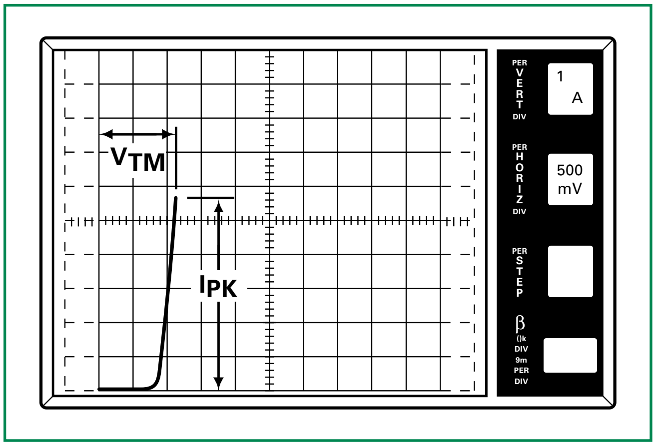


Figure AN1006.20 $V_{TM \text{ (Forward)}}$ = 1.1 V at I_{PK} = 5.6 A

Procedure 10: $V_{TM(Reverse)}$

To measure the $V_{TM\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable** Collector **Supply Voltage** until current reaches rated $I_{T(peak)}$.
4. Measure $V_{TM(Reverse)}$ the same as in Procedure 8. (Read measurements from upper right corner of screen).

Procedure 11: $I_{H(Forward\ and\ Reverse)}$

For these steps, it is again necessary to connect the *Trigger* to *MT2* through a 10 Ω resistor. The other connections remain the same.

To measure the $I_{H\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Power Dissipation** to *50 W*.
2. Set **Max Peak Volts** to *75 V*. (*80 V* on 370)
3. Set **Mode** to *DC*.
4. Set **Horizontal** knob to *5 V/DIV*.
5. Set **Vertical** knob to approximately 10% of the maximum I_H specified.

   Note: Due to large variations of holding current values, the scale may have to be adjusted to observe holding current.
6. Set **Terminal Selector** to *Emitter Grounded-Open Base*.

Procedure 12: $I_{H(Forward)}$

To measure the $I_{H\ (Forward)}$ parameter:

1. Set **Polarity** to (+).
2. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
3. Increase **Variable** Collector **Supply Voltage** to maximum position (*100*).

   Note: Depending on the vertical scale being used, the dot may disappear completely from the screen.
4. Decrease **Variable Collector Supply Voltage** to the point where the line on the CRT changes to a dot. The position of the beginning point of the line, just before the line changes to a dot, represents the I_H value. (Figure AN1006.21)

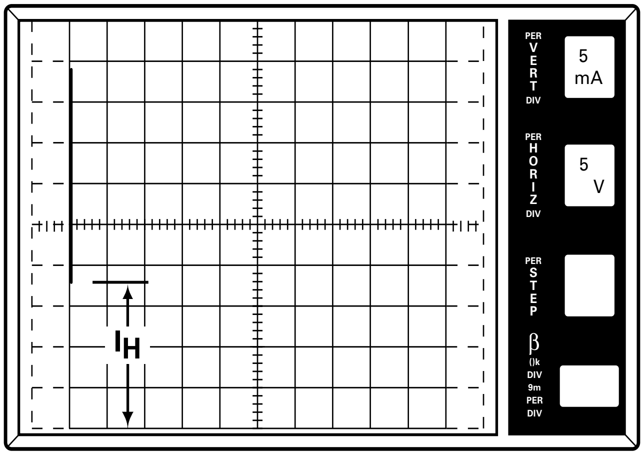


Figure AN1006.21 $I_{H\ (Forward)}$ = 18 mA

Procedure 13: $I_{H(Reverse)}$

To measure the $I_{H\ (Reverse)}$ parameter:

1. Set **Polarity** to (-).
2. Continue testing per Procedure 12 for measuring $I_{H\ (Reverse)}$.

SIDACs

The SIDAC is a bidirectional voltage-triggered switch. Upon application of a voltage exceeding the SIDAC breakover voltage point, the SIDAC switches on through a negative resistance region (similar to a DIAC) to a low on-state voltage. Conduction continues until current is interrupted or drops below minimum required holding current.

To connect the SIDAC:

1. Connect *MT1* to *the Emitter Terminal* (E).
2. Connect *MT2* to *the Collector Terminal* (C).

To begin testing, perform the following procedures.

Procedure 1: (+) V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, (-)I_{DRM}

Note: The (+) and (-) symbols are used to designate the polarity of MT2 with reference to MT1.

To measure the (+)V_{DRM}, (+)I_{DRM}, (-)V_{DRM}, and (-)I_{DRM} parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 Max Peak Volts.*
2. Set **Horizontal** knob to *50 V/DIV*.
3. Set **Mode** to *Leakage*.
4. Set **Polarity** to (+).
5. Set **Power Dissipation** to *2.2 W*. (*2 W* on 370)
6. Set **Terminal Selector** to *Emitter Grounded-Open Base*.
7. Set **Vertical** knob to *50 µA/DIV*. (Due to leakage mode, the CRT readout will show 50 nA.)

Procedure 2: (+)V_{DRM} and (+)I_{DRM}

To measure the (+)V_{DRM} and (+)I_{DRM} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Increase **Variable Collector Supply Voltage** to the rated V_{DRM} of the device and observe the dot on the CRT. Read across horizontally from the dot to the vertical current scale. This measured value is the leakage current. (Figure AN1006.22)

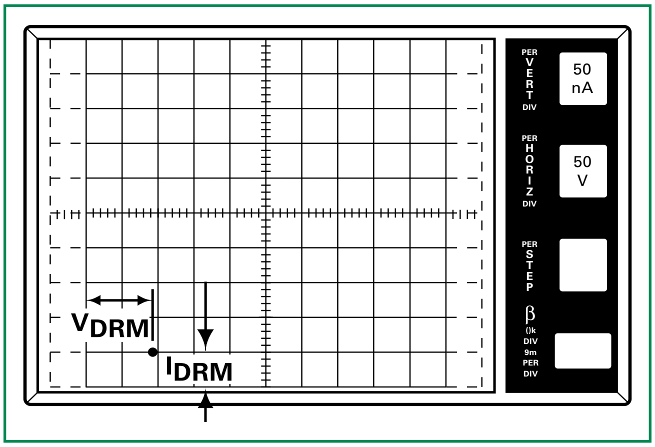


Figure AN1006.22 I_{DRM} = 50 nA at V_{DRM} = 90 V

Procedure 3: (-) V_{DRM} and (-) I_{DRM}

To measure the (-)V_{DRM} and (-)I_{DRM} parameter:

1. Set **Polarity** to (-).
2. Repeat Procedures 1 and 2. (Read measurements from upper right corner of the screen).

Procedure 4: V_{BO} and I_{BO}

To measure the V_{BO} and I_{BO} parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 Max Peak Volts*. (*2000 V* on 370)
2. Set **Horizontal** knob to a sufficient scale to allow viewing of trace at the required voltage level (*50 V/DIV* for 95 V to 215 V V_{BO} range devices and *100 V/DIV* for devices having $V_{BO} \geq 15$ V).
3. Set **Vertical** knob to *50 A/DIV.*
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *10 W.*
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
8. Set **Left-Right Terminal Jack Selector** to correspond with location of test fixture.

Procedure 5: V_{BO}

To measure the V_{BO} parameter, increase **Variable Collector Supply Voltage** until breakover occurs. (Figure AN1006.23) The voltage at which current begins to flow and voltage on CRT does not increase is the V_{BO} value.

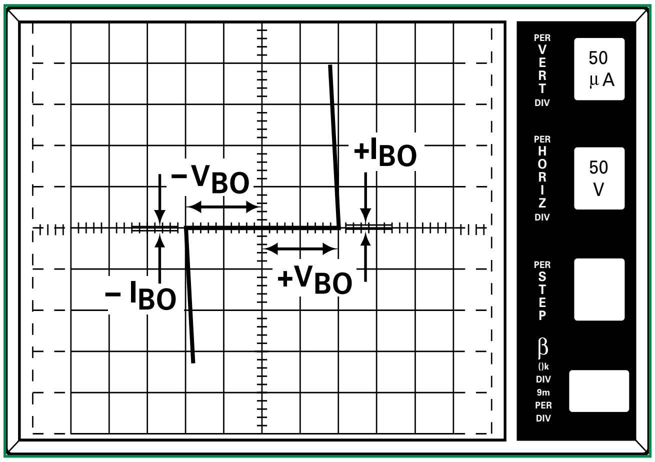


Figure AN1006.23 (+)V_{BO} = 100 V; (-)V_{BO} = 100 V; (±)I_{BO} < 10 µA

Procedure 6: I_{BO}

To measure the I_{BO} parameter, at the V_{BO} point, measure the amount of device current just before the device reaches the breakover mode. The measured current at this point is the I_{BO} value.

Note: If I_{BO} is less than 10 µA, the current cannot readily be seen on the curve tracer.

Procedure 7: $I_{H(Forward\ and\ Reverse)}$

To measure the $I_{H\ (Forward\ and\ Reverse)}$ parameter:

1. Set **Variable Collector Supply Voltage Range** to *1500 Max Peak Volts* (*400 V* on 577; *2000 V* on 370).
2. Set **Horizontal** knob to a sufficient scale to allow viewing of trace at the required voltage level (50 V/DIV for devices with V_{BO} range from 95 V to 215 V and 100 V/DIV for devices having $V_{BO} \geq 215$ V).
3. Set **Vertical** knob to 20% of maximum holding current specified.
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *220 W* (*100 W* on 577).
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*
8. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.

   WARNING: Limit test time to 15 seconds maximum.

9. Increase **Variable Collector Supply Voltage** until device breaks over and turns on. (Figure AN1006.24)

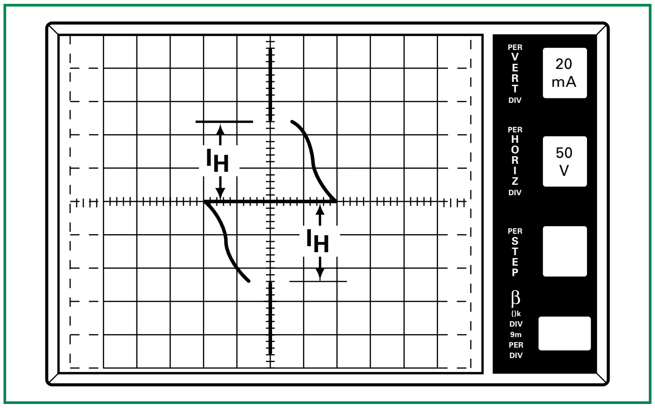


Figure AN1006.24 I_H = 48 mA in both forward and reverse directions

I_H is the vertical distance between the center horizontal axis and the beginning of the line located on center vertical axis.

Procedure 8: $V_{TM(\text{Forward and Reverse})}$

To measure the $V_{TM\ (\text{Forward and Reverse})}$ parameter:

1. Set **Variable Collector Supply Voltage Range** to *350 Max Peak Volts*. (*400 V* on 370)
2. Set **Horizontal** knob to *0.5 V/DIV.*
3. Set **Vertical** knob to *0.5 A/DIV.*
4. Set **Polarity** to (+).
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *220 W* (*100 W* on 577).
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*

Before continuing with testing, note the following:

- A Kelvin test fixture is required for this test. If a Kelvin fixture is not used, an error in measurement of V_{TM} will result due to voltage drop in fixture. If a Kelvin fixture is not available, Figure AN1006.3 shows necessary information to wire a test fixture with Kelvin Connections.

To continue testing, perform the following procedures.

Procedure 9: $V_{TM(\text{Forward})}$

To measure the $V_{TM\ (\text{Forward})}$ parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Increase **Variable Collector Supply Voltage** until current reaches rated $I_{T(peak)}$, which is 1.4 times the $I_{T(RMS)}$ rating of the SIDAC.

   Note: Model 370 current is limited. Set to 400 mA. Check for 1.1 V MAX.

   WARNING: Limit test time to 15 seconds.
3. To measure V_{TM}, follow along horizontal scale to the point where the trace crosses the $I_{T(peak)}$ value. This horizontal distance is the V_{TM} value. (Figure AN1006.25)

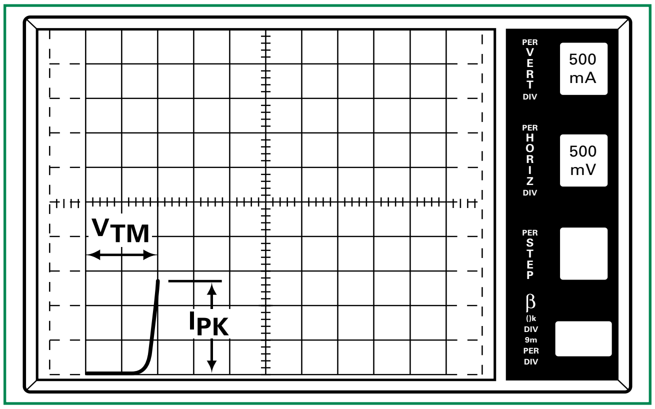


Figure AN1006.25 $V_{TM\ (\text{Forward})}$ = 950 mV at I_{PK} = 1.4 A

Procedure 10: $V_{TM(\text{Reverse})}$

To measure the $V_{TM\ (\text{Reverse})}$ parameter:

Set **Polarity** to (-).

Repeat Procedure 8 to measure $V_{TM(\text{Reverse})}$.

DIACs

DIACs are voltage breakdown switches used to trigger-on Triacs and non-sensitive SCRs in phase control circuits.

Note: DIACs are bi-directional devices and can be connected in either direction.

To connect the DIAC:

Connect one side of the DIAC to the Collector Terminal (C).

Connect other side of the DIAC to the Emitter Terminal (E).

To begin testing, perform the following procedures.

Procedure 1: Curve Tracer Setup

To set the curve tracer and begin testing:

1 Set **Variable Collector Supply Voltage Range** to *75 Max Peak Volts*. (*80 V* on 370)
2. Set **Horizontal** knob to sufficient scale to allow viewing of trace at the required voltage level (*10 V* to *20 V/DIV* depending on device being tested).
3. Set **Vertical** knob to *50 μA/DIV.*
4. Set **Polarity** to *AC.*
5. Set **Mode** to *Norm.*
6. Set **Power Dissipation** to *0.5 W.* (*0.4 W* on 370)
7. Set **Terminal Selector** to *Emitter Grounded-Open Base.*

Procedure 2: V_{BO}

To measure the V_{BO} parameter:

1. Set **Left-Right Terminal Jack Selector** to correspond with the location of the test fixture.
2. Set **Variable Collector Supply Voltage** to *55 V* (*65 V* for 370) and apply voltage to device under test (D.U.T.), using **Left-Right-Selector Switch**. The peak voltage at which current begins to flow is the V_{BO} value. (Figure AN1006.26)

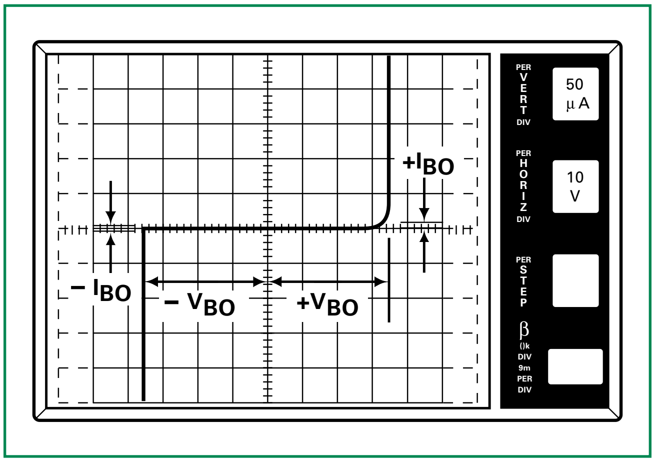


Figure AN1006.26 (+)V_{BO} = 35 V; (-)V_{BO} = 36 V; (±)I_{BO} < 15 µA; (-) I_{BO} < 10 µA and Cannot Be Read Easily

Procedure 3: I_{BO}

To measure the I_{BO} parameter, at the V_{BO} point, measure the amount of device current just before the device reaches the breakover mode. The measured current at this point is the I_{BO} value.

Note: If I_{BO} is less than 10 µA, the current cannot readily be seen on the curve tracer.

Procedure 4: $\Delta V_{BO(Voltage\ Breakover\ Symmetry)}$

To measure the $\Delta V_{BO\ (Voltage\ Breakover\ Symmetry)}$ parameter:

1. Measure positive and negative values of V_{BO} as shown in Figure AN1006.26.
2. Subtract the absolute value of V_{BO}(-) from V_{BO}(+).

   The absolute value of the result is:

   $\Delta V_{BO} = [\ |\ +V_{BO}\ | - |\ -V_{BO}\ |\ ]$

Model 370 Curve Tracer Procedure Notes

Because the curve tracer procedures in this application note are written for the Tektronix model 576 curve tracer, certain settings must be adjusted when using model 370. Variable Collector Supply Voltage Range and Power Dissipation controls have different scales than model 576. The following table shows the guidelines for setting Power Dissipation when using model 370. (Figure AN1006.27)

Model 576	Model 370
If power dissipation is 0.1 W,	set at 0.08 W.
If power dissipation is 0.5 W,	set at 0.4 W.
If power dissipation is 2.2 W,	set at 2 W.
If power dissipation is 10 W,	set at 10 W.
If power dissipation is 50 W,	set at 50 W.
If power dissipation is 220 W,	set at 220 W.

Although the maximum power setting on the model 370 curve tracer is 200 W, the maximum collector voltage available is only 400 V at 220 W. The following table shows the guidelines for adapting Collector Supply Voltage Range settings for model 370 curve tracer procedures:

Model 576	Model 370
If voltage range is 15 V	set at 16 V.
If voltage range is 75 V	set at 80 V.
If voltage range is 350 V	set at 400 V.
If voltage range is 1500 V	set at 2000 V

The following table shows the guidelines for adapting terminal selector knob settings for model 370 curve tracer procedures:

Model 576	Model 370
If Step generator (base) is emitter grounded	then Base Step generator is emitter common.
If Emitter grounded is open base	then Base open is emitter common.

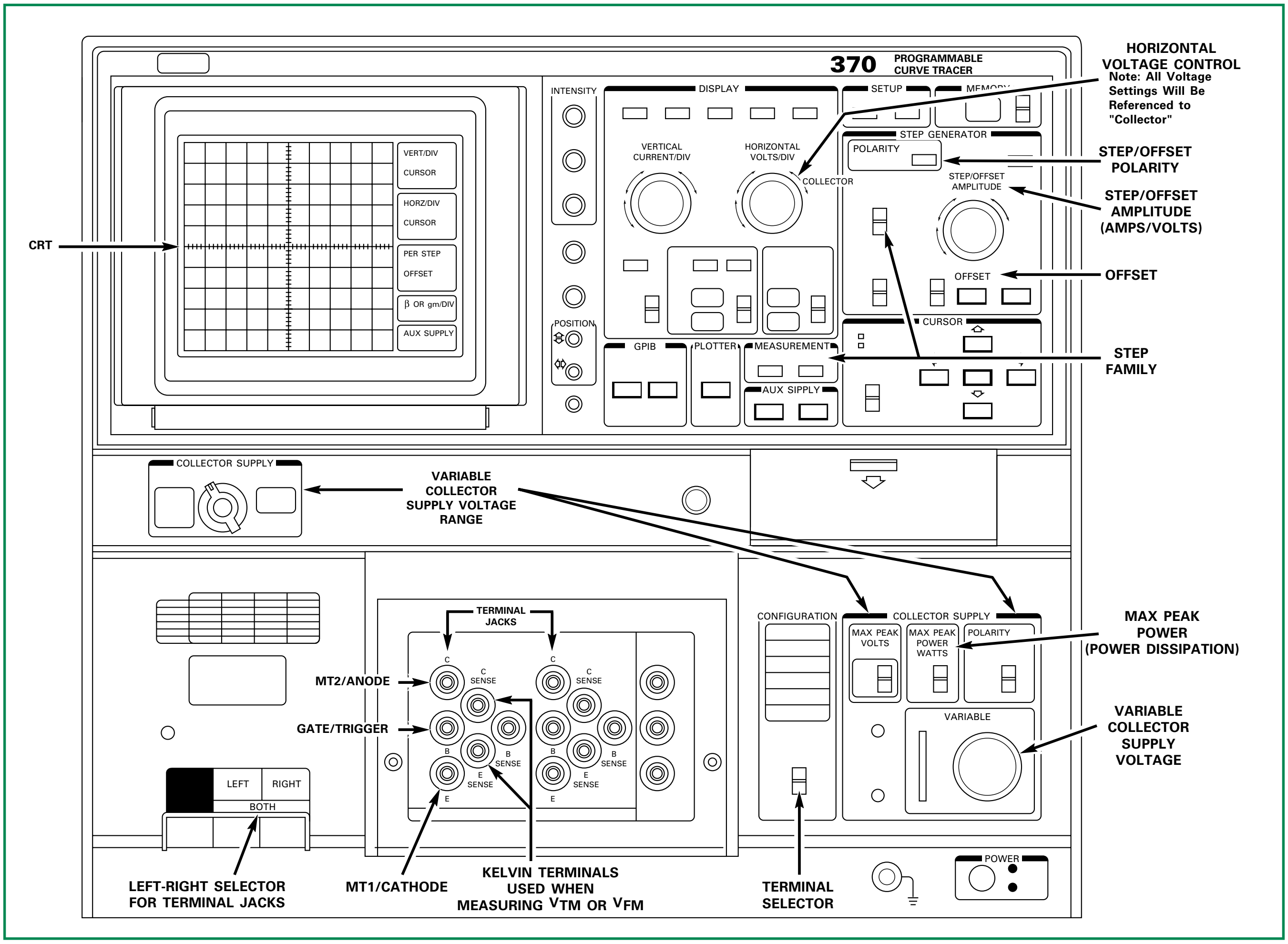


Figure AN1006.27 Tektronix Model 370 Curve Tracer

Model 577 Curve Tracer Procedure Notes

Because the curve tracer procedures in this application note are written for the Tektronix model 576 curve tracer, certain settings must be adjusted when using model 577. Model 576 curve tracer has separate controls for polarity (AC,+,-) and mode (Norm, DC, Leakage), whereas Model 577 has only a polarity control. The following table shows the guidelines for setting Collector Supply Polarity when using model 577. (Figure AN1006.28)

Model 576	Model 577
If using Leakage mode along with polarity setting of +(NPN) and -(PNP),[vertical scale divided by 1,000],	set **Collector Supply Polarity** to either *+DC* or *-DC*, depending on polarity setting specified in the procedure. The vertical scale is read directly from the scale on the control knob.
If using DC mode along with either +(NPN) or -(PNP) polarity,	set **Collector Supply Polarity** to either *+DC* or *-DC* depending on polarity specified.
If using Norm mode along with either +(NPN) or -(PNP) polarity,	set **Collector Supply Polarity** to either *+(NPN)* or *-(PNP)* per specified procedure.
If using Norm mode with *AC* polarity,	set **Collector Supply Polarity** to *AC*.

One difference between models 576 and 577 is the Step/Offset Polarity setting. The polarity is inverted when the button is depressed on the Model 576 curve tracer. The Model 577 is opposite — the Step/Offset Polarity is “inverted” when the button is extended and “Normal” when the button is depressed. The Step/Offset Polarity is used only when measuring I_{GT} and V_{GT} of Triacs and Quadracs in Quadrants I through IV.

Thyristor and Rectifier Testing Using Curve Tracers (continued)

Also, the Variable Collector Supply Voltage Range and Power Dissipation controls have different scales than model 576. The following table shows the guidelines for setting Power Dissipation when using model 577.

Model 576	Model 577
If power dissipation is 0.1 W,	set at 0.15 W.
If power dissipation is 0.5 W,	set at 0.6 W.
If power dissipation is 2.2 W,	set at 2.3 W.
If power dissipation is 10 W,	set at 9 W.
If power dissipation is 50 W,	set at 30 W.
If power dissipation is 220 W,	set at 100 W.

Although the maximum power setting on model 576 curve tracer is 220 W (compared to 100 W for model 577), the maximum collector current available is approximately the same. This is due to the minimum voltage range on model 577 curve tracer being 6.5 V compared to 15 V for model 576. The following table shows the guidelines for adapting Collector Voltage Supply Range settings for model 577 curve tracer procedures:

Model 576	Model 577
If voltage range is 15 V	set at either 6.5 V or 25 V, depending on parameter being tested. Set at 6.5 V when measuring V_{TM} (to allow maximum collector current) and set at 25 V when measuring I_{GT} and V_{GT}.
If voltage range is 75 V	set at 100 V.
If voltage range is 1500 V,	set at 1600 V.

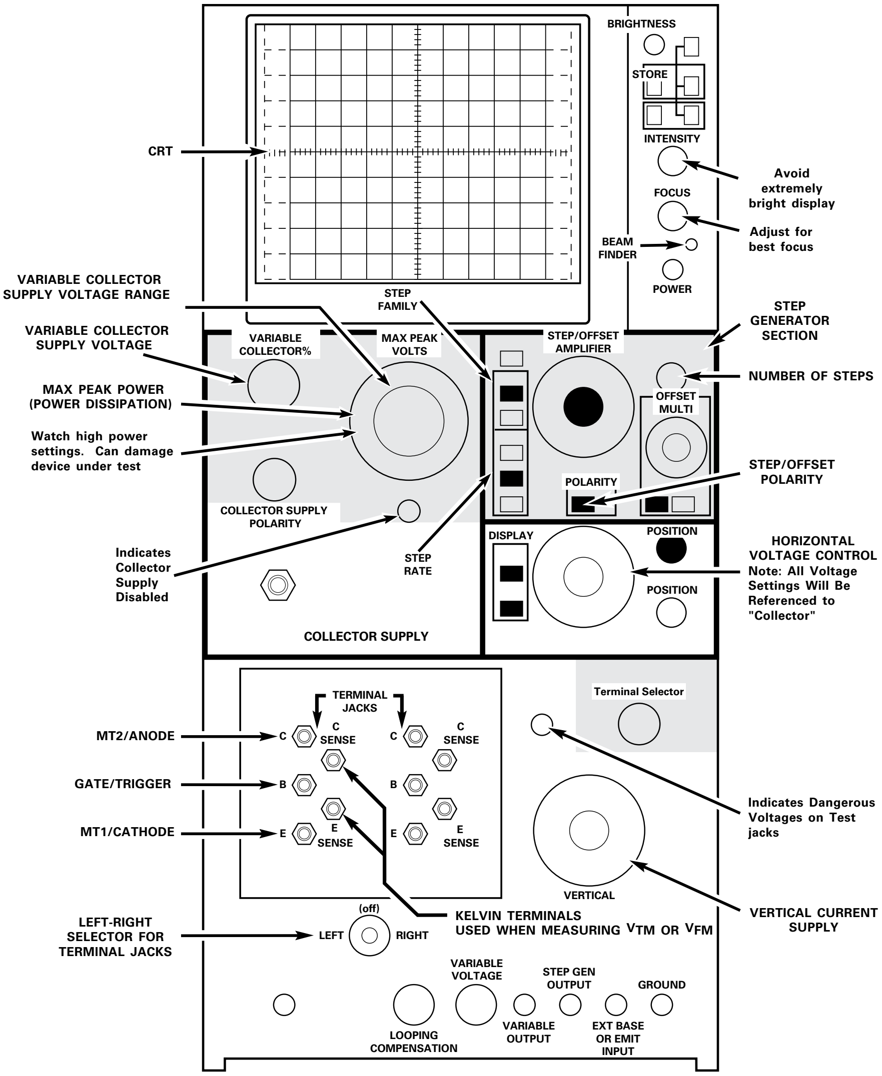


Figure AN1006.28 Tektronix Model 577 Curve Tracer

Thyristors Used as AC Static Switches and Relays

Introduction

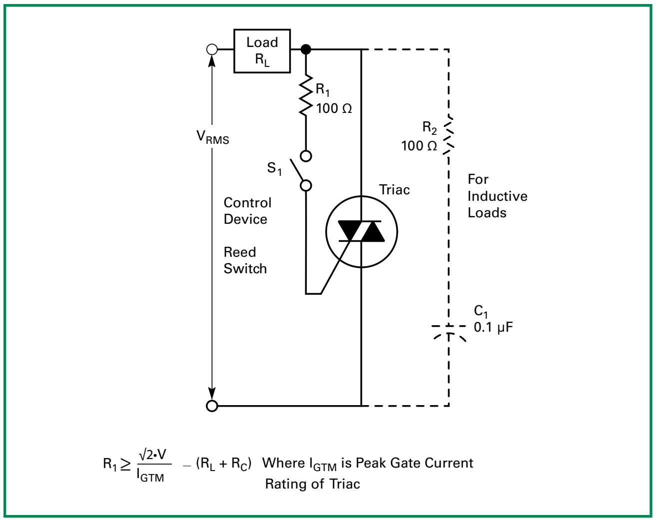
Since the SCR and the Triac are bistable devices, one of their broad areas of application is in the realm of signal and power switching. This application note describes circuits in which these Thyristors are used to perform simple switching functions of a general type that might also be performed non-statically by various mechanical and electromechanical switches. In these applications, the Thyristors are used to open or close a circuit completely, as opposed to applications in which they are used to control the magnitude of average voltage or energy being delivered to a load. These latter types of applications are described in detail in "Phase Control Using Thyristors" (AN1003).

Static AC Switches

Normally Open Circuit

The circuit shown in Figure AN1007.1 provides random (anywhere in half-cycle), fast turn-on (<10 µs) of AC power loads and is ideal for applications with a high-duty cycle. It eliminates completely the contact sticking, bounce, and wear associated with conventional electromechanical relays, contactors, and so on. As a substitute for control relays, Thyristors can overcome the differential problem; that is, the spread in current or voltage between pickup and dropout because Thyristors effectively drop out every half cycle. Also, providing resistor R_1 is chosen correctly, the circuits are operable over a much wider voltage range than is a comparable relay. Resistor R_1 is provided to limit gate current (I_{GTM}) peaks. Its resistance plus any contact resistance (R_C) of the control device and load resistance (R_L) should be just greater than the peak supply voltage divided by the peak gate current rating of the Triac. If R_1 is set too high, the Triacs may not trigger at the beginning of each cycle, and phase control of the load will result with consequent loss of load voltage and waveform distortion. For inductive loads, an RC snubber circuit, as shown in Figure AN1007.1, is required. However, a snubber circuit is not required when an alternistor Triac is used.

Figure AN1007.2 illustrates an analysis to better understand a typical static switch circuit. The circuit operation occurs when switch S_1 is closed, since the Triac Q_1 will initially be in the blocking condition. Current flow will be through load R_L, S_1, R_1, and gate to MT1 junction of the Thyristor. When this current reaches the required value of I_{GT}, the MT2 to MT1 junctions will switch to the conduction state and the voltage from MT2 to MT1 will be V_T. As the current approaches the zero crossing, the load current will fall below holding current turning the Triac Q_1 device off until it is refired in the next half cycle. Figure AN1007.3 illustrates the voltage waveform appearing across the MT2 to MT1 terminals of Q_1. Note that the maximum peak value of current which S_1 will carry would be 25 mA since Q_1 has a 25 mA maximum I_{GT} rating. Additionally, no arcing of a current value greater than 25 mA when opening S_1 will occur when controlling an inductive load. It is important also to note that the Triac Q_1 is operating in Quadrants I and III, the more sensitive and most suitable gating modes for Triacs. The voltage rating of S_1 (mechanical switch or reed switch) must be equivalent to or greater than line voltage applied.



$$R_1 \geq \frac{\sqrt{2}\cdot V}{I_{GTM}} - (R_L + R_C)$$

Figure AN1007.1 Basic Triac Static Switch

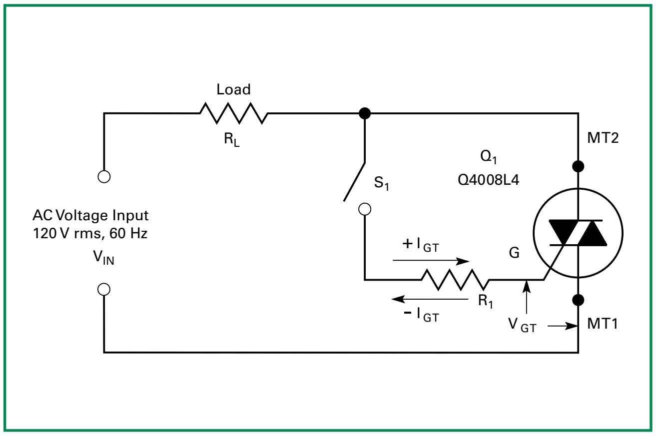


Figure AN1007.2 Analysis of Static Switch

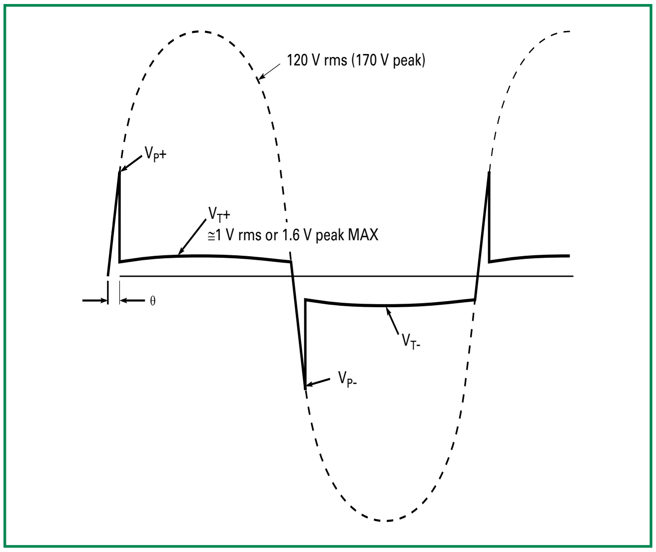


Figure AN1007.3 Waveform Across Static Switch

A typical example would be in the application of this type circuit for the control of 5 A resistive load with 120 V rms input voltage. Choosing a value of 100 Ω for $R^1$and assuming a typical value of 1 V for the gate to MT1 (V_{GT}) voltage, we can solve for V_P by the following:

$$V_P = I_{GT} (R_L + R_1) + V_{GT}$$

Note: R_C is not included since it is negligible.

$$V_P = 0.025 (24 + 100) + 1.0 = 4.1 \text{ V}$$

Additionally the turn-on angle is

$$\theta = \sin^{-1} \frac{4.1}{170V_{PK}} = 1.4^{O}$$

The power lost by the turn-on angle is essentially zero. The power dissipation in the gate resistor is very minute. A 100 Ω, 0.25 W rated resistor may safely be used. The small turn-on angle also ensures that no appreciable RFI is generated.

The relay circuit shown in Figure AN1007.1 and Figure AN1007.2 has several advantages in that it eliminates contact bounce, noise, and additional power consumption by an energizing coil and can carry an in-rush current of many times its steady state rating.

The control device S_1 indicated can be either electrical or mechanical in nature. Light-dependent resistors and light- activated semiconductors, optocoupler, magnetic cores, and magnetic reed switches are all suitable control elements. Regardless of the switch type chosen, it must have a voltage rating equal to or greater than the peak line voltage applied. In particular, the use of hermetically sealed reed switches as control elements in combination with Triacs offers many advantages. The reed switch can be actuated by passing DC current through a small coiled wire or by the proximity of a small magnet. In either case, complete electrical isolation exists between the control signal input, which may be derived from many sources, and the switched power output. Long life of the Triac/reed switch combination is ensured by the minimal volt-ampere switching load placed on the reed switch by the Triac triggering requirements. The Thyristor ratings determine the amount of load power that can be switched.

Normally Closed Circuit

With a few additional components, the Thyristor can provide a normally closed static switch function. The critical design portion of this static switch is a clamping device to turn off/eliminate gate drive and maintain very low power dissipation through the clamping component plus have low by-pass leakage around the power Thyristor device. In selecting the power Thyristor for load requirements, gate sensitivity becomes critical to maintain low power requirements. Either sensitive SCRs or sensitive logic Triacs must be considered, which limits the load in current capacity and type. However, this can be broader if an extra stage of circuitry for gating is permitted.

Figure AN1007.4 illustrates an application using a normally closed circuit driving a sensitive SCR for a simple but precise temperature controller. The same basic principle could be applied to a water level controller for a motor or solenoid. Of course, SCR and diode selection would be changed depending on load current requirements.

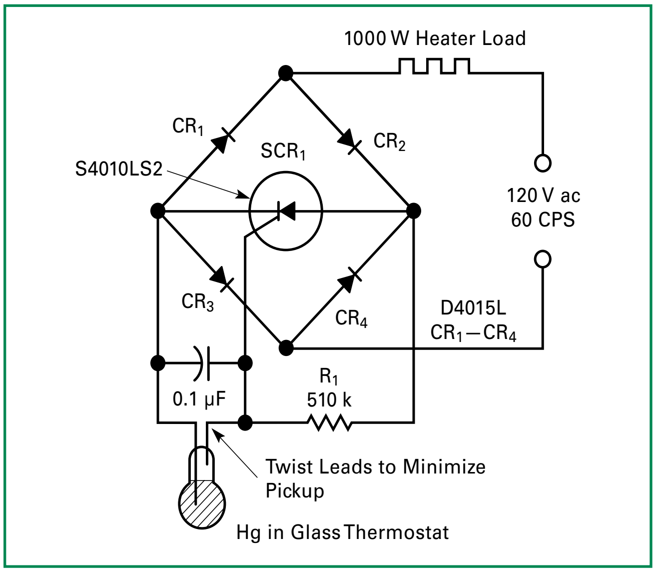


Figure AN1007.4 Normally Closed Temperature Controller

A mercury-in-glass thermostat is an extremely sensitive measuring instrument, capable of sensing changes in temperature as small as 0.1 °C. Its major limitation lies in its very low current-handling capability for reliability and long life, and contact current should be held below 1 mA. In the circuit of Figure AN1007.4, the S2010LS2 SCR serves as both current amplifier for the Hg thermostat and as the main load switching element.

With the thermostat open, the SCR will trigger each half cycle and deliver power to the heater load. When the thermostat closes, the SCR can no longer trigger and the heater shuts off. Maximum current through the thermostat in the closed position is less than 250 µA rms.

Figure AN1007.5 shows an all solid state, optocoupled, normally closed switch circuit. By using a low voltage SBS triggering device, this circuit can turn on with only a small delay in each half cycle and also keep gating power low. When the optocoupled transistor is turned on, the gate drive is removed with only a few milliamps of bypass current around the Triac power device. Also, by use of the BS08D and 0.1 µF, less sensitive Triacs and alternistors can be used to control various types of high current loads.

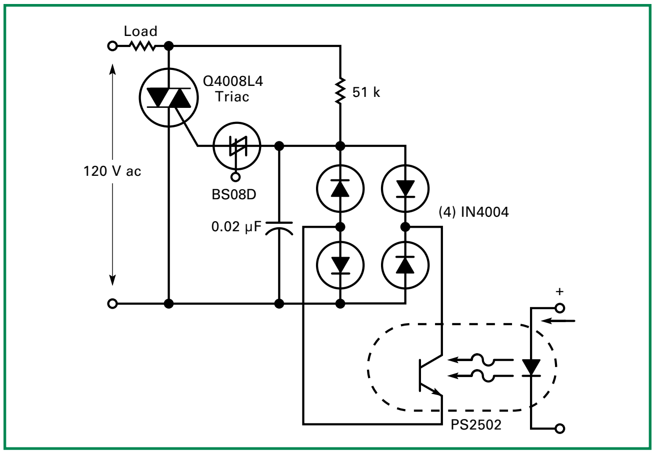


Figure AN1007.5 Normally Closed Switch Circuit

Optocoupled Driver Circuits

Random Turn-on, Normally Open

Many applications use optocouplers to drive Thyristors. The combination of a good optocoupler and a Triac or alternistor makes an excellent, inexpensive solid state relay. Application information provided by the optocoupler manufacturers is not always best for application of the power Thyristor. Figure AN1007.6 shows a standard circuit for a resistive load.

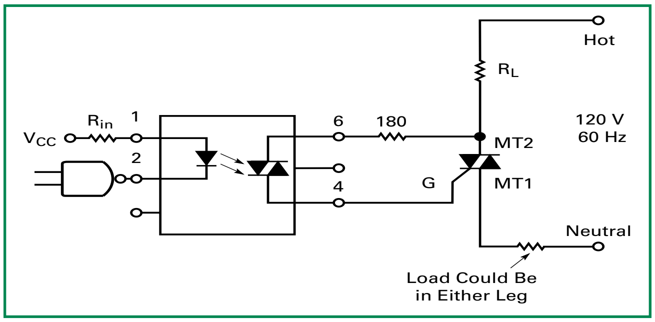


Figure AN1007.6 Optocoupled Circuit for Resistive Loads (Triac or Alternistor Triac)

A common mistake in this circuit is to make the series gate resistor too large in value. A value of 180 Ω is shown in a typical application circuit by optocoupler manufacturers. The 180 Ω is based on limiting the current to 1 A peak at the peak of a 120 V line input for Fairchild and Toshiba optocoupler I_{TSM} rating. This is good for protection of the optocoupler output Triac, as well as the gate of the power Triac on a 120 V line; however, it must be lowered if a 24 V line is being controlled, or if the R_L (resistive load) is 200 W or less. This resistor limits current for worst case turn-on at the peak line voltage, but it also sets turn-on point (conduction angle) in the sine wave, since Triac gate current is determined by this resistor and produced from the sine wave voltage as illustrated in Figure AN1007.2. The load resistance is also important, since it can also limit the amount of available Triac gate current. A 100 Ω gate resistor would be a better choice in most 120 V applications with loads greater than 200 W and optocouplers from Quality Technologies or Vishay with optocoupler output Triacs that can handle 1.7 A_{PK} (I_{TSM} rating) for a few microseconds at the peak of the line. For loads less than 200 W, the resistor can be dropped to 22 Ω. Remember that if the gate resistor is too large in value, the Triac will not turn on at all or not turn on fully, which can cause excessive power dissipation in the gate resistor, causing it to burn out. Also, the voltage and dv/dt rating of the optocoupler's output device must be equal to or greater than the voltage and dv/dt rating of the Triac or alternistor it is driving.

Figure AN1007.7 illustrates a circuit with a dv/dt snubber network included. This is a typical circuit presented by optocoupler manufacturers.

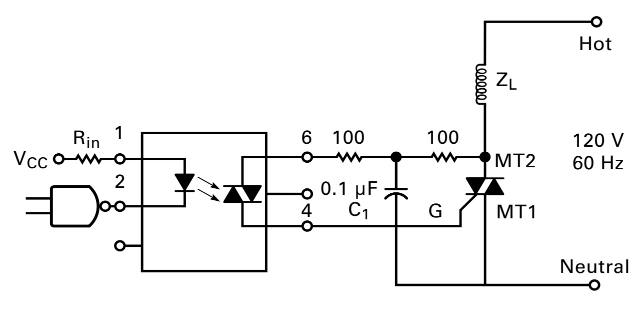


Figure AN1007.7 Optocoupler Circuit for Inductive Loads (Triac or Alternistor Triac)

This "T" circuit hinges around one capacitor to increase dv/dt capability to either the optocoupler output Triac or the power Triac. The sum of the two resistors then forms the Triac gate resistor.

Both resistors should then be standardized and lowered to 100 Ω. Again, this sum resistance needs to be low, allowing as much gate current as possible without exceeding the instantaneous current rating of the opto output Triac or Triac gate junction. By having 100 Ω for current limit in either direction from the capacitor, the optocoupler output Triac and power Triac can be protected against di/dt produced by the capacitor. Of course, it is most important that the capacitor be connected between proper terminals of Triac. For example, if the capacitor and series resistor are accidentally connected between the gate and MT2, the Triac will turn on from current produced by the capacitor, resulting in loss of control.

For low current (mA) and/or highly inductive loads, it may be necessary to have a latching network (3.3 kΩ + 0.047 µF) connected directly across the power Triac. The circuit shown in Figure AN1007.8 illustrates the additional latching network.

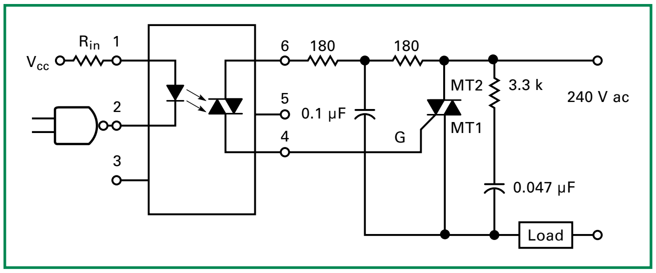


Figure AN1007.8 Optocoupler Circuit for Lower Current Inductive Loads (Triac or Alternistor Triac)

In this circuit, the series gate resistors are increased to 180 Ω each, since a 240 V line is applied. Note that the load is placed on the MT1 side of the power Triac to illustrate that load placement is **not** important for the circuit to function properly.

Also note that with standard U.S. residential 240 V home wiring, both sides of the line are hot with respect to ground (no neutral). Therefore, for some 240 V line applications, it will be necessary to have a Triac switch circuit in both sides of the 240 V line input.

If an application requires back-to-back SCRs instead of a Triac or alternistor, the circuit shown in Figure AN1007.9 may be used.

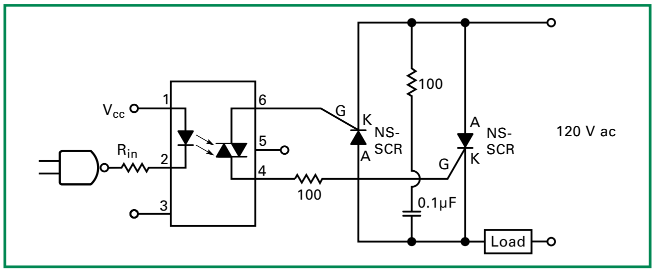


Figure AN1007.9 Optocoupled Circuit for Heavy-duty Inductive Loads

All application comments and recommendations for optocoupled switches apply to this circuit. However, the snubber network can be applied only across the SCRs as shown in the illustration. The optocoupler should be chosen for best noise immunity. Also, the voltage rating of the optocoupler output Triac must be equal to or greater than the voltage rating of SCRs.

Summary of Random Turn-on Relays

As shown in Figure AN1007.10, if the voltage across the load is to be phase controlled, the input control circuitry must be synchronized to the line frequency and the trigger pulses delayed from zero crossing every half cycle. If the series gate resistor is chosen to limit the peak current through the opto-driver to less than 1 A, then on a 120 V ac line the peak voltage is 170 V; therefore, the resistor is 180 Ω. On a 240 V ac line the peak voltage is 340 V; therefore, the resistor should be 360 Ω. These gate pulses are only as long as the device takes to turn on (typically, 5 µs to 6 µs); therefore, 0.25 W resistor is adequate.

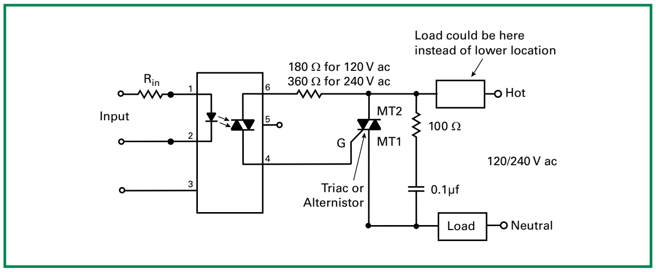


Figure AN1007.10 Random Turn-on Triac Driver

Select the Triac for the voltage of the line being used, the current through the load, and the type of load. Since the Gpeak voltage of a 120 V ac line is 170 V, you would choose a 200 V (MIN) device. If the application is used in an electrically noisy industrial environment, a 400 V device should be used. If the line voltage to be controlled is 240 V ac with a peak voltage of 340 V, then use at least a 400 V rated part or 600 V for more design margin. Selection of the voltage rating of the opto-driver must be the same or higher than the rating of the power Triac. In electrically noisy industrial locations, the dv/dt rating of the opto-driver and the Triac must be considered.

The RMS current through the load and main terminals of the Triac should be approximately 70% of the maximum rating of the device. However, a 40 A Triac should not be chosen to control a 1 A load due to low latching and holding current requirements. Remember that the case temperature of the Triac must be maintained at or below the current versus temperature curve specified on its data sheet. As with all semiconductors the lower the case temperature the better the reliability. Opto-driven gates normally do not use a sensitive gate Triac. The opto-driver can supply up to 1 A gate pulses and less sensitive gate Triacs have better dv/dt capability. If the load is resistive, it is acceptable to use a standard Triac. However, if the load is a heavy inductive type, then an alternistor Triac, or back-to-back SCRs as shown in Figure AN1007.9, is recommended. A series RC snubber network may or may not be necessary when using an alternistor Triac. Normally a snubber network is not needed when using an alternistor because of its high dv/dt and dv/dt(c) capabilities. However, latching network as described in Figure AN1007.8 may be needed for low current load variations.

Zero Crossing Turn-on, Normally Open Relay Circuits

When a power circuit is mechanically switched on and off mechanically, generated high-frequency components are generated that can cause interference problems such as RFI. When power is initially applied, a step function of voltage is applied to the circuit which causes a shock excitation. Random switch opening stops current off, again generating high frequencies. In addition, abrupt current interruption in an inductive circuit can lead to high induced-voltage transients.

The latching characteristics of Thyristors are ideal for eliminating interference problems due to current interruption since these devices can only turn off when the on-state current approaches zero, regardless of load power factor.

On the other hand, interference-free turn-on with Thyristors requires special trigger circuits. It has been proven experimentally that general purpose AC circuits will generate minimum electromagnetic interference (EMI) if energized at zero voltage.

The ideal AC circuit switch, therefore, consists of a contact which closes at the instant when voltage across it is zero and opens at the instant when current through it is zero. This has become known as "zero-voltage switching."

For applications that require synchronized zero-crossing turn-on, the illustration in Figure AN1007.11 shows a circuit which incorporates an optocoupler with a built-in zero-crossing detector

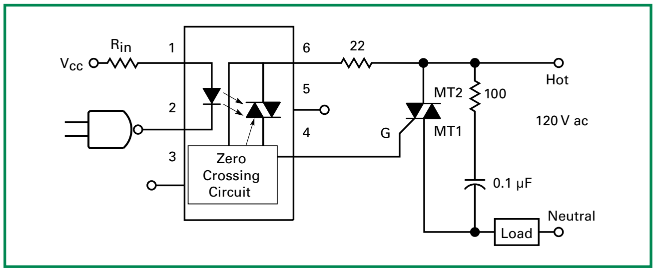


Figure AN1007.11 Optocoupled Circuit with Zero-crossing Turn-on (Triac or Alternistor Triac)

Also, this circuit includes a dv/dt snubber network connected across the power Triac. This typical circuit illustrates switching the hot line; however, the load may be connected to either the hot or neutral line. Also, note that the series gate resistor is low in value (22 Ω), which is possible on a 120 V line and above, since zero-crossing turn-on is ensured in any initial half cycle.

Zero Voltage Switch Power Controller

The UAA2016 (at www.onsemi.com) is designed to drive Triacs with the Zero Voltage technique which allows RFI-free power regulation of resistive loads. Operating directly on the AC power line, its main application is the precision regulation of electrical heating systems such as panel heaters or irons. It is available in eight-pin I.C. package variations.

A built-in digital sawtooth waveform permits proportional temperature regulation action over a ±1 °C band around the set point. For energy savings there is a programmable temperature reduction function, and for security a sensor failsafe inhibits output pulses when the sensor connection is broken. Preset temperature (in other words, defrost) application is also possible. In applications where high hysteresis is needed, its value can be adjusted up to 5 °C around the set point. All these features are implemented with a very low external component count.

Triac Choice and R_{out} Determination

The power switching Triac is chosen depending on power through load and adequate peak gate trigger current. The illustration in Figure AN1007.12 shows a typical heating control.

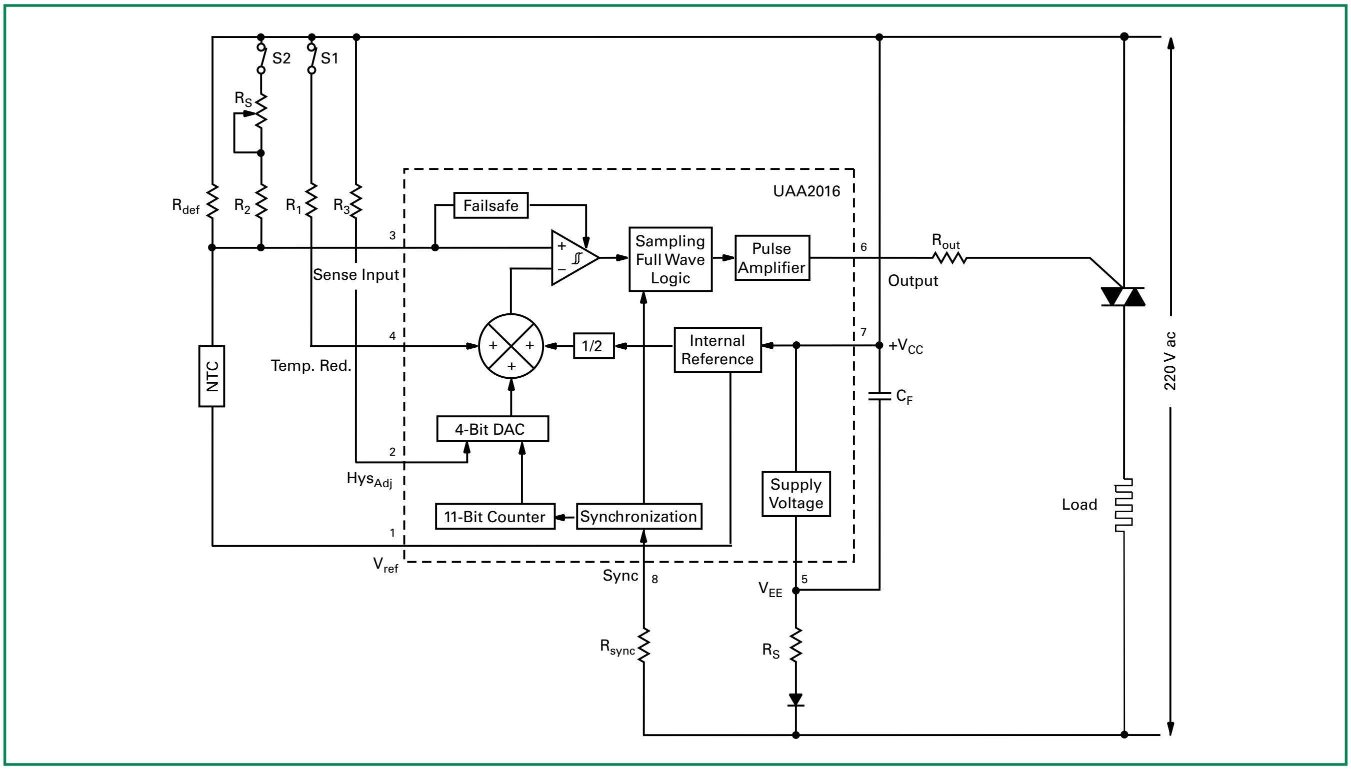


Figure AN1007.12 Heater Control Schematic

R_{out} limits the output current from UAA2016. Determine R_{out} according to the Triac maximum gate current (I_{GT}) and the application low temperature limit. For a 2 kw load at 220 V rms, a good Triac choice is Q6012LH5. Its maximum peak gate trigger current at 25 °C is 50 mA.

For an application to work down to -20 °C, R_{out} should be 68 Ω. since I_{GT} Q6012LH5 can typically be 80 mA and minimum current output from UAA2016 pin 6 is -90 mA at -8 V, -20 °C.

Output Pulse Width, R_{sync}

Figure AN1007.13 shows the output pulse width T_P determined by the Triac's I_H, I_L together with the load value, characteristics, and working conditions (frequency and voltage).

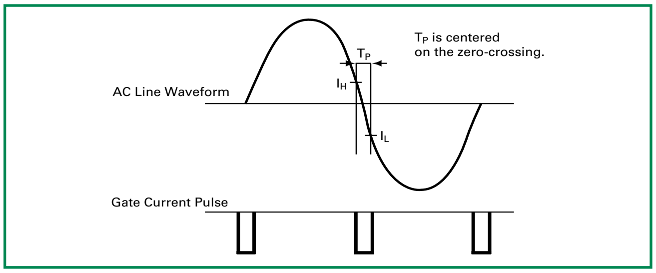


Figure AN1007.13 Zero Voltage Technique

To ensure best latching, T_P should be 200 µs, which means R_{sync} will have typical value >390 kΩ.

To ensure best latching, T_P should be 200 µs, which means R_{sync} will have typical value >390 kΩ.

R_S and Filter Capacitor (C_F)

For better UAA2016 power supply, typical value for R_S could be 27 kΩ, 2 W with C_F of 75 µF to keep ripple <1 V.

Summary of Zero Crossing Turn-on Circuits

Zero voltage crossing turn-on opto-drivers are designed to limit turn-on voltage to less than 20 V. This reduces the amount of RFI and EMI generated when the Thyristor switches on. Because of this zero turn-on, these devices cannot be used to phase control loads. Therefore, speed control of a motor and dimming of a lamp cannot be accomplished with zero turn-on opto-couplers.

Since the voltage is limited to 20 V or less, the series gate resistor that limits the gate drive current has to be much lower with a zero crossing opto-driver. With typical inhibit voltage of 5 V, an alternistor Triac gate could require a 160 mA at -30 °C (5 V/0.16 A = 31 Ω gate resistor). If the load has a high inrush current, then drive the gate of the Triac with as much current as reliably possible but stay under the I_{TSM} rating of the opto-driver. By using 22 Ω for the gate resistor, a current of at least 227 mA is supplied with only 5 V, but limited to 909 mA if the voltage goes to 20 V. As shown in Figure AN1007.14, Figure AN1007.15, and Figure AN1007.16, a 22 Ω gate resistor is a good choice for various zero crossing controllers.

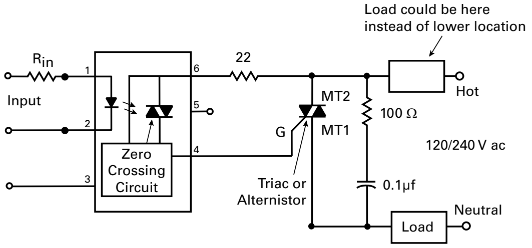


Figure AN1007.14 Zero Crossing Turn-on Opto Triac Driver

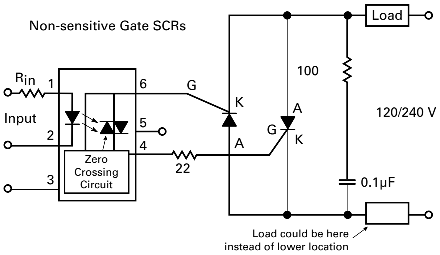


Figure AN1007.15 Zero Crossing Turn-on Non-sensitive SCR Driver

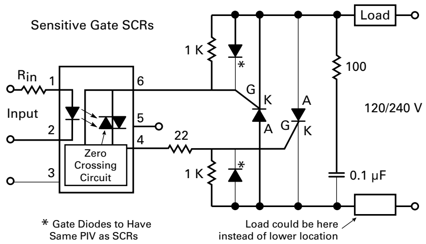


Figure AN1007.16 Zero Crossing Turn-on Opto-sensitive Gate SCR Driver

Time Delay Relay Circuit

By combining a 555 timer IC with a sensitive gate Triac, various time delays of several seconds can be achieved for delayed activation of solid state relays or switches. Figure AN1007.17 shows a solid state timer delay relay using a sensitive gate Triac and a 555 timer IC. The 555 timer precisely controls time delay of operation using an external resistor and capacitor, as illustrated by the resistor and capacitor combination curves. (Figure AN1007.18)

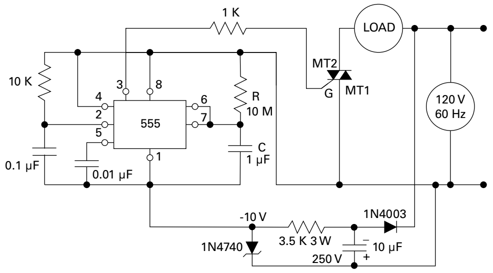


Figure AN1007.17 555 timer circuit with 10 second delay

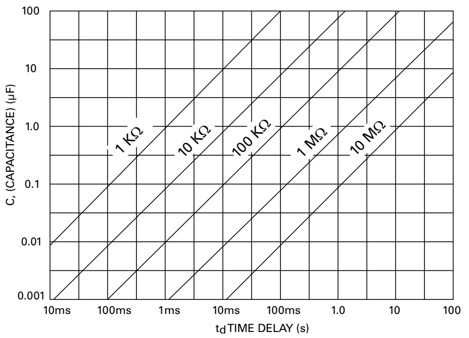


Figure AN1007.18 Resistor (R) and capacitor (C) combination curves

IR Motion Control

An example of a more complex Triac switch is an infrared (IR) motion detector controller circuit. Some applications for this circuit are alarm systems, automatic lighting, and auto doorbells.

Figure AN1007.19 shows an easy- to-implement automatic lighting system using an infrared motion detector control circuit. A commercially available LSI circuit HT761XB, from *Holtek*, integrates most of the analog functions. This LSI chip, U2, contains the op amps, comparators, zero crossing detection, oscillators, and a Triac output trigger. An external RC that is connected to the OSCD pin determines the output trigger pulse width. (*Holtek Semiconductor Inc*. is located at No.3, Creation Road II, Science-Based Industrial Park, Hsinchu, Taiwan, R.O.C.) Device U1 provides the infrared sensing. Device R13 is a photo sensor that serves to prevent inadvertent triggering under daylight or other high light conditions.

Choosing the right Triac depends on the load characteristics. For example, an incandescent lamp operating at 110 V requires a 200 V, 8 A Triac. This gives sufficient margin to allow for the high current state during lamp burn out. U2 provides a minimum output Triac negative gate trigger current of 40 mA, thus operating in QII & QIII. This meets the requirements of a 25 mA gate Triac. Teccor also offers alternistor Triacs for inductive load conditions.

This circuit has three operating modes (ON, AUTO, OFF), which can be set through the mode pin. While the LSI chip is working in the auto mode, the user can override it and switch to the test mode, or manual on mode, or return to the auto mode by switching the power switch. More information on this circuit, such as mask options for the infrared trigger pulse and flash options, are available in the *Holtek* HT761X General Purpose PIR Controller specifications.

Thyristors Used as AC Static Switches and Relays (continued)

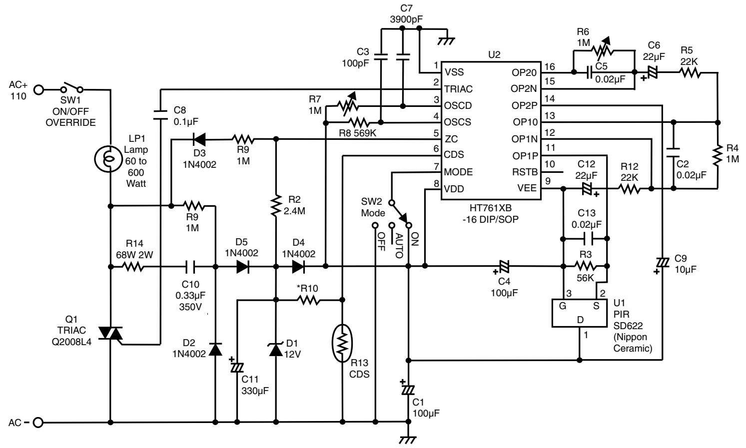


Figure AN1007.19 I R motion control circuit

Explanation of Maximum Ratings and Characteristics for Thyristors

Introduction

Data sheets for SCRs and Triacs give vital information regarding maximum ratings and characteristics of Thyristors. If the **maximum ratings** of the Thyristors are surpassed, possible irreversible damage may occur. The **characteristics** describe various pertinent device parameters which are guaranteed as either minimums or maximums. Some of these characteristics relate to the ratings but are not ratings in themselves. The characteristic does not define what the circuit must provide or be restricted to, but defines the device characteristic. For example, a minimum value is indicated for the dv/dt because this value depicts the guaranteed worst-case limit for all devices of the specific type. This minimum dv/dt value represents the maximum limit that the circuit should allow.

Maximum Ratings

V_{RRM}: Peak Repetitive Reverse Voltage -- SCR

The peak repetitive reverse voltage rating is the maximum peak reverse voltage that may be continuously applied to the main terminals (anode, cathode) of an SCR. (Figure AN1008.1) An open-gate condition and gate resistance termination is designated for this rating. An increased reverse leakage can result due to a positive gate bias during the reverse voltage exposure time of the SCR. The repetitive peak reverse voltage rating relates to case temperatures up to the maximum rated junction temperature.

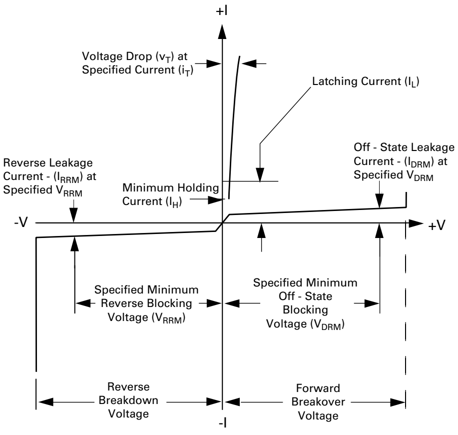


Figure AN1008.1 V-I Characteristics of SCR Device

V_{DRM}: Peak Repetitive Forward (Off-state) Voltage

SCR

The peak repetitive forward (off-state) voltage rating (Figure AN1008.1) refers to the maximum peak forward voltage which may be applied continuously to the main terminals (anode, cathode) of an SCR. This rating represents the maximum voltage the SCR should be required to block in the forward direction. The SCR may or may not go into conduction at voltages above the V_{DRM} rating. This rating is specified for an open-gate condition and gate resistance termination. A positive gate bias should be avoided since it will reduce the forward-voltage blocking capability. The peak repetitive forward (off-state) voltage rating applies for case temperatures up to the maximum rated junction temperature.

Triac

The peak repetitive off-state voltage rating should not be surpassed on a typical, non-transient, working basis. (Figure AN1008.2) V_{DRM} should not be exceeded even instantaneously. This rating applies for either positive or negative bias on main terminal 2 at the rated junction temperature. This voltage is less than the minimum breakover voltage so that breakover will not occur during operation. Leakage current is controlled at this voltage so that the temperature rise due to leakage power does not contribute significantly to the total temperature rise at rated current.

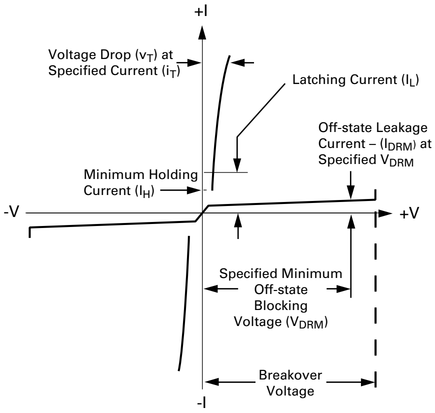


Figure AN1008.2 V-I Characteristics of Triac Device

I_T: Current Rating

SCR

For RMS and average currents, the restricting factor is usually confined so that the power dissipated during the on state and as a result of the junction-to-case thermal resistance will not produce a junction temperature in excess of the maximum junction temperature rating. Power dissipation is changed to RMS and average current ratings for a 60 Hz sine wave with a 180° conduction angle. The average current for conduction angles less than 180° is derated because of the higher RMS current connected with high peak currents. The DC current rating is higher than the average value for 180° conduction since no RMS component is present.

The dissipation for non-sinusoidal waveshapes can be determined in several ways. Graphically plotting instantaneous dissipation as a function of time is one method. The total maximum allowable power dissipation (P_D) may be determined using the following equation for temperature rise:

$$P_D = \frac{T_{J(MAX)} - T_C}{R_{\theta JC}}$$

where T_J(max) is the maximum rated junction temperature (at zero rated current), T_C is the actual operating case temperature, and $R_{\theta JC}$ is the published junction-to-case thermal resistance. Transient thermal resistance curves are required for short interval pulses.

Triac

The limiting factor for RMS current is determined by multiplying power dissipation by thermal resistance. The resulting current value will ensure an operating junction temperature within maximum value. For convenience, dissipation is converted to RMS current at a 360° conduction angle. The same RMS current can be used at a conduction angle of less than 360°. For information on non-sinusoidal waveshapes and a discussion of dissipation, refer to the preceding description of SCR current rating.

I_{TSM}: Peak Surge (Non-repetitive) On-state Current -- SCR and Triac

The peak surge current is the maximum peak current that may be applied to the device for one full cycle of conduction without device degradation. The maximum peak current is usually specified as sinusoidal at 50 Hz or 60 Hz. This rating applies when the device is conducting rated current before the surge and, thus, with the junction temperature at rated values before the surge. The junction temperature will surpass the rated operating temperature during the surge, and the blocking capacity may be decreased until the device reverts to thermal equilibrium.

The surge-current curve in Figure AN1008.3 illustrates the peak current that may be applied as a function of surge duration. This surge curve is not intended to depict an exponential current decay as a function of applied overload. Instead, the peak current shown for a given number of cycles is the maximum peak surge permitted for that time period. The current must be derated so that the peak junction temperature during the surge overload does not exceed maximum rated junction temperature if blocking is to be retained after a surge.

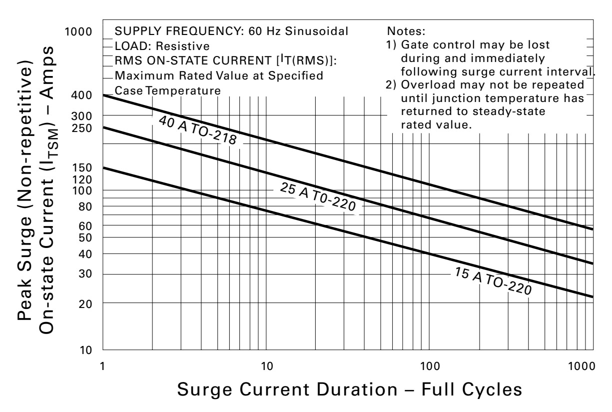


Figure AN1008.3 Peak Surge Current versus Surge Current Duration

I_{TM}: Peak Repetitive On-state Current – SCR and Triac

The I_{TM} rating specifies the maximum peak current that may be applied to the device during brief pulses. When the device operates under these circumstances, blocking capability is maintained. The minimum pulse duration and shape are defined and control the applied di/dt. The operating voltage, the duty factor, the case temperature, and the gate waveform are also defined. This rating must be followed when high repetitive peak currents are employed, such as in pulse modulators, capacitive-discharge circuits, and other applications where snubbers are required.

di/dt: Rate-of-change of On-state Current – SCR and Triac

The di/dt rating specifies the maximum rate-of-rise of current through a Thyristor device during turn-on. The value of principal voltage prior to turn-on and the magnitude and rise time of the gate trigger waveform during turn-on are among the conditions under which the rating applies. If the rate-of-change of current (di/dt) exceeds this maximum value, or if turn-on with high di/dt during minimum gate drive occurs (such as dv/dt or overvoltage events), then localized heating may cause device degradation.

During the first few microseconds of initial turn-on, the effect of di/dt is more pronounced. The di/dt capability of the Thyristor is greatly increased as soon as the total area of the pellet is in full conduction.

The di/dt effects that can occur as a result of voltage or transient turn-on (non-gated) is not related to this rating. The di/dt rating is specified for maximum junction temperature.

As shown in Figure AN1008.4, the di/dt of a surge current can be calculated by means of the following equation.

$$\frac{di}{dt} = \frac{I_{TM}}{2_{t_1}}$$

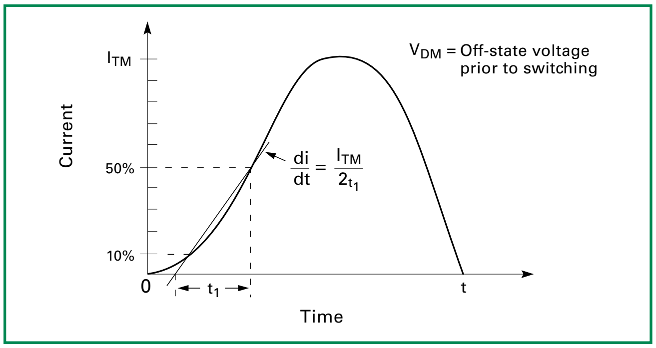


Figure AN1008.4 Relationship of Maximum Current Rating to Time

I^2t Rating -- SCR and Triac

The I^2t rating gives an indication of the energy-absorbing capability of the Thyristor device during surge-overload conditions. The rating is the product of the square of the RMS current $(I_{RMS})^2$ that flows through the device and the time during which the current is present and is expressed in A^2s. This rating is given for fuse selection purposes. It is important that the I^2t rating of the fuse is less than that of the Thyristor device. Without proper fuse or current limit, overload or surge current will permanently damage the device due to excessive junction heating.

P_G: Gate Power Dissipation -- SCR and Triac

Gate power dissipation ratings define both the peak power (P_{GM}) forward or reverse and the average power ($P_{G(AV)}$) that may be applied to the gate. Damage to the gate can occur if these ratings are not observed. The width of the applied gate pulses must be considered in calculating the voltage and current allowed since the peak power allowed is a function of time. The peak power that results from a given signal source relies on the gate characteristics of the specific unit. The average power resulting from high peak powers must not exceed the average-power rating.

T_S, T_J: Temperature Range -- SCR and Triac

The maximum storage temperature (T_S) is greater than the maximum operating temperature (actually maximum junction temperature). Maximum storage temperature is restricted by material limits defined not so much by the silicon but by peripheral materials such as solders used on the chip/die and lead attachments as well as the encapsulating epoxy. The forward and off-state blocking capability of the device determines the maximum junction (T_J) temperature. Maximum blocking voltage and leakage current ratings are established at elevated temperatures near maximum junction temperature; therefore, operation in excess of these limits may result in unreliable operation of the Thyristor.

Characteristics

V_{BO}: Instantaneous Breakover Voltage -- SCR and Triac

Breakover voltage is the voltage at which a device turns on (switches to on state by voltage breakover). (Figure AN1008.1) This value applies for open-gate or gate-resistance termination. Positive gate bias lowers the breakover voltage. Breakover is temperature sensitive and will occur at a higher voltage if the junction temperature is kept below maximum T_J value. If SCRs and Triacs are turned on as a result of an excess of breakover voltage, instantaneous power dissipations may be produced that can damage the chip or die.

I_{DRM}: Peak Repetitive Off-state (Blocking) Current

SCR

I_{DRM} is the maximum leakage current permitted through the SCR when the device is forward biased with rated positive voltage on the anode (DC or instantaneous) at rated junction temperature and with the gate open or gate resistance termination. A 1000 Ω resistor connected between gate and cathode is required on all sensitive SCRs. Leakage current decreases with decreasing junction temperatures. Effects of the off-state leakage currents on the load and other circuitry must be considered for each circuit application. Leakage currents can usually be ignored in applications that control high power.

Triac

The description of peak off-state (blocking/leakage) current for the Triac is the same as for the SCR except that it applies with either positive or negative bias on main terminal 2.(Figure AN1008.2)

I_{RRM}: Peak Repetitive Reverse Current – SCR

This characteristic is essentially the same as the peak forward off-state (blocking/leakage) current except negative voltage is applied to the anode (reverse biased).

V_{TM}: Peak On-State Voltage -- SCR and Triac

The instantaneous on-state voltage (forward drop) is the principal voltage at a specified instantaneous current and case temperature when the Thyristor is in the conducting state. To prevent heating of the junction, this characteristic is measured with a short current pulse. The current pulse should be at least 100 μs duration to ensure the device is in full conduction. The forward-drop characteristic determines the on-state dissipation. See Figure AN1008.5, and refer to "IT: Current Rating" on page AN1008-2.

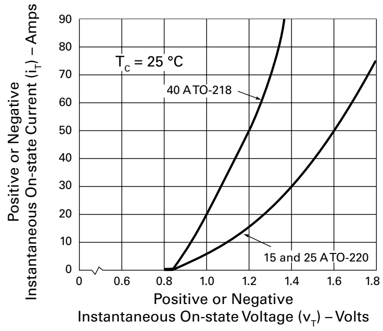


Figure AN1008.5 On-state Current versus On-state Voltage (Typical)

I_{GT}: DC Gate Trigger Current

SCR

I_{GT} is the minimum DC gate current required to cause the Thyristor to switch from the non-conducting to the conducting state for a specified load voltage and current as well as case temperature. The characteristic curve illustrated in Figure AN1008.6 shows that trigger current is temperature dependent. The Thyristor becomes less sensitive (requires more gate current) with decreasing junction temperatures. The gate current should be increased by a factor of two to five times the minimum threshold DC trigger current for best operation. Where fast turn-on is demanded and high di/dt is present or low temperatures are expected, the gate pulse may be 10 times the minimum IGT, plus it must be fast-rising and of sufficient duration in order to properly turn on the Thyristor.

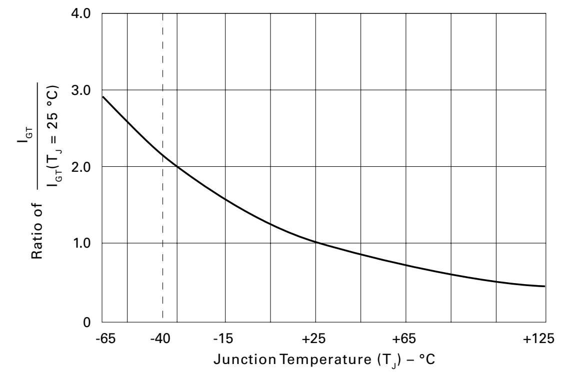


Figure AN1008.6 Normalized DC Gate Trigger Current for All Quadrants versus Case Temperature

Triac

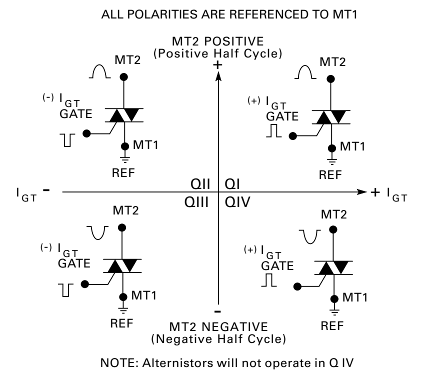
The description for the SCR applies as well to the Triac with the addition that the Triac can be fired in four possible modes (Figure AN1008.7):

Quadrant I (main terminal 2 positive, gate positive)

Quadrant II (main terminal 2 positive, gate negative)

Quadrant III (main terminal 2 negative, gate negative)

Quadrant IV (main terminal 2 negative, gate positive)


ALL POLARITIES ARE REFERENCED TO MT1

NOTE: Alternistors will not operate in Q IV

Figure AN1008.7 Definition of Operating Quadrants

V_{GT}: DC Gate Trigger Voltage

SCR

V_{GT} is the DC gate-cathode voltage that is present just prior to triggering when the gate current equals the DC trigger current. As shown in the characteristic curve in Figure AN1008.8, the gate trigger voltage is higher at lower temperatures. The gate-cathode voltage drop can be higher than the DC trigger level if the gate is driven by a current higher than the trigger current.

Triac

The difference in V_{GT} for the SCR and the Triac is that the Triac can be fired in four possible modes. The threshold trigger voltage can be slightly different, depending on which of the four operating modes is actually used.

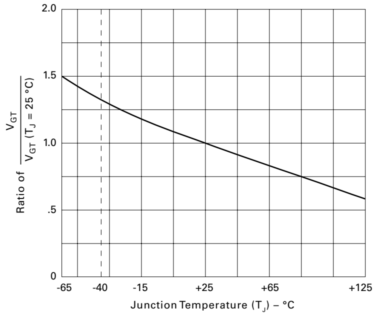


Figure AN1008.8 Normalized DC Gate Trigger Voltage for All Quadrants versus Case Temperature

I_L: Latching Current

SCR

Latching current is the DC anode current above which the gate signal can be withdrawn and the device stays on. It is related to, has the same temperature dependence as, and is somewhat greater than the DC gate trigger current. (Figure AN1008.1 and Figure AN1008.2) Latching current is at least equal to or much greater than the holding current, depending on the Thyristor type.

Latching current is greater for fast-rise-time anode currents since not all of the chip/die is in conduction. It is this dynamic latching current that determines whether a device will stay on when the gate signal is replaced with very short gate pulses. The dynamic latching current varies with the magnitude of the gate drive current and pulse duration. In some circuits, the anode current may oscillate and drop back below the holding level or may even go negative; hence, the unit may turn off and not latch if the gate signal is removed too quickly.

Triac

The description of this characteristic for the Triac is the same as for the SCR, with the addition that the Triac can be latched on in four possible modes (quadrants). Also, the required latching is significantly different depending on which gating quadrants are used. Figure AN1008.9 illustrates typical latching current requirements for the four possible quadrants of operation.

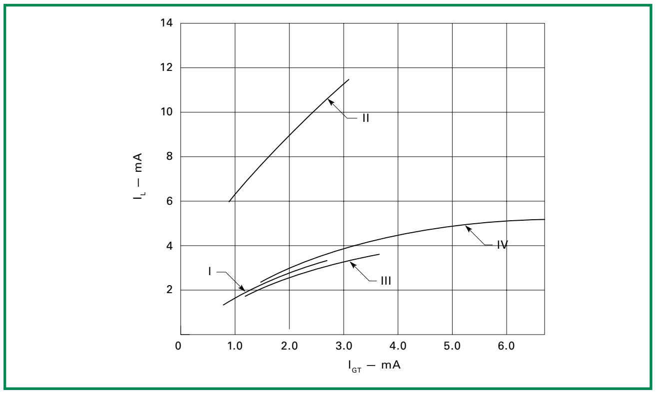


Figure AN1008.9 Typical Triac Latching (I_L) Requirements for Four Quadrants versus Gate Current (I_{GT})

I_H: Holding Current -- SCR and Triac

The holding current is the DC principal on-state current below which the device will not stay in regeneration/on state after latching and gate signal is removed. This current is equal to or lower in value than the latching current (Figure AN1008.1 and Figure AN1008.2) and is related to and has the same temperature dependence as the DC gate trigger current shown in Figure AN1008.10. Both minimum and maximum holding current may be important. If the device is to stay in conduction at low-anode currents, the maximum holding current of a device for a given circuit must be considered. The minimum holding current of a device must be considered if the device is expected to turn off at a low DC anode current. Note that the low DC principal current condition is a DC turn-off mode, and that an initial on-state current (latching current) is required to ensure that the Thyristor has been fully turned on prior to a holding current measurement.

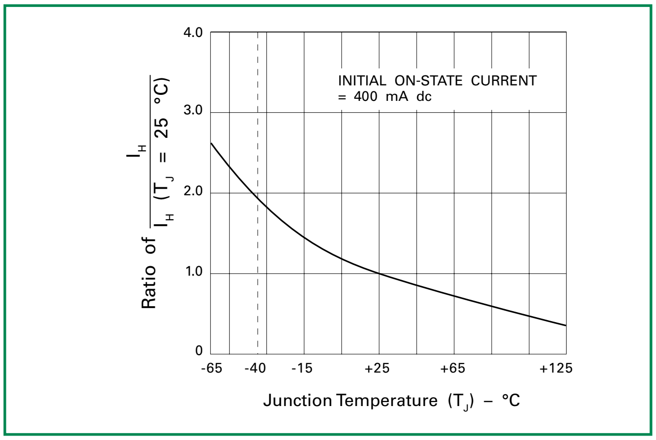


Figure AN1008.10 Normalized DC Holding Current versus Case Temperature

dv/dt, Static: Critical Rate-of-rise of Off-state Voltage — SCR and Triac

Static dv/dt is the minimum rate-of-rise of off-state voltage that a device will hold off, with gate open, without turning on. Figure AN1008.11 illustrates the exponential definition. This value will be reduced by a positive gate signal. This characteristic is temperature-dependent and is lowest at the maximum-rated junction temperature. Therefore, the characteristic is determined at rated junction temperature and at rated forward off-state voltage which is also a worst-case situation. Line or other transients which might be applied to the Thyristor in the off state must be reduced, so that neither the rate-of-rise nor the peak voltage are above specifications if false firing is to be prevented. Turn-on as result of dv/dt is non-destructive as long as the follow current remains within current ratings of the device being used.

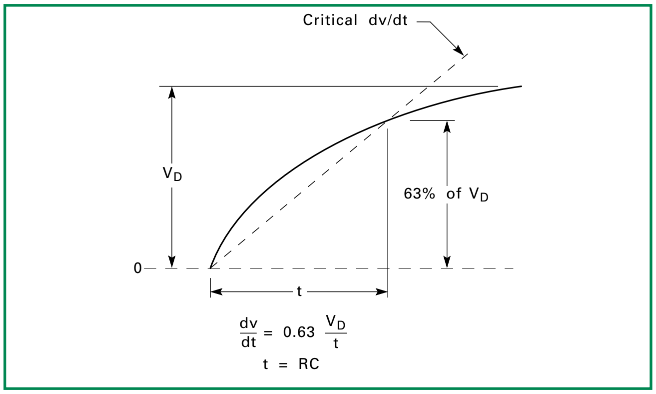


Figure AN1008.11 Exponential Rate-of-rise of Off-state Voltage Defining dv/dt

dv/dt, Commutating: Critical Rate-of-rise of Commutation Voltage -- Triac

Commutating dv/dt is the rate-of-rise of voltage across the main terminals that a Triac can support (block without switching back on) when commutating from the on state in one half cycle to the off state in the opposite half cycle. This parameter is specified at maximum rated case temperature (equal to T_J) since it is temperature-dependent. It is also dependent on current (commutating di/dt) and peak reapplied voltage (line voltage) and is specified at rated current and voltage. All devices are guaranteed to commutate rated current with a resistive load at 50 Hz to 60 Hz. Commutation of rated current is not guaranteed at higher frequencies, and no direct relationship can be made with regard to current/temperature derating for higher-frequency operation. With inductive loading, when the voltage is out of phase with the load current, a voltage stress (dv/dt) occurs across the main terminals of the Triac during the zero-current crossing. (Figure AN1008.12) A snubber (series RC across the Triac) should be used with inductive loads to decrease the applied dv/dt to an amount below the minimum value which the Triac can be guaranteed to commutate off each half cycle.

Commutating dv/dt is specified for a half sinewave current at 60 Hz which fixes the di/dt of the commutating current. The commutating di/dt for 50 Hz is approximately 20% lower while I_{RMS} rating remains the same. (Figure AN1008.4)

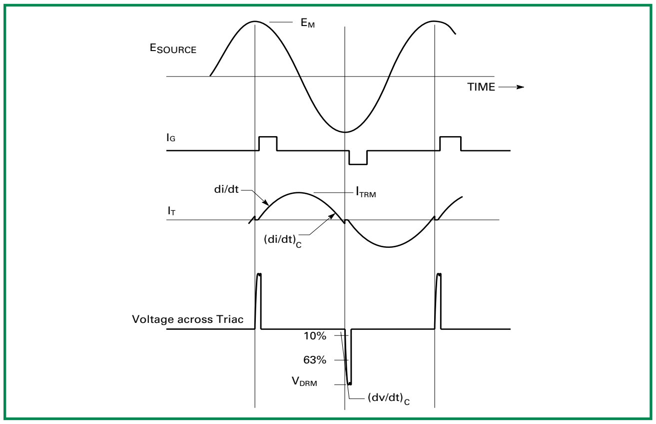


Figure AN1008.12 Waveshapes of Commutating dv/dt and Associated Conditions

t_{gt}: Gate-controlled Turn-on Time -- SCR and Triac

The t_{gt} is the time interval between the application of a gate pulse and the on-state current reaching 90% of its steady-state value. (Figure AN1008.13) As would be expected, turn-on time is a function of gate drive. Shorter turn-on times occur for increased gate drives. This turn-on time is actually only valid for resistive loading. For example, inductive loading would restrict the rate-of-rise of anode current. For this reason, this parameter does not indicate the time that must be allowed for the device to stay on if the gate signal is removed. (Refer to the description of "IL: Latching Current" on page AN1008-4.) However, if the load was resistive and equal to the rated load current value, the device definitely would be operating at a current above the dynamic latching current in the turn-on time interval since current through the device is at 90% of its peak value during this interval.

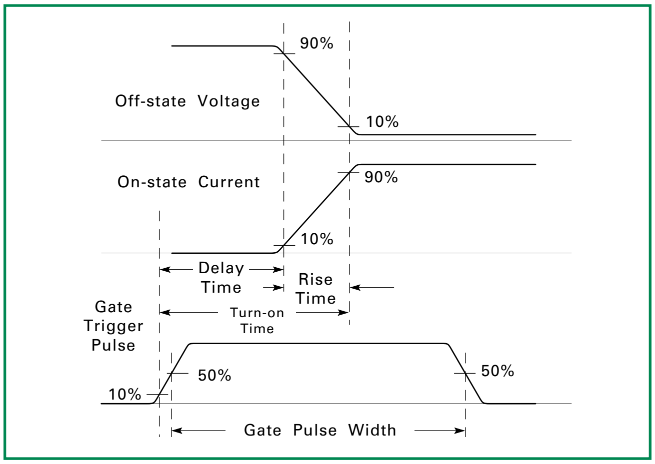


Figure AN1008.13 Waveshapes for Turn-on Time and Associated Conditions

t_q: Circuit-commutated Turn-off Time -- SCR

The circuit-commutated turn-off time of the device is the time during which the circuit provides reverse bias to the device (negative anode) to commutate it off. The turn-off time occurs between the time when the anode current goes negative and when the anode positive voltage may be reapplied. (Figure AN1008.14) Turn-off time is a function of many parameters and very dependent on temperature and gate bias during the turn-off interval. Turn-off time is lengthened for higher temperature so a high junction temperature is specified. The gate is open during the turn-off interval. Positive bias on the gate will lengthen the turn-off time; negative bias on the gate will shorten it.

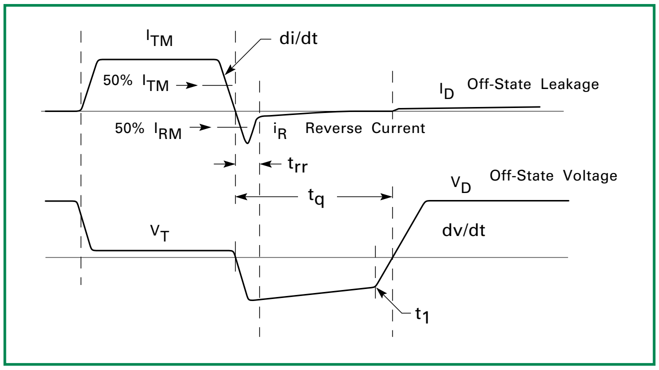


Figure AN1008.14 Waveshapes of t_q Rating Test and Associated Conditions

$R_{\theta JC}$, $R_{\theta JA}$: Thermal Resistance (Junction-to-case, Junction-to-ambient) -- SCR and Triac

The thermal-resistance characteristic defines the steady-state temperature difference between two points at a given rate of heat-energy transfer (dissipation) between the points. The thermal-resistance system is an analog to an electrical circuit where thermal resistance is equivalent to electrical resistance, temperature difference is equivalent to voltage difference, and rate of heat-energy transfer (dissipation) is equivalent to current. Dissipation is represented by a constant current generator since generated heat must flow (steady-state) no matter what the resistance in its path. Junction-to-case thermal resistance establishes the maximum case temperature at maximum rated steady-state current. The case temperature must be held to the maximum at maximum ambient temperature when the device is operating at rated current. Junction-to-ambient thermal resistance is established at a lower steady-state current, where the device is in free air with only the external heat sinking offered by the device package itself. For $R_{\theta JA,}$ power dissipation is limited by what the device package can dissipate in free air without any additional heat sink:

$$R_{\theta JC} = \frac{T_J - T_C}{P_{(AV)}}$$

$$R_{\theta JA} = \frac{T_J - T_A}{P_{(AV)}}$$

Miscellaneous Design Tips and Facts

Introduction

This application note presents design tips and facts on the following topics:

- Relationship of I_{AV}, I_{RMS}, and I_{PK}
- dv/dt Definitions
- Examples of gate terminations
- Curves for Average Current at Various Conduction Angles
- Double-exponential Impulse Waveform
- Failure Modes of Thyristor
- Characteristics Formulas for Phase Control Circuits

Relationship of I_{AV}, I_{RMS}, and I_{PK}

Since a single rectifier or SCR passes current in one direction only, it conducts for only half of each cycle of an AC sinewave. The average current (I_{AV}) then becomes half of the value determined for full-cycle conduction, and the RMS current (I_{RMS}) is equal to the square root of half the mean-square value for full-cycle conduction or half the peak current (I_{PK}). In terms of half-cycle sinewave conduction (as in a single-phase half-wave circuit), the relationships of the rectifier currents can be shown as follows:

$I_{PK} = \pi \bullet I_{AV} = 3.14 \bullet I_{AV}$

$I_{AV} = (1/\pi)\ I_{PK} = 0.32 \bullet I_{PK}$

$I_{PK} = 2 \bullet I_{RMS}$

$I_{RMS} = 0.5 \bullet I_{PK}$

$I_{AV} = (2/\pi)\ I_{RMS} = 0.64 \bullet I_{RMS}$

$I_{RMS} = (\pi/2)\ I_{AV} = 1.57 \bullet I_{AV}$

When two identically rated SCRs are connected inverse parallel for full-wave operation, as shown in Figure AN1009.1, they can handle 1.41 times the RMS current rating of either single SCR. Therefore, the RMS value of two half sinewave current pulses in one cycle is √2 times the RMS value of one such pulse per cycle.

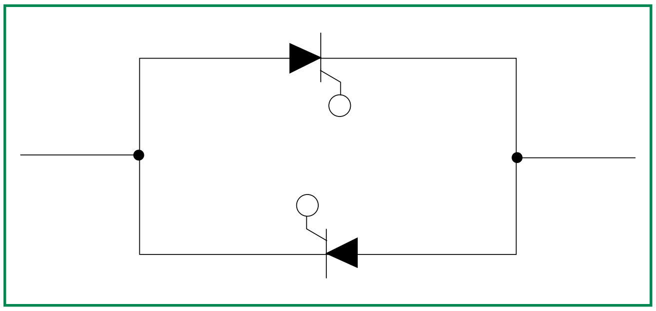


Figure AN1009.1 SCR Anti-parallel Circuit

dv/dt Definitions

The rate-of-rise of voltage (dv/dt) of an exponential waveform is 63% of peak voltage (excluding any overshoots) divided by the time at 63% minus 10% peak voltage. (Figure AN1009.2)

Exponential dv/dt = $0.63 \bullet [V_{PK}] = (t_2 - t_1)$

Resistor Capacitor circuit $t = RC = (t_2 - t_1)$

Resistor Capacitor circuit $4 \bullet RC = (t_3 - t_2)$

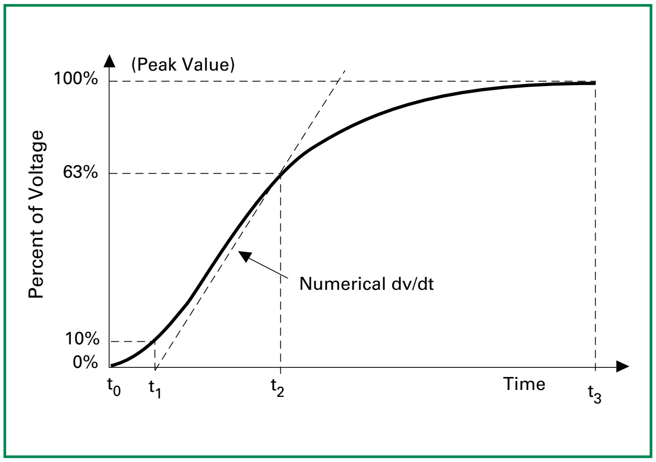


Figure AN1009.2 Exponential dv/dt Waveform

The rate-of-rise of voltage (dv/dt) of a linear waveform is 80% of peak voltage (excluding any overshoots) divided by the time at 90% minus 10% peak voltage. (Figure AN1009.3)

Linear dv/dt = $0.8 = [V_{PK}] = (t_2 - t_1)$

Linear dv/dt = $[0.9 \bullet V_{PK} - 0.1 \bullet V_{PK}] = (t_2 - t_1)$

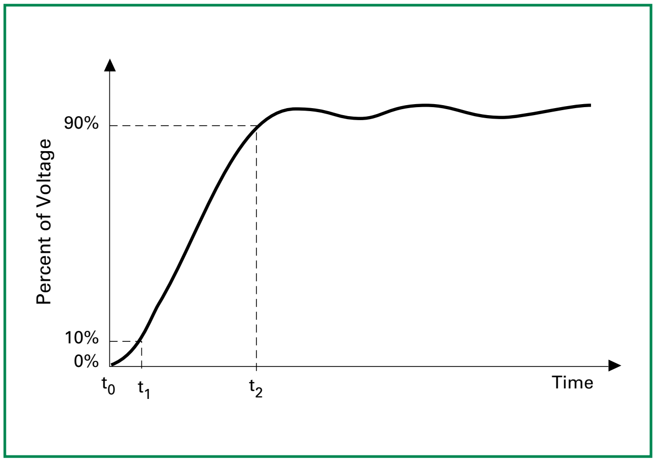
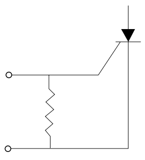
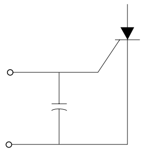
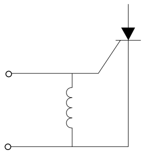
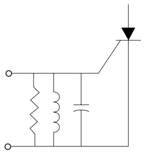
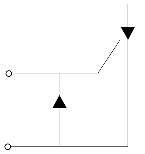
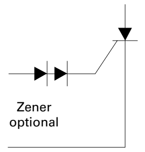
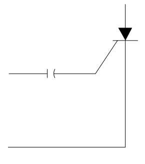


Figure AN1009.3 Linear dv/dt Waveform

Miscellaneous Design Tips and Facts (continued)

Examples of Gate Terminations

	**Primary Purpose** (1) Increase dv/dt capability (2) Keep gate clamped to ensure V_{DRM} capability (3) Lower t_q time **Related Effect –** Raises the device latching and holding current
	**Primary Purpose** (1) Increase dv/dt capability (2) Remove high frequency noise **Related Effects** (1) Increases delay time (2) Increases turn-on interval (3) Lowers gate signal rise time (4) Lowers di/dt capability (5) Increases t_q time
	**Primary Purpose** (1) Decrease DC gate sensitivity (2) Decrease t_q time **Related Effects** (1) Negative gate current increases holding current and causes gate area to drop out of conduction (2) In pulse gating gate signal tail may cause device to drop out of conduction
	**Primary Purpose –** Select frequency **Related Effects –** Unless circuit is "damped," positive and negative gate current may inhibit conduction or bring about sporadic anode current
	**Primary Purpose** (1) Supply reverse bias in off period (2) Protect gate and gate supply for reverse transients (3) Lower t_q time **Related Effects –** Isolates the gate if high impedance signal source is used without sustained diode current in the negative cycle
	**Primary Purpose –** Decrease threshold sensitivity **Related Effects** (1) Affects gate signal rise time and di/dt rating (2) Isolates the gate
	**Primary Purpose –** Isolate gate circuit DC component **Related Effects –** In narrow gate pulses and low impedance sources, I_{gt} followed by reverse gate signals which may inhibit conduction

Curves for Average Current at Various Conduction Angles

SCR maximum average current curves for various conduction angles can be established using the factors for maximum average current at conduction angle of:

30° = 0.40 x Avg 180°
60° = 0.56 x Avg 180°
90° = 0.70 x Avg 180°
120° = 0.84 x Avg 180°

The reason for different ratings is that the average current for conduction angles less than 180° is derated because of the higher RMS current connected with high peak currents.

Note that maximum allowable case temperature (T_C) remains the same for each conduction angle curve but is established from average current rating at 180° conduction as given in the data sheet for any particular device type. The maximum T_C curve is then derated down to the maximum junction (T_J). The curves illustrated in Figure AN1009.4 are derated to 125 °C since the maximum T_J for the non-sensitive SCR series is 125 °C.

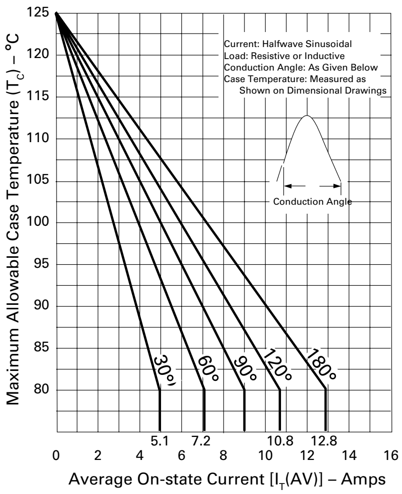


Figure AN1009.4 Typical Curves for Average On-state Current at Various Conduction Angles versus T_C for a SXX20L SCR.

Double-Exponential Impulse Waveform

A double-exponential impulse waveform or waveshape of current or voltage is designated by a combination of two numbers (t_r/t_d or t_r x t_d μs). The first number is an exponential rise time (t_r) or wave front and the second number is an exponential decay time (t_d) or wave tail. The rise time (t_r) is the maximum rise time permitted. The decay time (t_d) is the minimum time permitted. Both the t_r and the t_d are in the same units of time, typically microseconds, designated at the end of the waveform description as defined by ANSI/IEEE C62.1-1989.

The rise time (t_r) of a current waveform is 1.25 times the time for the current to increase from 10% to 90% of peak value. See Figure AN1009.5.

$$t_r = \text{Rise Time} = 1.25 \bullet [t_c - t_a]$$

$$t_r = 1.25 \bullet [t(0.9\ I_{PK}) - t(0.1\ I_{PK})] = T_1 - T_0$$

The rise time (t_r) of a voltage waveform is 1.67 times the time for the voltage to increase from 30% to 90% of peak value. (Figure AN1009.5)

$$t_r = \text{Rise Time} = 1.67 \bullet [t_c - t_b]$$

$$t_r = 1.67 \bullet [t(0.9\ V_{PK}) - t(0.3\ V_{PK})] = T_1 - T_0$$

The decay time (t_d) of a waveform is the time from virtual zero (10% of peak for current or 30% of peak for voltage) to the time at which one-half (50%) of the peak value is reached on the wave tail. (Figure AN1009.5)

$$\text{Current Waveform } t_d = \text{Decay Time}$$

$$= [t(0.5\ I_{PK}) - t(0.1\ I_{PK})] = T_2 - T_0$$

$$\text{Voltage Waveform } t_d = \text{Decay Time}$$

$$= [t(0.5\ V_{PK}) - t(0.3\ V_{PK})] = T_2 - T_0$$

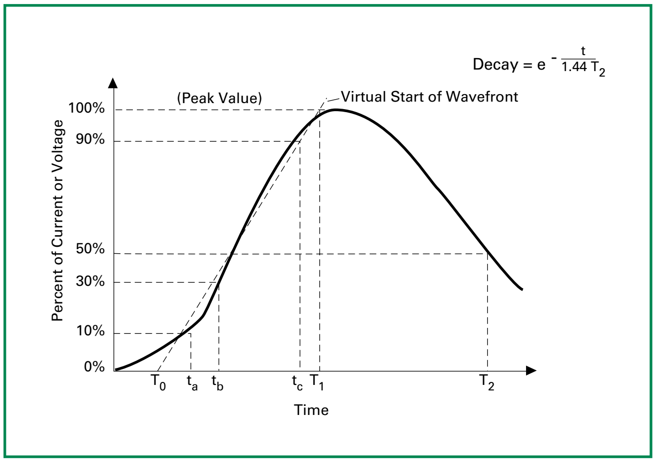


Figure AN1009.5 Double-exponential Impulse Waveform

Failure Modes of Thyristor

Thyristor failures may be broadly classified as either degrading or catastrophic. A degrading type of failure is defined as a change in some characteristic which may or may not cause a catastrophic failure, but could show up as a latent failure. Catastrophic failure is when a device exhibits a sudden change in characteristic that renders it inoperable. To minimize degrading and catastrophic failures, devices must be operated within maximum ratings at all times.

Degradation Failures

A significant change of on-state, gate, or switching characteristics is quite rare. The most vulnerable characteristic is blocking voltage. This type of degradation increases with rising operating voltage and temperature levels.

Catastrophic Failures

A catastrophic failure can occur whenever the Thyristor is operated beyond its published ratings. The most common failure mode is an electrical short between the main terminals, although a Triac can fail in a half-wave condition. It is possible, but not probable, that the resulting short-circuit current could melt the internal parts of the device which could result in an open circuit.

Failure Causes

Most Thyristor failures occur due to exceeding the maximum operating ratings of the device. Overvoltage or overcurrent operations are the most probable cause for failure. Overvoltage failures may be due to excessive voltage transients or may also occur if inadequate cooling allows the operating temperature to rise above the maximum allowable junction temperature. Overcurrent failures are generally caused by improper fusing or circuit protection, surge current from load initiation, load abuse, or load failure. Another common cause of device failure is incorrect handling procedures used in the manufacturing process. Mechanical damage in the form of excessive mounting torque and/or force applied to the terminals or leads can transmit stresses to the internal Thyristor chip and cause cracks in the chip which may not show up until the device is thermally cycled.

Prevention of Failures

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should also limit the maximum current through the main terminals to 75% of the device rating. Correct mounting and forming of the leads also help ensure against infant mortality and latent failures. The two best ways to ensure long life of a Thyristor is by proper heat sink methods and correct voltage rating selection for worst case conditions. Overheating, overvoltage, and surge currents are the main killers of semiconductors.

Most Common Thyristor Failure Mode

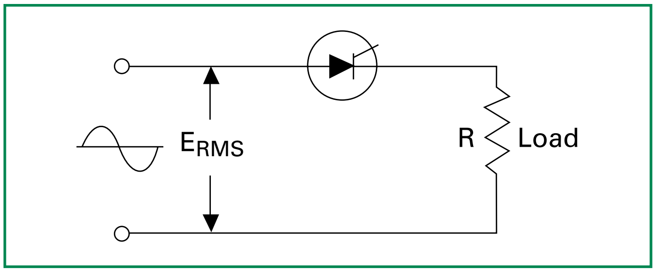
When a Thyristor is electrically or physically abused and fails either by degradation or a catastrophic means, it will short (full-wave or half-wave) as its normal failure mode. Rarely does it fail open circuit. The circuit designer should add line breaks, fuses, over-temperature interrupters or whatever is necessary to protect the end user and property if a shorted or partially shorted Thyristor offers a safety hazard.

Miscellaneous Design Tips and Facts (continued)

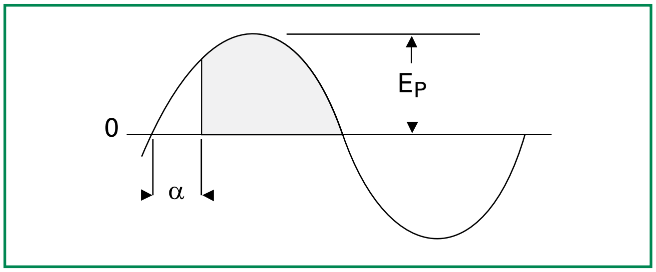
Characteristics Formulas for Phase Control Circuits

Circuit Name	Max Thyristor Voltage	PRV	Max. Load Voltage E_d=Avg. E_a=RMS Load	Load Voltage with Delayed Firing	Max. Average Thyristor or Rectifier Current	
		SCR			Avg. Amps	Conduction Period
Half-wave Resistive Load	1.4 E_{RMS}	E_P	$E_d = \frac{E_p}{\pi}$ $E_a = \frac{E_p}{2}$	$E_d = \frac{E_p}{2\pi}(1+\cos\alpha)$ $E_a = \frac{E_p}{2\sqrt{\pi}}\sqrt{(\pi - \alpha + \frac{1}{2}\sin 2\alpha)}$	$\frac{E_p}{\pi R}$	180°
Full-wave Bridge	1.4 E_{RMS}	E_P	$E_d = \frac{2E_p}{\pi}$	$E_d = \frac{E_p}{2\sqrt{\pi}}(1+\cos\alpha)$	$\frac{E_p}{\pi R}$	180°
Full-wave AC Switch Resistive Load	1.4 E_{RMS}	E_P	$E_a = \frac{E_p}{1.4}$	$E_a = \frac{E_p}{\sqrt{2\pi}}\sqrt{(\pi - \alpha + \frac{1}{2}\sin 2\alpha)}$	$\frac{E_p}{\pi R}$	180°

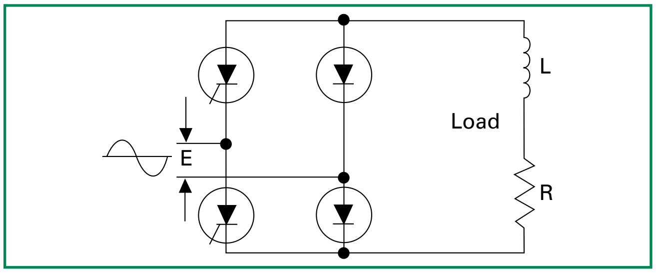
NOTE: Angle alpha (α) is in radians.



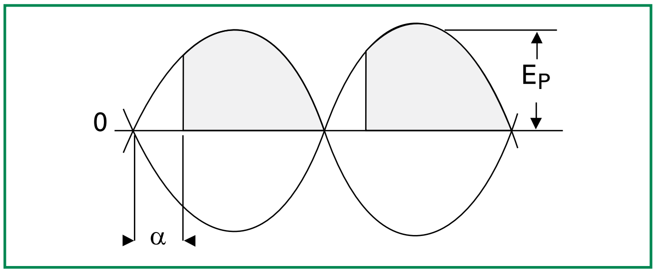
Half-wave Resistive Load - Schematic



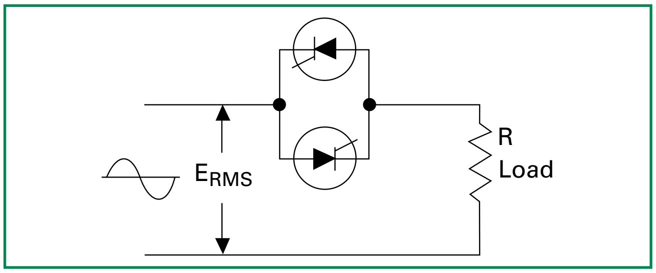
Half-wave Resistive Load - Waveform



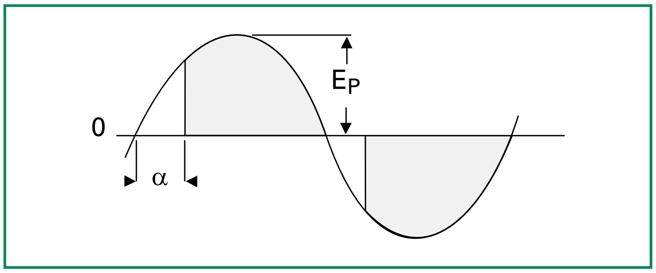
Full-wave Bridge - Schematic



Full-wave Bridge - Waveform



Full-wave AC Switch Resistive Load - Schematic



Full-wave AC Switch Resistive Load - Waveform

Thyristors for Ignition of Fluorescent Lamps

Introduction

One of the many applications for Thyristors is in fluorescent lighting. Standard conventional and circular fluorescent lamps with filaments can be ignited easily and much more quickly by using Thyristors instead of the mechanical starter switch, and solid state Thyristors are more reliable. Thyristors produce a pure solid state igniting circuit with no mechanical parts in the fluorescent lamp fixture. Also, because the lamp ignites much faster, the life of the fluorescent lamp can be increased since the filaments are activated for less time during the ignition. The Thyristor ignition eliminates any audible noise or flashing off and on which most mechanical starters possess.

Standard Fluorescent Circuit

The standard starter assembly is a glow switch mechanism with option small capacitor in parallel. (Figure AN1010.1)

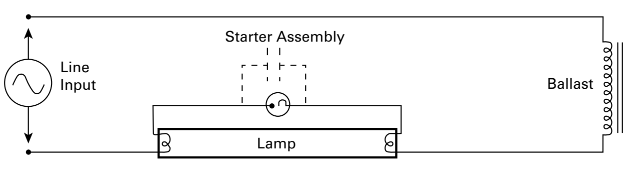


Figure AN1010.1 Typical Standard Fluorescent Circuit

The glow switch is made in a small glass bulb containing neon or argon gas. Inside the bulb is a U-shaped bimetallic strip and a fixed post. When the line input current is applied, the voltage between the bimetallic strip and the fixed post is high enough to ionize and produce a glow similar to a standard neon lamp. The heat from the ionization causes the bimetallic strip to move and make contact to the fixed post. At this time the ionization ceases and current can flow through and pre-heat the filaments of the fluorescent lamp.

Since ionization (glowing) has ceased, the bimetallic strip begins to cool down and in a few seconds opens to start ionization (glowing) again. The instant the bimetallic ceases to make contact (opens), an inductive kick from the ballast produces some high voltage spikes 400 V to 600 V, which can ignite (strike) the fluorescent lamp. If the lamp fails to ignite or start, the glow switch mechanically repeats its igniting cycle over and over until the lamp ignites, usually within a few seconds.

In this concept the ballast (inductor) is able to produce high voltage spikes using a mechanical switch opening and closing, which is fairly slow.

Since Thyristors (solid state switches) do not mechanically open and close, the conventional fluorescent lighting circuit concept must be changed in order to use Thyristors. In order to ignite (strike) a fluorescent lamp, a high voltage spike must be produced. The spike needs to be several hundred volts to quickly initiate ionization in the fluorescent lamp. A series ballast can only produce high voltage if a mechanical switch is used in conjunction with it. Therefore, with a Thyristor, a standard series ballast (inductor) is only useful as a current limiter.

Methods for Producing High Voltage

The circuits illustrated in Figure AN1010.2 through Figure AN1010.5 show various methods for producing high voltage to ignite fluorescent lamps using Thyristors (solid state switches).

Note: Due to many considerations in designing a fluorescent fixture, the illustrated circuits are not necessarily the optimum design.

One 120 V ac circuit consists of Triac and DIAC Thyristors with a capacitor to ignite the fluorescent lamp. (Figure AN1010.2)

This circuit allows the 5 µF ac capacitor to be charged and added to the peak line voltage, developing close to 300 V peak or 600 V peak to peak. This is accomplished by using a Triac and DIAC phase control network set to fire near the 90° point of the input line. A capacitor-charging network is added to ensure that the capacitor is charged immediately, letting tolerances of components or temperature changes in the Triac and DIAC circuit to be less critical. By setting the Triac and DIAC phase control to fire at near the 90° point of the sinewave, maximum line voltages appear across the lamp for ignition. As the Triac turns on during each half cycle, the filaments are pre-heated and in less than a second the lamp is lit. Once the lamp is lit the voltage is clamped to approximately 60 V peak across the 15 W to
20 W lamp, and the Triac and DIAC circuit no longer functions until the lamp is required to be ignited again.

Thyristors for Ignition of Fluorescent Lamps (continued)

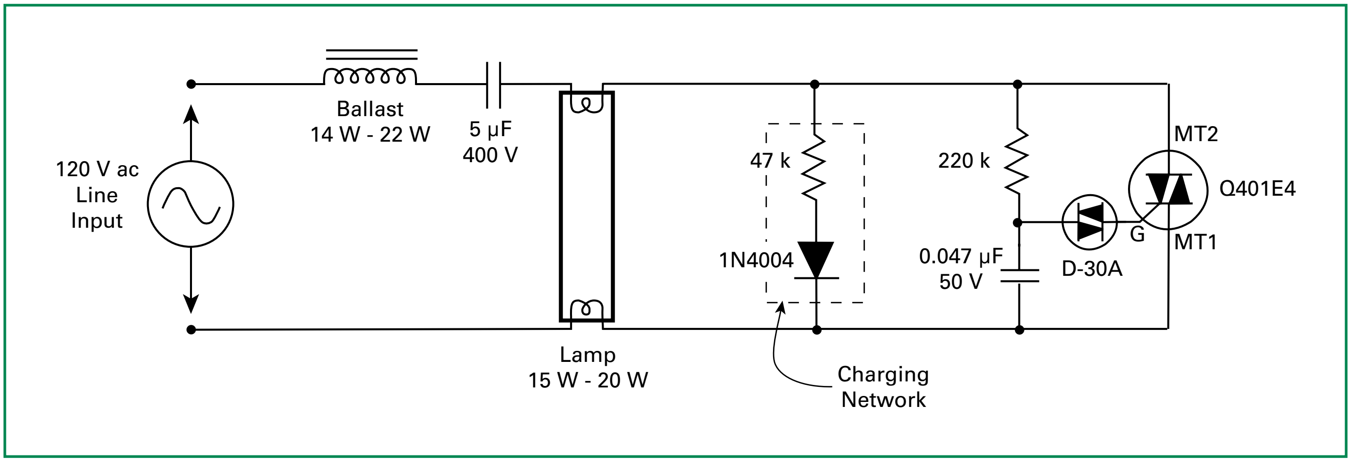


Figure AN1010.2 120 V ac Triac/DIAC Circuit

Figure AN1010.3 illustrates a circuit using a SIDAC (a simpler Thyristor) phase control network to ignite a 120 V ac fluorescent lamp. As in the Triac/DIAC circuit, the 5 µF ac capacitor is charged and added to the peak line voltage, developing greater than 200 V peak or 400 V peak to peak. Since the SIDAC is a voltage breakover (V_{BO}) activated device with no gate, a charging network is essential in this circuit to charge the capacitor above the peak of the line in order to break over (turn on) the SIDAC with a V_{BO} of 220 V to 250 V.

As the SIDAC turns on each half cycle, the filaments are pre-heated and in less than 1.5 seconds the lamp is lit. Once the lamp is lit, the voltage across it clamps to approximately 60 V peak (for a 15 W to 20 W lamp), and the SIDAC ceases to function until the lamp is required to be ignited again.

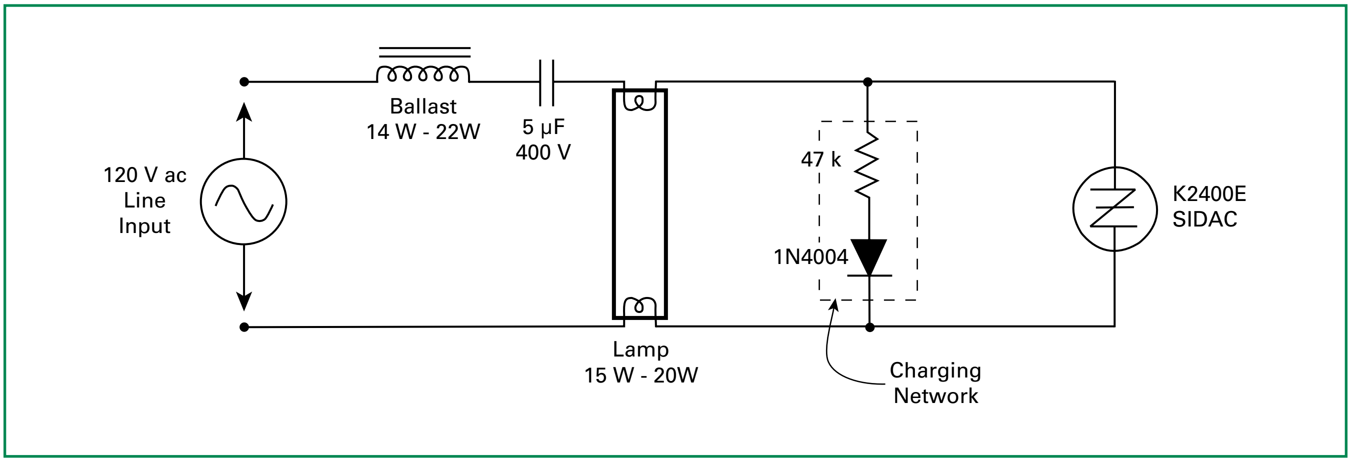


Figure AN1010.3 120 V ac SIDAC Circuit

The circuits illustrated in Figure AN1010.2 and Figure AN1010.3 use 15 W to 20 W lamps. The same basic circuits can be applied to higher wattage lamps. However, with higher wattage lamps the voltage developed to fire (light) the lamp will need to be somewhat higher. For instance, a 40 W lamp is critical on line input voltage to ignite, and after it is lit the voltage across the lamp will clamp to approximately 130 V peak. For a given type of lamp, the current must be limited to constant current regardless of the wattage of the lamp.

Thyristors for Ignition of Fluorescent Lamps (continued)

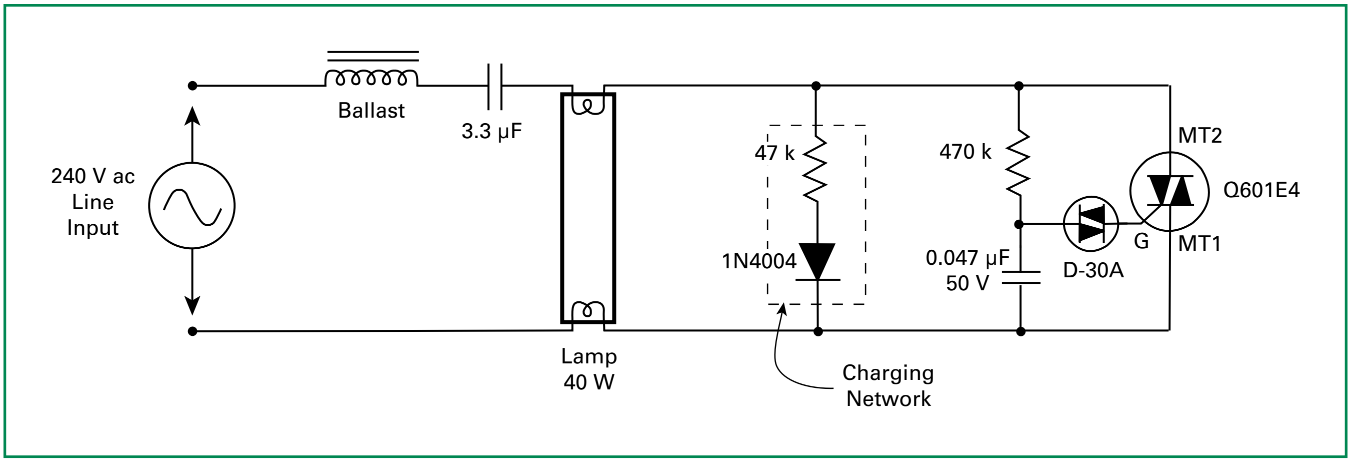


Figure AN1010.4 240 V ac Triac/DIAC Circuit

Figure AN1010.4 shows a circuit for igniting a fluorescent lamp with 240 V line voltage input using Triac and DIAC networks.

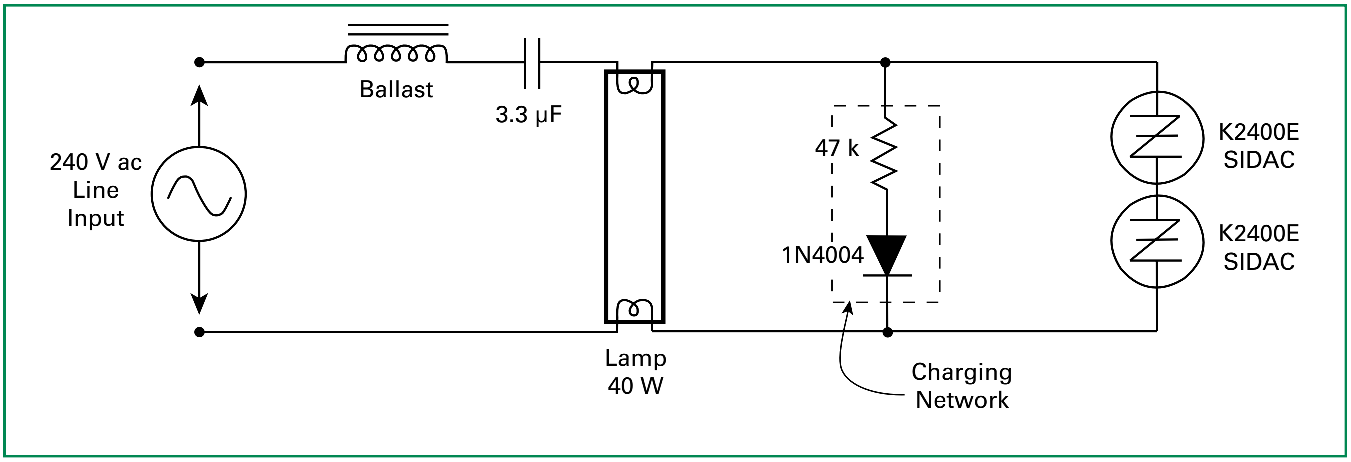
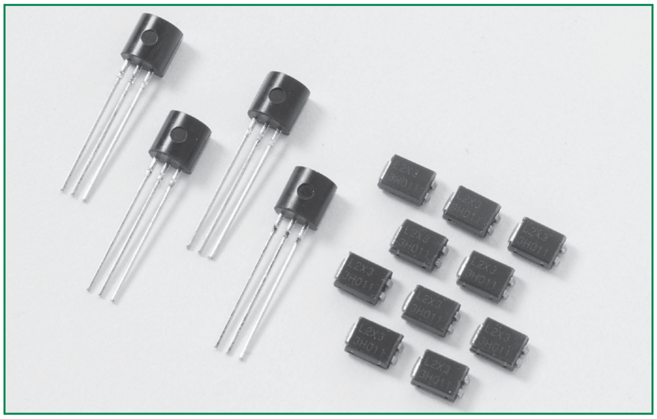


Figure AN1010.5 240 V ac SIDAC Circuit

Figure AN1010.5 illustrates a circuit using a SIDAC phase control network to ignite a 240 V ac fluorescent lamp. This circuit works basically the same as the 120 V circuit shown in Figure AN1010.3, except that component values are changed to compensate for higher voltage. The one major change is that two K2400E devices in series are used to accomplish high firing voltage for a fluorescent lamp.

LxX8Ex & LxXx & QxX8E & QxXx Series

RoHS



Description

0.8 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Sensitive type devices guarantee gate control in Quadrants I & IV needed for digital control circuitry.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Features

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 10 A

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	0.8	A
V_{DRM}/V_{RRM}	400 to 600	V
$I_{GT\ (Q1)}$	3 to 25	mA

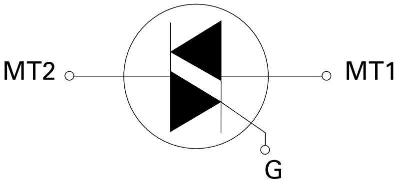
Applications

Excellent for lower current heating controls, water valves, and solenoids.

Typical applications are AC solid-state switches, home/brown goods and white goods appliances.

Sensitive gate Triacs can be directly driven by microprocessor or popular opto-couplers/isolators.

Schematic Symbol



Additional Information

Datasheet

Resources

Samples

Absolute Maximum Ratings — Sensitive Triacs (4 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	LxX8y/LxXy	T_C = 50°C	0.8	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	8.3	A
		f = 60 Hz	t = 16.7 ms	10	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		0.41	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 50mA with ≤ 0.1μs rise time)	f = 120 Hz	T_J = 110°C	20	A/μs
I_{GTM}	Peak gate trigger current	t_p = 10 μs	T_J = 110°C	1	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.2	W
T_{stg}	Storage temperature range		LxX8Ey	-65 to 150	°C
			LxXy	-40 to 150	
T_J	Operating junction temperature range		LxX8Ey	-65 to 110	°C
			LxXy	-40 to 110	

Note: x = voltage, y = sensitivity

Revised: 12/14/14

Absolute Maximum Ratings — Standard Triac

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	QxXE8y/ QxXy	T_C = 60°C	0.8	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	8.3	A
		f = 60 Hz	t = 16.7 ms	10	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		0.41	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 200mA with ≤ 0.1μs rise time)	f = 120 Hz	T_J = 125°C	20	A/μs
I_{GTM}	Peak gate trigger current	t_p = 10 μs; $I_{GT} \leq I_{GTM}$	T_J = 125°C	1	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.2	W
T_{stg}	Storage junction temperature range		QxX8Ey	-65 to 150	°C
			QxXy	-40 to 150	
T_J	Operating junction temperature range		QxX8Ey	-65 to 125	°C
			QxXy	-40 to 125	

Note: x = voltage, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Sensitive Triac (4 Quadrants)

Symbol	Test Conditions	Quadrant		LxX8E3 LxX3	LxX8E5 LxX5	LxX8E6 LxX6	LxX8E8 LxX8	Unit
I_{GT}	V_D = 12V R_L = 30 Ω	I – II – III	MAX.	3	5	5	10	mA
		IV		3	5	10	20	
V_{GT}		ALL	MAX.	1.3				V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	ALL	MIN.	0.2				V
I_H	I_T = 100mA		MAX.	5	10	10	15	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 100°C	400V	TYP.	15	15	25	30	V/μs
		600V		10	10	20	25	
(dv/dt)c	(di/dt)c = 0.43 A/ms T_J = 110°C		TYP.	0.5	1	1	2	V/μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 1.13 A(pk)		TYP.	2.8	3.0	3.0	3.2	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		QxX8E3 QxX3	QxX8E4 QxX4	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	25	mA
		IV	TYP.	25	50	
V_{GT}		I – II – III	MAX.	1.3	1.3	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	ALL	MIN.	0.2	0.2	V
I_H	I_T = 200mA		MAX.	15	25	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	25	35	V/μs
		600V		15	25	
(dv/dt)c	(di/dt)c = 0.43 A/ms T_J = 125°C		TYP.	1	1	V/μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 1.13 A(pk)		TYP.	2.5	3.0	μs

Note: x = voltage

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions					Value	Unit
V_{TM}	I_{TM} = 1.13A t_p = 380 µs	MAX.				1.60	V
I_{DRM} I_{RRM}	$V_{DRM} = V_{RRM}$	MAX.	LxX8Ey / LxXy	T_J = 25°C	400-600V	2	µA
				T_J = 110°C	400-600V	0.1	mA
			QxX8Ey / QxXy	T_J = 25°C	400-600V	5	µA
				T_J = 125°C	400-600V	1	mA

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	L/QxX8Ey	60	°C/W
		L/QxXy	60*	
$R_{\theta(J-A)}$	Junction to ambient	L/QxX8Ey	135	°C/W

Note: * = Mounted on 1 cm^2 1 copper (two-ounce) foil surface

Figure 1: Definition of Quadrants

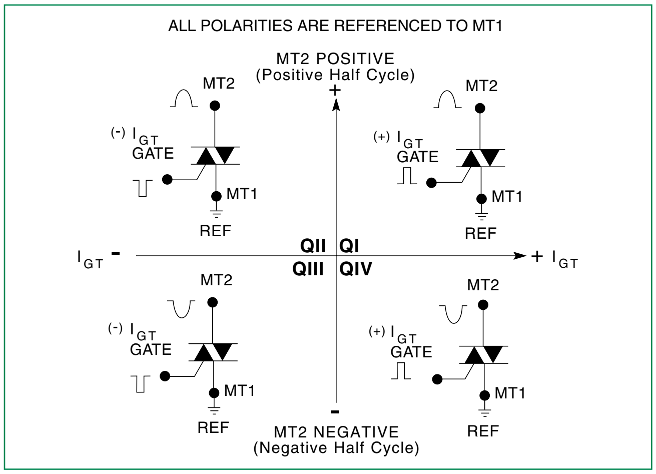


Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

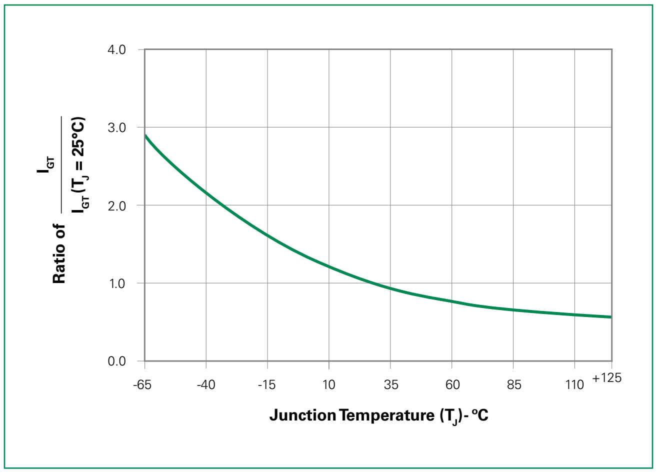


Figure 3: Normalized DC Holding Current vs. Junction Temperature

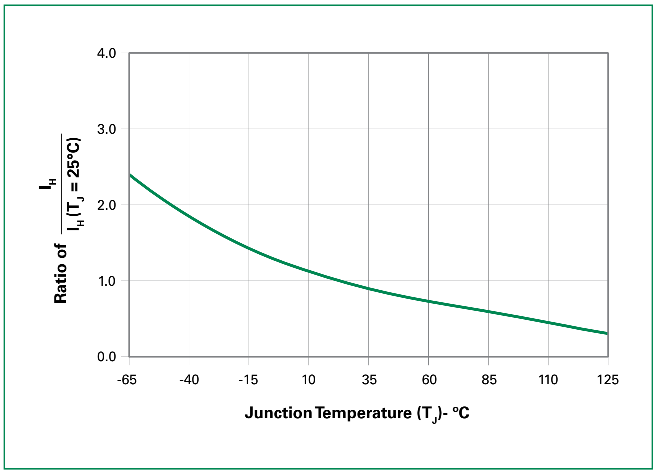


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

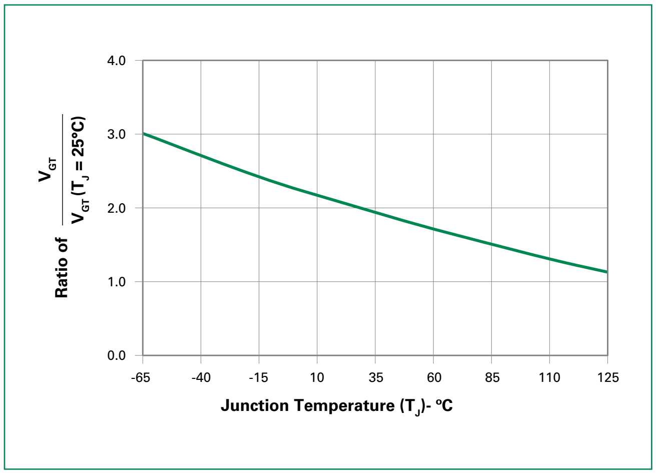


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

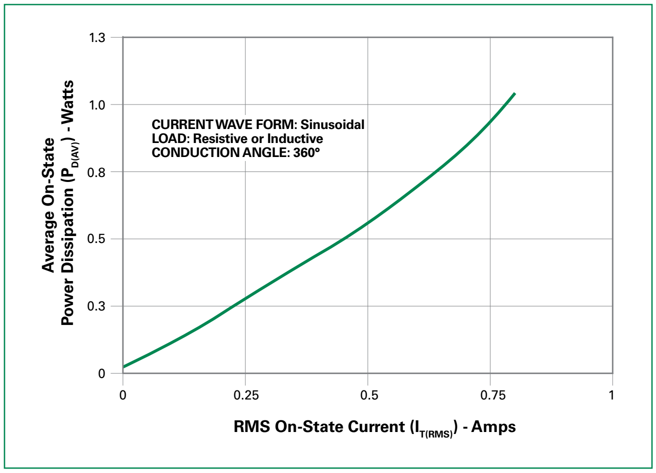


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

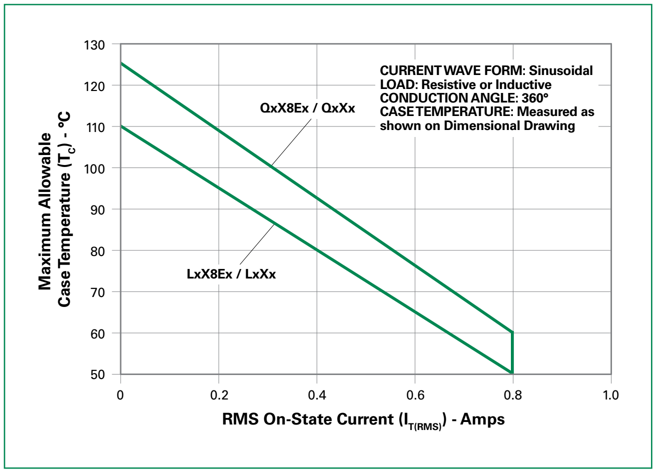


Figure 7: Maximum Allowable Ambient Temperature vs. On-State Current

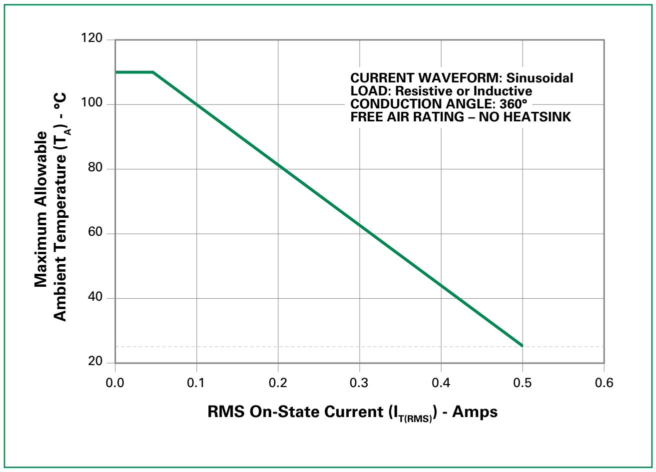


Figure 8: On-State Current vs. On-State Voltage (Typical)

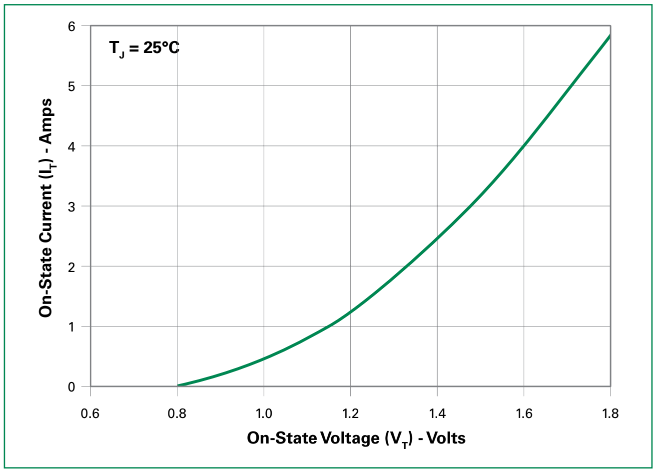
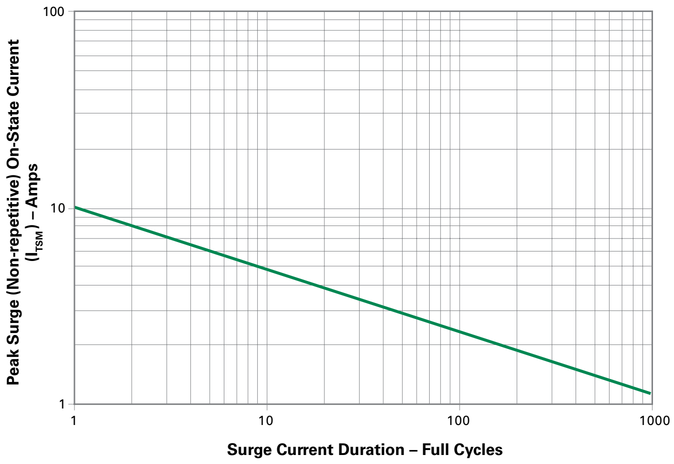


Figure 9: Surge Peak On-State Current vs. Number of Cycles



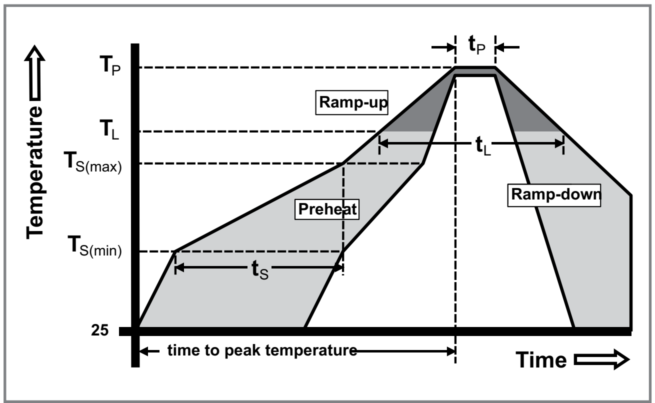
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Revised: 12/14/14

Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

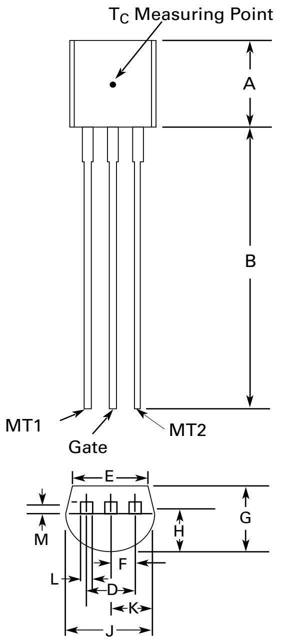
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

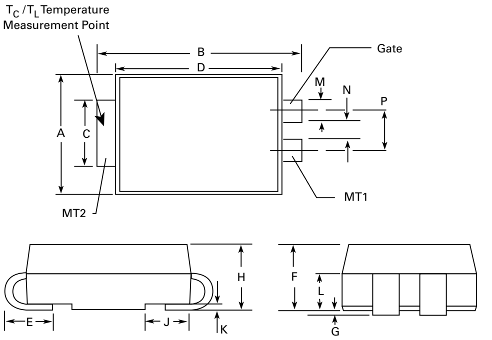
Dimensions — TO-92 (E Package)

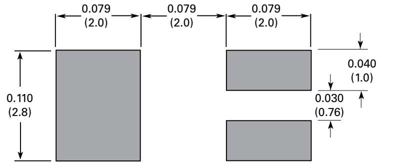


Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500		12.70	
D	0.095	0.105	2.41	2.67
E	0.150		3.81	
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43

All leads insulated from case. Case is electrically nonconductive.

Dimensions — Compak (C Package)





Pad Outline

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
J	0.043	0.053	1.09	1.35
K	0.006	0.016	0.15	0.41
L	0.030	0.055	0.76	1.40
M	0.022	0.028	0.56	0.71
N	0.027	0.033	0.69	0.84
P	0.052	0.058	1.32	1.47

Product Selector

Part Number	Voltage		Gate Sensitivity Quadrants		Type	Package
	400V	600V	I – II – III	IV		
LxX8E3	X	X	3 mA	3 mA	Sensitive Triac	TO-92
LxX3	X	X	3 mA	3 mA	Sensitive Triac	Compak
LxX8E5	X	X	5 mA	5 mA	Sensitive Triac	TO-92
LxX5	X	X	5 mA	5 mA	Sensitive Triac	Compak
LxX8E6	X	X	5 mA	10 mA	Sensitive Triac	TO-92
LxX8E8	X	X	10 mA	20 mA	Sensitive Triac	TO-92
QxX8E3	X	X	10 mA		Standard Triac	TO-92
QxX3	X	X	10 mA		Standard Triac	Compak
QxX8E4	X	X	25 mA		Standard Triac	TO-92
QxX4	X	X	25 mA		Standard Triac	Compak

Note: x = voltage

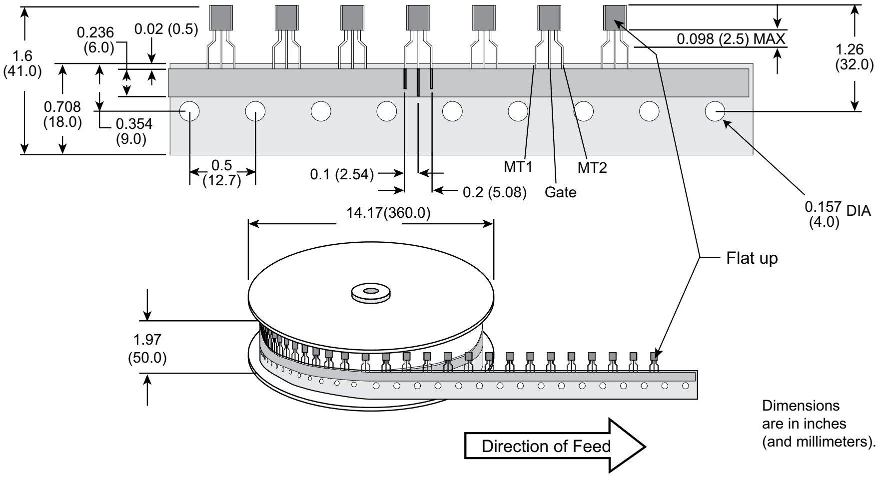
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
L/QxX8Ey	L/QxX8Ey	0.188 g	Bulk	2000
L/QxX8EyRP	L/QxX8Ey	0.188 g	Reel Pack	2000
L/QxX8EyAP	L/QxX8Ey	0.188 g	Ammo Pack	2000
L/QxXyRP	L/QxXy	0.081 g	Embossed Carrier	2500

Note: x = voltage, y = sensitivity

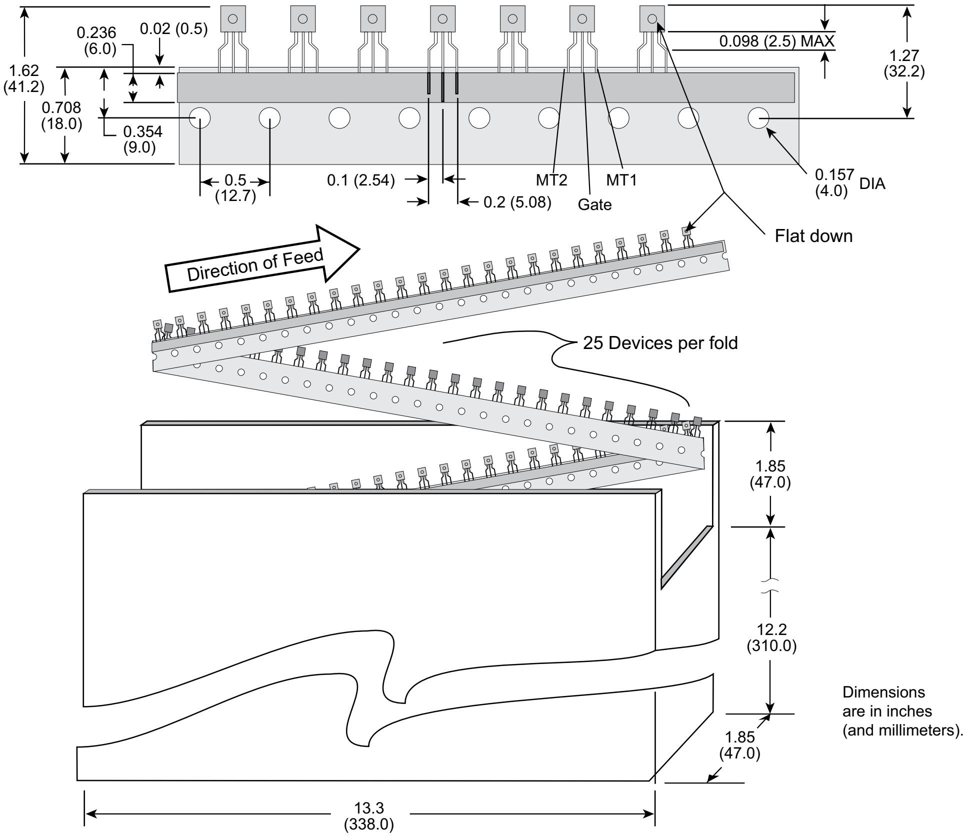
TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

Meets all EIA-468-C Standards



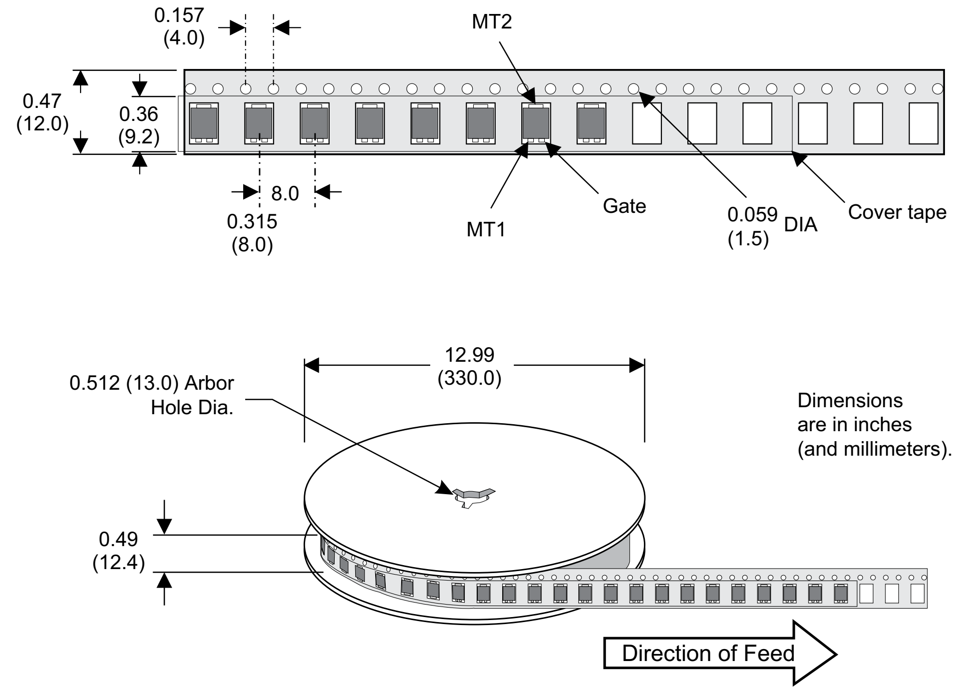
TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards



Compak Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-1 Standards



Part Numbering System

L 4 X8 E 5

DEVICE TYPE
L : Sensitive Triac
Q : Triac

VOLTAGE RATING
4 : 400V
6 : 600V

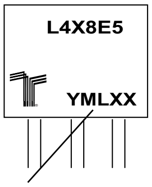
CURRENT RATING
X8 : 0.8A (TO-92)
X : 0.8A (Compak)

SENSITIVITY & TYPE
Sensitive Triac:
3 : 3 mA (QI, II, III, IV)
5 : 5 mA (QI, II, III, IV)
6 : 5 mA (QI, II, III)
10 mA (QIV)
8 : 10 mA (QI, II, III)
20 mA (QIV)
Standard Triac:
3 : 10 mA (QI, II, III)
4 : 25 mA (QI, II, III)

PACKAGE TYPE
Blank : Compak (Surface Mount)
E : TO-92

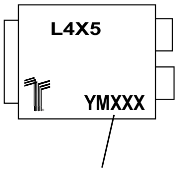
Part Marking System

TO-92 (E Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

Compak (C Package)

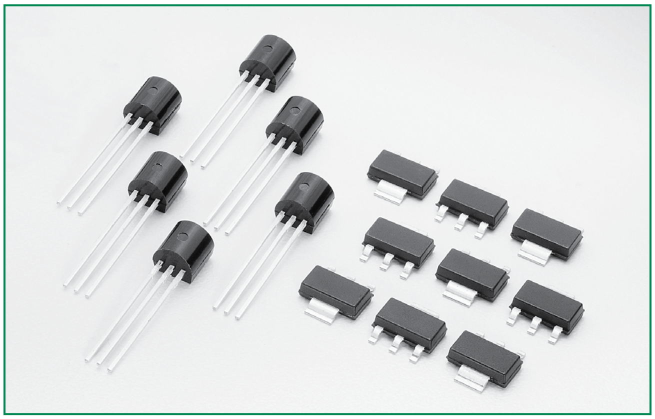


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

LX8 Series

HF RoHS



Description

New 0.8 Amp bi-directional solid state switch series offering direct interface to microprocessor drivers in economical TO-92 and surface mount packages. The die voltage blocking junctions are glass-passivated to ensure long term reliability and parametric stability.

Features & Benefits

- RoHS compliant and Halogen-Free
- Blocking voltage (V_{DRM}) capability — up to 600V
- Surge capability > 9.5Amps
- Static dv/dt > 10 Volts/µsec
- Thru hole and surface mount packages

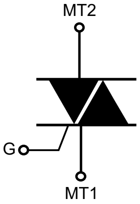
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	0.8	A
V_{DRM}/V_{RRM}	400 to 600	V
I_{GT}	3 to 5	mA

Applications

The LX8 EV Series is especially designed for low current applications such as heating controls in hair care products, as well as replacement of mechanical switch contacts where long life is required.

Schematic Symbol



Additional Information

Datasheet	Resources	Samples

Absolute Maximum Ratings

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	TO-92	T_C = 50°C	0.8A	A
		SOT-223	T_L = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (Single cycle, T_J initial = 25°C)	TO-92	F = 50 Hz	8.0	A
		SOT-223	F = 60 Hz	9.5	
I^2t	I^2t Value for fusing	t_p = 10 ms	F = 50 Hz	0.32	A^2s
		t_p = 8.3 ms	F = 60 Hz	0.37	
di/dt	Critical rate of rise of on-state current $I_G = 2 \times I_{GT}$	TO-92 SOT-223	T_J = 110°C	20	A/µs
I_{GTM}	Peak gate current	t_p = 10 µs	T_J = 110°C	1	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.1	W
T_{stg}	Storage junction temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Revised: 12/14/14

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Quadrant	Limit	Value		Unit
					LX803xy	LX807xy	
I_{GT}	DC Gate Trigger Current	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX.	3 5	5 7	mA
V_{GT}	DC Gate Trigger Voltage		ALL	MAX.	1.3	1.3	V
I_H	Holding Current	Gate Open		MAX.	5	5	mA
dv/dt	Critical Rate-of-Rise of Off-State Voltage	T_J = 110°C $V_D = V_{DRM}$ Exponential Waveform Gate Open		MIN.	10	10	V/μs
(dv/dt)c	Critical Rate-of-Rise of Commutating Voltage	(di/dt)c = 0.43A/ms T_J = 110°C		MIN.	1.5	1.5	V/μs
t_{gt}	Turn-On Time	I_G = 25mA PW = 15μs I_T = 1.2A (pk)		MAX.	2.0	2.0	μs

NOTE: x = voltage, y = package

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Limit	Value	Unit
V_{TM}	Peak On-State Voltage	I_{TM} = 1.13A (pk)	MAX	1.60	V
I_{DRM}	Off-State Current, Peak Repetitive	$V_D = V_{DRM}$ T_J = 25°C	MAX	5	μA
		$V_D = V_{DRM}$ T_J = 110°C		100	μA

Thermal Resistances

Symbol	Description	Test Conditions		Value	Unit
$R_{th(j-c)}$	Junction to case (AC)	$I_T = 0.8A_{(RMS)}$ [1]	TO-92	60	°C/W
			SOT-223	25	
$R_{th(j-a)}$	Junction to ambient	$I_T = 0.8A_{(RMS)}$ [1]	TO-92	150	°C/W
			SOT-223	60	

[1] 60Hz AC resistive load condition, 100% conduction.

Figure 1: Definition of Quadrants

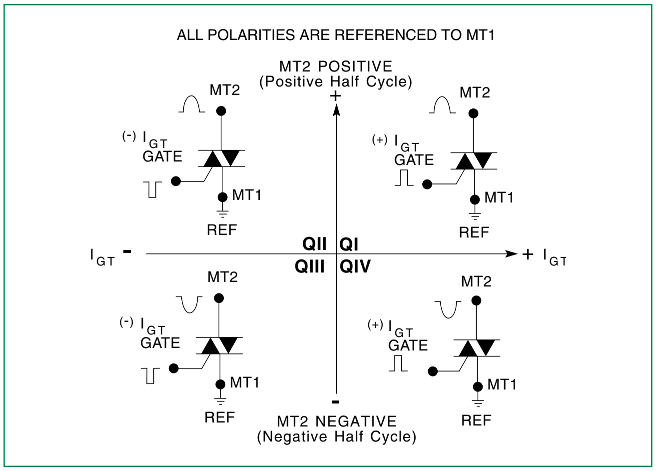


Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

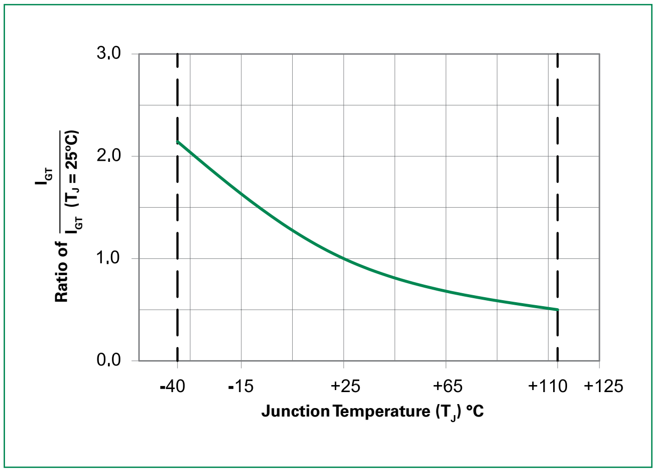


Figure 3: Normalized DC Holding Current vs. Junction Temperature

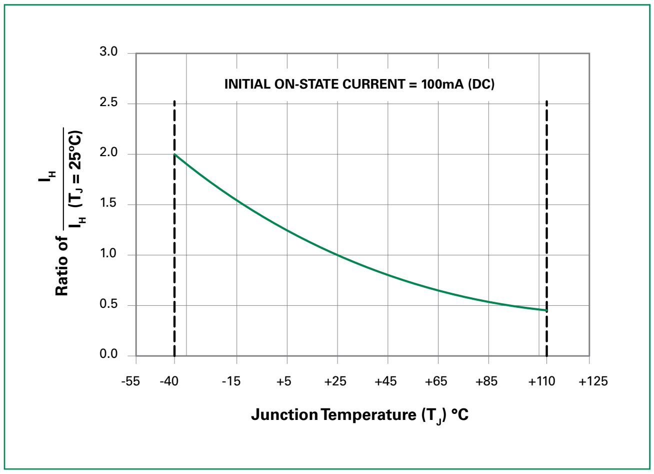


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

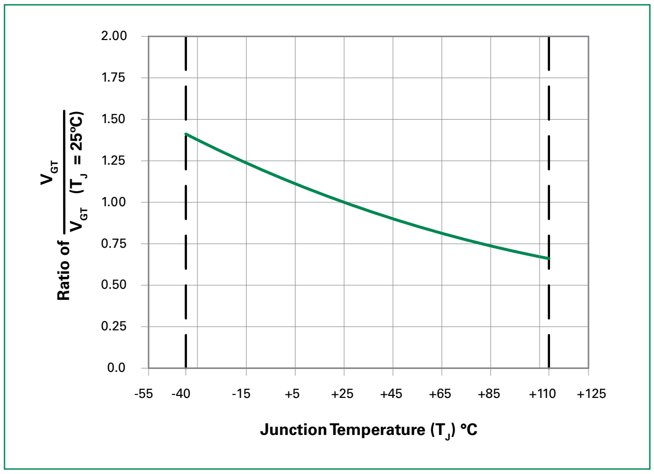


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

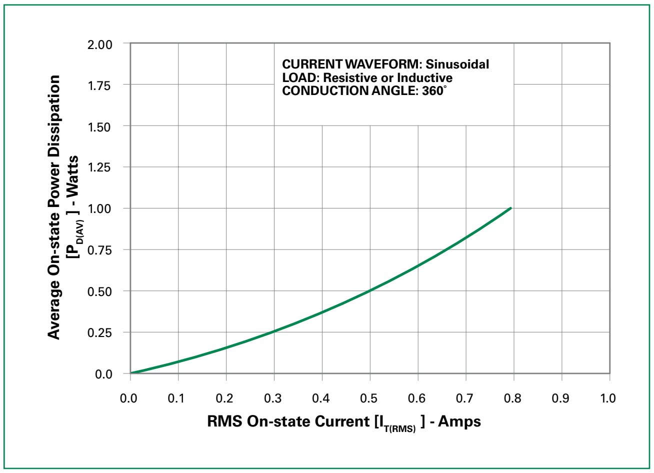


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

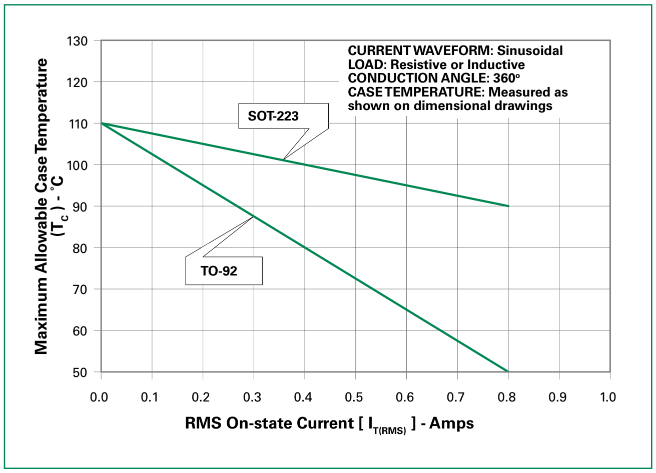
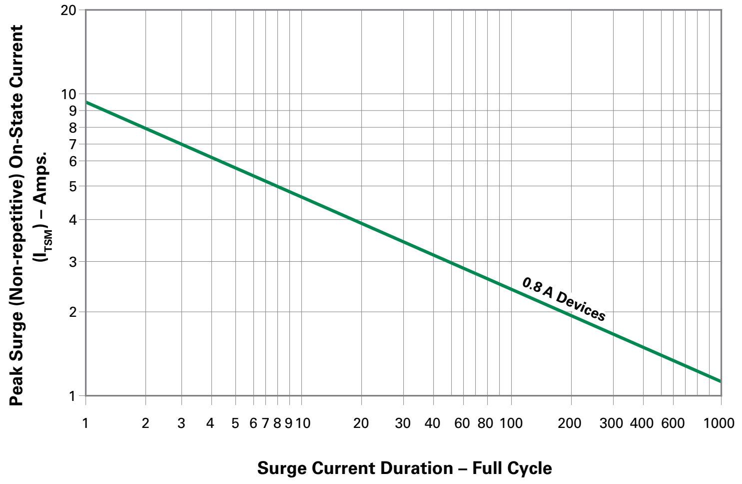


Figure 7: Surge Peak On-State Current vs. Number of Cycles

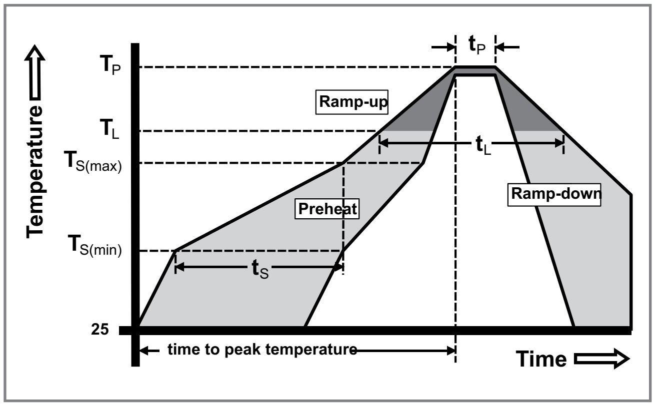


Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.
Lead Material	Copper Alloy

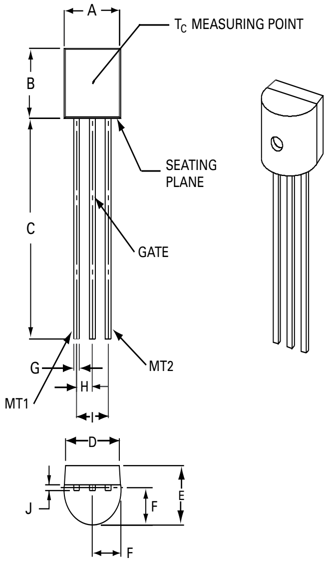
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

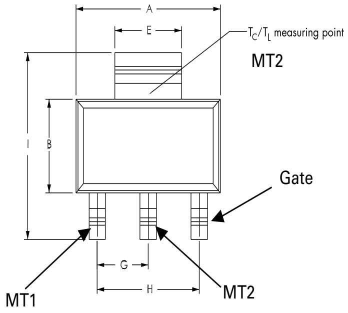
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 110°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

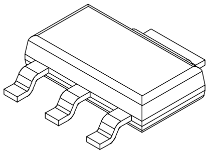
Dimensions — TO-92 (E Package)

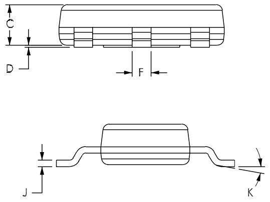


Dimensions	Inches		Millimeters	
	Min	Max	Min	Max
A	0.175	0.205	4.450	5.200
B	0.170	0.210	4.320	5.330
C	0.500		12.70	
D	0.135		3.430	
E	0.125	0.165	3.180	4.190
F	0.080	0.105	2.040	2.660
G	0.016	0.021	0.407	0.533
H	0.045	0.055	1.150	1.390
I	0.095	0.105	2.420	2.660
J	0.015	0.020	0.380	0.500

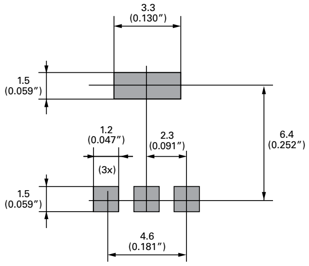
Dimensions – SOT-223







Pad Layout for SOT-223



Dimensions in Millimeters (Inches)

Dimensions	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.248	0.256	0.264	6.30	6.50	6.70
B	0.130	0.138	0.146	3.30	3.50	3.70
C	—	—	0.071	—	—	1.80
D	0.001	—	0.004	0.02	—	0.10
E	0.114	0.118	0.124	2.90	3.00	3.15
F	0.024	0.027	0.034	0.60	0.70	0.85
G	—	0.090	—	—	2.30	—
H	—	0.181	—	—	4.60	—
I	0.264	0.276	0.287	6.70	7.00	7.30
J	0.009	0.010	0.014	0.24	0.26	0.35
K	10° MAX					

Product Selector

Part Number	Voltage	Gate Sensitivity Quadrants		Package
		I – II – III	IV	
LX803DE	400 V	3 mA	5 mA	TO-92
LX803ME	600 V	3 mA	5 mA	TO-92
LX803DT	400 V	3 mA	5 mA	SOT-223
LX803MT	600 V	3 mA	5 mA	SOT-223
LX807DE	400 V	5 mA	7 mA	TO-92
LX807ME	600 V	5 mA	7 mA	TO-92
LX807DT	400 V	5 mA	7 mA	SOT-223
LX807MT	600 V	5 mA	7 mA	SOT-223

Packing Options

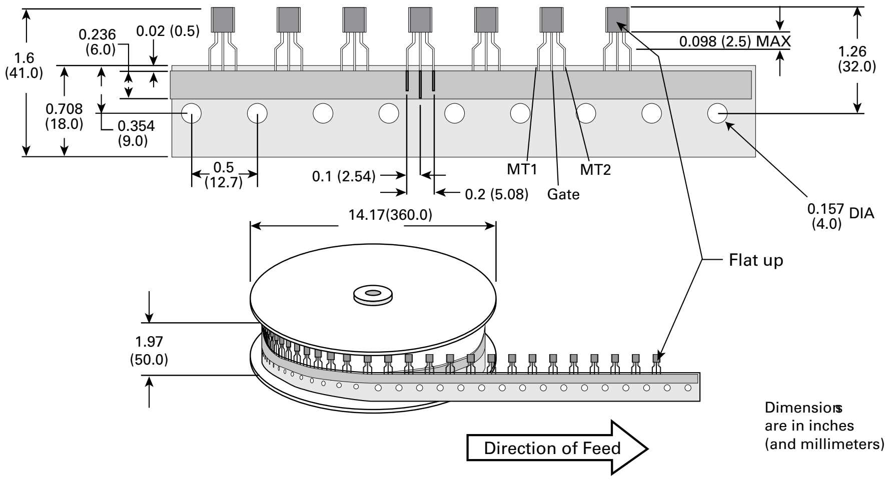
Part Number	Marking	Weight	Packing Mode	Base Quantity
LX8xxyE	LX8xxyE	0.170 g	Bulk	2500
LX8xxyEAP	LX8xxyE	0.170 g	Ammo Pack	2000
LX8xxyERP	LX8xxyE	0.170 g	Tape & Reel	2000
LX8xxyTRP	LX8xxyT	0.120 g	Tape & Reel	1000

Note: xx = gate sensitivity, y = voltage

Revised: 12/14/14

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

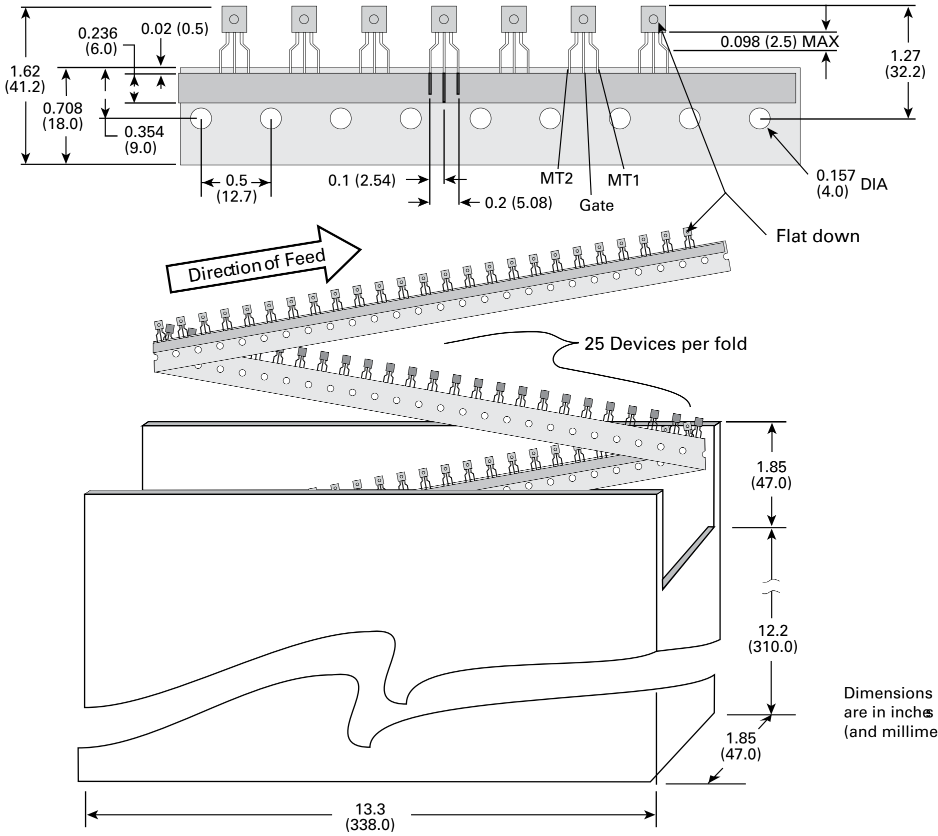
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

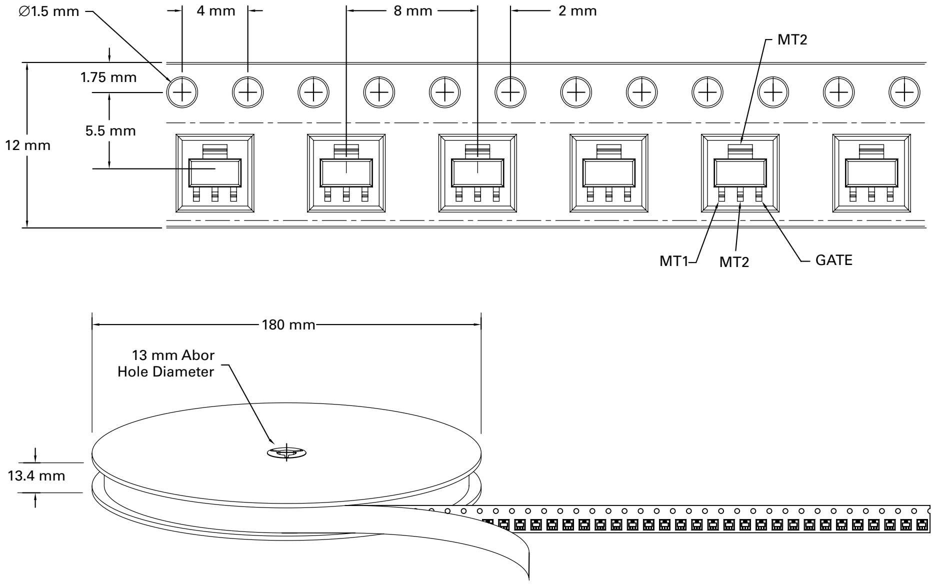
TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

SOT-223 Reel Pack (RP) Specifications



Part Numbering System

L X8 xx x x xx

TRIAC SERIES

CURRENT
X8: 0.8A

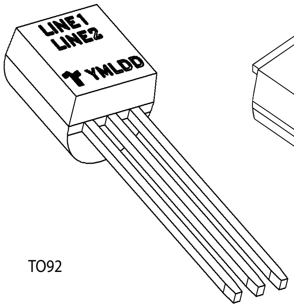
SENSITIVITY & TYPE
03: 3, 3, 3, 5mA Triac
07: 5, 5, 5, 7mA Triac

VOLTAGE
D: 400V
M: 600V

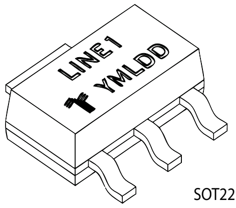
PACKAGE TYPE
E: TO-92
T: SOT-223

PACKING TYPE
Blank: Bulk Pack
RP : Reel Pack (TO-92)
: Embossed Carrier Pack (SOT-223)
AP : Ammo Pack (TO-92)

Part Marking System



TO92

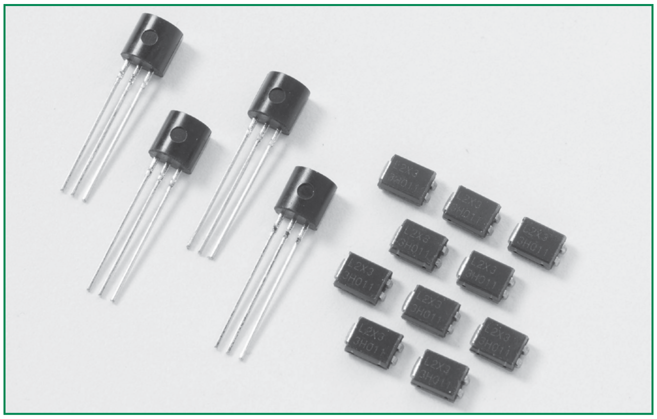


SOT223

Line1 = Littelfuse Part Number
Line2 = continuation…Littelfuse Part Number
Y = Last Digit of Calendar Year
M = Letter Month Code (A-L for Jan-Dec)
L = Location Code
DD = Calendar Date

Lx01Ex & LxNx & Qx01Ex & QxNx Series

RoHS



Description

1 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Sensitive type devices guarantee gate control in Quadrants I & IV needed for digital control circuitry.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

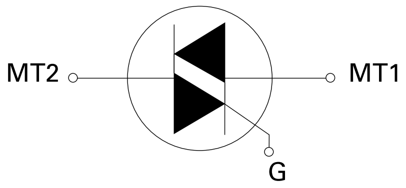
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	1	A
V_{DRM}/V_{RRM}	400 to 600	V
$I_{GT\ (Q1)}$	3 to 25	mA

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 20 A

Schematic Symbol



Applications

Excellent for lower current heating controls, water valves, and solenoids.

Typical applications are AC solid-state switches, home/brown goods and white goods appliances.

Sensitive gate Triacs can be directly driven by microprocessor or popular opto-couplers/isolators.

Additional Information

Datasheet | **Resources** | **Samples**

Absolute Maximum Ratings — Sensitive Triacs (4 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Lx01Ey/LxNy	T_C = 50°C	1	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	16.7	A
		f = 60 Hz	t = 16.7 ms	20	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		1.6	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 50mA with ≤ 0.1µs rise time)	f = 120 Hz	T_J = 110°C	20	A/µs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 µs	T_J = 110°C	1	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.2	W
T_{stg}	Storage temperature range		Lx01Ey	-65 to 150	°C
			LxNy	-40 to 125	
T_J	Operating junction temperature range		Lx01Ey	-65 to 110	°C
			LxNy	-40 to 110	

Note: x = voltage, y = sensitivity

Revised: 12/14/14

Absolute Maximum Ratings — Standard Triacs

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qx01Ey/QxNy	T_C = 60°C	1	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	16.7	A
		f = 60 Hz	t = 16.7 ms	20	
I²t	I²t Value for fusing	t_p = 8.3 ms		1.6	A²s
di/dt	Critical rate of rise of on-state current (I_G = 200mA with ≤ 0.1µs rise time)	f = 120 Hz	T_J = 125°C	20	A/µs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 µs; I_{GT} ≤ I_{GTM}	T_J = 125°C	1	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.2	W
T_{stg}	Storage temperature range		Qx01Ey	-65 to 150	°C
			QxNy	-40 to 150	
T_J	Operating junction temperature range		Qx01Ey	-65 to 125	°C
			QxNy	-40 to 125	

Note: x = voltage, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Sensitive Triac (4 Quadrants)

Symbol	Test Conditions	Quadrant		Lx01E3 LxN3	Lx01E5 LxN5	Lx01E6 LxN6	Lx01E8 LxN8	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	3	5	5	10	mA
		IV		3	5	10	20	
V_{GT}		ALL	MAX.	1.3				V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 110°C	ALL	MIN.	0.2				V
I_H	I_T = 100mA		MAX.	5	10	10	15	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 100°C	400V	TYP.	20	20	30	35	V/µs
		600V		10	10	20	25	
(dv/dt)c	(di/dt)c = 0.54 A/ms T_J = 110°C		TYP.	0.5	1	1	1	V/µs
t_{gt}	I_G = 2 x I_{GT} PW = 15µs I_T = 1.41 A(pk)		TYP.	2.8	3.0	3.0	3.2	µs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Qx01E3 QxN3	Qx01E4 QxN4	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	25	mA
		IV	TYP.	25	50	
V_{GT}		I – II – III	MAX.	1.3	1.3	V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C	ALL	MIN.	0.2	0.2	V
I_H	I_T = 200mA		MAX.	15	25	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 125°C	400V	MIN.	30	40	V/µs
		600V		20	30	
(dv/dt)c	(di/dt)c = 0.54 A/ms T_J = 125°C		TYP.	1	1	V/µs
t_{gt}	I_G = 2 x I_{GT} PW = 15µs I_T = 1.41 A(pk)		TYP.	2.5	3.0	µs

Note: x = voltage, y = sensitivity

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions					Value	Unit
V_{TM}	I_{TM} = 1.41A t_p = 380 µs	MAX.				1.60	V
I_{DRM} I_{RRM}	$V_{DRM} = V_{RRM}$	MAX.	Lx01Ey / LxNy	T_J = 25°C	400-600V	2	µA
				T_J = 110°C	400-600V	0.1	mA
			Qx01Ey / QxNy	T_J = 25°C	400-600V	5	µA
				T_J = 125°C	400-600V	1	mA

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	L/Qx01Ey	50	°C/W
		L/QxNy	40*	
$R_{\theta(J\text{-}A)}$	Junction to ambient	L/Qx01Ey	95	°C/W

Note: * = Mounted on 1 cm² copper (two-ounce) foil surface

Figure 1: Definition of Quadrants

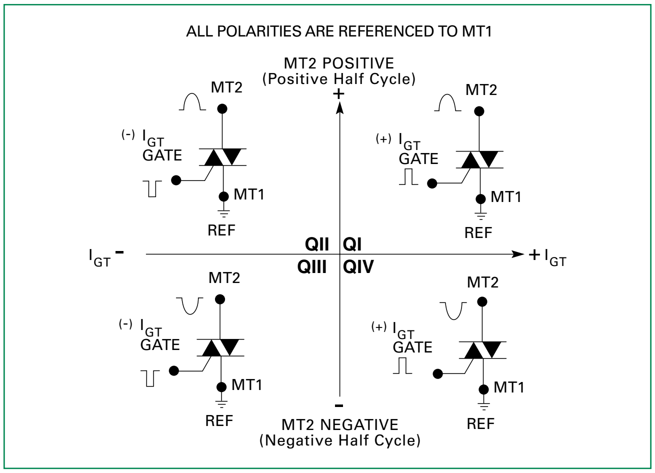


Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

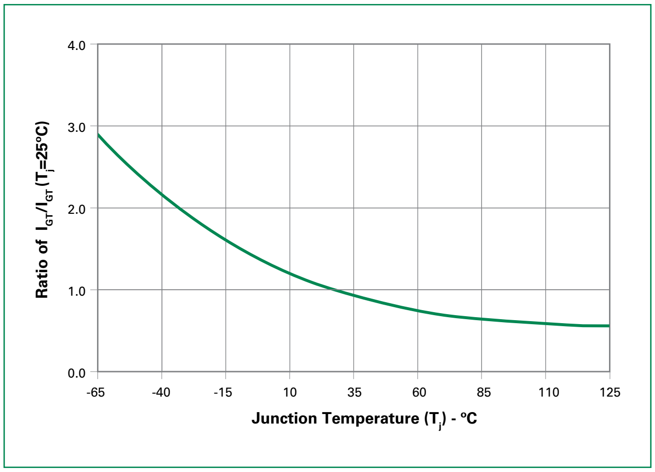


Figure 3: Normalized DC Holding Current vs. Junction Temperature

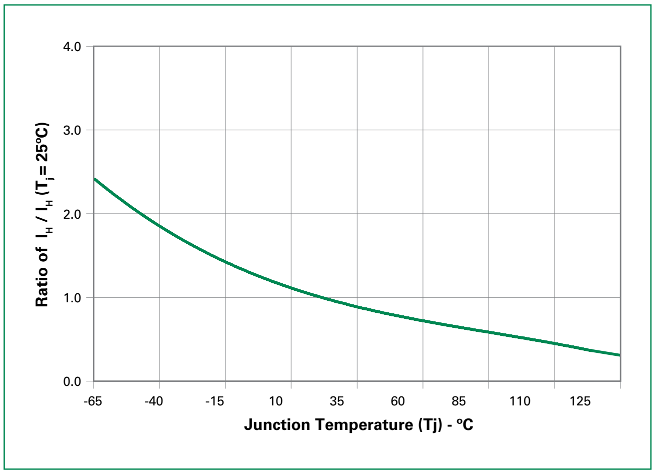


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

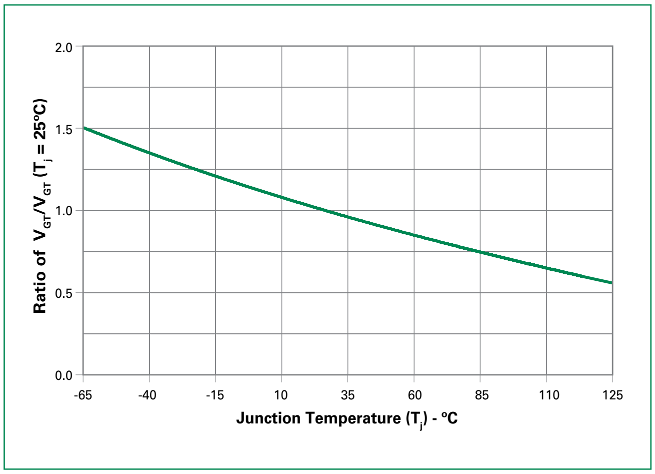


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

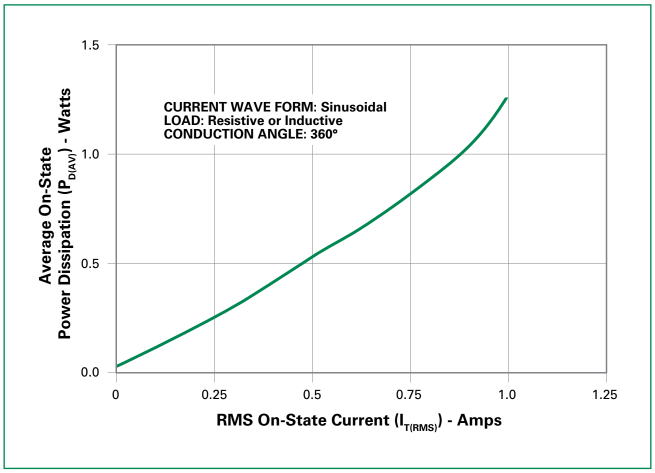


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

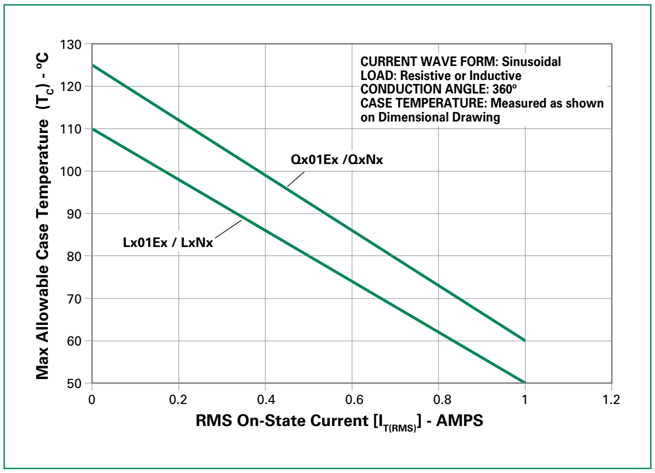


Figure 7: Maximum Allowable Ambient Temperature vs. On-State Current

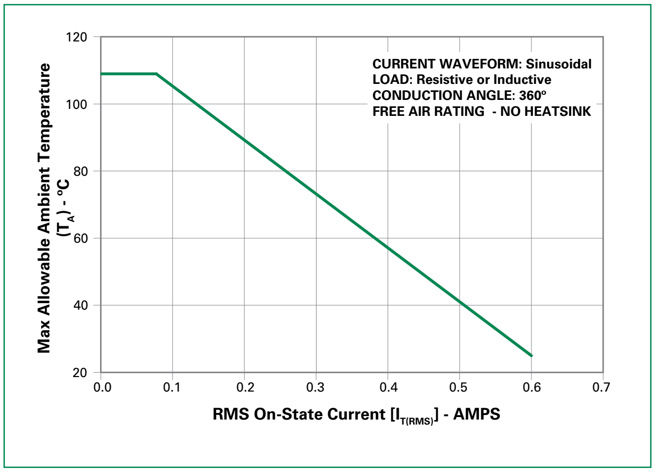


Figure 8: On-State Current vs. On-State Voltage (Typical)

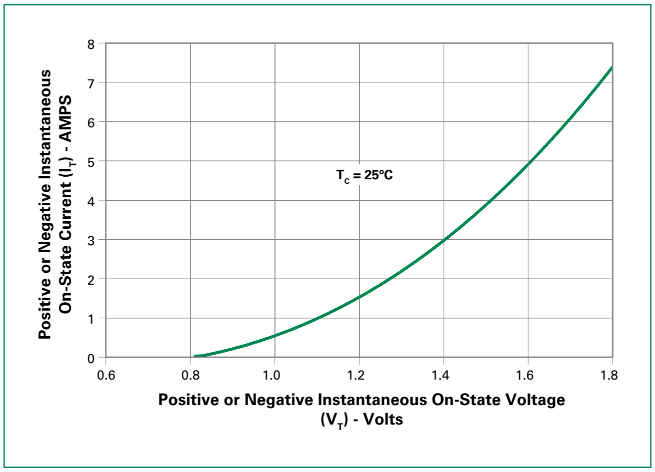
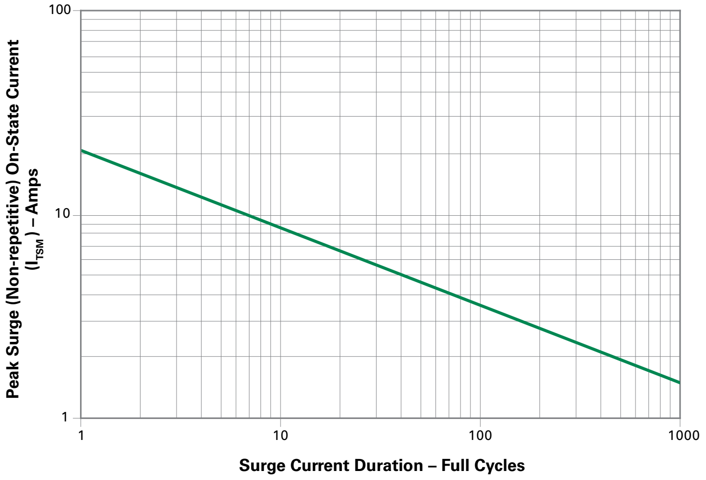


Figure 9: Surge Peak On-State Current vs. Number of Cycles



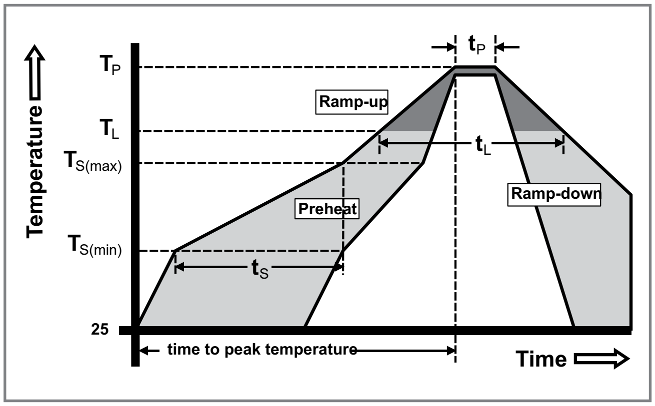
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

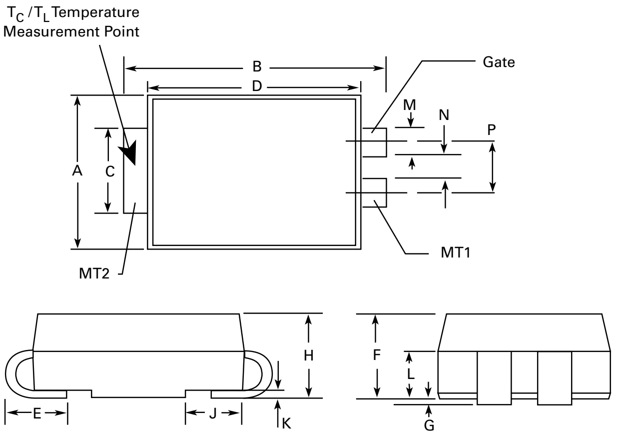
Design Considerations

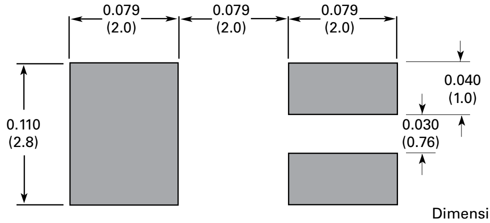
Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Dimensions - Compak (C Package)



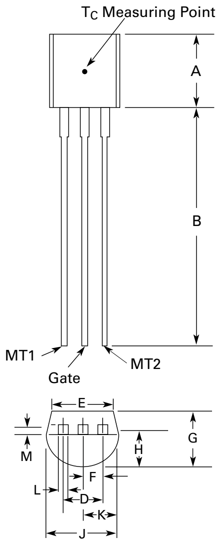


Dimensions are in inches (and millimeters).

Pad Outline

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
J	0.043	0.053	1.09	1.35
K	0.006	0.016	0.15	0.41
L	0.030	0.055	0.76	1.40
M	0.022	0.028	0.56	0.71
N	0.027	0.033	0.69	0.84
P	0.052	0.058	1.32	1.47

Dimensions - TO-92 (E Package)



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500	-	12.70	-
D	0.095	0.105	2.41	2.67
E	0.150	-	3.81	-
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43

All leads insulated from case. Case is electrically nonconductive.

Product Selector

Part Number	Voltage		Gate Sensitivity Quadrants		Type	Package
	400V	600V	I – II – III	IV		
Lx01E3	X	X	3 mA	3 mA	Sensitive Triac	TO-92
LxN3	X	X	3 mA	3 mA	Sensitive Triac	Compak
Lx01E5	X	X	5 mA	5 mA	Sensitive Triac	TO-92
LxN5	X	X	5 mA	5 mA	Sensitive Triac	Compak
Lx01E6	X	X	5 mA	10 mA	Sensitive Triac	TO-92
Lx01E8	X	X	10 mA	20 mA	Sensitive Triac	TO-92
Qx01E3	X	X	10 mA		Standard Triac	TO-92
QxN3	X	X	10 mA		Standard Triac	Compak
Qx01E4	X	X	25 mA		Standard Triac	TO-92
QxN4	X	X	25 mA		Standard Triac	Compak

Note: x- voltage

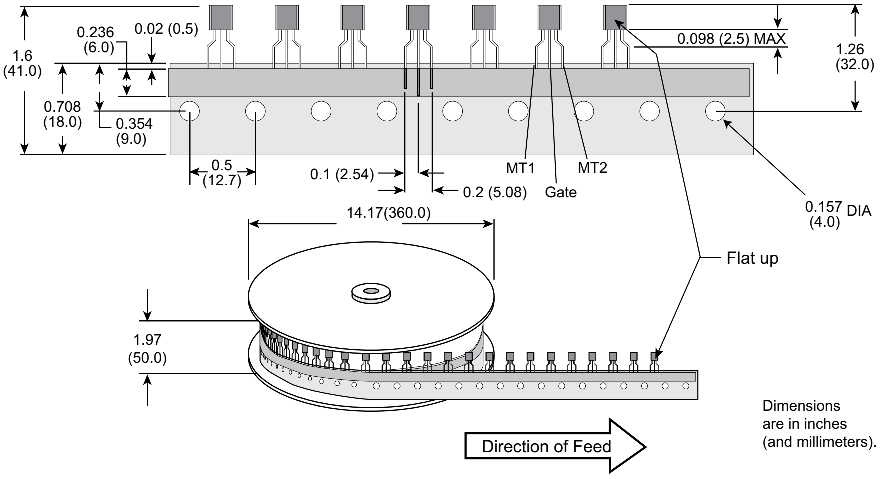
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
L/Qx01Ey	L/Qx01Ey	0.188 g	Bulk	2000
L/Qx01EyRP	L/Qx01Ey	0.188 g	Reel Pack	2000
L/Qx01EyAP	L/Qx01Ey	0.188 g	Ammo Pack	2000
L/QxNyRP	L/QxNy	0.081 g	Embossed Carrier	2500

Note: x = Voltage; y = Sensitivity

TO-92 (3-lead) Reel Pack (RP) Radial Leaded

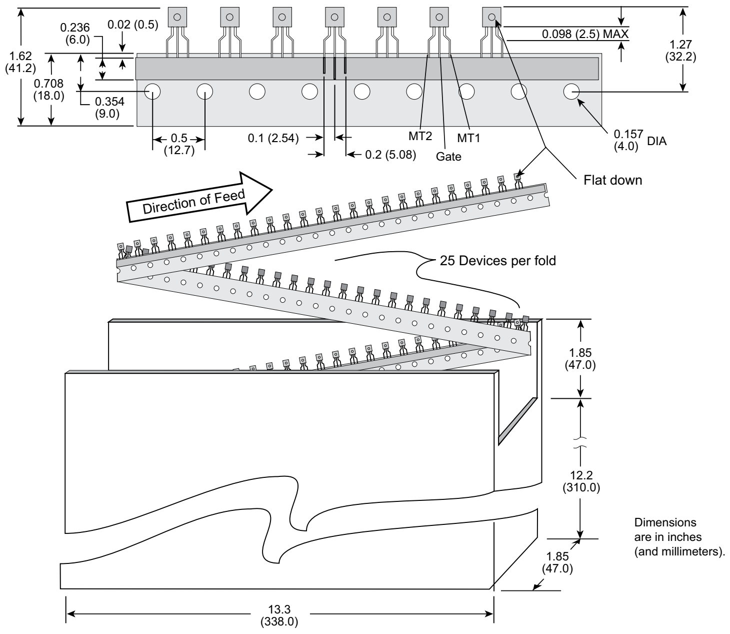
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

TO-92 (3-lead) Ammo Pack (AP) Radial Leaded

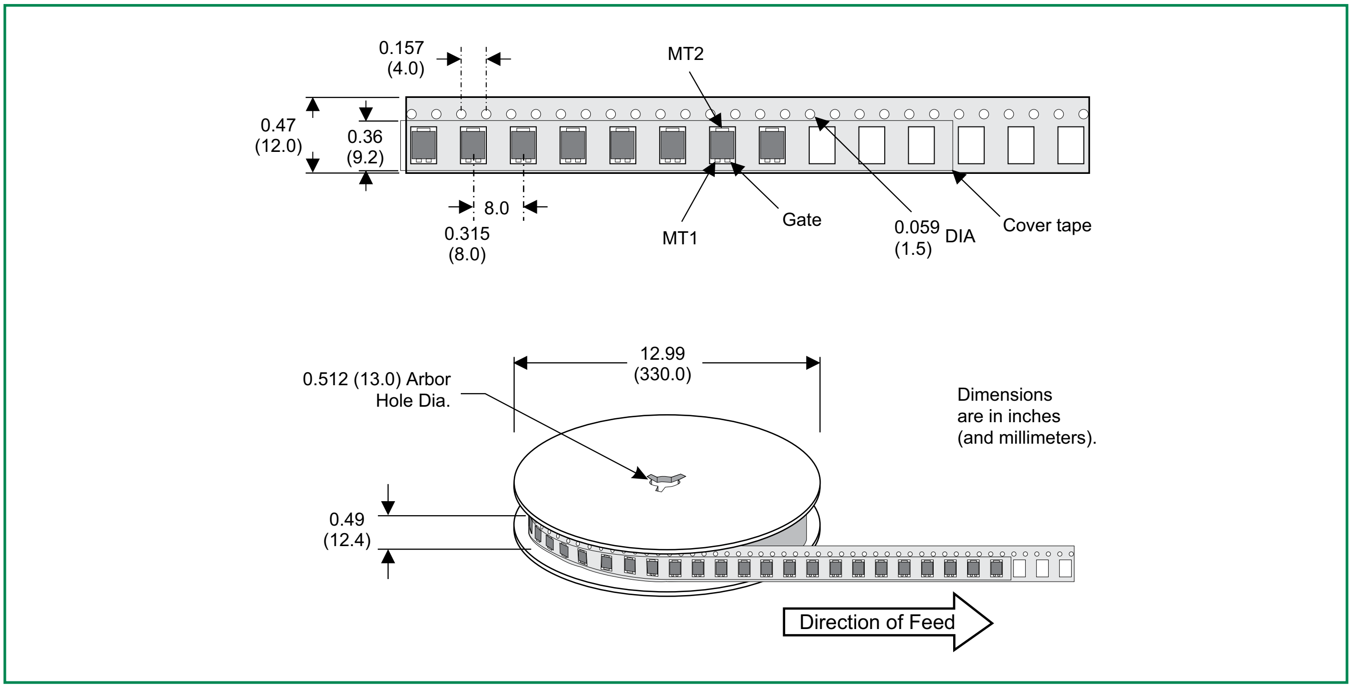
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

Compak Embossed Carrier Reel Pack (RP)

Meets all EIA-481-1 Standards



Part Numbering System

L 4 01 E 3

DEVICE TYPE
- **L** : Sensitive Triac
- **Q** : Triac

VOLTAGE RATING
- **4** : 400V
- **6** : 600V

CURRENT RATING
- **01** : 1.0A (TO-92)
- **N** : 1.0A (Compak)

SENSITIVITY & TYPE

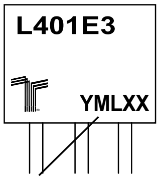
Sensitive Triac:
- **3** : 3 mA (QI, II, III, IV)
- **5** : 5 mA (QI, II, III, IV)
- **6** : 5 mA (QI, II, III)
  10 mA (QIV)
- **8** : 10 mA (QI, II, III)
  20 mA (QIV)

Standard Triac:
- **3** : 10 mA (QI, II, III)
- **4** : 25 mA (QI, II, III)

PACKAGE TYPE
- **Blank** : Compak (Surface Mount)
- **E** : TO-92

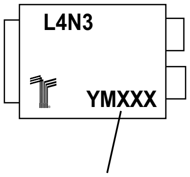
Part Marking System

TO-92 (E Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

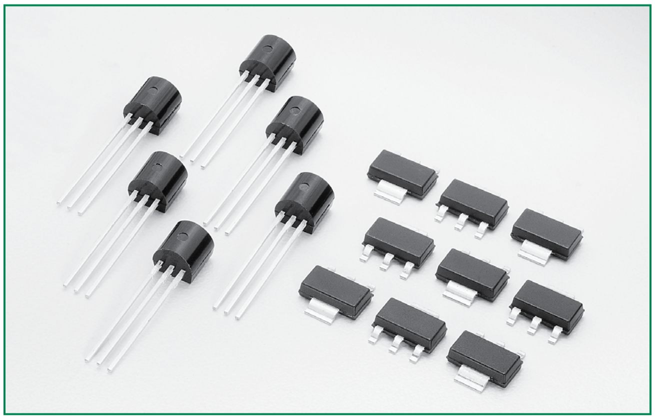
Compak (C Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

L01 Series

HF RoHS



Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	1	A
V_{DRM}/V_{RRM}	400 to 800	V
I_{GT}	3 to 10	mA

Additional Information

Datasheet

Resources

Samples

Description

New 1 Amp bi-directional solid state switch series offering direct interface to microprocessor drivers in economical TO-92 and surface mount packages. The die voltage blocking junctions are glass-passivated to ensure long term reliability and parametric stability.

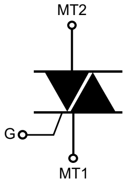
Features

- RoHS compliant and Halogen-Free
- Blocking voltage (V_{DRM}) capability — up to 800V
- Surge capability > 10Amps
- Static dv/dt > 20 Volts/µsec
- Thru hole and surface mount packages

Applications

The L01 EV Series is especially designed for white goods applications such as valve controls in washing machines as well as replacement of mechanical and hybrid relays where long life is required.

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	TO-92	T_C = 50°C	1.0A	A
		SOT-223	T_L = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (Single cycle, T_J initial = 25°C)	TO-92 SOT-223	F = 50 Hz	10	A
			F = 60 Hz	12	
I^2t	I^2t Value for fusing	t_p = 10 ms	F = 50 Hz	0.50	A^2s
		t_p = 8.3 ms	F = 60 Hz	0.59	
di/dt	Critical rate of rise of on-state current $I_G = 2 \times I_{GT}$	TO-92 SOT-223	T_J = 125°C	20	A/µs
I_{GTM}	Peak gate current	t_p = 10 µs	T_J = 125°C	1	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.1	W
T_{stg}	Storage junction temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Quadrant	Limit	Value			Unit
					L0103xy	L0107xy	L0109xy	
I_{GT}	DC Gate Trigger Current	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX.	3 5	5 7	10 10	mA
V_{GT}	DC Gate Trigger Voltage		ALL	MAX.	—	1.3	—	V
I_H	Holding Current	Gate Open		MAX.	7	10	10	mA
dv/dt	Critical Rate-of-Rise of Off-State Voltage	T_J = 110°C V_D = V_{DRM} Exponential Waveform Gate Open		MIN.	10	20	50	V/µs
(dv/dt)c	Critical Rate-of-Rise of Commutating Voltage	(di/dt)c = 0.54A/ms T_J = 110°C		MIN.	0.5	1.0	2.0	V/µs
T_{gt}	Turn-On Time	I_G = 25mA PW = 15µs I_T = 1.2A (pk)		MAX.	2.0	2.0	2.0	µs

Note: x = voltage, y = package

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Limit	Value	Unit
V_{TM}	Peak On-State Voltage	I_{TM} = 1.4A (pk)	MAX	1.60	V
I_{DRM}	Off-State Current, Peak Repetitive	V_D= V_{DRM} T_J = 25°C	MAX	5	µA
		V_D= V_{DRM} T_J = 125°C		500	µA

Thermal Resistances

Symbol	Description	Test Conditions		Value	Unit
$R_{th(j-c)}$	Junction to case (AC)	I_T = 1.0A $_{(RMS)}$ [1]	TO-92	50	°C/W
			SOT-223	23	
$R_{th(j-a)}$	Junction to ambient	I_T = 1.0A $_{(RMS)}$ [1]	TO-92	100	°C/W
			SOT-223	55	

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[1] 60Hz AC resistive load condition, 100% conduction.

Figure 1: Definition of Quadrants

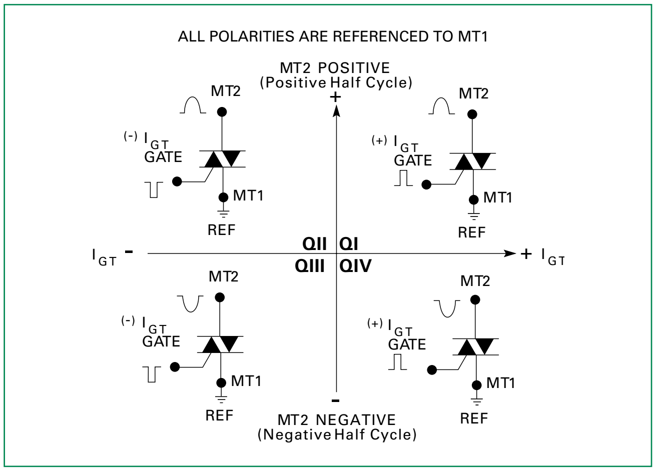


Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

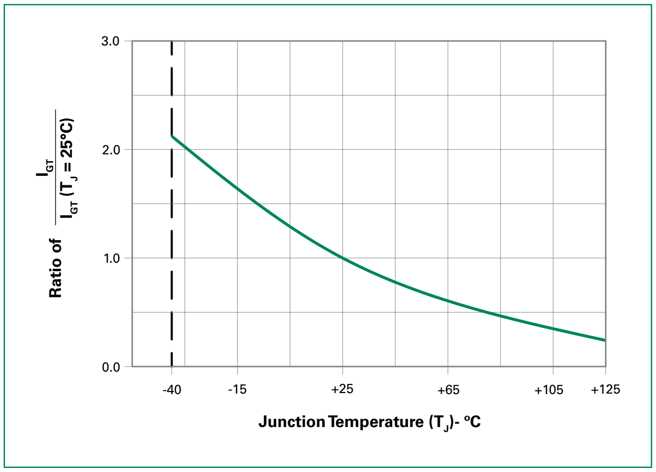


Figure 3: Normalized DC Holding Current vs. Junction Temperature

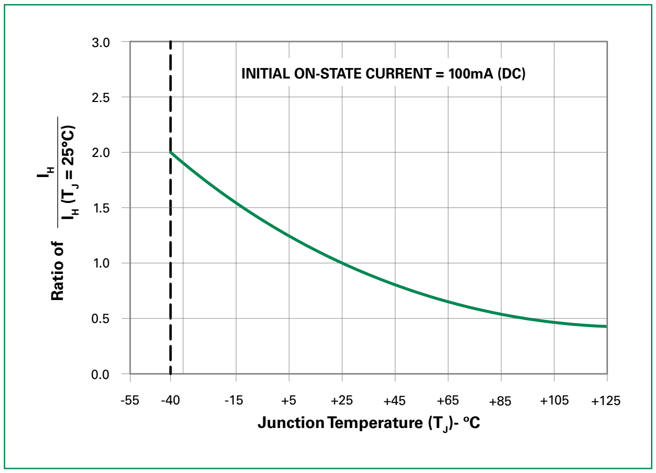


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

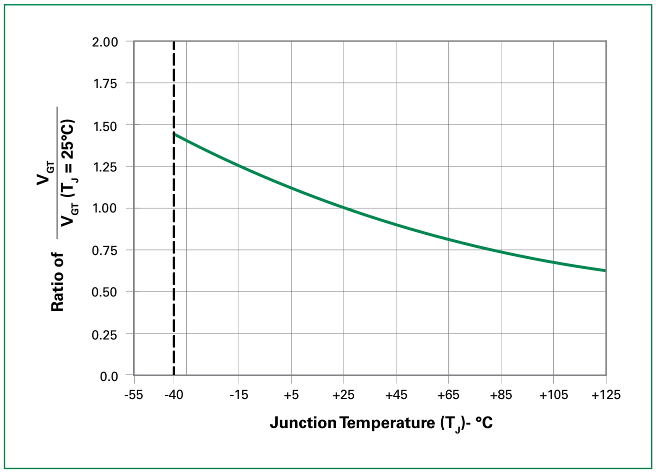


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

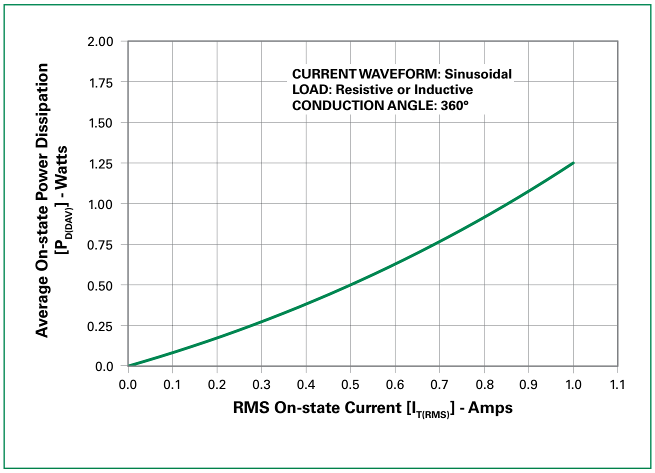


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

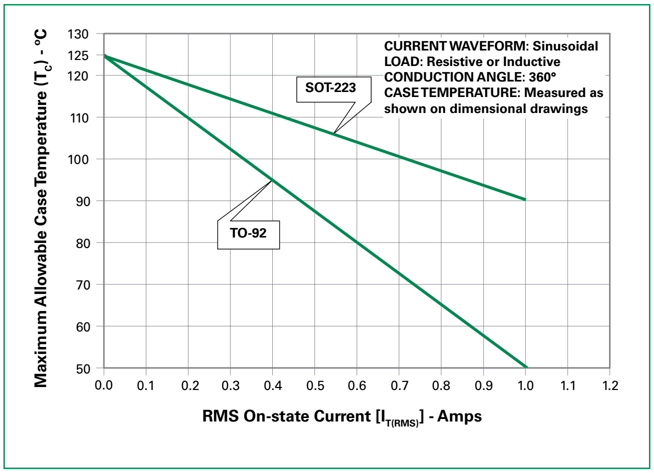
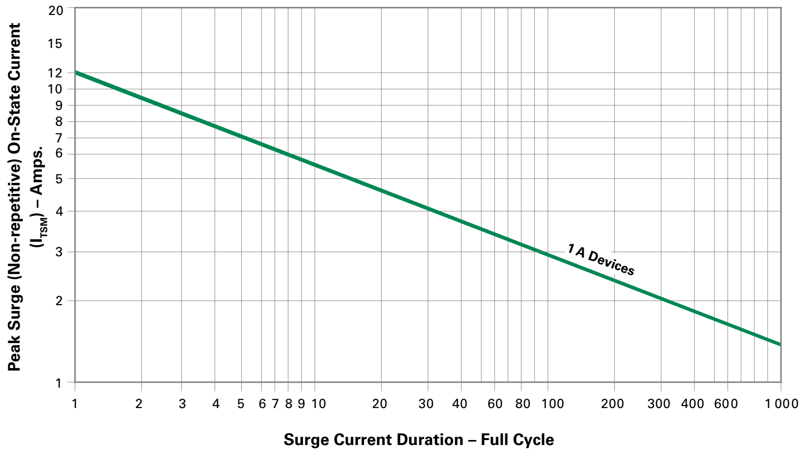


Figure 7: Surge Peak On-State Current vs. Number of Cycles

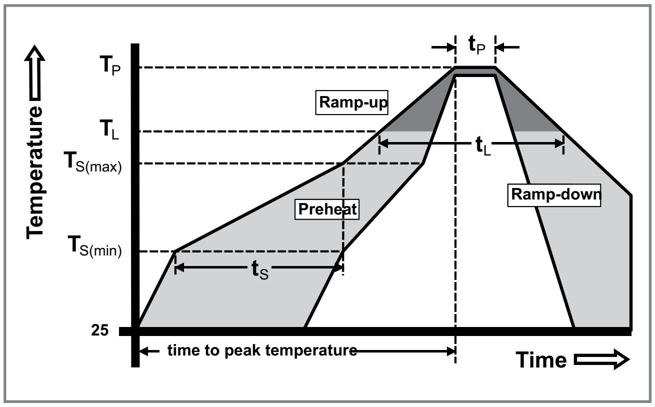


Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.
Lead Material	Copper Alloy

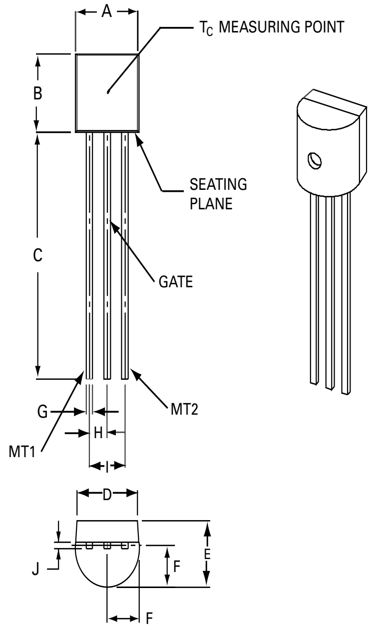
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

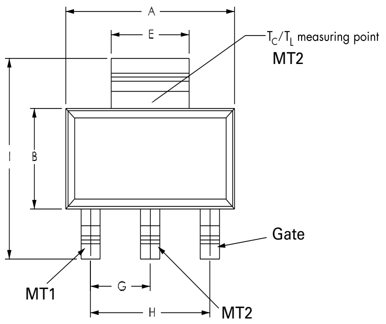
Dimensions — TO-92 (E Package)

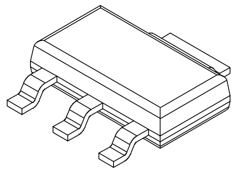


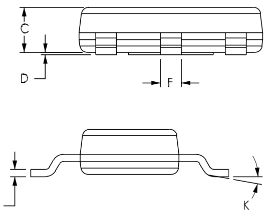
Dimensions	Inches		Millimeters	
	Min	Max	Min	Max
A	0.175	0.205	4.450	5.200
B	0.170	0.210	4.320	5.330
C	0.500		12.70	
D	0.135		3.430	
E	0.125	0.165	3.180	4.190
F	0.080	0.105	2.040	2.660
G	0.016	0.021	0.407	0.533
H	0.045	0.055	1.150	1.390
I	0.095	0.105	2.420	2.660
J	0.015	0.020	0.380	0.500

Revised: 12/14/14

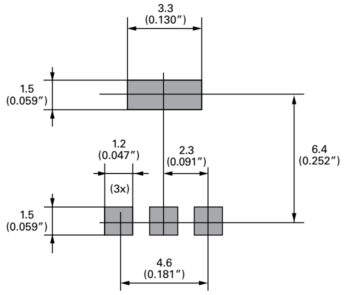
Dimensions – SOT-223







Pad Layout for SOT-223



Dimensions in Millimeters (Inches)

Dimensions	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.248	0.256	0.264	6.30	6.50	6.70
B	0.130	0.138	0.146	3.30	3.50	3.70
C	—	—	0.071	—	—	1.80
D	0.001	—	0.004	0.02	—	0.10
E	0.114	0.118	0.124	2.90	3.00	3.15
F	0.024	0.027	0.034	0.60	0.70	0.85
G	—	0.090	—	—	2.30	—
H	—	0.181	—	—	4.60	—
I	0.264	0.276	0.287	6.70	7.00	7.30
J	0.009	0.010	0.014	0.24	0.26	0.35
K	10° MAX					

Product Selector

Part Number	Voltage	Gate Sensitivity Quadrants		Package
		I II III	IV	
L0103DE	400 V	3 mA	5 mA	TO-92
L0103ME	600 V	3 mA	5 mA	TO-92
L0103NE	800 V	3 mA	5 mA	TO-92
L0103DT	400 V	3 mA	5 mA	SOT-223
L0103MT	600 V	3 mA	5 mA	SOT-223
L0103NT	800 V	3 mA	5 mA	SOT-223
L0107DE	400 V	5 mA	7 mA	TO-92
L0107ME	600 V	5 mA	7 mA	TO-92
L0107NE	800 V	5 mA	7 mA	TO-92
L0107DT	400 V	5 mA	7 mA	SOT-223
L0107MT	600 V	5 mA	7 mA	SOT-233
L0107NT	800 V	5 mA	7 mA	SOT-233
L0109DE	400 V	10 mA	10 mA	TO-92
L0109ME	600 V	10 mA	10 mA	TO-92
L0109NE	800 V	10 mA	10 mA	TO-92
L0109DT	400 V	10 mA	10 mA	SOT-223
L0109MT	600 V	10 mA	10 mA	SOT-223
L0109NT	800 V	10 mA	10 mA	SOT-223

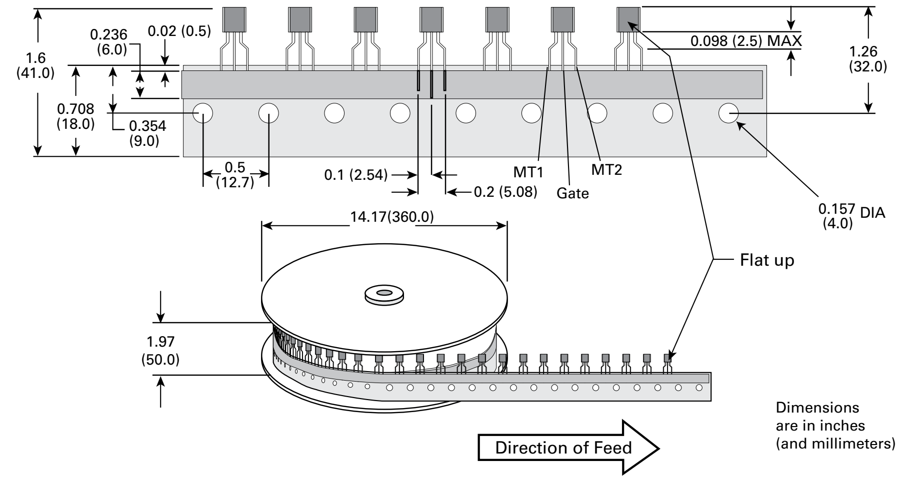
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
L01xxyE	L01xxyE	0.170 g	Bulk	2500
L01xxyEAP	L01xxyE	0.170 g	Ammo Pack	2000
L01xxyERP	L01xxyE	0.170 g	Tape & Reel	2000
L01xxyTRP	L01xxyT	0.120 g	Tape & Reel	1000

Note: xx = gate sensitivity, y = voltage

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

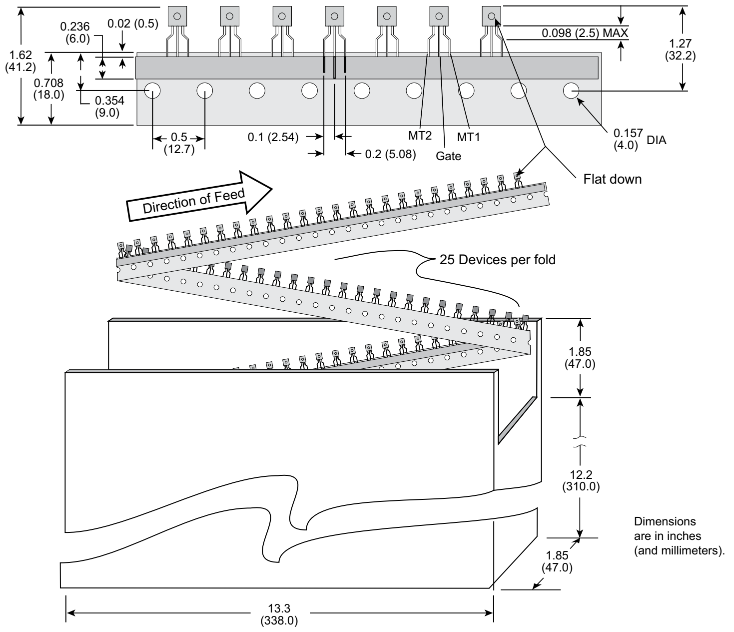
Meets all EIA-468-C Standards



Dimensions are in inches (and millimeters).

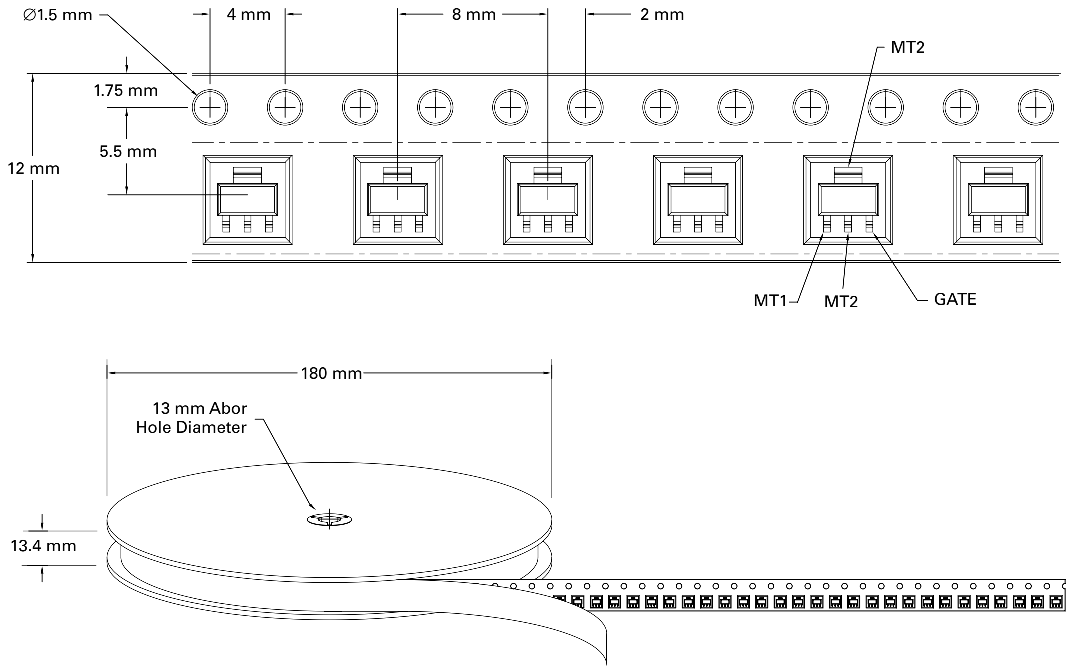
TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards



Dimensions are in inches (and millimeters).

SOT-223 Reel Pack (RP) Specifications



Part Numbering System

L 01 xx x xx xx

TRIAC SERIES

CURRENT
01: 1A

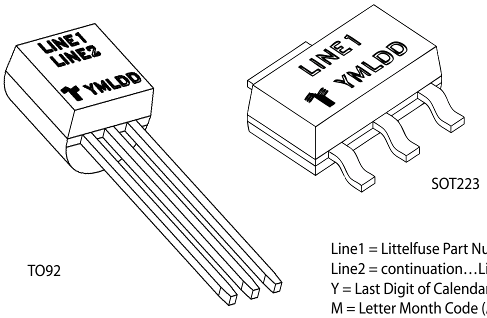
SENSITIVITY & TYPE
03: 3, 3, 3, 5mA Triac
07: 5, 5, 5, 7mA Triac
09: 10, 10, 10, 10mA Triac

VOLTAGE
D: 400V
M: 600V
N: 800V

PACKAGE TYPE
E: TO-92
T: SOT-223

PACKING TYPE
Blank: Bulk Pack
RP : Reel Pack (TO-92)
: Embossed Carrier Pack (SOT-223)
AP : Ammo Pack (TO-92)

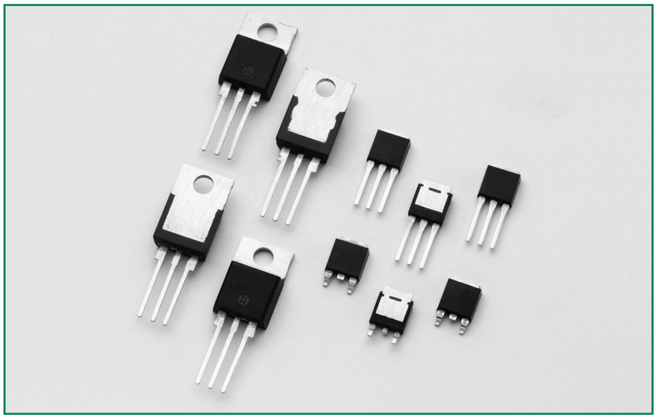
Part Marking System



Line1 = Littelfuse Part Number
Line2 = continuation…Littelfuse Part Number
Y = Last Digit of Calendar Year
M = Letter Month Code (A-L for Jan-Dec)
L = Location Code
DD = Calendar Date

Lxx04xx & Qxx04xx Series

RoHS



Description

4 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Sensitive type devices guarantee gate control in Quadrants I & IV needed for digital control circuitry.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

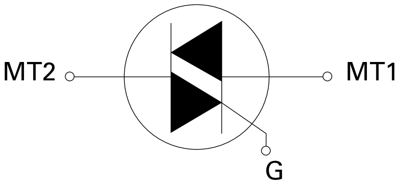
Agency Approval

Agency	Agency File Number
UL	L Package : E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	4	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	3 to 25	mA

Schematic Symbol



Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 55 A
- Electrically isolated "L-Package" is UL recognized for 2500Vrms
- Solid-state switching eliminates arcing or contact bounce that create voltage transients
- No contacts to wear out from reaction of switching events
- Restricted (or limited) RFI generation, depending on activation point of sine wave
- Requires only a small gate activation pulse in each half-cycle

Applications

Typical applications are AC solid-state switches, power tools, home/brown goods and white goods appliances.

Sensitive gate Triacs can be directly driven by microprocessor or popular opto-couplers/isolators.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Absolute Maximum Ratings — Sensitive Triacs (4 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Lxx04Ly / Lxx04Dy	T_C = 85°C	4	A
		Lxx04Ry / Lxx04Vy	T_C = 75°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	33	A
		f = 60 Hz	t = 16.7 ms	40	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		6.6	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 50mA with ≤ 0.1μs rise time)	f = 120 Hz	T_J = 110°C	50	A/μs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ μs	T_J = 110°C	1.2	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.3	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Standard Triacs

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx04Ly / Qxx04Dy	T_C = 95°C	4	A
		Qxx04Ry / Qxx04Vy	T_C = 85°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	46	A
		f = 60 Hz	t = 16.7 ms	55	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		12.5	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 50mA with ≤ 0.1μs rise time)	f = 120 Hz	T_J = 125°C	50	A/μs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ μs; $I_{GT} \leq I_{GTM}$	T_J = 125°C	1.2	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.3	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Sensitive Triac (4 Quadrants)

Symbol	Test Conditions	Quadrant		Lxx04x3	Lxx04x5	Lxx04x6	Lxx04x8	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	3	5	5	10	mA
		IV		3	5	10	20	
V_{GT}		ALL	MAX.	1.3				V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	ALL	MIN.	0.2				V
I_H	I_T = 100mA		MAX.	5	10	10	15	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 100°C	400V	TYP.	25	25	30	35	V/μs
		600V		15	15	20	25	
(dv/dt)c	(di/dt)c = 2.16 A/ms T_J = 110°C		TYP.	0.5	1	1	1	V/μs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15μs I_T = 5.6 A(pk)		TYP.	2.8	3.0	3.0	3.2	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Qxx04x3	Qxx04x4	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	25	mA
		IV	TYP.	25	50	
V_{GT}		I – II – III	MAX.	1.3	1.3	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	ALL	MIN.	0.2	0.2	V
I_H	I_T = 200mA		MAX.	20	30	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	40	75	V/μs
		600V		30	50	
		800V			40	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V			50	
(dv/dt)c	(di/dt)c = 2.16 A/ms T_J = 125°C		TYP.	2	2	V/μs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15μs I_T = 5.6 A(pk)		TYP.	2.5	3.0	μs

Note: xx = voltage, x = package

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions					Value	Unit
V_{TM}	I_{TM} = 5.6A t_p = 380 µs	MAX.				1.60	V
I_{DRM} I_{RRM}	$V_{DRM} = V_{RRM}$	MAX.	Lxx04xy	T_J = 25°C	400-600V	5	µA
				T_J = 110°C	400-600V	200	µA
			Qxx04xy	T_J = 25°C	400-1000V	10	µA
				T_J = 125°C	400-800V	2	mA
				T_J = 100°C	1000V	3	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	L/Qxx04Dy	3.5	°C/W
		L/Qxx04Ly	3.6	
		L/Qxx04Ry	3.6	
		L/Qxx04Vy	6.0	
$R_{\theta(J\text{-}A)}$	Junction to ambient	L/Qxx04Ly	50	°C/W
		L/Qxx04Ry	45	
		L/Qxx04Vy	70	

Note: xx = voltage, x = package, y = sensitivity

Figure 1: Definition of Quadrants

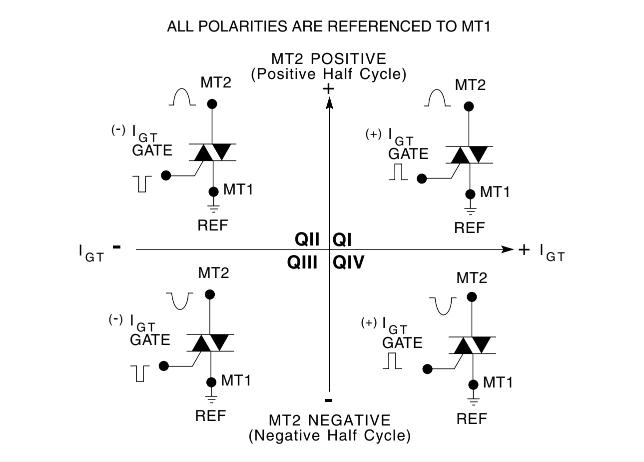
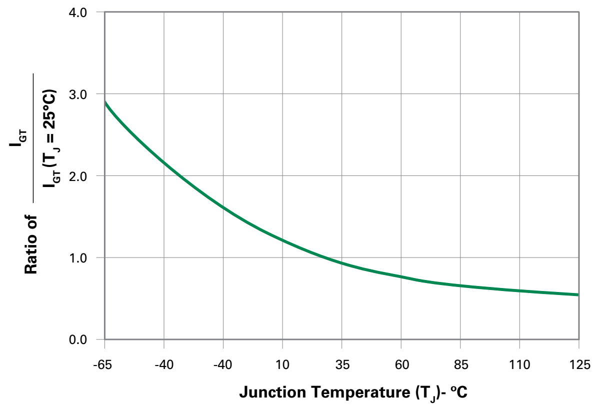


Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature



Additional Information

Datasheet

Resources

Samples

Revised: 12/14/14

Figure 3: Normalized DC Holding Current vs. Junction Temperature

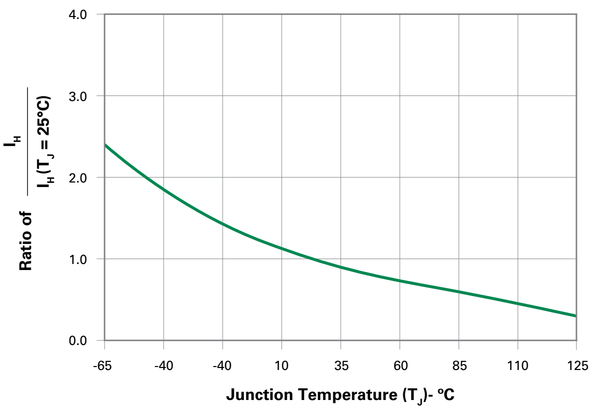


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

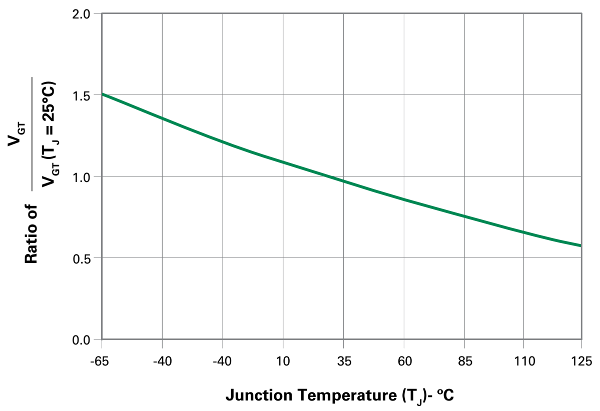


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

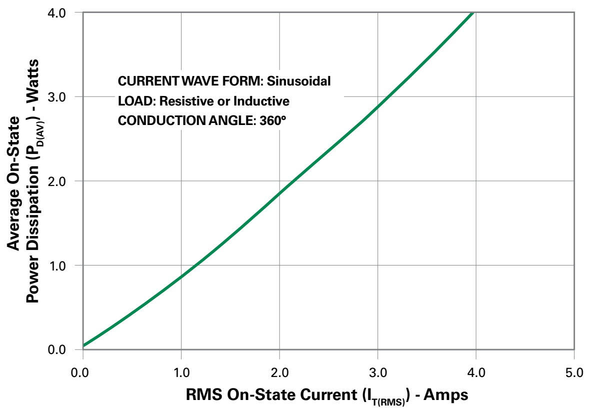


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

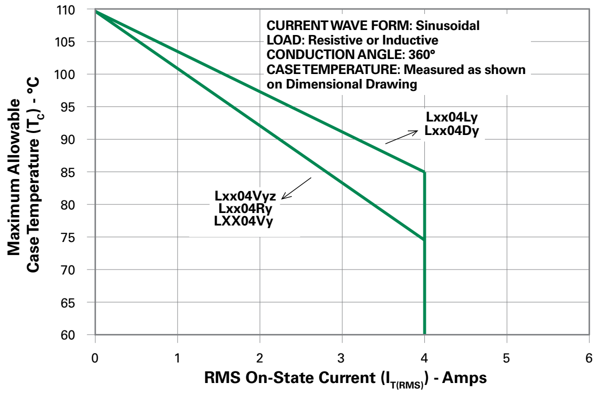
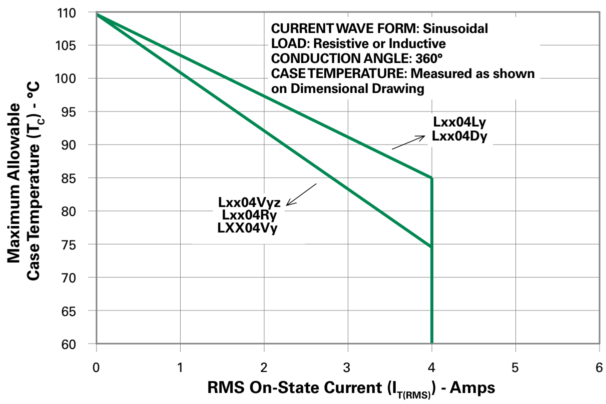


Figure 7: Maximum Allowable Case Temperature vs. On-State Current



Note: xx = voltage, y = sensitivity

Figure 8: Maximum Allowable Ambient Temperature vs. On-State Current

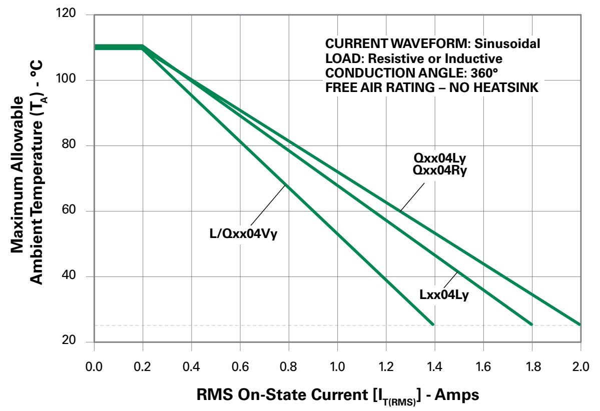


Figure 9: On-State Current vs. On-State Voltage (Typical)

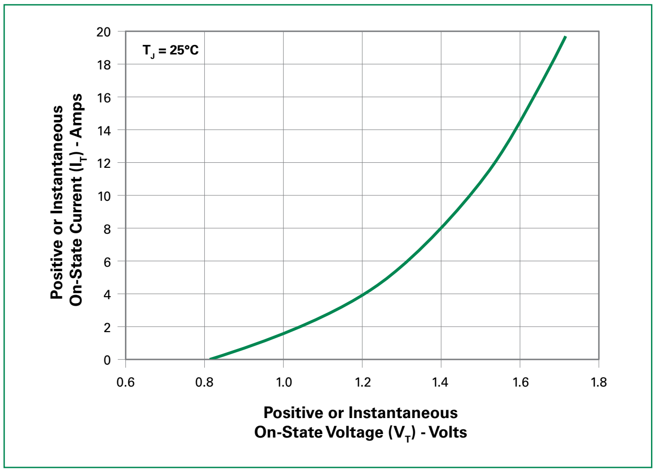
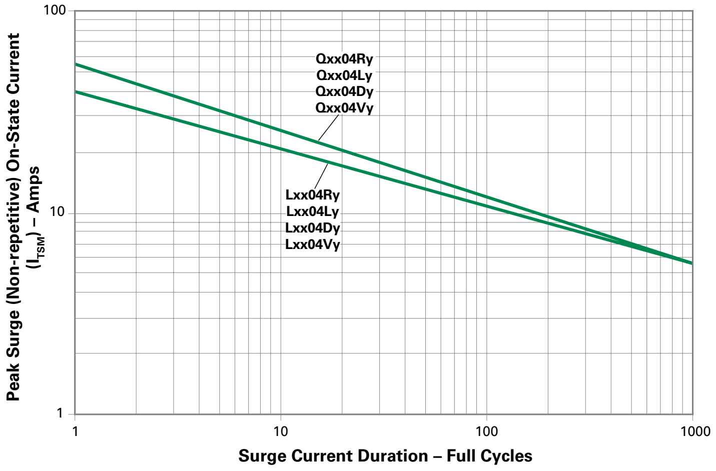


Figure 10: Surge Peak On-State Current vs. Number of Cycles



Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

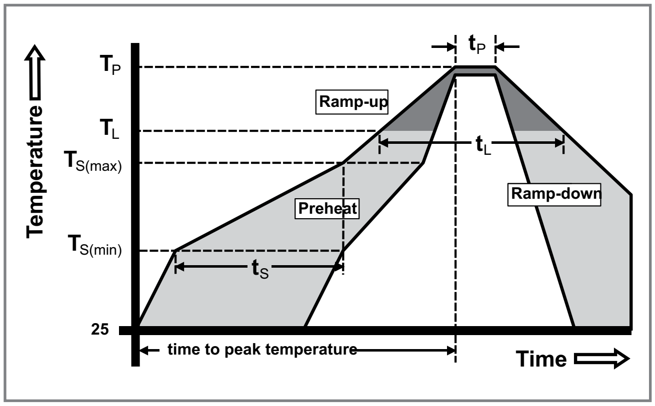
Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = voltage, y = sensitivity

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		260°C $^{+0/-5}$
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

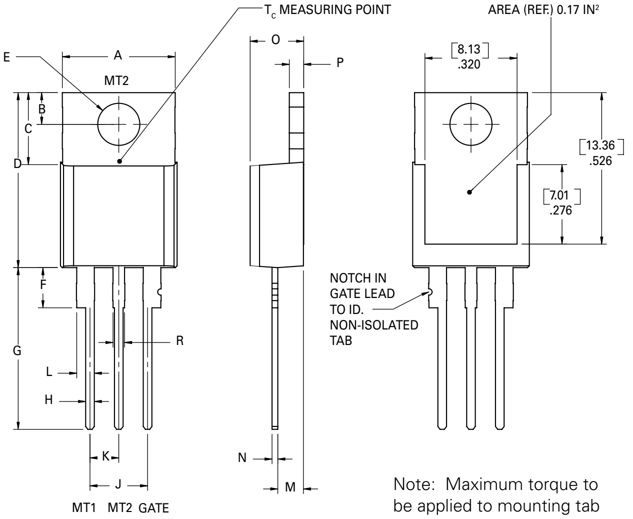
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

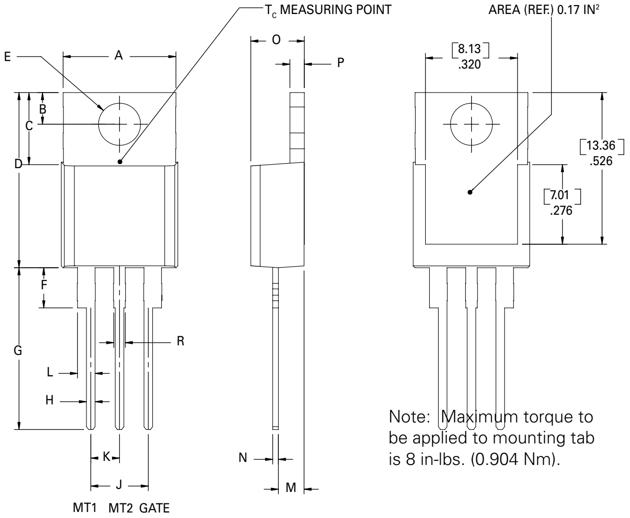
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

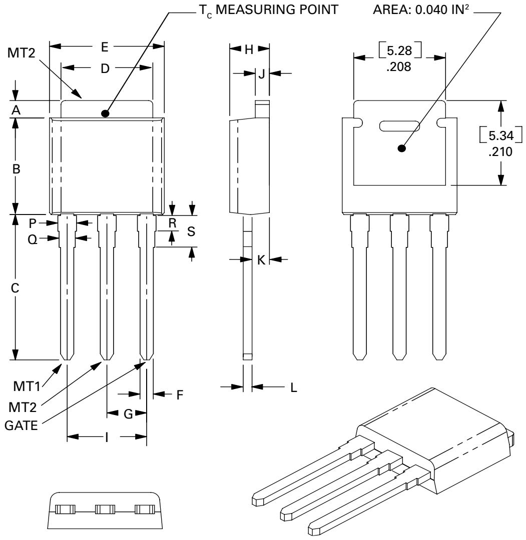
Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

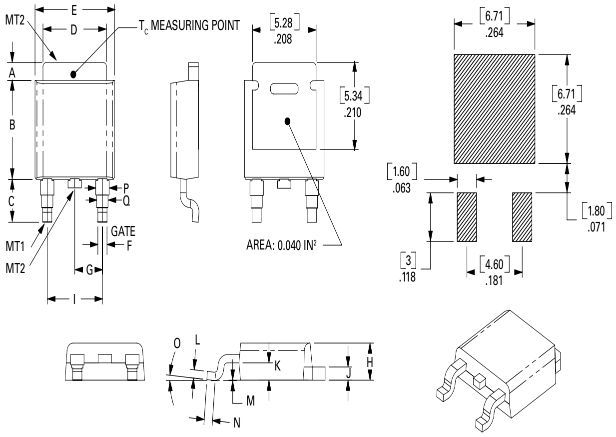
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-251AA (V-Package) — V-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Product Selector

Part Number	Voltage				Gate Sensitivity Quadrants		Type	Package
	400V	600V	800V	1000V	I – II – III	IV		
Lxx04L3	X	X			3 mA	3 mA	Sensitive Triac	TO-220L
Lxx04D3	X	X			3 mA	3 mA	Sensitive Triac	TO-252 D-PAK
Lxx04R3	X	X			3mA	3mA	Sensitive Triac	TO-220R
Lxx04V3	X	X			3 mA	3 mA	Sensitive Triac	TO-251 V-PAK
Lxx04L5	X	X			5 mA	5 mA	Sensitive Triac	TO-220L
Lxx04D5	X	X			5 mA	5 mA	Sensitive Triac	TO-252 D-PAK
Lxx04R5	X	X			5mA	5mA	Sensitive Triac	TO-220R
Lxx04V5	X	X			5 mA	5 mA	Sensitive Triac	TO-251 V-PAK
Lxx04L6	X	X			5 mA	10 mA	Sensitive Triac	TO-220L
Lxx04D6	X	X			5 mA	10 mA	Sensitive Triac	TO-252 D-PAK
Lxx04R6	X	X			5mA	10mA	Sensitive Triac	TO-220R
Lxx04V6	X	X			5 mA	10 mA	Sensitive Triac	TO-251 V-PAK
Lxx04L8	X	X			10 mA	20 mA	Sensitive Triac	TO-220L
Lxx04D8	X	X			10 mA	20 mA	Sensitive Triac	TO-252 D-PAK
Lxx04R8	X	X			10mA	20mA	Sensitive Triac	TO-220R
Lxx04V8	X	X			10 mA	20 mA	Sensitive Triac	TO-251 V-PAK
Qxx04L3	X	X			10 mA		Standard Triac	TO-220L
Qxx04D3	X	X			10 mA		Standard Triac	TO-252 D-PAK
Qxx04V3	X	X			10 mA		Standard Triac	TO-251 V-PAK
Qxx04R3	X	X			10mA		Standard Triac	TO-220R
Qxx04L4	X	X	X	X	25 mA		Standard Triac	TO-220L
Qxx04D4	X	X	X	X	25 mA		Standard Triac	TO-252 D-PAK
Qxx04R4	X	X	X	X	25mA		Standard Triac	TO-220R
Qxx04V4	X	X	X	X	25 mA		Standard Triac	TO-251 V-PAK

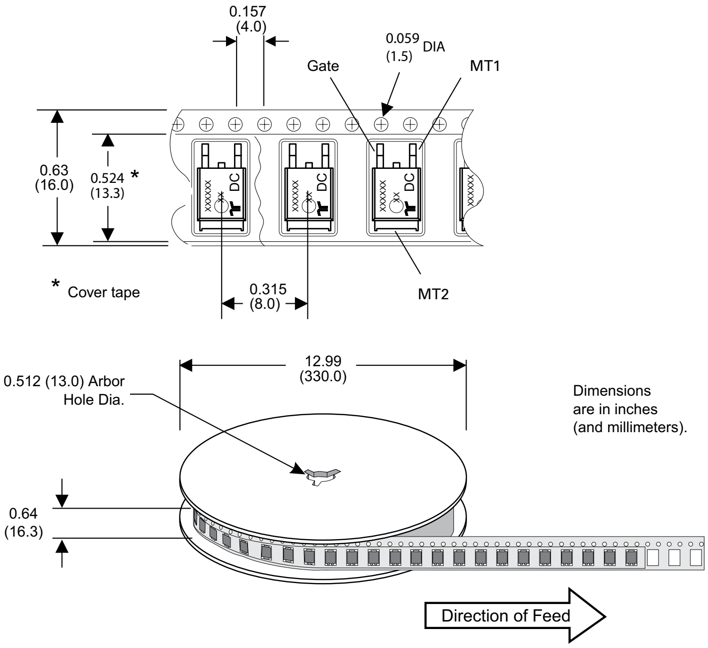
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
L/Q004L/Ry/TP	L/Qxx04L/Ry	2.2 g	Bulk	500
L/Qxx04LyTP	L/Qxx04Ly	2.2 g	Tube	500 (50 per tube)
L/Qxx04DyRP	L/Qxx04Dy	0.3 g	Embossed Carrier	2500
L/Qxx04DyTP	L/Qxx04Dy	0.3 g	Tube Pack	750 (75 per tube)
L/Qxx04VyTP	L/Qxx04Vy	0.4 g	Tube Pack	750 (75 per tube)

Note: xx = Voltage; y = Sensitivity

TO-252 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System

Q 60 04 L 4 xx

DEVICE TYPE
L : Sensitive Triac
Q : Standard Triac

VOLTAGE RATING
40 : 400V
60 : 600V
80 : 800V
K0 : 1000V

CURRENT RATING
04 : 4A

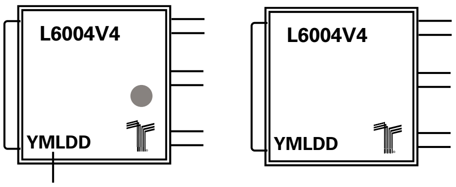
LEAD FORM DIMENSIONS
xx : Lead Form Option

SENSITIVITY & TYPE
Sensitive Triac:
3 : 3 mA (QI, II, III, IV)
5 : 5 mA (QI, II, III, IV)
6 : 5 mA (QI, II, III)
10 mA (QIV)
8 : 10 mA (QI, II, III)
20 mA (QIV)
Standard Triac:
3 : 10 mA (QI, II, III)
4 : 25 mA (QI, II, III)

PACKAGE TYPE
L :TO-220 Isolated
R :TO-220 Non-Isolated
V :TO-251 (V-Pak)
D :TO-252 (D-Pak)

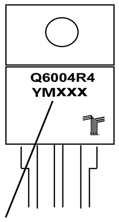
Part Marking System

TO-251AA- (V Package)
TO-252AA- (D Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

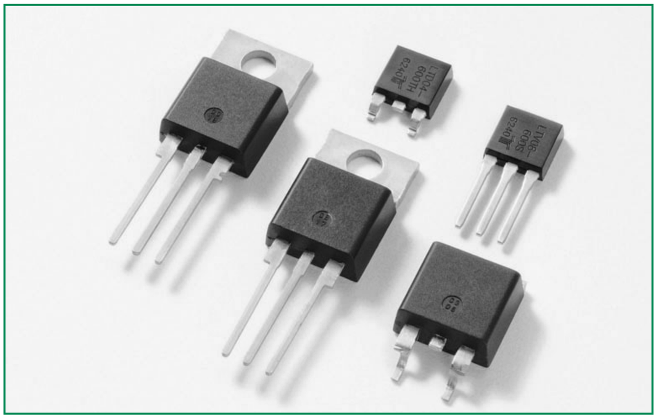
TO-220 AB - (L and R Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Lxx06xx & Qxx06xx & Qxx06xHx Series

RoHS



Description

6 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Sensitive type devices guarantee gate control in Quadrants I & IV needed for digital control circuitry.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Agency Approval

Agency	Agency File Number
UL	L Package: E71639

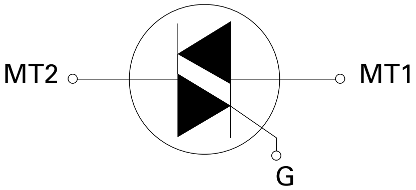
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	6	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	5 to 50	mA

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 85 A
- Electrically isolated "L - Package" is UL recognized for 2500Vrms
- Solid-state switching eliminates arcing or contact bounce that create voltage transients
- No contacts to wear out from reaction of switching events
- Restricted (or limited) RFI generation, depending on activation point of sine wave
- Requires only a small gate activation pulse in each half-cycle

Schematic Symbol



Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, light dimmers, power tools, home/brown goods and white goods appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Absolute Maximum Ratings — Sensitive Triac (4 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Lxx06Ly	T_C = 80°C	6	A
		Lxx06Vy / Lxx06Dy/ Lxx06Ry	T_C = 85°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	50	A
		f = 60 Hz	t = 16.7 ms	60	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		15	A^2s
di/dt	Critical rate of rise of on-state current I_G = 50mA with 0.1μs rise time	f = 120 Hz	T_J = 110°C	70	A/μs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ μs	T_J = 110°C	1.6	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.4	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Note: xx = voltage, y = sensitivity

Revised: 12/14/14

Absolute Maximum Ratings — Standard Triac

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx06Ry / Qxx06Ny	T_C = 95°C	6	A
		Qxx06Ly	T_C = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	65	A
		f = 60 Hz	t = 16.7 ms	80	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		26.5	A^2s
di/dt	Critical rate of rise of on-state current I_G = 200mA with 0.1µs rise time	f = 120 Hz	T_J = 125°C	70	A/µs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ µs; $I_{GT} \leq I_{GTM}$	T_J = 125°C	1.6	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Alternistor Triac (3 Quadrants)

Symbol	Parameter				Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx06LHy		T_C = 95°C	6	A
		Qxx06RHy / Qxx06NHy Qxx06VHy / Qxx06DHy		T_C = 100°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	Qxx06VHy Qxx06DHy	55	A
				Qxx06LHy Qxx06RHy Qxx06NHy	80	
		f = 60 Hz	t = 16.7 ms	Qxx06VHy Qxx06DHy	65	
				Qxx06LHy Qxx06RHy Qxx06NHy	85	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		Qxx06VHy Qxx06DHy	17.5	A^2s
				Qxx06LHy Qxx06RHy Qxx06NHy	30	
di/dt	Critical rate of rise of on-state current	f = 120 Hz		T_J = 125°C	70	A/µs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ µs; $I_{GT} \leq I_{GTM}$		T_J = 125°C	1.6	A
$P_{G(AV)}$	Average gate power dissipation			T_J = 125°C	0.5	W
T_{stg}	Storage temperature range				-40 to 150	°C
T_J	Operating junction temperature range				-40 to 125	°C

Note: xx = voltage, y = sensitivity

Additional Information

Datasheet | **Resources** | **Samples**

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Sensitive Triac (4 Quadrants)

Symbol	Test Conditions	Quadrant		Value			Unit
				Lxx06x5	Lxx06x6	Lxx06x8	
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX.	5 5	5 10	10 20	mA
V_{GT}		ALL	MAX.	1.3			V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 110°C	ALL	MIN.	0.2			V
I_H	I_T = 100mA		MAX.	10	10	20	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 100°C	400V	TYP.	30	30	40	V/μs
		600V		20	20	30	
(dv/dt)c	(di/dt)c = 3.2 A/ms T_J = 110°C		TYP.	1	2	2	V/μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 8.5 A(pk)		TYP.	3.0	3.0	3.2	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Value		Unit
				Qxx06x4	Qxx06x5	
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX. TYP.	25 50	50 75	mA
V_{GT}		I – II – III	MAX.	1.3		V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C	ALL	MIN.	0.2		V
I_H	I_T = 200mA		MAX.	50	50	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 125°C	400V	MIN.	120		V/μs
		600V			100	
		800V			85	
	V_D = V_{DRM} Gate Open T_J = 100°C	1000V			100	
(dv/dt)c	(di/dt)c = 3.2 A/ms T_J = 125°C		TYP.	4	4	V/μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 8.5 A(pk)		TYP.	3.0	3.0	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant			Value		Unit
					Qxx06xH3	Qxx06xH4	
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.		10	35	mA
V_{GT}		I – II – III	MAX.		1.3		V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.		0.2		V
I_H	I_T = 100mA		MAX.		15	35	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 125°C	Qxx06VHy / Qxx06DHy	MIN.	400V	75	400	V/μs
				600V	50	300	
				800V		200	
		Qxx06LHy / Qxx06RHy / Qxx06NHy		400V	75	450	
				600V	50	350	
				800V		250	
	V_D = V_{DRM} Gate Open T_J = 100°C	ALL		1000V		150	
(dv/dt)c	(di/dt)c = 3.2 A/ms T_J = 125°C		MIN.		20	25	V/μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 8.5 A(pk)		TYP.		4.0	4.0	μs

Note: xx = voltage, x = package, y = sensitivity

Static Characteristics

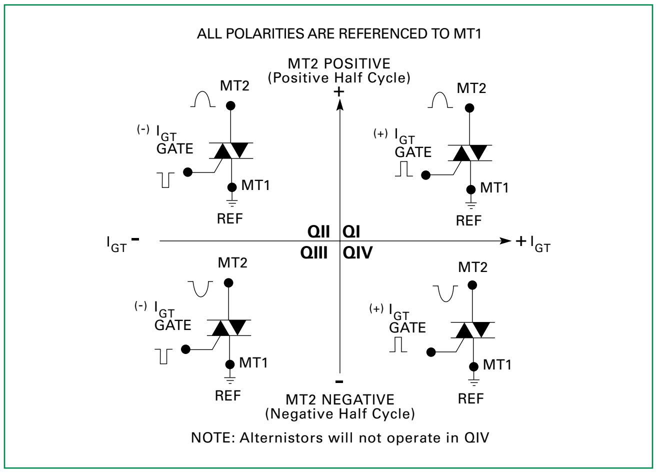
Symbol	Test Conditions					Value	Unit
V_{TM}	I_{TM} = 11.3A t_p = 380 µs				MAX.	1.60	V
I_{DRM} / I_{RRM}	V_{DRM} = V_{RRM}	Lxx06xy	T_J = 25°C	400 - 600V	MAX.	20	µA
			T_J = 110°C	400 - 600V		0.5	mA
		Qxx06xy	T_J = 25°C	400 - 1000V		50	µA
			T_J = 125°C	400 - 800V		2	mA
			T_J = 100°C	1000V		3	
		Qxx06xHy	T_J = 25°C	400 - 800V		10	µA
				1000V		20	
			T_J = 125°C	400 - 800V		3	mA
			T_J = 100°C	1000V		2	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	L/Qxx06Ryy / L/Qxx06Nyy	1.8	°C/W
		L/Qxx06Lyy	3.3	
		L/Qxx06Vyy / L/Qxx06Dyy	3.2	
$R_{\theta(J-A)}$	Junction to ambient	L/Qxx06Ryy	45	°C/W
		L/Qxx06Lyy	50	
		L/Qxx06Vyy	70	

Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

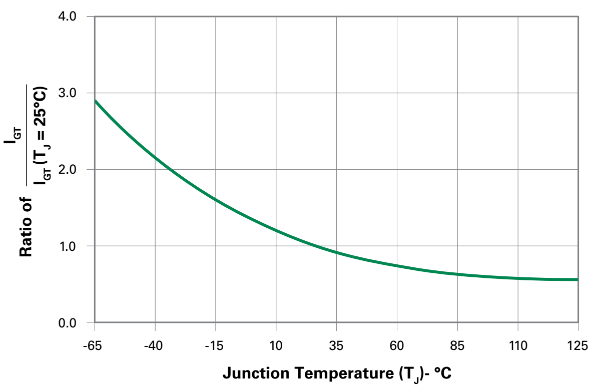


Figure 3: Normalized DC Holding Current vs. Junction Temperature

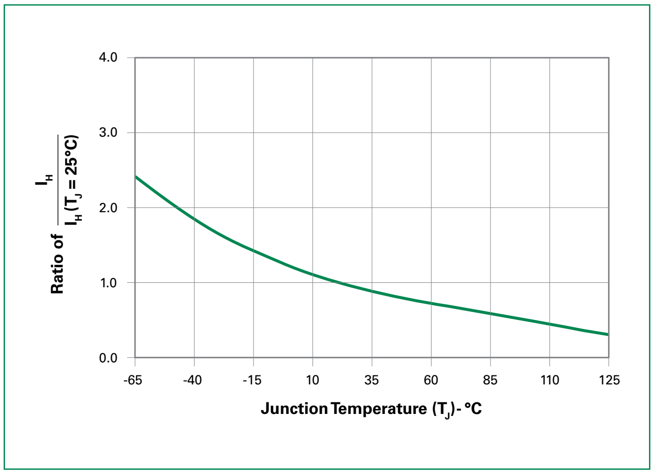


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

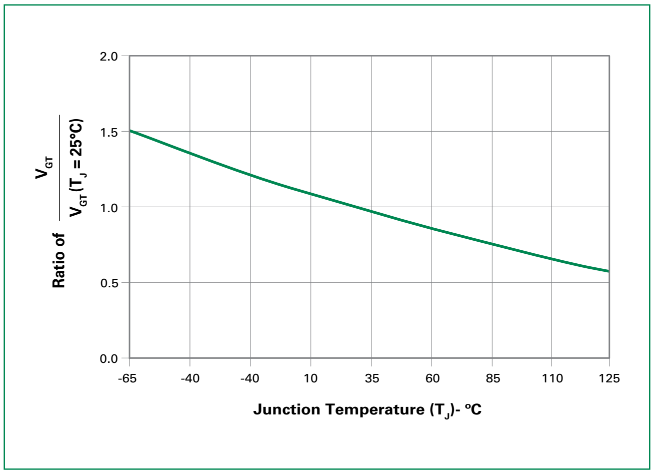
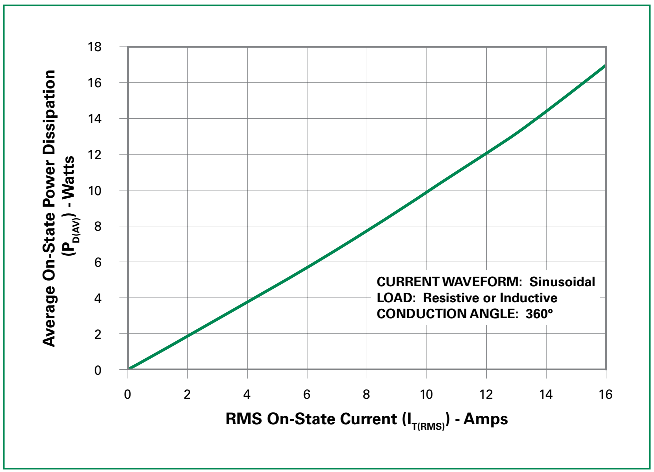
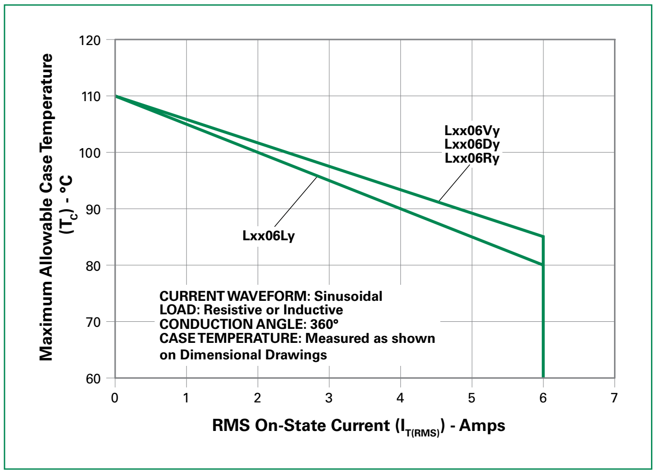


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current



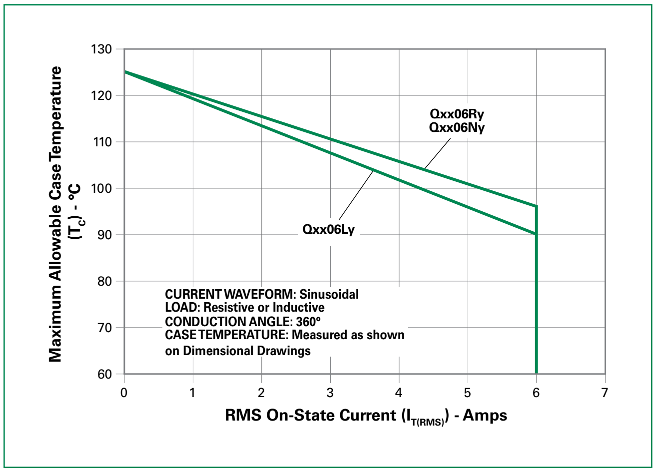
CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 360°

Figure 6: Maximum Allowable Case Temperature vs. On-State Current (Sensitive Triac)



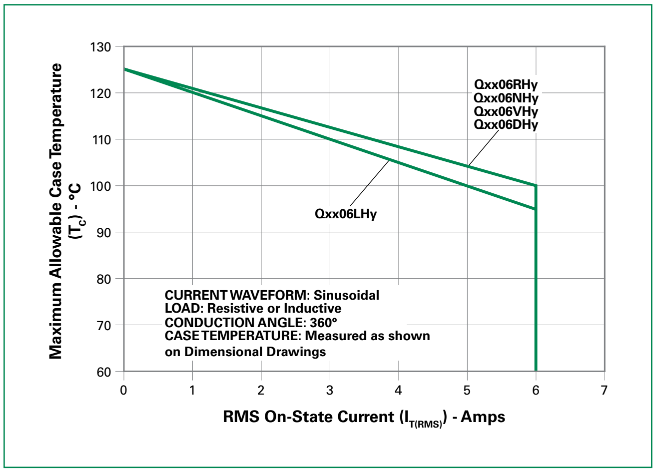
CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 360°
CASE TEMPERATURE: Measured as shown on Dimensional Drawings

Figure 7: Maximum Allowable Case Temperature vs. On-State Current (Standard Triac)



CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 360°
CASE TEMPERATURE: Measured as shown on Dimensional Drawings

Figure 8: Maximum Allowable Case Temperature vs. On-State Current (Alternistor Triac)



CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 360°
CASE TEMPERATURE: Measured as shown on Dimensional Drawings

Figure 9: Maximum Allowable Ambient Temperature vs. On-State Current (Sensitive / Standard Triac)

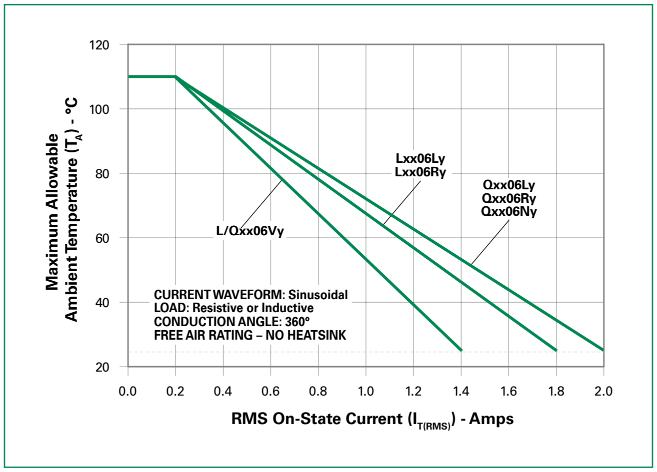


Figure 10: Maximum Allowable Ambient Temperature vs. On-State Current (Alternistor Triac)

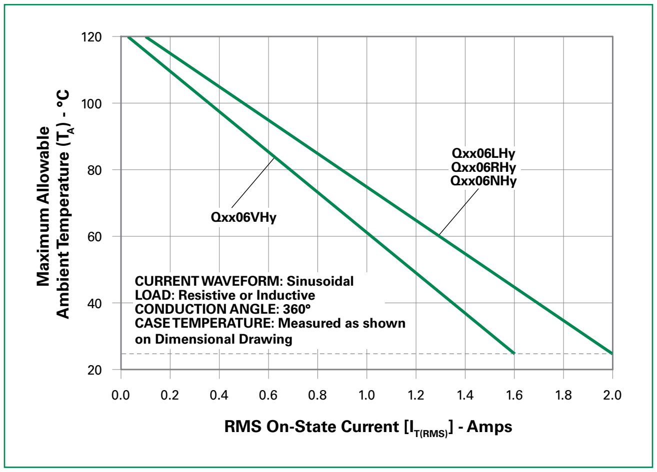


Figure 11: On-State Current vs. On-State Voltage (Typical)

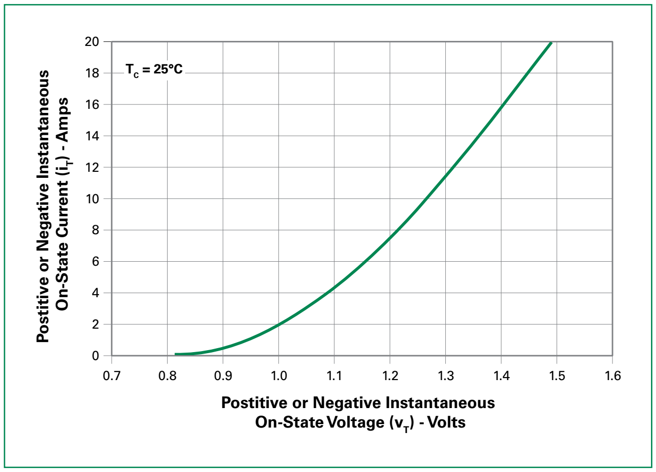
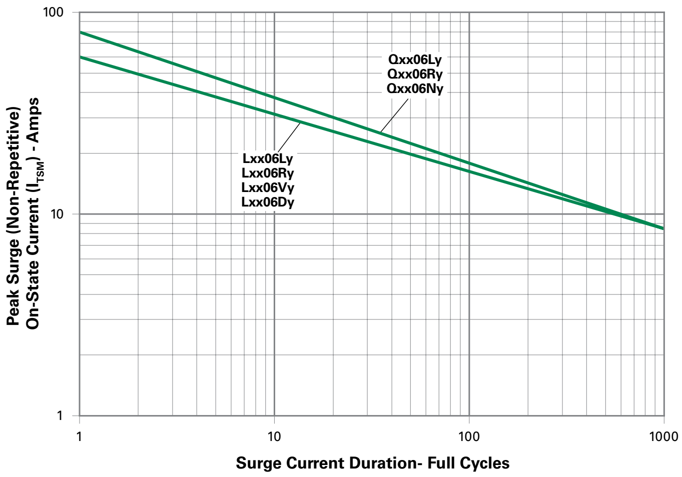


Figure 12: Surge Peak On-State Current vs. Number of Cycles (Sensitive / Standard Triac)

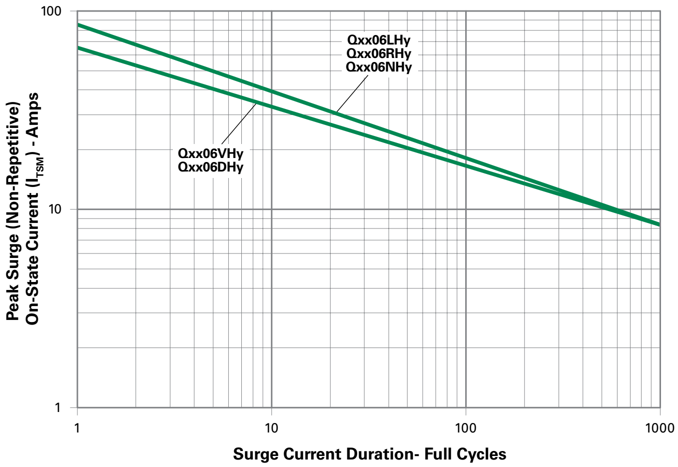


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 13: Surge Peak On-State Current vs. Number of Cycles (Alternistor Triac)



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

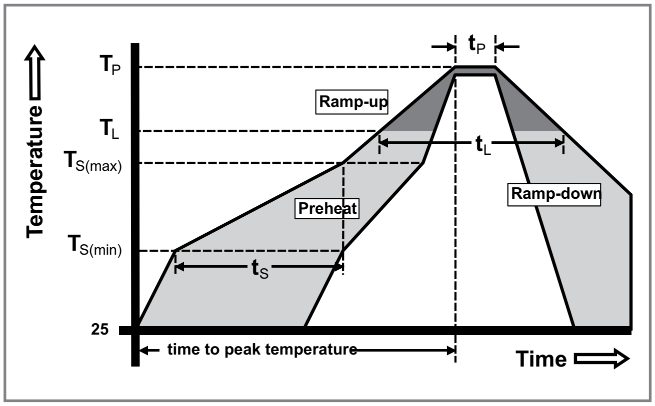
Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

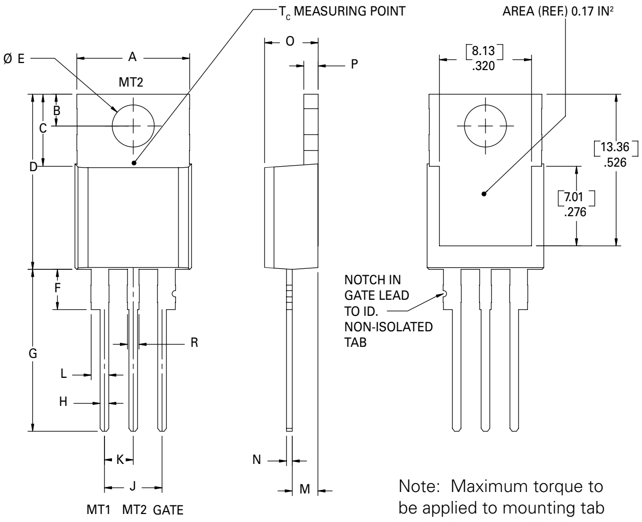
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking (V_{DRM})	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

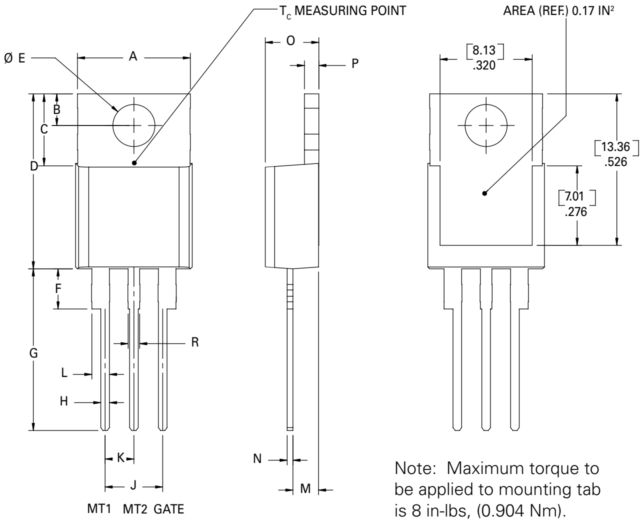
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs, (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab

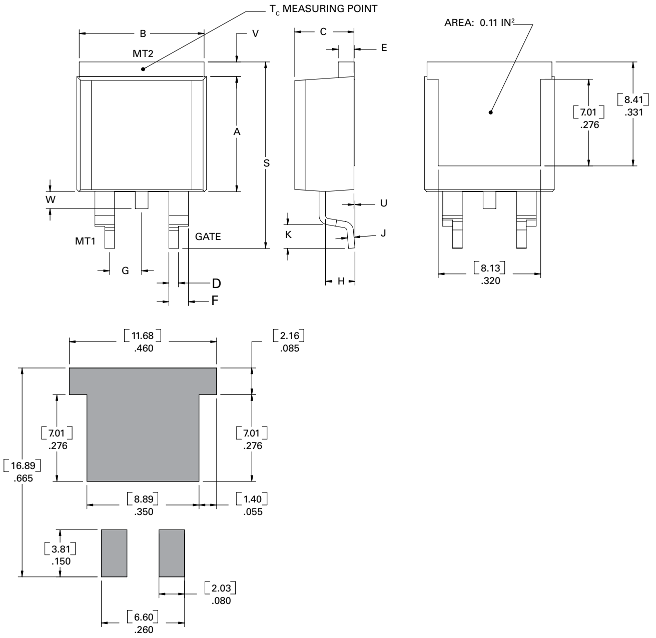


Note: Maximum torque to be applied to mounting tab is 8 in-lbs, (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

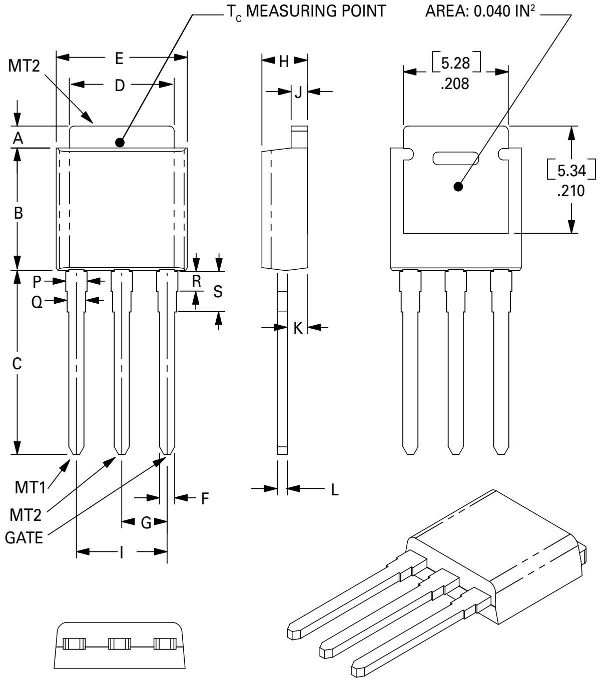
Revised: 12/14/14

Dimensions — TO-263AB (N-Package) — D²-PAK Surface Mount



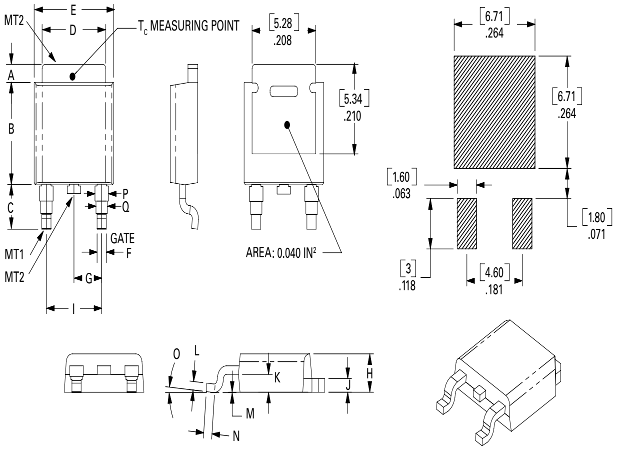
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Dimensions — TO-251AA (V-Package) — V-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Product Selector

Part Number	Voltage				Gate Sensitivity Quadrants		Type	Package
	400V	600V	800V	1000V	I - II - III	IV		
Lxx06L5	X	X			5 mA	5 mA	Sensitive Triac	TO-220L
Lxx06D5	X	X			5 mA	5 mA	Sensitive Triac	TO-252 D-PAK
Lxx06R5	X	X			5mA	5mA	Sensitive Triac	TO-220R
Lxx06V5	X	X			5 mA	5 mA	Sensitive Triac	TO-251 V-PAK
Lxx06L6	X	X			5 mA	10 mA	Sensitive Triac	TO-220L
Lxx06D6	X	X			5 mA	10 mA	Sensitive Triac	TO-252 D-PAK
Lxx06R6	X	X			5mA	10mA	Sensitive Triac	TO-220R
Lxx06V6	X	X			5 mA	10 mA	Sensitive Triac	TO-251 V-PAK
Lxx06L8	X	X			10 mA	20 mA	Sensitive Triac	TO-220L
Lxx06D8	X	X			10 mA	20 mA	Sensitive Triac	TO-252 D-PAK
Lxx06R8	X	X			10mA	20mA	Sensitive Triac	TO-220R
Lxx06V8	X	X			10 mA	20 mA	Sensitive Triac	TO-251 V-PAK
Qxx06VH3	X	X			10 mA		Alternistor Triac	TO-251 V-PAK
Qxx06DH3	X	X			10 mA		Alternistor Triac	TO-252 D-PAK
Qxx06L4	X				25 mA		Standard Triac	TO-220L
Qxx06R4	X				25 mA		Standard Triac	TO-220R
Qxx06N4	X				25 mA		Standard Triac	TO-263 D²-PAK
Qxx06RH3	X	X			10mA		Alternistor Triac	TO-220R
Qxx06LH4	X	X	X	X	35 mA		Alternistor Triac	TO-220L
Qxx06RH4	X	X	X	X	35 mA		Alternistor Triac	TO-220R
Qxx06VH4	X	X	X	X	35 mA		Alternistor Triac	TO-251 V-PAK
Qxx06DH4	X	X	X	X	35 mA		Alternistor Triac	TO-252 D-PAK
Qxx06NH4	X	X	X	X	35 mA		Alternistor Triac	TO-263 D²-PAK
Qxx06L5		X	X	X	50 mA		Standard Triac	TO-220L
Qxx06R5		X	X	X	50 mA		Standard Triac	TO-220R
Qxx06N5		X	X	X	50 mA		Standard Triac	TO-263 D²-PAK

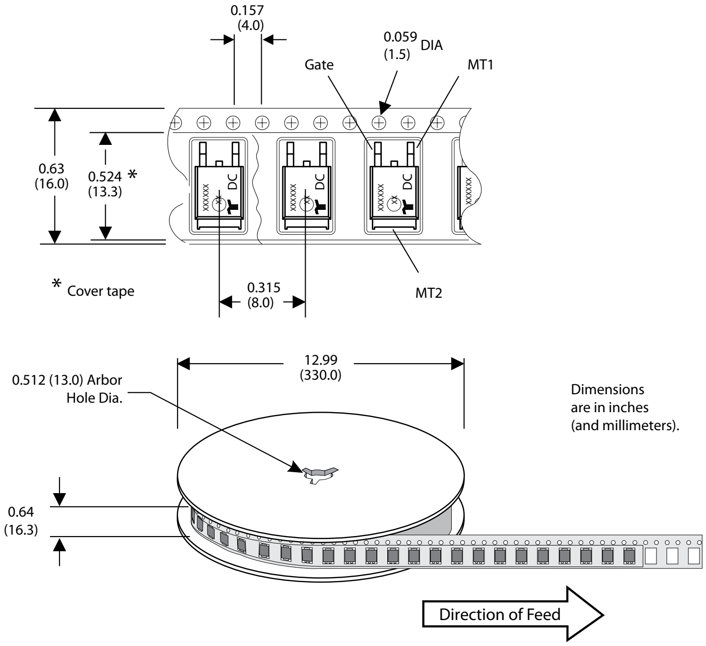
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Lxx06L/Ry	Lxx06L/Ry	2.2 g	Bulk	500
Lxx06L/RyTP	Lxx06L/Ry	2.2 g	Tube Pack	500 (50 per tube)
Lxx06DyTP	Lxx06Dy	0.3 g	Tube	750 (75 per tube)
Lxx06DyRP	Lxx06Dy	0.3 g	Embossed Carrier	2500
Lxx06VyTP	Lxx06Vy	0.4 g	Tube	750 (75 per tube)
Qxx06L/Ryy	Qxx06L/Ryy	2.2 g	Bulk	500
Qxx06L/RyyTP	Qxx06L/Ryy	2.2 g	Tube Pack	500 (50 per tube)
Qxx06NyyTP	Qxx06Nyy	1.6 g	Tube	500 (50 per tube)
Qxx06NyyRP	Qxx06Nyy	1.6 g	Embossed Carrier	500
Qxx06DyyTP	Qxx06Dyy	0.3 g	Tube	750 (75 per tube)
Qxx06DyyRP	Qxx06Dyy	0.3 g	Embossed Carrier	2500
Qxx06VyyTP	Qxx06Vyy	0.4 g	Tube	750 (75 per tube)

Note: xx = voltage; yy = sensitivity

TO-252 Embossed Carrier Reel Pack (RP) Specifications

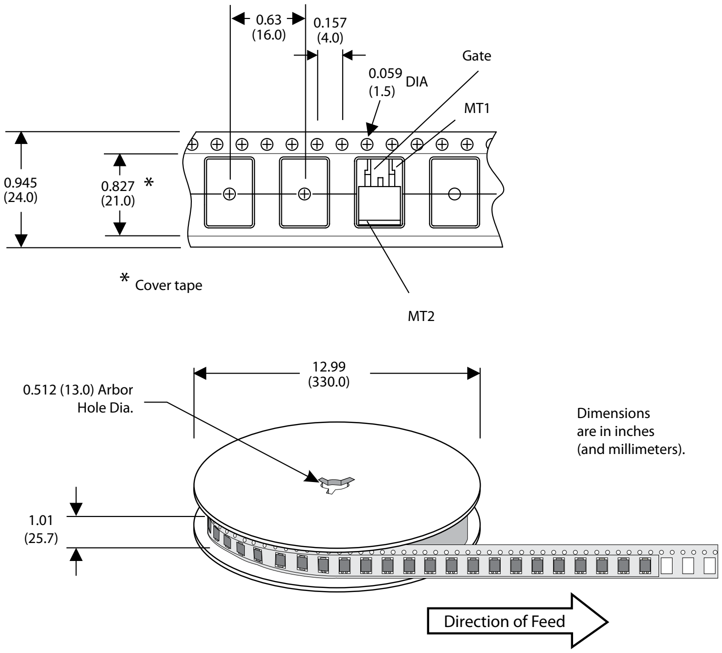
Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System

Q 60 06 L H4 56

DEVICE TYPE
L : Sensitive Triac
Q : Triac or Alternistor

VOLTAGE RATING
40 : 400V
60 : 600V
80 : 800V
K0 : 1000V

CURRENT
06: 6A

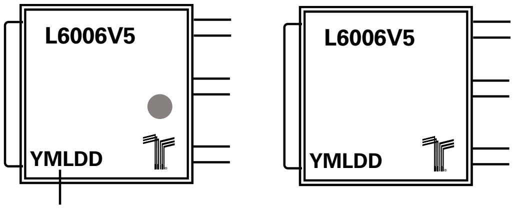
PACKAGE TYPE
L : TO-220 Isolated
R : TO-220 Non-Isolated
N : TO-263 (D²PAK)
V : TO-251 (VPAK)
D : TO-252 (DPAK)

LEAD FORM DIMENSIONS
xx : Lead Form Option

SENSITIVITY & TYPE
Sensitive Triac:
3 : 3 mA (QI, II, III, IV)
5 : 5 mA (QI, II, III, IV)
6 : 5 mA (QI, II, III)
10 mA (QIV)
8 : 10 mA (QI, II, III)
20 mA (QIV)
Standard Triac:
4 : 25 mA (QI, II, III)
5 : 50 mA (QI, II, III)
Alternistor Triac:
H3 : 10 mA (QI, II, III)
H4 : 35 mA (QI, II, III)

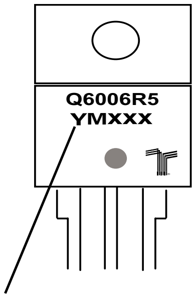
Part Marking System

TO-251AA- (V Package)
TO-252AA- (D Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

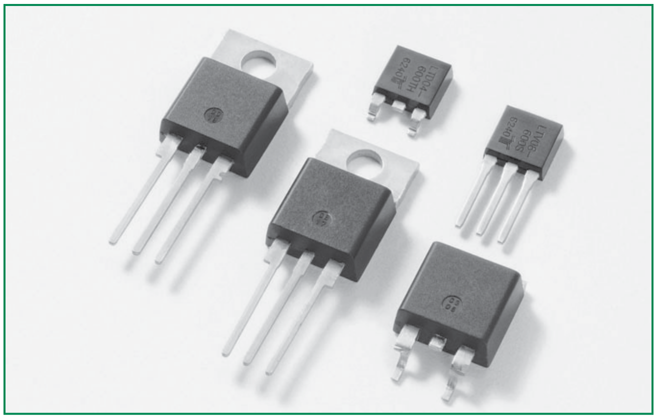
TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Lxx08xx & Qxx08xx & Qxx08xHx Series

RoHS



Description

8 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Sensitive type devices guarantee gate control in Quadrants I & IV needed for digital control circuitry.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Agency Approval

Agency	Agency File Number
®	L Package: E71639

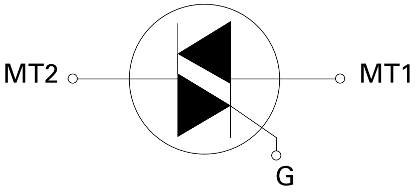
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	8	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	5 to 50	mA

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 100 A
- Electrically isolated "L-Package" is UL recognized for 2500Vrms
- Solid-state switching eliminates arcing or contact bounce that create voltage transients
- No contacts to wear out from reaction of switching events
- Restricted (or limited) RFI generation, depending on activation point of sine wave
- Requires only a small gate activation pulse in each half-cycle

Schematic Symbol



Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, light dimmers, power tools, home/brown goods and white goods appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet	Resources	Samples

Revised: 12/14/14

Absolute Maximum Ratings — Sensitive Triac (4 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Lxx08Ly	T_C = 80°C	8	A
		Lxx08Ry / Lxx08Vy / Lxx08Dy	T_C = 85°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	65	A
		f = 60 Hz	t = 16.7 ms	85	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		26.5	A^2s
di/dt	Critical rate of rise of on-state current I_G = 50mA with 0.1µs rise time	f = 120 Hz	T_J = 110°C	70	A/µs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 µs	T_J = 110°C	1.6	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.4	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Standard Triac

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx08Ry / Qxx08Ny	T_C = 95°C	8	A
		Qxx08Ly	T_C = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	83	A
		f = 60 Hz	t = 16.7 ms	100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate of rise of on-state current I_G = 200mA with ≤ 0.1µs rise time	f = 120 Hz	T_J = 125°C	70	A/µs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 µs; $I_{GT} \leq T_{GTM}$	T_J = 125°C	1.8	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Alternistor (3 Quadrants)

Symbol	Parameter				Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx08LHy		T_C = 90°C	8	A
		Qxx08RHy / Qxx08NHy Qxx08VHy / Qxx08DHy		T_C = 95°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	Qxx08VHy / Qxx08DHy	80	A
				Qxx08LHy / Qxx08RHy / Qxx08NHy	83	
		f = 60 Hz	t = 16.7 ms	Qxx08VHy / Qxx08DHy	85	
				Qxx08LHy / Qxx08RHy / Qxx08NHy	100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		Qxx08VHy / Qxx08DHy	30	A^2s
				Qxx08LHy / Qxx08RHy / Qxx08NHy	41	
di/dt	Critical rate of rise of on-state current	f = 120 Hz		T_J = 125°C	70	A/μs
I_{GTM}	Peak gate trigger current	$t_p \leq$ 10 μs; $I_{GT} \leq I_{GTM}$	T_J = 125°C	Qxx08VHy / Qxx08DHy	1.6	A
				Qxx08LHy / Qxx08RHy / Qxx08NHy	2.0	
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C	I_{GT} = 10mA	Qxx08VHy / Qxx08DHy	0.4	W
			I_{GT} = 35mA	Qxx08LHy / Qxx08RHy / Qxx08NHy	0.5	
T_{stg}	Storage temperature range				-40 to 150	°C
T_J	Operating junction temperature range				-40 to 125	°C

Note: xx = voltage, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Sensitive Triac (4 Quadrants)

Symbol	Test Conditions	Quadrant		Lxx08x6	Lxx08x8	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX.	5 10	10 20	mA
V_{GT}		ALL	MAX.	1.3		V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	ALL	MIN.	0.2		V
I_H	I_T = 100mA		MAX.	10	20	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 100°C	400V	TYP.	30	40	V/μs
		600V		20	30	
(dv/dt)c	(di/dt)c = 4.3 A/ms T_J = 110°C		TYP.	2	2	V/μs
t_{gt}	I_G = 100mA PW = 15μs I_T = 11.3 A(pk)		TYP.	3.0	3.2	μs

Note: xx = voltage, x = package, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Qxx08x4	Qxx08x5	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX. TYP.	25 50	50 75	mA
V_{GT}		I – II – III	MAX.	1.3		V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C	ALL	MIN.	0.2		V
I_H	I_T = 200mA		MAX.	50	50	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 125°C	400V	MIN.	150		V/µs
		600V			125	
		800V			100	
		1000V			80	
(dv/dt)c	(di/dt)c = 4.3 A/ms T_J = 125°C		TYP.	4	4	V/µs
t_{gt}	I_G = 100mA PW = 15µs I_T = 11.3 A(pk)		TYP.	3.0	3.0	µs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant			Qxx08xH3	Qxx08xH4	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.		10	35	mA
V_{GT}		I – II – III	MAX.		1.3		V
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.		0.2		V
I_H	I_T = 100mA		MAX.		15	35	mA
dv/dt	V_D = V_{DRM} Gate Open T_J = 125°C	Qxx08LHy / Qxx08RHy / Qxx08NHy	MIN.	400V	75	400	V/µs
				600V	50	300	
				800V		200	
				1000V		100	
		Qxx08VHy / Qxx08DHy		400V	75	450	
				600V	50	350	
				800V		250	
				1000V		150	
(dv/dt)c	(di/dt)c = 4.3 A/ms T_J = 125°C		MIN.		20	25	V/µs
t_{gt}	I_G = 100mA PW = 15µs I_T = 11.3 A(pk)		TYP.		4.0	4.0	µs

Note : xx = voltage, x = package, y = sensitivity

Static Characteristics

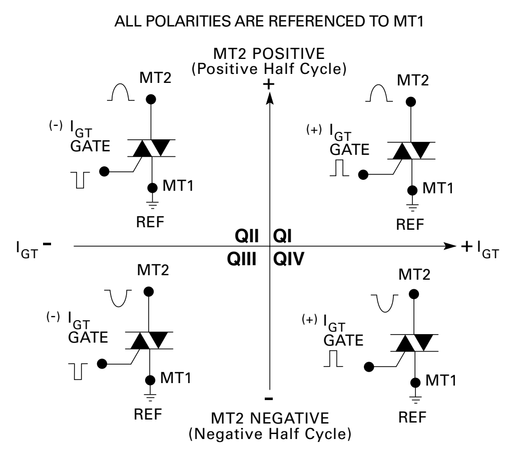
Symbol	Test Conditions					Value	Unit
V_{TM}	I_{TM} = 11.3A t_p = 380 µs				MAX.	1.60	V
I_{DRM} I_{RRM}	$V_{DRM} = V_{RRM}$	Lxx08xy	T_J = 25°C	400 - 600V	MAX.	10	µA
			T_J = 110°C	400 - 600V		0.5	mA
		Qxx08xy	T_J = 25°C	400 - 1000V		20	µA
			T_J = 125°C	400 - 800V		2	mA
			T_J = 100°C	1000V		3	
		Qxx08xHy	T_J = 25°C	400 - 800V		10	µA
				1000V		20	
			T_J = 125°C	400 - 800V		2	mA
			T_J = 100°C	1000V		3	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	L/Qxx08Ryy / L/Qxx08Nyy	1.5	°C/W
		L/Qxx08Lyy	2.8	
		L/Qxx08Vyy	2.1	
$R_{\theta(J-A)}$	Junction to ambient	L/Qxx08Ryy	45	°C/W
		L/Qxx08Lyy	50	
		L/Qxx08Vyy	64	

Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

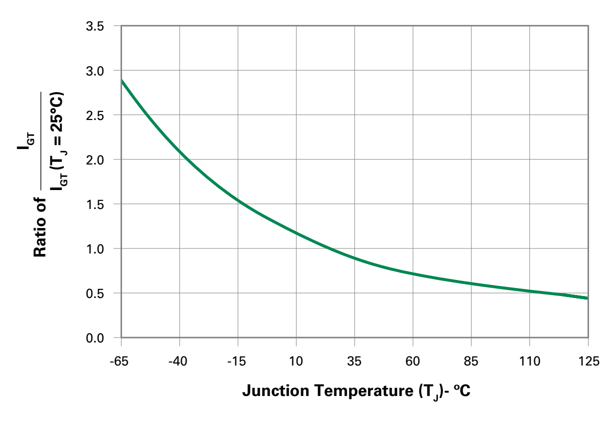


Figure 3: Normalized DC Holding Current vs. Junction Temperature

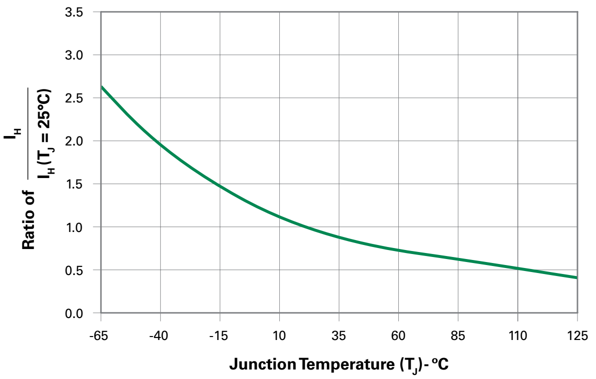


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

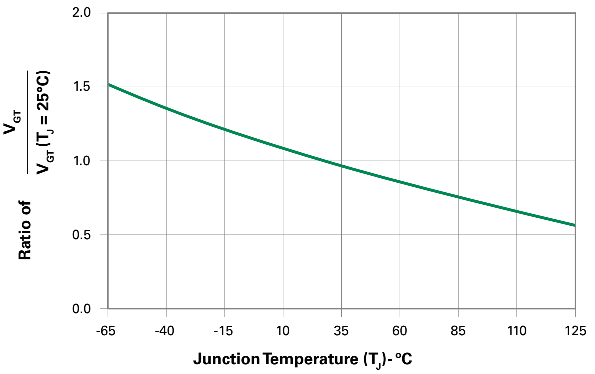


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

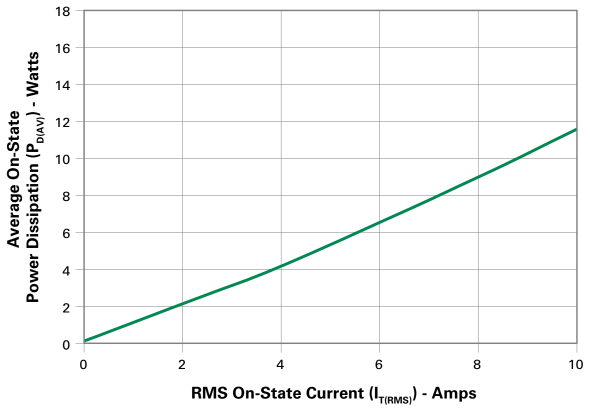


Figure 6: Maximum Allowable Case Temperature vs. On-State Current (Sensitive Triac)

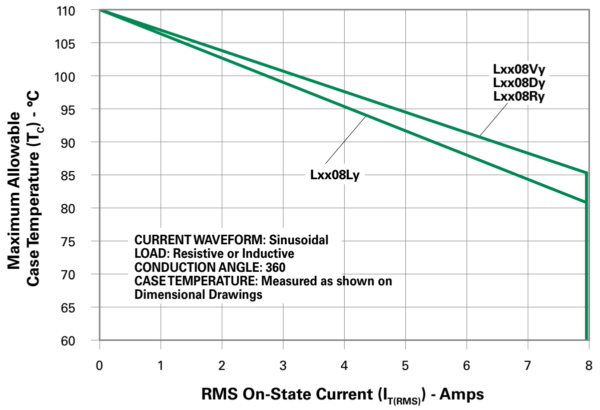
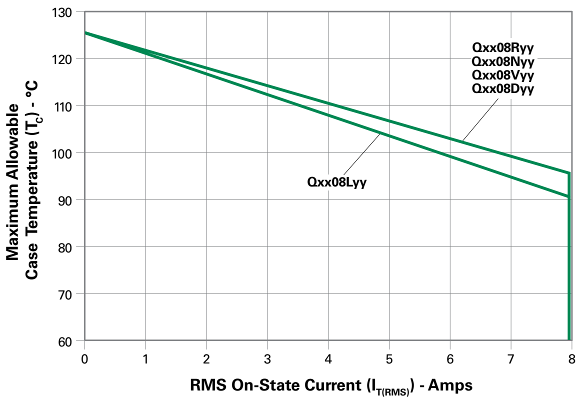


Figure 7: Maximum Allowable Case Temperature vs. On-State Current (Standard / Alternistor Triac)



Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

Figure 8: On-State Current vs. On-State Voltage (Typical)

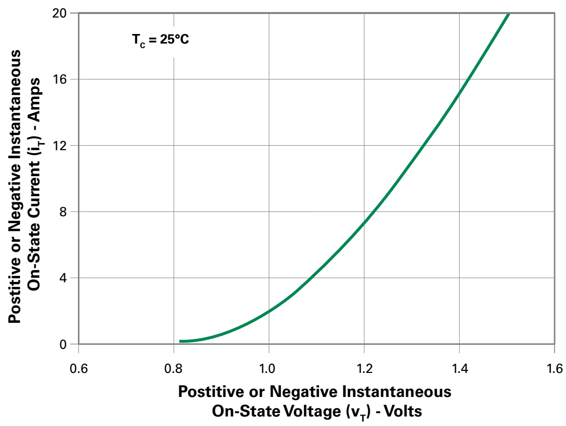


Figure 9: Maximum Allowable Ambient Temperature vs. On-State Current

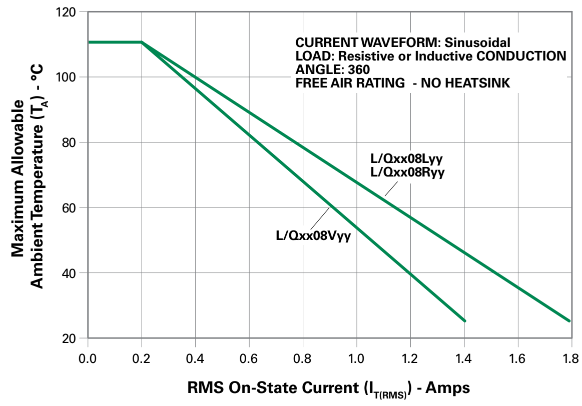
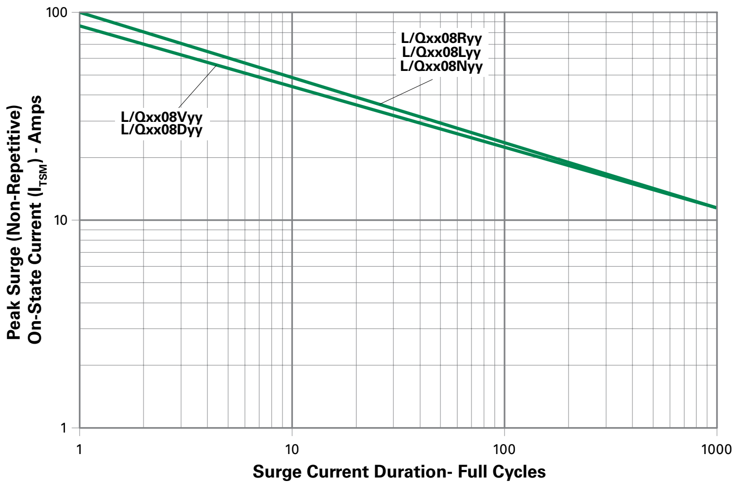


Figure 10: Surge Peak On-State Current vs. Number of Cycles



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

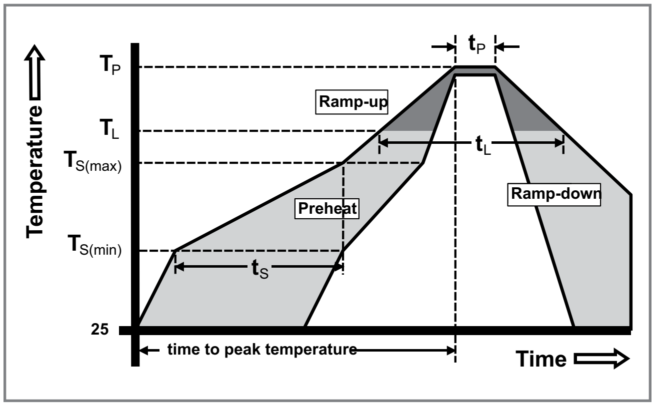
Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

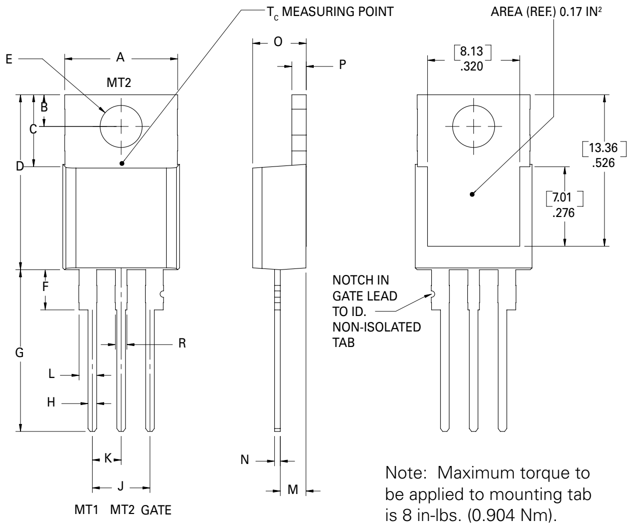
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking (V_{DRM})	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

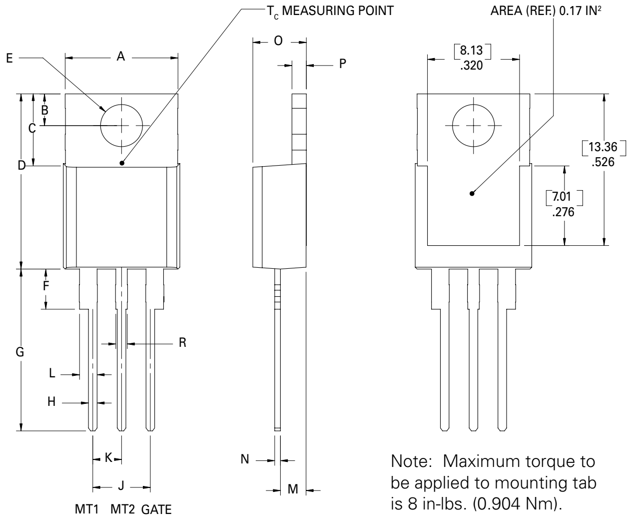
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

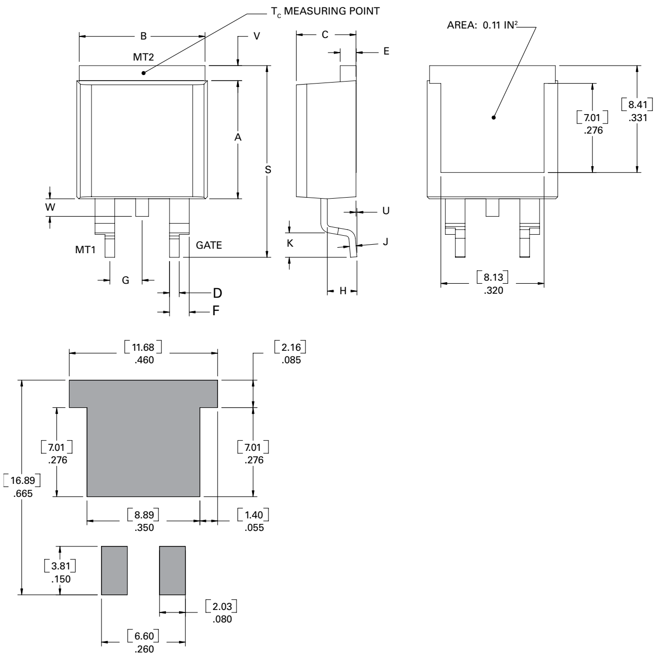
Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

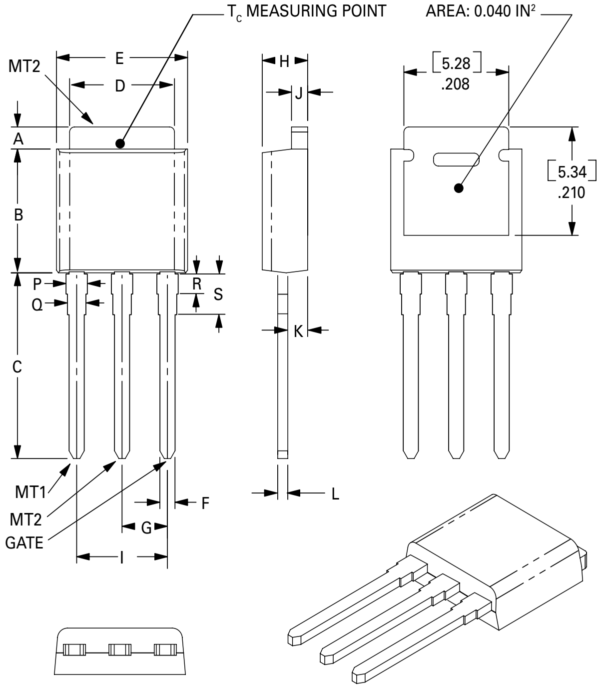
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-263AB (N-Package) — D²-PAK Surface Mount



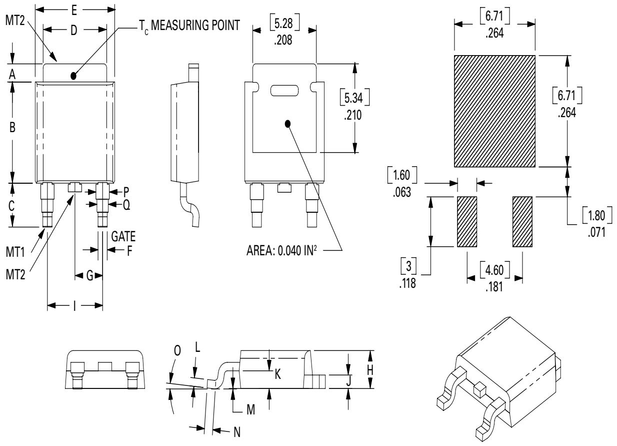
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Dimensions — TO-251AA (V-Package) — V-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Revised: 12/14/14

Product Selector

Part Number	Voltage (xx)				Gate Sensitivity Quadrants		Type	Package
	400V	600V	800V	1000V	I – II – III	IV		
Lxx08L6	X	X			5 mA	10 mA	Sensitive Triac	TO-220L
Lxx08D6	X	X			5 mA	10 mA	Sensitive Triac	TO-252 D-PAK
Lxx08R6	X	X			5mA	10mA	Sensitive Triac	TO-220R
Lxx08V6	X	X			5 mA	10 mA	Sensitive Triac	TO-251 V-PAK
Lxx08L8	X	X			10 mA	20 mA	Sensitive Triac	TO-220L
Lxx08D8	X	X			10 mA	20 mA	Sensitive Triac	TO-252 D-PAK
Lxx08R8	X	X			10mA	20mA	Sensitive Triac	TO-220R
Lxx08V8	X	X			10 mA	20 mA	Sensitive Triac	TO-251 V-PAK
Qxx08NH3	X	X			10mA		Alternistor Triac	TO-263 D²-PAK
Qxx08RH3	X	X			10 mA		Alternistor Triac	TO-220R
Qxx08VH3	X	X			10 mA		Alternistor Triac	TO-251 V-PAK
Qxx08DH3	X	X			10 mA		Alternistor Triac	TO-252 D-PAK
Qxx08L4	X				25 mA		Triac	TO-220L
Qxx08R4	X				25 mA		Triac	TO-220R
Qxx08N4	X				25 mA		Triac	TO-263 D²-PAK
Qxx08LH4	X	X	X	X	35 mA		Alternistor Triac	TO-220L
Qxx08RH4	X	X	X	X	35 mA		Alternistor Triac	TO-220R
Qxx08VH4	X	X	X	X	35 mA		Alternistor Triac	TO-251 V-PAK
Qxx08DH4	X	X	X	X	35 mA		Alternistor Triac	TO-252 D-PAK
Qxx08NH4	X	X	X	X	35 mA		Alternistor Triac	TO-263 D²-PAK
Qxx08L5		X	X	X	50 mA		Triac	TO-220L
Qxx08R5		X	X	X	50 mA		Triac	TO-220R
Qxx08N5		X	X	X	50 mA		Triac	TO-263 D²-PAK

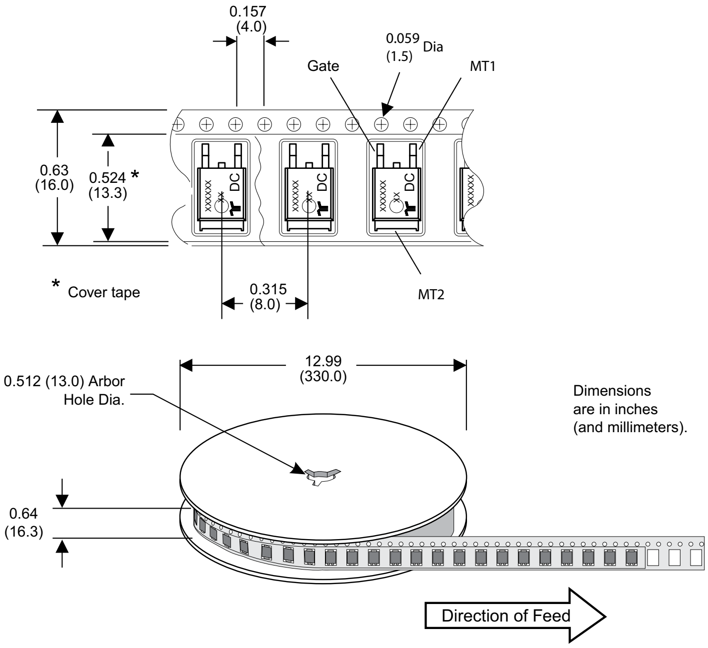
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
L/Qxx08L/Ryy	L/Qxx08L/Ryy	2.2 g	Bulk	500
L/Qxx08L/RyyTP	L/Qxx08L/Ryy	2.2 g	Tube Pack	500 (50 per tube)
Qxx08NyyTP	Qxx08Nyy	1.6 g	Tube	500 (50 per tube)
Qxx08NyyRP	Qxx08Nyy	1.6 g	Embossed Carrier	500
L/Qxx08DyyTP	L/Qxx08Dyy	0.3 g	Tube	750 (75 per tube)
L/Qxx08DyyRP	L/Qxx08Dyy	0.3 g	Embossed Carrier	2500
L/Qxx08VyyTP	L/Qxx08Vyy	0.4 g	Tube	750 (75 per tube)

Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

TO-252 Embossed Carrier Reel Pack (RP) Specifications

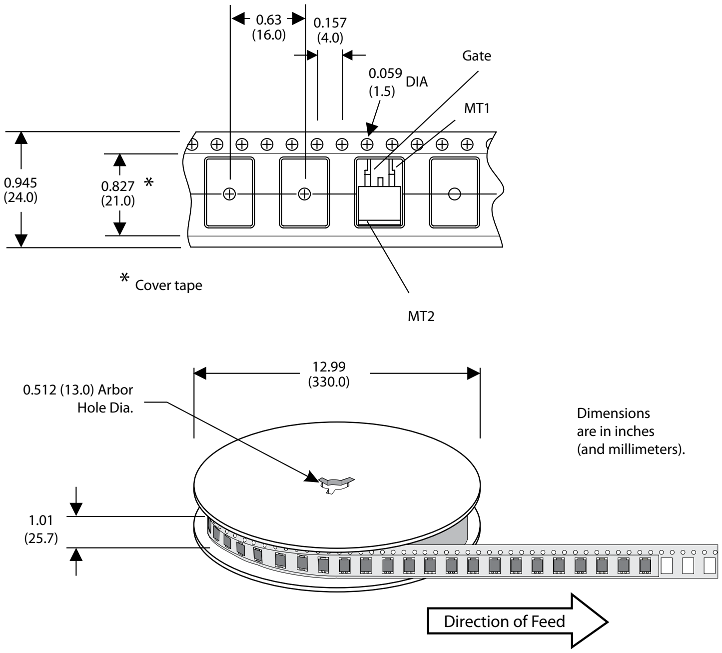
Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

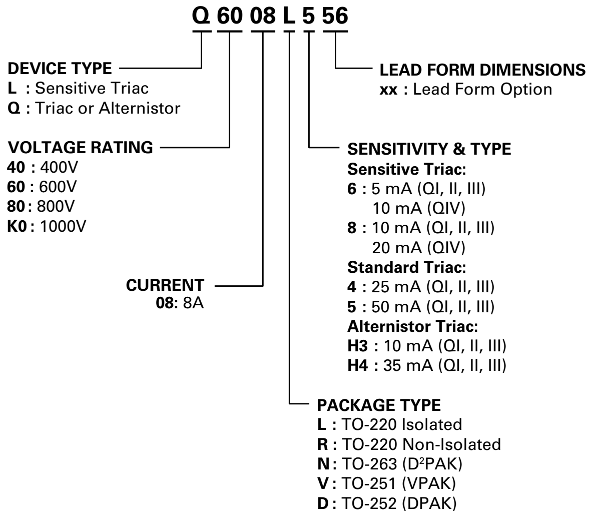
TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System



Q 60 08 L 5 56

DEVICE TYPE
L : Sensitive Triac
Q : Triac or Alternistor

VOLTAGE RATING
40 : 400V
60 : 600V
80 : 800V
K0 : 1000V

CURRENT
08: 8A

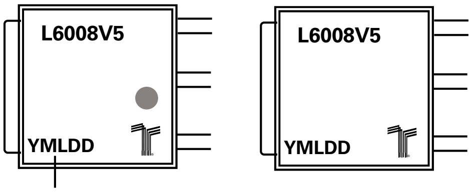
LEAD FORM DIMENSIONS
xx : Lead Form Option

SENSITIVITY & TYPE
Sensitive Triac:
6 : 5 mA (QI, II, III)
10 mA (QIV)
8 : 10 mA (QI, II, III)
20 mA (QIV)
Standard Triac:
4 : 25 mA (QI, II, III)
5 : 50 mA (QI, II, III)
Alternistor Triac:
H3 : 10 mA (QI, II, III)
H4 : 35 mA (QI, II, III)

PACKAGE TYPE
L : TO-220 Isolated
R : TO-220 Non-Isolated
N : TO-263 (D^{2}PAK)
V : TO-251 (VPAK)
D : TO-252 (DPAK)

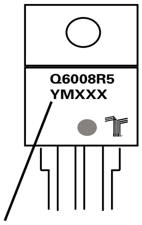
Part Marking System

TO-251AA – (V Package)
TO-252AA – (D Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Teccor® brand Thyristors

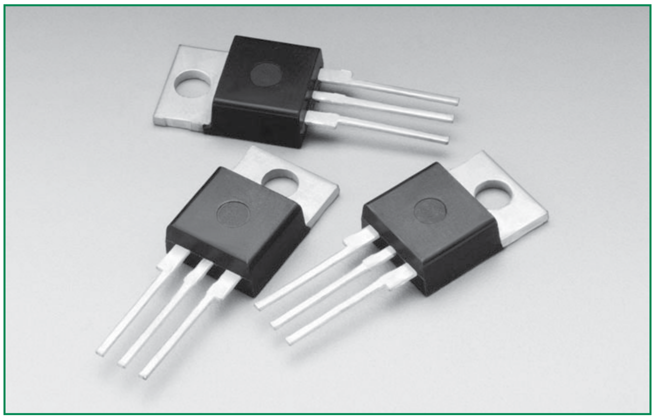
8 Amp Alternistor (High Commutation) Triac for LED dimmer application

Littelfuse®

Expertise Applied | Answers Delivered

Q6008LH1LED Series

RoHS



Description

Q6008LH1LED series is designed to meet low load current characteristics typical in LED lighting applications.

By keeping holding current at 6mA maximum, this Triac series is characterized and specified to perform best with LED loads. The Q6008LH1LED series is best suited for LED dimming controls to obtain the lowest levels of light output with a minimum probability of flickering.

Q6008LH1LED series is offered in the industry standard TO-220AB package with an isolated mounting tab that makes it best suited for adding an external heat sink.

Agency Approval

Agency	Agency File Number
®	L Package: E71639

Main Features

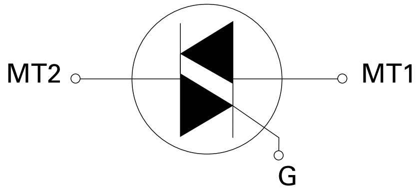
Symbol	Value	Unit
$I_{T(RMS)}$	8	A
V_{DRM}/V_{RRM}	600	V
I_{GT}	10	mA

Features

Benefits

Features	Benefits
• As low as 6mA max holding current	• Provides full control of light out put at the extreme low end of load conditions.
• UL recognized TO-220AB package	• 2500V $_{AC}$ min isolation between mounting tab and active terminals
• 110°C rated junction temperature	• Improves margin of safe operation with less heat sinking required
• di/dt performance of 70A/μs	• Enable survivability of typically LED load operating characteristics
• QUADRAC version includes intergrated DIAC	• Simplicity of circuit design & layout

Schematic Symbol



Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, lighting controls with LED lamp loads, small low current motor in power tools, and low current motors in home/brown goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Absolute Maximum Ratings

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)		T_C = 80°C	8	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	80	A
		f = 60 Hz	t = 16.7 ms	85	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	30	A^2s
di/dt	Critical rate of rise of on-state current	f = 120 Hz	T_J = 110°C	70	A/μs
I_{GTM}	Peak gate trigger current	$t_P \leq 10$ μs; $I_{GT} \leq I_{GTM}$	T_J = 110°C	1.6	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 110°C	I_{GT} = 35mA	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions	Quadrant		Value	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	mA
V_{GT}		I – II – III		1.3	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	I – II – III	MIN.	0.2	V
I_H	I_T = 15mA		MAX.	6	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 110°C		MIN.	50	V/μs
(dv/dt)c	(di/dt)c = 4.3 A/ms T_J = 110°C		MIN.	10	V/μs
t_{gt}	I_G = 100mA PW = 15μs I_T = 11.3 A(pk)		TYP.	4.0	μs

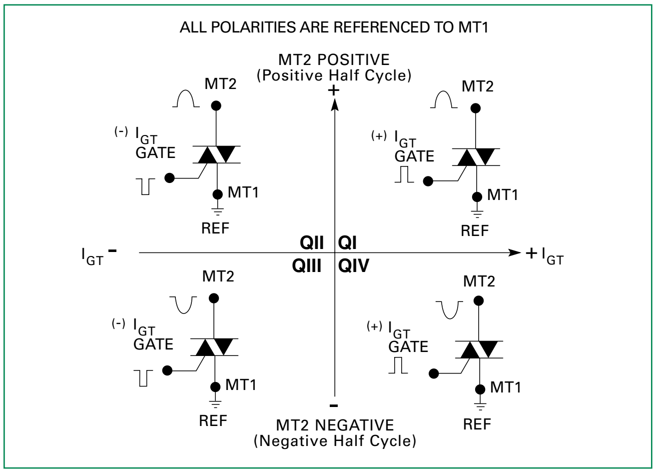
Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_{TM} = 11.3A t_p = 380 μs		MAX.	1.60	V
I_{DRM} I_{RRM}	$V_{DRM} = V_{RRM}$	T_J = 110°C	MAX.	500	μA

Thermal Resistances

Symbol	Parameter	Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	2.8	°C/W
$R_{\theta(J-A)}$	Junction to ambient	50	°C/W

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

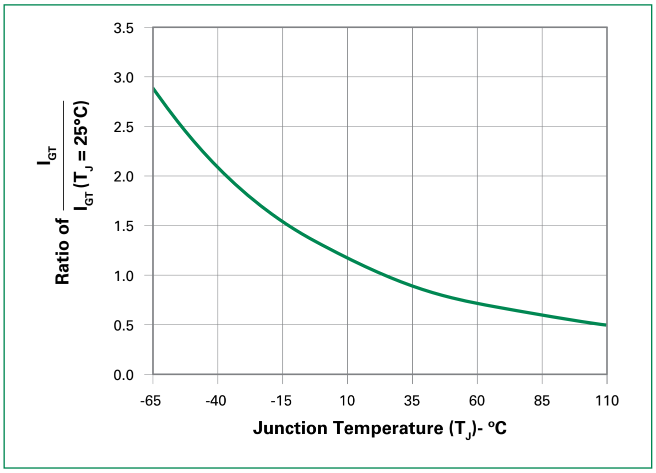


Figure 3: Normalized DC Holding Current vs. Junction Temperature

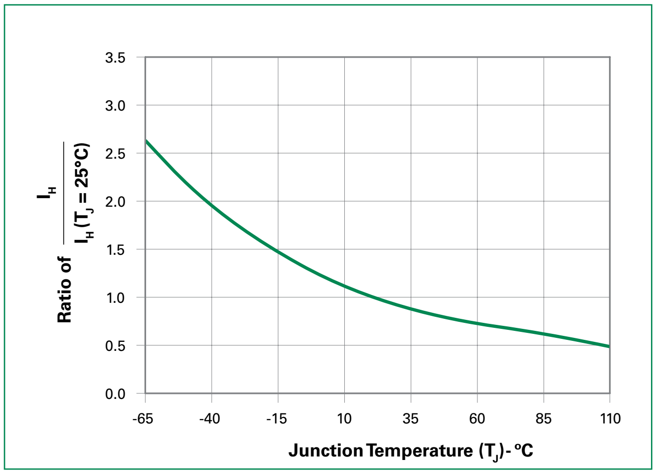


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

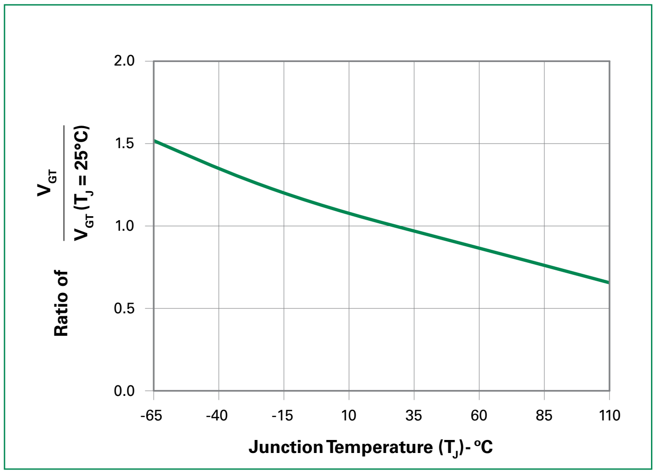


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

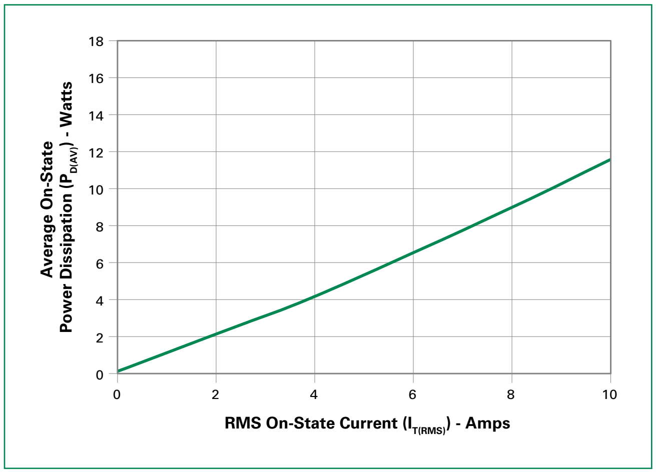


Figure 6: Maximum Allowable Case Temperature vs. On-State Current (Standard / Alternistor Triac)

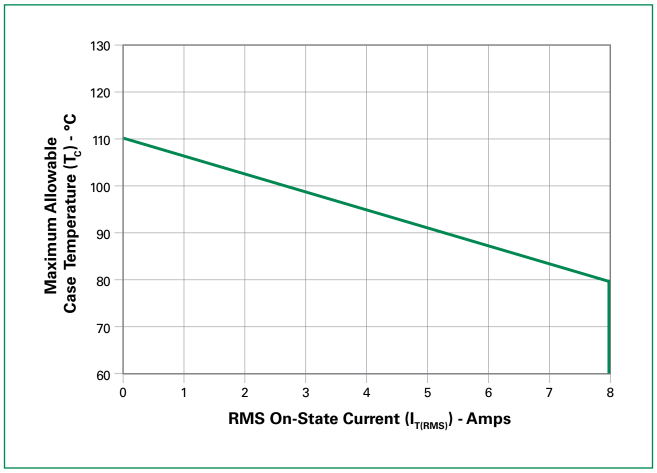


Figure 7: On-State Current vs. On-State Voltage (Typical)

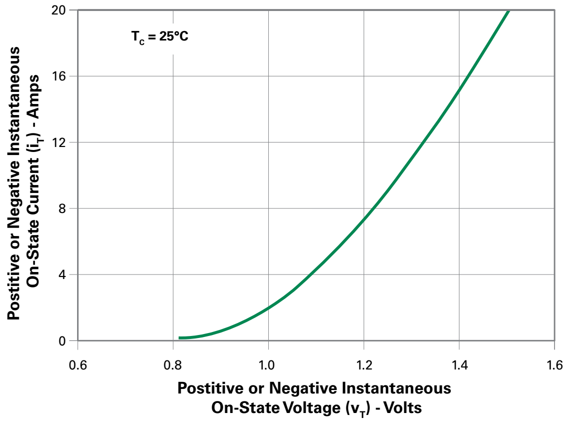


Figure 8: Maximum Allowable Ambient Temperature vs. On-State Current

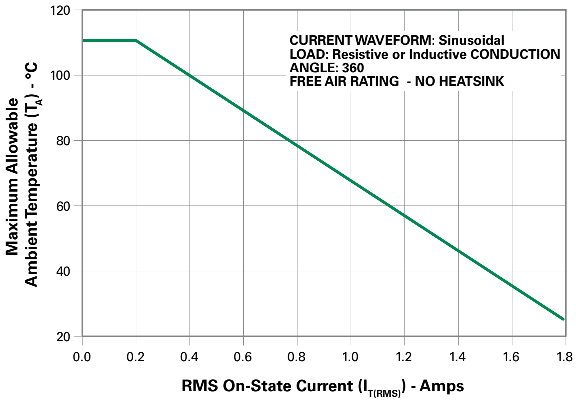
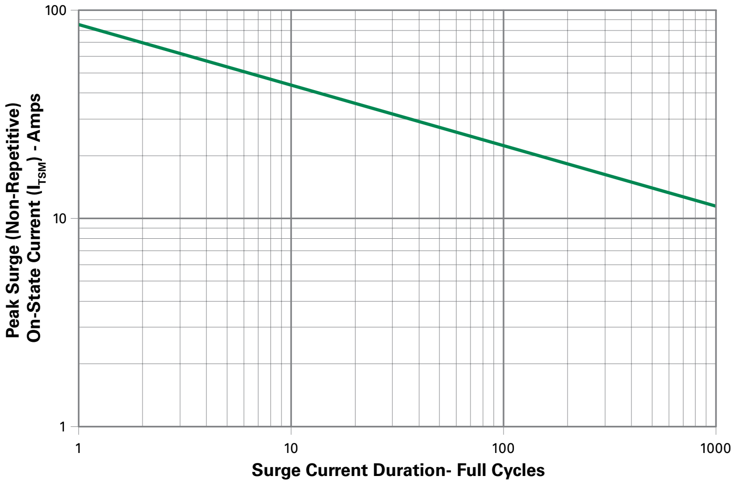


Figure 9: Surge Peak On-State Current vs. Number of Cycles

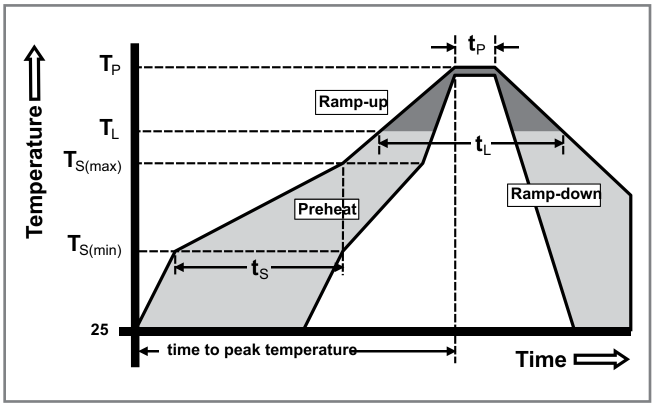


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		260$^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

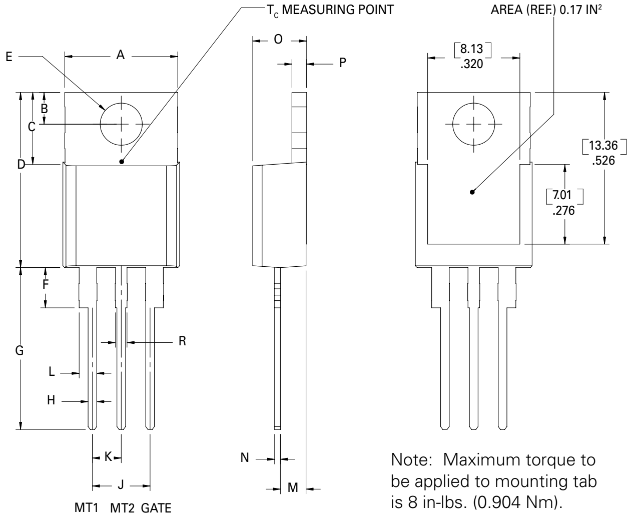
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking (V_{DRM})	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 110°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

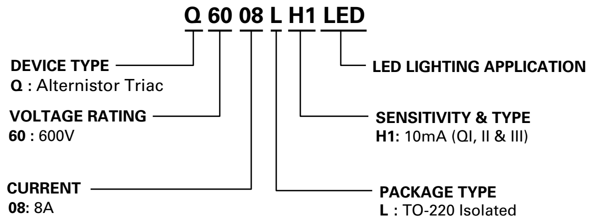
Product Selector

Part Number	Gate Sensitivity Quadrants	Type	Package
	I – II – III		
Q6008LH1LED	10 mA	Alternistor Triac	TO-220L

Packing Options

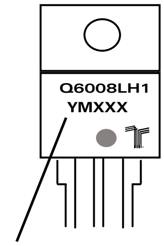
Part Number	Marking	Weight	Packing Mode	Base Quantity
Q6008LH1LED	Q6008LH1	2.2 g	Bulk	500
Q6008LH1LEDTP	Q6008LH1	2.2 g	Tube Pack	500 (50 per tube)

Part Numbering System



Part Marking System

TO-220 AB - (L Package)

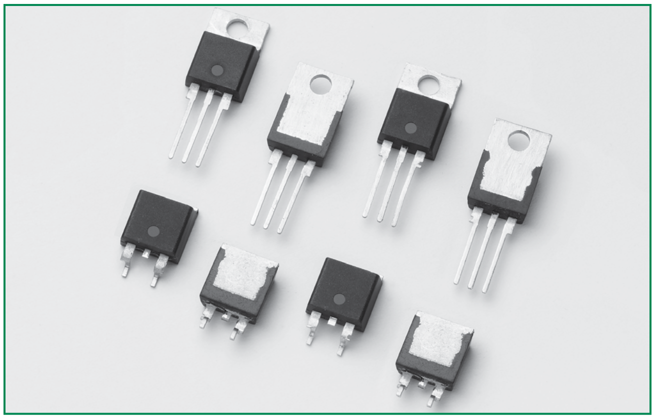


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

Qxx10xx & Qxx10xHx Series

RoHS UR



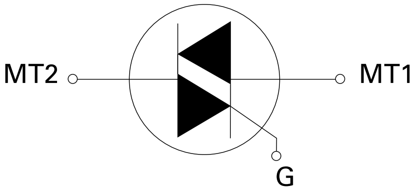
Agency Approval

Agency	Agency File Number
®UR	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	10	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	25 to 50	mA

Schematic Symbol



Description

10 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 120 A
- Electrically isolated package "L - Package" and UL recognized for 2500Vrms
- Solid-state switching eliminates arcing or contact bounce that create voltage transients
- No contacts to wear out from reaction of switching events
- Restricted (or limited) RFI generation, depending on activation point sine wave

Applications

Alternistor type devices are used in applications requiring high commutation performance such as controlling inductive loads. Isolated packages are offered with internal construction, having the case or mounting tab electrically isolated from the semiconductor chip.

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Absolute Maximum Ratings — Standard Triac

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx10Ry/ Qxx10Ny	T_C = 95°C	10	A
		Qxx10Ly	T_C = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	100	A
		f = 60 Hz	t = 16.7 ms	120	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		60	A^2s
di/dt	Critical rate of rise of on-state current I_G = 200mA with ≤ 0.1µs rise time	f = 120 Hz	T_J = 125°C	70	A/µs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 µs $I_{GT} \le I_{GTM}$	T_J = 125°C	1.8	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Absolute Maximum Ratings — Alternistor Triac (3 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx10LHy	T_C = 90°C	10	A
		Qxx10RHy/ Qxx10NHy	T_C = 95°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	110	A
		f = 60 Hz	t = 16.7 ms	120	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		60	A^2s
di/dt	Critical rate of rise of on-state current	f = 120 Hz	T_J = 125°C	70	A/µs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 µs $I_{GT} \le I_{GTM}$	T_J = 125°C	2.0	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Qxx10x4	Qxx10x5	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III IV	MAX.	25 50	50 75 (TYP)	mA
V_{GT}		I – II – III	MAX.	1.3		V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	ALL	MIN.	0.2		V
I_H	I_T = 200mA		MAX.	35	50	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	150	225	V/µs
		600V		100	200	
		800V		75	175	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V		50	150	
(dv/dt)c	(di/dt)c = 5.4 A/ms T_J = 125°C		TYP.	2	4	V/µs
t_{gt}	I_G = 2 x IGT PW = 15µs I_T = 14.1 A(pk)		TYP.	3.0	3.0	µs

Note: xx = voltage, x = package, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant		Value	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	50	mA
V_{GT}		I – II – III	MAX.	1.3	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.	0.2	V
I_H	I_T = 100mA		MAX.	50	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	750	V/μs
		600V		650	
		800V		500	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V		300	
(dv/dt)c	(di/dt)c = 5.4 A/ms T_J = 125°C		TYP.	30	V/μs
t_{gt}	I_G = 2 x IGT PW = 15μs I_T = 14.1 A(pk)		TYP.	4.0	μs

Static Characteristics

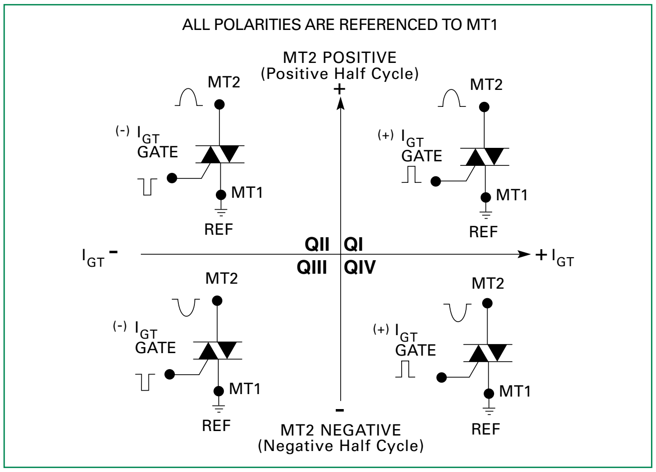
Symbol	Test Conditions				Value	Unit
V_{TM}	I_{TM} = 14.1A t_p = 380 μs			MAX.	1.60	V
I_{DRM} I_{RRM}	$V_{DRM} = V_{RRM}$	T_J = 25°C	400 - 600V	MAX.	10	μA
		T_J = 125°C	400 - 800V		2	mA
		T_J = 100°C	1000V		3	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Qxx10Ryy/ Qxx10Nyy	1.3	°C/W
		Qxx10Lyy	2.6	
$R_{\theta(J-A)}$	Junction to ambient (AC)	Qxx10Ryy	45	°C/W
		Qxx10Lyy	50	

Note: xx = voltage, x = package, y = sensitivity, yy = type & sensitivity

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

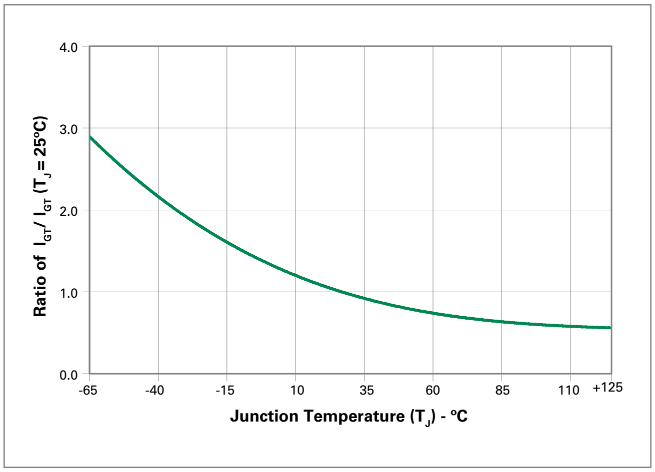


Figure 3: Normalized DC Holding Current vs. Junction Temperature

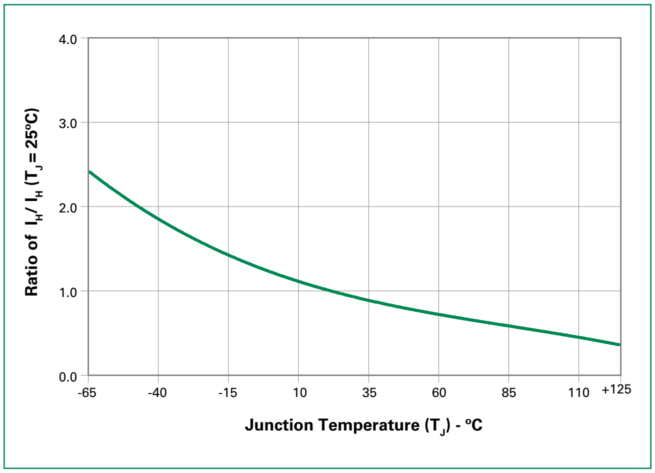


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

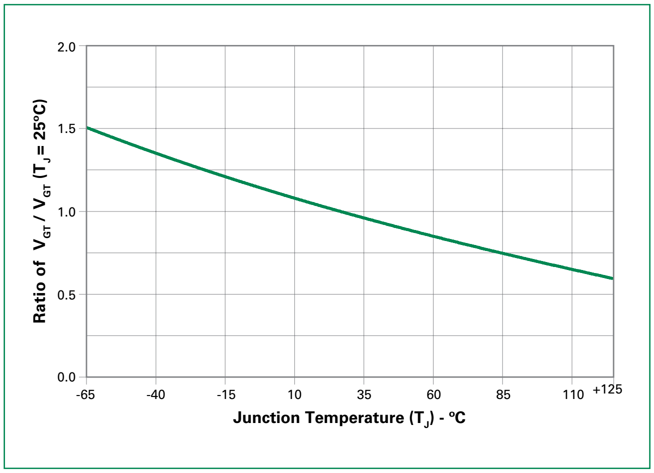


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

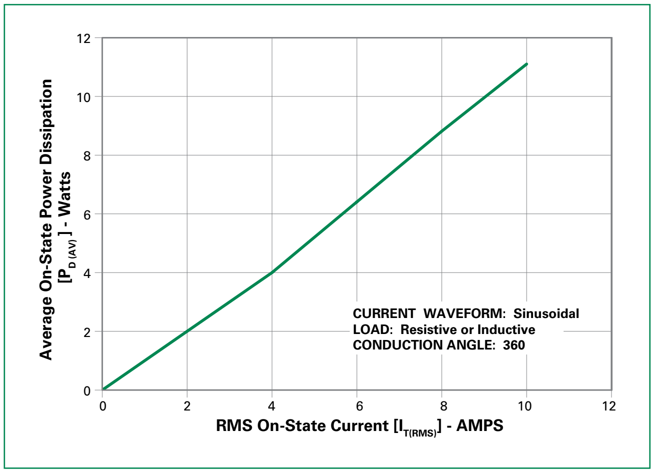


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

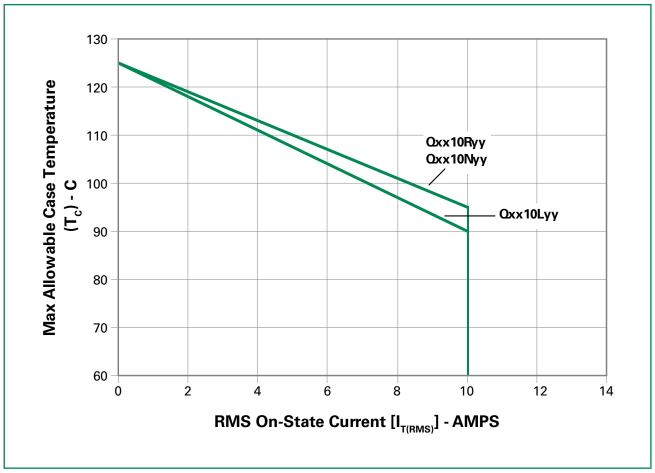
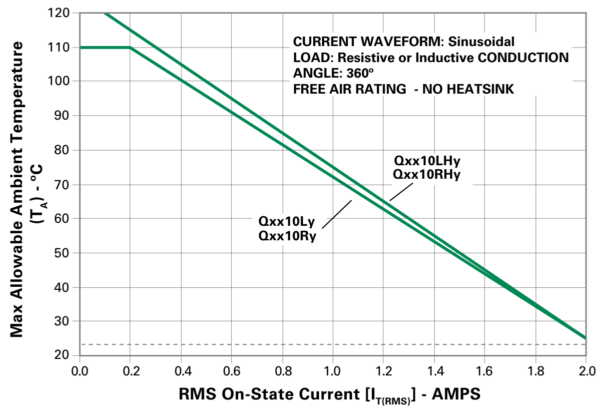
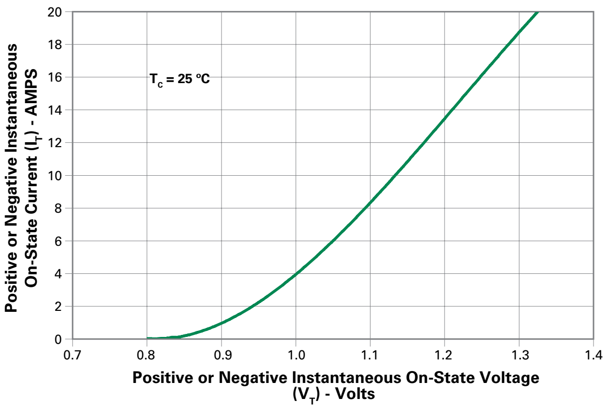


Figure 7: Maximum Allowable Ambient Temperature vs. On-State Current



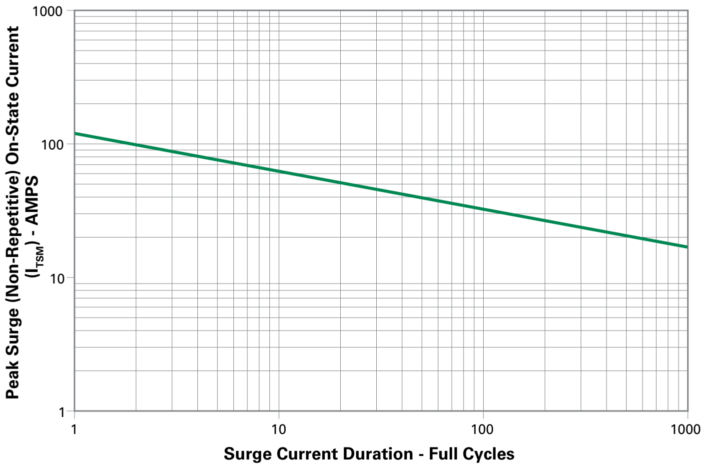
CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive CONDUCTION
ANGLE: 360°
FREE AIR RATING - NO HEATSINK

Figure 8: On-State Current vs. On-State Voltage (Typical)



T_C = 25 °C

Figure 9: Surge Peak On-State Current vs. Number of Cycles

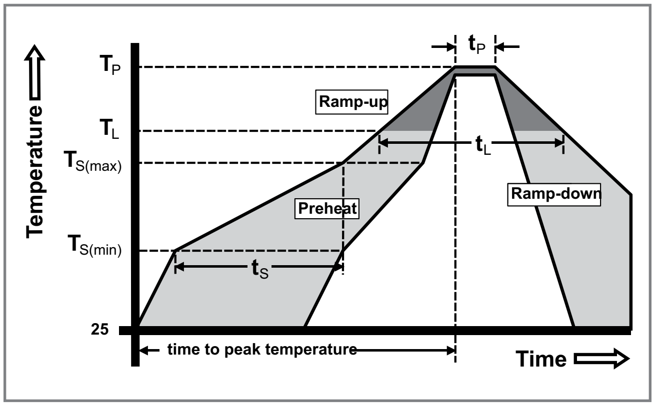


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammabilty classification 94V-0.
Terminal Material	Copper Alloy

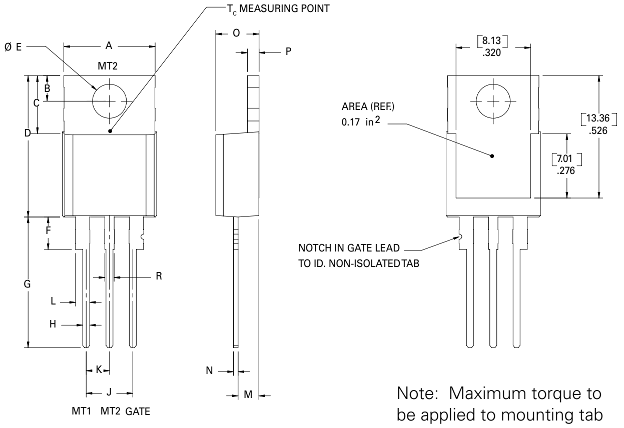
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C, 15-min dwell-time
Temperature/ Humidity	EIA/JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA/JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3 Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

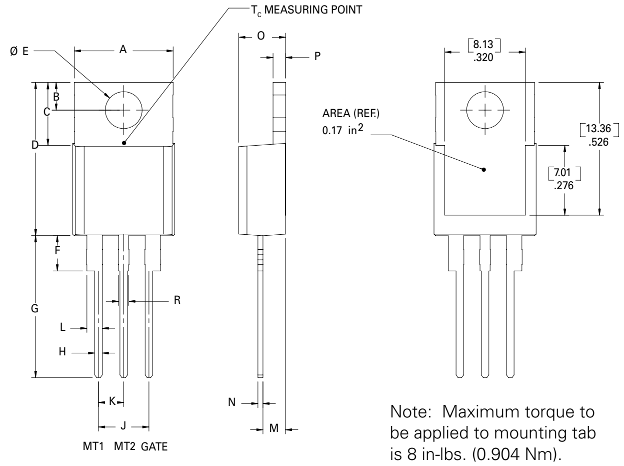
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.965	1.22

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab

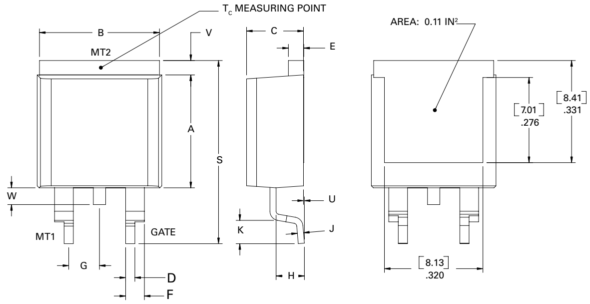


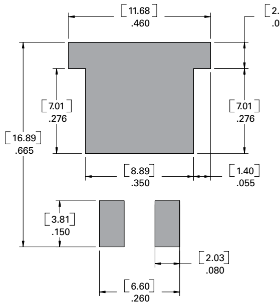
Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.965	1.22

Revised: 12/14/14

Dimensions — TO-263AB (N-Package) — D²-PAK Surface Mount





Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.016	1.78

Product Selector

Part Number	Voltage (xx)				Gate Sensitivity Quadrants		Type	Package
	400V	600V	800V	1000V	I – II – III	IV		
Qxx10L4	X	X	X	X	25 mA	50 mA	Standard Triac	TO-220L
Qxx10R4	X	X	X	X	25 mA	50 mA	Standard Triac	TO-220R
Qxx10N4	X	X	X	X	25 mA	50 mA	Standard Triac	TO-263 D²-PAK
Qxx10L5	X	X	X	X	50 mA		Standard Triac	TO-220L
Qxx10R5	X	X	X	X	50 mA		Standard Triac	TO-220R
Qxx10N5	X	X	X	X	50 mA		Standard Triac	TO-263 D²-PAK
Qxx10LH5	X	X	X	X	50 mA		Alternistor Triac	TO-220L
Qxx10RH5	X	X	X	X	50 mA		Alternistor Triac	TO-220R
Qxx10NH5	X	X	X	X	50 mA		Alternistor Triac	TO-263 D²-PAK

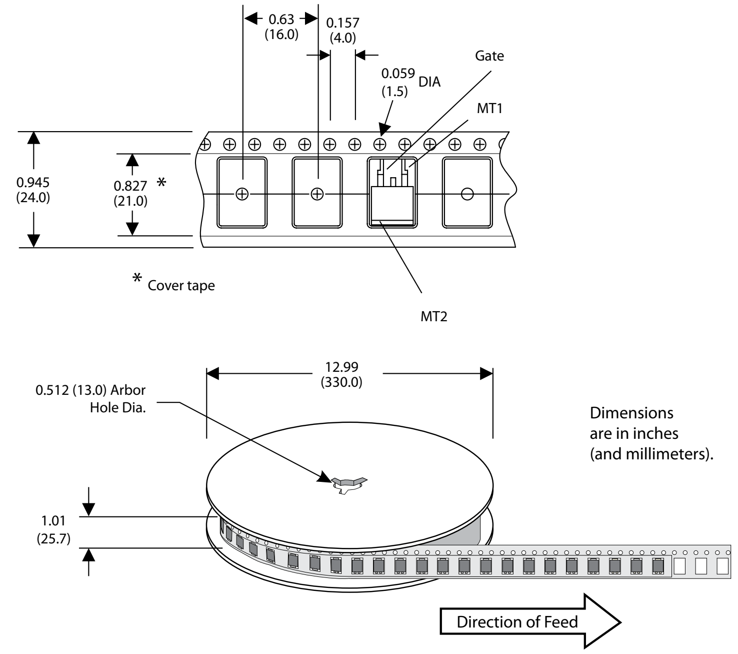
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx10L/Ryy	Qxx10L/Ryy	2.2 g	Bulk	500
Qxx10L/RyyTP	Qxx10L/Ryy	2.2 g	Tube Pack	500 (50 per tube)
Qxx10NyyTP	Qxx10Nyy	1.6 g	Tube	500 (50 per tube)
Qxx10NyyRP	Qxx10Nyy	1.6 g	Embossed Carrier	500

Note: xx = voltage, yy = type & sensitivity

TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System

Q 60 10 L H5 56

DEVICE TYPE
Q: Triac or Alternistor

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
10: 10A

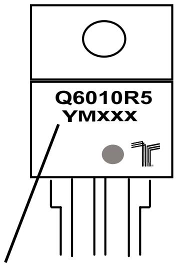
PACKAGE TYPE
L: TO-220 Isolated
R: TO-220 Non-Isolated
N: TO-263 (D² Pak)

LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY
Standard Triac:
4: 25 mA (QI, II, III)
50 mA (QIV)
5: 50 mA (QI, II, III)
Alternistor Triac:
H5: 50mA (QI, II, III)

Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

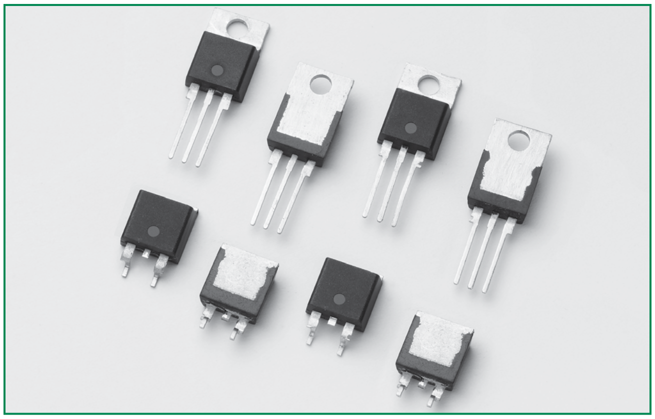
Littelfuse®
Expertise Applied | Answers Delivered

Teccor® brand Thyristors

12 Amp Alternistor (High Communitation) Triacs

Qxx12xHx Series

RoHS



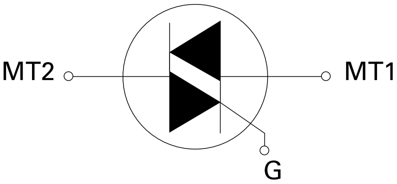
Agency Approval

Agency	Agency File Number
UL	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	12	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	10 to 50	mA

Schematic Symbol



Description

12 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 120 A
- Electrically isolated "L-Package" is UL recognized for 2500Vrms
- Solid-state switching eliminates arcing or contact bounce that create voltage transients
- No contacts to wear out from reaction of switching events
- Restricted (or limited) RFI generation, depending on activation point sine wave
- Requires only a small gate activation pulse in each half-cycle

Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, light dimmers, power tools, lawn care equipment, home/brown goods and white goods appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Absolute Maximum Ratings — Alternistor (3 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx12LHy	T_C = 90°C	12	A
		Qxx12RHy Qxx12NHy	T_C = 105°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	110	A
		f = 60 Hz	t = 16.7 ms	120	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	60	A^2s
di/dt	Critical rate of rise of on-state current	f = 120 Hz	T_J = 125°C	70	A/μs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ μs; $I_{GT} \leq I_{GTM}$	T_J = 125°C	2.0	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant		Qxx12xH2	Qxx12xH5	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	50	mA
V_{GT}		I – II – III	MAX.	1.3	1.3	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.	0.2	0.2	V
I_H	I_T = 100mA		MAX.	15	50	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	300	750	V/μs
		600V		200	650	
		800V		150	500	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V		150	300	
(dv/dt)c	(di/dt)c = 6.5 A/ms T_J = 125°C		MIN.	2	30	V/μs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15μs I_T = 17.0 A(pk)		TYP.	4	4	μs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	I_{TM} = 17.0A t_p = 380 μs			MAX.	1.60	V
I_{DRM} I_{RRM}	$V_D = V_{DRM} / V_{RRM}$	T_J = 25°C	400-1000V	MAX.	10	μA
		T_J = 125°C	400-800V		2	mA
		T_J = 100°C	1000V		3	

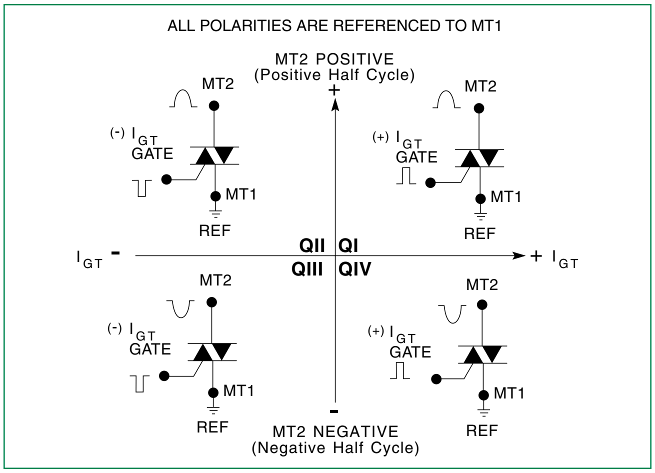
Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Qxx12RHy Qxx12NHy	1.2	°C/W
		Qxx12LHy	2.3	
$R_{\theta(J-A)}$	Junction to ambient (AC)	Qxx12RHy	45	°C/W
		Qxx12LHy	90	

ote: xx = voltage, y = sensitivity

Revised: 12/14/14

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

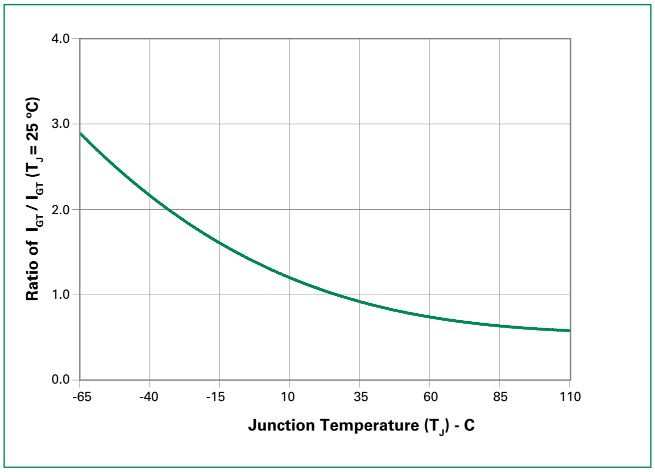


Figure 3: Normalized DC Holding Current vs. Junction Temperature

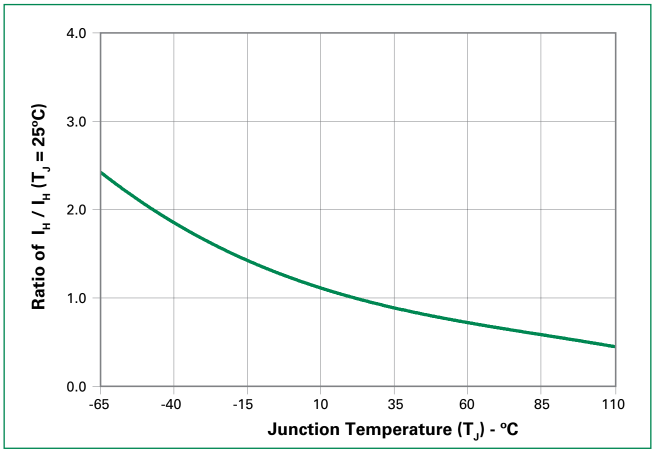


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

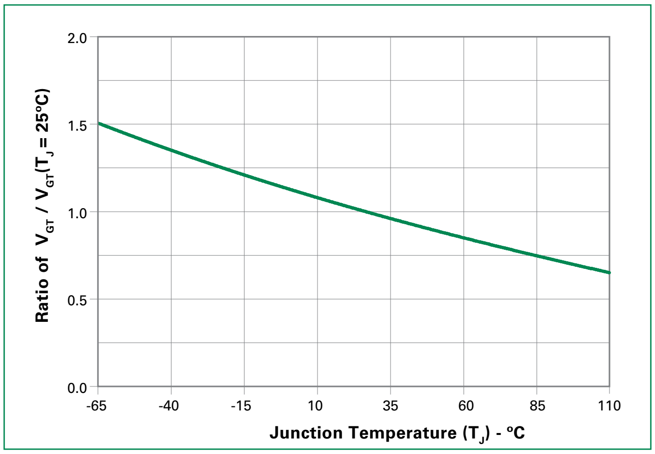


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

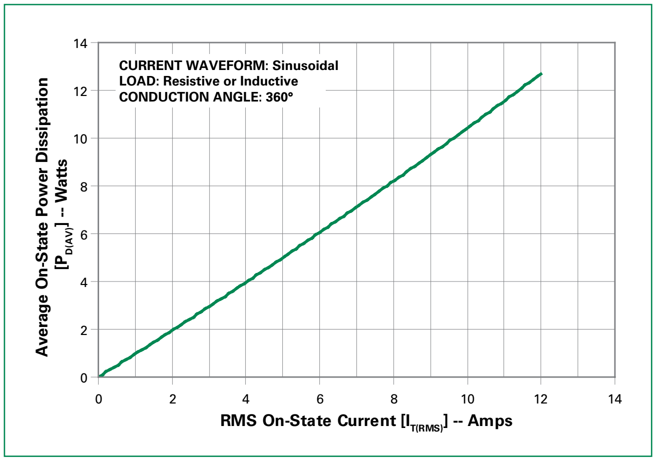


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

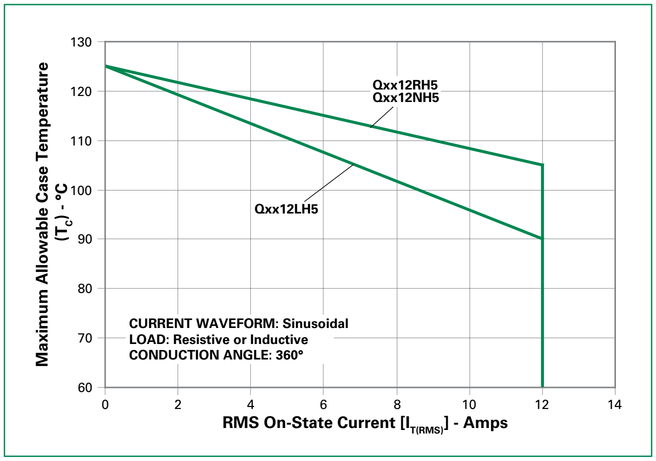


Figure 7: Maximum Allowable Ambient Temperature vs. On-State Current

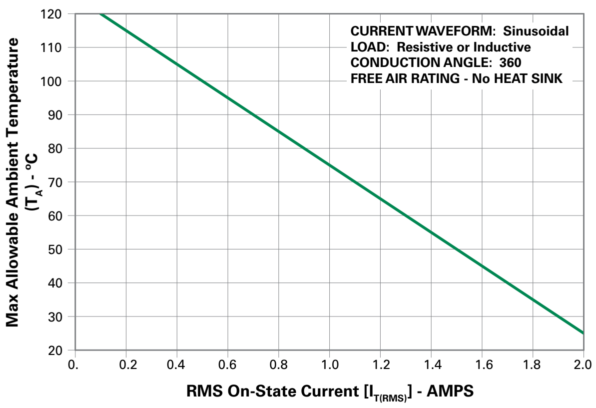


Figure 8: On-State Current vs. On-State Voltage (Typical)

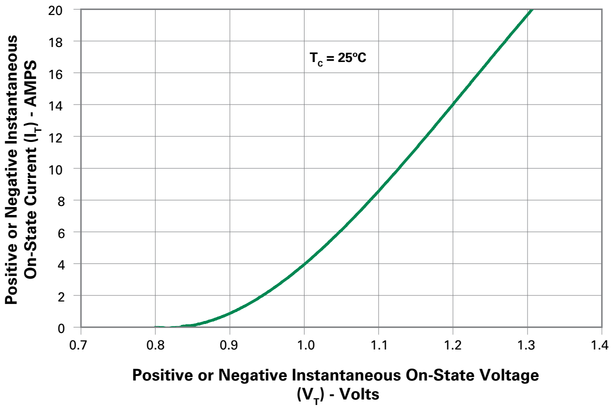
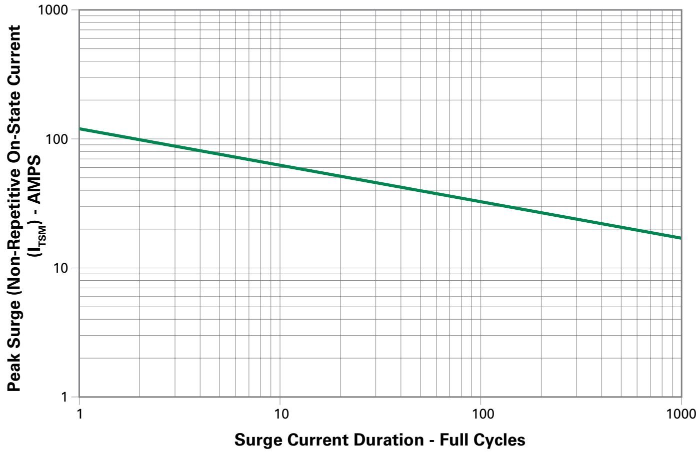


Figure 9: Surge Peak On-State Current vs. Number of Cycles



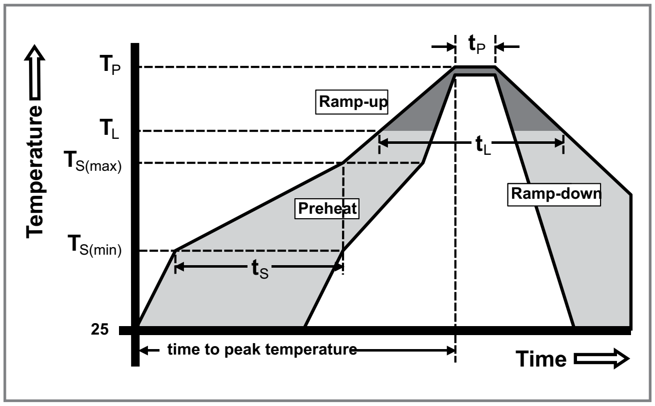
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current [$I_{T(RMS)}$: Maximum]
Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

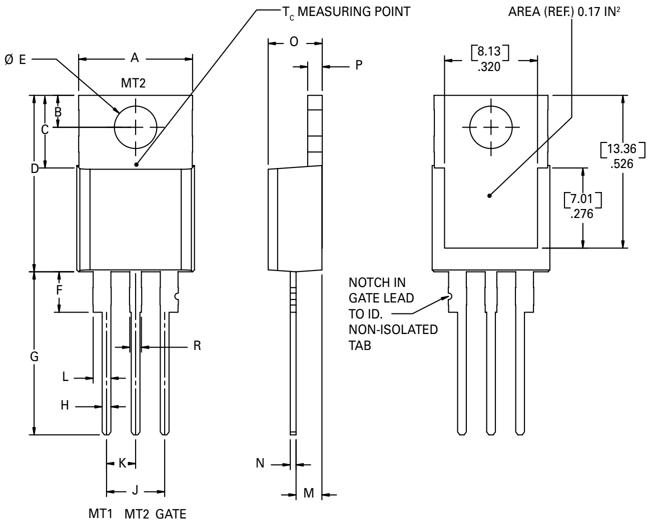
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

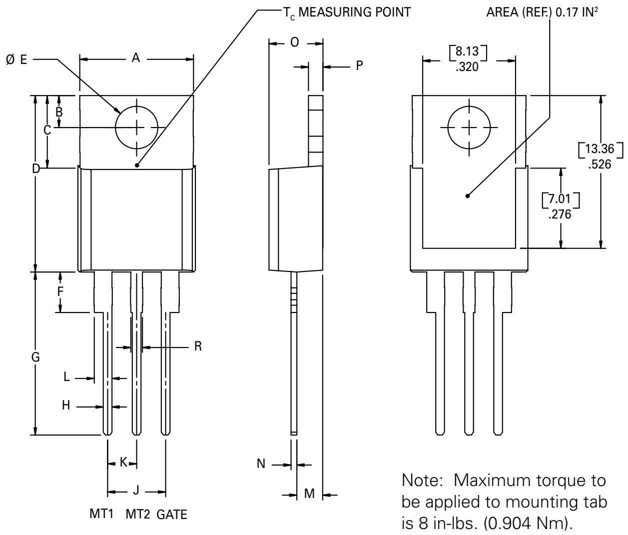
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

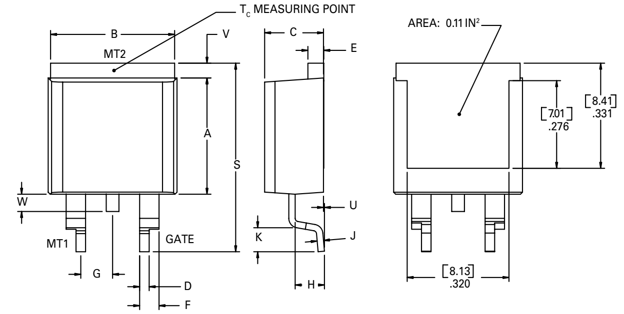
Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab

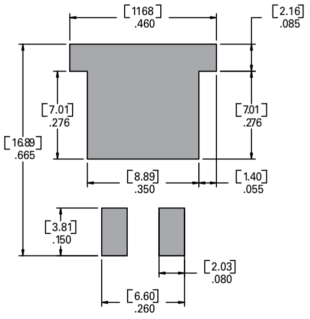


Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-263AB (N-Package) — D²Pak Surface Mount





Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Product Selector

Part Number	Voltage				Gate Sensitivity Quadrants	Type	Package
	400V	600V	800V	1000V	I – II – III		
Qxx12LH2	X	X	X		10 mA	Alternistor Triac	TO-220L
Qxx12RH2	X	X	X		10 mA	Alternistor Triac	TO-220R
Qxx12NH2	X	X	X		10 mA	Alternistor Triac	TO-263 D²-PAK
Qxx12LH5	X	X	X	X	50 mA	Alternistor Triac	TO-220L
Qxx12RH5	X	X	X	X	50 mA	Alternistor Triac	TO-220R
Qxx12NH5	X	X	X	X	50 mA	Alternistor Triac	TO-263 D²-PAK

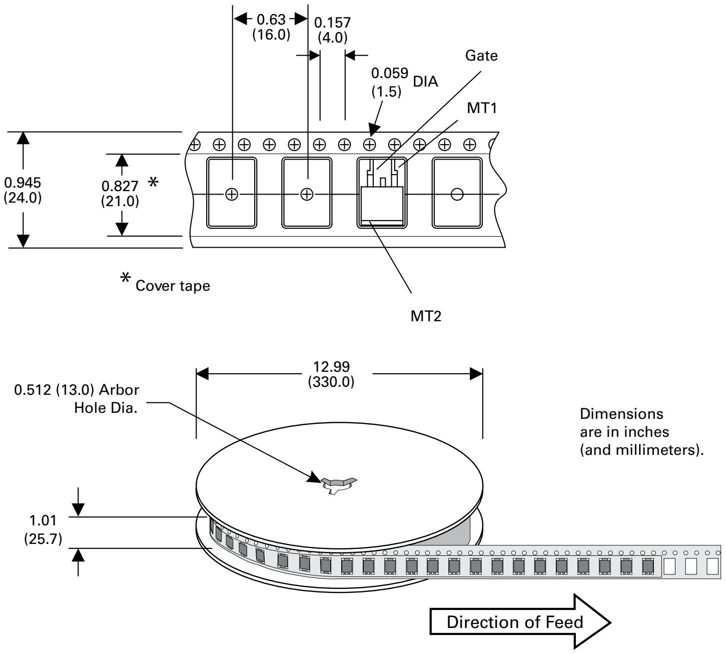
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx12L/RHy	Qxx12L/RHy	2.2 g	Bulk	500
Qxx12L/RHyTP	Qxx12L/RHy	2.2 g	Tube Pack	500 (50 per tube)
Qxx12NHyTP	Qxx12NHy	1.6 g	Tube	500 (50 per tube)
Qxx12NHyRP	Qxx12NHy	1.6 g	Embossed Carrier	500

Note: xx = Voltage; y = Sensitivity

TO-263 Embossed Carrier Reel Pack (RP)

Meets all EIA-481-2 Standards



Part Numbering System

Q 60 12 L H5 56

DEVICE TYPE
Q: Alternistor

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
12: 12A

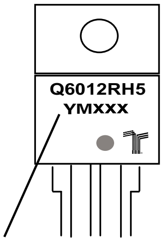
LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY & TYPE
H2: 10mA (QI, II, III)
H5: 50mA (QI, II, III)

PACKAGE TYPE
L : TO-220 Isolated
R : TO-220 Non-Isolated
N : TO-263 (D²Pak)

Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

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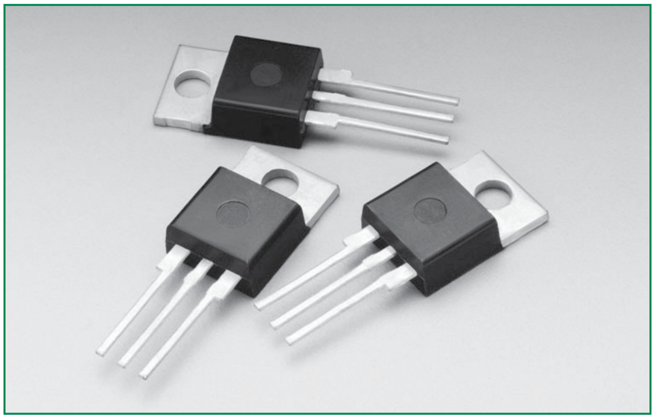
Expertise Applied | Answers Delivered

Teccor® brand Thyristors

12 Amp Alternistor (High Communitation) Triac for LED dimmer Application

Q6012LH1LED Series

RoHS



Description

Q6012LH1LED series is designed to meet low load current characteristics typical in LED lighting applications.

By keeping holding current at 8mA maximum, this Triac series is characterized and specified to perform best with LED loads. The Q6008LH1LED series is best suited for LED dimming controls to obtain the lowest levels of light output with a minimum probability of flickering.

Q6012LH1LED series is offered in the industry standard TO-220AB package with an isolated mounting tab that makes it best suited for adding an external heat sink.

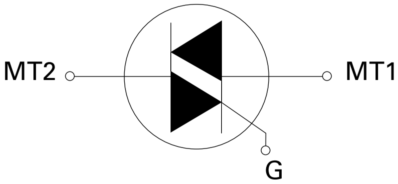
Agency Approval

Agency	Agency File Number
®RU	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	12	A
V_{DRM}/V_{RRM}	600	V
I_{GT}	10	mA

Schematic Symbol



Additional Information

Datasheet | **Resources** | **Samples**

Features

- As low as 8mA max holding current
- UL recognized TO-220AB package
- 110°C rated junction temperature
- di/dt performance of 70A/μs
- QUADRAC version includes intergrated DIAC

Benefits

- Provides full control of light out put at the extreme low end of load conditions.
- 2500V $_{AC}$ min isolation between mounting tab and active terminals
- Improves margin of safe operation with less heat sinking required
- Enable survivability of typically LED load operating characteristics
- Simplicity of circuit design & layout

Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches,lighting controls with LED lamp loads, small low current motor in power tools, lower current motor in home/brown goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Revised: 12/14/14

Absolute Maximum Ratings

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)		T_C = 90°C	12	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	110	A
		f = 60 Hz	t = 16.7 ms	120	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	60	A^2s
di/dt	Critical rate of rise of on-state current	f = 120 Hz	T_J = 110°C	70	A/μs
I_{GTM}	Peak gate trigger current	$t_p \le$ 10 μs; $I_{GT} \le I_{GTM}$	T_J = 110°C	2.0	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 110°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions	Quadrant		Qxx12LH1	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	mA
V_{GT}		I – II – III	MAX.	1.3	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	I – II – III	MIN.	0.2	V
I_H	I_T = 20mA		MAX.	8	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 110°C		MIN.	45	V/μs
(dv/dt)c	(di/dt)c = 6.5 A/ms T_J = 110°C		MIN.	2	V/μs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15μs I_T = 17.0 A(pk)		TYP.	4	μs

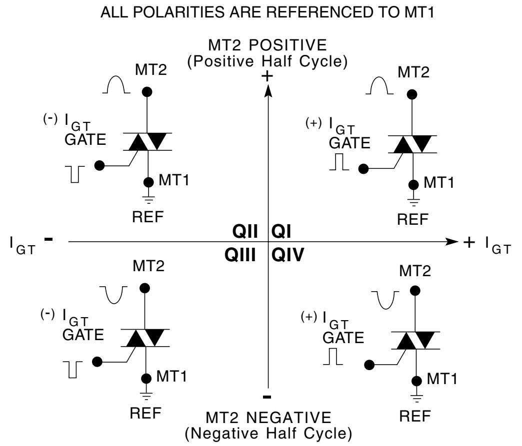
Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_{TM} = 17.0A t_p = 380 μs		MAX.	1.60	V
I_{DRM} I_{RRM}	$V_D = V_{DRM} / V_{RRM}$	T_J = 25°C	MAX.	10	μA
		T_J = 110°C		1	mA

Thermal Resistances

Symbol	Parameter	Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	2.3	°C/W
$R_{\theta(J-A)}$	Junction to ambient	55	°C/W

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

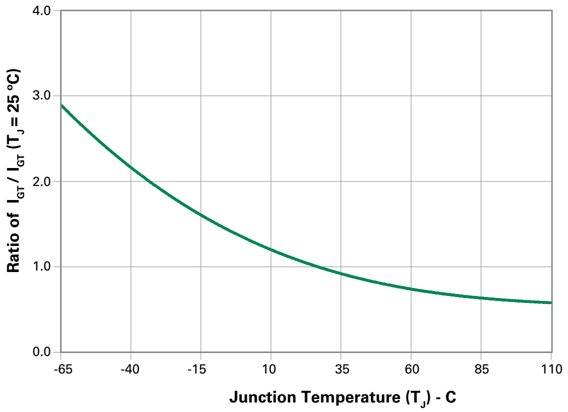


Figure 3: Normalized DC Holding Current vs. Junction Temperature

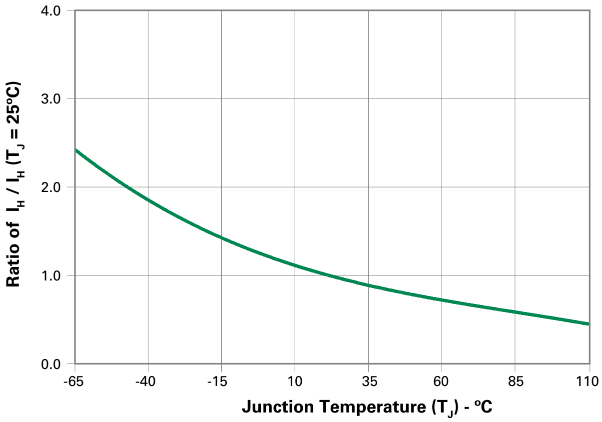
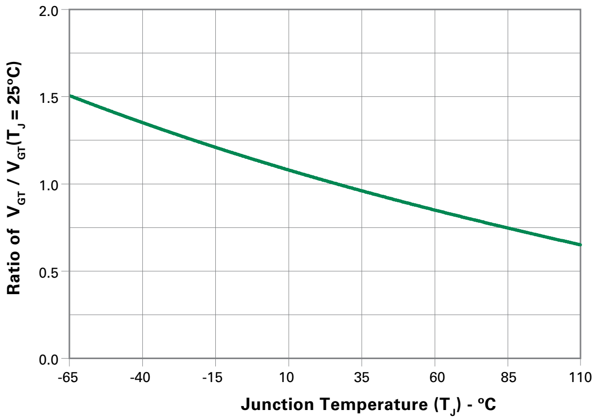


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature



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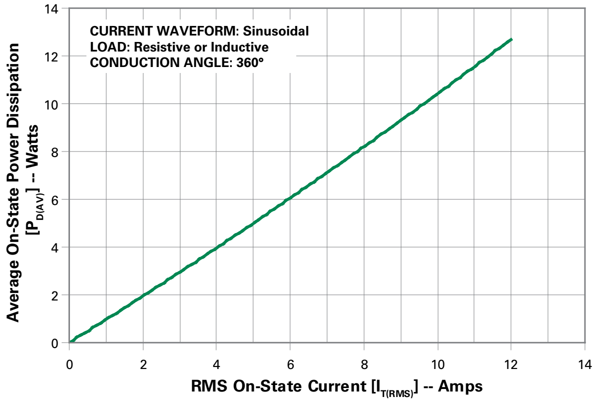


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

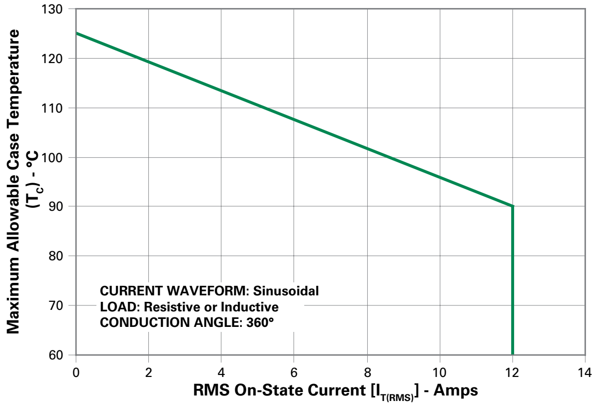


Figure 7: Maximum Allowable Ambient Temperature vs. On-State Current

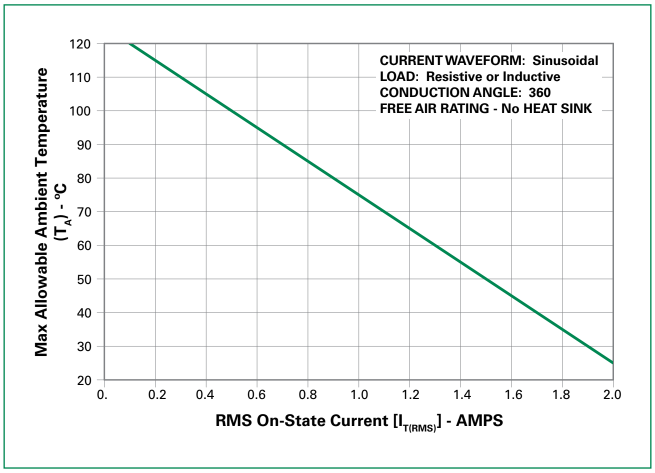


Figure 8: On-State Current vs. On-State Voltage (Typical)

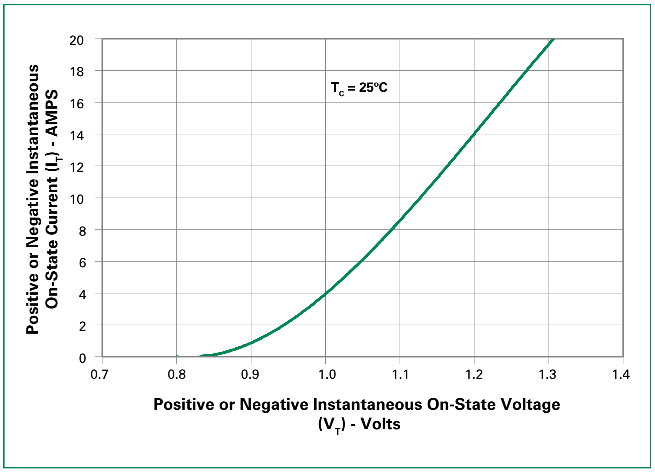
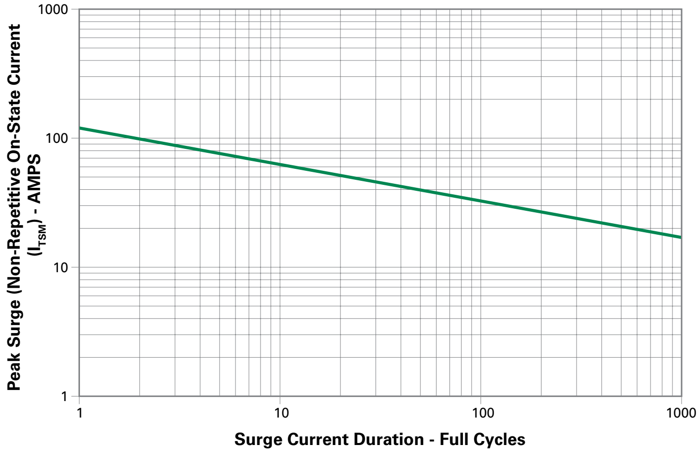


Figure 9: Surge Peak On-State Current vs. Number of Cycles



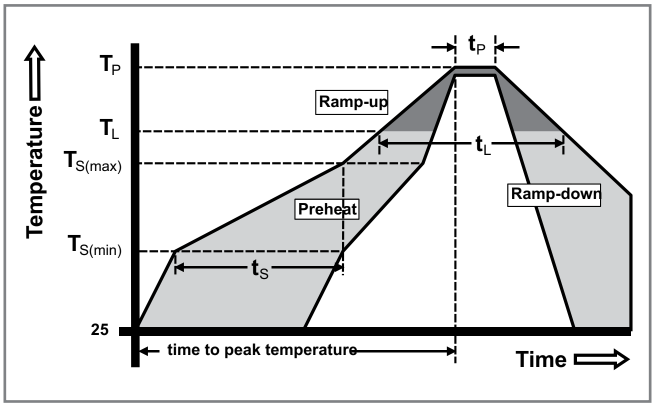
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current [$I_{T(RMS)}$: Maximum]
Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

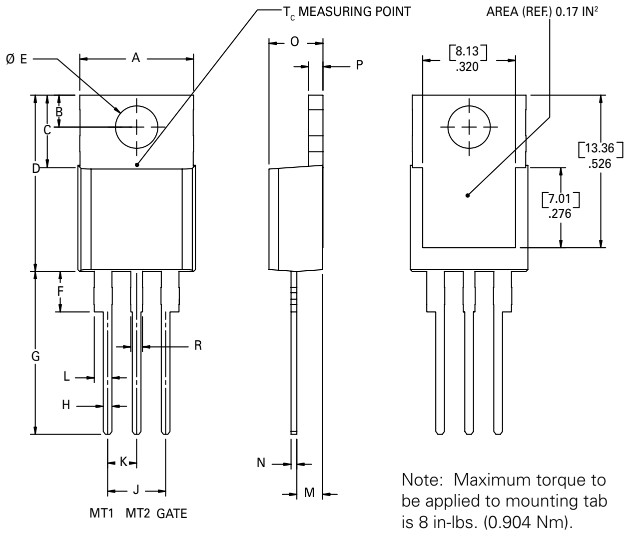
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 110°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

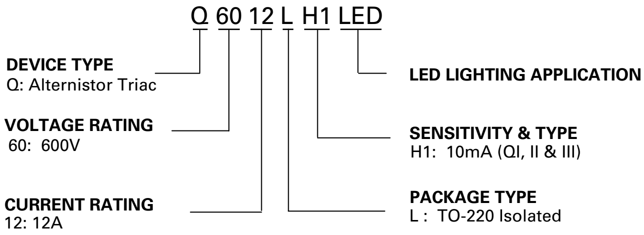
Product Selector

Part Number	Gate Sensitivity Quadrants	Type	Package
	I – II – III		
Q6012LH1LED	10 mA	Alternistor Triac	TO-220L

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Q6012LH1LED	Q6012LH1	2.2 g	Bulk	500
Q6012LH1LEDTP	Q6012LH1	2.2 g	Tube Pack	500 (50 per tube)

Part Numbering System



DEVICE TYPE
Q: Alternistor Triac

VOLTAGE RATING
60: 600V

CURRENT RATING
12: 12A

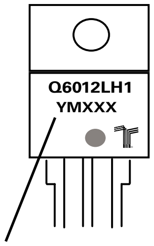
LED LIGHTING APPLICATION

SENSITIVITY & TYPE
H1: 10mA (QI, II & III)

PACKAGE TYPE
L : TO-220 Isolated

Part Marking System

TO-220 AB - (L Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

Littelfuse®

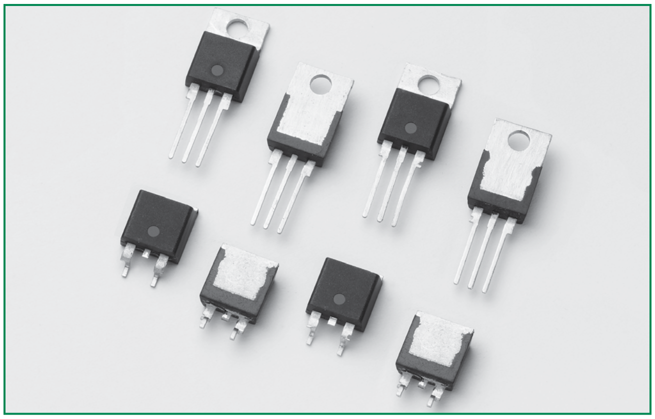
Expertise Applied | Answers Delivered

Teccor® brand Thyristors

15 Amp Standard & 16 Amp Alternistor (High Commutation) Triacs

Qxx15xx & Qxx16xHx Series

RoHS



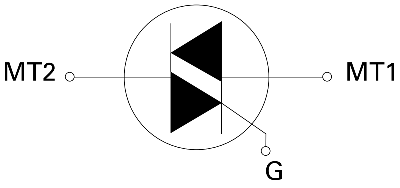
Agency Approval

Agency	Agency File Number
®ƦU	L Package : E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	15 & 16	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	10 to 80	mA

Schematic Symbol



Additional Information

Datasheet

Resources

Samples

Description

15 Amp and 16 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 200 A
- Electrically isolated "L-Package" is UL recognized for 2500Vrms
- Solid-state switching eliminates arcing or contact bounce that create voltage transients
- No contacts to wear out from reaction of switching events
- Restricted (or limited) RFI generation, depending on activation point in sine wave
- Requires only a small gate activation pulse in each half-cycle

Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, light dimmers, power tools, lawn care equipment, home/brown goods and white goods appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Absolute Maximum Ratings — Standard Triac

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx15Ly	T_C = 80°C	15	A
		Qxx15Ry Qxx15Ny	T_C = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	167	A
		f = 60 Hz	t = 16.7 ms	200	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	166	A^2s
di/dt	Critical rate of rise of on-state current	f = 120 Hz	T_J = 125°C	100	A/μs
I_{GTM}	Peak gate trigger current	$t_p \le 10$ μs $I_{GT} \le I_{GTM}$	T_J = 125°C	2.0	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Alternistor Triac (3 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx16LHy	T_C = 80°C	16	A
		Qxx16RHy Qxx16NHy	T_C = 90°C		
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	167	A
		f = 60 Hz	t = 16.7 ms	200	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	166	A^2s
di/dt	Critical rate of rise of on-state current	f = 120 Hz	T_J = 125°C	100	A/μs
I_{GTM}	Peak gate trigger current	$t_p \le 10$ μs; $I_{GT} \le I_{GTM}$	T_J = 125°C	2.0	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, y = sensitivity

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Value	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	50	mA
V_{GT}		I – II – III	MAX.	2.0	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.	0.2	V
I_H	I_T = 100mA		MAX.	70	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	275	V/μs
		600V		225	
		800V		200	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V		200	
(dv/dt)c	(di/dt)c = 8.1 A/ms T_J = 125°C		MIN.	4	V/μs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15μs I_T = 22.6 A(pk)		TYP.	4	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant		Qxx16xH2	Qxx16xH3	Qxx16xH4	Qxx16xH6	Unit
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	10	20	35	80	mA
V_{GT}		I – II – III	MAX.	1.3				V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.	0.2				V
I_H	I_T = 100mA		MAX.	15	35	50	70	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	200	350	475	925	V/µs
		600V		150	250	400	850	
		800V		100	200	350	475	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V		100	200	300	350	
(dv/dt)c	(di/dt)c = 8.6 A/ms T_J = 125°C		MIN.	2	20	25	30	V/µs
t_{gt}	I_G = 2 x I_{GT} PW = 15µs I_T = 22.6 A(pk)		TYP.	3	3	3	5	µs

Static Characteristics

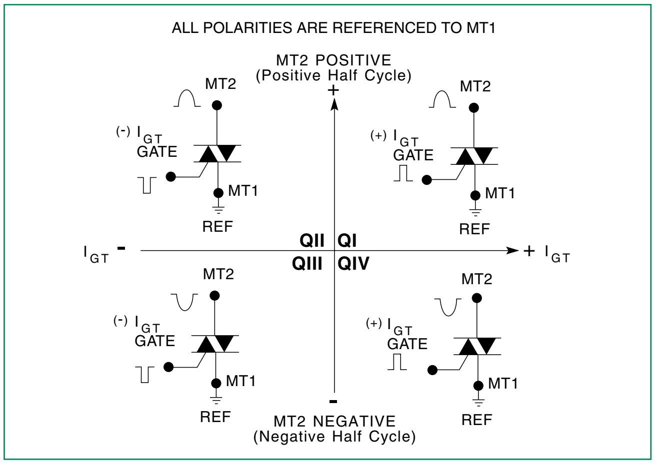
Symbol	Test Conditions				Value	Unit
V_{TM}	15A Device I_T = 21.2A t_p = 380µs			MAX	1.60	V
	16A Device I_T = 22.6A t_p = 380µs					
I_{DRM} I_{RRM}	$V_D = V_{DRM} / V_{RRM}$	T_J = 25°C	400-1000V	MAX	5	µA
		T_J = 125°C	400-800V		2	mA
		T_J = 100°C	1000V		3	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Qxx15Ry Qxx15Ny Qxx16RHy Qxx16NHy	1.7	°C/W
		Qxx15Ly Qxx16LHy	2.1	
$R_{\theta(J-A)}$	Junction to ambient	Qxx15Ry Qxx16RHy	45	°C/W
		Qxx15Ly Qxx16LHy	50	

Note: xx = voltage; y = sensitivity

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

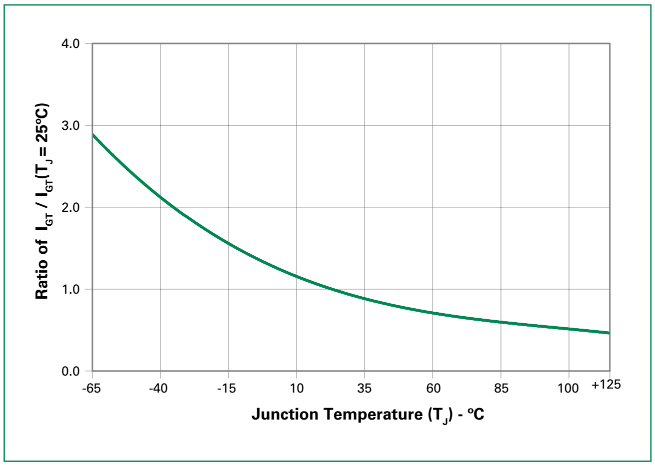


Figure 3: Normalized DC Holding Current vs. Junction Temperature

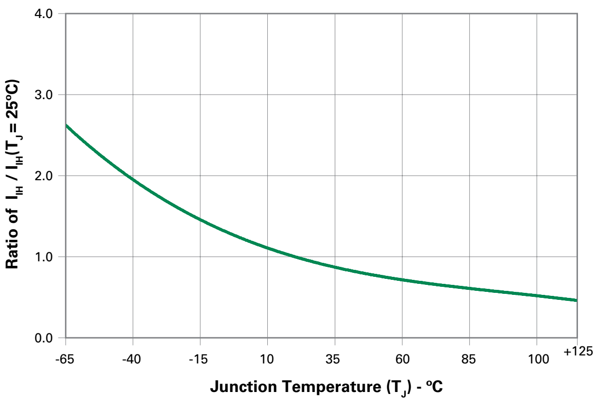


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

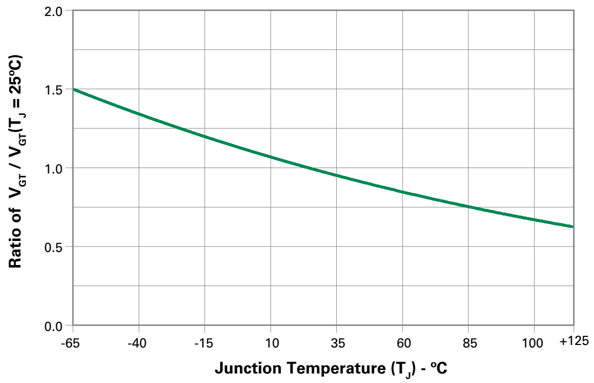


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

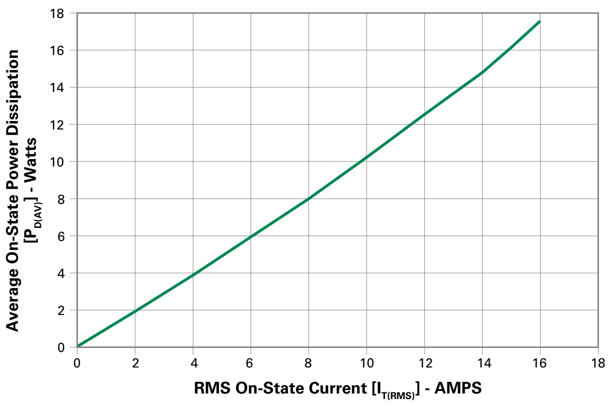


Figure 6: Maximum Allowable Case Temperature vs. On-State Current (15A devices)

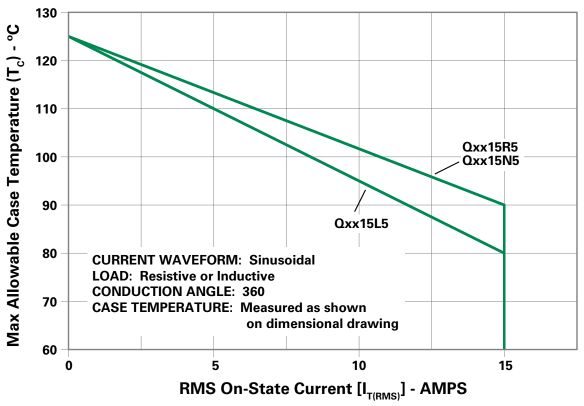


Figure 7: Maximum Allowable Case Temperature vs. On-State Current (16A devices)

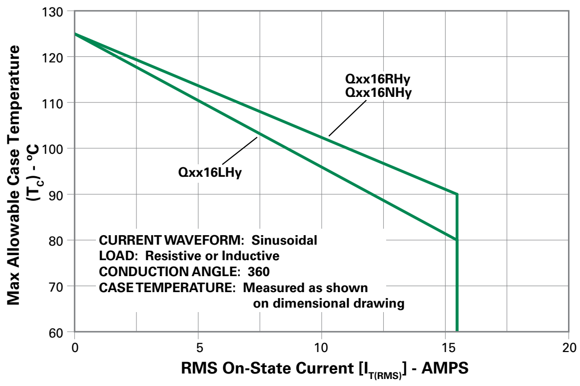


Figure 8: Maximum Allowable Ambient Temperature vs. On-State Current

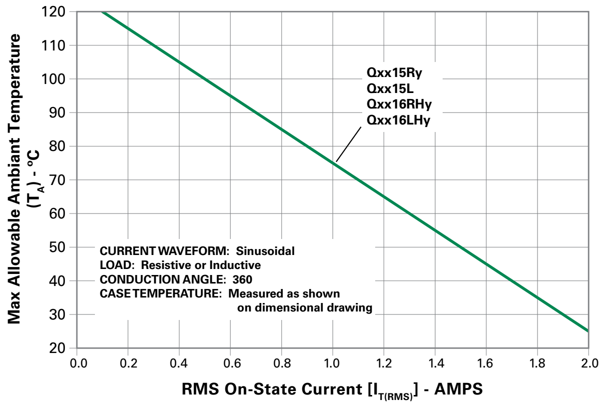


Figure 9: On-State Current vs. On-State Voltage (Typical)

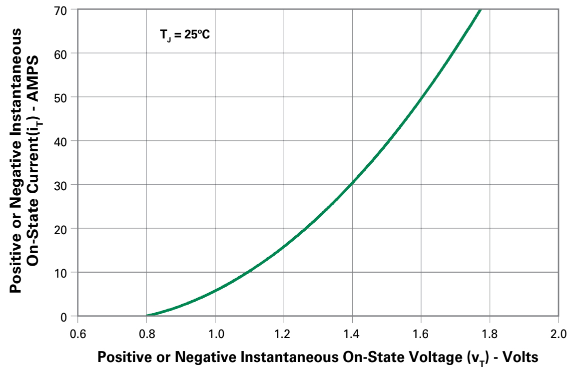
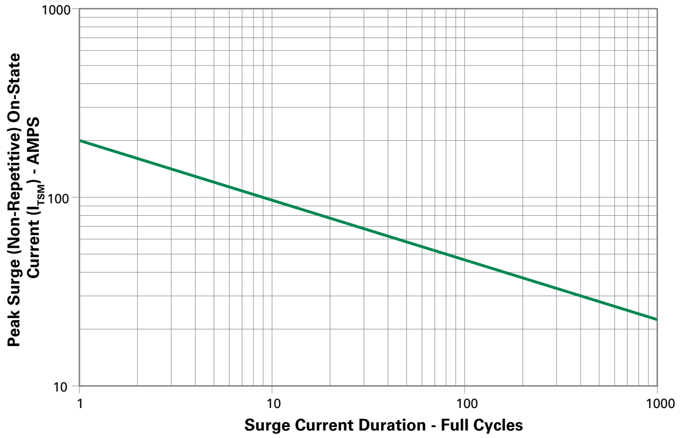


Figure 10: Surge Peak On-State Current vs. Number of Cycles



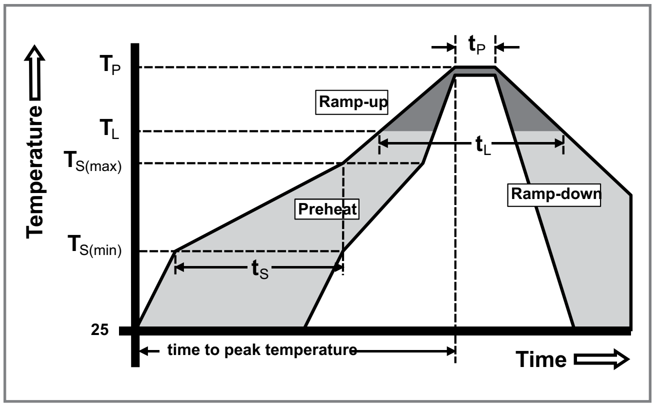
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Terminal Material	Copper Alloy

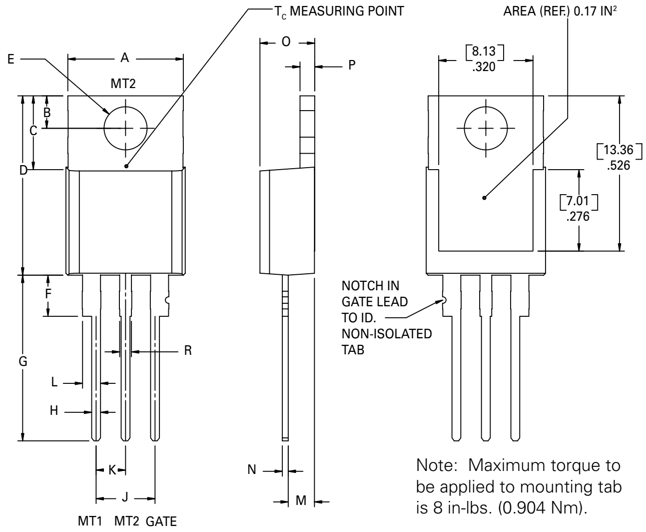
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

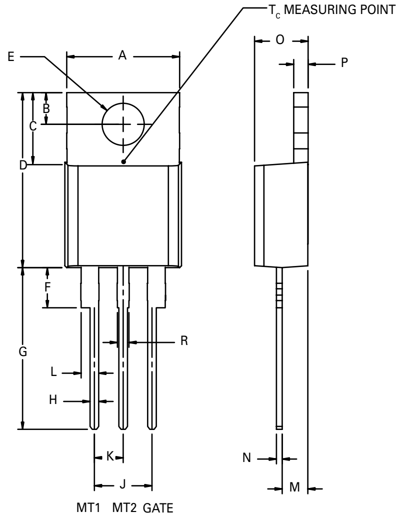
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead

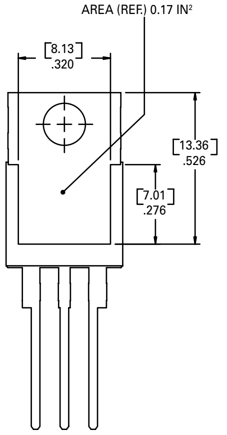


Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.66	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab

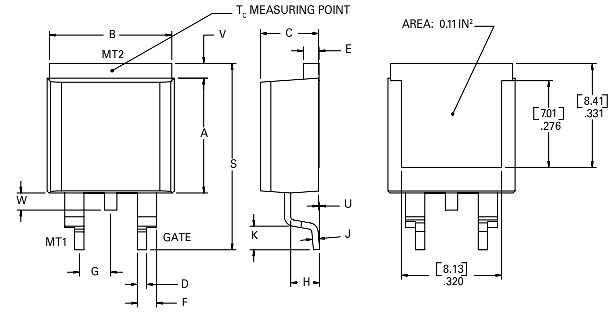


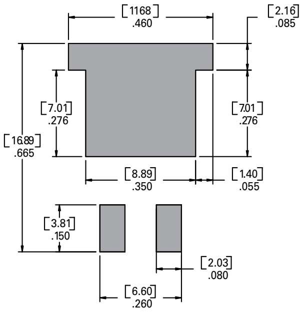


Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.60
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-263AB (N-Package) — D²Pak Surface Mount





Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Product Selector

Part Number	Voltage				Gate Sensitivity Quadrants	Type	Package
	400V	600V	800V	1000V	I – II – III		
Qxx15L5	X	X	X	X	50 mA	Standard Triac	TO-220L
Qxx15R5	X	X	X	X	50 mA	Standard Triac	TO-220R
Qxx15N5	X	X	X	X	50 mA	Standard Triac	TO-263 D²-PAK
Qxx16LH2	X	X	X	X	10 mA	Alternistor Triac	TO-220L
Qxx16RH2	X	X	X	X	10 mA	Alternistor Triac	TO-220R
Qxx16NH2	X	X	X	X	10 mA	Alternistor Triac	TO-263 D²-PAK
Qxx16LH3	X	X	X	X	20 mA	Alternistor Triac	TO-220L
Qxx16RH3	X	X	X	X	20 mA	Alternistor Triac	TO-220R
Qxx16NH3	X	X	X	X	20 mA	Alternistor Triac	TO-263 D²-PAK
Qxx16LH4	X	X	X	X	35 mA	Alternistor Triac	TO-220L
Qxx16RH4	X	X	X	X	35 mA	Alternistor Triac	TO-220R
Qxx16NH4	X	X	X	X	35 mA	Alternistor Triac	TO-263 D²-PAK
Qxx16LH6	X	X	X	X	80 mA	Alternistor Triac	TO-220L
Qxx16RH6	X	X	X	X	80 mA	Alternistor Triac	TO-220R
Qxx16NH6	X	X	X	X	80 mA	Alternistor Triac	TO-263 D²-PAK

Packing Options

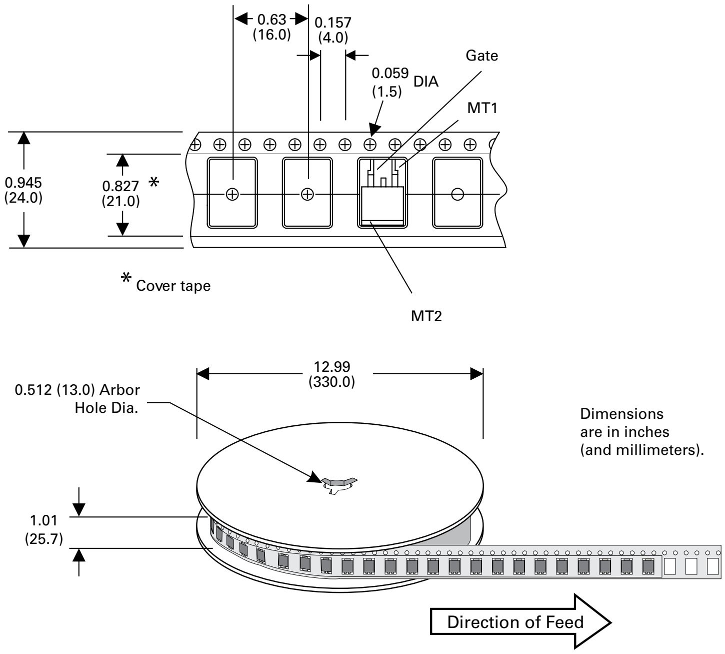
Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx15L/Ry	Qxx15L/Ry	2.2 g	Bulk	500
Qxx15L/RyTP	Qxx15L/Ry	2.2 g	Tube Pack	500 (50 per tube)
Qxx15NyTP	Qxx15Ny	1.6 g	Tube	500 (50 per tube)
Qxx15NyRP	Qxx15Ny	1.6 g	Embossed Carrier	500
Qxx16L/RHy	Qxx16L/RHy	2.2 g	Bulk	500
Qxx16L/RHyTP	Qxx16L/RHy	2.2 g	Tube Pack	500 (50 per tube)
Qxx16NHyTP	Qxx16NHy	1.6 g	Tube	500 (50 per tube)
Qxx16NHyRP	Qxx16NHy	1.6 g	Embossed Carrier	500

Note: xx = Voltage; y = Sensitivity

Revised: 12/14/14

TO-263 Embossed Carrier Reel Pack (RP)

Meets all EIA-481-2 Standards



Dimensions are in inches (and millimeters).

Part Numbering System

Q 60 16 L H4 56

DEVICE TYPE
Q: Triac or Alternistor

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
15: 15A
16: 16A

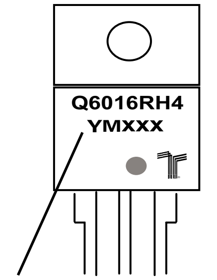
LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY & TYPE
Standard Triac
5: 50mA (QI, II, III)
Alternistor Triac
H2: 10mA (QI, II, III)
H3: 20mA (QI, II, III)
H4: 35mA (QI, II, III)
H6: 80mA (QI, II, III)

PACKAGE TYPE
L: TO-220 Isolated
R: TO-220 Non-Isolated
N: TO-263 (D²-Pak)

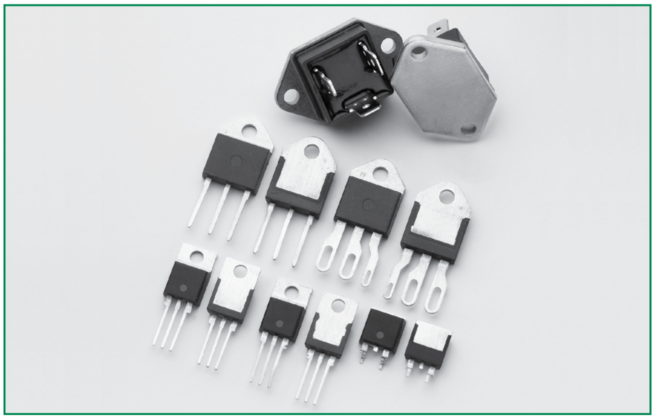
Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Qxx25xx & Qxx25xHx Series



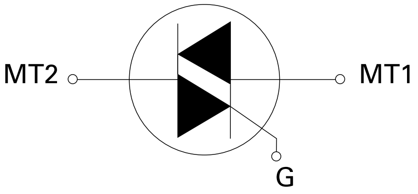
Agency Approval

Agency	Agency File Number
®UL	TO-220L, TO-218K, TO-218J & Fastpak Packages: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	25	A
V_{DRM}/V_{RRM}	1000	V
I_{GT}	50 to 80	mA

Schematic Symbol



Description

25 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 250 A

Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Absolute Maximum Ratings – Standard Triac

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Qxx25R5 Qxx25N5	T_C = 85°C	25	A
		Qxx25P5	T_C = 57°C		
I_{TSM}	Peak non-repetitive surge current	Qxx25R5 Qxx25N5	full cycle; f = 50Hz; T_J (initial) = 25°C	167	A
			full cycle; f = 60Hz; T_J (initial) = 25°C	200	
		Qxx25P5	full cycle; f = 50Hz; T_J (initial) = 25°C	220	
			full cycle; f = 60Hz; T_J (initial) = 25°C	250	
I^2t	I^2t Value for fusing	Qxx25R5 Qxx25N5	t_p = 8.3ms	166	A^2s
		Qxx25P5		260	
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =125°C		100	A/μs
I_{GTM}	Peak gate current	T_J = 125°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.5	W
T_{stg}	Storage temperature range			-40 to 125	°C
T_J	Operating junction temperature range	Qxx25R5 Qxx25N5		-40 to 125	°C
		Qxx25P5		-25 to 125	

Absolute Maximum Ratings – Alternistor Triac

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Qxx25LH5 Qxx25L6	T_C = 65°C	25	A
		Qxx25K6 Qxx25J6	T_C = 85°C		
		Qxx25RH5 Qxx25NH5 Qxx25R6 Qxx25NH6	T_C = 95°C		
I_{TSM}	Peak non-repetitive surge current	full cycle; f = 50Hz; T_J (initial) = 25°C		208	A
		full cycle; f = 60Hz; T_J (initial) = 25°C		250	
I^2t	I^2t Value for fusing	t_p = 8.3ms		260	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =125°C		100	A/μs
I_{GTM}	Peak gate current	T_J = 125°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.5	W
T_{stg}	Storage temperature range			-40 to 125	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Value		Unit
				Qxx25R5 Qxx25N5	Qxx25P5	
I_{GT}	V_D = 12V; R_L = 60 Ω	I – II – III	MAX.	50		mA
		IV	TYP.	120		
V_{GT}		I – II – III	MAX.	1.3		V
		IV	TYP.	2.5		
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ ; T_J = 125°C	ALL	MIN.	0.2		V
I_H	I_T = 400mA (initial)		MAX.	100	50	mA
dv/dt	V_D = V_{DRM}; Gate Open; T_J = 125°C	400V	MIN.	275	—	V/μs
		600V		225	475	
		800V		200	400	
	V_D = V_{DRM}; Gate Open; T_J = 100°C	1000V		200	—	
(dv/dt)c	(di/dt)c = 13.3 A/ms; T_J = 125°C		MIN.	5		V/μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 35.4 A		TYP.	4	3	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac

Symbol	Test Conditions	Quadrant		Value		Unit
				Qxx25RH5 Qxx25LH5 Qxx25NH5	Qxx25R6 Qxx25L6 Qxx25NH6 Qxx25K6 Qxx25J6	
I_{GT}	V_D = 12V; R_L = 60 Ω	I – II – III	MAX.	50	80	mA
V_{GT}		I – II – III	MAX.	1.3		V
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ ; T_J = 125°C	I – II – III	MIN.	0.2		V
I_H	I_T = 400mA (initial)		MAX.	50	100	mA
dv/dt	V_D = V_{DRM}; Gate Open; T_J = 125°C	400V	MIN.	575	600	V/μs
		600V		500	600	
		800V		400	475	
	V_D = V_{DRM}; Gate Open; T_J = 100°C	1000V		—	400	
(dv/dt)c	(di/dt)c = 13.3 A/ms; T_J = 125°C		MIN.	20	30	V/μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 35.4 A		TYP.	3	5	μs

Static Characteristics

Symbol	Test Conditions				Value		Unit
					Qxx25R5 Qxx25N5 Qxx25xH5 Qxx25x6 Qxx25NH6	Qxx25P5	
V_{TM}	I_T = 35.4A; t_p = 380 μs			MAX.	1.8	1.4	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	600 – 800V	MAX.	10	100	μA
			1000V		20	—	
		T_J = 100°C	600 – 800V		500	—	
			1000V		1000	—	
		T_J = 125°C	600 – 800V		2000	5000	

Note: xx = voltage, x = package

Revised: 12/14/14

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Qxx25R5 / Qxx25N5 Qxx25R6 / Qxx25NH6 Qxx25RH5 / Qxx25NH5	0.89	°C/W
		Qxx25P5	1.6	
		Qxx25L6 / Qxx25LH5	2.0	
		Qxx25K6 / Qxx25J6	1.32	
$R_{\theta(J-A)}$	Junction to ambient	Qxx25Ry	45	°C/W
		Qxx25L6 / Qxx25LH5	50	

Note: xx = voltage, y = sensitivity

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

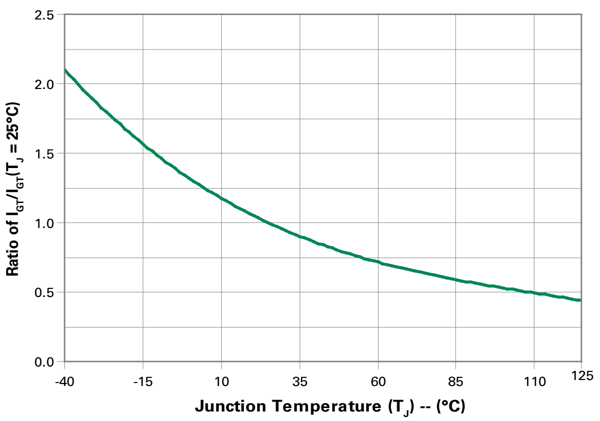


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

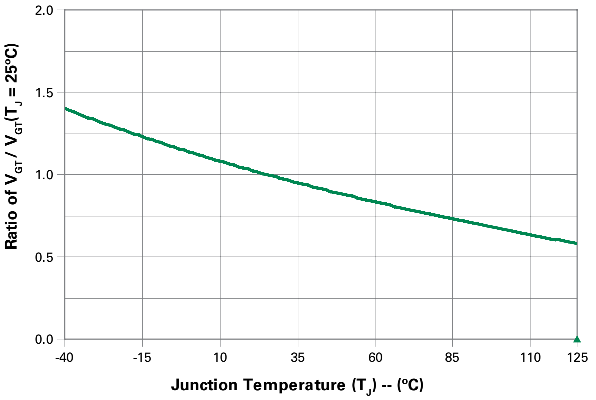


Figure 3: Normalized DC Holding Current vs. Junction Temperature

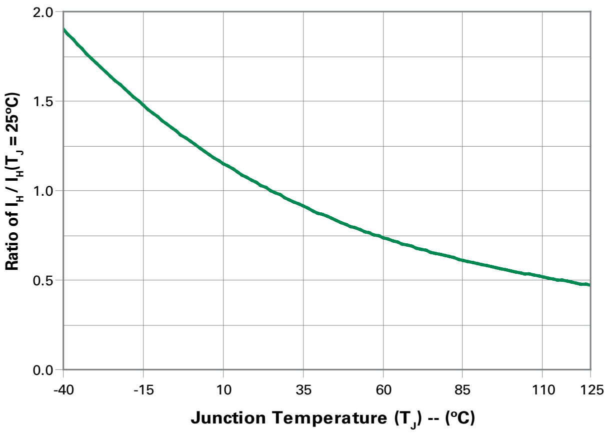


Figure 4: On-State Current vs. On-State Voltage (Typical)

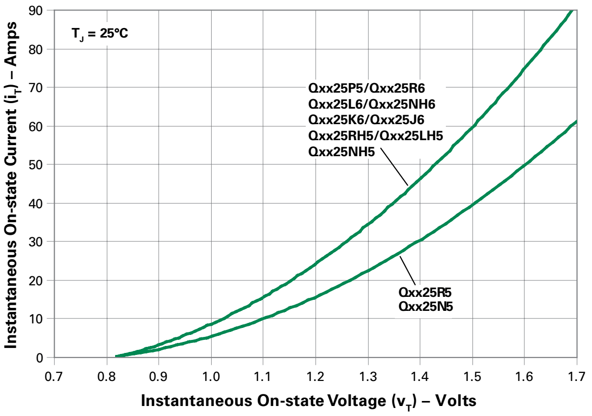


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

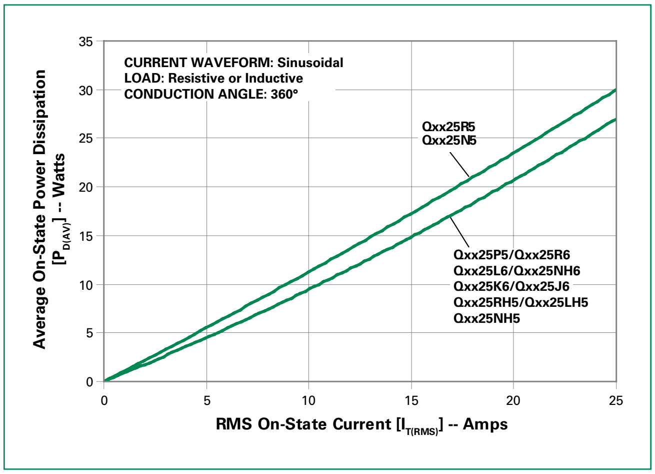


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

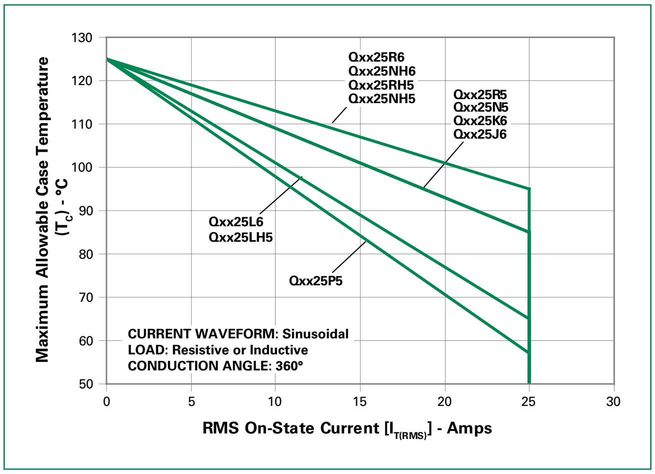


Figure 7: Maximum Allowable Ambient Temperature vs. RMS On-State Current (TO-220 packages only)

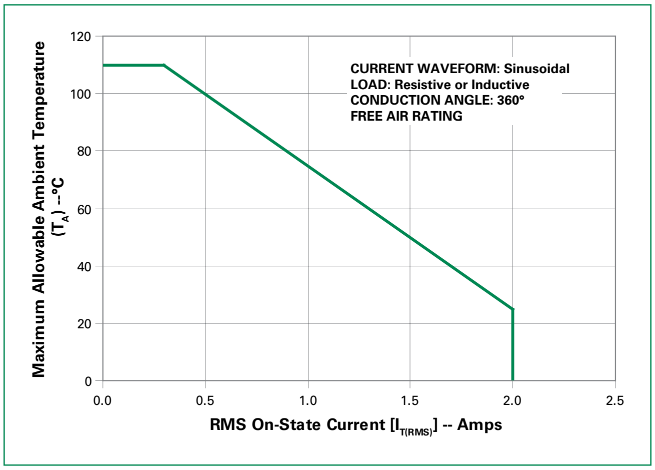
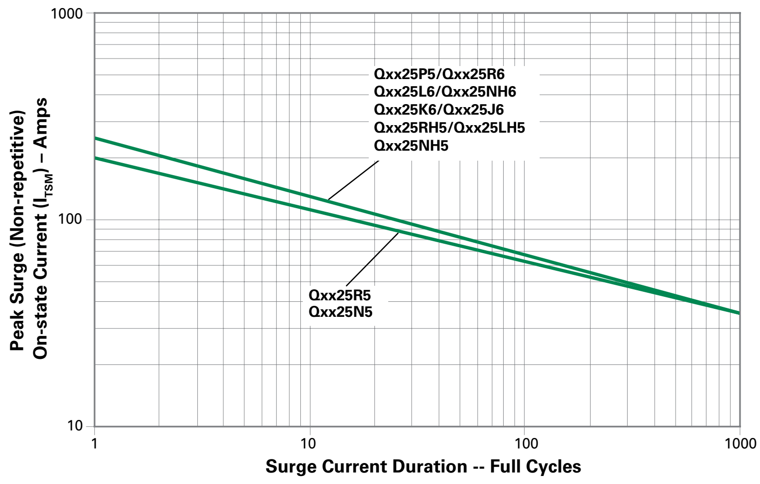


Figure 8: Surge Peak On-State Current vs. Number of Cycles

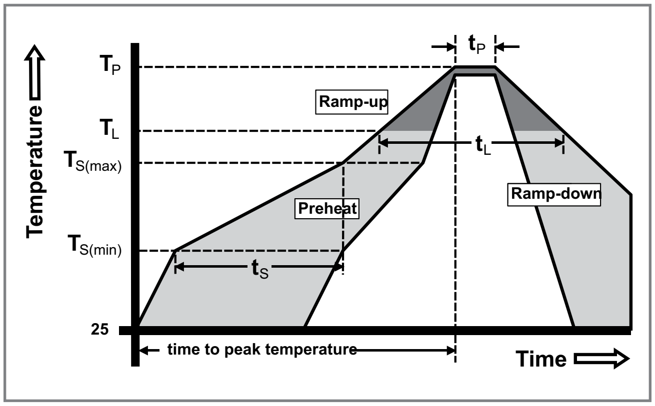


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

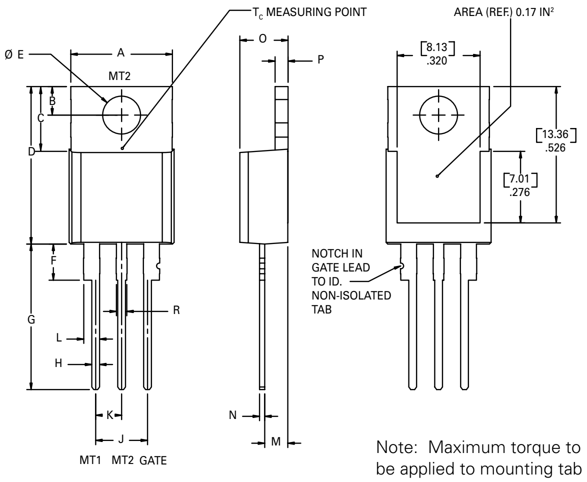
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{RRM}, 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 125°C, 15-minute dwell, 100 cycles
Biased Temp & Humidity	EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours
High Temp. Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002, Category 3, Test A
Lead Bend	MIL-STD-750: Method 2036, Condition E

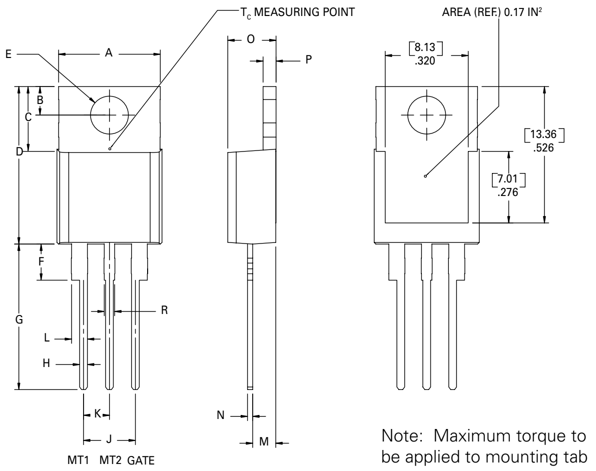
Dimensions — TO-220AB (R Package) — Non-isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-220AB (L Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.66	2.92
C	0.230	0.250	5.85	6.35
D	0.590	0.620	14.98	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.80	3.30
G	0.540	0.575	13.71	14.60
H	0.025	0.035	0.63	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	1.78	2.16
N	0.018	0.024	0.45	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.53
R	0.038	0.048	0.97	1.22

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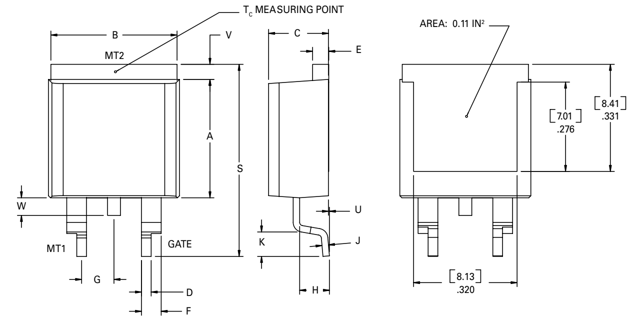
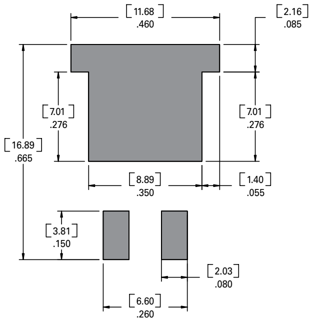
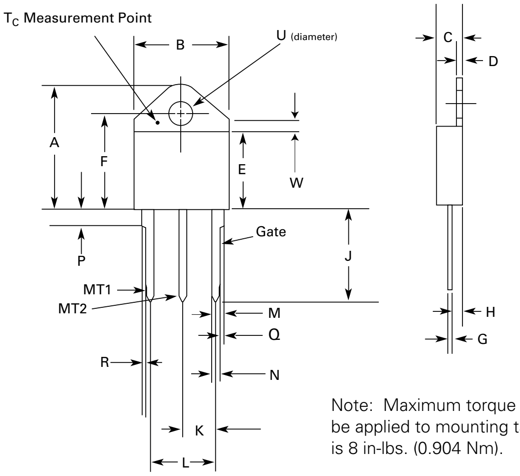
Dimensions — TO-263 (N Package) — D²Pak Surface Mount





Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

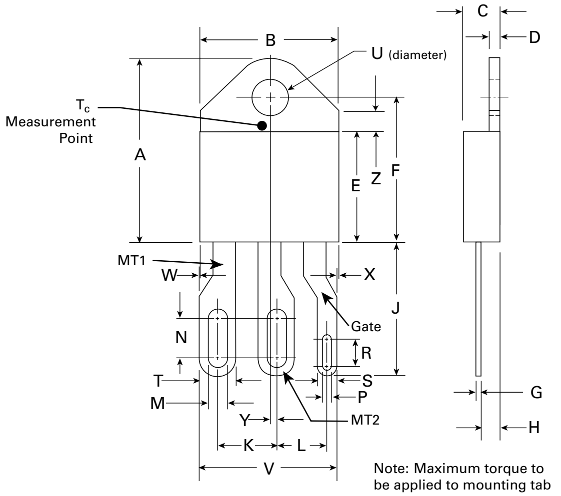
Dimensions — TO-218AC (K Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.058	0.068	1.47	1.73
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
Q	0.008	0.016	0.20	0.41
R	0.008	0.016	0.20	0.41
U	0.164	0.165	4.10	4.20
W	0.085	0.095	2.17	2.42

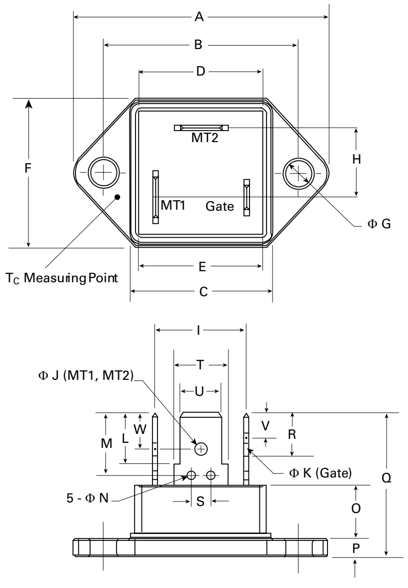
Dimensions — TO-218X (J Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.256	0.264	6.50	6.71
L	0.220	0.228	5.58	5.79
M	0.080	0.088	2.03	2.24
N	0.169	0.177	4.29	4.49
P	0.034	0.042	0.86	1.07
R	0.113	0.121	2.87	3.07
S	0.086	0.096	2.18	2.44
T	0.156	0.166	3.96	4.22
U	0.164	0.165	0.410	0.420
V	0.603	0.618	15.31	15.70
W	0.000	0.005	0.00	0.13
X	0.003	0.012	0.07	0.30
Y	0.028	0.032	0.71	0.81
Z	0.085	0.095	2.17	2.42

Dimensions — TO-3 (P Package) Fastpak — Isolated Mounting Tab



Thickness off all three copper-alloy terminals is .032" (0.81 mm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	1.531	1.543	38.90	39.20
B	1.177	1.185	29.90	30.10
C	0.843	0.850	21.40	21.60
D	0.780	0.795	19.80	20.20
E	0.783	0.791	19.90	20.10
F	0.874	0.906	22.20	23.00
G	0.161	0.169	4.10	4.30
H	0.386	0.465	9.80	11.80
I	0.508	0.587	12.90	14.90
J	0.079	0.087	2.00	2.20
K	0.047	0.055	1.20	1.40
L	0.307	0.319	7.80	8.10
M	0.372	0.396	9.45	10.05
N	0.043	0.059	1.10	1.50
O	0.315	0.331	8.00	8.40
P	0.098	0.106	2.50	2.70
Q	0.846	0.886	21.50	22.50
R	0.244	0.256	6.20	6.50
S	0.106	0.130	2.70	3.30
T (MT1)	0.321	0.329	8.15	8.35
T (MT2)	0.321	0.329	8.15	8.35
T (Gate)	0.220	0.228	5.60	5.80
U (MT1)	0.246	0.254	6.25	6.45
U (MT2)	0.246	0.254	6.25	6.45
U (Gate)	0.183	0.191	4.65	4.85
V	0.120	0.130	3.05	3.30
W	0.175	0.185	4.45	4.70

Maximum torque to be applied to mounting tab is 8 in-lbs (0.904Nm).

Revised: 12/14/14

Product Selector

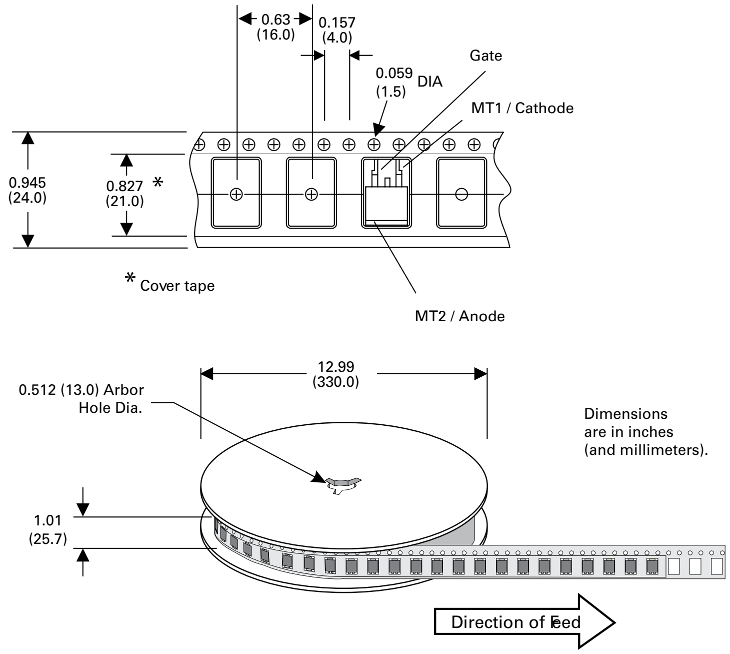
Part Number	Voltage				Gate Sensitivity Quadrants		Package
	400V	600V	800V	1000V	I - II - III	IV	
Qxx25R5	X	X	X	X	50 mA	120 mA (TYP)	TO-220R
Qxx25N5	X	X	X	X	50 mA	120 mA (TYP)	TO-263 D^2-Pak
Qxx25P5		X	X		50 mA	120 mA (TYP)	Fastpak
Qxx25RH5	X	X	X		50 mA		TO-220R
Qxx25LH5	X	X	X		50 mA		TO-220L
Qxx25NH5	X	X	X		50 mA		TO-263 D^2-Pak
Qxx25R6	X	X	X	X	80 mA		TO-220R
Qxx25L6	X	X	X	X	80 mA		TO-220L
Qxx25NH6	X	X	X	X	80 mA		TO-263 D^2-Pak
Qxx25J6	X	X	X		80 mA		TO-218X
Qxx25K6	X	X	X	X	80 mA		TO-218AC

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx25R5	Qxx25R5	2.20g	Bulk	500
Qxx25R5TP	Qxx25R5	2.20g	Tube	500 (50 per tube)
Qxx25N5TP	Qxx25N5	1.60g	Tube	500 (50 per tube)
Qxx25N5RP	Qxx25N5	1.60g	Embossed Carrier	500
Qxx25RH5	Qxx25RH5	2.20g	Bulk	500
Qxx25RH5TP	Qxx25RH5	2.20g	Tube	500 (50 per tube)
Qxx25LH5	Qxx25LH5	2.20g	Bulk	500
Qxx25LH5TP	Qxx25LH5	2.20g	Tube	500 (50 per tube)
Qxx25NH5TP	Qxx25NH5	1.60g	Tube	500 (50 per tube)
Qxx25NH5RP	Qxx25NH5	1.60g	Embossed Carrier	500
Qxx25P5	Qxx25P5	21.4g	Bulk	160
Qxx25R6	Qxx25R6	2.20g	Bulk	500
Qxx25R6TP	Qxx25R6	2.20g	Tube	500 (50 per tube)
Qxx25L6	Qxx25L6	2.20g	Bulk	500
Qxx25L6TP	Qxx25L6	2.20g	Tube	500 (50 per tube)
Qxx25NH6TP	Qxx25NH6	1.60g	Tube	500 (50 per tube)
Qxx25NH6RP	Qxx25NH6	1.60g	Embossed Carrier	500
Qxx25J6TP	Qxx25J6	5.23g	Tube	250 (25 per tube)
Qxx25K6TP	Qxx25K6	4.40g	Tube	250 (25 per tube)

TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System

Q 60 25 N H6

DEVICE TYPE
Q: Triac or Alternistor

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

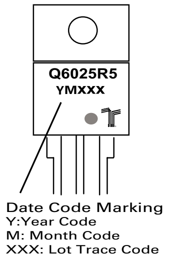
CURRENT RATING
25: 25A

SENSITIVITY
Standard Triac
5: 50mA
Alternistor
H5: 50mA
6: 80mA
H6: 80mA

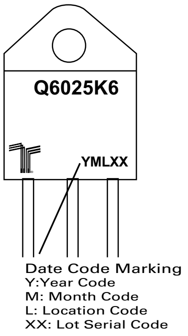
PACKAGE TYPE
L : TO-220AB Isolated
R : TO-220AB Non-Isolated
N : TO-263 (D² -Pak)
K : TO-218AC Isolated
J : TO-218X Isolated
P : Fastpak

Part Marking System

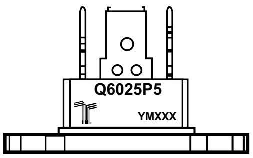
TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



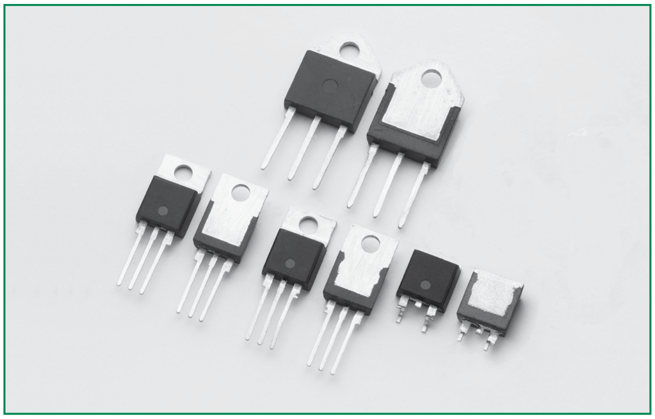
TO-218AC - (K Package)
TO-218X - (J Package)



Fastpak - (P Package)



HQ6025xH5 Series



Description

25Amp bi-directional Alternistor Triac is designed for AC switching and phase control applications requiring a higher temperature environment.

Alternistor type devices only operate in quadrants I, II, & and are used in circuits requiring high dv/dt capability.

Features & Benefits

- 150°C maximum junction temperature
- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 300 A

Applications

Typically used in high-temperature environments where available heat-sinking is minimal such as heating and white goods applications.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet | **Resources** | **Samples**

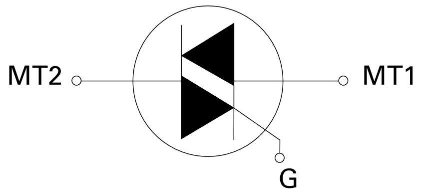
Agency Approval

Agency	Agency File Number
®ЯU	L and K Packages: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	25	A
V_{DRM}/V_{RRM}	600	V
I_{GT}	50	mA

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	HQ6025LH5	T_C = 95°C	25	A
		HQ6025RH5 HQ6025NH5 HQ6025KH5	T_C = 102°C		
I_{TSM}	Peak non-repetitive surge current		full cycle; f = 50Hz; T_J (initial) = 25°C	250	A
			full cycle; f = 60Hz; T_J (initial) = 25°C	300	
I^2t	I^2t Value for fusing	t_p = 8.3ms		373	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =150°C		100	A/μs
I_{GTM}	Peak gate current	T_J = 150°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 150°C		0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 150	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions	Quadrant		Value	Unit
I_{GT}	V_D = 12V; R_L = 60 Ω	I – II – III	MAX.	50	mA
V_{GT}		I – II – III	MAX.	1.3	V
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ ; T_J = 150°C	I – II – III	MIN.	0.2	V
I_H	I_T = 400mA (initial)		MAX.	80	mA
dv/dt	V_D = V_{DRM}; Gate Open; T_J = 150°C		MIN.	350	V/μs
(dv/dt)c	(di/dt)c = 13.3 A/ms; T_J = 150°C		MIN.	20	V/μs
t_{gt}	I_G = 2 x I_{GT} ; PW = 15μs; I_T = 35.4 A		TYP.	3	μs

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_T = 35.4A; t_p = 380 μs		MAX.	1.4	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	MAX.	5	μA
		T_J = 150°C		6000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	HQ6025LH5	2.0	°C/W
		HQ6025RH5 HQ6025NH5	0.86	
		HQ6025KH5	1.35	
$R_{\theta(J-A)}$	Junction to ambient	HQ6025LH5	50	°C/W
		HQ6025RH5	45	

Note: xx = voltage

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

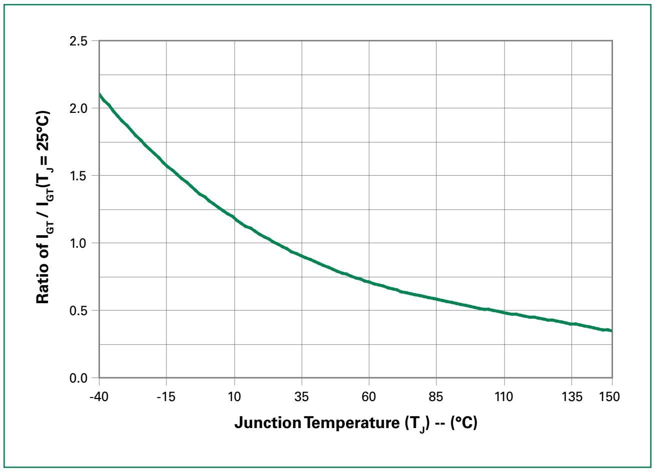


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

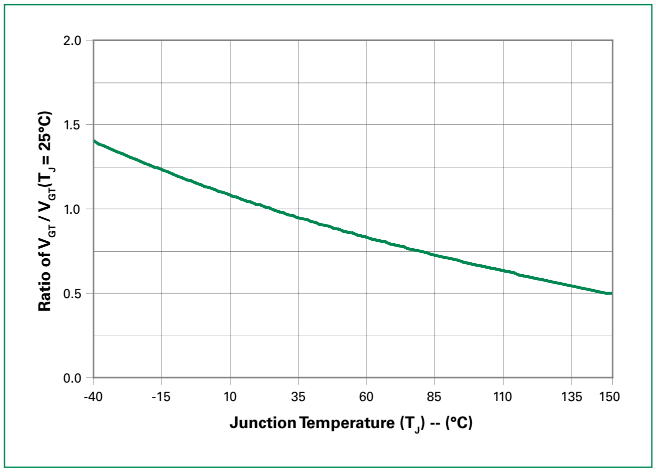


Figure 3: Normalized DC Holding Current vs. Junction Temperature

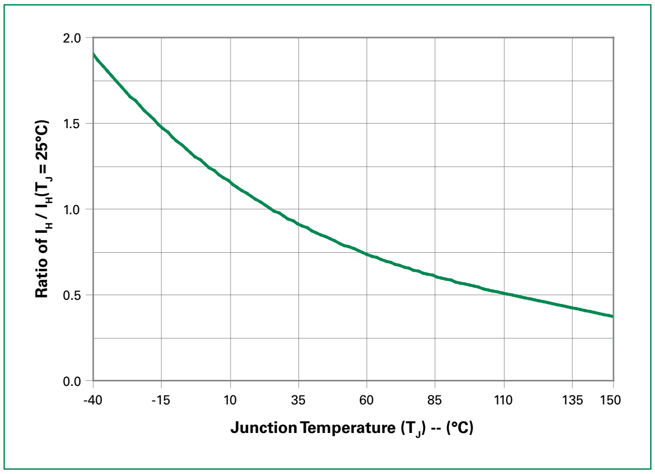


Figure 4: On-State Current vs. On-State Voltage (Typical)

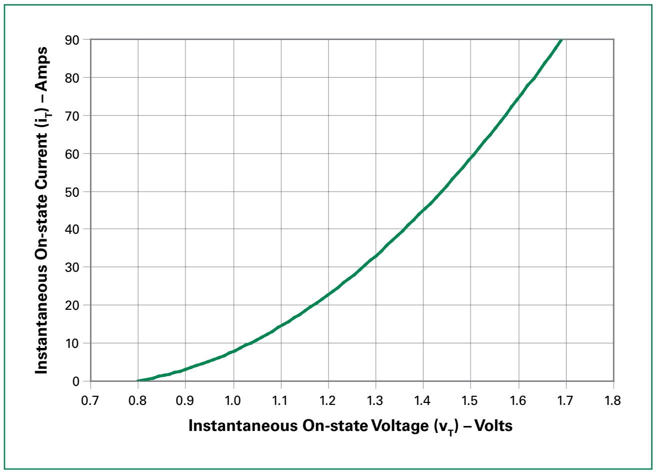


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

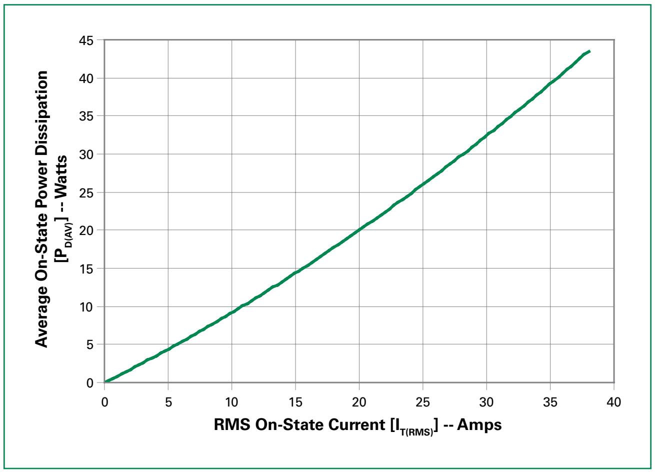


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

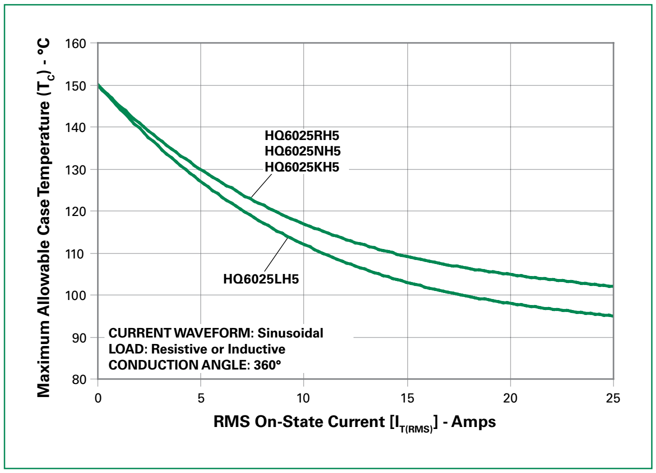


Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

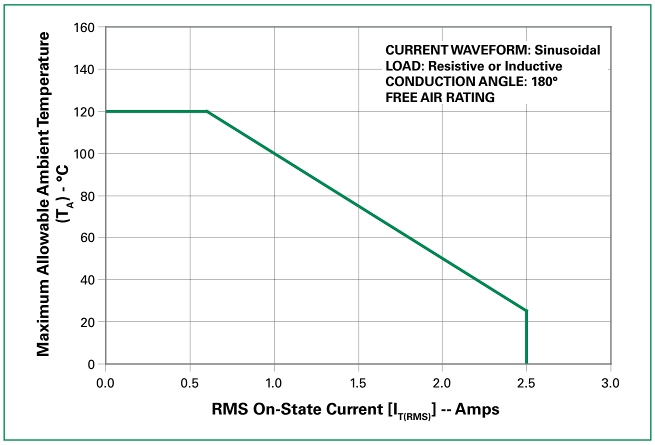
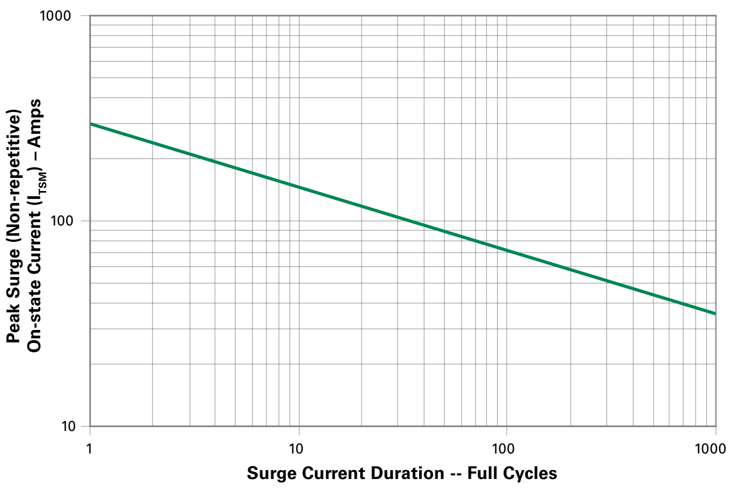


Figure 8: Surge Peak On-State Current vs. Number of Cycles



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

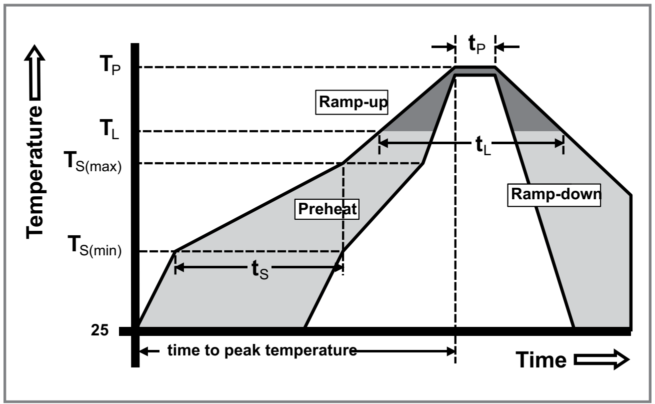
Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Revised: 12/14/14

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Material	Copper Alloy
Terminal Finish	100% Matte Tin Plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0

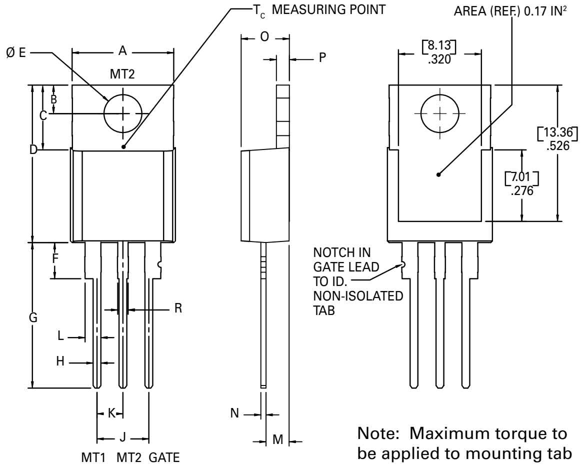
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{RRM}, 150°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temp & Humidity	EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours
High Temp. Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002, Category 3, Test A
Lead Bend	MIL-STD-750: Method 2036, Condition E

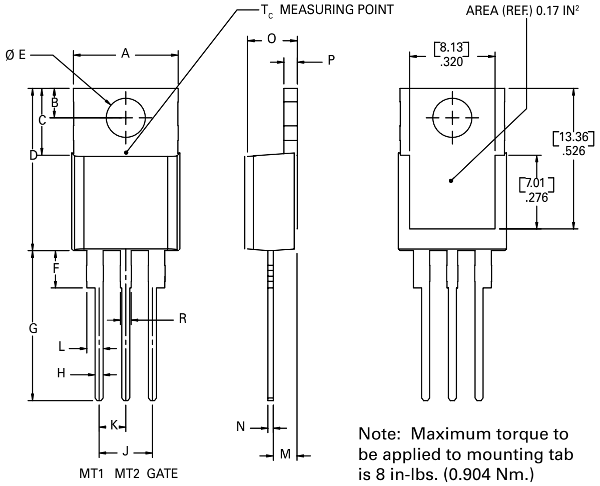
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm.)

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

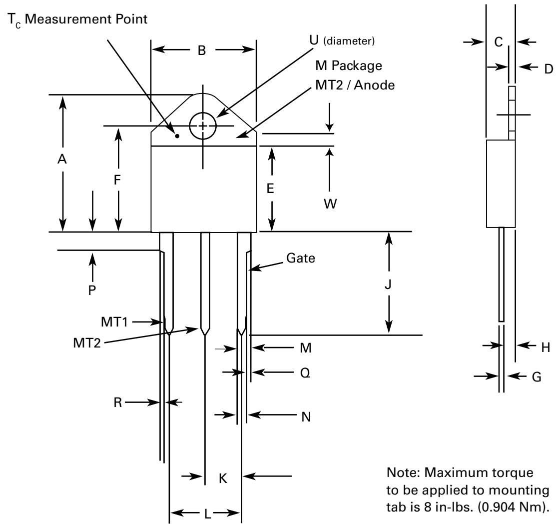
Dimensions — TO- 220AB (L Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm.)

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

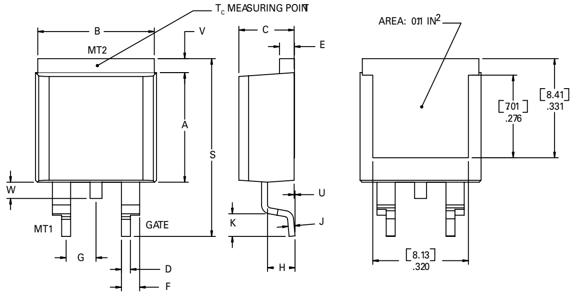
Dimensions — TO- 218AC (K Package) — Isolated Mounting Tab

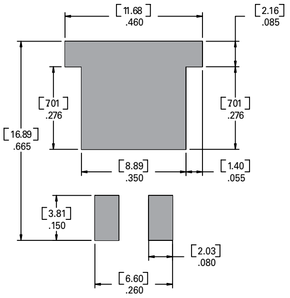


Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.058	0.068	1.47	1.73
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
Q	0.008	0.016	0.20	0.41
R	0.008	0.016	0.20	0.41
U	0.159	0.163	4.04	4.14
W	0.085	0.095	2.17	2.42

Dimensions — TO-263AB (N-Package) — D² -PAK Surface Mount





Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Product Selector

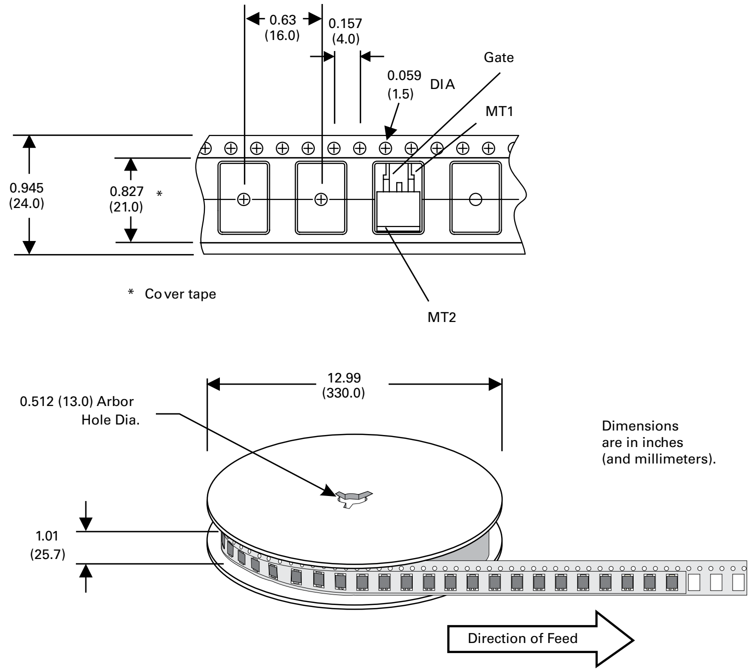
Part Number	Voltage				Gate Sensitivity	Package
	400V	600V	800V	1000V		
HQ6025RH5		X			50 mA	TO-220R
HQ6025NH5		X			50 mA	TO-263
HQ6025LH5		X			50 mA	TO-220L
HQ6025KH5		X			50 mA	TO-218K

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
HQ6025RH5	HQ6025RH5	2.2g	Bulk	500
HQ6025RH5TP	HQ6025RH5	2.2g	Tube	500 (50 per tube)
HQ6025NH5TP	HQ6025NH5	1.6g	Tube	500 (50 per tube)
HQ6025NH5RP	HQ6025NH5	1.6g	Embossed Carrier	500
HQ6025LH5TP	HQ6025LH5	2.2g	Tube	500 (50 per tube)
HQ6025KH5TP	HQ6025KH5	4.4g	Tube	250 (25 per tube)

TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System

HQ 60 25 L H5 81

DEVICE TYPE
HQ: Triac

VOLTAGE RATING
60: 600V

CURRENT RATING
25: 25A

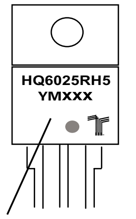
LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY & TYPE
H5: 50mA

PACKAGE TYPE
L: TO-220 AB (Isolated)
K: TO-218 AC (Isolated)
R: TO-220AB (Non-isolated)
N: TO-263 (D^2 Pak)

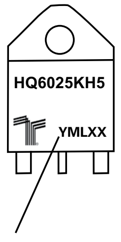
Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

TO-218AC - (K Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

Revised: 12/14/14

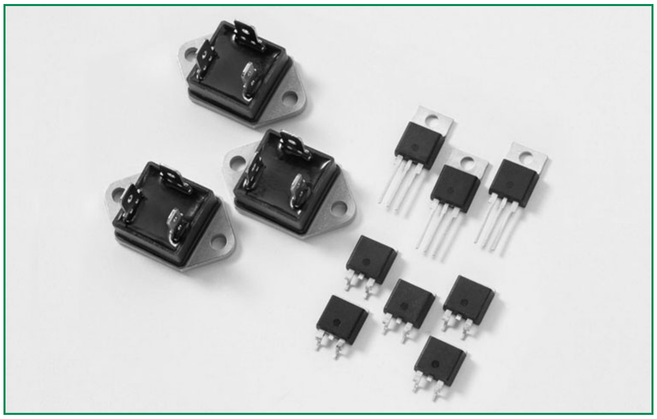
Littelfuse®
Expertise Applied | Answers Delivered

Teccor® brand Thyristors

35 Amp Standard & 30 / 35 Amp Alternistor (High Commutation) Triacs

Qxx30xHx & Qxx35xx & Qxx35xHx Series

RoHS



Description

30 Amp / 35 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Standard type devices normally operate in Quadrants I & III triggered from AC line.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Agency Approval

Agency	Agency File Number
UL	FASTPAK & L Package: E71639

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 800V
- Surge capability up to 350A
- Electrically isolated package “FASTPAK” & “L - Package” are UL recognized for 2500Vrms

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	30 & 35	A
V_{DRM}/V_{RRM}	400 to 800	V
$I_{GT\ (Q1)}$	50	mA

Applications

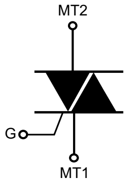
Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Absolute Maximum Ratings — Standard Triac

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx35P5	T_C = 55°C	35	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	300	A
		f = 60 Hz	t = 16.7 ms	350	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	508	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 200mA with ≤ 0.1µs rise time)	f = 120 Hz	T_J = 125°C	100	A/µs
I_{GTM}	Peak gate trigger current	$t_p \leq 10$ µs $I_{GT} \leq I_{GTM}$	T_J = 125°C	2	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 125	°C
T_J	Operating junction temperature range			-25 to 125	°C

Note: xx = voltage

Revised: 12/14/14

Absolute Maximum Ratings — Alternistor Triac (3 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx35RH5/Qxx35NH5	T_C = 90°C	35	A
		Qxx30LH5/Qxx30LH3	T_C = 50°C	30	
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	290	A
		f = 60 Hz	t = 16.7 ms	350	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	508	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 200mA with ≤ 0.1μs rise time)	f = 120 Hz	T_J = 125°C	100	A/μs
I_{GTM}	Peak gate trigger current	$t_p \le 10$ μs $I_{GT} \le I_{GTM}$	T_J = 125°C	2	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-25 to 125	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard Triac

Symbol	Test Conditions	Quadrant		Qxx35P5	Unit
I_{GT}	V_D = 12V R_L = 30 Ω	I – II – III	MAX.	50	mA
		IV	TYP.	120	
V_{GT}		I – II – III	MAX.	2.75	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	ALL	MIN.	0.2	V
I_H	I_T = 400mA		MAX.	50	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	600V	MIN.	475	V/μs
		800V		400	
(dv/dt)c	(di/dt)c = 18.9 A/ms T_J = 125°C		TYP.	5	V/μs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15μs I_T = 49.5A(pk)		TYP.	3	μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant		Qxx35RH5 Qxx35NH5 Qxx30LH5	Qxx30LH3	Unit
I_{GT}	V_D = 12V R_L = 30 Ω	I – II – III	MAX.	50	25	mA
V_{GT}		I – II – III	MAX.	2	2	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.	0.2	0.2	V
I_H	I_T = 400mA		MAX.	75	40	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	475	350	V/μs
		600V		400	250	
(dv/dt)c	(di/dt)c = 18.9 A/ms T_J = 125°C		MIN.	20	10	V/μs
t_{gt}	35A device $I_G = 2 \times I_{GT}$ PW = 15μs I_T = 49.5A(pk)		TYP.	3	3	μs
	30A device $I_G = 2 \times I_{GT}$ PW = 15μs I_T = 42.4A(pk)					

Note: xx = voltage

Static Characteristics

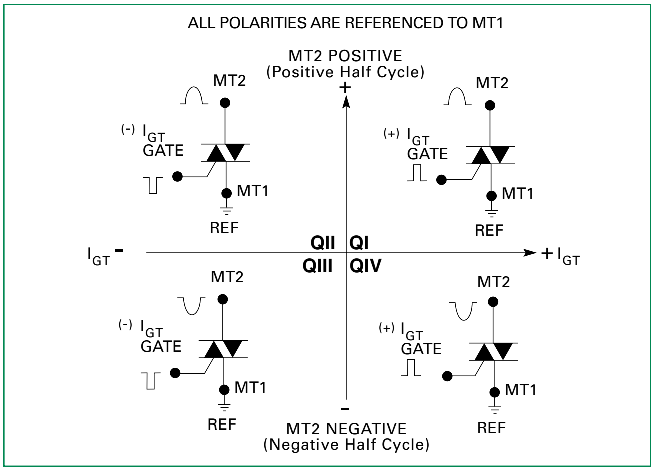
Symbol	Test Conditions					Value	Unit
V_{TM}	35A device I_{TM} = 49.5A t_p = 380 µs				MAX.	1.5	V
	30A device I_{TM} = 42.4A t_p = 380 µs					1.4	
I_{DRM} I_{RRM}	$V_D = V_{DRM} / V_{RRM}$	Qxx35P5	T_J = 25°C	600 - 800V	MAX.	100	µA
			T_J = 125°C	600 - 800V		5	mA
		Qxx35R/NH5 Qxx30LH5 Qxx30LH3	T_J = 25°C	400 - 600V	MAX.	10	µA
			T_J = 125°C	400 - 600V		2	mA

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	Qxx35P5	1.50	°C/W
		Qxx35RH5 / Qxx35NH5	0.85	
		Qxx30LH5 / Qxx30LH3	2.30	
$R_{\theta(J\text{-}A)}$	Junction to ambient	Qxx35RH5	45	°C/W
		Qxx30LH5 / Qxx30LH3	50	

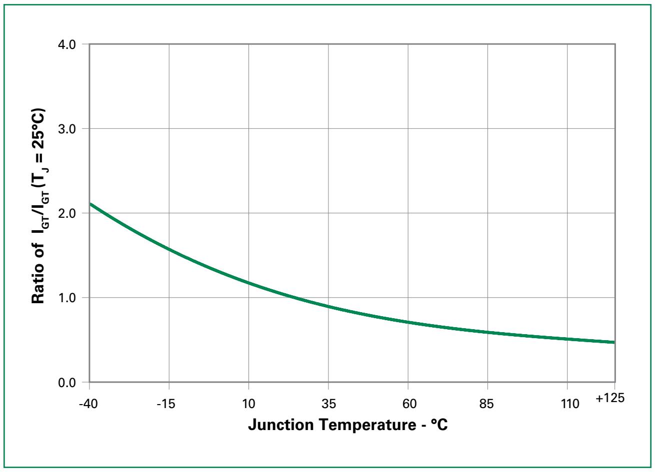
Note: xx = voltage

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature



Additional Information

Datasheet	Resources	Samples

Revised: 12/14/14

Figure 3: Normalized DC Holding Current vs. Junction Temperature

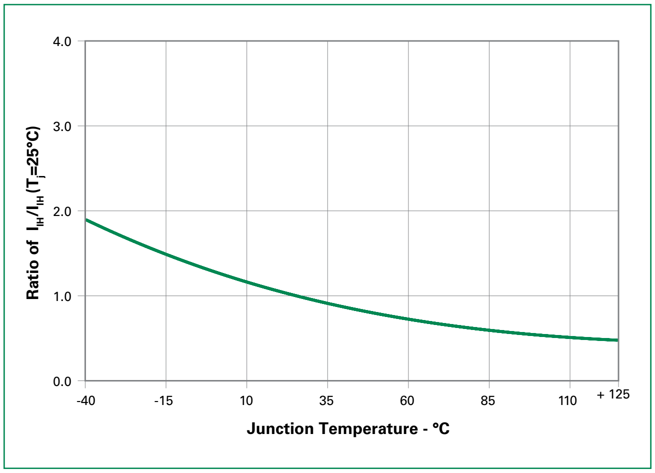


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

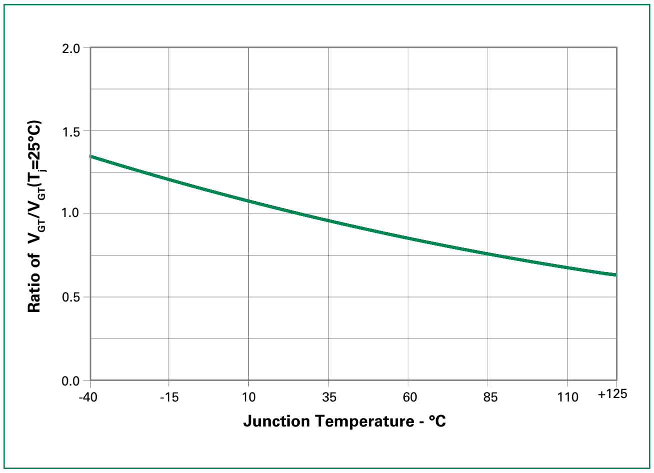


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

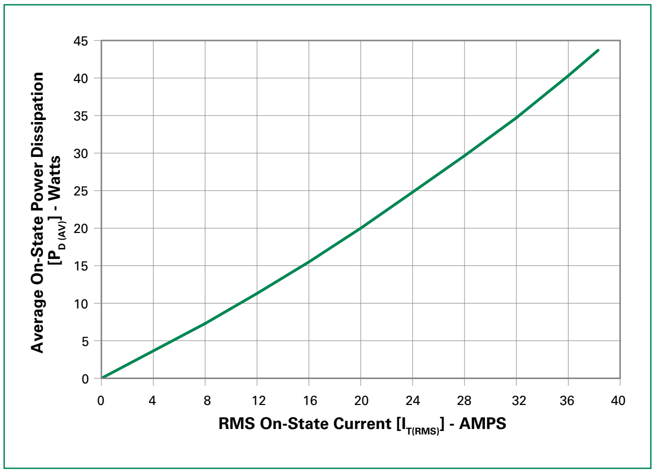
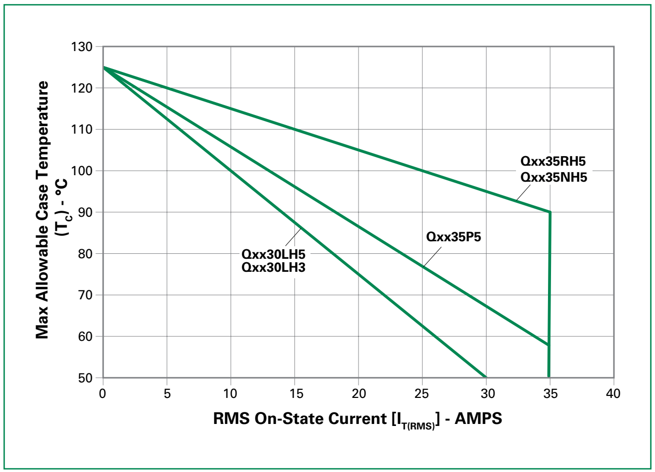


Figure 6: Maximum Allowable Case Temperature vs. On-State Current



Note: xx = voltage

Figure 7: On-State Current vs. On-State Voltage (Typical)

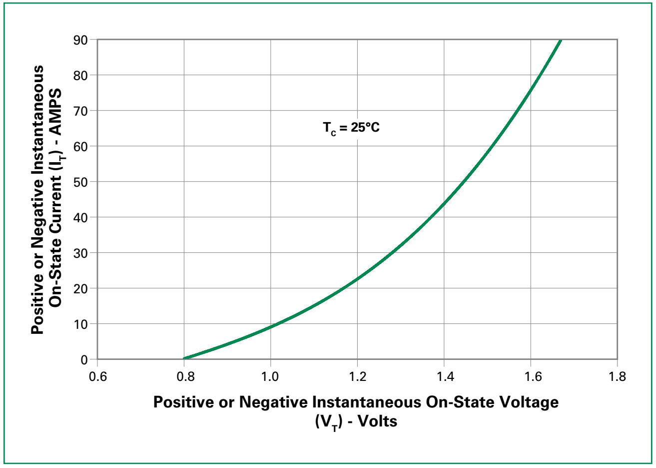
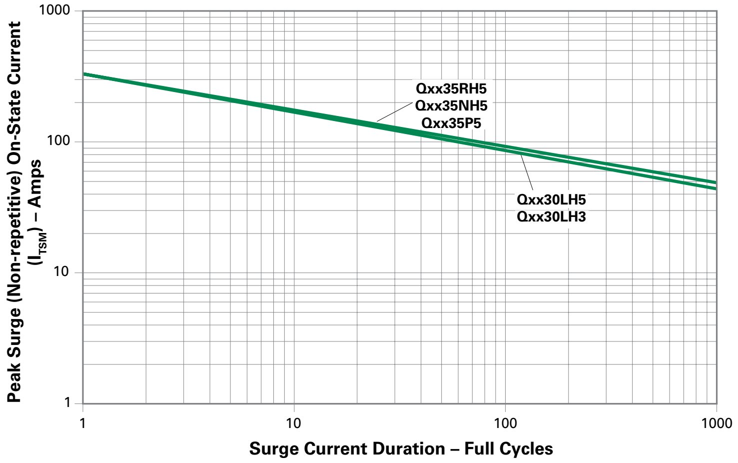


Figure 8: Surge Peak On-State Current vs. Number of Cycles



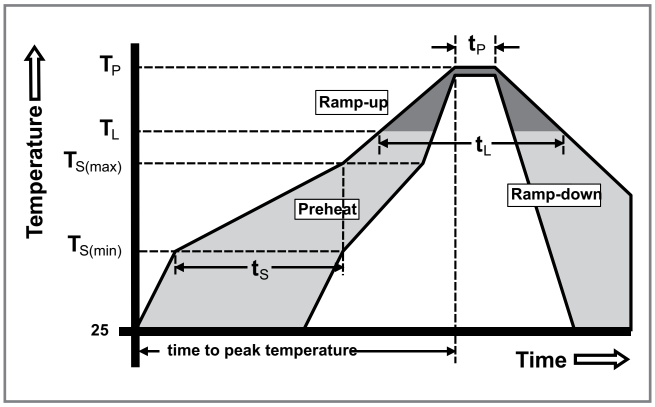
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:
1) Gate control may be lost during and immediately following surge current interval.
2) Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = voltage

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		260$^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.
Terminal Material	Copper Alloy

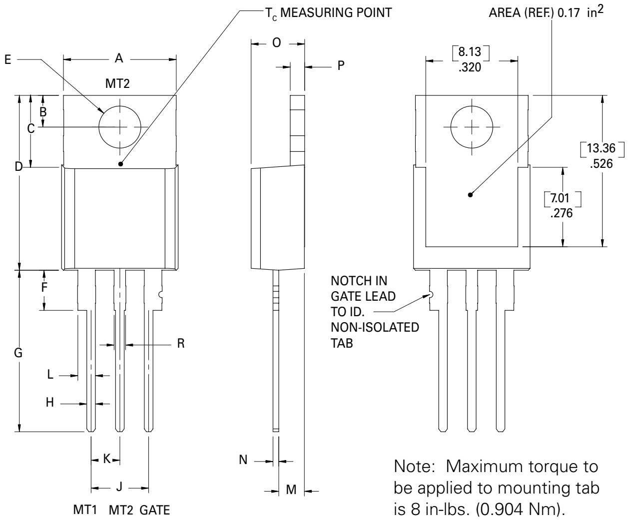
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

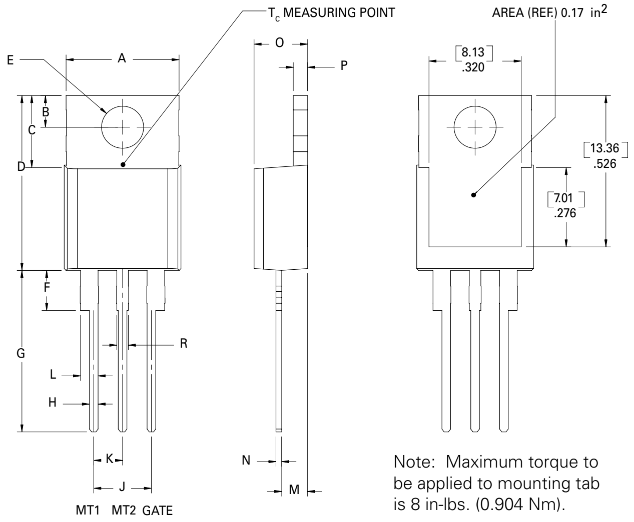
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

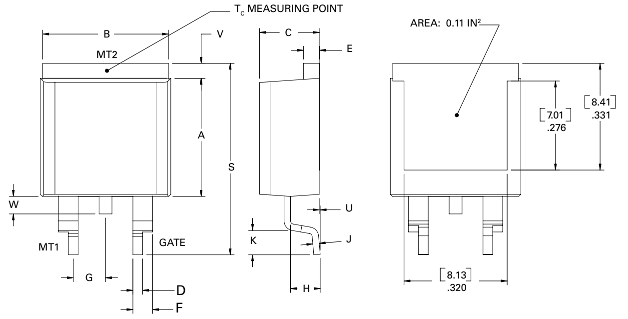
Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab

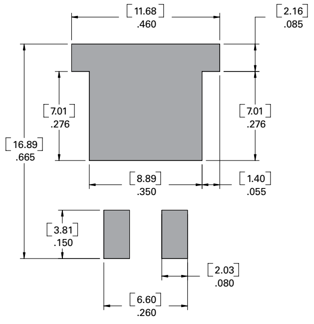


Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

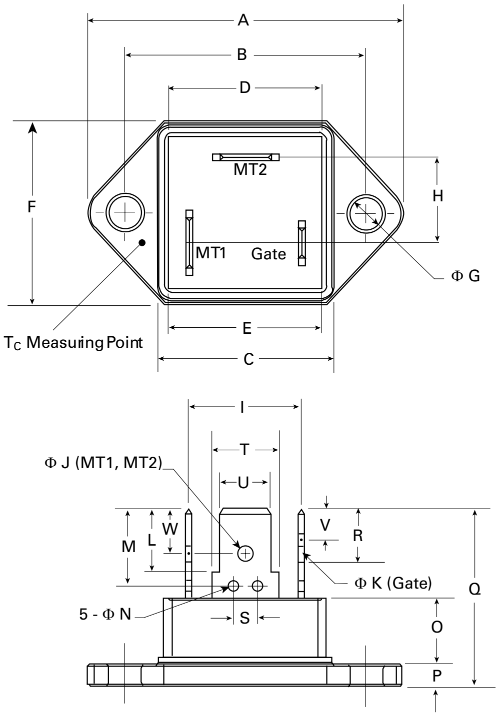
Dimensions — TO-263 (N-Package) — D² Pak Surface Mount





Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.016	1.78

Dimensions — TO-3 Fastpak (P Package) — Isolated Mounting Tab



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	1.531	1.543	38.90	39.20
B	1.177	1.185	29.90	30.10
C	0.843	0.850	21.40	21.60
D	0.780	0.795	19.80	20.20
E	0.783	0.791	19.90	20.10
F	0.874	0.906	22.20	23.00
G	0.161	0.169	4.10	4.30
H	0.386	0.465	9.80	11.80
I	0.508	0.587	12.90	14.90
J	0.079	0.087	2.00	2.20
K	0.047	0.055	1.20	1.40
L	0.307	0.319	7.80	8.10
M	0.372	0.396	9.45	10.05
N	0.043	0.059	1.10	1.50
O	0.315	0.331	8.00	8.40
P	0.098	0.106	2.50	2.70
Q	0.846	0.886	21.50	22.50
R	0.244	0.256	6.20	6.50
S	0.106	0.130	2.70	3.30
T(MT1)	0.321	0.329	8.15	8.35
T(MT2)	0.321	0.329	8.15	8.35
T(Gate)	0.220	0.228	5.60	5.80
U(MT1)	0.246	0.254	6.25	6.45
U(MT1)	0.246	0.254	6.25	6.45
U(Gate)	0.183	0.191	4.65	4.85
V	0.120	0.130	3.05	3.30
W	0.175	0.185	4.45	4.70

Maximum torque to be applied to mounting tab is 8 in-lbs (0.904 Nm)

Product Selector

Part Number	Voltage			Gate Sensitivity Quadrants		$I_{T(RMS)}$	Type	Package
	400V	600V	800V	I – II – III	IV			
Qxx35P5		X	X	50 mA	120 mA (TYP)	35A	Standard Triac	FASTPACK
Qxx35RH5	X	X		50 mA		35A	Alternistor Triac	TO-220R
Qxx35NH5	X	X		50 mA		35A	Alternistor Triac	TO-263 D^2-PAK
Qxx30LH5	X	X		50 mA		30A	Alternistor Triac	TO-220L
Qxx30LH3	X	X		25 mA		30A	Alternistor Triac	TO-220L

Note: xx = Voltage

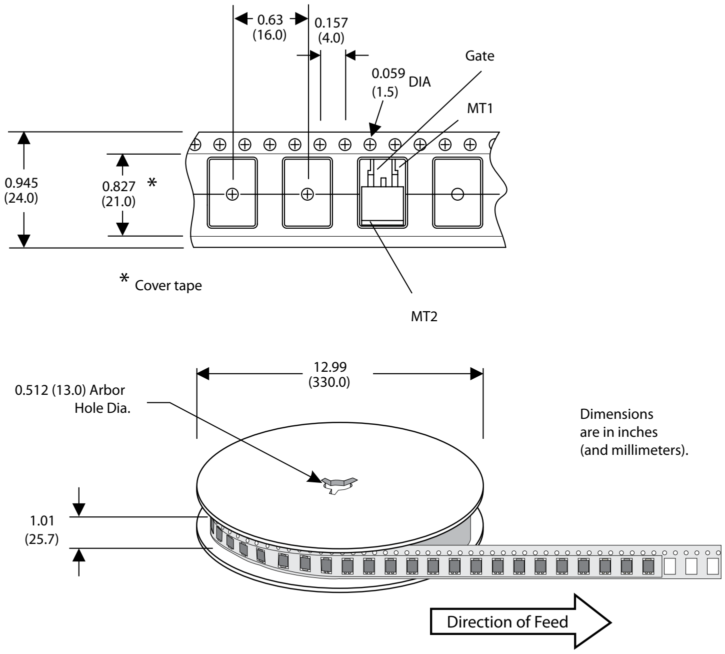
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx35P5	Qxx35P5	21.4 g	Bulk	160
Qxx35RH5	Qxx35RH5	2.20 g	Bulk	500
Qxx35RH5TP	Qxx35RH5	2.20 g	Tube	500 (50 per tube)
Qxx35NH5TP	Qxx35NH5	1.60 g	Tube	500 (50 per tube)
Qxx35NH5RP	Qxx35NH5	1.60 g	Embossed Carrier	500
Qxx30LH5	Qxx30LH5	2.20 g	Bulk	500
Qxx30LH5TP	Qxx30LH5	2.20 g	Tube	500 (50 per tube)
Qxx30LH3	Qxx30LH3	2.20 g	Bulk	500
Qxx30LH3TP	Qxx30LH3	2.20 g	Tube	500 (50 per tube)

Note: xx = Voltage

TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System

Q 60 35 P 5

DEVICE TYPE
Q : Triac or Alternistor Triac

VOLTAGE
40 : 400V
60 : 600V
80 : 800V

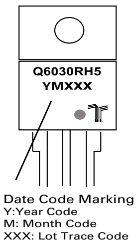
CURRENT
30 : 30A
35 : 35A

SENSITIVITY & TYPE
Standard Triac
5 : 50mA (QI, II, III)
Alternistor Triac
H5 : 50mA (QI, II, III)
H3 : 25mA (QI, II, III)

PACKAGE TYPE
L : TO-220 Isolated
R : TO-220 Non-Isolated
N: TO-263 (D²-PAK)
P : FASTPAK

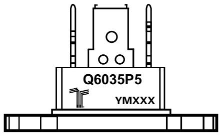
Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)



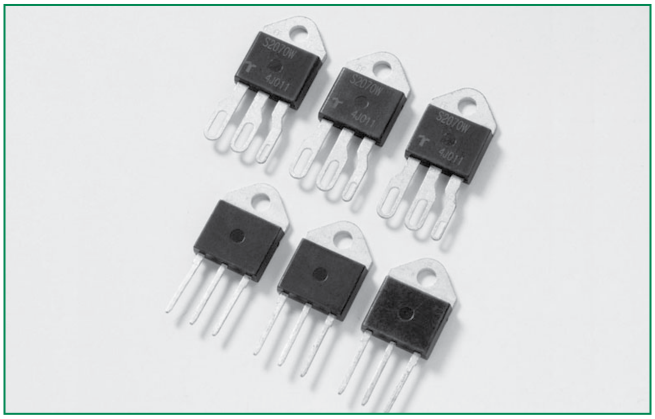
Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

FASTPAK - (P Package)



Qxx40xx Series

RoHS



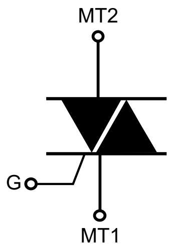
Agency Approval

Agency	Agency File Number
®UL	K & J Packages: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	40	A
V_{DRM}/V_{RRM}	400 to 1000	V
$I_{GT\ (Q1)}$	50 to 100	mA

Schematic Symbol



Description

40 Amp bi-directional solid state switch series is designed for AC switching and phase control applications such as motor speed and temperature modulation controls, lighting controls, and static switching relays.

Alternistor type devices only operate in quadrants I, II, & III and are used in circuits requiring high dv/dt capability.

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 1000V
- Surge capability up to 400A
- Electrically isolated K & J -Packages are UL recognized for 2500Vrms

Applications

Excellent for AC switching and phase control applications such as heating, lighting, and motor speed controls.

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Alternistor Triacs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Absolute Maximum Ratings — Alternistor Triac (3 Quadrants)

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	Qxx40x7 Qxx40xH6	T_C = 75°C	40	A
I_{TSM}	Non repetitive surge peak on-state current (full cycle, T_J initial = 25°C)	f = 50 Hz	t = 20 ms	335	A
		f = 60 Hz	t = 16.7 ms	400	
I^2t	I^2t Value for fusing		t_p = 8.3 ms	664	A^2s
di/dt	Critical rate of rise of on-state current (I_G = 2 x I_{GT}, tr ≤ 100 ns)	f = 120 Hz	T_J = 125°C	150	A/μs
I_{GTM}	Peak gate trigger current	t_p ≤ 10 μs $I_{GT} \leq I_{GTM}$	T_J = 125°C	4	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.8	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage, x = package

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Alternistor Triac (3 Quadrants)

Symbol	Test Conditions	Quadrant		Value			Unit
				Qxx40xH6	Qxx40K5	Qxx40x7	
I_{GT}	V_D = 12V R_L = 60 Ω	I – II – III	MAX.	80	50	100	mA
V_{GT}		I – II – III	MAX.	1.3	1.3	2.0	V
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C	I – II – III	MIN.	0.2			V
I_H	I_T = 400mA		MAX.	80	75	100	mA
dv/dt	$V_D = V_{DRM}$ Gate Open T_J = 125°C	400V	MIN.	600	500	700	V/μs
		600V		500	475	625	
		800V		475	400	575	
	$V_D = V_{DRM}$ Gate Open T_J = 100°C	1000V			- -	500	
(dv/dt)c	(di/dt)c = 21.6 A/ms T_J = 125°C		MIN.	30	20	50	V/μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 56.6A(pk)		TYP.	5			μs

Static Characteristics

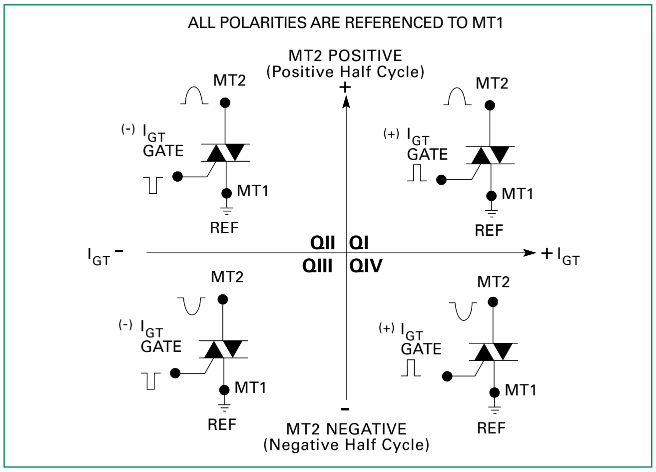
Symbol	Test Conditions				Value	Unit
V_{TM}	I_{TM} = 56.6A t_p = 380 μs	T_J = 25°C	MAX.		1.8	V
I_{DRM} I_{RRM}	$V_D = V_{DRM} / V_{RRM}$	T_J = 25°C	400 –1000V	MAX.	20	μA
		T_J = 125°C	400 – 800V	MAX.	5	mA
		T_J = 100°C	1000V	MAX.	5	mA

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Qxx40KH6 Qxx40K5 Qxx40K7	0.97	°C/W
		Qxx40JH6 Qxx40J7	0.95	

Note: xx = voltage

Figure 1: Definition of Quadrants



Note: Alternistors will not operate in QIV

Figure 2: Normalized DC Gate Trigger Current for All Quadrants vs. Junction Temperature

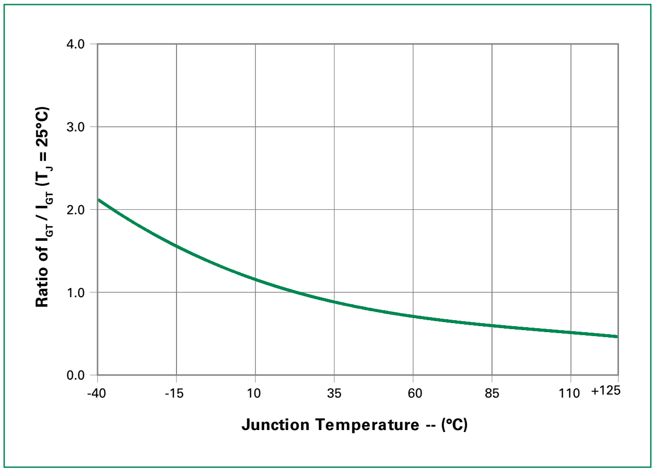


Figure 3: Normalized DC Holding Current vs. Junction Temperature

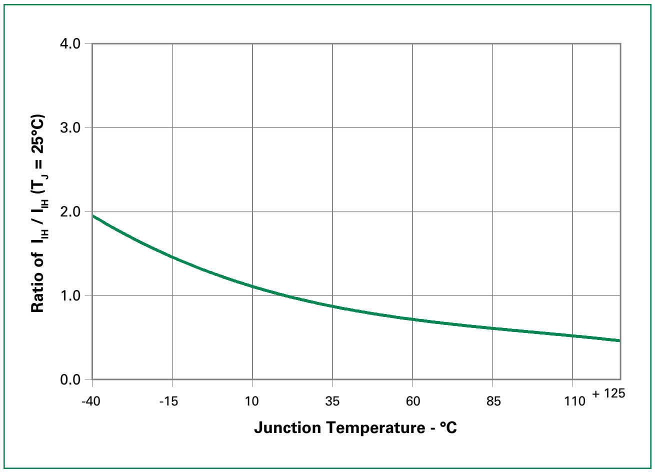


Figure 4: Normalized DC Gate Trigger Voltage for All Quadrants vs. Junction Temperature

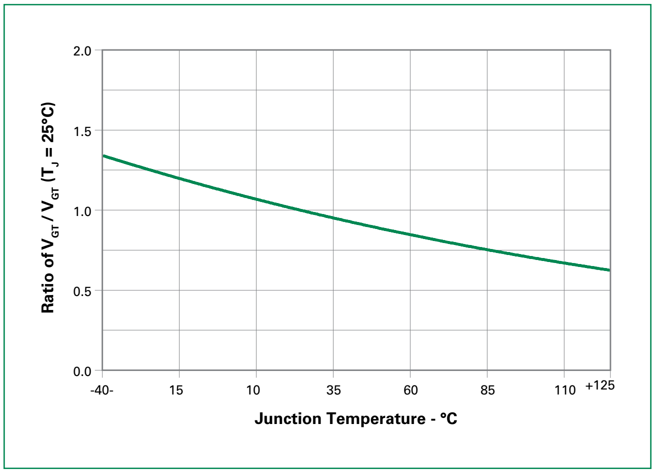


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

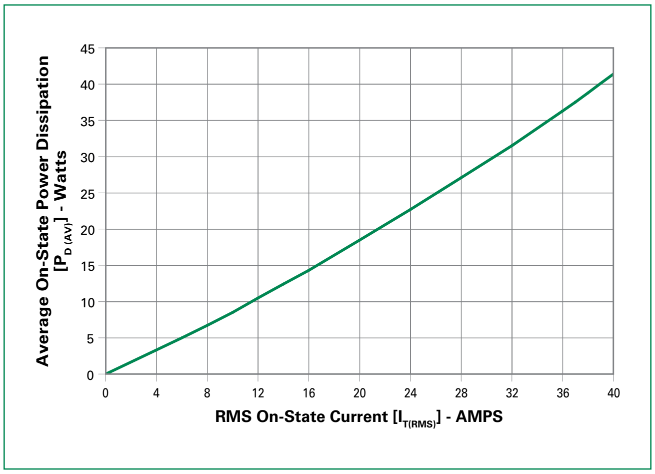


Figure 6: Maximum Allowable Case Temperature vs. On-State Current

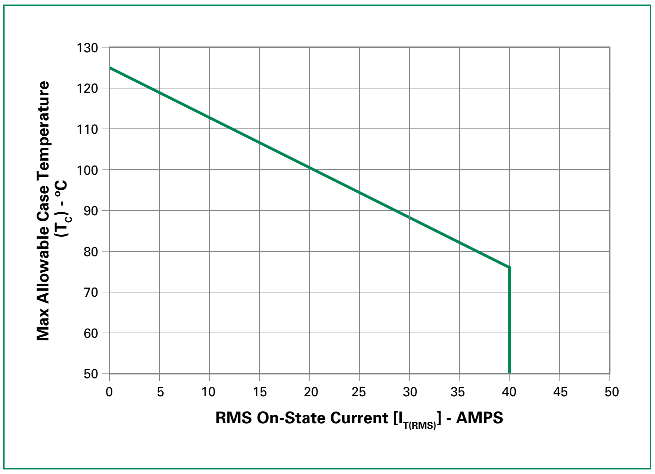


Figure 7: On-State Current vs. On-State Voltage (Typical)

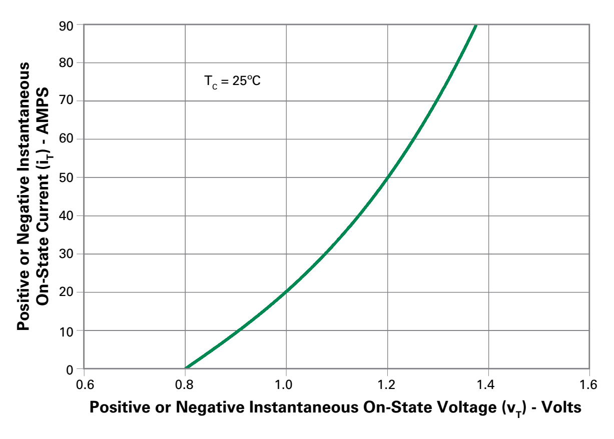
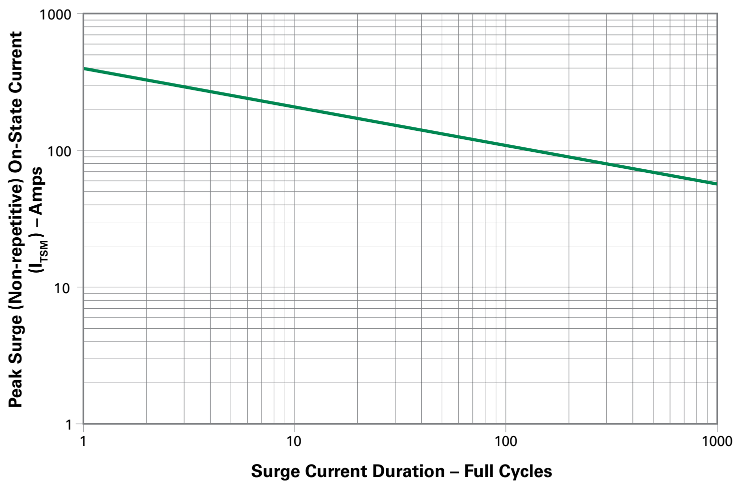


Figure 8: Surge Peak On-State Current vs. Number of Cycles



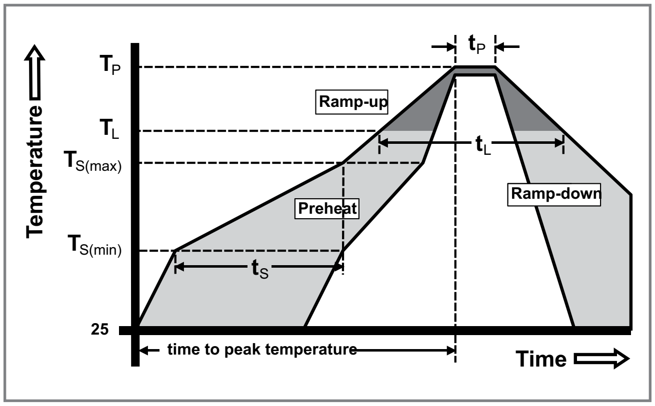
Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:
1) Gate control may be lost during and immediately following surge current interval.
2) Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = voltage

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.
Lead Material	Copper Alloy

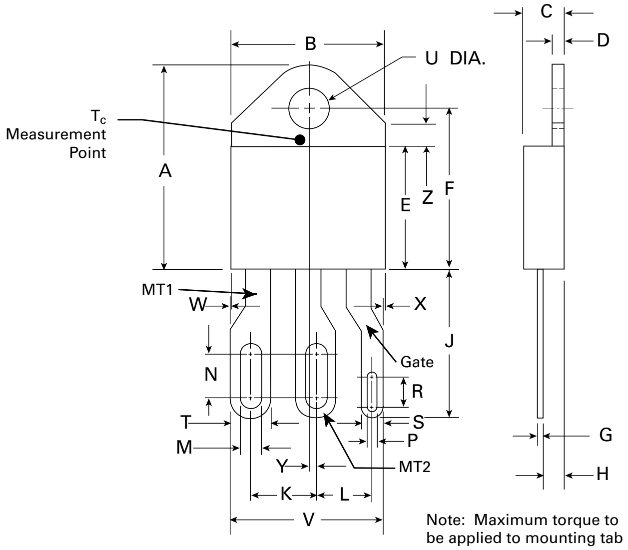
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

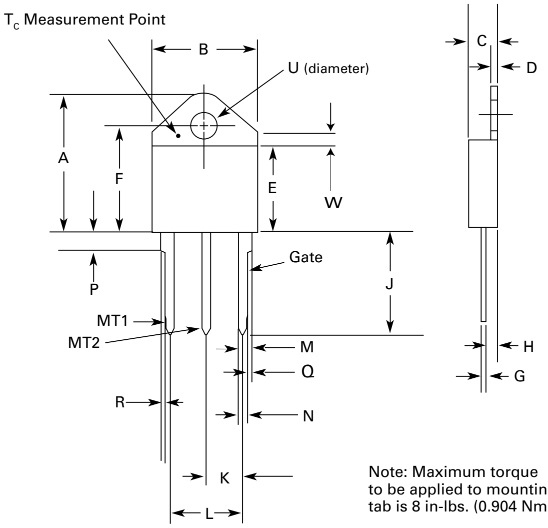
Dimensions — TO-218X (J Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.256	0.264	6.50	6.71
L	0.220	0.228	5.58	5.79
M	0.080	0.088	2.03	2.24
N	0.169	0.177	4.29	4.49
P	0.034	0.042	0.86	1.07
R	0.113	0.121	2.87	3.07
S	0.086	0.096	2.18	2.44
T	0.156	0.166	3.96	4.22
U	0.161	0.165	4.10	4.20
V	0.603	0.618	15.31	15.70
W	0.000	0.005	0.00	0.13
X	0.003	0.012	0.07	0.30
Y	0.028	0.032	0.71	0.81
Z	0.085	0.095	2.17	2.42

Dimensions — TO-218AC (K Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.058	0.068	1.47	1.73
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
Q	0.008	0.016	0.20	0.41
R	0.008	0.016	0.20	0.41
U	0.161	0.165	4.10	4.20
W	0.085	0.095	2.17	2.42

Product Selector

Part Number	Voltage				Gate Sensitivity Quadrants		$I_{T(RMS)}$	Type	Package
	400V	600V	800V	1000V	I – II – III	IV			
Qxx40KH6	X	X	X	X	80mA		40A	Alternistor Triac	TO-218AC
Qxx40JH6	X	X	X		80mA		40A	Alternistor Triac	TO-218X
Qxx40K5	X	X	X		50mA		40A	Alternistor Triac	TO-218AC
Qxx40K7	X	X	X	X	100 mA		40A	Alternistor Triac	TO-218AC
Qxx40J7	X	X	X		100 mA		40A	Alternistor Triac	TO-218X

Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx40KH6TP	Qxx40KH6	4.40g	Tube	250 (25 per tube)
Qxx40JH6TP	Qxx40JH6	5.23g	Tube	250 (25 per tube)
Qxx40K5TP	Qxx40K5	4.40g	Tube	250 (25 per tube)
Qxx40K7TP	Qxx40K7	4.40g	Tube	250 (25 per tube)
Qxx40J7TP	Qxx40J7	5.23g	Tube	250 (25 per tube)

Note: xx = Voltage

Part Numbering System

Q 60 40 K 7

DEVICE TYPE
Q : Alternistor Triac

VOLTAGE
40 : 400V
60 : 600V
80 : 800V
K0 : 1000V

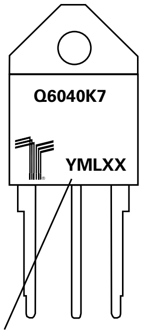
CURRENT
40 : 40A

SENSITIVITY
H6: 80mA (QI, II, III)
7 : 100mA (QI, II, III)
5 : 50mA, (QI, II, III)

PACKAGE TYPE
K : TO-218AC Isolated
J : TO-218X Isolated

Part Marking System

TO-218 AC - (K Package)
TO-218 X - (J Package)



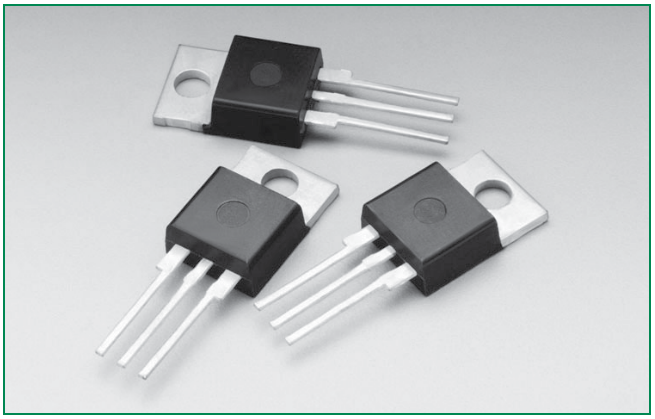
Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

Teccor® brand Thyristors

4 / 6 / 8 / 10 / 15 Amp Quadracs

QxxxxLTx Series

RoHS



Description

The Quadrac is an internally triggered Triac designed for AC switching and phase control applications. It is a Triac and DIAC in a single package, which saves user expense by eliminating the need for separate Triac and DIAC components.

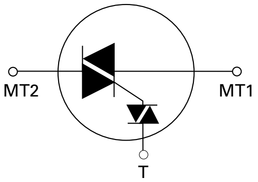
Standard type devices normally operate in Quadrants I & III triggered from AC line.

Alternistor type Quadracs are used in circuits requiring high dv/dt capability.

Agency Approval

Agency	Agency File Number
®	L Package : E71639

Schematic Symbol



Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	4 to 15	A
V_{DRM} / V_{RRM}	400 to 600	V
DIAC V_{BO}	33 to 43	V

Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 200 A

Applications

Excellent for AC switching and phase control applications such as lighting and heating. Typical applications are AC solid-state switches, light dimmers, power tools, home/ brown goods and white goods appliances.

Alternistor Quadracs (no snubber required) are used in applications with extremely inductive loads requiring highest commutation performance.

Internally constructed isolated package is offered for ease of heat sinking with highest isolation voltage.

Additional Information

Datasheet	Resources	Samples

Absolute Maximum Ratings

Symbol	Parameter		Value: Qxx04LT	Value: Qxx06LT / Qxx06LTH	Value: Qxx08LT / Qxx08LTH	Value: Qxx10LT / Qxx10LTH	Value: Qxx15LT / Qxx15LTH	Unit
$I_{T(RMS)}$	RMS forward current	Qxx04LT: T_C = 95°C Qxx06LT/Qxx08LT/Qxx10LT: T_C = 90°C Qxx15LT: T_C = 80°C	4	6	8	10	15	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	46	65	83	100	167	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	55	80	100	120	200	
I^2t	I^2t value for fusing	t_p = 8.3ms	12.5	26.5	41	60	166	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =125°C	50	70			100	A/μs
I_{GM}	Peak gate current	T_J = 125°C	1.5					A
T_{stg}	Storage temperature range		-40 to 150					°C
T_J	Operating junction temperature range		-40 to 125					°C

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Standard Quadrac

Symbol	Test Conditions			Value: Qxx04LT	Value: Qxx06LT	Value: Qxx08LT	Value: Qxx10LT	Value: Qxx15LT	Unit
I_H	I_T = 200mA (initial)	MAX.		40	50	60	60	70	mA
dv/dt	V_D = V_{DRM}; gate open; T_J=100°C	MIN.	400V	75	150	175	200	300	V/μs
			600V	50	125	150	175	200	
	V_D = V_{DRM}; gate open; T_J=125°C	MIN.	400V	50	100	120	150	200	
			600V	50	85	100	120	150	
dv/dt(c)	di/dt(c) = 0.54 x $I_{T(rms)}$ / ms; T_J = 125°C	MIN.		3	4				V/μs
t_{gt}	(note 1)	TYP.		3					μs

(1) Reference test circuit in figure 10 and waveform in figure 11; C_T = 0.1μF with 0.1μs rise time.
Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Alternistor Quadrac

Symbol	Test Conditions			Value: Qxx06LTH	Value: Qxx08LTH	Value: Qxx10LTH	Value: Qxx15LTH	Unit
I_H	I_T = 20mA (initial)	MAX.		50	50	60	70	mA
dv/dt	V_D = V_{DRM}; gate open; T_J=100°C	MIN.	400V	575		925		V/μs
			600V	425		775		
	V_D = V_{DRM}; gate open; T_J=125°C	MIN.	400V	450		700		
			600V	350		600		
dv/dt(c)	di/dt(c) = 0.54 x $I_{T(rms)}$ / ms; T_J = 125°C	MIN.		25		30		V/μs
t_{gt}	(note 1)	TYP.		3				μs

(1) Reference test circuit in figure 10 and waveform in figure 11; C_T = 0.1μF with 0.1μs rise time.
Note: xx = voltage

Trigger DIAC Specifications

Symbol	Test Conditions		Value	Unit
ΔV_{BO}	Breakover Voltage Symmetry	MAX.	3	V
V_{BO}	Breakover Voltage, forward and reverse	MIN.	33	V
		MAX.	43	
[ΔV±]	Dynamic Breakback Voltage, forward and reverse (note 1)	MIN.	5	V
I_{BO}	Peak Breakover Current	MAX.	25	uA
C_T	Trigger Firing Capacitance	MAX.	0.1	µF

(1) Reference test circuit in figure 10 and waveform in figure 11.

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	$I_T = 1.41 \times I_{T(rms)}$ A; $t_p = 380\mu s$		MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	$T_J = 25°C$	MAX.	10	µA
		$T_J = 100°C$		500	
		$T_J = 125°C$		2000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Qxx04LT	3.6	°C/W
		Qxx06LT / Qxx06LTH	3.3	
		Qxx08LT / Qxx08LTH	2.8	
		Qxx10LT / Qxx10LTH	2.6	
		Qxx15LT / Qxx15LTH	2.1	
$R_{\theta(J-A)}$	Junction to ambient		50	°C/W

Note : xx = voltage

Figure 1: Normalized DC Holding Current vs. Junction Temperature

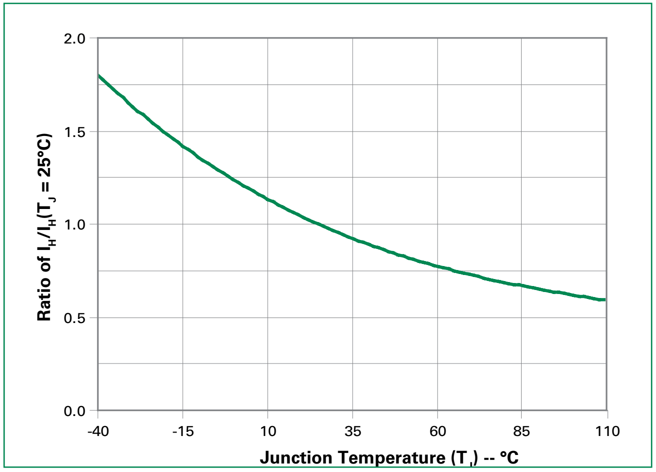


Figure 2: On-State Current vs. On-State Voltage (Typical) (4A)

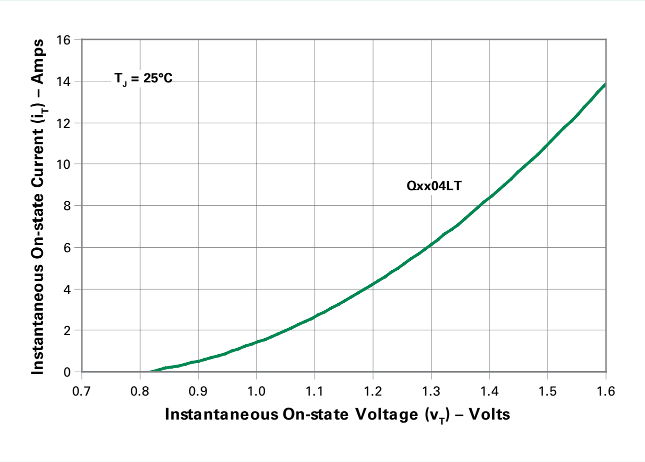


Figure 3: On-State Current vs. On-State Voltage (Typical) (6A to 15A)

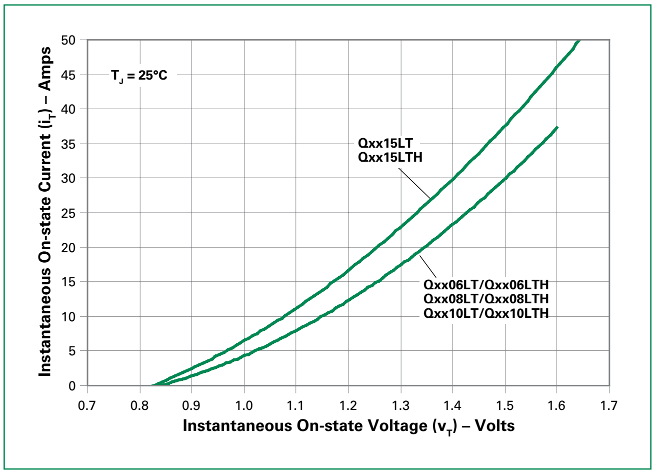


Figure 4: Power Dissipation vs. RMS On-State Current (Typical) (4A)

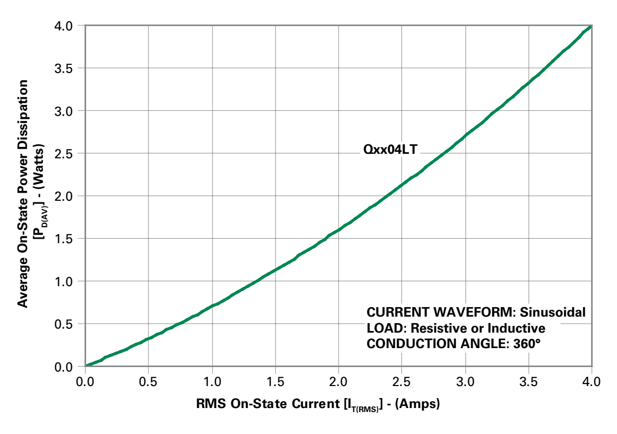


Figure 5: Power Dissipation vs. RMS On-State Current (Typical) (6A to 15A)

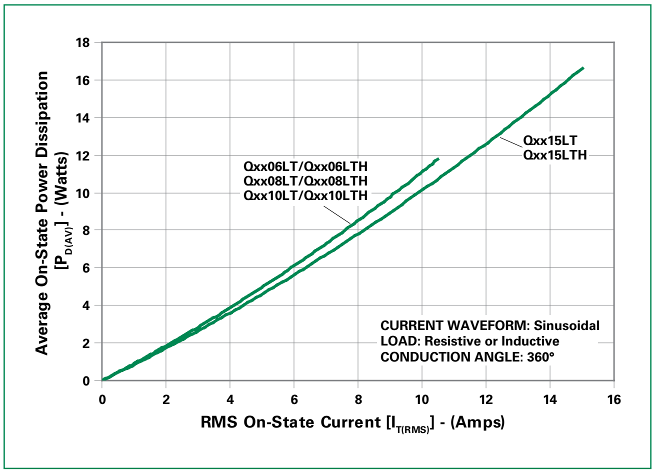


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

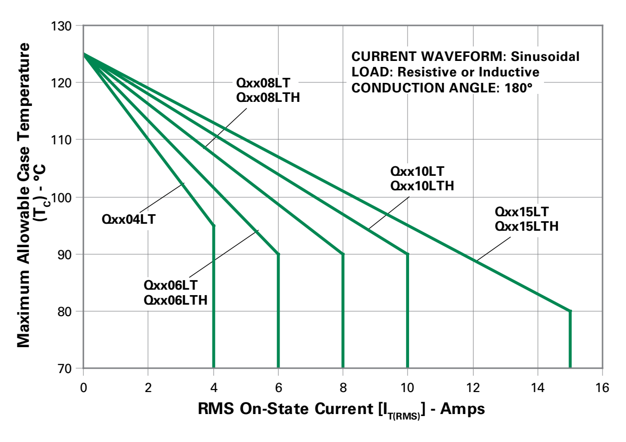
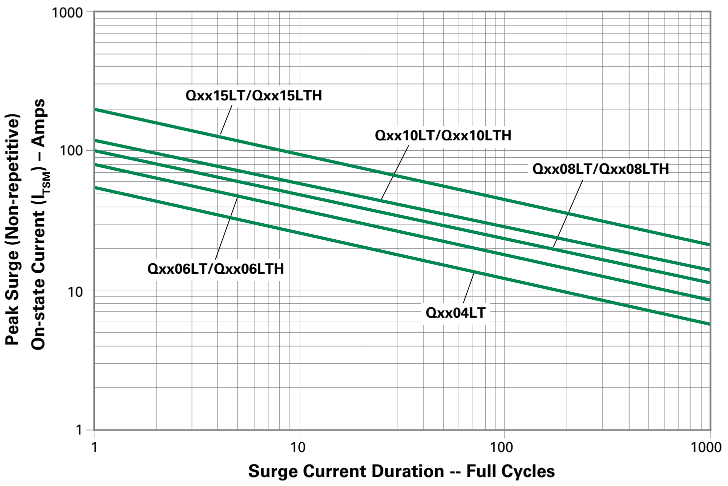


Figure 7: Surge Peak On-State Current vs. Number of Cycles



Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = voltage

Figure 8: DIAC V_{BO} Change vs. Junction Temperature

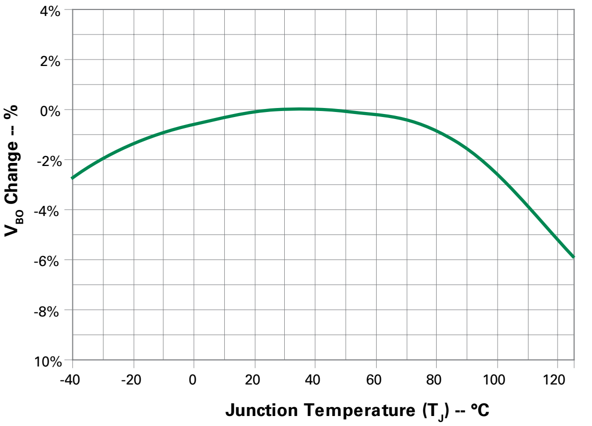


Figure 9: Test Circuit

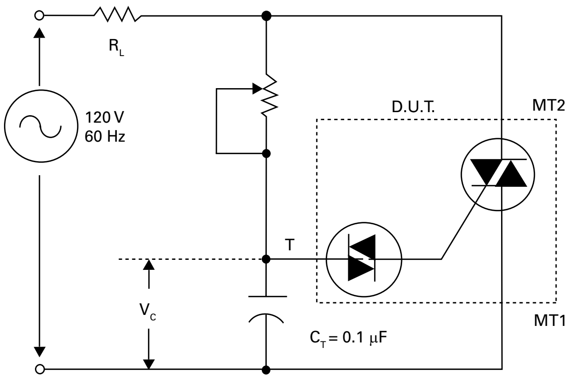
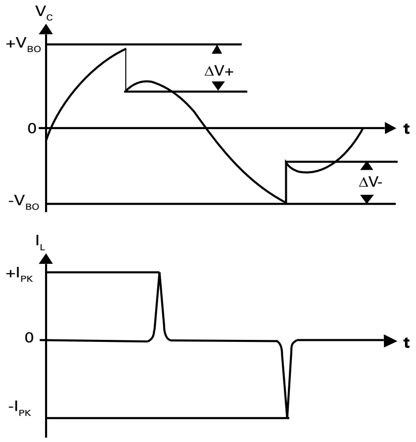
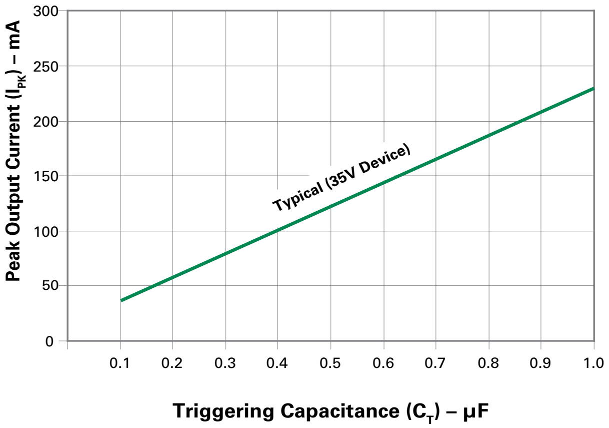


Figure 10: Test Circuit Waveform



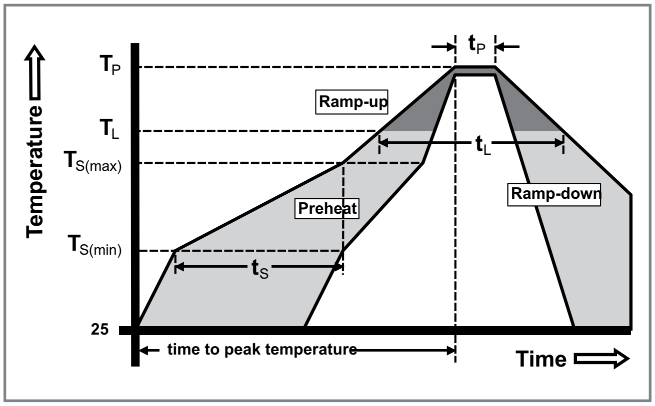
Typical pulse base width is 10μs

Figure 11: Peak Output Current vs Triggering Capacitance (Per Figure 9)



Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	1005 Matte Tin-plated
Body Material	UL Recognized epoxy meeting flammability classification 94v-0
Lead Material	Copper Alloy

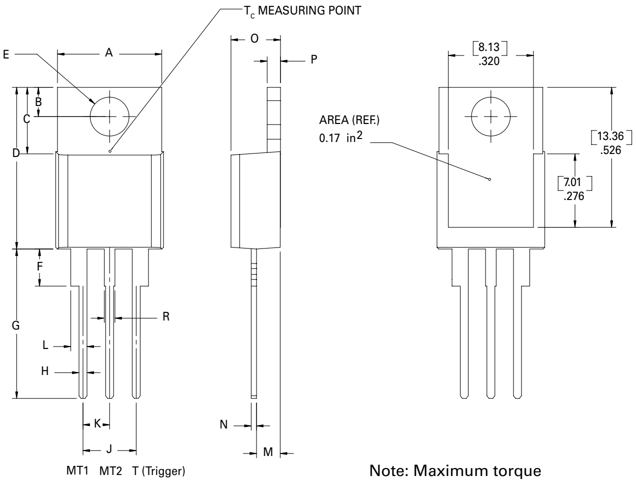
Environmental Specifications

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002, Category 3, Test A
Lead Bend	MIL-STD-750: Method 2036, Condition E

Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Product Selector

Part Number	Voltage				Type	Package
	400V	600V	800V	1000V		
Qxx04LT	X	X			Quadrac	TO-220L
Qxx06LT	X	X			Quadrac	TO-220L
Qxx06LTH	X	X			Alternistor Quadrac	TO-220L
Qxx08LT	X	X			Quadrac	TO-220L
Qxx08LTH	X	X			Alternistor Quadrac	TO-220L
Qxx10LT	X	X			Quadrac	TO-220L
Qxx10LTH	X	X			Alternistor Quadrac	TO-220L
Qxx15LT	X	X			Quadrac	TO-220L
Qxx15LTH	X	X			Alternistor Quadrac	TO-220L

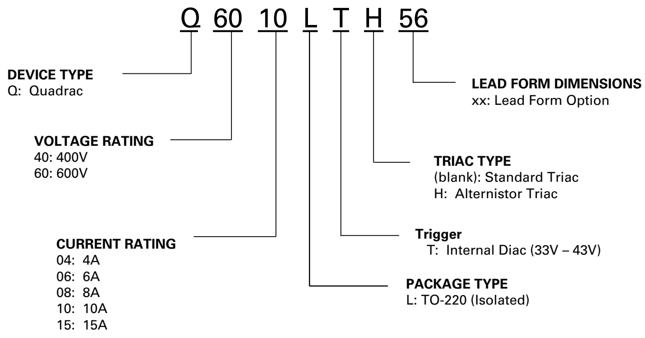
Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Qxx04LT	Qxx04LT	2.2 g	Bulk	500
Qxx04LTTP	Qxx04LT	2.2 g	Tube	500 (50 per tube)
Qxx06LT	Qxx06LT	2.2 g	Bulk	500
Qxx06LTTP	Qxx06LT	2.2 g	Tube	500 (50 per tube)
Qxx06LTH	Qxx06LTH	2.2 g	Bulk	500
Qxx06LTHTP	Qxx06LTH	2.2 g	Tube	500 (50 per tube)
Qxx08LT	Qxx08LT	2.2 g	Bulk	500
Qxx08LTTP	Qxx08LT	2.2 g	Tube	500 (50 per tube)
Qxx08LTH	Qxx08LTH	2.2 g	Bulk	500
Qxx08LTHTP	Qxx08LTH	2.2 g	Tube	500 (50 per tube)
Qxx10LT	Qxx10LT	2.2 g	Bulk	500
Qxx10LTTP	Qxx10LT	2.2 g	Tube	500 (50 per tube)
Qxx10LTH	Qxx10LTH	2.2 g	Bulk	500
Qxx10LTHTP	Qxx10LTH	2.2 g	Tube	500 (50 per tube)
Qxx15LT	Qxx15LT	2.2 g	Bulk	500
Qxx15LTTP	Qxx15LT	2.2 g	Tube	500 (50 per tube)
Qxx15LTH	Qxx15LTH	2.2 g	Bulk	500
Qxx15LTHTP	Qxx15LTH	2.2 g	Tube	500 (50 per tube)

Note: xx = Voltage

Part Numbering System



Q 60 10 L T H 56

DEVICE TYPE
Q: Quadrac

VOLTAGE RATING
40: 400V
60: 600V

CURRENT RATING
04: 4A
06: 6A
08: 8A
10: 10A
15: 15A

LEAD FORM DIMENSIONS
xx: Lead Form Option

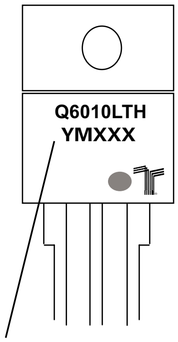
TRIAC TYPE
(blank): Standard Triac
H: Alternistor Triac

Trigger
T: Internal Diac (33V – 43V)

PACKAGE TYPE
L: TO-220 (Isolated)

Part Marking System

TO-220 AB - (L Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

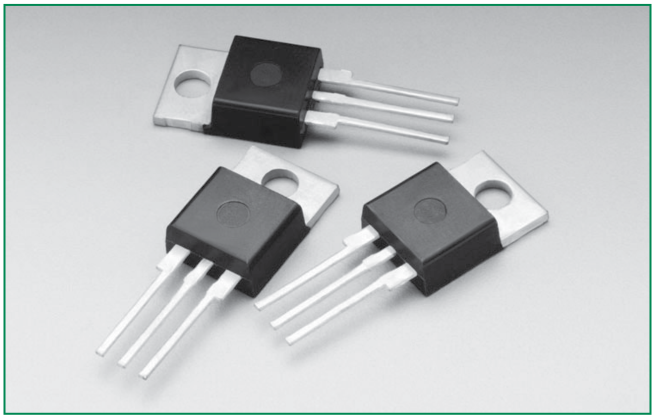
Expertise Applied | Answers Delivered

Teccor® brand Thyristors

8 Amp Alternistor Quadrac for LED dimmer applications

Q6008LTH1LED Series

RoHS



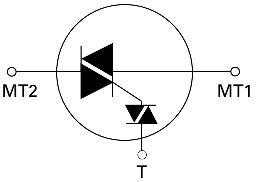
Agency Approval

Agency	Agency File Number
®	L Package : E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	8	A
V_{DRM} / V_{RRM}	600	V
DIAC V_{BO}	33 to 43	V

Schematic Symbol



Additional Information

Datasheet

Resources

Samples

Description

The Quadrac is an internally triggered Triac designed for AC switching and phase control applications. It is a Triac and DIAC in a single package, which saves user expense by eliminating the need for separate Triac and DIAC components.

Q6008LTH1LED series is designed to meet low load current characteristics typical in LED lighting applications.

By keeping holding current at 6mA maximum, this Quadrac series is characterized and specified to perform best with LED loads. The Q6008LTH1LED series is best suited for LED dimming controls to obtain the lowest levels of light output with a minimum probability of flickering.

Q6008LTH1LED series is offered in the industry standard TO-220AB package with an isolated mounting tab that makes it best suited for adding an external heat sink.

Features	Benefits
• As low as 6mA max holding current	• Provides full control of light out put at the extreme low end of load conditions.
• UL recognized TO-220AB package	• 2500V $_{AC}$ min isolation between mounting tab and active terminals
• 110°C rated junction temperature	• Improves margin of safe operation with less heat sinking required
• di/dt performance of 70A/μs	• Enable survivability of typically LED load operating characteristics
• QUADRAC version includes intergrated DIAC	• Simplicity of circuit design & layout

Applications

Excellent for AC switching and phase control applications such as lighting and motor speed controls. Typical applications are AC solid-state switches, light dimmers with LED loads, small low current motor in power tools, and low current motors in home/brown goods appliances.

Internally constructed isolated package is offered for ease of heat sinking with highest isolation voltage.

Revised: 12/14/14

Absolute Maximum Ratings

Symbol	Parameter		Value	Unit
$I_{T(RMS)}$	RMS forward current	Tc = 80°C	8	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	80	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	85	
I^2t	I^2t value for fusing	t_p = 8.3ms	30	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =110°C	70	A/μs
I_{GM}	Peak gate current	T_J = 110°C	1.5	A
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 110	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Alternistor Quadrac

Symbol	Test Conditions		Value	Unit
I_H	I_T = 15mA (initial)	MAX.	6	mA
dv/dt	$V_D = V_{DRM}$; gate open; T_J=110°C	MIN.	50	V/μs
dv/dt(c)	di/dt(c) = 0.54 x $I_{T(rms)}$ / ms; T_J = 110°C	MIN.	10	V/μs
t_{gt}	(note 1)	TYP.	3	μs

(1) Reference test circuit in figure 7 and waveform in figure 8; C_T = 0.1μF with 0.1μs rise time.

Trigger DIAC Specifications

Symbol	Test Conditions		Value	Unit
ΔV_{BO}	Breakover Voltage Symmetry	MAX.	3	V
V_{BO}	Breakover Voltage, forward and reverse	MIN.	33	V
		MAX.	43	
[ΔV±]	Dynamic Breakback Voltage, forward and reverse (note 1)	MIN.	5	V
I_{BO}	Peak Breakover Current	MAX.	25	uA
C_T	Trigger Firing Capacitance	MAX.	0.1	μF

(1) Reference test circuit in figure 7 and waveform in figure 8.

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_T = 1.41 x $I_{T(rms)}$ A; t_p = 380μs		MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	MAX.	10	μA
		T_J = 110°C		500	

Thermal Resistances

Symbol	Parameter	Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	2.8	°C/W
$R_{\theta(J-A)}$	Junction to ambient	50	°C/W

Figure 1: Normalized DC Holding Current vs. Junction Temperature

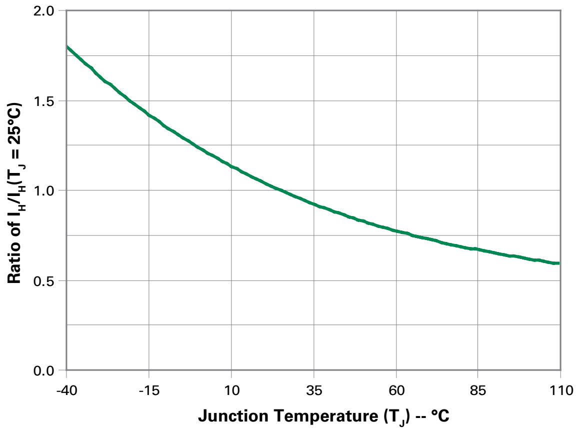


Figure 2: On-State Current vs. On-State Voltage (Typical)

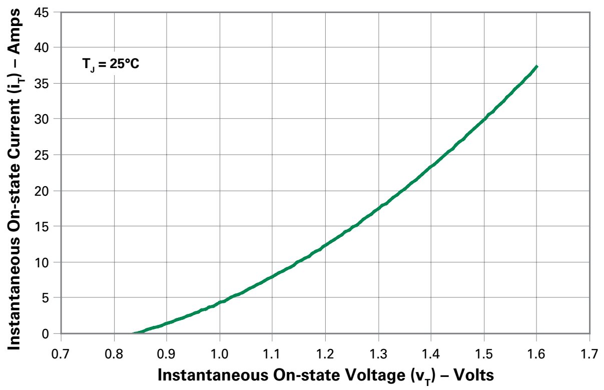


Figure 3: Power Dissipation vs. RMS On-State Current (Typical)

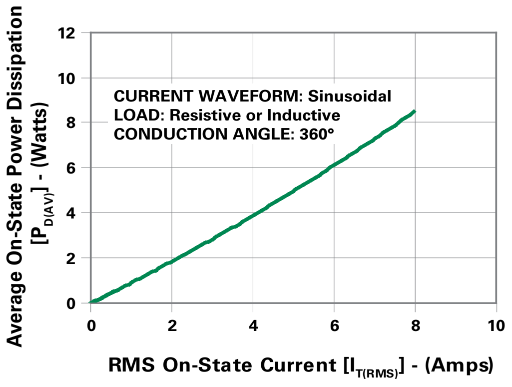


Figure 4: Maximum Allowable Case Temperature vs. RMS On-State Current

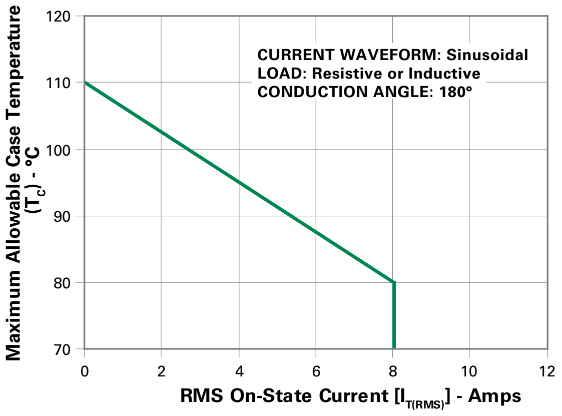
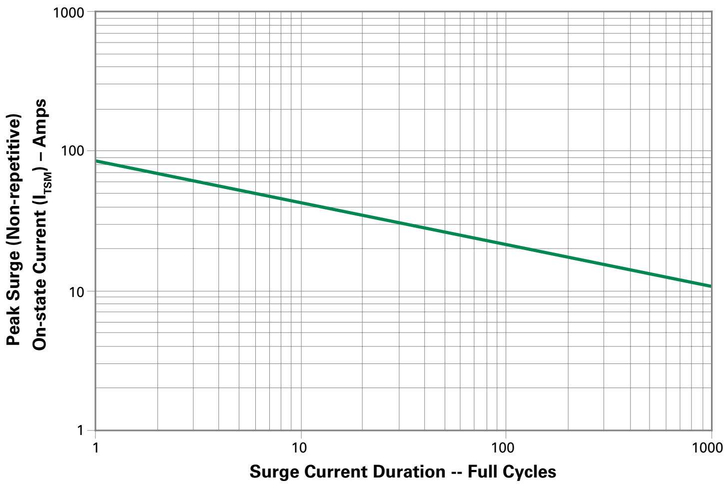


Figure 5: Surge Peak On-State Current vs. Number of Cycles



Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 6: DIAC V_{BO} Change vs. Junction Temperature

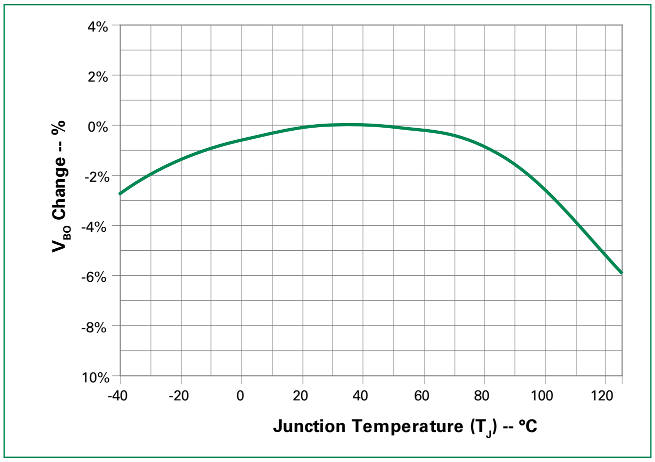


Figure 7: Test Circuit

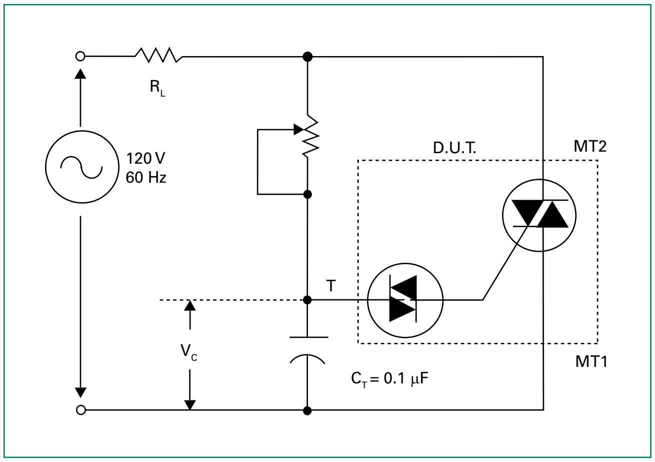
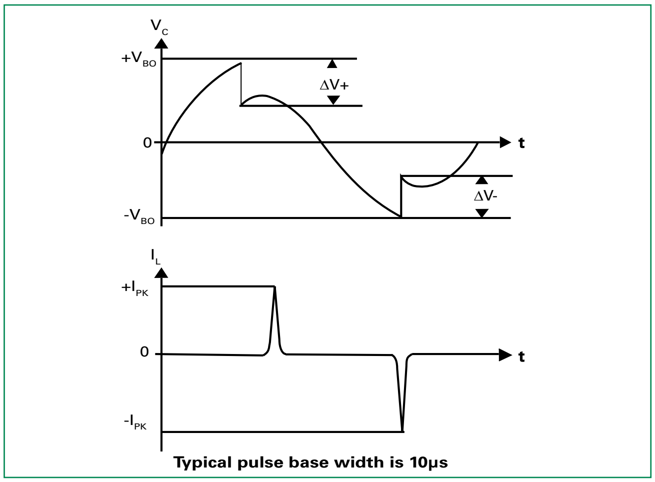
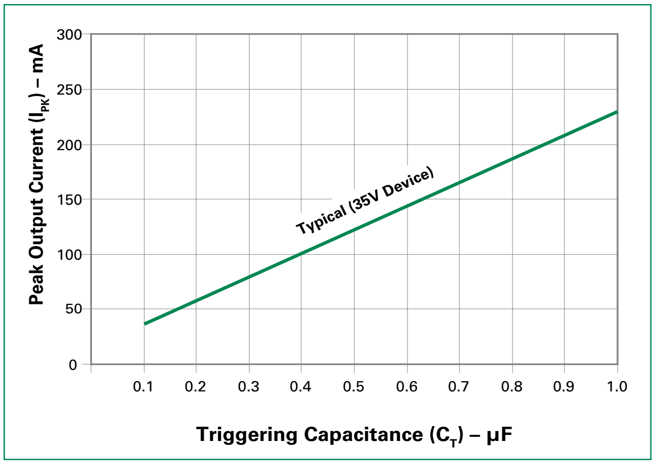


Figure 8: Test Circuit Waveform



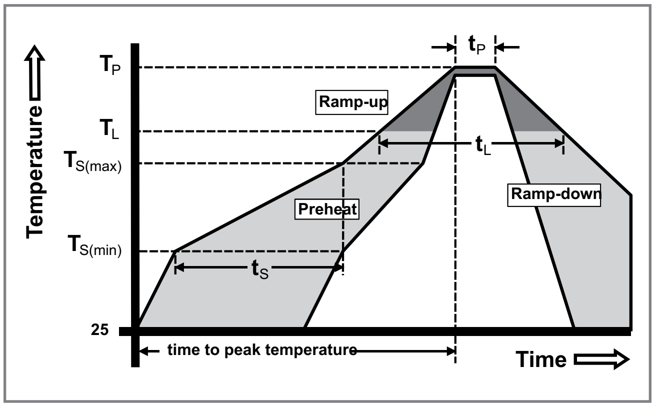
Typical pulse base width is 10µs

Figure 9: Peak Output Current vs Triggering Capacitance (Per Figure 7)



Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		260°C $^{+0/-5}$
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



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Terminal Finish	1005 Matte Tin-plated
Body Material	UL Recognized epoxy meeting flammability classification 94v-0
Lead Material	Copper Alloy

Design Considerations

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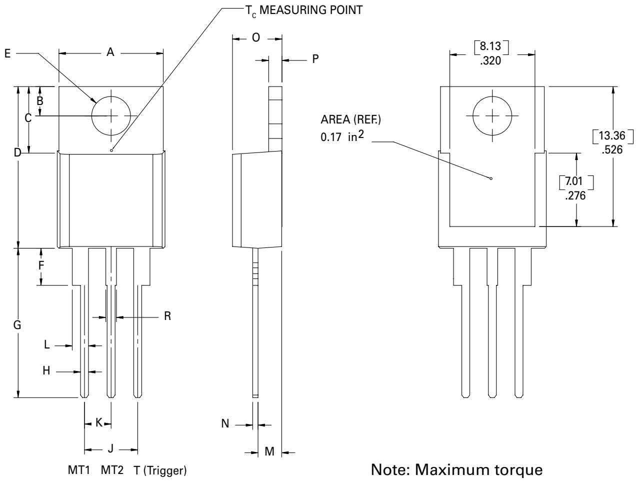
Environmental Specifications

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 110°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002, Category 3, Test A
Lead Bend	MIL-STD-750: Method 2036, Condition E

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque
to be applied to mounting tab
is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
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O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Product Selector

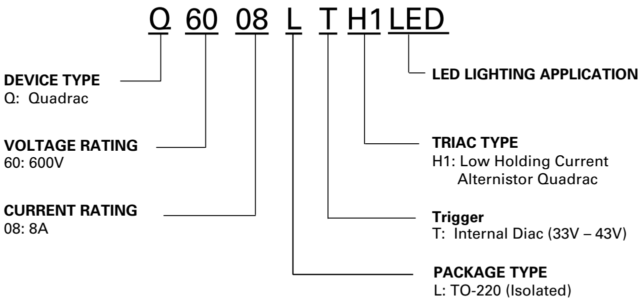
Part Number	Type	Package
Q6008LTH1LED	Alternistor Quadrac	TO-220L

Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Q6008LTH1LED	Q6008LTH1	2.2 g	Bulk	500
Q6008LTH1LEDTP	Q6008LTH1	2.2 g	Tube	500 (50 per tube)

Part Numbering System



Q 60 08 L T H1 LED

DEVICE TYPE
Q: Quadrac

VOLTAGE RATING
60: 600V

CURRENT RATING
08: 8A

LED LIGHTING APPLICATION

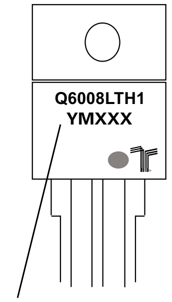
TRIAC TYPE
H1: Low Holding Current
Alternistor Quadrac

Trigger
T: Internal Diac (33V – 43V)

PACKAGE TYPE
L: TO-220 (Isolated)

Part Marking System

TO-220 AB - (L Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

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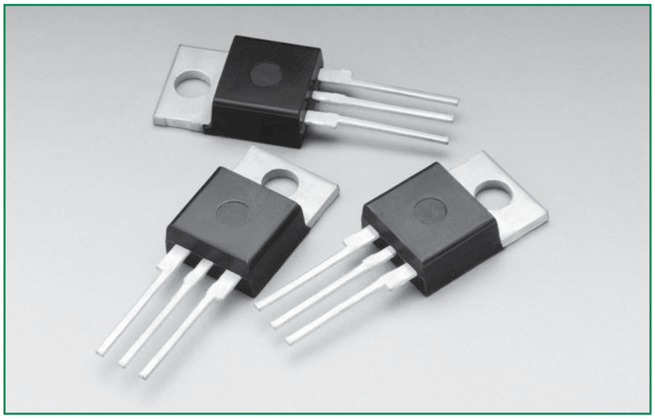
Teccor® brand Thyristors

12 Amp Alternistor Quadrac for LED dimmer applications

Q6012LTH1LED Series

RoHS



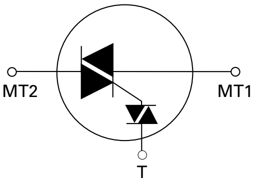
Agency Approval

Agency	Agency File Number
®Ꮢ	L Package : E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	12	A
V_{DRM} / V_{RRM}	600	V
DIAC V_{BO}	33 to 43	V

Schematic Symbol



Description

The Quadrac is an internally triggered Triac designed for AC switching and phase control applications. It is a Triac and DIAC in a single package, which saves user expense by eliminating the need for separate Triac and DIAC components.

Q6012LTH1LED series is designed to meet low load current characteristics typical in LED lighting applications.

By keeping holding current at 8mA maximum, this Quadrac series is characterized and specified to perform best with LED loads. The Q6012LTH1LED series is best suited for LED dimming controls to obtain the lowest levels of light output with a minimum probability of flickering.

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Features	Benefits
• As low as 8mA max holding current	• Provides full control of light out put at the extreme low end of load conditions.
• UL recognized TO-220AB package	• 2500V $_{AC}$ min isolation between mounting tab and active terminals
• 110°C rated junction temperature	• Improves margin of safe operation with less heat sinking required
• di/dt performance of 70A/μs	• Enable survivability of typically LED load operating characteristics
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Applications

Excellent for AC switching and phase control applications such as lighting and motor speed controls. Typical applications are AC solid-state switches, light dimmers with LED loads, small low current motor in power tools, and low current motors in home/brown goods appliances.

Internally constructed isolated package is offered for ease of heat sinking with highest isolation voltage.

Revised: 12/14/14

Absolute Maximum Ratings

Symbol	Parameter		Value	Unit
$I_{T(RMS)}$	RMS forward current	Tc = 90°C	12	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	110	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	120	
I^2t	I^2t value for fusing	t_p = 8.3ms	60	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =110°C	70	A/μs
I_{GM}	Peak gate current	T_J = 110°C	1.5	A
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 110	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Alternistor Quadrac

Symbol	Test Conditions		Value	Unit
I_H	I_T = 20mA (initial)	MAX.	8	mA
dv/dt	$V_D = V_{DRM}$; gate open; T_J=110°C	MIN.	45	V/μs
dv/dt(c)	di/dt(c) = 0.54 x $I_{T(rms)}$ / ms; T_J = 110°C	MIN.	2	V/μs
t_{gt}	(note 1)	TYP.	3	μs

(1) Reference test circuit in figure 7 and waveform in figure 8; C_T = 0.1μF with 0.1μs rise time.

Trigger DIAC Specifications

Symbol	Test Conditions		Value	Unit
ΔV_{BO}	Breakover Voltage Symmetry	MAX.	3	V
V_{BO}	Breakover Voltage, forward and reverse	MIN.	33	V
		MAX.	43	
[ΔV±]	Dynamic Breakback Voltage, forward and reverse (note 1)	MIN.	5	V
I_{BO}	Peak Breakover Current	MAX.	25	uA
C_T	Trigger Firing Capacitance	MAX.	0.1	μF

(1) Reference test circuit in figure 7 and waveform in figure 8.

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_T = 1.41 x $I_{T(rms)}$ A; t_p = 380μs		MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	MAX.	10	μA
		T_J = 110°C		1000	

Thermal Resistances

Symbol	Parameter	Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	2.3	°C/W
$R_{\theta(J-A)}$	Junction to ambient	50	°C/W

Revised: 12/14/14

Figure 1: Normalized DC Holding Current vs. Junction Temperature

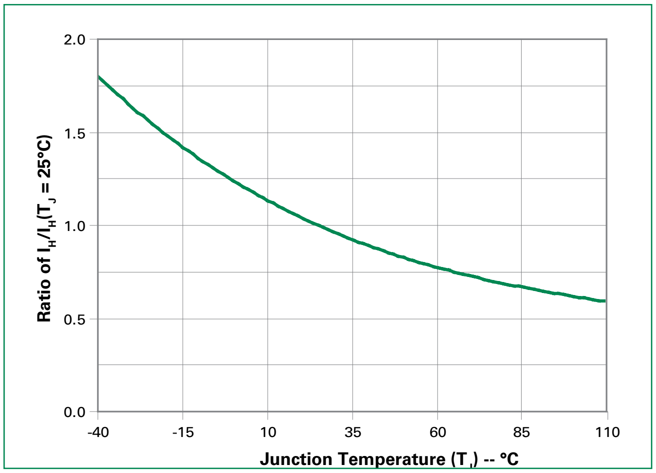


Figure 2: On-State Current vs. On-State Voltage (Typical)

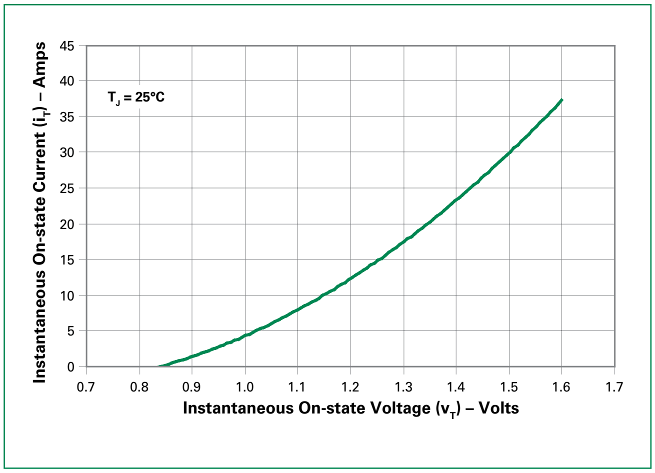


Figure 3: Power Dissipation vs. RMS On-State Current (Typical)

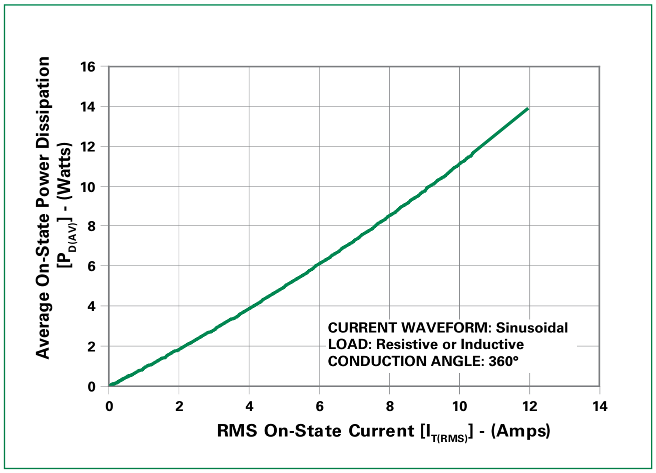


Figure 4: Maximum Allowable Case Temperature vs. RMS On-State Current

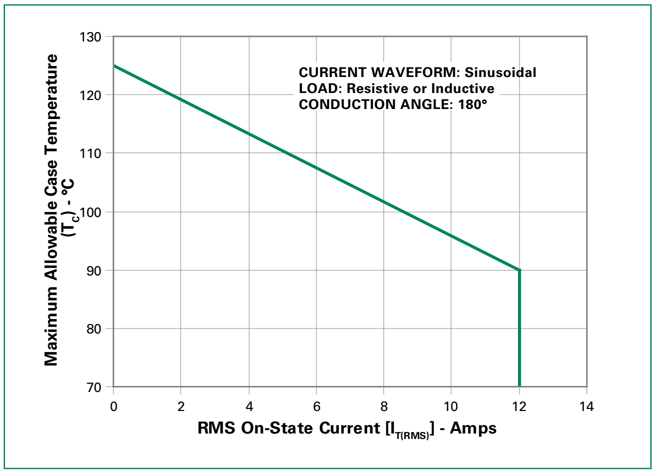
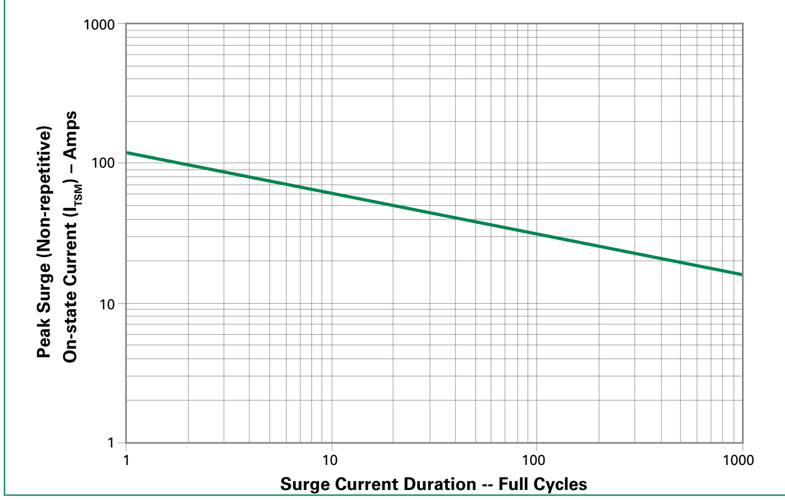


Figure 5: Surge Peak On-State Current vs. Number of Cycles



Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specific Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 6: DIAC V_{BO} Change vs. Junction Temperature

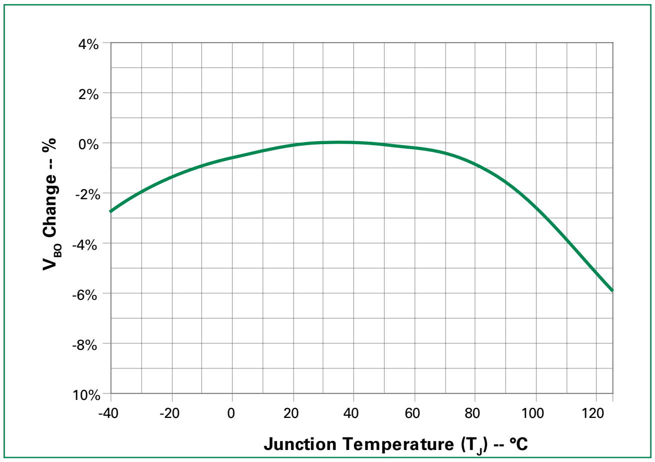


Figure 7: Test Circuit

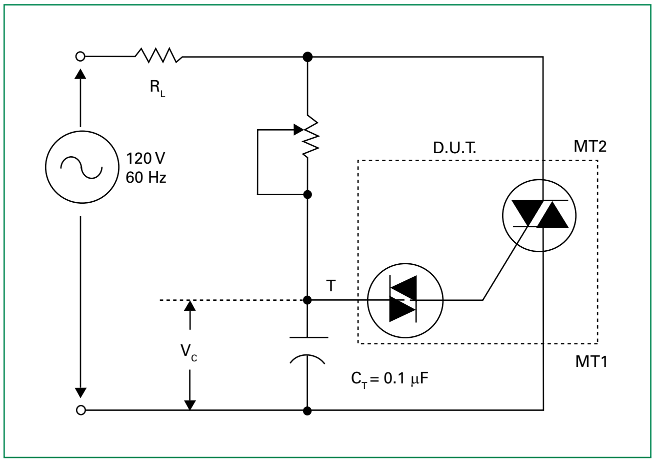
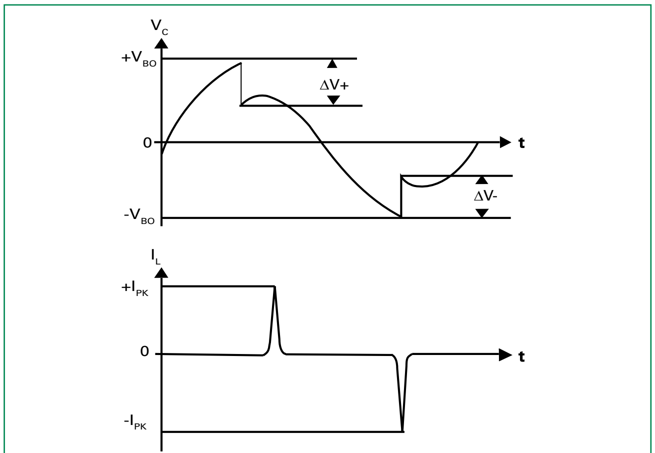
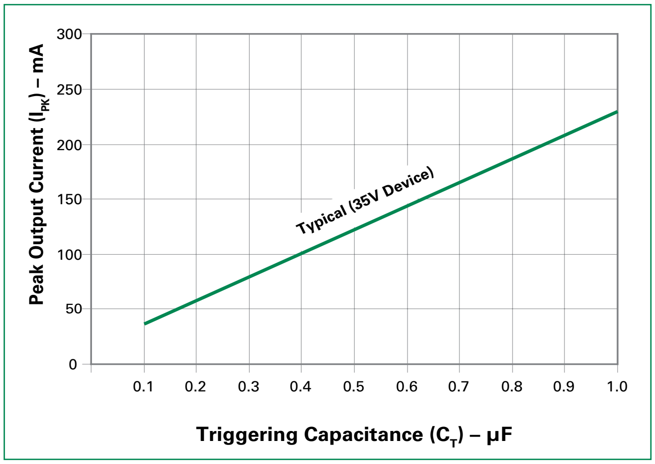


Figure 8: Test Circuit Waveform



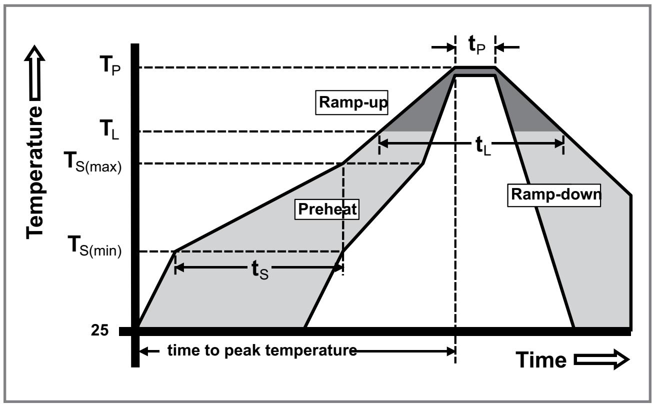
Typical pulse base width is 10µs

Figure 9: Peak Output Current vs Triggering Capacitance (Per Figure 7)



Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		260°C $^{+0/-5}$
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	1005 Matte Tin-plated
Body Material	UL Recognized epoxy meeting flammability classification 94v-0
Lead Material	Copper Alloy

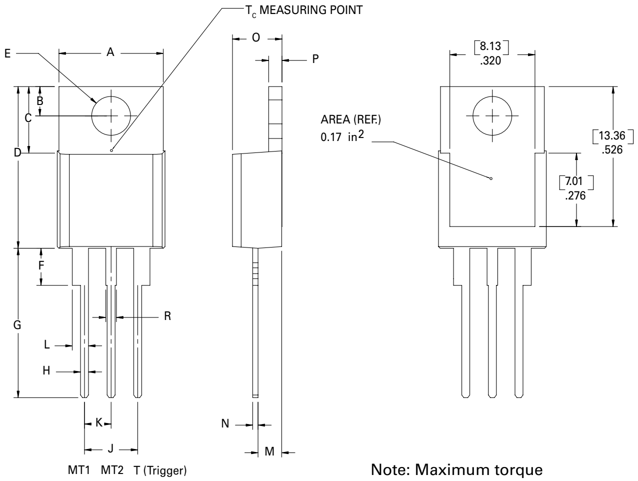
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 110°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002, Category 3, Test A
Lead Bend	MIL-STD-750: Method 2036, Condition E

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Product Selector

Part Number	Type	Package
Q6012LTH1LED	Alternistor Quadrac	TO-220L

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Q6012LTH1LED	Q6012LTH1	2.2 g	Bulk	500
Q6012LTH1LEDTP	Q6012LTH1	2.2 g	Tube	500 (50 per tube)

Part Numbering System

Q 60 12 L T H1 LED

DEVICE TYPE
Q: Quadrac

VOLTAGE RATING
60: 600V

CURRENT RATING
12: 12A

LED LIGHTING APPLICATION

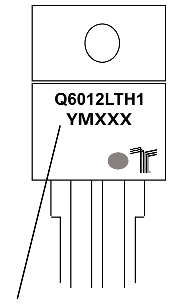
TRIAC TYPE
H1: Low Holding Current Alternistor Quadrac

Trigger
T: Internal Diac (33V – 43V)

PACKAGE TYPE
L: TO-220 (Isolated)

Part Marking System

TO-220 AB - (L Package)

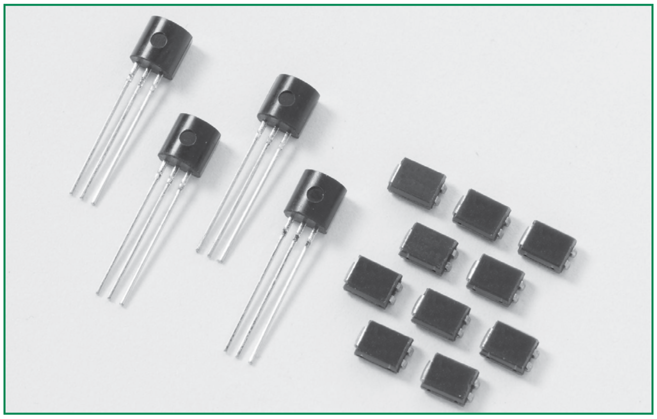


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

EC103xx & SxSx Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Sensitive gate SCRs are easily triggered with microAmps of current as furnished by sense coils, proximity switches, and microprocessors.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 20 A

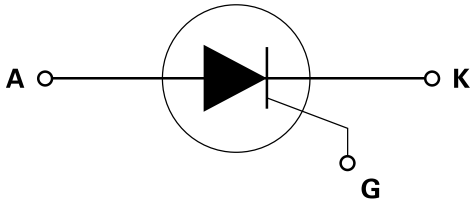
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	0.8	A
V_{DRM}/V_{RRM}	400 to 600	V
I_{GT}	12 to 500	μA

Applications

Typical applications are capacitive discharge systems for strobe lights and gas engine ignition. Also controls for power tools, home/brown goods and white goods appliances.

Schematic Symbol



Additional Information

Datasheet | **Resources** | **Samples**

Absolute Maximum Ratings — Sensitive SCRs

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 75°C	0.8	A
$I_{T(AV)}$	Average on-state current	T_C = 75°C	0.51	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	16	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	20	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	1.6	A^2s
di/dt	Critical rate of rise of on-state current	f = 60 Hz ; T_J = 110°C	50	A/μs
I_{GM}	Peak gate current	T_J = 110°C	1	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 110°C	0.1	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 110	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value				Unit
				SxS1 EC103X1	SxS2 EC103X2	SxS / 2N6565 EC103X	SxS3 EC103X3	
I_{GT}	V_D = 6V; R_L = 100 Ω		MAX.	12	50	200	500	μA
V_{GT}			MAX.	0.8				V
dv/dt	V_D = V_{DRM}; R_{GK} = 1kΩ	400V	MIN.	20	25	30	40	V/μs
		600V		10	10	15	20	
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ; T_J = 110°C		MIN.	0.2	0.25			V
I_H	I_T = 20mA (initial), R_{GK} = 1kΩ		MAX.	5			8	mA
t_q	(1)		MAX.	60		50	45	μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 1.6A		TYP.	2	5	20	30	μs

(1) I_T=1A; t_p=50μs; dv/dt=5V/μs; di/dt=-5A/μs

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_T = 1.2A; t_p = 380 μs		MAX.	1.7	V
I_{DRM} / I_{RRM}	V_{DRM} = V_{RRM} R_{GK} = 1kΩ	T_J = 25°C	MAX.	1	μA
		T_J = 100°C		50	
		T_J = 110°C		100	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	EC103xy/2N6565	75	°C/W
		SxSy	60*	
$R_{\theta(J-A)}$	Junction to ambient	EC103xy/2N6565	160	°C/W

Notes: x = voltage, y = sensitivity
* = Mounted on 1 cm^2 copper (two-ounce) foil surface

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

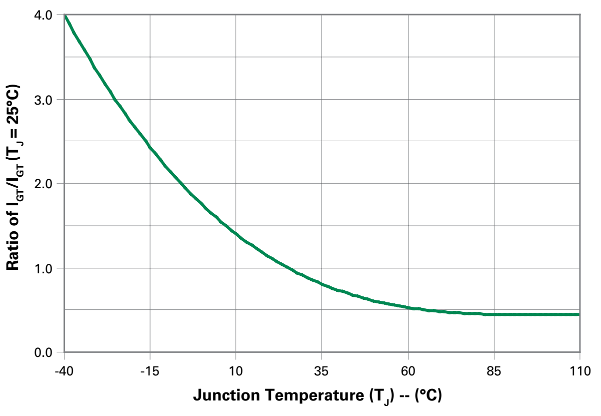


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

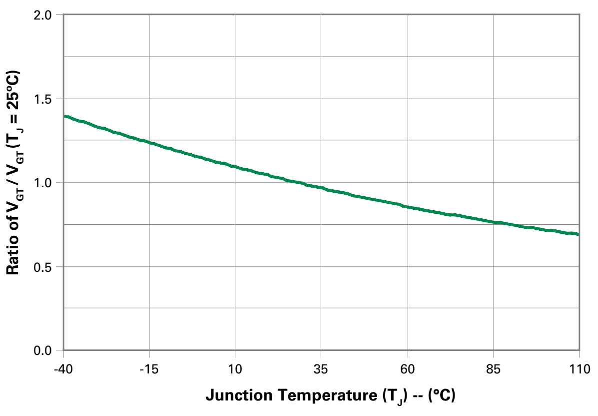


Figure 3: Normalized DC Holding Current vs. Junction Temperature

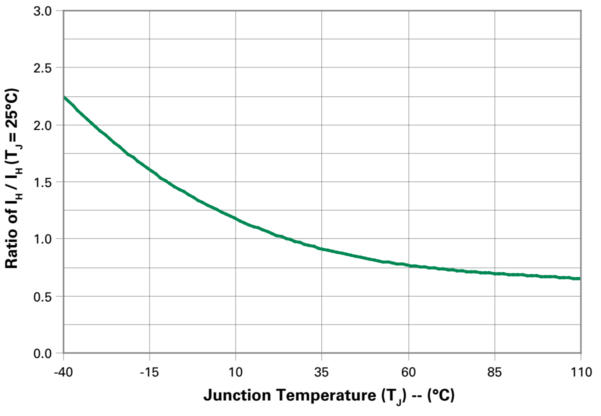


Figure 4: On-State Current vs. On-State Voltage (Typical)

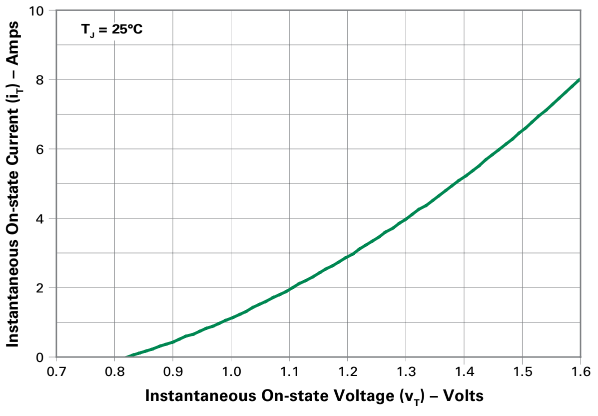


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

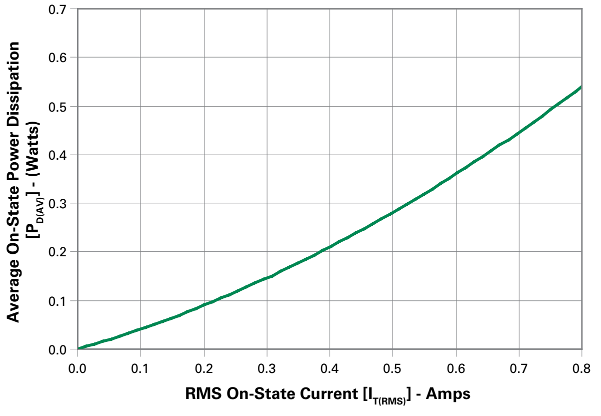


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

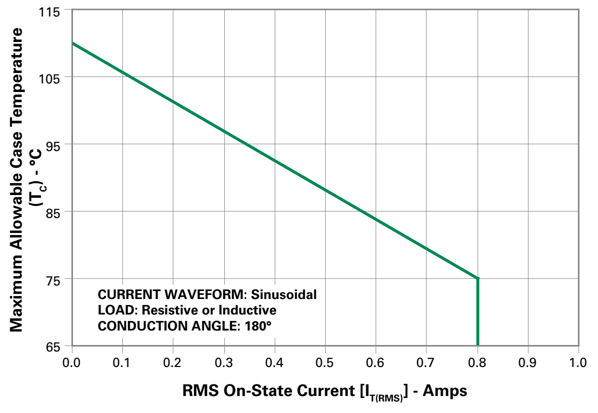


Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

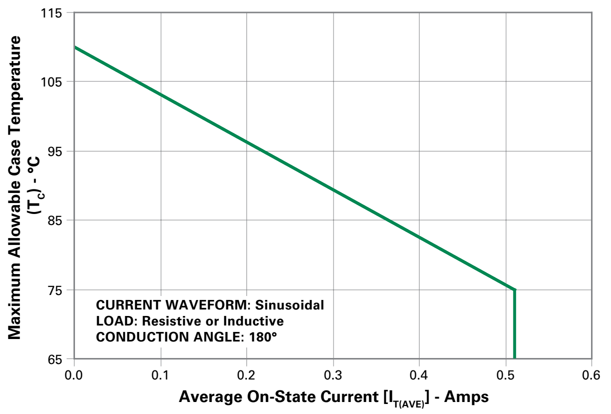


Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current

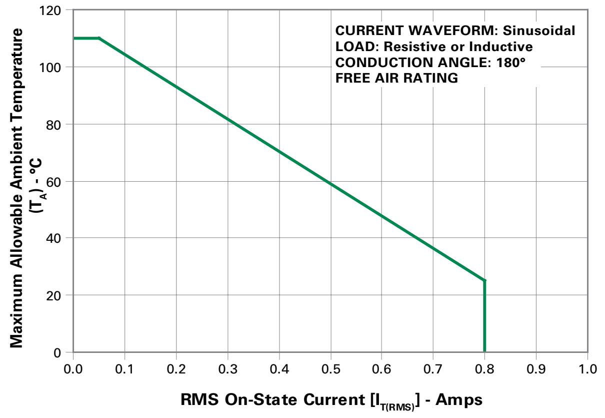


Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current

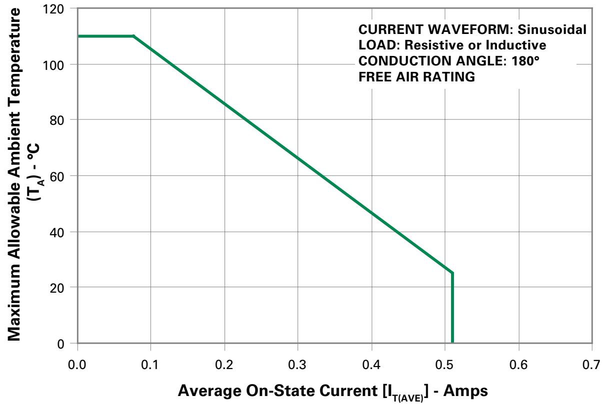


Figure 10: Peak Capacitor Discharge Current

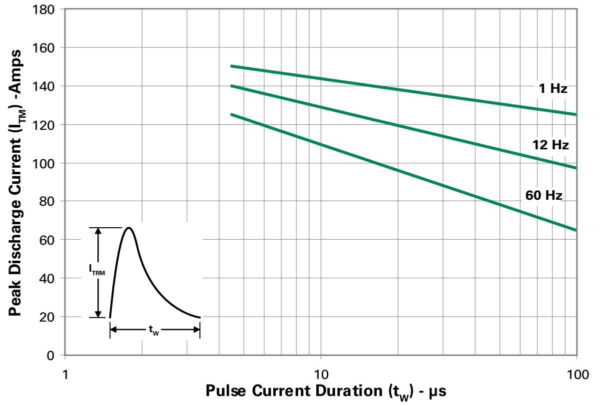


Figure 11: Peak Repetitive Sinusoidal Pulse Current

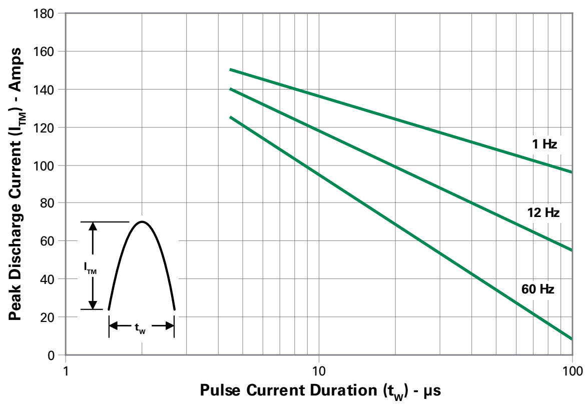
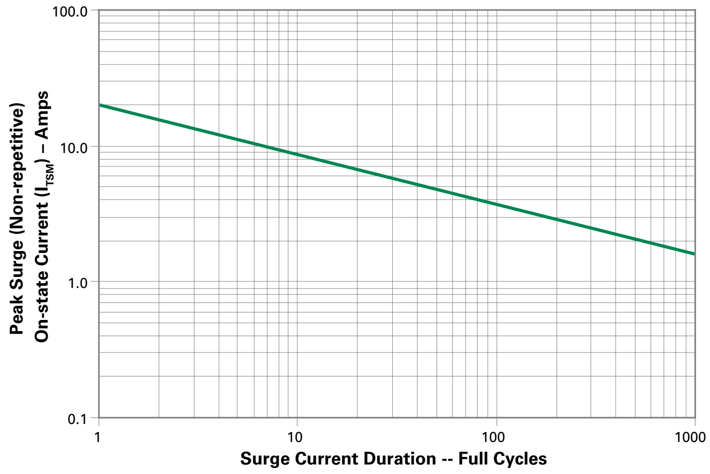


Figure 12: Surge Peak On-State Current vs. Number of Cycles

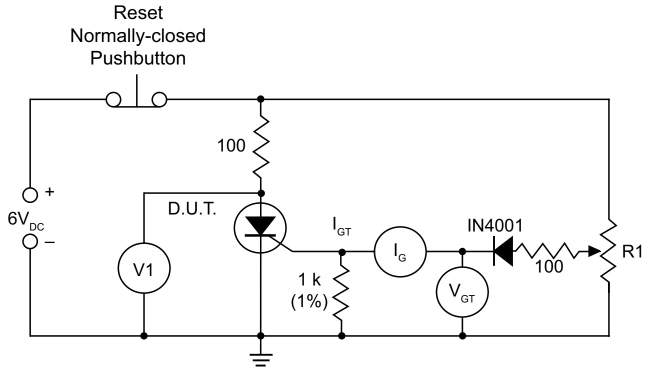


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 13: Simple Test Circuit for Gate Trigger Voltage and Current



Note: V1 — 0 V to 10 V dc meter
V_{GT} — 0 V to 1 V dc meter
I_G — 0 mA to 1 mA dc milliammeter
R1 — 1 k potentiometer

To measure gate trigger voltage and current, raise gate voltage (V_{GT}) until meter reading V1 drops from 6 V to 1 V. Gate trigger voltage is the reading on V_{GT} just prior to V1 dropping. Gate trigger current I_{GT} Can be computed from the relationship

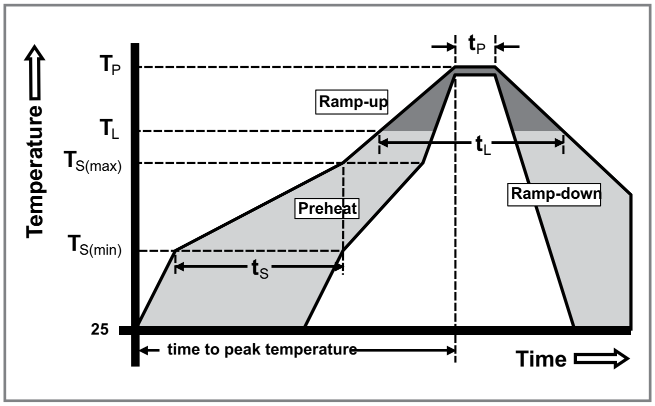
$$I_{GT} = I_G - \frac{V_{GT}}{1000} \text{ Amps}$$

where I_G is reading (in amperes) on meter just prior to V1 dropping

Note: I_{GT} may turn out to be a negative quantity (trigger current flows out from gate lead). If negative current occurs, I_{GT} value is not a valid reading. Remove 1 k resistor and use I_G as the more correct I_{GT} value. This will occur on 12 µA gate products.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated/Pb-free Solder Dipped
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

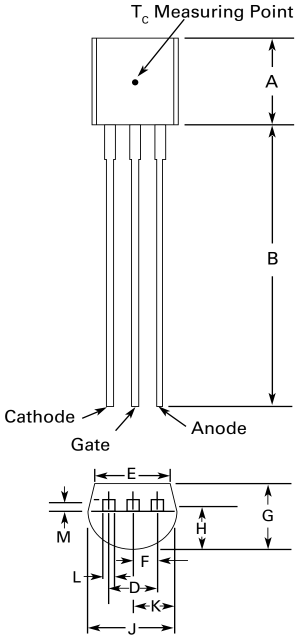
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 110°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

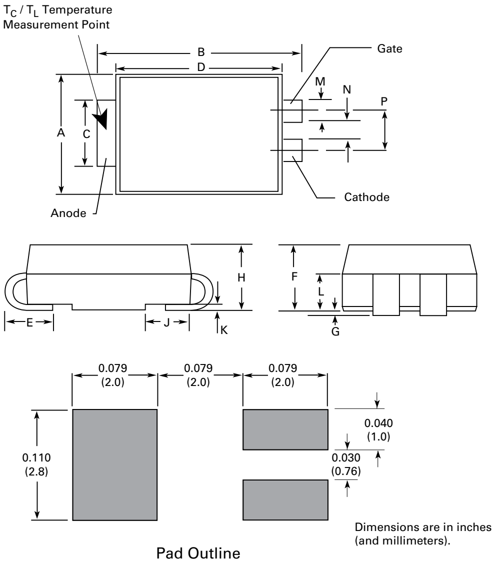
Dimensions – TO-92 (E Package)



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500	-	12.70	-
D	0.095	0.105	2.41	2.67
E	0.150	-	3.81	-
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43

All leads insulated from case. Case is electrically nonconductive.

Dimensions — Compak (C Package)



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
J	0.043	0.053	1.09	1.35
K	0.006	0.016	0.15	0.41
L	0.030	0.055	0.76	1.40
M	0.022	0.028	0.56	0.71
N	0.027	0.033	0.69	0.84
P	0.052	0.058	1.32	1.47

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
EC103 x 1	X	X			12µA	Sensitive SCR	TO-92
EC103 x 2	X	X			50µA	Sensitive SCR	TO-92
EC103 x	X / 2N6565	X			200µA	Sensitive SCR	TO-92
EC103 x 3	X	X			500µA	Sensitive SCR	TO-92
S x S1	X	X			12µA	Sensitive SCR	Compak
S x S2	X	X			50µA	Sensitive SCR	Compak
S x S	X	X			200µA	Sensitive SCR	Compak
S x S3	X	X			500µA	Sensitive SCR	Compak

Note: x = Voltage

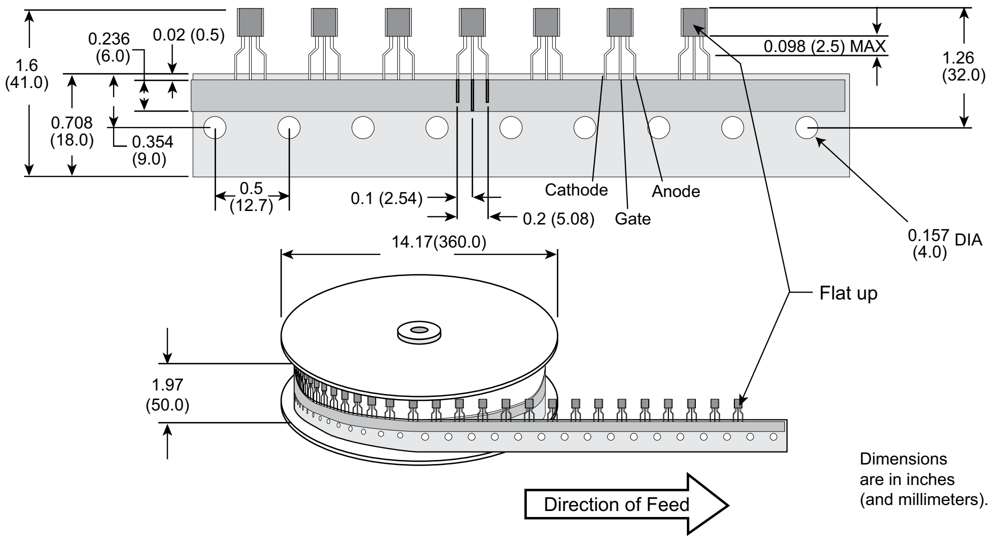
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
EC103xy / 2N6565	EC103xy / 2N6565	0.19 g	Bulk	2000
EC103xyRP	EC103xy	0.19 g	Reel Pack	2000
EC103xyAP	EC103xy	0.19 g	Ammo Pack	2000
SxSyRP	SxSy	0.08 g	Embossed Carrier	2500

Note: x = Voltage, y = sensitivity

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

Meets all EIA-468-C Standards

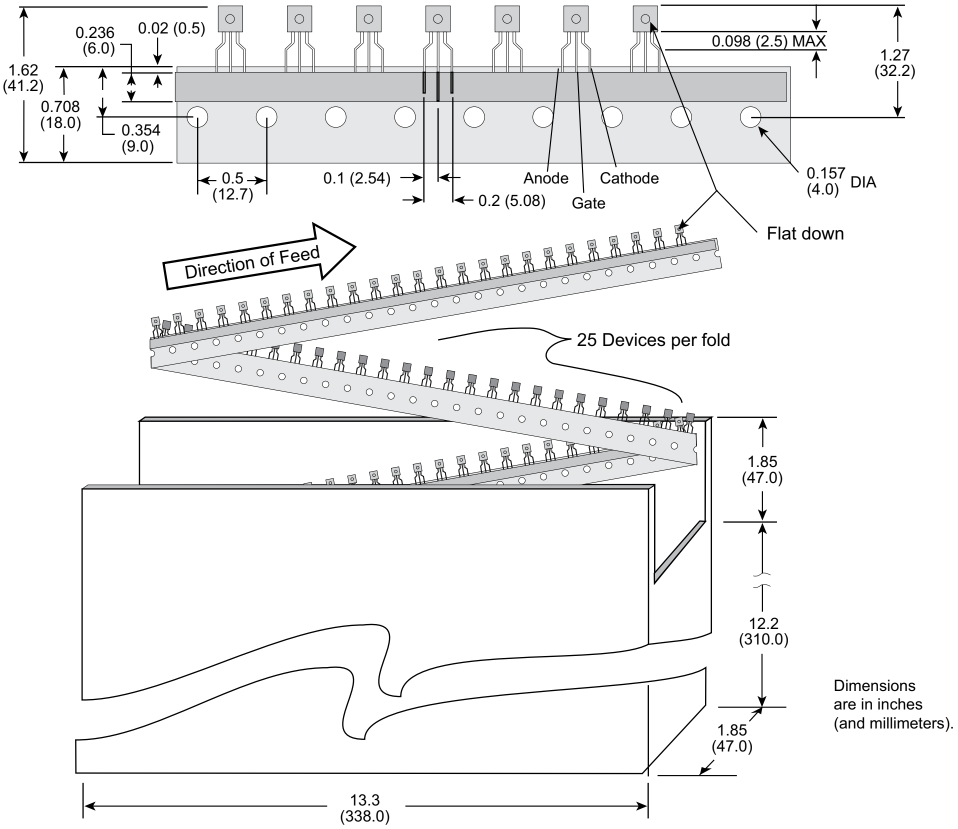


Dimensions
are in inches
(and millimeters).

Revised: 12/14/14

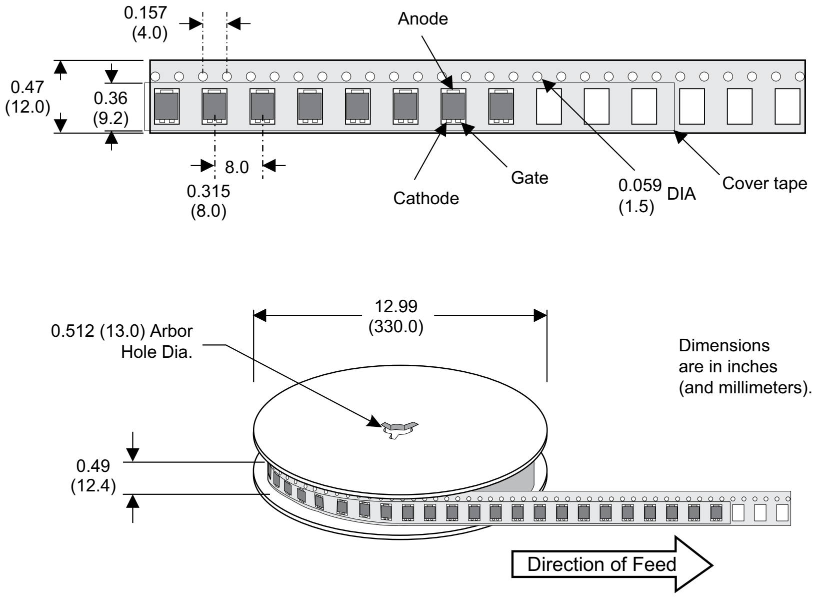
TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards

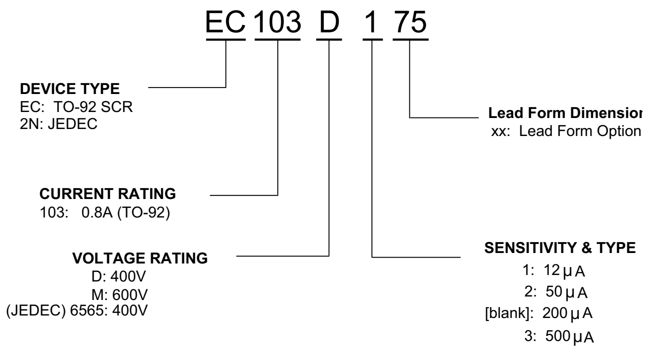


Compak Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-1 Standards

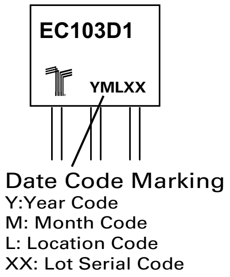


Part Numbering System (TO-92)

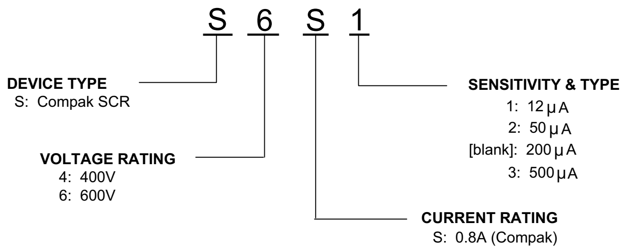


Part Marking System

TO-92 (E Package)

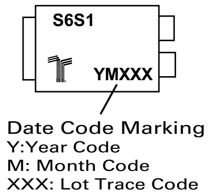


Part Numbering System (Compak)



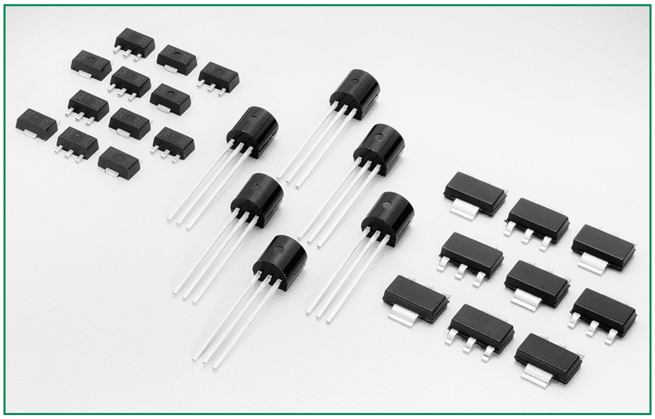
Part Marking System (Compak)

Compak (C Package)



SxX8xSx Series

HF RoHS



Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	0.8	A
V_{DRM}/V_{RRM}	400 to 800	V
I_{GT}	5 to 200	μA

Applications

The SxX8xSx EV series is specifically designed for GFCI (Ground Fault Circuit Interrupter) and gas ignition applications.

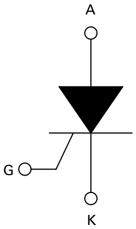
Description

New device series offers high static dv/dt and lower turn off (t_q) sensitive SCR with its small die planar construction design. It is specifically designed for GFCI (Ground Fault Circuit Interrupter) and Gas Ignition applications. All SCRs junctions are glass-passivated to ensure long term reliability and parametric stability.

Features

- RoHS compliant and Halogen-Free
- Thru-hole and surface mount packages
- Surge current capability > 10Amps
- Blocking voltage (V_{DRM} / V_{RRM}) capability - up to 800V
- High dv/dt noise immunity
- Improved turn-off time (t_q) < 25 μsec
- Sensitive gate for direct microprocessor interface

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	TO-92	T_C = 55°C	0.8	A
		SOT-89	T_C = 60°C	0.8	A
		SOT-223	T_L = 60°C	0.8	A
$I_{T(AV)}$	Average on-state current	TO-92	T_C = 55°C	0.51	A
		SOT-89	T_C = 60°C	0.51	A
		SOT-223	T_L = 60°C	0.51	A
I_{TSM}	Non repetitive surge peak on-state current (Single cycle, T_J initial = 25°C)	TO-92 SOT-89 SOT-223	F= 50Hz	8	A
			F= 60Hz	10	A
I^2t	I^2t Value for fusing	t_p = 10 ms	F = 50 Hz	0.32	A^2s
		t_p = 8.3 ms	F = 60 Hz	0.41	A^2s
di/dt	Critical rate of rise of on-state current I_G = 10mA	TO-92 SOT-89 SOT-223	T_J = 125°C	50	A/μs
I_{GM}	Peak Gate Current	t_p = 10 μs	T_J = 125°C	1.0	A
$P_{G(AV)}$	Average gate power dissipation	—	T_J = 125°C	0.1	W
T_{stg}	Storage junction temperature range	—	—	-40 to 150	°C
T_J	Operating junction temperature range	—	—	-40 to 125	°C

Revised: 12/14/14

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Limit	Value			Unit
				SxX8yS1	SxX8yS2	SxX8yS	
I_{GT}	DC Gate Trigger Current	V_D = 6V R_L = 100 Ω	MIN.	0.5	1	15	µA
			MAX.	5	50	200	µA
V_{GT}	DC Gate Trigger Voltage	V_D = 6V R_L = 100 Ω	MAX.	0.8			V
V_{GRM}	Peak Reverse Gate Voltage	I_{RG} = 10µA	MIN.	5			V
I_H	Holding Current	R_{GK} = 1 KΩ Initial Current = 20mA	MAX.	5			mA
(dv/dt)s	Critical Rate-of-Rise of Off-State Voltage	T_J = 125°C $V_D = V_{DRM} / V_{RRM}$ Exp. Waveform R_{GK} =1 kΩ	MIN.	75			V/µs
V_{GD}	Gate Non-Trigger Voltage	$V_D = V_{DRM}$ R_{GK} =1 kΩ T_J = 25°C	MIN.	0.2			V
t_q	Turn-Off Time	T_J = 25°C @ 600 V R_{GK} =1 kΩ	MAX.	30	25	25	µs
t_{gt}	Turn-On Time	I_G=10mA PW = 15µsec I_T = 1.6A(pk)	TYP.	2.0	2.0	2.0	µs

Note: x = voltage, y = package

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Limit	Value	Unit
V_{TM}	Peak On-State Voltage	I_{TM} = 1.6A (pk)	MAX.	1.70	V
I_{DRM}	Off-State Current, Peak Repetitive	T_J = 25°C @ $V_D = V_{DRM}$ R_{GK} =1 kΩ	MAX.	3	µA
		T_J = 125°C @ VD = V_{DRM} R_{GK} =1 kΩ	MAX.	500	µA

Thermal Resistances

Symbol	Description	Test Conditions		Value	Unit
$R_{th(j-c)}$	Junction to case (AC)	I_T = 0.8A $_{(RMS)}$ [1]	TO-92	75	°C/W
			SOT-223	30	°C/W
			SOT-89	50	°C/W
$R_{th(j-a)}$	Junction to ambient	I_T = 0.8A $_{(RMS)}$ [1]	TO-92	150	°C/W
			SOT-223	60	°C/W
			SOT-89	90	°C/W

[1] 60Hz AC resistive load condition, 100% conduction.

Revised: 12/14/14

Figure 1: Normalized DC Gate Trigger Current For All Quadrants vs. Junction Temperature

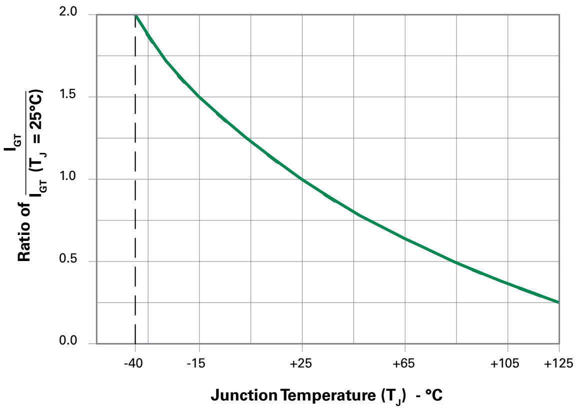


Figure 2: Normalized DC Holding Current vs. Junction Temperature

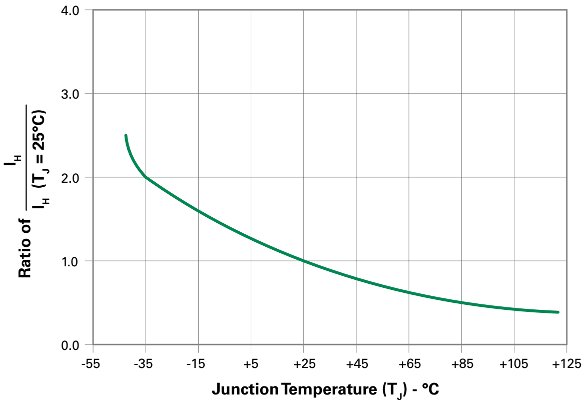


Figure 3: Normalized DC Gate Trigger Voltage vs. Junction Temperature

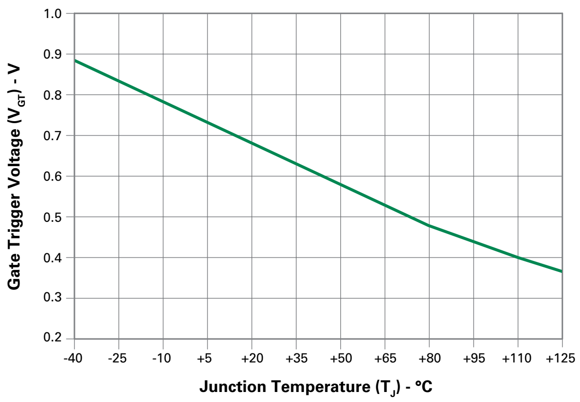


Figure 4: Power Dissipation (Typical) vs. RMS On-State Current

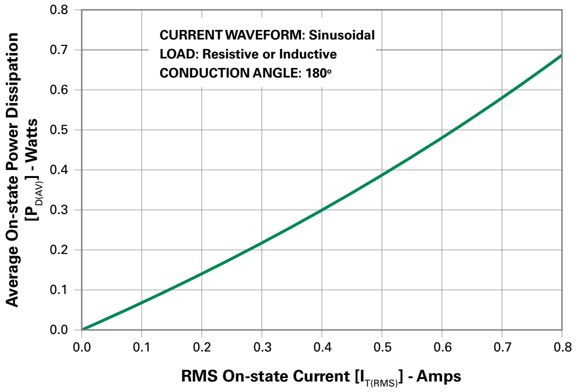


Figure 5: Maximum Allowable Case Temperature vs. On-State Current

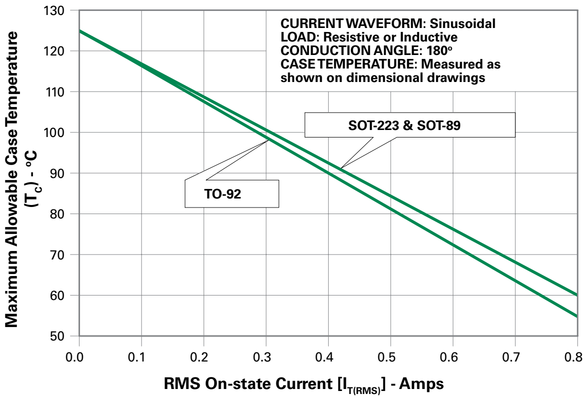
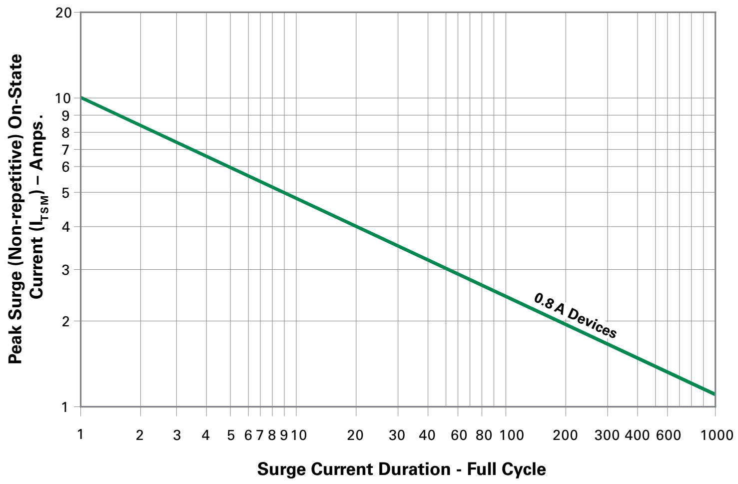


Figure 6: Surge Peak On-State Current vs. Number of Cycles

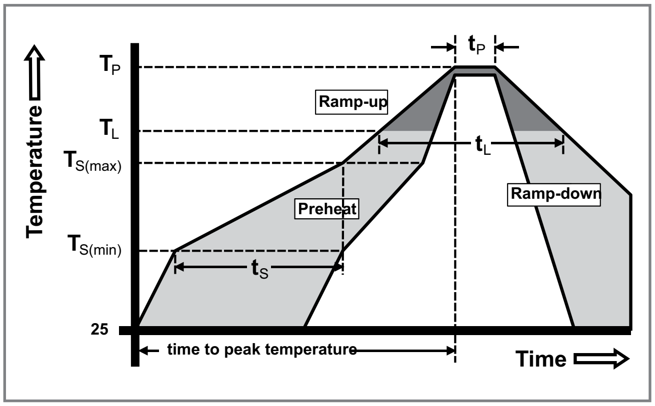


Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Additional Information

Datasheet

Resources

Samples

Revised: 12/14/14

Physical Specifications

Terminal Finish	100% Matte Tin-plated.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.
Lead Material	Copper Alloy

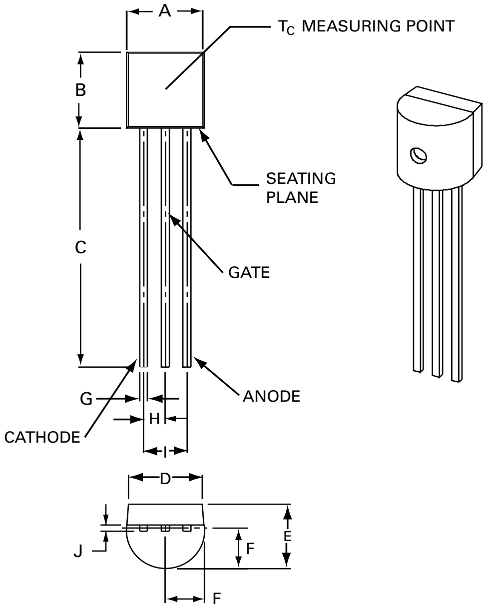
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

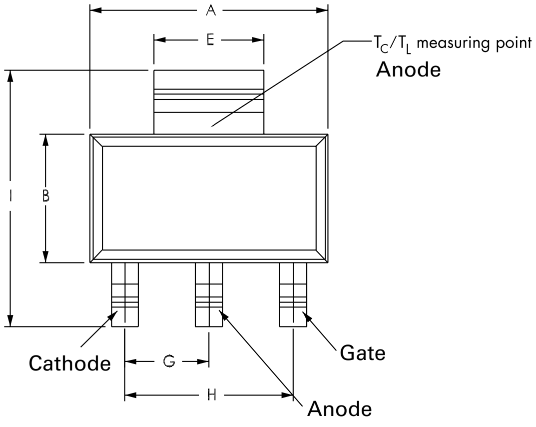
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 110°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

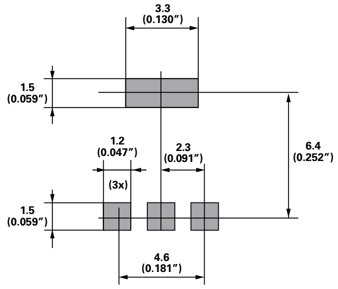
Dimensions – TO-92



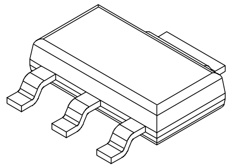
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.175	0.205	4.450	5.200
B	0.170	0.210	4.320	5.330
C	0.500		12.70	
D	0.135		3.430	
E	0.125	0.165	3.180	4.190
F	0.080	0.105	2.040	2.660
G	0.016	0.021	0.407	0.533
H	0.045	0.055	1.150	1.390
I	0.095	0.105	2.420	2.660
J	0.015	0.020	0.380	0.500

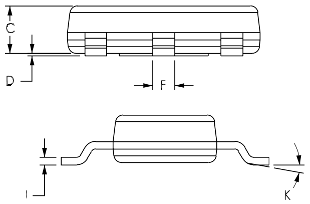
Dimensions – SOT-223





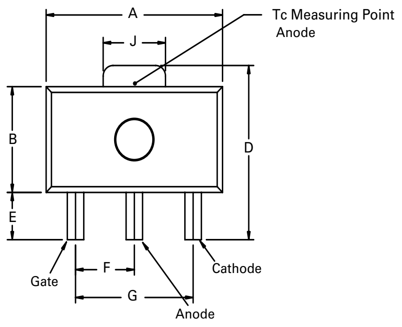
Dimensions in Millimeters (Inches)

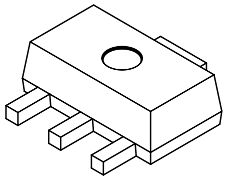


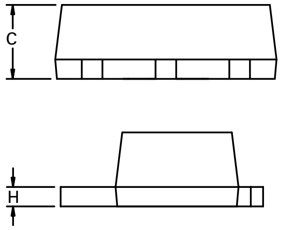


Dimensions	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.248	0.256	0.264	6.30	6.50	6.70
B	0.130	0.138	0.146	3.30	3.50	3.70
C	—	—	0.071	—	—	1.80
D	0.001	—	0.004	0.02	—	0.10
E	0.114	0.118	0.124	2.90	3.00	3.15
F	0.024	0.027	0.034	0.60	0.70	0.85
G	—	0.090	—	—	2.30	—
H	—	0.181	—	—	4.60	—
I	0.264	0.276	0.287	6.70	7.00	7.30
J	0.009	0.010	0.014	0.24	0.26	0.35
K	10° MAX					

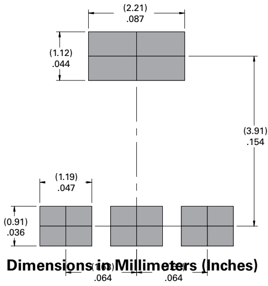
Dimensions – SOT-89







Pad Layout for SOT-89



Dimensions in Millimeters (Inches)

Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.173	—	0.181	4.40	—	4.60
B	0.090	—	0.102	2.29	—	2.60
C	0.055	—	0.063	1.40	—	1.60
D	0.155	—	0.167	3.94	—	4.25
E	0.035	—	0.047	0.89	—	1.20
F	0.056	—	0.062	1.42	—	1.57
G	0.115	—	0.121	2.92	—	3.07
H	0.014	—	0.017	0.35	—	0.44
I	0.014	—	0.019	0.36	—	0.48
J	0.064	—	0.072	1.62	—	1.83

Product Selector

Part Number	Voltage			Gate Sensitivity	Package
	400V	600V	800V		
S4X8ES	X	—	—	200 µA	TO-92
S6X8ES	—	X	—	200 µA	TO-92
S8X8ES	—	—	X	200 µA	TO-92
S4X8TS	X	—	—	200 µA	SOT-223
S6X8TS	—	X	—	200 µA	SOT-223
S8X8TS	—	—	X	200 µA	SOT-223
S4X8BS	X	—	—	200 µA	SOT-89
S6X8BS	—	X	—	200 µA	SOT-89
S4X8ES1	X	—	—	5 µA	TO-92
S6X8ES1	—	X	—	5 µA	TO-92
S8X8ES1	—	—	X	5 µA	TO-92
S4X8TS1	X	—	—	5 µA	SOT-223
S6X8TS1	—	X	—	5 µA	SOT-223
S8X8TS1	—	—	X	5 µA	SOT-223
S4X8ES2	X	—	—	50 µA	TO-92
S6X8ES2	—	X	—	50 µA	TO-92
S8X8ES2	—	—	X	50 µA	TO-92
S4X8TS2	X	—	—	50 µA	SOT-223
S6X8TS2	—	X	—	50 µA	SOT-223
S8X8TS2	—	—	X	50 µA	SOT-223

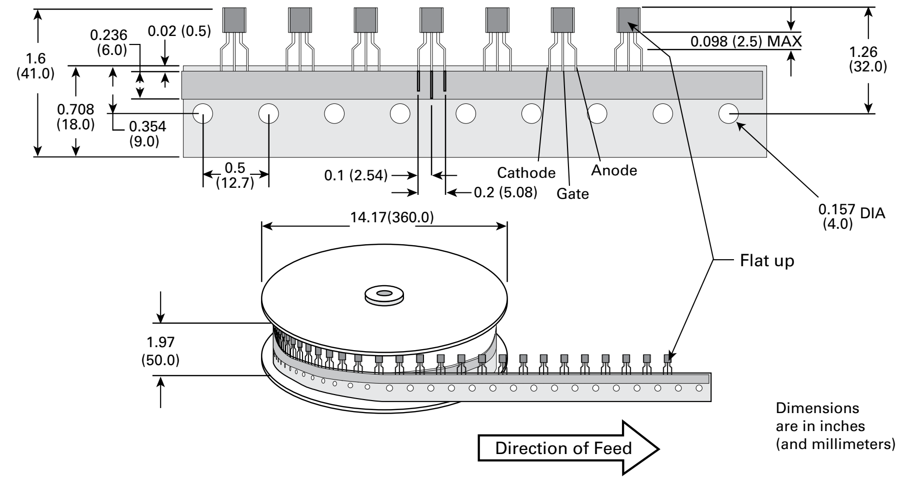
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
SxX8ESy	SxX8ESy	0.170g	Bulk	2500
SxX8ESyAP	SxX8ESy	0.170g	Ammo Pack	2000
SxX8ESyRP	SxX8ESy	0.170g	Tape & Reel	2000
SxX8TSyRP	SxX8TSy	0.120g	Tape & Reel	1000
SxX8BSRP	xX8	0.053g	Tape & Reel	1000
SxX8BSRP1	xX8	0.053g	Tape & Reel	1000

Note: x = voltage, y = gate sensitivity

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

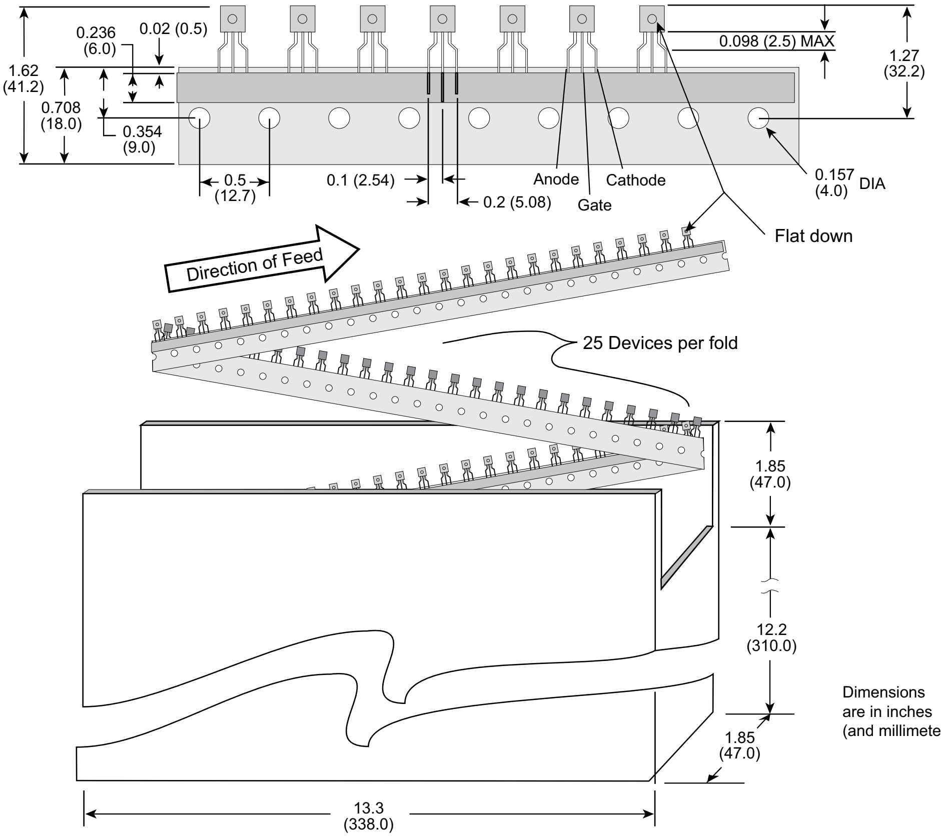
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

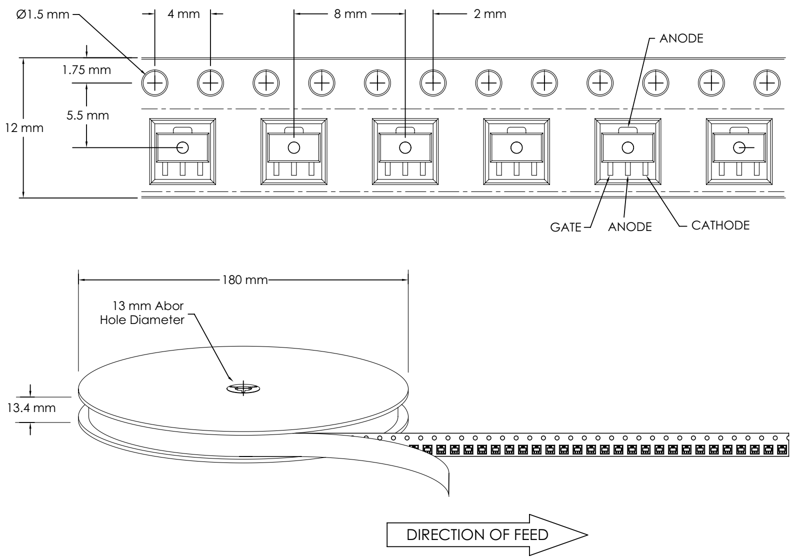
TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards

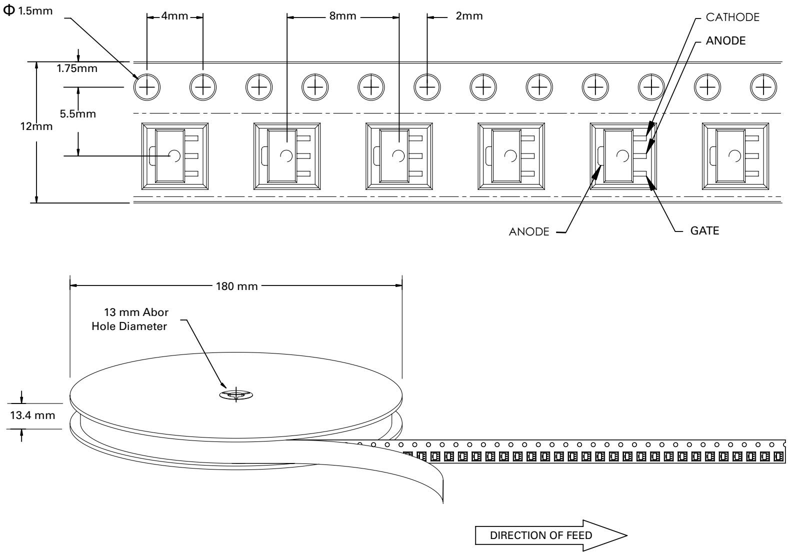


Dimensions
are in inches
(and millimeters).

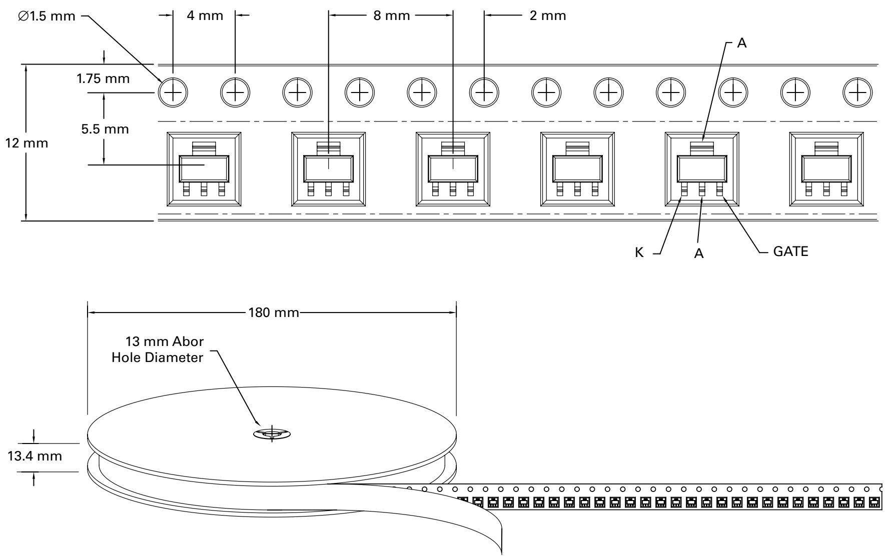
SOT-89 Reel Pack (RP) Specifications



SOT-89 Reel Pack (RP1) Specifications



SOT-223 Reel Pack (RP) Specifications



Part Numbering System

S x X8 x xx xx

SERIES
S: SCR

VOLTAGE
4: 400V
6: 600V
8: 800V

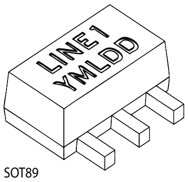
CURRENT
X8: 0.8A

PACKING TYPE
Blank: Bulk Pack
RP: Reel Pack (TO-92)
Embossed Carrier Pack (SOT-223)
Embossed Carrier Pack (SOT-89)
RP1: Embossed Carrier Pack (SOT-89)
(alternate orientation)
AP: Ammo Pack (TO-92)

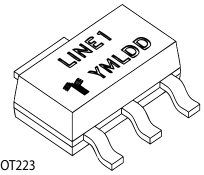
SENSITIVITY & TYPE
S1: 5μA Sensitive SCR
S2: 50μA Sensitive SCR
S: 200μA Sensitive SCR

PACKAGE TYPE
E: TO-92
T: SOT-223
B: SOT-89

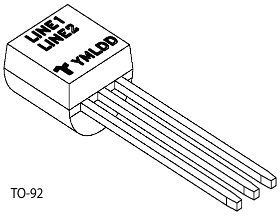
Part Marking System



SOT89



SOT223



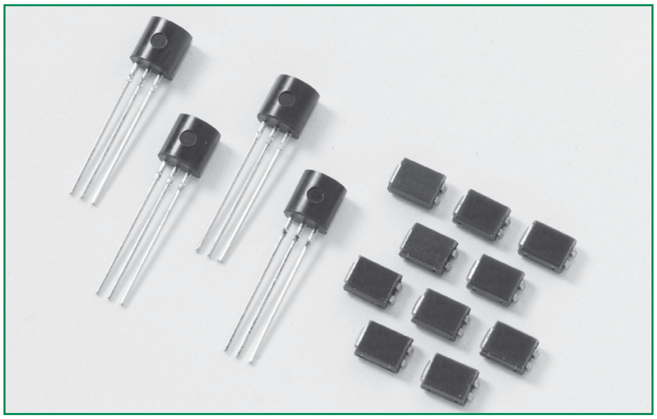
TO-92

Line1 = Littelfuse Part Number
Line2 = continuation…Littelfuse Part Number
Y = Last Digit of Calendar Year
M = Letter Month Code (A-L for Jan-Dec)
L = Location Code
DD = Calendar Date

Revised: 12/14/14

Sx01E & SxN1 Series

RoHS



Description

Excellent for lower current heat, lamp, and audible alarm controls for home goods.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 30 A

Applications

Typical applications are AC solid-state switches, fluidlevel sensors, strobes, and capacitive-discharge ignition systems.

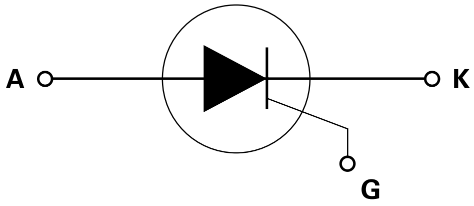
Additional Information

Datasheet | **Resources** | **Samples**

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	1	A
V_{DRM}/V_{RRM}	400 to 600	V
I_{GT}	10	mA

Schematic Symbol



Absolute Maximum Ratings — Standard SCRs

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 90°C	1	A
$I_{T(AV)}$	Average on-state current	T_C = 90°C	0.64	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	25	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	30	
I^2t	I_2t Value for fusing	t_p = 8.3 ms	3.7	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C	50	A/μs
I_{GM}	Peak gate current	T_J = 125°C	1.5	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C	0.3	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 125	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions		Value	Unit
I_{GT}	V_D = 12V; R_L = 60 Ω	MAX.	10	mA
		MIN.	1	
V_{GT}		MAX.	1.5	V
dv/dt	V_D = V_{DRM}; gate open; T_J = 100°C	MIN.	20	V/μs
	V_D = V_{DRM}; gate open; T_J = 125°C		40	
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ; T_J = 125°C	MIN.	0.2	V
I_H	I_T = 200mA (initial)	MAX.	30	mA
t_q	(1)	MAX.	35	μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 2A	TYP.	2	μs

(1) I_T=1A; t_p=50μs; dv/dt=20V/μs; di/dt=-10A/μs

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	I_T = 2A; t_p = 380 μs		MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} = V_{RRM}	T_J = 25°C	MAX.	10	μA
		T_J = 100°C		200	
		T_J = 125°C		500	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	Sx01E	50	°C/W
		SxN1	35*	
$R_{\theta(J\text{-}A)}$	Junction to ambient	Sx01E	145	°C/W

Notes : x = voltage
* = Mounted on 1 cm² copper (two-ounce) foil surface

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

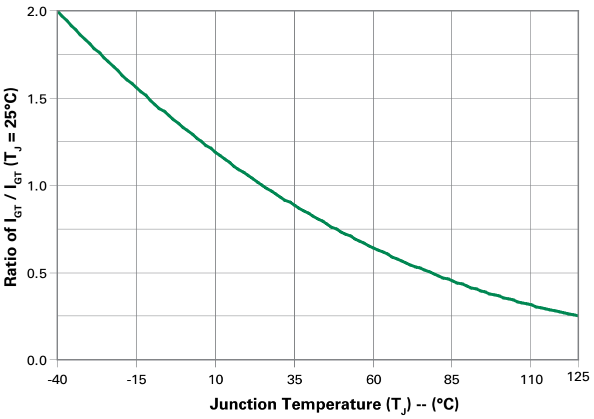


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

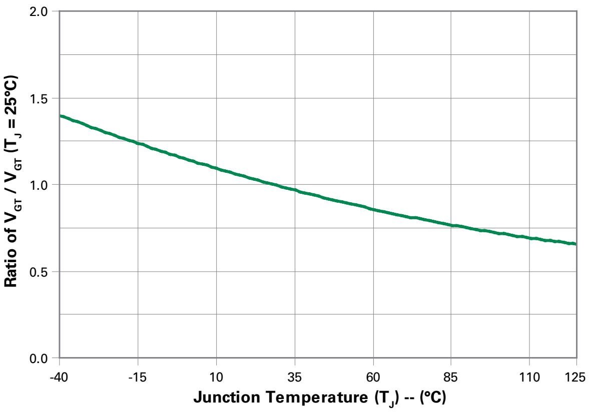


Figure 3: Normalized DC Holding Current vs. Junction Temperature

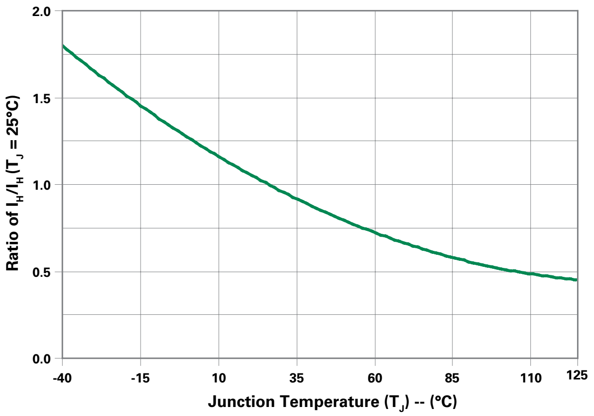


Figure 4: On-State Current vs. On-State Voltage (Typical)

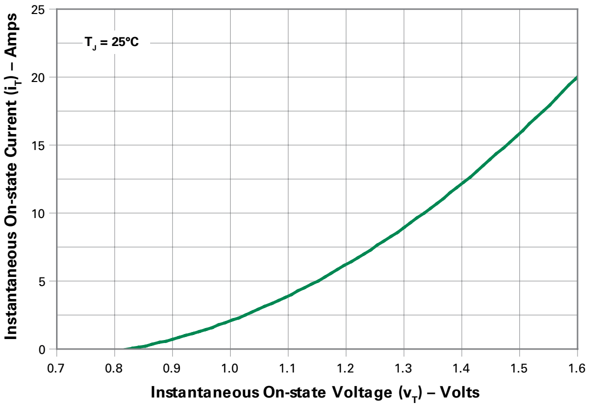


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

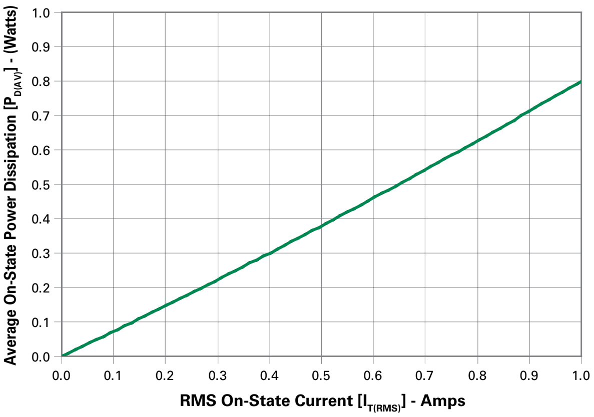


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

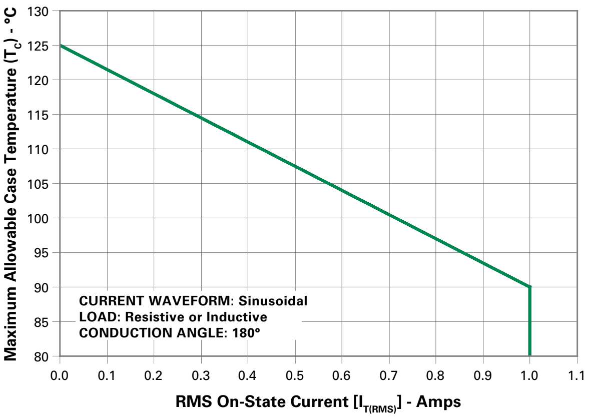


Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

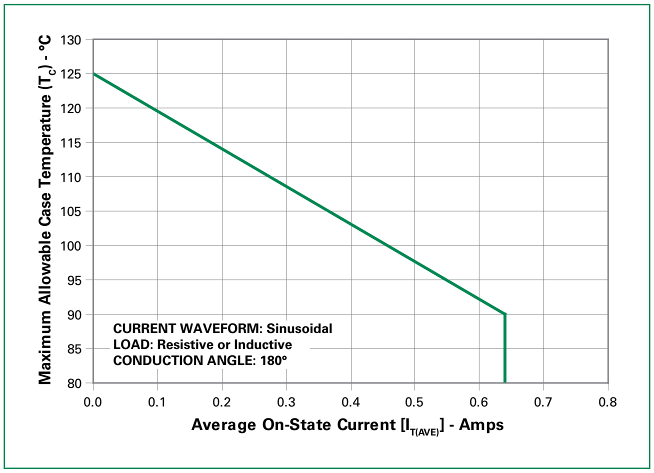


Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current

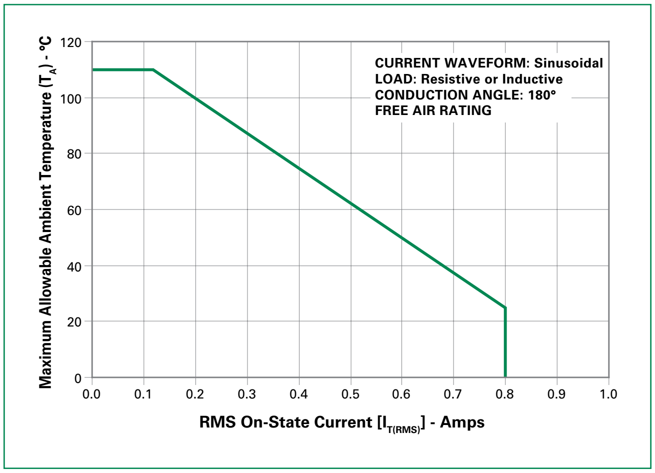


Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current

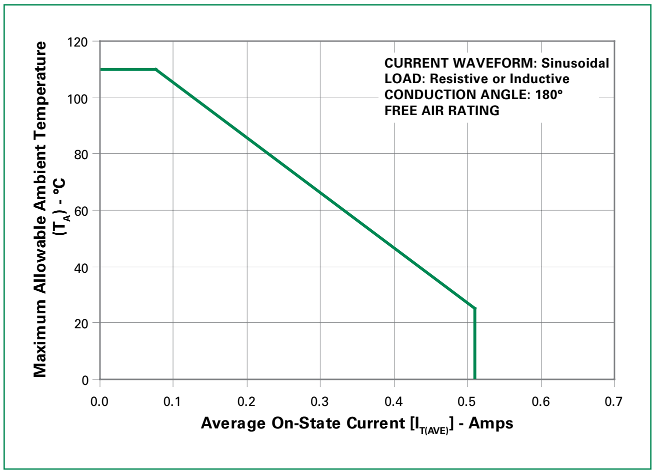


Figure 10: Peak Capacitor Discharge Current

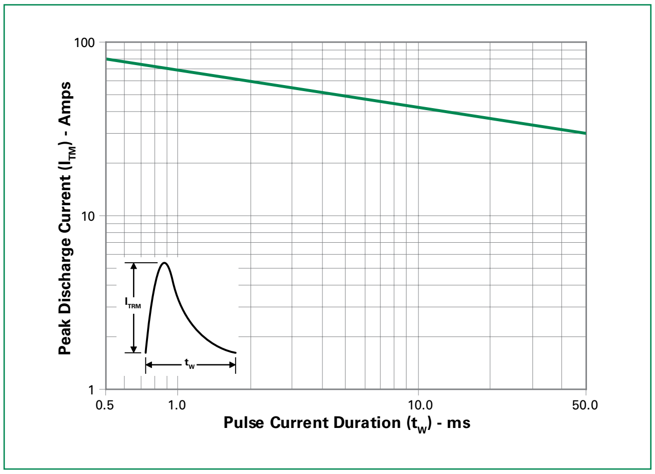


Figure 11: Peak Capacitor Discharge Current Derating

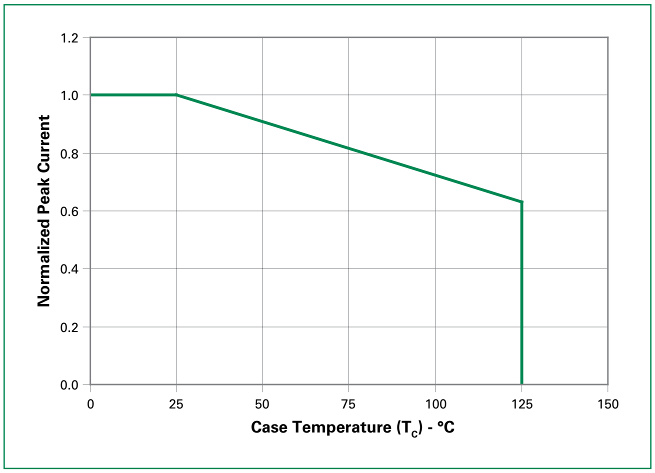
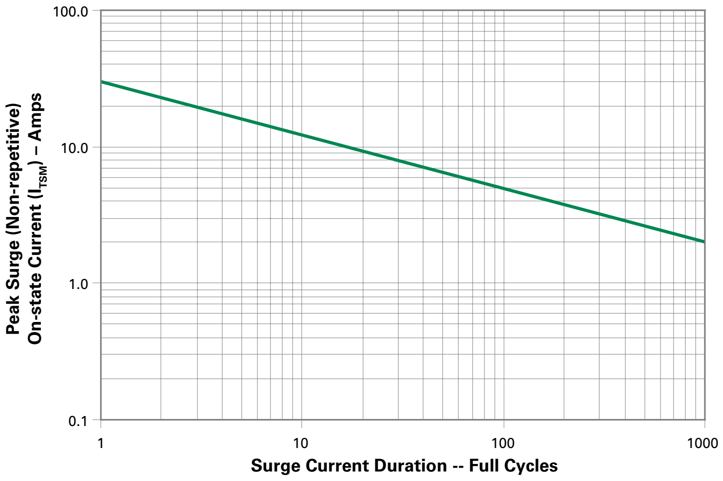


Figure 12: Surge Peak On-State Current vs. Number of Cycles



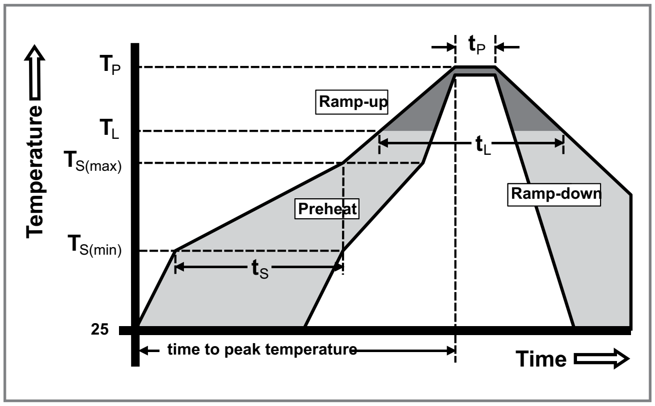
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

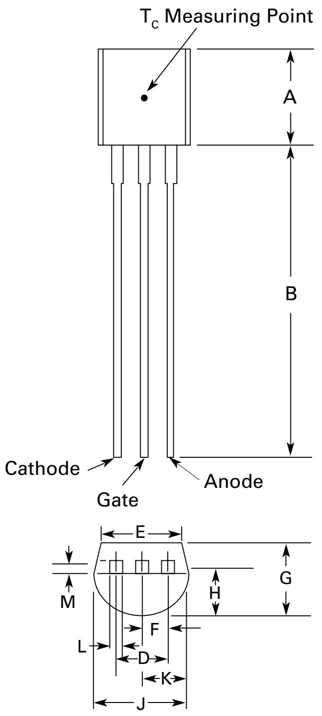
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

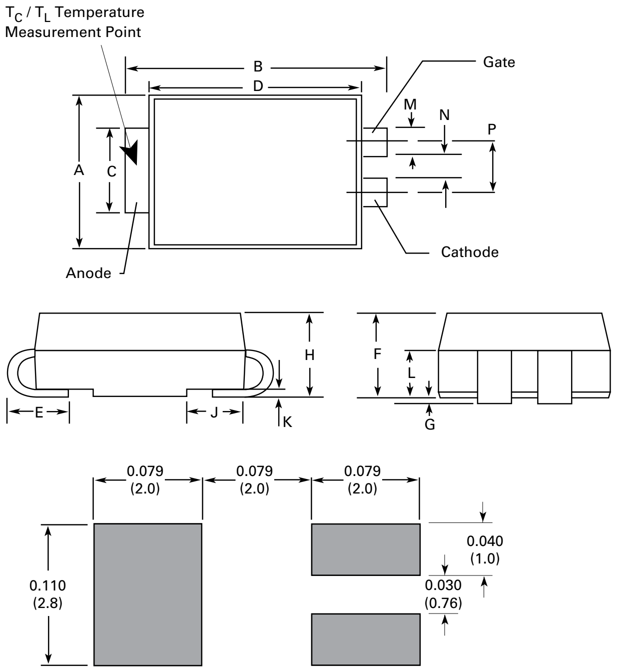
Dimensions – TO-92 (E Package)



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500		12.70	
D	0.095	0.105	2.41	2.67
E	0.150		3.81	
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43

All leads insulated from case. Case is electrically nonconductive.

Dimensions - Compak (C Package)



Dimensions are in inches (and millimeters).

Pad Outline

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
J	0.043	0.053	1.09	1.35
K	0.006	0.016	0.15	0.41
L	0.030	0.055	0.76	1.40
M	0.022	0.028	0.56	0.71
N	0.027	0.033	0.69	0.84
P	0.052	0.058	1.32	1.47

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sx01E	X	X			10mA	Standard SCR	TO-92
SxN1	X	X			10mA	Standard SCR	Compak

Note: x = Voltage

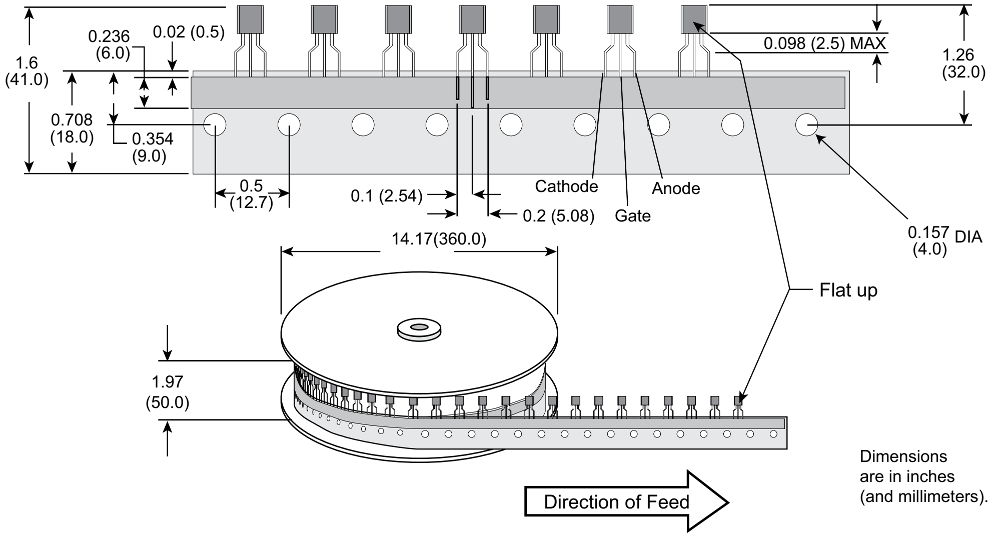
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sx01E	Sx01E	0.19 g	Bulk	2000
Sx01ERP	Sx01E	0.19 g	Reel Pack	2000
Sx01EAP	Sx01E	0.19 g	Ammo Pack	2000
SxN1RP	SxN1	0.08 g	Embossed Carrier	2500

Note: x = Voltage

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

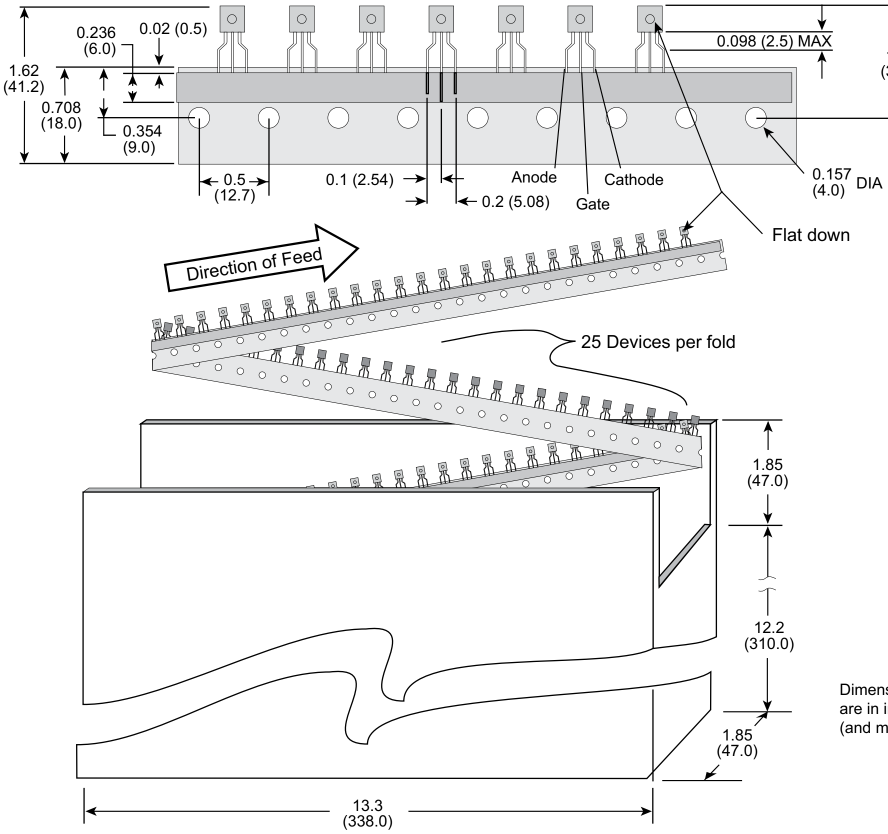
Meets all EIA-468-C Standards



Dimensions are in inches (and millimeters).

TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards

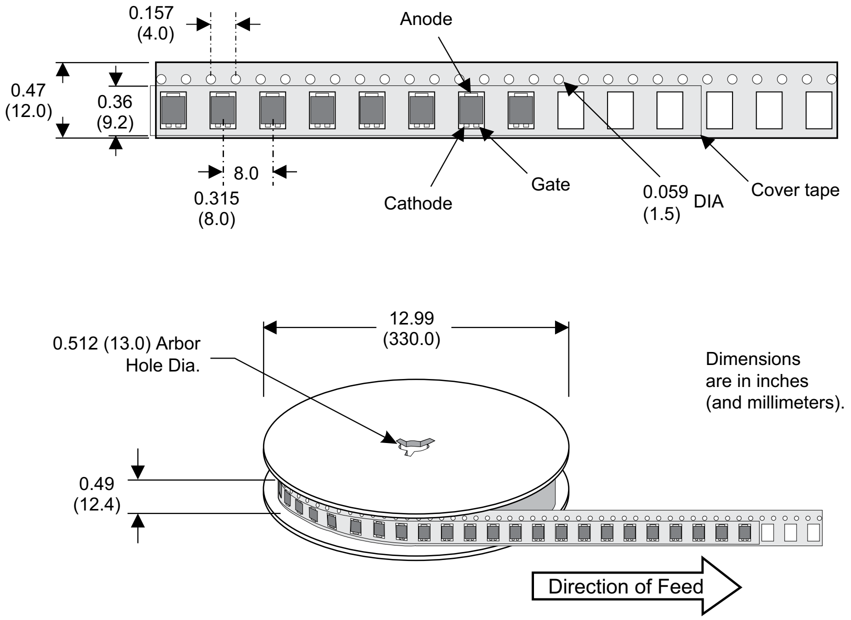


Dimensions are in inches (and millimeters).

Revised: 12/14/14

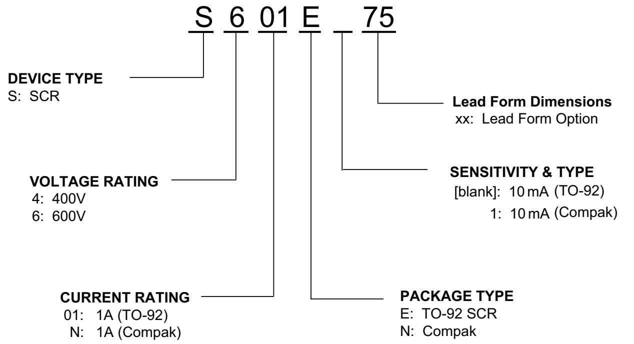
Compak Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-1 Standards

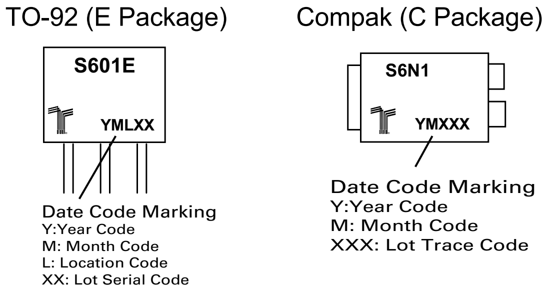


Dimensions are in inches (and millimeters).

Part Numbering System

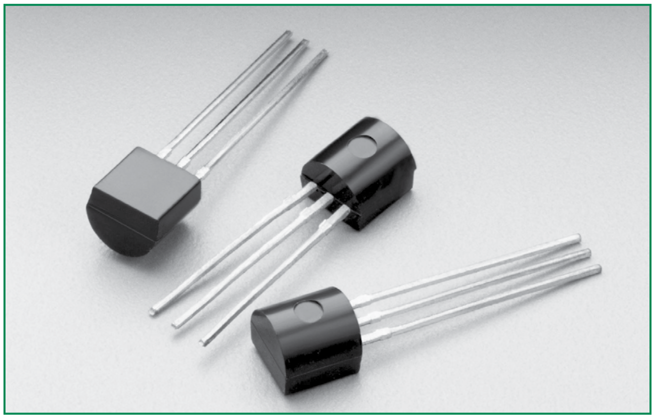


Part Marking System



TCR22-x Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Sensitive gate SCRs are easily triggered with microAmps of current as furnished by sense coils, proximity switches, and microprocessors.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 20 A

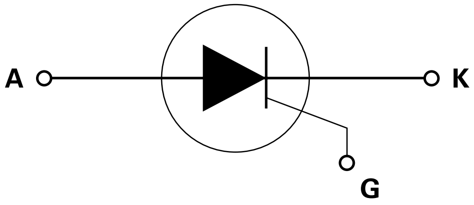
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	1.5	A
V_{DRM}/V_{RRM}	400 to 600	V
I_{GT}	200	µA

Applications

Typical applications are capacitive discharge systems for strobe lights and gas engine ignition. Also controls for power tools, home/brown goods and white goods appliances.

Schematic Symbol



Additional Information

Datasheet

Resources

Samples

Absolute Maximum Ratings — Sensitive SCRs

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 40°C	1.5	A
$I_{T(AV)}$	Average on-state current	T_C = 40°C	0.95	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	16	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	20	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	1.6	A^2s
di/dt	Critical rate of rise of on-state current	f = 60 Hz ; T_J = 110°C	50	A/µs
I_{GM}	Peak gate current	T_J = 110°C	1	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 110°C	0.1	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 110	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value	Unit
I_{GT}	V_D = 6V; R_L = 100 Ω		MAX.	200	µA
V_{GT}			MAX.	0.8	V
dv/dt	$V_D = V_{DRM}$; R_{GK} = 1kΩ	400V	MIN.	40	V/µs
		600V		30	
V_{GD}	$V_D = V_{DRM}$; R_L = 3.3 kΩ; T_J = 110°C		MIN.	0.25	V
V_{GRM}	I_{GR} = 10µA		MIN.	6	V
I_H	I_T = 200mA (initial)		MAX.	5	mA
t_q	(1)		MAX.	50	µs
t_{gt}	$I_G = 2 \times I_{GT}$; PW = 15µs; I_T = 3A		TYP.	20	µs

(1) I_T=1A; t_p=50µs; dv/dt=5V/µs; di/dt=-10A/µs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	I_T = 3A; t_p = 380 µs			MAX.	1.5	V
I_{DRM} / I_{RRM}	$V_{DRM} = V_{RRM}$	T_J = 25°C	400V	MAX.	1	µA
			600V		2	
		T_J = 110°C			100	

Thermal Resistances

Symbol	Parameter	Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	50	°C/W
$R_{\theta(J\text{-}A)}$	Junction to ambient	160	°C/W

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

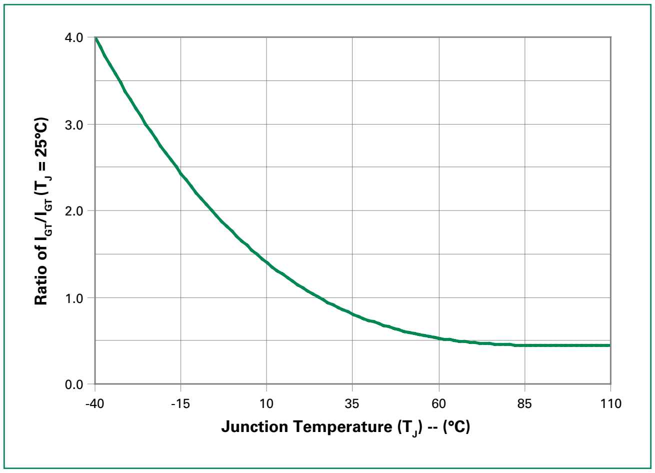


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

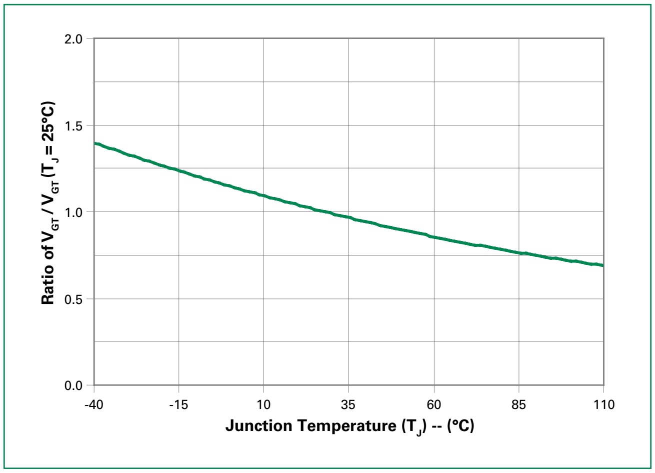


Figure 3: Normalized DC Holding Current vs. Junction Temperature

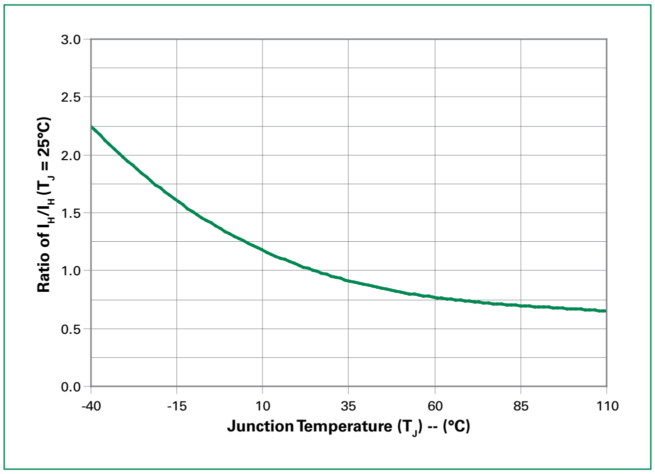


Figure 4: Normalized DC Latching Current vs. Junction Temperature

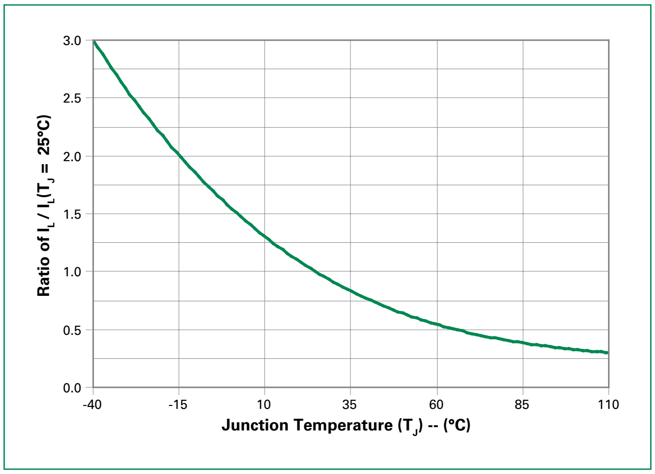


Figure 5: On-State Current vs. On-State Voltage (Typical)

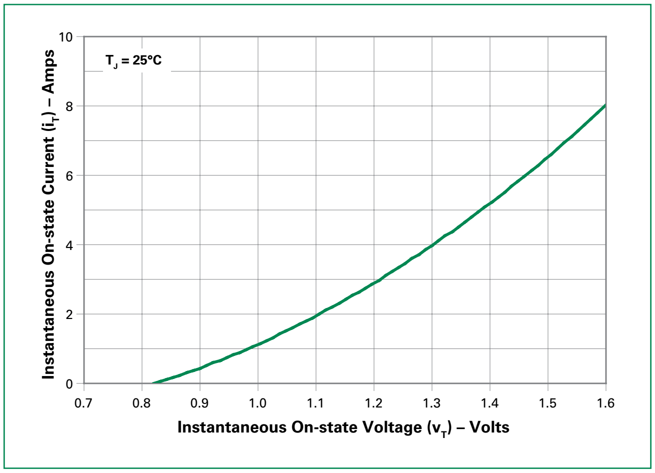


Figure 6: Power Dissipation (Typical) vs. RMS On-State Current

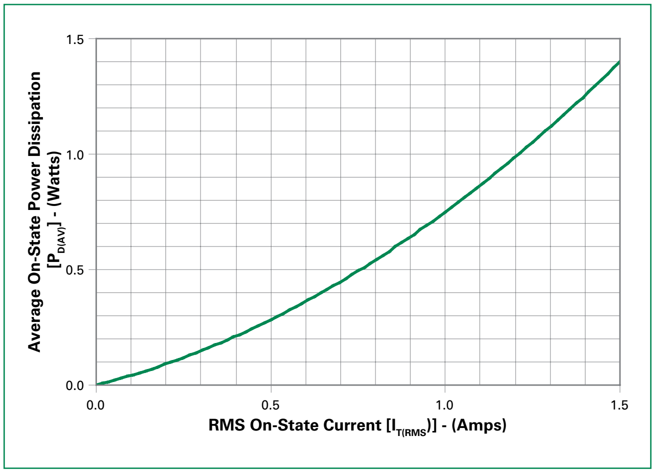


Figure 7: Maximum Allowable Case Temperature vs. RMS On-State Current

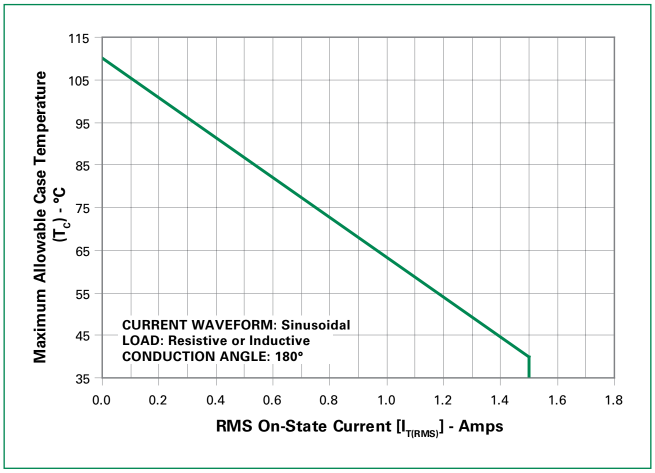


Figure 8: Maximum Allowable Case Temperature vs. Average On-State Current

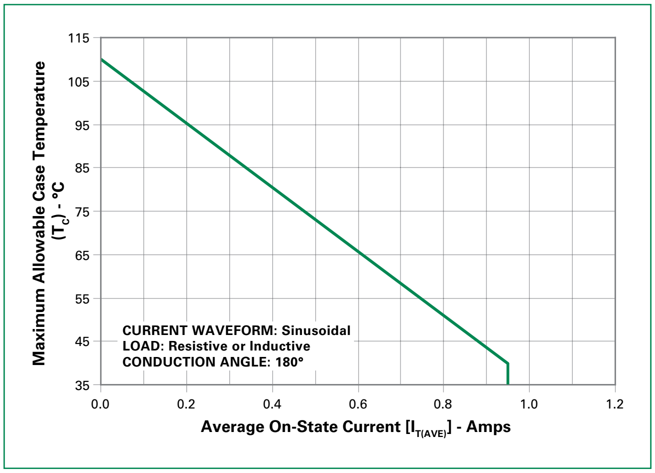


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

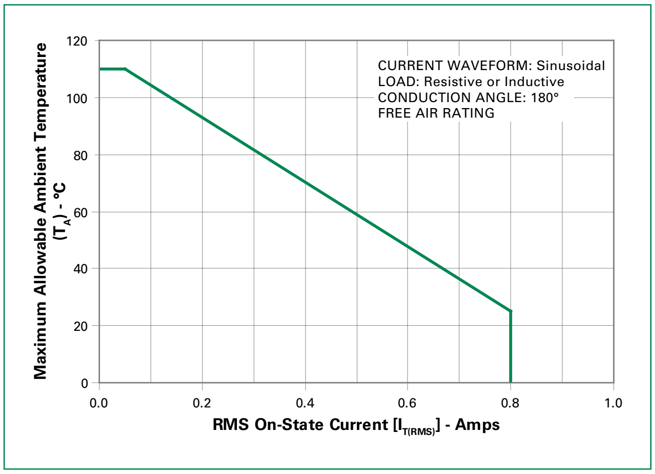


Figure 10: Maximum Allowable Ambient Temperature vs. Average On-State Current

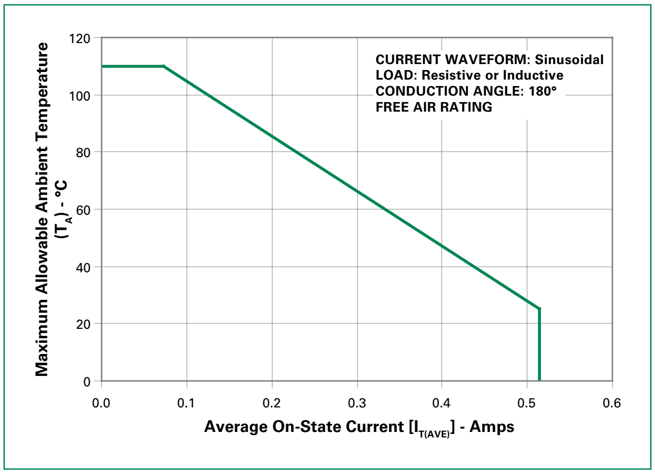


Figure 11: Peak Repetitive Capacitor Discharge Current

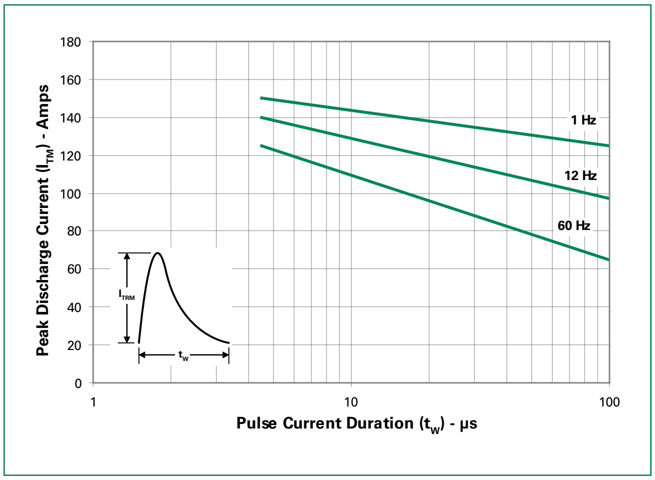


Figure 12: Peak Repetitive Sinusoidal Pulse Current

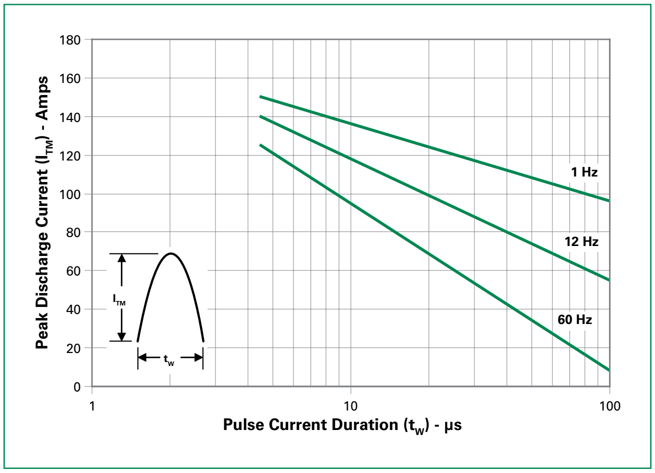
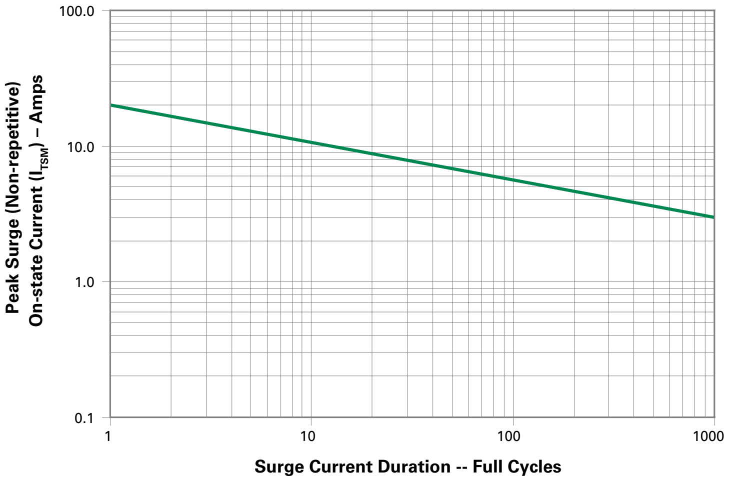


Figure 13: Surge Peak On-State Current vs. Number of Cycles

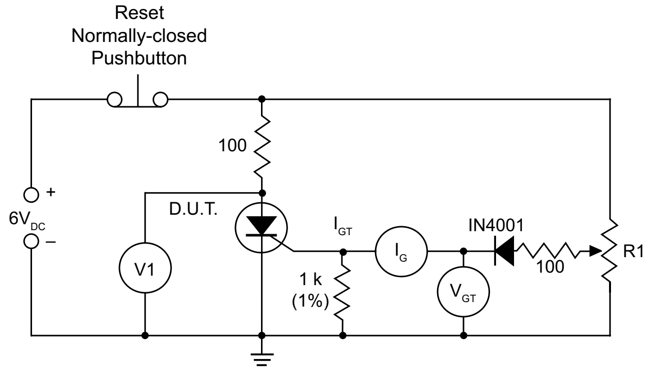


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 14: Simple Test Circuit for Gate Trigger Voltage and Current



Note: V1 — 0 V to 10 V dc meter
V_{GT} — 0 V to 1 V dc meter
I_G — 0 mA to 1 mA dc milliammeter
R1 — 1 k potentiometer

To measure gate trigger voltage and current, raise gate voltage (V_{GT}) until meter reading V1 drops from 6 V to 1 V. Gate trigger voltage is the reading on V_{GT} just prior to V1 dropping. Gate trigger current I_{GT} Can be computed from the relationship

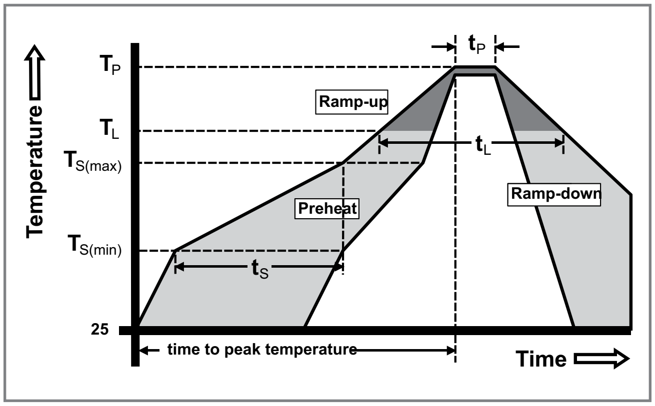
$$I_{GT} = I_G - \frac{V_{GT}}{1000} \text{ Amps}$$

where I_G is reading (in amperes) on meter just prior to V1 dropping

Note: I_{GT} may turn out to be a negative quantity (trigger current flows out from gate lead). If negative current occurs, I_{GT} value is not a valid reading. Remove 1 k resistor and use I_G as the more correct I_{GT} value. This will occur on 12 µA gate products.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matt Tin-plated/Pb-free Solder Dipped
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

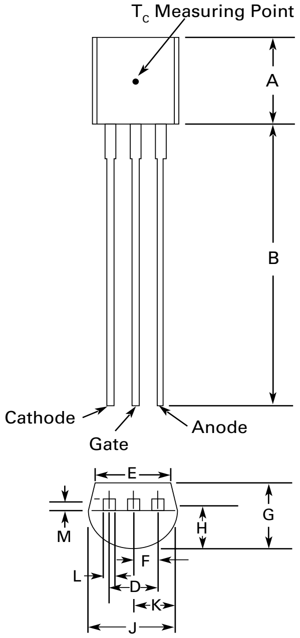
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 110°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Dimensions – TO-92 (E Package)



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500		12.70	
D	0.095	0.105	2.41	2.67
E	0.150		3.81	
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43

All leads insulated from case. Case is electrically nonconductive.

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
TCR22-6	X				200μA	Sensitive SCR	TO-92
TCR22-8		X			200μA	Sensitive SCR	TO-92

Note: x = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
TCR22-x	TCR22-x	0.19 g	Bulk	2000
TCR22-xRP	TCR22-x	0.19 g	Reel Pack	2000
TCR22-xAP	TCR22-x	0.19 g	Ammo Pack	2000

Note: x = Voltage

Part Numbering System

TCR 22 – 8 75

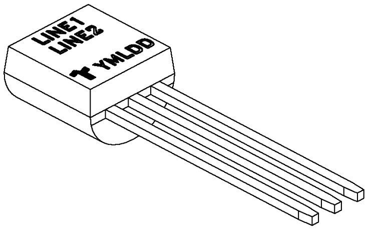
DEVICE TYPE
TCR: SCR

CURRENT RATING
22: 1.5A

VOLTAGE RATING
6: 400V
8: 600V

LEAD FORM DIMENSIONS
xx: Lead Form Option

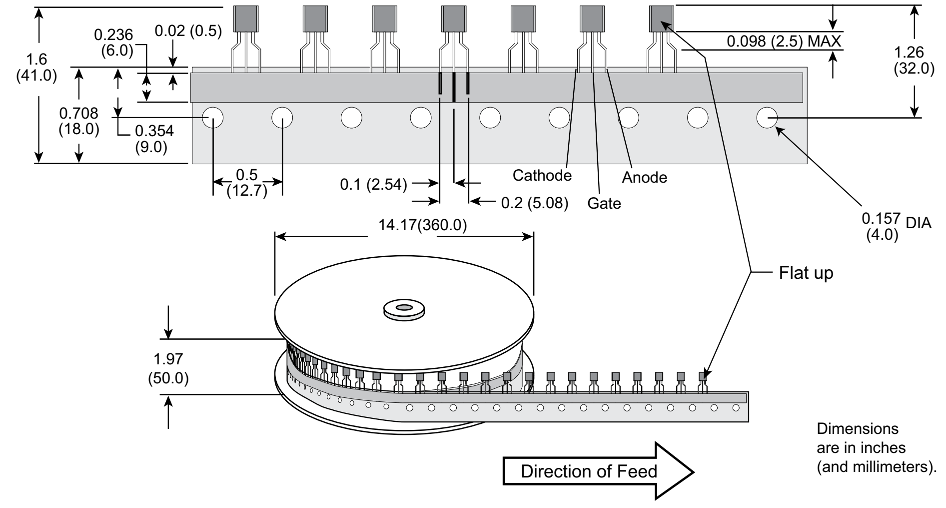
Part Marking System



Line1 = Littelfuse Part Number
Line2 = continuation…Littelfuse Part Number
Y = Last Digit of Calendar Year
M = Letter Month Code (A-L for Jan-Dec)
L = Location Code
DD = Calendar Date

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

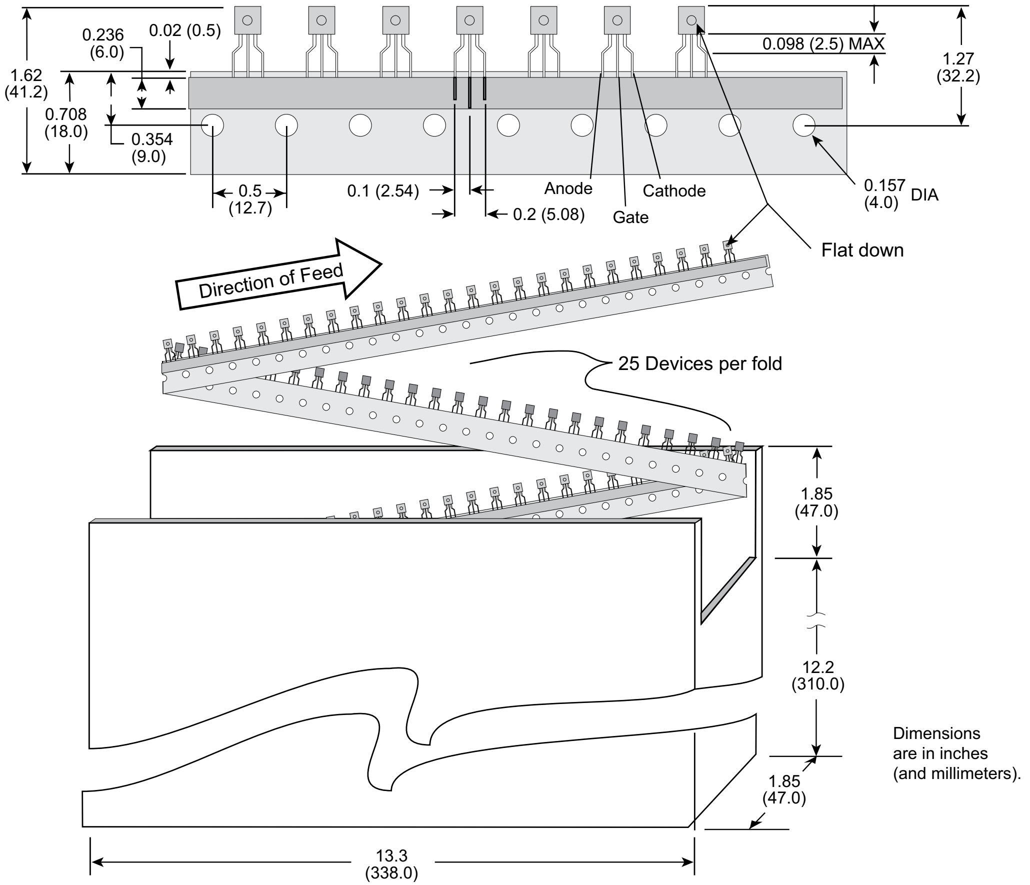
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

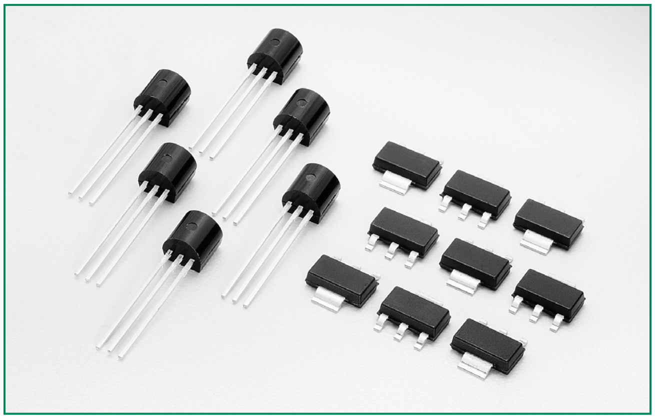
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

Sx02xS Series

RoHS



Description

New 1.5 Amp sensitive gate SCR series offers high static dv/dt with low turn off time (tq) through small die planar construction design. All SCR's junctions are glass-passivated to ensure long term reliability and parametric stability.

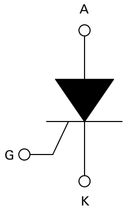
Features

- RoHS compliant and Halogen-Free
- Thru hole and surface mount packages
- Surge capability > 15Amps
- Blocking voltage (V_{DRM} / V_{RRM}) capability — up to 600V
- High dv/dt noise immunity
- Improved turn-off time (tq) < 35 μsec.
- Sensitive gate for direct microprocessor interface

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	1.5	A
V_{DRM} / V_{RRM}	400 to 600	V
I_{GT}	200	μA

Schematic Symbol



Applications

The Sx02xS EV series is specifically designed for Gas Ignition applications that require high pulse surge current capability.

Absolute Maximum Ratings

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current (full sine wave)	TO-92	T_C = 65°C	1.5	A
		SOT-223	T_L = 95°C		
$I_{T(AV)}$	Average on-state current	TO-92	T_C = 65°C	0.95	A
		SOT-223	T_C = 95°C		
I_{TSM}	Non repetitive surge peak on-state current (Single cycle, T_J initial = 25°C)	TO-92 SOT-223	F = 50 Hz	12.5	A
			F = 60 Hz	15.0	
I^2t	I^2t Value for fusing	t_p = 10 ms	F = 50 Hz	0.78	A^2s
		t_p = 8.3 ms	F = 60 Hz	0.93	
di/dt	Critical rate of rise of on-state current IG = 10mA	TO-92 SOT-223	T_J = 125°C	50	A/μs
I_{GM}	Peak gate current	t_p = 10 μs	T_J = 125°C	1.0	A
$P_{G(AV)}$	Average gate power dissipation		T_J = 125°C	0.1	W
T_{stg}	Storage junction temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Revised: 12/14/14

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Sx02xS		Unit
			Min	Max	
I_{GT}	DC Gate Trigger Current	V_D = 12V R_L = 60 Ω	15	200	µA
V_{GT}	DC Gate Trigger Voltage		—	0.8	V
V_{GRM}	Peak Reverse Gate Voltage	I_{RG} = 10µA	5	—	V
I_H	Holding Current	R_{GK} = 1 kΩ	—	5	mA
(dv/dt)s	Critical Rate-of-Rise of Off-State Voltage	T_J = 125°C V_D = V_{DRM} / V_{RRM} Exponential Waveform R_{GK} = 1 kΩ	25	—	V/µs
t_q	Turn-Off Time	T_J = 125°C @ 600 V R_{GK} = 1 kΩ	—	35	µs
t_{gt}	Turn-On Time	I_G = 10mA PW = 15µsec I_T = 3.0A (pk)	—	3	µs

Static Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Description	Test Conditions	Value		Unit
			Min	Max	
V_{TM}	Peak On-State Voltage	I_{TM} = 3.0A (pk)	—	1.70	V
I_{DRM}	Off-State Current, Peak Repetitive	T_J = 25°C @ V_D= V_{DRM} R_{GK} = 1 kΩ	—	5	µA
		T_J = 125°C @ V_D= V_{DRM} R_{GK} = 1 kΩ	—	500	µA

Thermal Resistances

Symbol	Parameter			Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	$_T$ = 1.5A $_{(RMS)}$ [1]	TO-92	50	°C/W
			SOT-223	25	
$R_{\theta(J-A)}$	Junction to ambient	I_T = 1.5A $_{(RMS)}$ [1]	TO-92	160	°C/W
			SOT-223	60	

[1] 60Hz AC resistive load condition, 100% conduction.

Additional Information

Datasheet	Resources	Samples

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

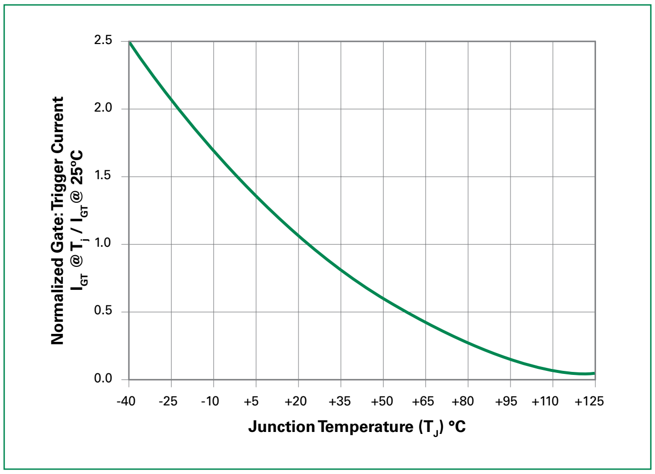


Figure 2: Normalized DC Holding Current vs. Junction Temperature

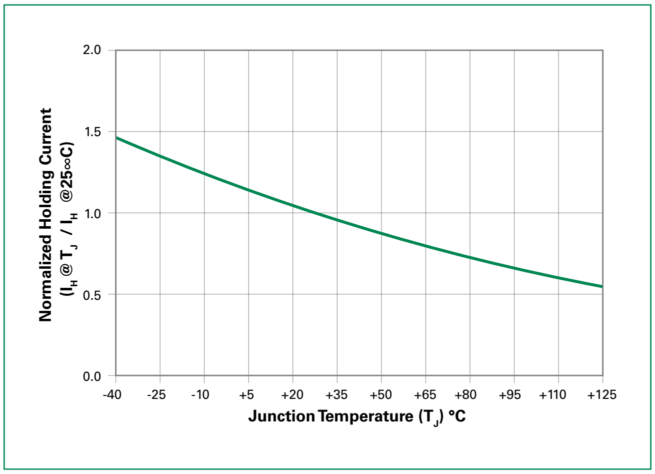


Figure 3: Normalized DC Gate Trigger Voltage vs. Junction Temperature

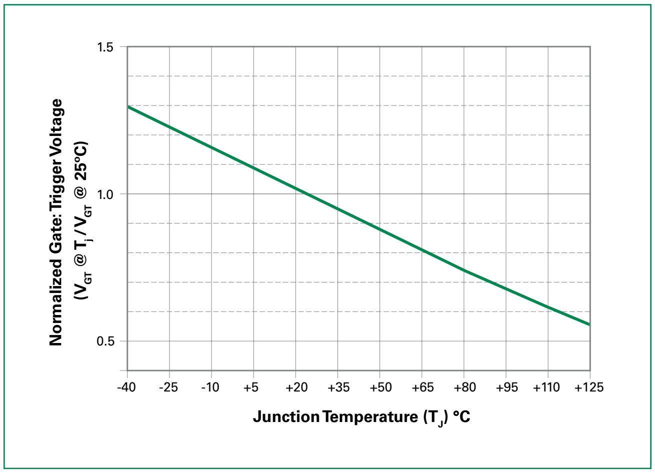


Figure 4: Power Dissipation (Typical) vs. RMS On-State Current

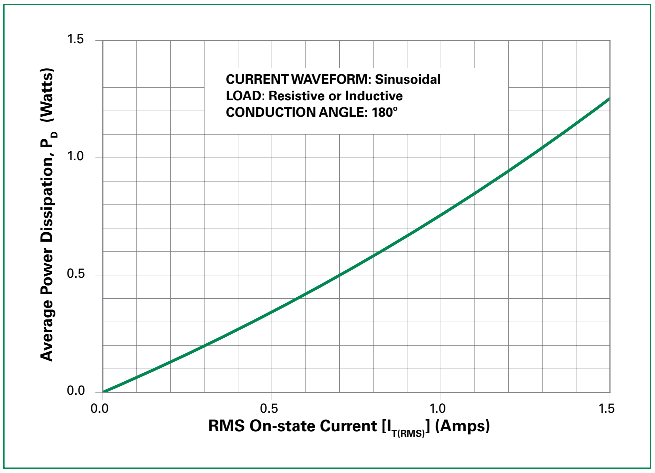


Figure 5: Maximum Allowable Case Temperature vs. On-State Current

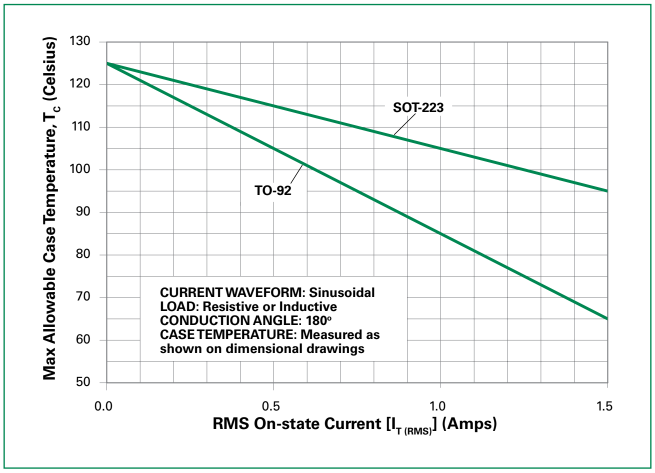
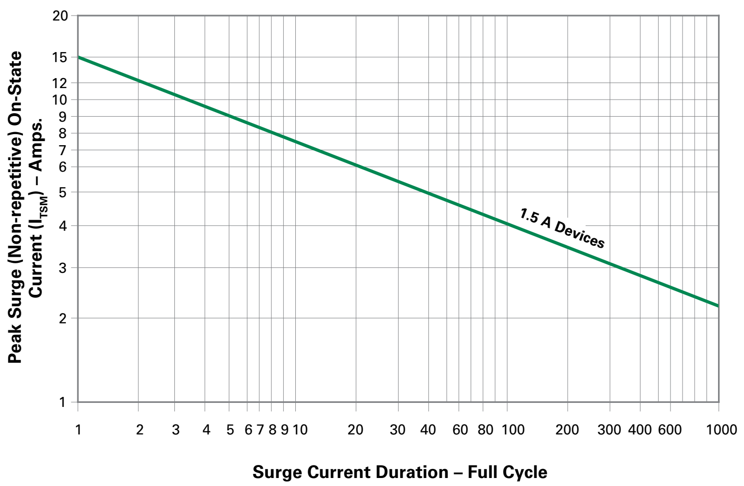


Figure 6: Surge Peak On-State Current vs. Number of Cycles

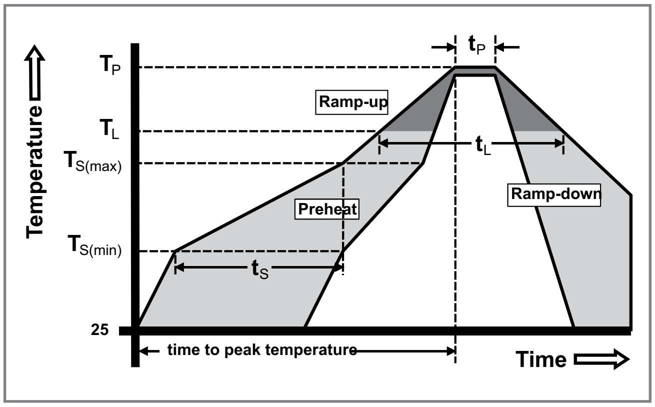


Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS On-State Current [$I_{T(RMS)}$]: Max Rated Value at Specific Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Time (min to max) (t_s)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.
Lead Material	Copper Alloy

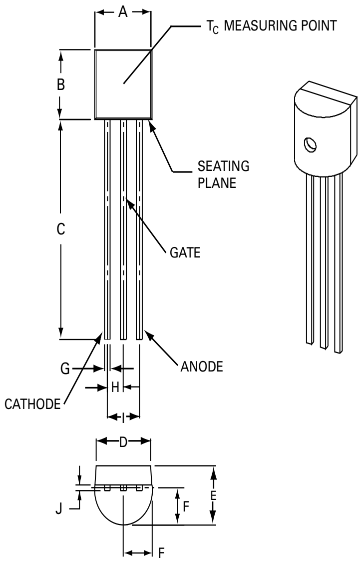
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

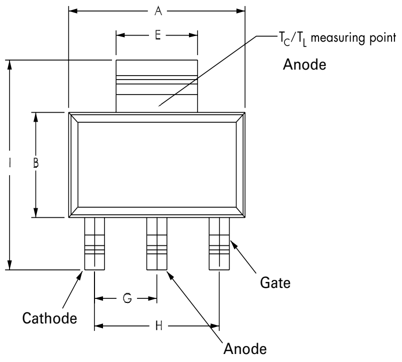
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

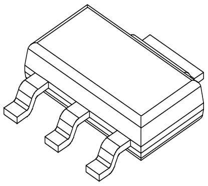
Dimensions — TO-92 (E Package)

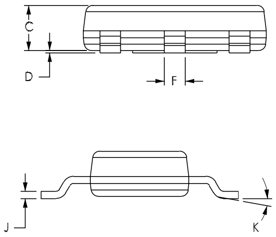


Dimensions	Inches		Millimeters	
	Min	Max	Min	Max
A	0.175	0.205	4.450	5.200
B	0.170	0.210	4.320	5.330
C	0.500	—	12.700	—
D	0.135	—	3.430	—
E	0.125	0.165	3.180	4.190
F	0.080	0.105	2.040	2.660
G	0.016	0.021	0.407	0.533
H	0.045	0.055	1.150	1.390
I	0.095	0.105	2.420	2.660
J	0.015	0.020	0.380	0.500

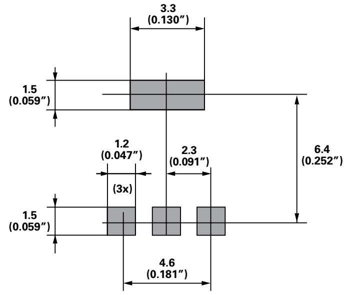
Dimensions – SOT-223







Pad Layout for SOT-223



Dimensions in Millimeters (Inches)

Dimensions	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.248	0.256	0.264	6.30	6.50	6.70
B	0.130	0.138	0.146	3.30	3.50	3.70
C	—	—	0.071	—	—	1.80
D	0.001	—	0.004	0.02	—	0.10
E	0.114	0.118	0.124	2.90	3.00	3.15
F	0.024	0.027	0.034	0.60	0.70	0.85
G	—	0.090	—	—	2.30	—
H	—	0.181	—	—	4.60	—
I	0.264	0.276	0.287	6.70	7.00	7.30
J	0.009	0.010	0.014	0.24	0.26	0.35
K	10° MAX					

Product Selector

Part Number	Voltage		Gate Sensitivity	Package
	400V	600V		
S402ES	X	—	200µA	TO-92
S602ES	—	X	200µA	TO-92
S402TS	X	—	200µA	SOT-223
S602TS	—	X	200µA	SOT-223

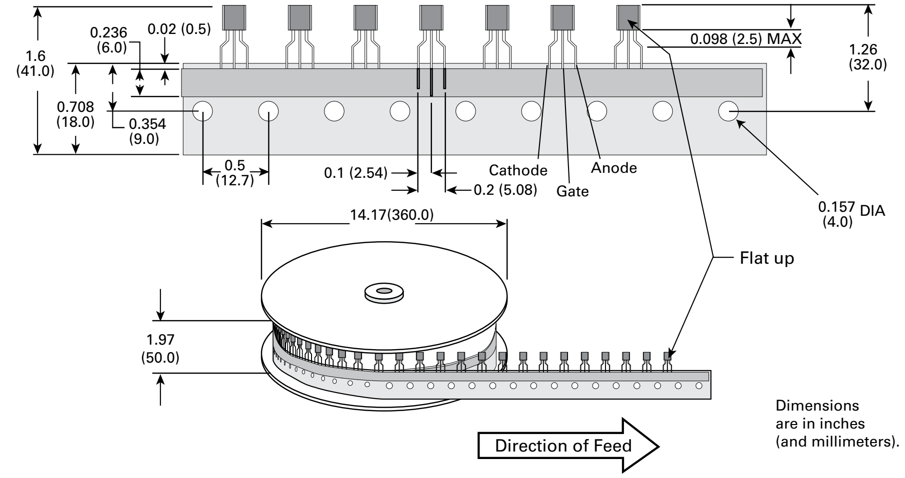
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sx02ES	Sx02ES	0.170 g	Bulk	2500
Sx02ESAP	Sx02ES	0.170 g	Ammo Pack	2000
Sx02ESRP	Sx02ES	0.170 g	Tape & Reel	2000
Sx02TSRP	Sx02TS	0.120 g	Tape & Reel	1000

Note: x = voltage

TO-92 (3-lead) Reel Pack (RP) Radial Leaded Specifications

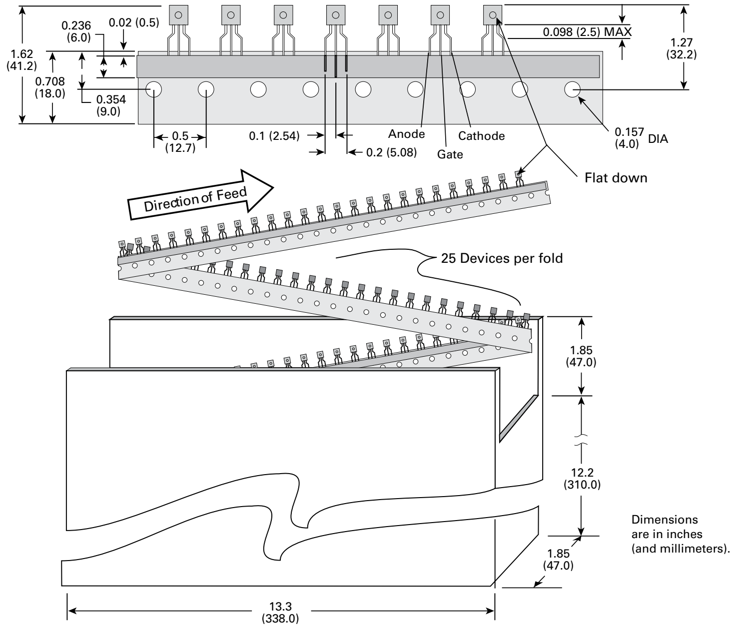
Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

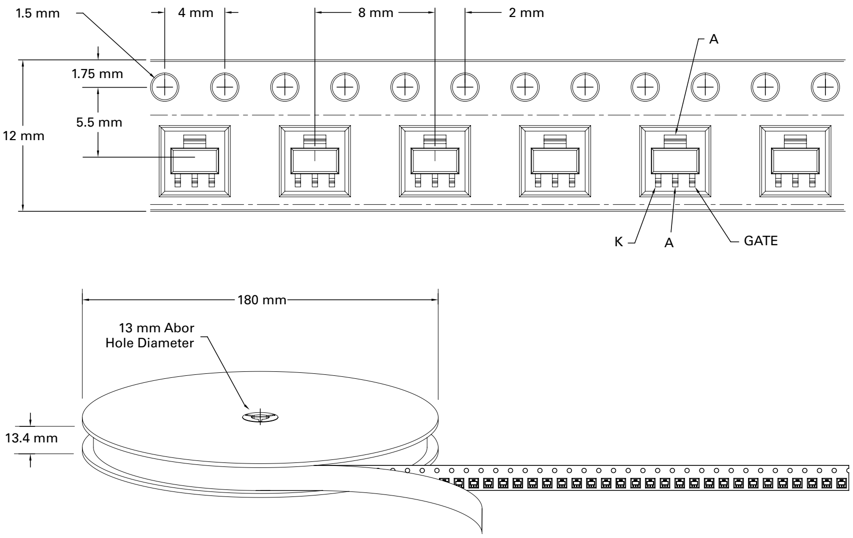
TO-92 (3-lead) Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards



Dimensions
are in inches
(and millimeters).

SOT-223 Reel Pack (RP) Specifications



Part Numbering System

Sx02xxxx

SCR SERIES

VOLTAGE
4: 400V
6: 600V

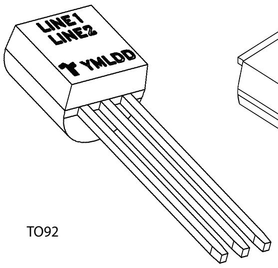
CURRENT
02: 1.5A

PACKAGE TYPE
E: TO-92
T: SOT-223

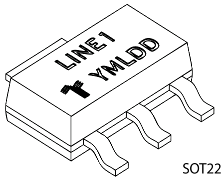
SENSITIVITY
S: 200µA Sensitive SCR

PACKING TYPE
Blank: Bulk
RP: Reel Pack (TO-92)
: Embossed Carrier Pack (SOT-223)
AP: Ammo Pack (TO-92)

Part Marking System



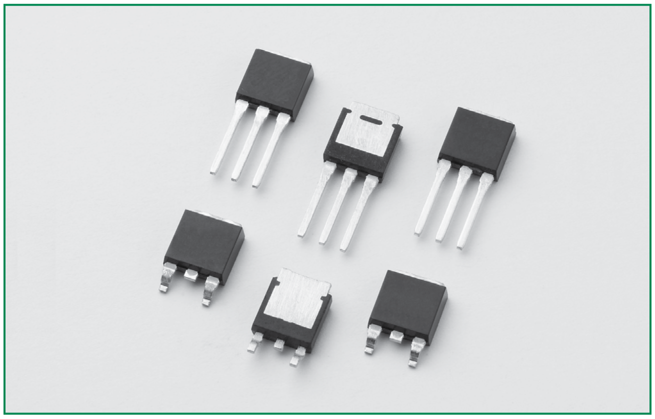
TO92



SOT223

Line1 = Littelfuse Part Number
Line2 = continuation…Littelfuse Part Number
Y = Last Digit of Calendar Year
M = Letter Month Code (A-L for Jan-Dec)
L = Location Code
DD = Calendar Date

Sxx04xSx Series



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Sensitive gate SCRs are easily triggered with microAmps of current as furnished by sense coils, proximity switches, and microprocessors.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 600 V
- Surge capability up to 30 A

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	4	A
V_{DRM}/V_{RRM}	400 to 600	V
I_{GT}	50 to 500	μA

Applications

Typical applications are capacitive discharge systems for strobe lights, nailers, staplers and gas engine ignition. Also controls for power tools, home/brown goods and white goods appliances.

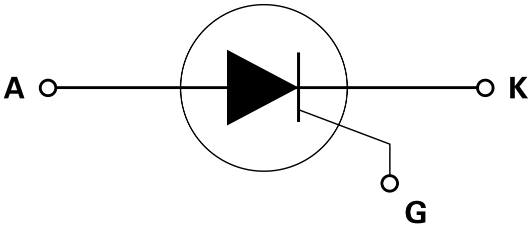
Additional Information

Datasheet

Resources

Samples

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	$T_C = 95°C$	4	A
$I_{T(AV)}$	Average on-state current	$T_C = 75°C$	2.5	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	25	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	30	
I^2t	I^2t Value for fusing	$t_p = 8.3$ ms	3.7	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; $T_J = 110°C$	50	A/μs
I_{GM}	Peak gate current	$T_J = 110°C$	1	A
$P_{G(AV)}$	Average gate power dissipation	$T_J = 110°C$	0.1	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 110	°C

Revised: 12/14/14

Electrical Characteristics — (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions		Value		Unit
			Sxx04xS1	Sxx04xS2	
I_{GT}	V_D = 6V; R_L = 100 Ω	MAX.	50	200	µA
V_{GT}		MAX.	0.8		V
dv/dt	V_D = V_{DRM}; R_{GK} = 1kΩ	TYP.	8		V/µs
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ; T_J = 110°C	MIN.	0.2		V
V_{GRM}	I_{GR} = 10µA	MIN.	6		V
I_H	I_T = 20mA (initial); R_{GK} = 1kohm	MAX.	4	6	mA
t_q	(1)	MAX.	50		µs
t_{gt}	I_G = 2 x I_{GT}; PW = 15µs; I_T = 8A	TYP.	3	4	µs

Notes :
xx = voltage, x = package
(1) I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-10A/µs

Static Characteristics

Symbol	Test Conditions			Value	Unit
V_{TM}	Sxx04xSy I_T = 8A; t_p = 380 µs		MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM} - R_{GK} = 1kohm	T_J = 25°C	MAX.	2	µA
		T_J = 110°C		100	

Note : xx or z = voltage, x = package, y = sensitivity

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Sxx04VSy	3.8	°C/W
		Sxx04DSy	3.0	
$R_{\theta(J-A)}$	Junction to ambient	Sxx04VSy	85	°C/W

Notes: xx = voltage, y = sensitivity

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

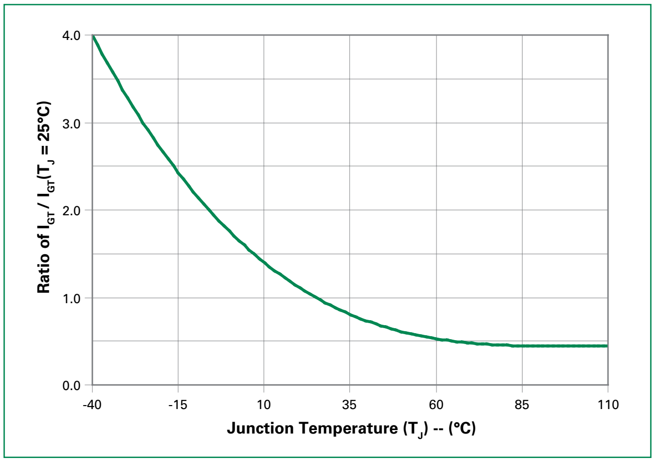


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

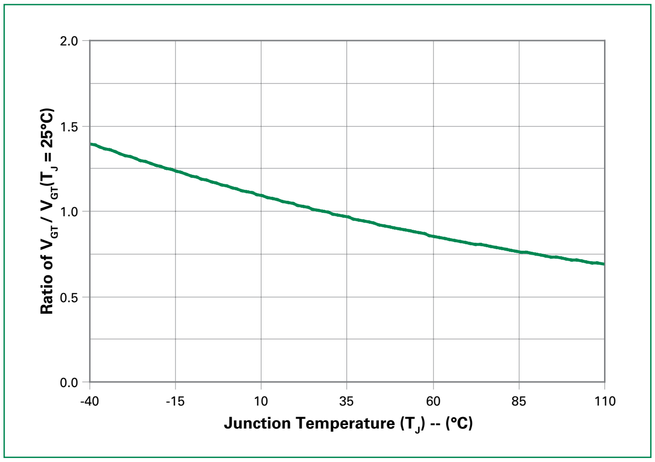


Figure 3: Normalized DC Holding Current vs. Junction Temperature

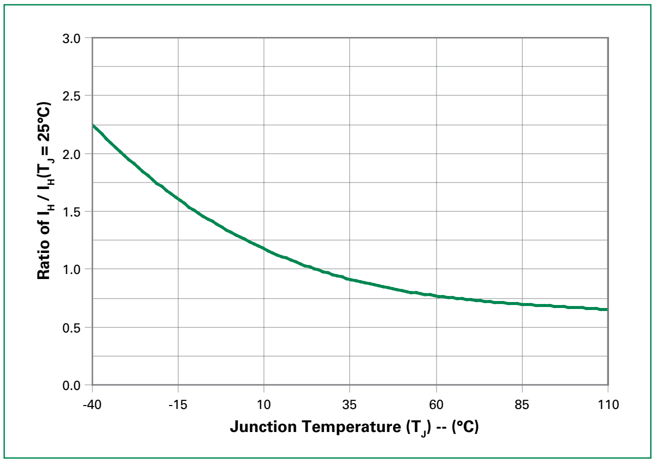


Figure 4: Normalized DC Latching Current vs. Junction Temperature

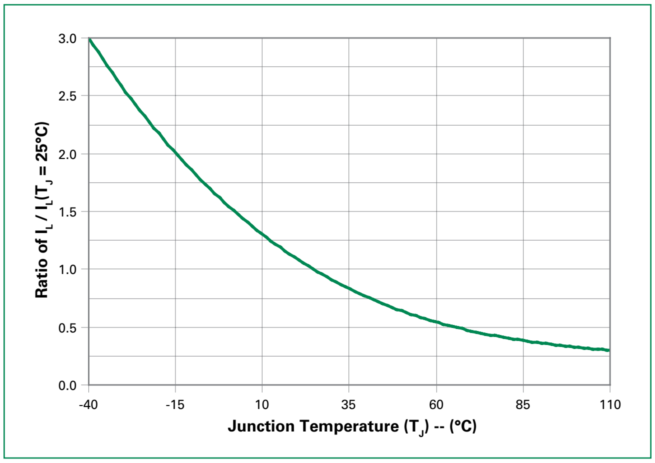


Figure 5: On-State Current vs. On-State Voltage (Typical)

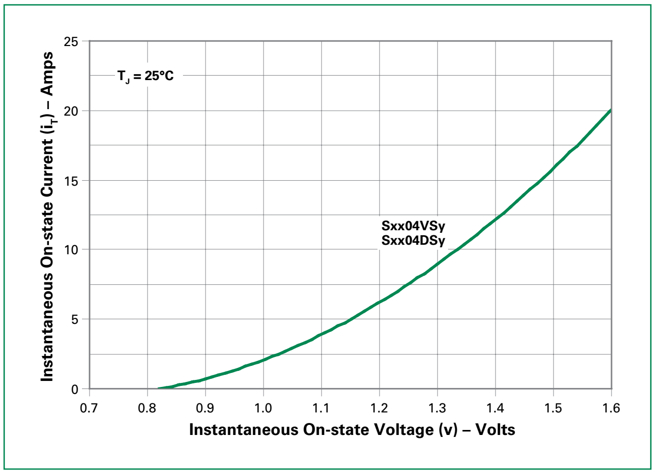
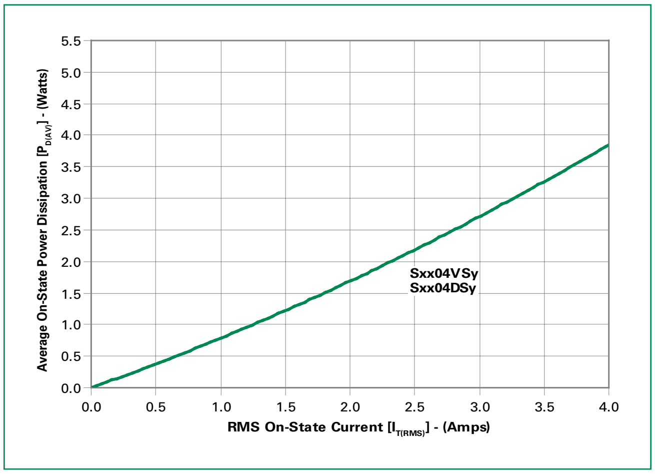


Figure 6: Power Dissipation (Typical) vs. RMS On-State Current



Note: xx or z = voltage, y = sensitivity

Figure 7: Maximum Allowable Case Temperature vs. RMS On-State Current

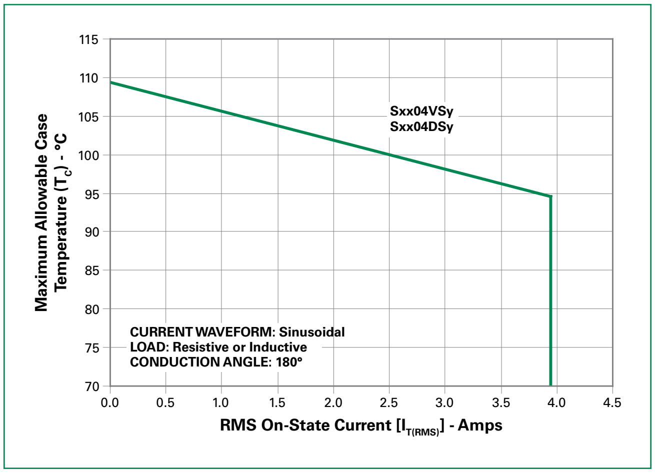


Figure 8: Maximum Allowable Case Temperature vs. Average On-State Current

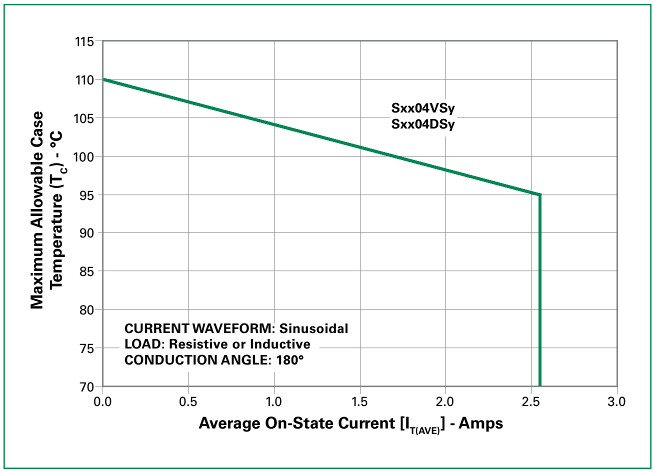


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

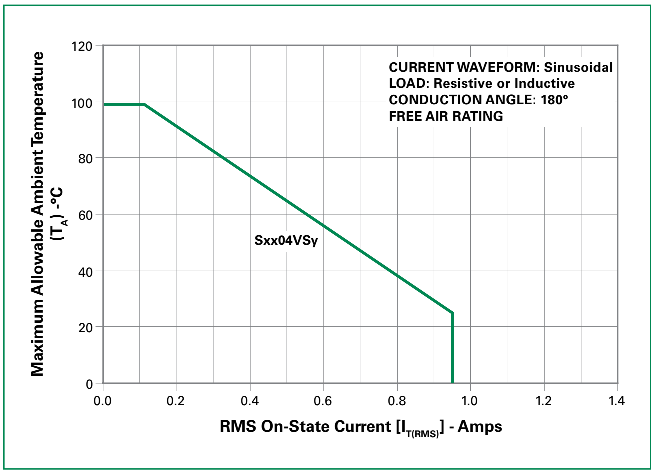


Figure 10: Maximum Allowable Ambient Temperature vs. Average On-State Current

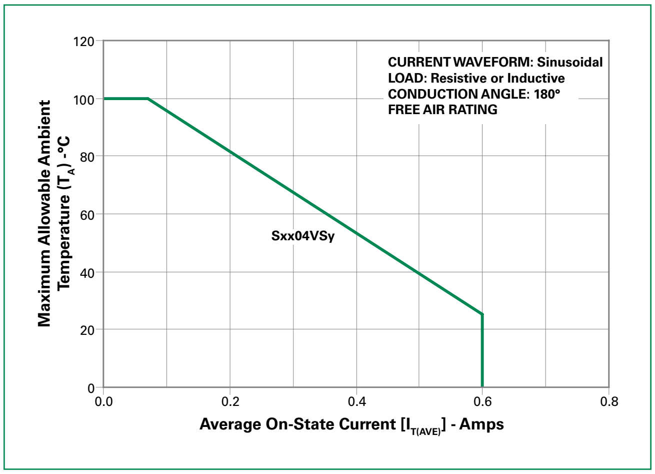


Figure 11: Peak Repetitive Capacitor Discharge Current

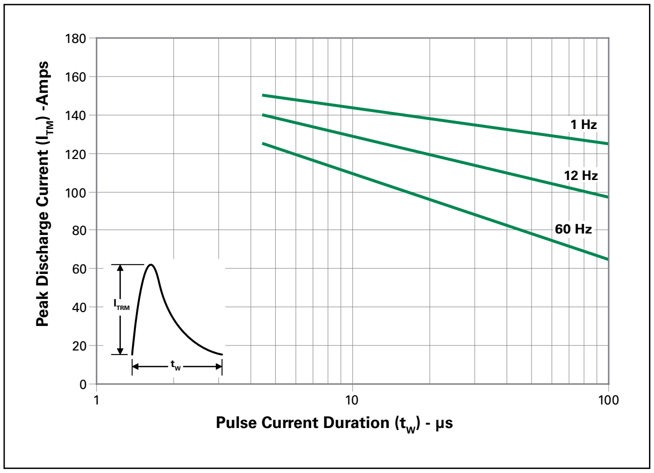
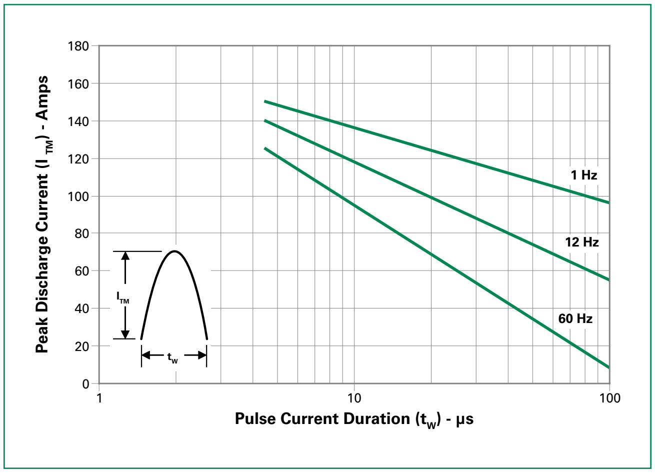
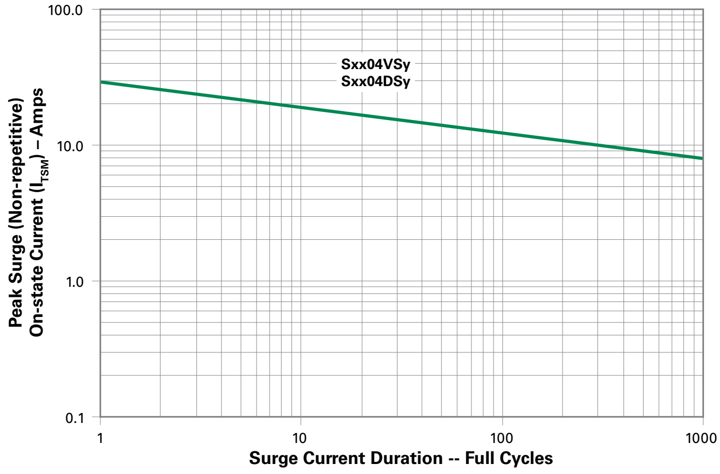


Figure 12: Peak Repetitive Sinusoidal Pulse Current



Note: xx = voltage, y = sensitivity

Figure 13: Surge Peak On-State Current vs. Number of Cycles



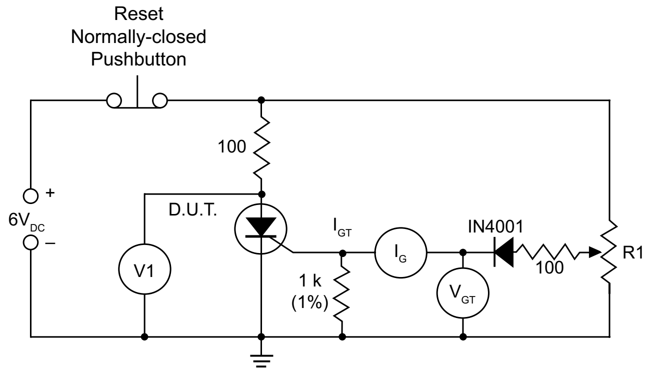
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx or z - voltage, y = sensitivity

Figure 14: Simple Test Circuit for Gate Trigger Voltage and Current



Note: V1 — 0 V to 10 V dc meter
V_{GT} — 0 V to 1 V dc meter
I_G — 0 mA to 1 mA dc milliammeter
R1 — 1 k potentiometer

To measure gate trigger voltage and current, raise gate voltage (V_{GT}) until meter reading V1 drops from 6 V to 1 V. Gate trigger voltage is the reading on V_{GT} just prior to V1 dropping. Gate trigger current I_{GT} Can be computed from the relationship

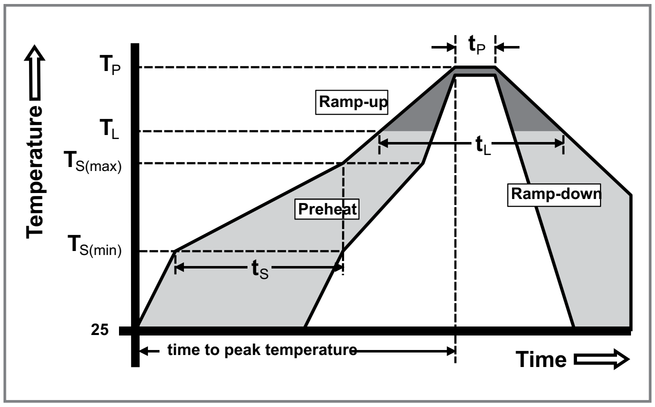
$$I_{GT} = I_G - \frac{V_{GT}}{1000} \text{ Amps}$$

where I_G is reading (in amperes) on meter just prior to V1 dropping

Note: I_{GT} may turn out to be a negative quantity (trigger current flows out from gate lead). If negative current occurs, I_{GT} value is not a valid reading. Remove 1 k resistor and use I_G as the more correct I_{GT} value. This will occur on 12 µA gate products.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

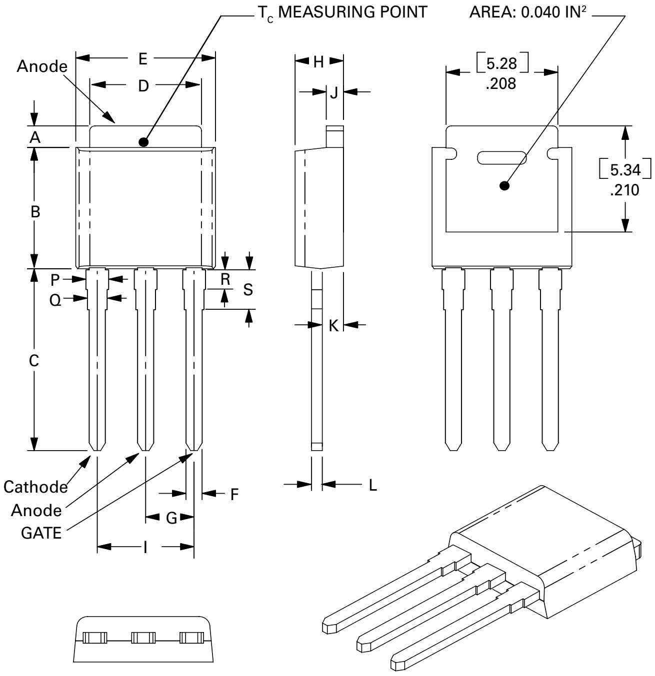
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

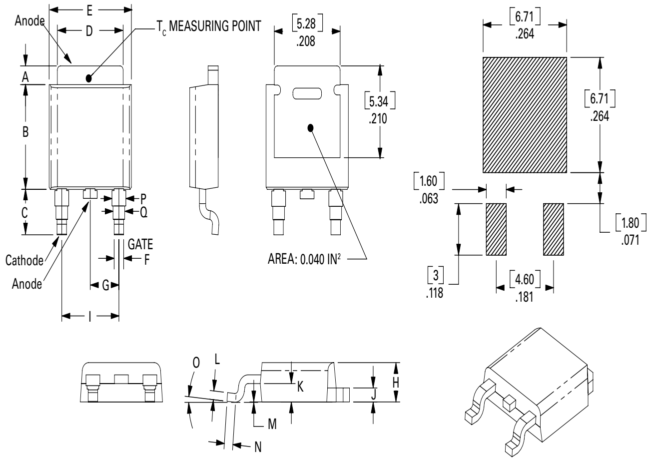
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours , R_{GK} = 1kohms
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwelltime at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Dimensions — TO-251AA (V/I-Package) — V/I-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx04DS1	X	X			50µA	Sensitive SCR	TO-252
Sxx04DS2	X	X			200µA	Sensitive SCR	TO-252
Sxx04VS1	X	X			50µA	Sensitive SCR	TO-251
Sxx04VS2	X	X			200µA	Sensitive SCR	TO-251

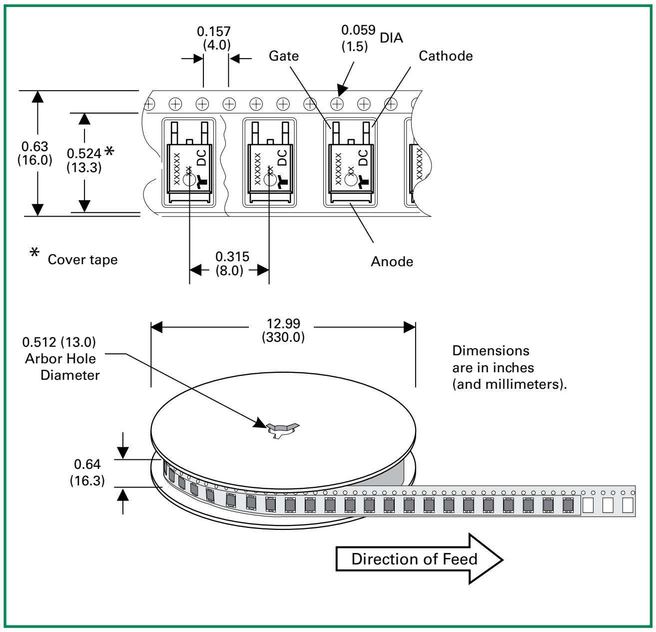
Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx04DSyTP	Sxx04DSy	0.3g	Tube	750 (75 per tube)
Sxx04DSyRP	Sxx04DSy	0.3g	Embossed Carrier	2500
Sxx04VSyTP	Sxx04VSy	0.4g	Tube	750 (75 per tube)

Note: xx = voltage, y = sensitivity

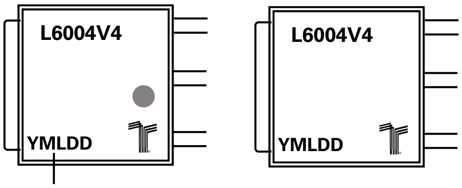
TO-252 Embossed Carrier Reel Pack (RP) Specs



Dimensions are in inches (and millimeters).

Part Marking System

TO-251AA- (V Package)
TO-252AA- (D Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

Part Numbering System

S 60 04 V S1

DEVICE TYPE
S: SCR

VOLTAGE RATING
4: 400V
6: 600V

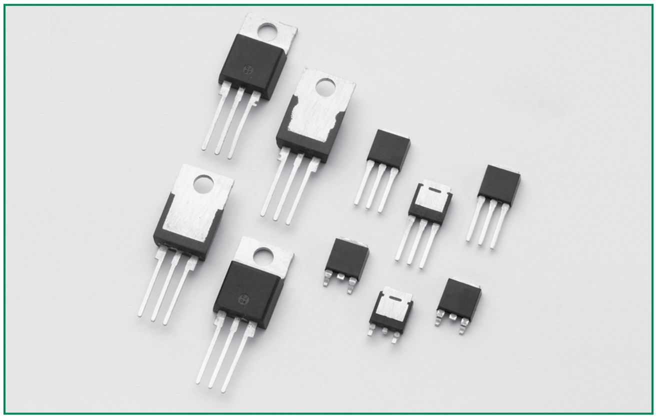
CURRENT RATING
04: 4A

PACKAGE TYPE
V: TO-251 (V/I-Pak)
D: TO-252 (D-Pak)

SENSITIVITY & TYPE
S1: 50µA
S2: 200µA

Sxx06xSx & Sxx06x Series

RoHS



Agency Approval

Agency	Agency File Number
®	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	6	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	0.2 to 15	mA

Additional Information

Datasheet	Resources	Samples

Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Sensitive gate SCRs are easily triggered with microAmps of current as furnished by sense coils, proximity switches, and microprocessors.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

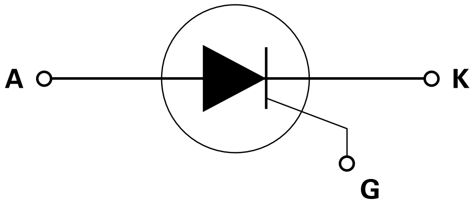
- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 100 A

Applications

Typical applications are capacitive discharge systems for strobe lights, nailers, staplers and gas engine ignition. Also controls for power tools, home/brown goods and white goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Revised: 12/14/14

Absolute Maximum Ratings — Sensitive SCRs

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx06LSy	T_C = 80°C	6	A
		Sxx06RSy Sxx06DSy Sxx06VSy	T_C = 95°C		
$I_{T(AV)}$	Average on-state current	Sxx06LSy	T_C = 80°C	3.8	A
		Sxx06RSy Sxx06DSy Sxx06VSy	TC = 95°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		83	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz; T_J = 110°C		100	A/μs
I_{GTM}	Peak gate current	T_J = 110°C		1	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 110°C		0.1	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Standard SCRs

Symbol	Parameter			Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx06L	T_C = 100°C	6	A
		Sxx06R Sxx06D Sxx06V	T_C = 110°C		
$I_{T(AV)}$	Average on-state current	Sxx06L	T_C = 100°C	3.8	A
		Sxx06R Sxx06D Sxx06V	T_C = 110°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		83	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		100	
I^2t	I^2t value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60Hz; T_J =125°C		100	A/μs
I_{GTM}	Peak gate current	T_J = 125°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Sensitive SCRs

Symbol	Test Conditions		Value		Unit
			Sxx06xS2	Sxx06xS3	
I_{GT}	V_D = 6V R_L = 100 Ω	MAX.	200	500	μA
V_{GT}		MAX.	0.8		V
dv/dt	V_D = V_{DRM}; R_{GK} = 1kΩ; T_J = 110°C	TYP.	8		V/μs
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 110°C	MIN.	0.2		V
V_{GRM}	I_{GR} = 10μA	MIN.	6		V
I_H	I_T = 20mA (initial)	MAX.	6	8	mA
t_q	I_T = 2A; t_p= 50μs; dv/dt=5V/μs; di/dt=-30A/μs	MAX.	50	45	μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 12A	TYP.	4	5	μs

Note: xx = voltage, x = package

Electrical Characteristics (T_J = 25°C, unless otherwise specified) — Standard SCRs

Symbol	Test Conditions			Value	Unit
				Sxx06x	
I_{GT}	V_D = 12V R_L = 60 Ω		MAX.	15	mA
V_{GT}			MAX.	1.5	V
dv/dt	V_D = V_{DRM}; gate open; T_J = 100°C	400V	MIN.	350	V/μs
		600V		300	
		800V		250	
		1000V		100	
	V_D = V_{DRM}; gate open; T_J = 125°C	400V		250	
		600V		225	
		800V		200	
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C		MIN.	0.2	V
I_H	I_T = 200mA (initial)		MAX.	30	mA
t_q	I_T = 2A; t_p= 50μs; dv/dt=5V/μs; di/dt=-30A/μs		MAX.	35	μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 12A		TYP.	2	μs

Note: xx = voltage, x = package

Static Characteristics

Symbol	Test Conditions					Value	Unit
V_{TM}	I_T = 12A; t_p = 380 µs				MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} = V_{RRM}	Sxx06xyy	T_J = 25°C	400 – 600V	MAX.	5	µA
			T_J = 110°C	400 – 600V		250	
		Sxx06x	T_J = 25°C	400 – 800V		10	
				1000V		20	
			T_J = 100°C	400 – 800V		200	
				1000V		3000	
			T_J = 125°C	400 – 800V		500	

Note: xx = voltage, x = package, yy = sensitivity

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	Sxx06RSy	2.6	°C/W
		Sxx06LSy	4.3	
		Sxx06VSy	2.4	
		Sxx06DSy	1.8	
		Sxx06R	2.5	
		Sxx06L	4.0	
		Sxx06V	2.3	
		Sxx06D	1.7	
$R_{\theta(J\text{-}A)}$	Junction to ambient	Sxx06RSy	40	°C/W
		Sxx06LSy	65	
		Sxx06VSy	85	
		Sxx06R	40	
		Sxx06L	50	
		Sxx06V	70	

Note: xx = voltage, y = sensitivity

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature (Sensitive SCR)

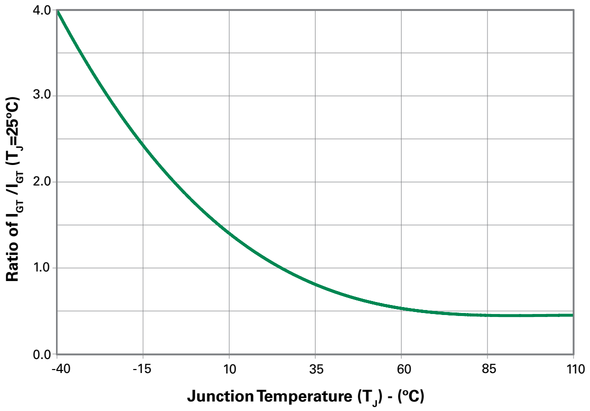


Figure 2: Normalized DC Gate Trigger Current vs. Junction Temperature (Standard SCR)

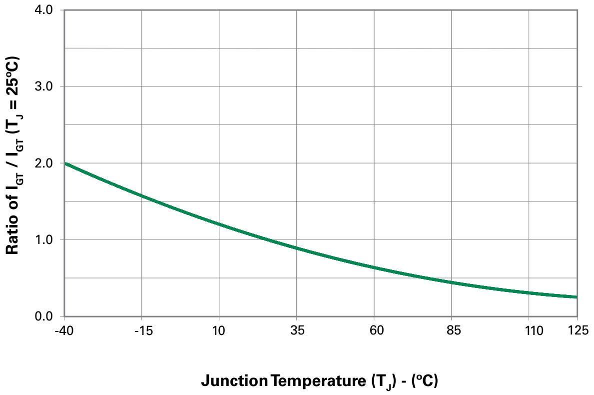


Figure 3: Normalized DC Gate Trigger Voltage vs. Junction Temperature

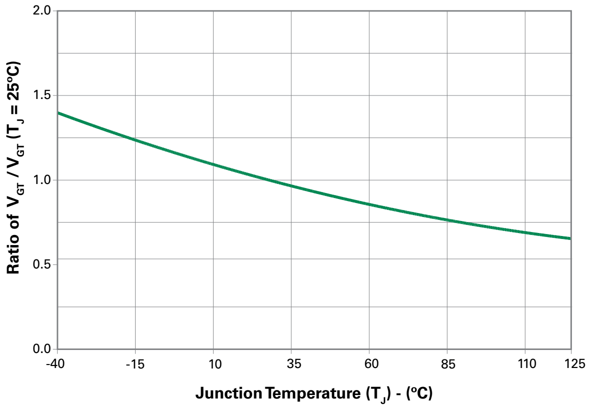


Figure 4: Normalized DC Holding Current vs. Junction Temperature

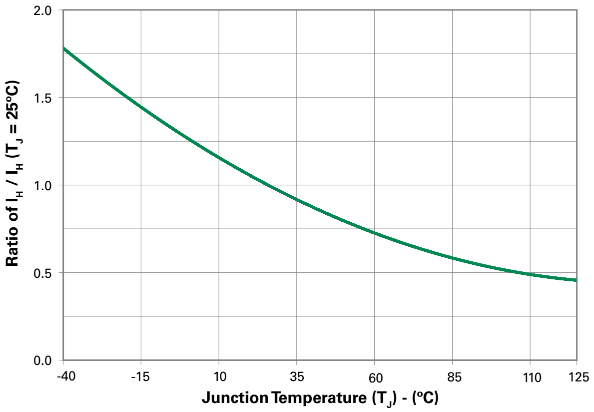


Figure 5: On-State Current vs. On-State Voltage (Typical)

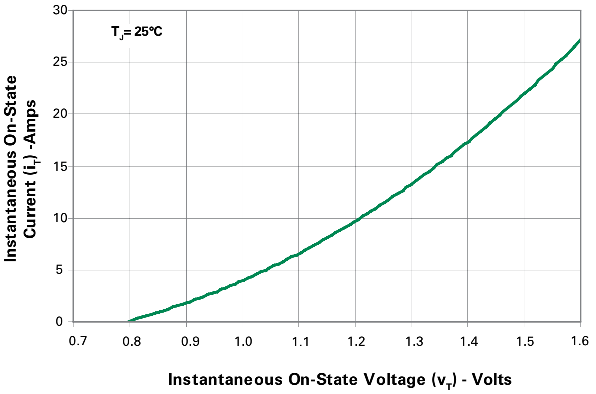


Figure 6: Power Dissipation (Typical) vs. RMS On-State Current

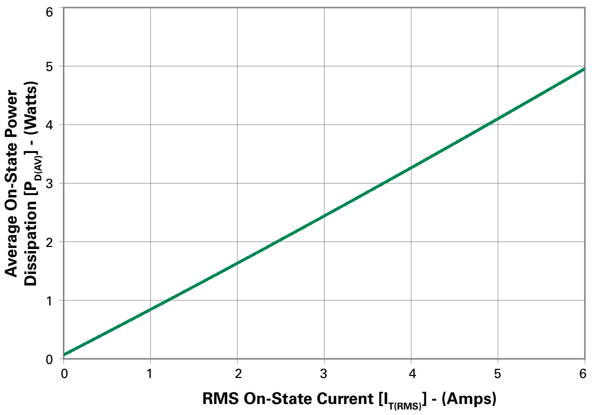


Figure 7: Maximum Allowable Case Temperature vs. RMS On-State Current

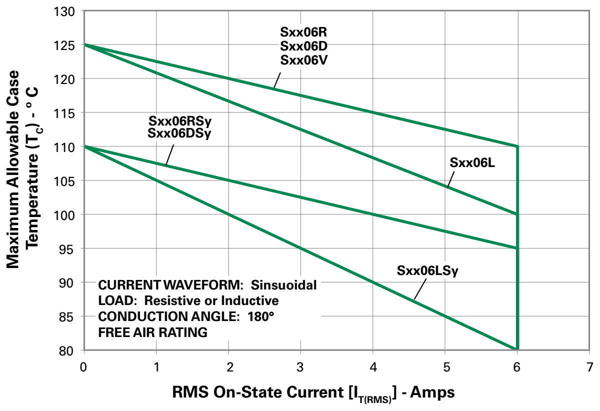


Figure 8: Maximum Allowable Case Temperature vs. Average On-State Current

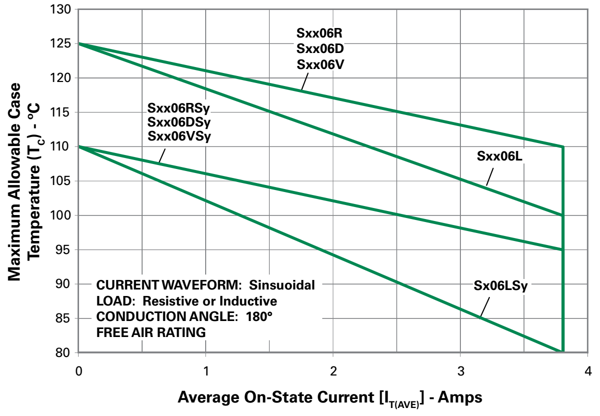


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

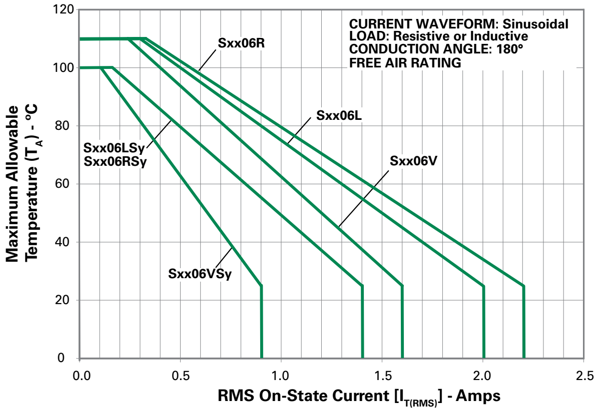
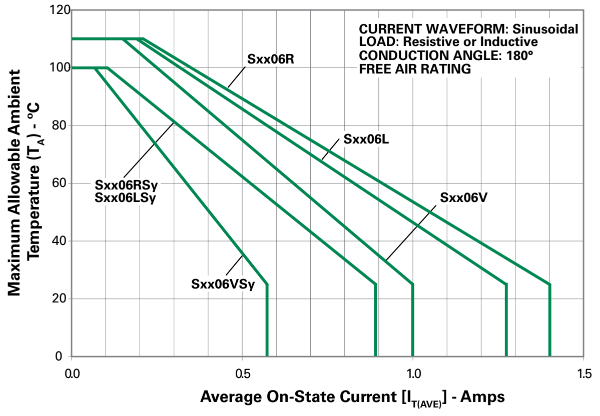


Figure 10: Maximum Allowable Ambient Temperature vs. Average On-State Current



Note: xx = voltage, y = sensitivity

Figure 11: Peak Capacitor Discharge Current

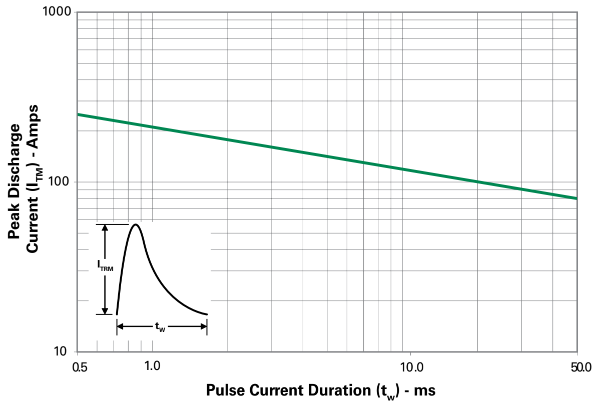


Figure 12: Peak Capacitor Discharge Current Derating

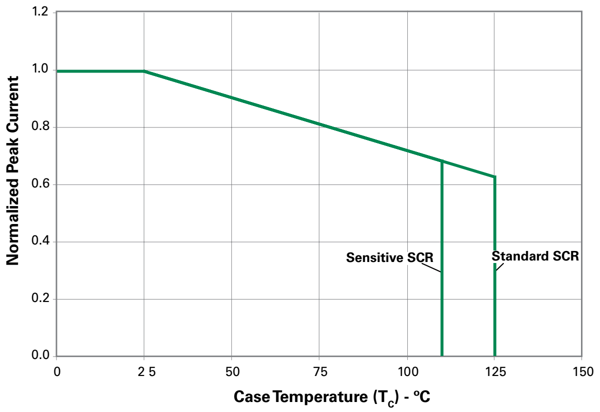
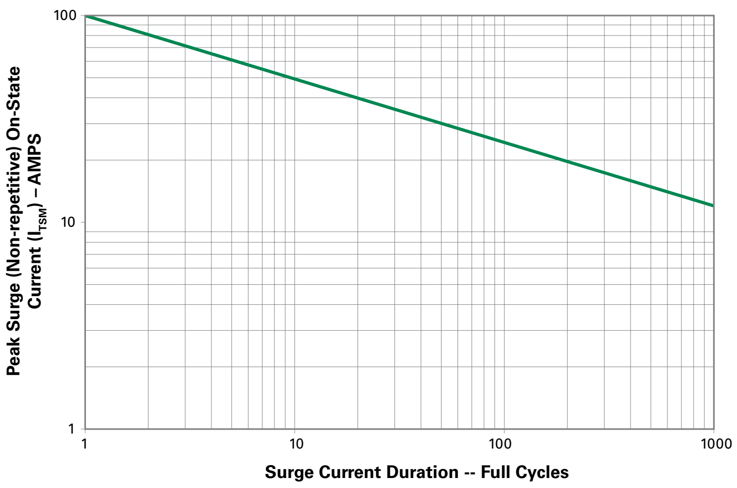


Figure 13: Surge Peak On-State Current vs. Number of Cycles



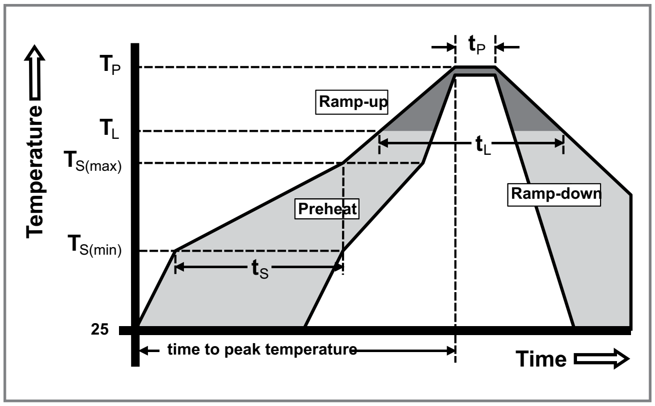
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

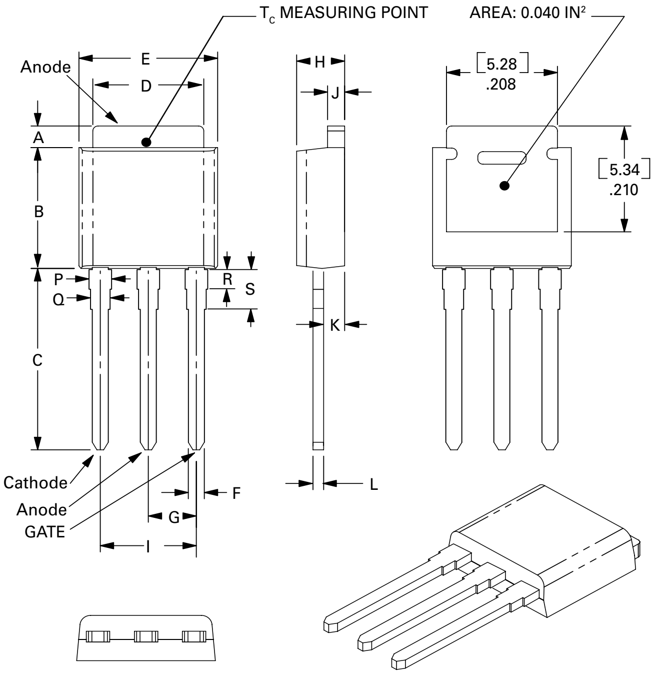
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx06RS2	X	X			0.2mA	Sensitive SCR	TO-220R
Sxx06LS2	X	X			0.2mA	Sensitive SCR	TO-220L
Sxx06VS2	X	X			0.2mA	Sensitive SCR	TO-251
Sxx06DS2	X	X			0.2mA	Sensitive SCR	TO-252
Sxx06RS3	X	X			0.5mA	Sensitive SCR	TO-220R
Sxx06LS3	X	X			0.5mA	Sensitive SCR	TO-220L
Sxx06VS3	X	X			0.5mA	Sensitive SCR	TO-251
Sxx06DS3	X	X			0.5mA	Sensitive SCR	TO-252
Sxx06R	X	X	X	X	15mA	Standard SCR	TO-220R
Sxx06L	X	X	X	X	15mA	Standard SCR	TO-220L
Sxx06V	X	X	X	X	15mA	Standard SCR	TO-251
Sxx06D	X	X	X	X	15mA	Standard SCR	TO-252

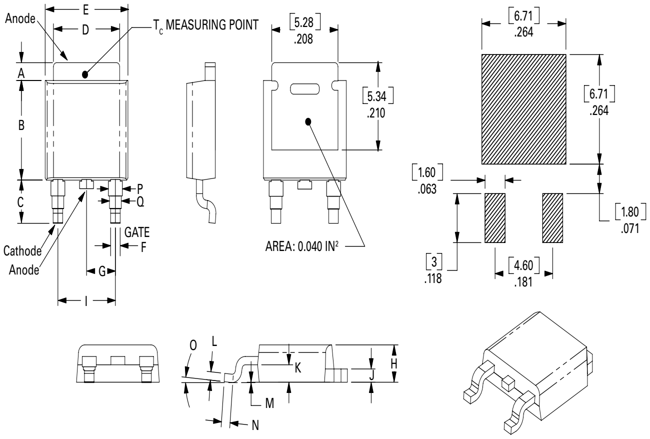
Note: xx = voltage

Dimensions — TO-251AA (V/I-Package) — V/I-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

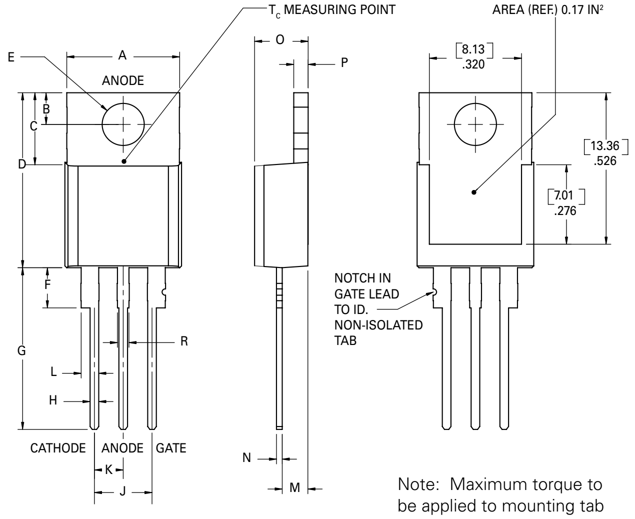
Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Revised: 12/14/14

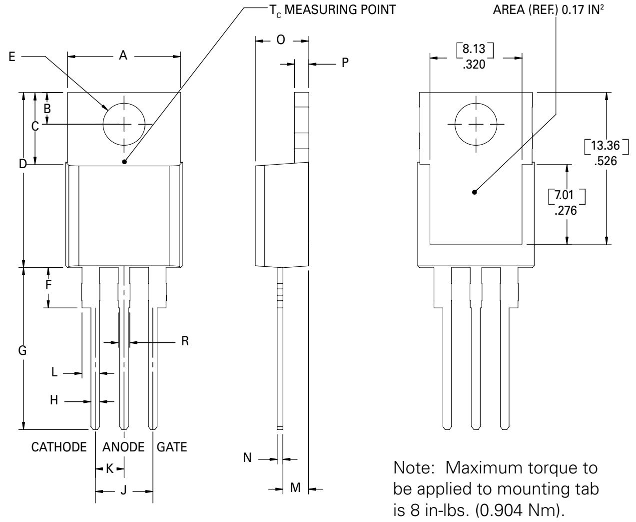
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

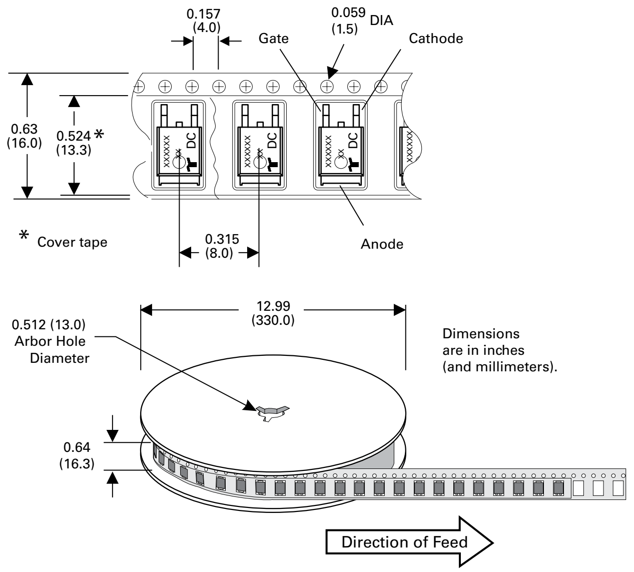
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx06L/Ryy	Sxx06L/Ryy	2.2 g	Bulk	500
Sxx06L/RyyTP	Sxx06L/Ryy	2.2 g	Tube	500 (50 per tube)
Sxx06DyyTP	Sxx06Dyy	0.3 g	Tube	750 (75 per tube)
Sxx06DyyRP	Sxx06Dyy	0.3 g	Embossed Carrier	2500
Sxx06VyyTP	Sxx06Vyy	0.4 g	Tube	750 (75 per tube)
Sxx06L/R	Sxx06L/R	2.2 g	Bulk	500
Sxx06L/RTP	Sxx06L/R	2.2 g	Tube	500 (50 per tube)
Sxx06DTP	Sxx06D	0.3 g	Tube	750 (75 per tube)
Sxx06DRP	Sxx06D	0.3 g	Embossed Carrier	2500
Sxx06VTP	Sxx06V	0.4 g	Tube	750 (75 per tube)

Note: xx = Voltage; yy = Sensitivity

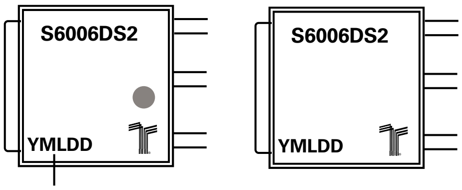
TO-252 Embossed Carrier Reel Pack (RP) Specs

Meets all EIA-481-2 Standards



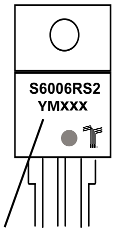
Part Marking System

TO-251AA- (V Package)
TO-252AA- (D Package)



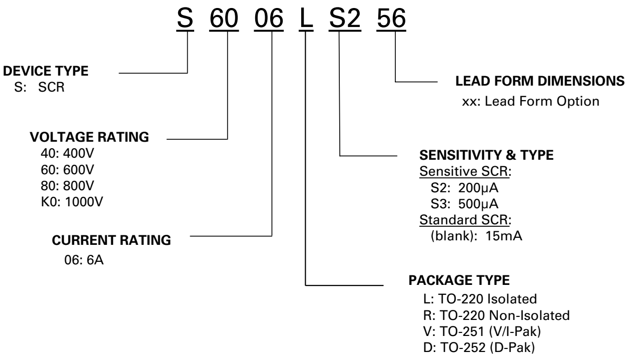
Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

TO-220 AB - (L and R Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Part Numbering System



S 60 06 L S2 56

DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
06: 6A

LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY & TYPE
Sensitive SCR:
S2: 200µA
S3: 500µA
Standard SCR:
(blank): 15mA

PACKAGE TYPE
L: TO-220 Isolated
R: TO-220 Non-Isolated
V: TO-251 (V/I-Pak)
D: TO-252 (D-Pak)

Littelfuse®

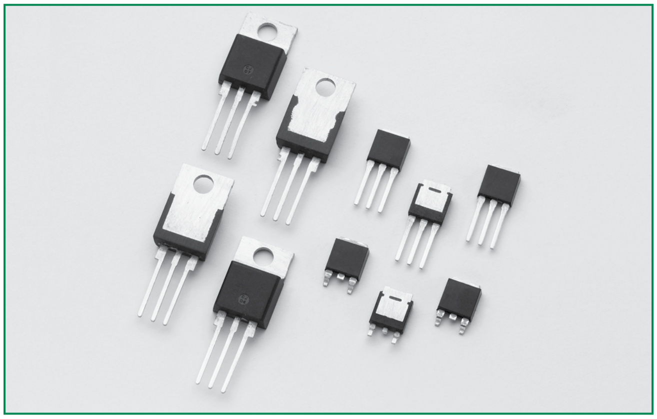
Expertise Applied | Answers Delivered

Teccor® brand Thyristors

8 Amp Sensitive & Standard SCRs

Sxx08xSx & Sxx08x Series

RoHS



Agency Approval

Agency	Agency File Number
UL	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	8	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	0.2 to 15	mA

Additional Information

Datasheet

Resources

Samples

Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Sensitive gate SCRs are easily triggered with microAmps of current as furnished by sense coils, proximity switches, and microprocessors.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

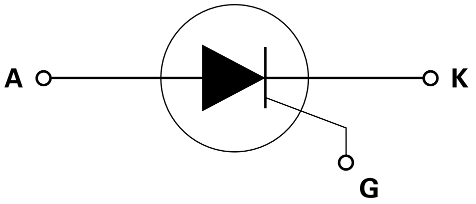
- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 100 A

Applications

Typical applications are capacitive discharge systems for strobe lights, nailers, staplers and gas engine ignition. Also controls for power tools, home/brown goods and white goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Revised: 12/14/14

Absolute Maximum Ratings — Sensitive SCRs

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx08LSy	T_C = 80°C	8	A
		Sxx08RSy Sxx08DSy Sxx08VSy	T_C = 95°C		
$I_{T(AV)}$	Average on-state current	Sxx08LSy	T_C = 80°C	5.1	A
		Sxx08RSy Sxx08DSy Sxx08VSy	T_C = 95°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		83	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate of rise of on-state current	f = 60 Hz ; T_J = 110°C		70	A/μs
I_{GTM}	Peak gate current	T_J = 110°C		1.6	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 110°C		0.4	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Standard SCRs

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx08L	T_C = 100°C	8	A
		Sxx08R Sxx08D Sxx08V	T_C = 110°C		
$I_{T(AV)}$	Average on-state current	Sxx08L	T_C = 100°C	5.1	A
		Sxx08R Sxx08D Sxx08V	T_C = 110°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		83	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60 Hz T_J = 125°C		100	A/μs
I_{GM}	Peak gate current	T_J = 125°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Sensitive SCRs

Symbol	Test Conditions		Value		Unit
			Sxx08xS2	Sxx08xS3	
I_{GT}	V_D = 6V R_L = 100 Ω	MAX.	200	500	µA
V_{GT}		MAX.	0.8		V
dv/dt	$V_D = V_{DRM}$; R_{GK} = 1kΩ; T_J = 110°C	TYP.	8		V/µs
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C	MIN.	0.2		V
V_{GRM}	I_{GR} = 10µA	MIN.	6		V
I_H	I_T = 20mA (initial)	MAX.	6	8	mA
t_q	I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-30A/µs	MAX.	50	45	µs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15µs I_T = 12A	TYP.	4	5	µs

Note: xx = voltage x = package

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Standard SCRs

Symbol	Test Conditions			Value	Unit
				Sxx08x	
I_{GT}	V_D = 12V R_L = 60 Ω		MAX.	15	mA
V_{GT}			MAX.	1.5	V
dv/dt	$V_D = V_{DRM}$; gate open; T_J = 100°C	400V	MIN.	350	V/µs
		600V		300	
		800V		250	
		1000V		100	
	$V_D = V_{DRM}$; gate open; T_J = 125°C	400V		250	
		600V		225	
		800V		200	
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 125°C		MIN.	0.2	V
I_H	I_T = 200mA (initial)		MAX.	30	mA
t_q	I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-30A/µs		MAX.	35	µs
t_{gt}	$I_G = 2 \times I_{GT}$ PW = 15µs I_T = 16A		TYP.	2	µs

Note: xx = voltage x = package

Static Characteristics

Symbol	Test Conditions					Value	Unit
V_{TM}	I_T = 16A; t_p = 380 µs				MAX.	1.6	V
I_{DRM} / I_{RRM}	$V_{DRM} = V_{RRM}$	Sxx08xyy	T_J = 25°C	400 - 600V	MAX.	5	µA
			T_J = 110°C	400 - 600V		250	
		Sxx08x	T_J = 25°C	400 - 800V		10	
				1000V		20	
			T_J = 100°C	400 - 800V		200	
				1000V		3000	
			T_J = 125°C	400 - 800V		500	

Note: xx = voltage, x = package, yy = sensitivity

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	Sxx08RSy	1.8	°C/W
		Sxx08LSy	3.4	
		Sxx08VSy	2.1	
		Sxx08DSy	1.5	
		Sxx08R	1.8	
		Sxx08L	3.4	
		Sxx08V	2.0	
		Sxx08D	1.5	
$R_{\theta(J\text{-}A)}$	Junction to ambient	Sxx08RSy	40	°C/W
		Sxx08LSy	65	
		Sxx08VSy	85	
		Sxx08R	40	
		Sxx08L	50	
		Sxx08V	70	

Note: xx = voltage, y = sensitivity

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature (Sensitive SCR)

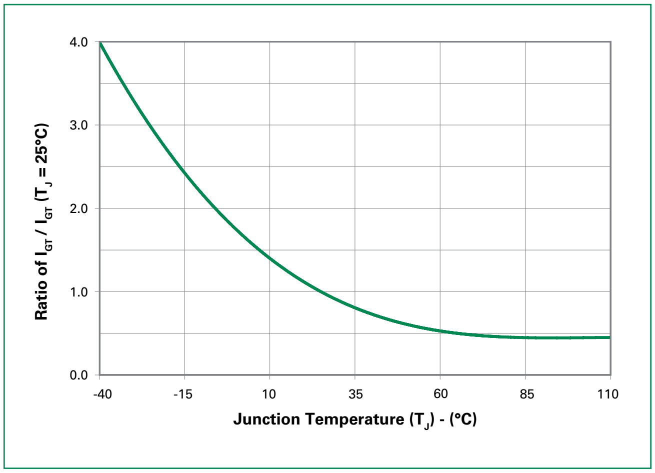


Figure 2: Normalized DC Gate Trigger Current vs. Junction Temperature (Standard SCR)

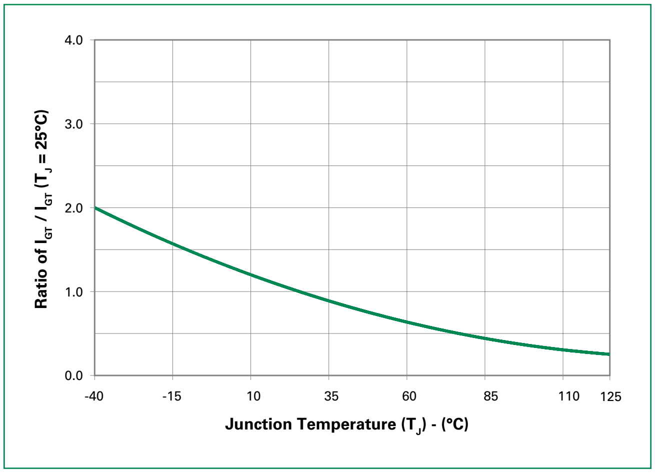


Figure 3: Normalized DC Gate Trigger Voltage vs. Junction Temperature

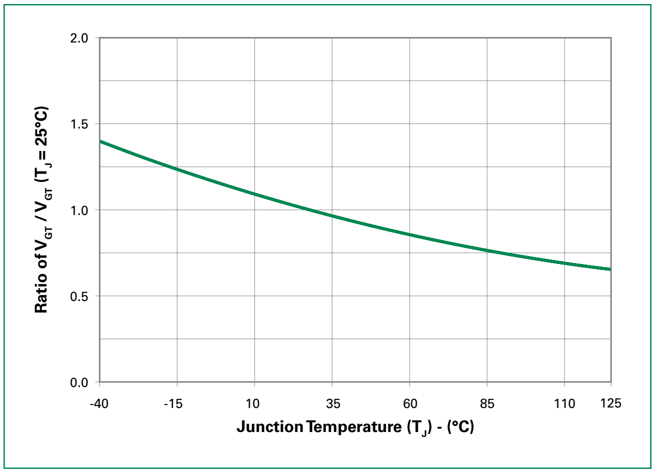


Figure 4: Normalized DC Holding Current vs. Junction Temperature

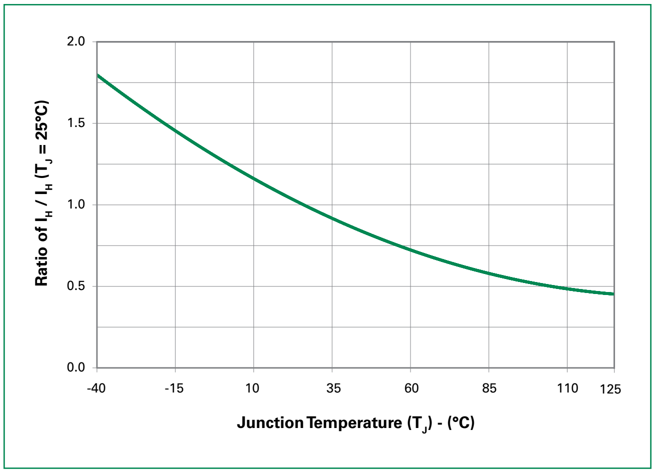


Figure 5: On-State Current vs. On-State Voltage (Typical)

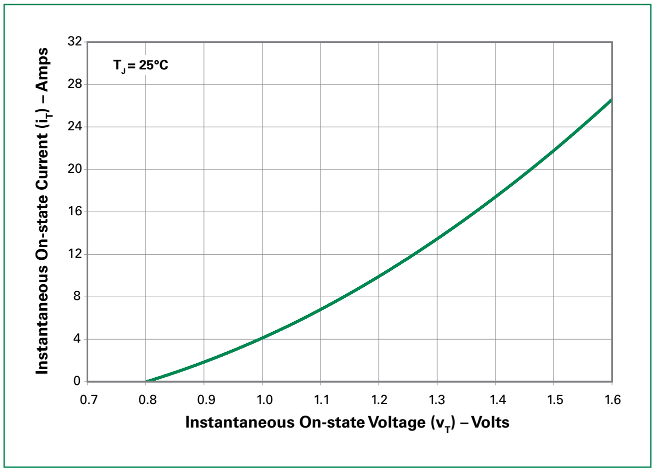


Figure 6: Power Dissipation (Typical) vs. RMS On-State Current

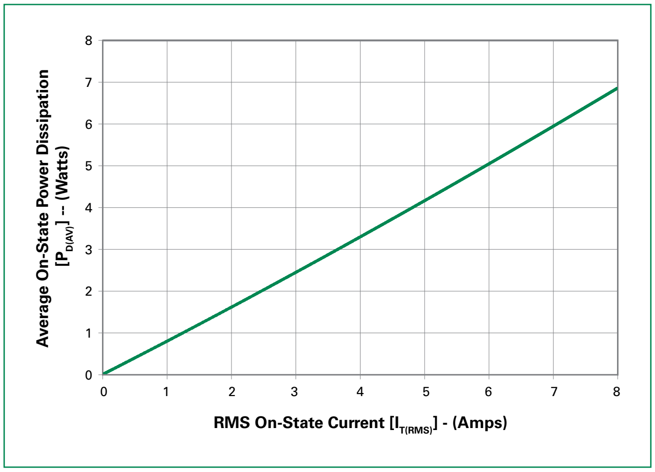


Figure 7: Maximum Allowable Case Temperature vs. RMS On-State Current

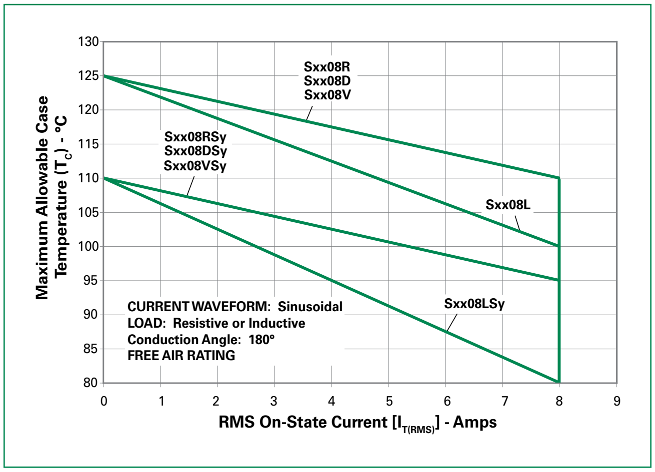


Figure 8: Maximum Allowable Case Temperature vs. Average On-State Current

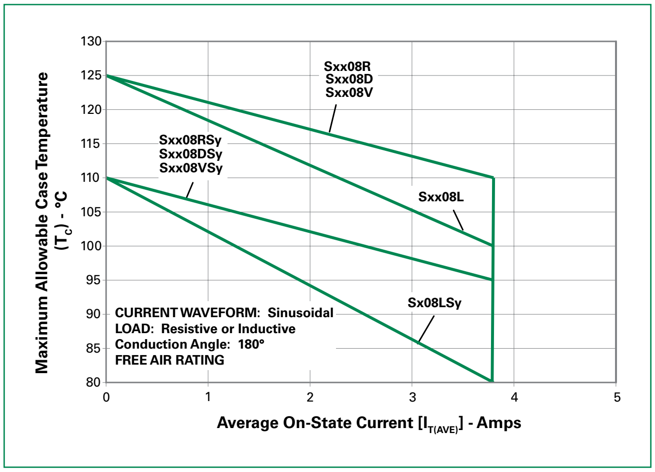


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

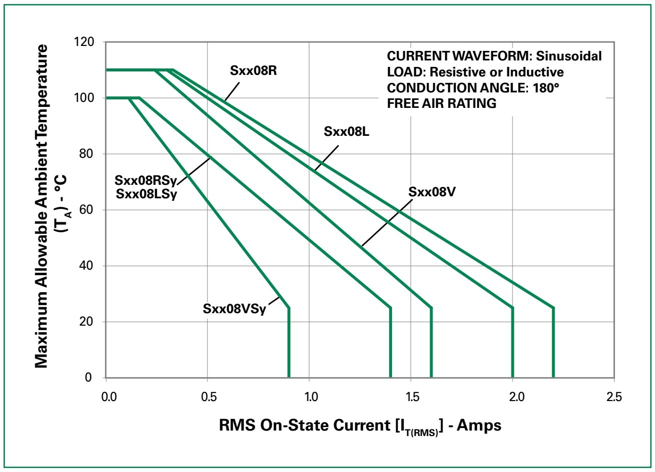
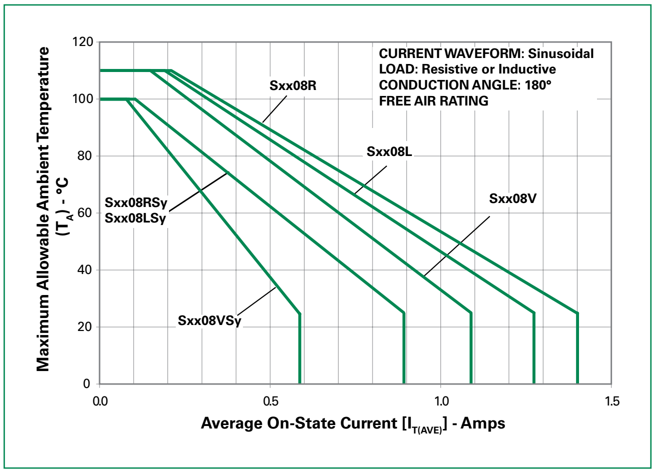


Figure 10: Maximum Allowable Ambient Temperature vs. Average On-State Current



Note: xx = voltage, y = sensitivity

Figure 11: Peak Capacitor Discharge Current

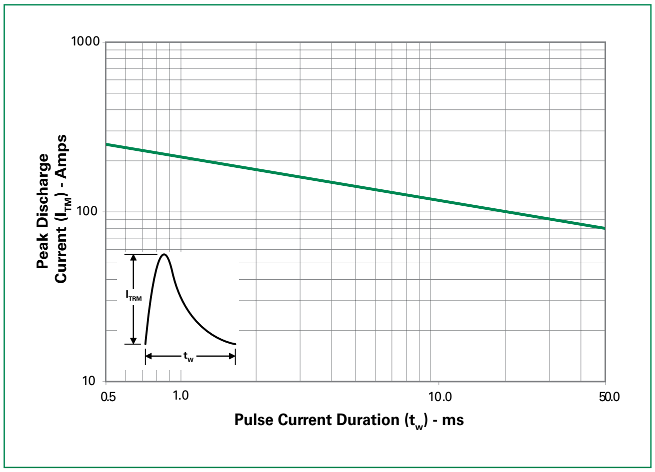


Figure 12: Peak Capacitor Discharge Current Derating

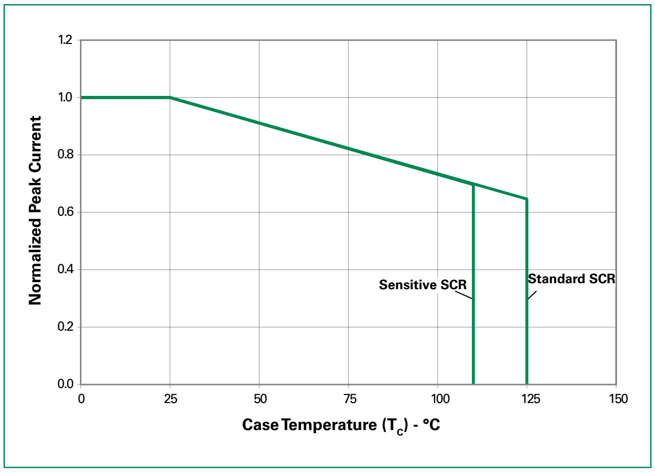


Figure 13: Surge Peak On-State Current vs. Number of Cycles

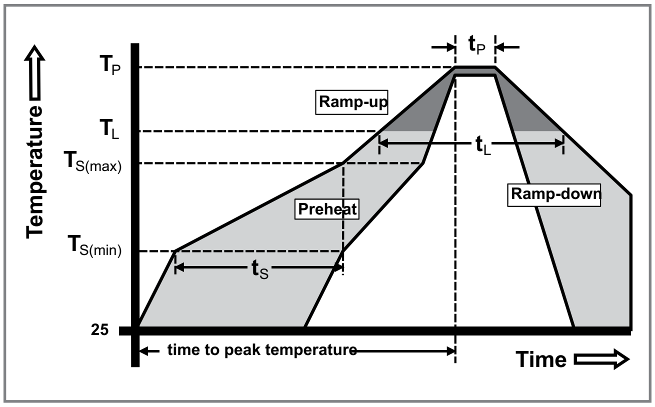
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

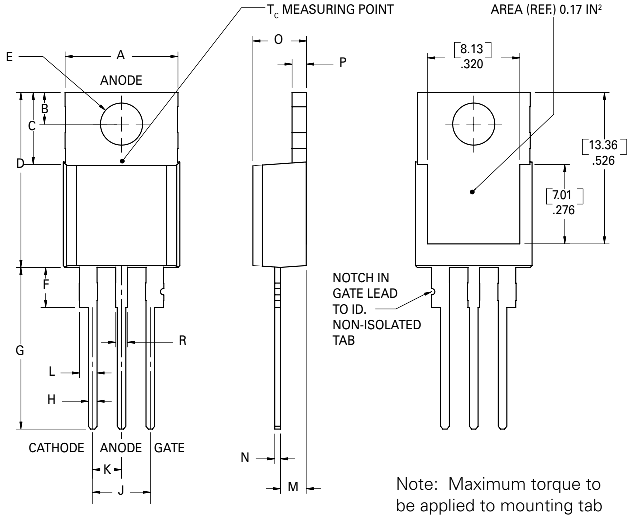
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

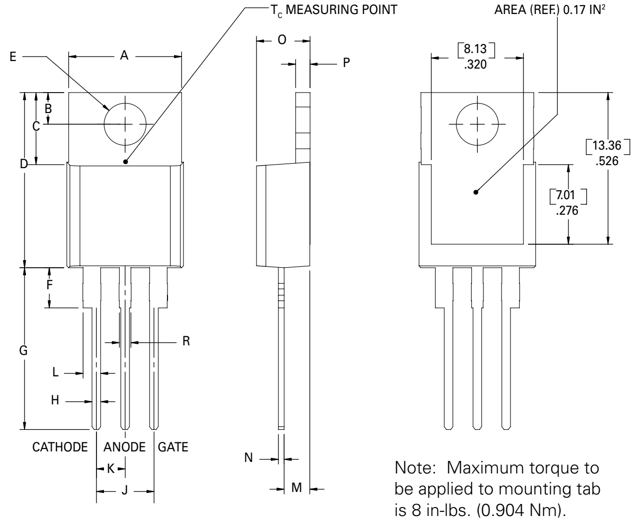
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab

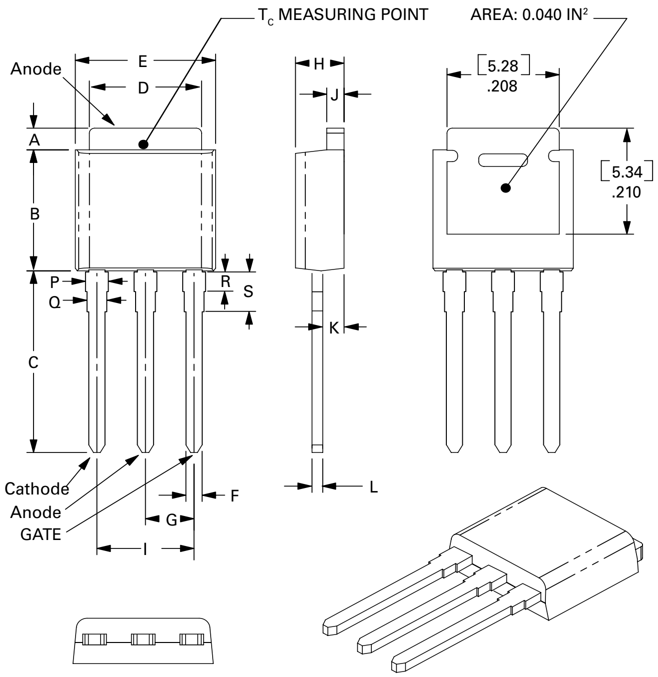


Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

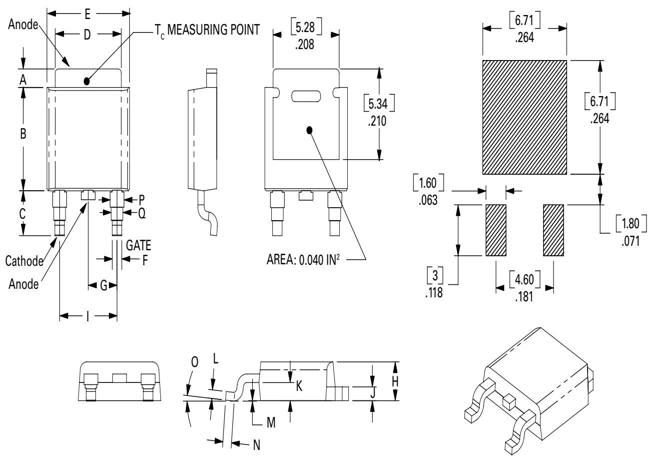
Revised: 12/14/14

Dimensions — TO-251AA (V/I-Package) — V/I-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx08RS2	X	X			0.2mA	Sensitive SCR	TO-220R
Sxx08LS2	X	X			0.2mA	Sensitive SCR	TO-220L
Sxx08VS2	X	X			0.2mA	Sensitive SCR	TO-251
Sxx08DS2	X	X			0.2mA	Sensitive SCR	TO-252
Sxx08RS3	X	X			0.5mA	Sensitive SCR	TO-220R
Sxx08LS3	X	X			0.5mA	Sensitive SCR	TO-220L
Sxx08VS3	X	X			0.5mA	Sensitive SCR	TO-251
Sxx08DS3	X	X			0.5mA	Sensitive SCR	TO-252
Sxx08R	X	X	X	X	15mA	Standard SCR	TO-220R
Sxx08L	X	X	X	X	15mA	Standard SCR	TO-220L
Sxx08V	X	X	X	X	15mA	Standard SCR	TO-251
Sxx08D	X	X	X	X	15mA	Standard SCR	TO-252

Note: xx = Voltage

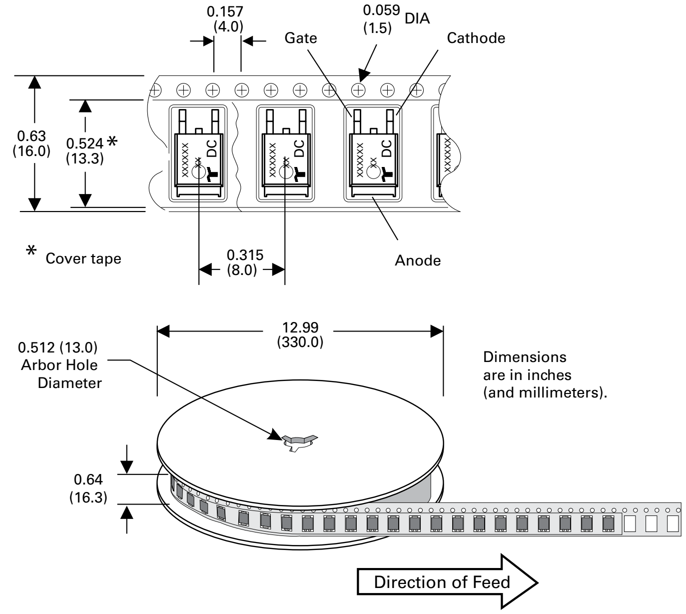
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx08L/Ryy	Sxx08L/Ryy	2.2 g	Bulk	500
Sxx08L/RyyTP	Sxx08L/Ryy	2.2 g	Tube	500 (50 per tube)
Sxx08DyyTP	Sxx08Dyy	0.3 g	Tube	750 (75 per tube)
Sxx08DyyRP	Sxx08Dyy	0.3 g	Embossed Carrier	2500
Sxx08VyyTP	Sxx08Vyy	0.4 g	Tube	750 (75 per tube)
Sxx08L/R	Sxx08L/R	2.2 g	Bulk	500
Sxx08L/RTP	Sxx08L/R	2.2 g	Tube	500 (50 per tube)
Sxx08DTP	Sxx08D	0.3 g	Tube	750 (75 per tube)
Sxx08DRP	Sxx08D	0.3 g	Embossed Carrier	2500
Sxx08VTP	Sxx08V	0.4 g	Tube	750 (75 per tube)

Note: xx = Voltage; yy = Sensitivity

TO-252 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Part Numbering System

S 60 08 L S2 56

DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
08: 8A

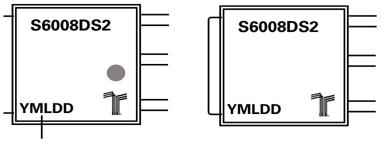
PACKAGE TYPE
L: TO-220 Isolated
R: TO-220 Non-Isolated
V: TO-251 (V/I-Pak)
D: TO-252 (D-Pak)

SENSITIVITY & TYPE
Sensitive SCR:
S2: 200µA
S3: 500µA
Standard SCR:
(blank): 15mA

LEAD FORM DIMENSIONS
xx: Lead Form Option

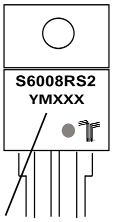
Part Marking System

TO-251AA - (V Package)
TO-252AA - (D Package)



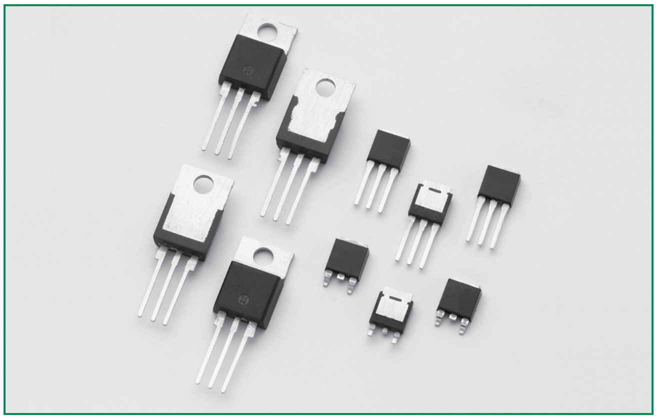
Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

TO-220 AB - (L and R Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Sxx10xSx & Sxx10x Series



Agency Approval

Agency	Agency File Number
®	TO-220L Package : E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	10	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	0.2 to 15	mA

Additional Information

Datasheet | **Resources** | **Samples**

Description

Excellent unidirectional switches for phase control and general switching applications such as heating, motor control controls, converters / rectifiers and capacitive discharge ignitions.

Sensitive gate SCRs are easily triggered with microAmps of current as furnished by sense coils, proximity switches, and microprocessors.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

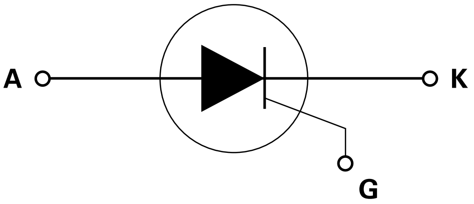
- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 100 A

Applications

Typical applications includes capacitive discharge system for motorcycle engine CDI, portable generator engine ignition, strobe lights and nailers, as well as generic rectifiers, battery voltage regulators and converters. Also controls for power tools, home/brown good and white goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Revised: 12/14/14

Absolute Maximum Ratings — Sensitive SCRs

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx10LSy	T_C = 80°C	10	A
		Sxx10RSy Sxx10DSy Sxx10VSy	T_C = 95°C		
$I_{T(AV)}$	Average on-state current	Sxx10LSy	T_C = 80°C	6.4	A
		Sxx10RSy Sxx10DSy Sxx10VSy	T_C = 95°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		83	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate of rise of on-state current	f = 60 Hz ; T_J = 110°C		100	A/μs
I_{GM}	Peak gate current	T_J = 110°C		1	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 110°C		0.1	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 110	°C

Note: xx = voltage, y = sensitivity

Absolute Maximum Ratings — Standard SCRs

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx10L	T_C = 95°C	10	A
		Sxx10R Sxx10D Sxx10V	T_C = 105°C		
$I_{T(AV)}$	Average on-state current	Sxx10L	T_C = 95°C	6.4	A
		Sxx10R Sxx10D Sxx10V	T_C = 105°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		83	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		100	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		41	A^2s
di/dt	Critical rate-of-rise of on-state current	f = 60 Hz T_J = 125°C		100	A/μs
I_{GM}	Peak gate current	T_J = 125°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Sensitive SCRs

Symbol	Test Conditions		Value		Unit
			Sxx10xS2	Sxx10xS3	
I_{GT}	V_D = 6V R_L = 100 Ω	MAX.	200	500	μA
V_{GT}		MAX.	0.8		V
dv/dt	$V_D = V_{DRM}$; R_{GK} = 1kΩ ; T_J = 110°C	TYP.	8		V/μs
V_{GD}	$V_D = V_{DRM}$; R_L = 3.3 kΩ; T_J = 110°C	MIN.	0.2		V
V_{GRM}	I_{GR} = 10μA	MIN.	6		V
I_H	I_T = 20mA (initial)	MAX.	6	8	mA
t_q	(1)	MAX.	50	45	μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 12A	TYP.	4	5	μs

NOTE: xx = voltage, x = package
(1) I_T=2A; t_p=50μs; dv/dt=5V/μs; di/dt=-30A/μs

Electrical Characteristics (T_J = 25°C, unless otherwise specified) – Standard SCRs

Symbol	Test Conditions			Value	Unit
				Sxx10x	
I_{GT}	V_D = 12V R_L = 60 Ω		MAX.	15	mA
V_{GT}			MAX.	1.5	V
dv/dt	$V_D = V_{DRM}$; gate open; T_J = 100°C	400V	MIN.	350	V/μs
		600V		300	
		800V		250	
		1000V		100	
	$V_D = V_{DRM}$; gate open; T_J = 125°C	400V		250	
		600V		225	
		800V		200	
V_{GD}	$V_D = V_{DRM}$; R_L = 3.3 kΩ; T_J = 125°C		MIN.	0.2	V
I_H	I_T = 200mA (initial)		MAX.	30	mA
t_q	(1)		MAX.	35	μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 20A		TYP.	2	μs

NOTE: xx = voltage, x = package
(1) I_T=2A; t_p=50μs; dv/dt=5V/μs; di/dt=-30A/μs

Static Characteristics

Symbol	Test Conditions					Value	Unit
V_{TM}	I_T = 20A; t_p = 380 μs				MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	Sxx10xyy	T_J = 25°C	400 - 600V	MAX.	5	μA
			T_J = 110°C	400 - 600V		250	
		Sxx10x	T_J = 25°C	400 - 800V		10	
				1000V		20	
			T_J = 100°C	400 - 800V		200	
				1000V		3000	
			T_J = 125°C	400 - 800V		500	

Note: xx = voltage, x = package, yy = sensitivity

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	Sxx10RSy	1.6	°C/W
		Sxx10LSy	3.0	
		Sxx10VSy	1.7	
		Sxx10DSy	1.45	
		Sxx10R	1.6	
		Sxx10L	3.0	
		Sxx10V	1.7	
		Sxx10D	1.45	
$R_{\theta(J\text{-}A)}$	Junction to ambient	Sxx10RSy	40	°C/W
		Sxx10LSy	65	
		Sxx10VSy	85	
		Sxx10R	40	
		Sxx10L	50	
		Sxx10V	70	

Note: xx = voltage, y = sensitivity

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature (Sensitive SCR)

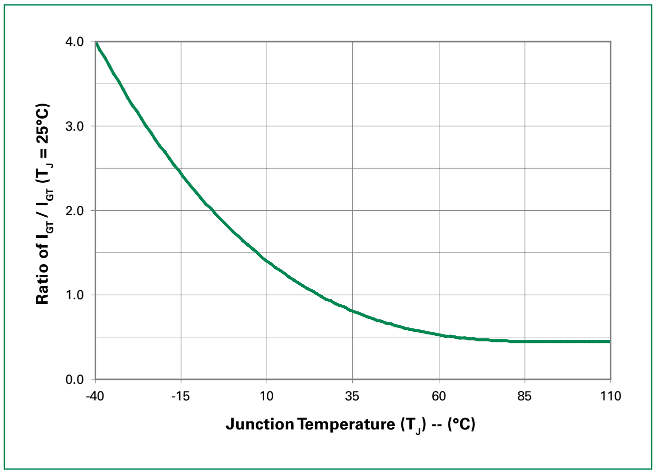


Figure 2: Normalized DC Gate Trigger Current vs. Junction Temperature (Standard SCR)

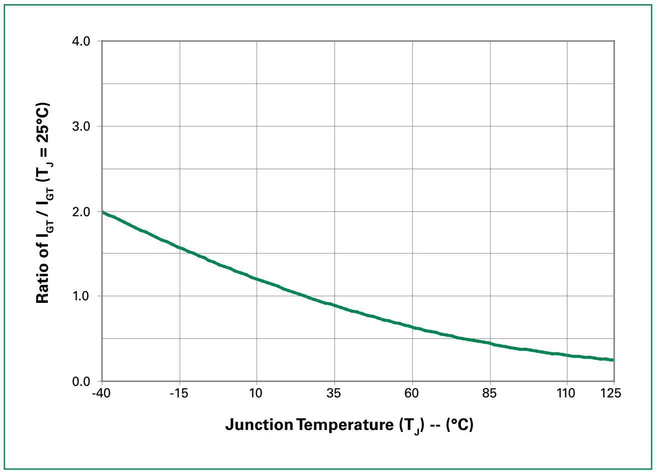


Figure 3: Normalized DC Gate Trigger Voltage vs. Junction Temperature

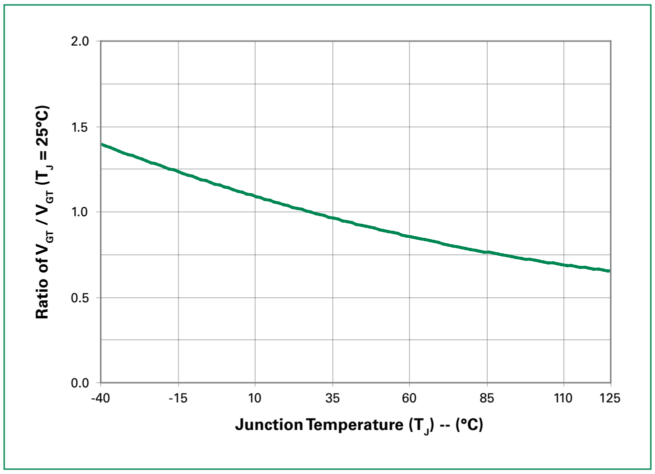


Figure 4: Normalized DC Holding Current vs. Junction Temperature

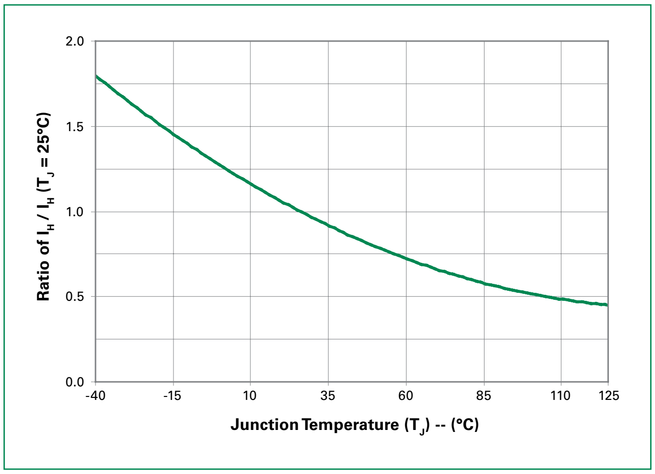


Figure 5: On-State Current vs. On-State Voltage (Typical)

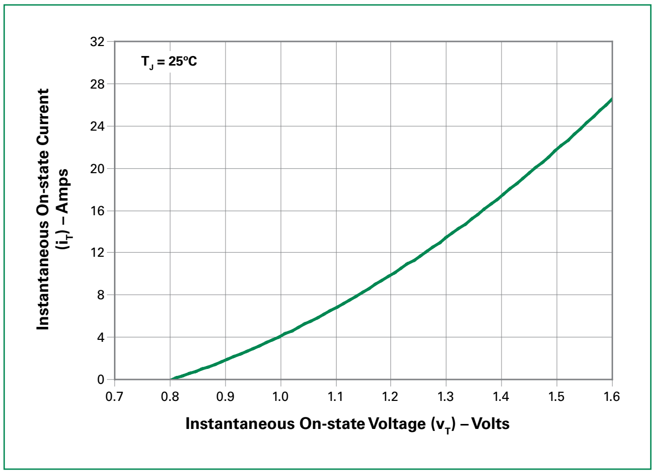


Figure 6: Power Dissipation (Typical) vs. RMS On-State Current

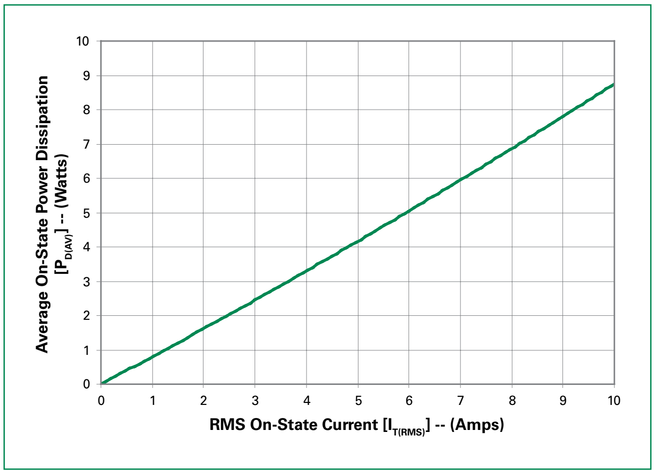


Figure 7: Maximum Allowable Case Temperature vs. RMS On-State Current

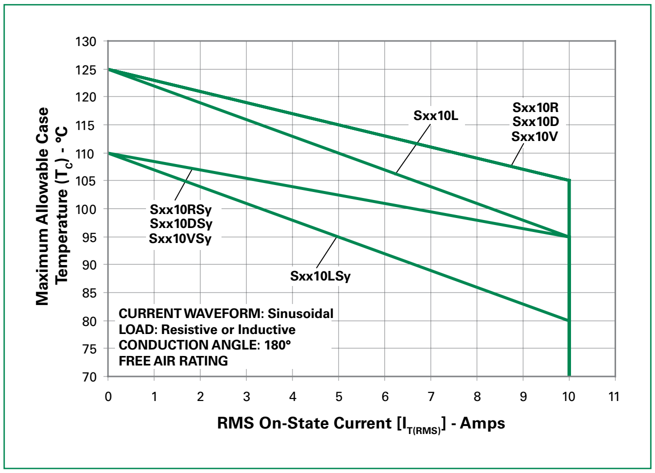


Figure 8: Maximum Allowable Case Temperature vs. Average On-State Current

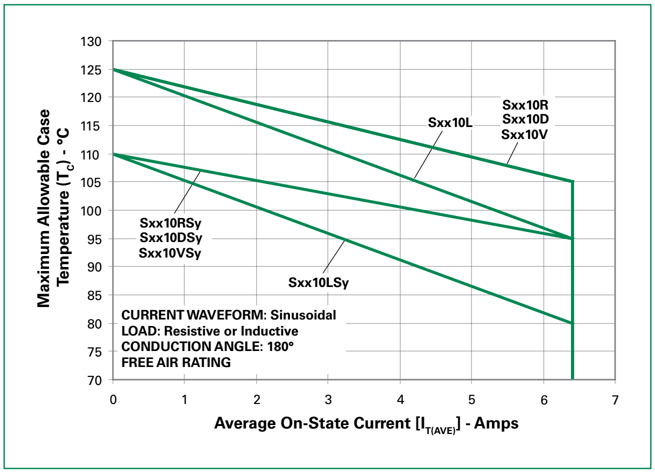


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

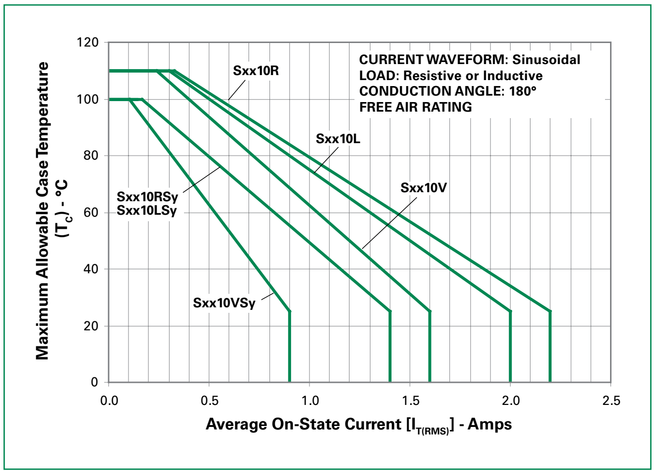
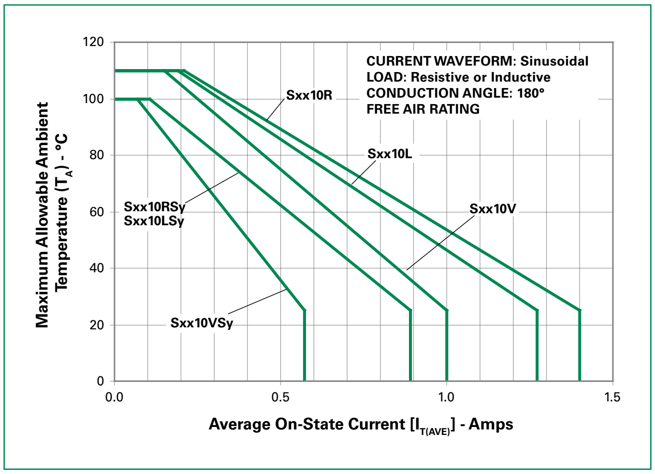


Figure 10: Maximum Allowable Ambient Temperature vs. Average On-State Current



Note: xx = voltage, y = sensitivity

Figure 11: Peak Capacitor Discharge Current

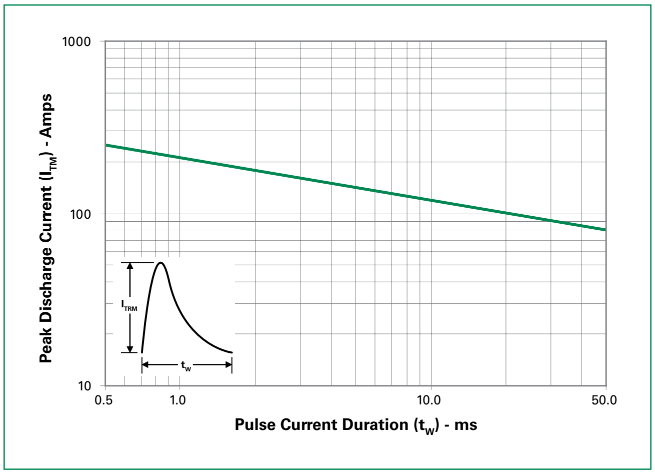


Figure 12: Peak Capacitor Discharge Current Derating

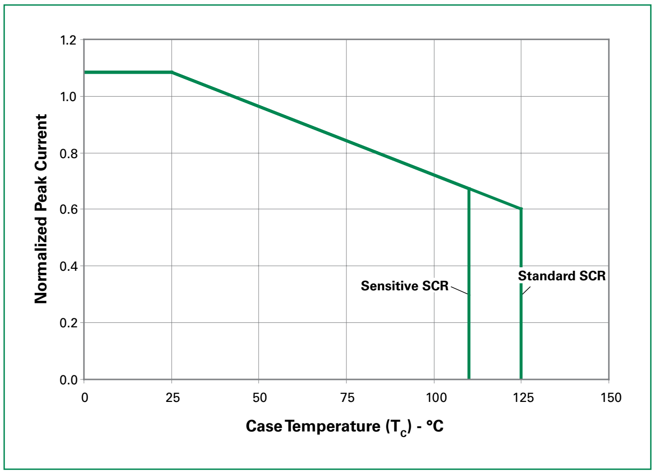
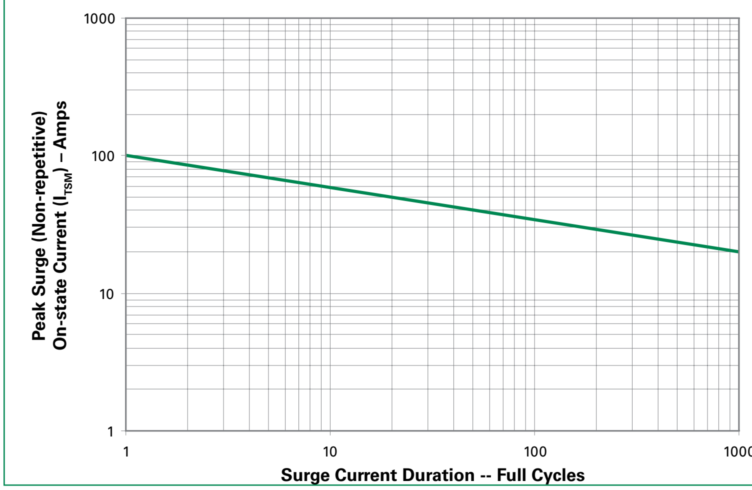


Figure 13: Surge Peak On-State Current vs. Number of Cycles

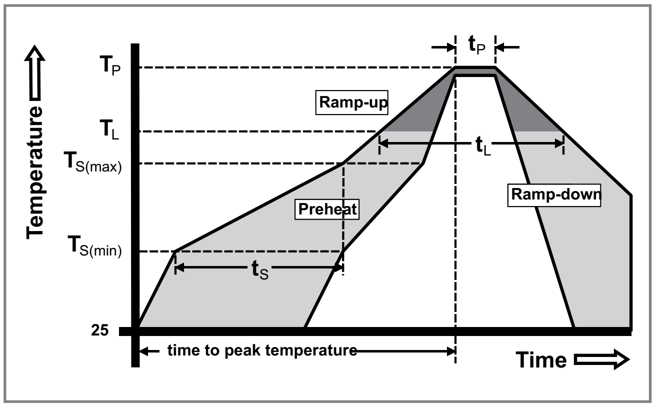


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

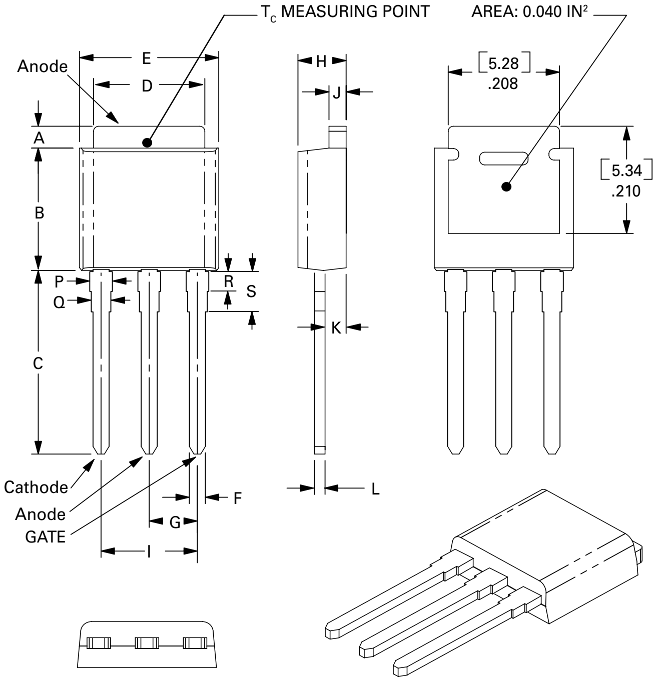
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx10RS2	X	X			0.2mA	Sensitive SCR	TO-220R
Sxx10LS2	X	X			0.2mA	Sensitive SCR	TO-220L
Sxx10VS2	X	X			0.2mA	Sensitive SCR	TO-251
Sxx10DS2	X	X			0.2mA	Sensitive SCR	TO-252
Sxx10RS3	X	X			0.5mA	Sensitive SCR	TO-220R
Sxx10LS3	X	X			0.5mA	Sensitive SCR	TO-220L
Sxx10VS3	X	X			0.5mA	Sensitive SCR	TO-251
Sxx10DS3	X	X			0.5mA	Sensitive SCR	TO-252
Sxx10R	X	X	X	X	15mA	Standard SCR	TO-220R
Sxx10L	X	X	X	X	15mA	Standard SCR	TO-220L
Sxx10V	X	X	X	X	15mA	Standard SCR	TO-251
Sxx10D	X	X	X	X	15mA	Standard SCR	TO-252

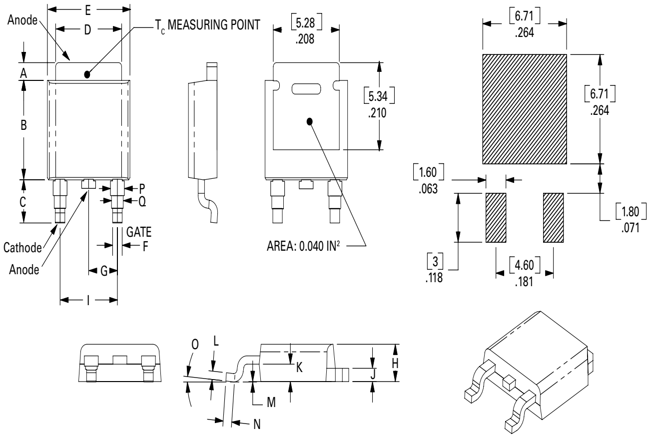
Note: xx = Voltage

Dimensions — TO-251AA (V/I-Package) — V/I-PAK Through Hole



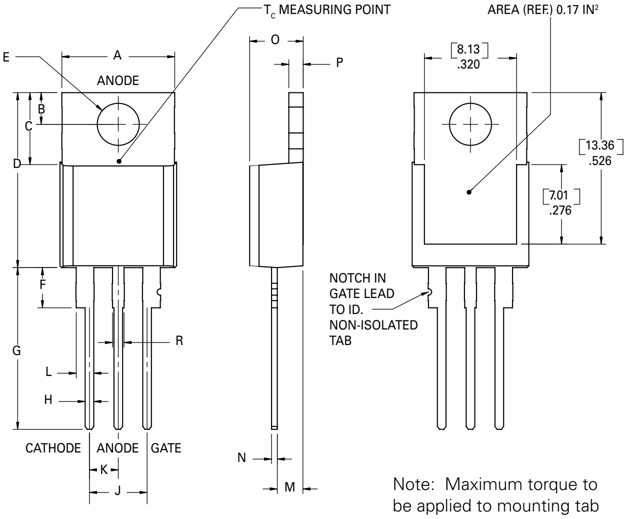
Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.037	0.040	0.043	0.94	1.01	1.09
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.035	0.037	0.039	0.90	0.95	1.00
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

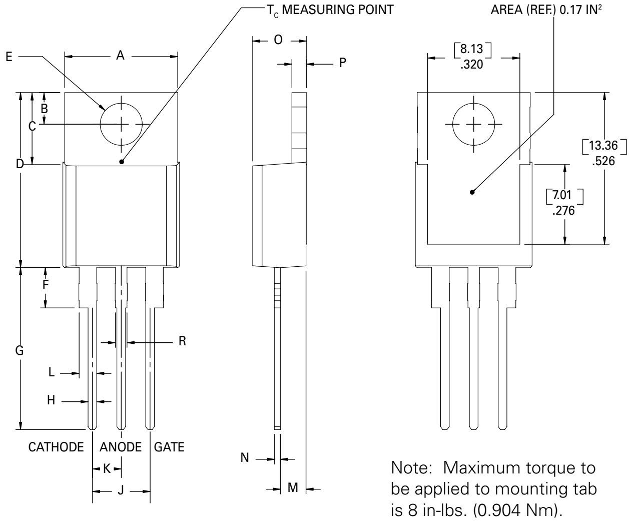
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

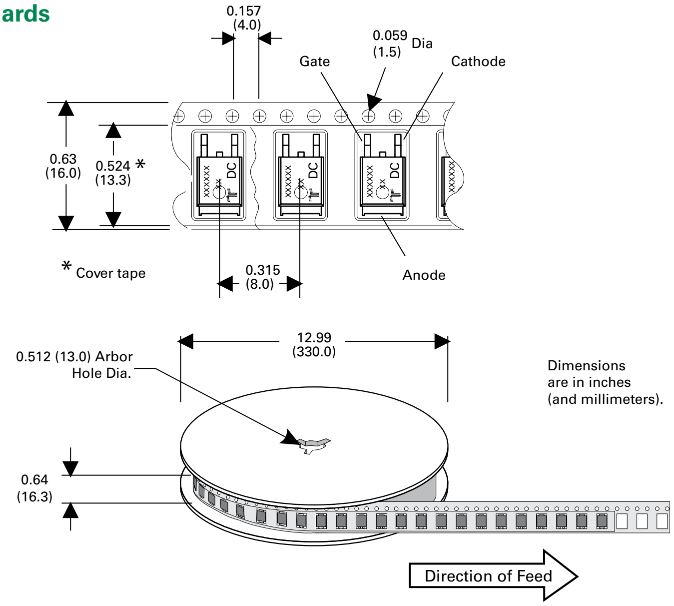
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx10L/Ryy	Sxx10L/Ryy	2.2 g	Bulk	500
Sxx10L/RyyTP	Sxx10L/Ryy	2.2 g	Tube	500 (50 per tube)
Sxx10DyyTP	Sxx10Dyy	0.3 g	Tube	750 (75 per tube)
Sxx10DyyRP	Sxx10Dyy	0.3 g	Embossed Carrier	2500
Sxx10VyyTP	Sxx10Vyy	0.4 g	Tube	750 (75 per tube)
Sxx10L/R	Sxx10L/R	2.2 g	Bulk	500
Sxx10L/RTP	Sxx10L/R	2.2 g	Tube	500 (50 per tube)
Sxx10DTP	Sxx10D	0.3 g	Tube	750 (75 per tube)
Sxx10DRP	Sxx10D	0.3 g	Embossed Carrier	2500
Sxx10VTP	Sxx10V	0.4 g	Tube	750 (75 per tube)

Note: xx = Voltage; yy = Sensitivity

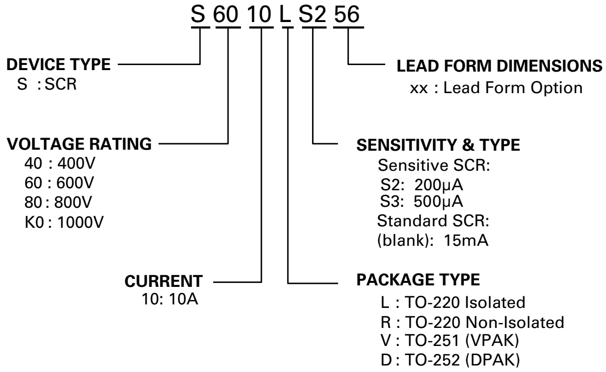
TO-252 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Dimensions
are in inches
(and millimeters).

Part Numbering System



DEVICE TYPE
S : SCR

VOLTAGE RATING
40 : 400V
60 : 600V
80 : 800V
K0 : 1000V

CURRENT
10: 10A

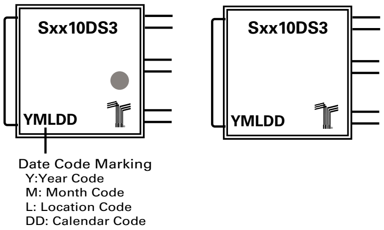
LEAD FORM DIMENSIONS
xx : Lead Form Option

SENSITIVITY & TYPE
Sensitive SCR:
S2: 200µA
S3: 500µA
Standard SCR:
(blank): 15mA

PACKAGE TYPE
L : TO-220 Isolated
R : TO-220 Non-Isolated
V : TO-251 (VPAK)
D : TO-252 (DPAK)

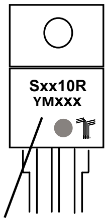
Part Marking System

TO-251AA - (V Package)
TO-252AA - (D Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

TO-220 AB - (L and R Package)



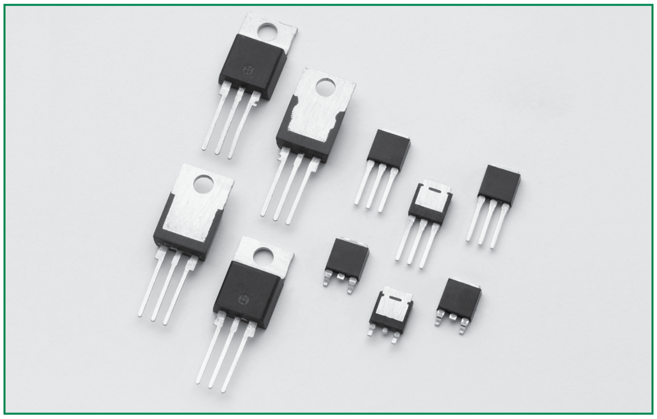
Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

Teccor® brand Thyristors
12 Amp Standard SCRs

Sxx12x Series

RoHS



Agency Approval

Agency	Agency File Number
® UL	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	12	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	20	mA

Additional Information

Datasheet	Resources	Samples

Description

Excellent unidirectional switches for phase control and general switching applications such as heating, motor control controls, converters / rectifiers and capacitive discharge ignitions.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

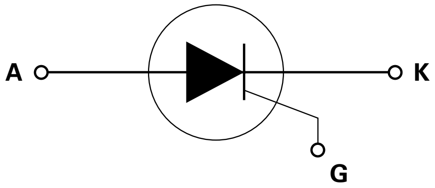
- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 120 A

Applications

Typical applications includes capacitive discharge system for motorcycle engine CDI, portable generator engine ignition, strobe lights and nailers, as well as generic rectifiers, battery voltage regulators and converters. Also controls for power tools, home/brown good and white goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Revised: 12/14/14

Absolute Maximum Ratings

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx12L	T_C = 72°C	12	A
		Sxx12R Sxx12D Sxx12V	T_C = 105°C		
$I_{T(AV)}$	Average on-state current	Sxx12L	T_C =72°C	7.6	A
		Sxx12R Sxx12D Sxx12V	T_C =105°C		
I_{TSM}	Peak non-repetitive surge current (single half cycle, T_J (initial) = 25°C)	Sxx12L Sxx12R	f = 50Hz	120	A
			f = 60Hz	130	
		Sxx12D Sxx12V	f = 50Hz	100	
			f = 60Hz	120	
I^2t	I^2t Value for fusing	Sxx12L Sxx12R	t_p = 8.3 ms	70	A^2s
		Sxx12D Sxx12V		60	
di/dt	Critical rate of rise of on-state current	f = 60Hz; T_J = 125°C		100	A/μs
I_{GM}	Peak gate current	T_J = 125°C		2	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.5	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value	Unit
I_{GT}	V_D = 12V R_L = 60 Ω		MAX.	20	mA
			MIN.	1	
V_{GT}			MAX.	1.5	V
dv/dt	V_D = V_{DRM}; gate open; T_J = 100°C	400V	MIN.	350	V/μs
		600V		300	
		800V		250	
		1000V		100	
	V_D = V_{DRM}; gate open; T_J = 125°C	400V		250	
		600V		225	
		800V		200	
V_{GD}	V_D = V_{DRM} R_L = 3.3 kΩ T_J = 125°C		MIN.	0.2	V
I_H	I_T = 200mA (initial)		MAX.	40	mA
t_q	I_T = 2A; t_p = 50μs; dv/dt = 5V/μs; di/dt = 30A/μs		MAX.	35	μs
t_{gt}	I_G = 2 x I_{GT} PW = 15μs I_T = 20A		TYP.	2	μs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	I_T = 24A; t_p = 380 µs			MAX.	1.6	V
I_{DRM} / I_{RRM}	V_{DRM} = V_{RRM}	T_J = 25°C	400 – 600V	MAX.	10	µA
			800 – 1000V		20	
		T_J = 100°C	400 – 800V		500	
			1000V		3000	
		T_J = 125°C	400 – 800V		1000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Sxx12L	3.2	°C/W
		Sxx12R	1.5	
		Sxx12V	1.6	
		Sxx12D	1.4	
$R_{\theta(J-A)}$	Junction to ambient	Sxx12L	50	°C/W
		Sxx12R	40	
		Sxx12V	70	

Note: xx = voltage

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

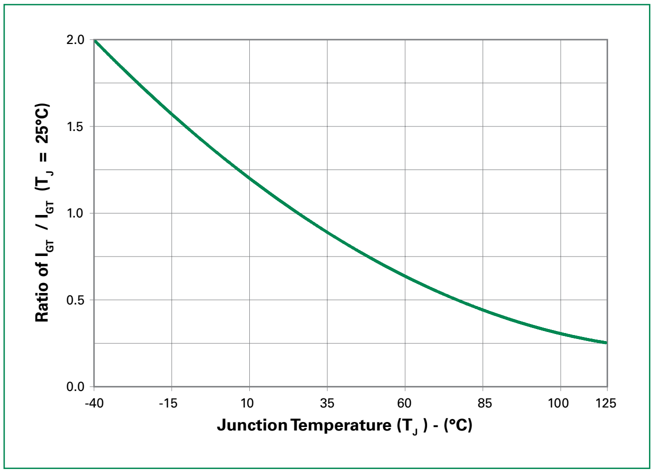


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

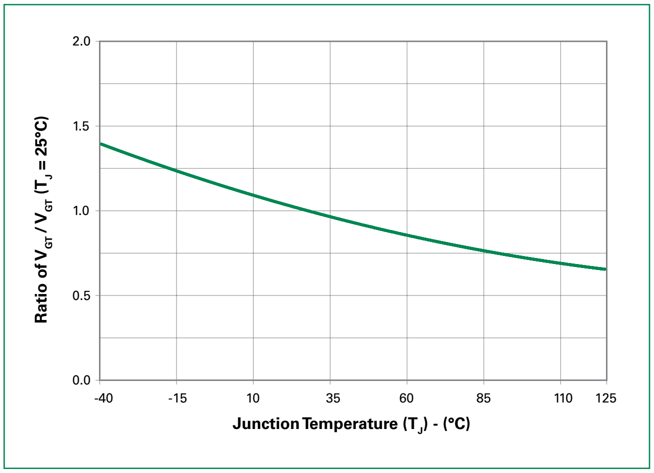


Figure 3: Normalized DC Holding Current vs. Junction Temperature

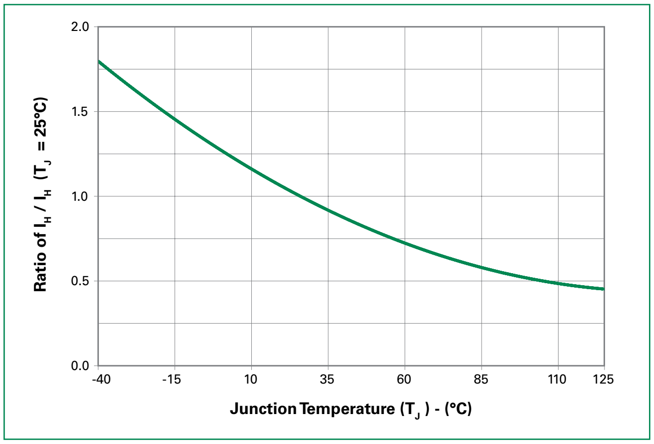


Figure 4: On-State Current vs. On-State Voltage (Typical)

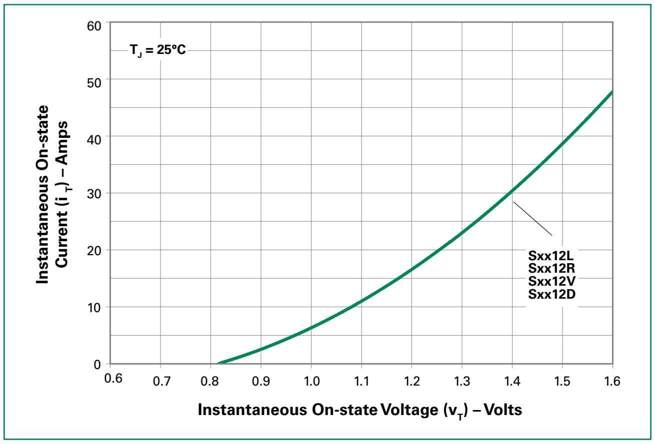


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

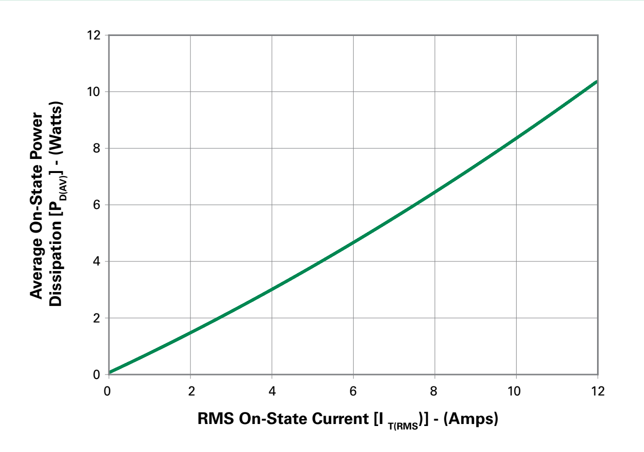


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

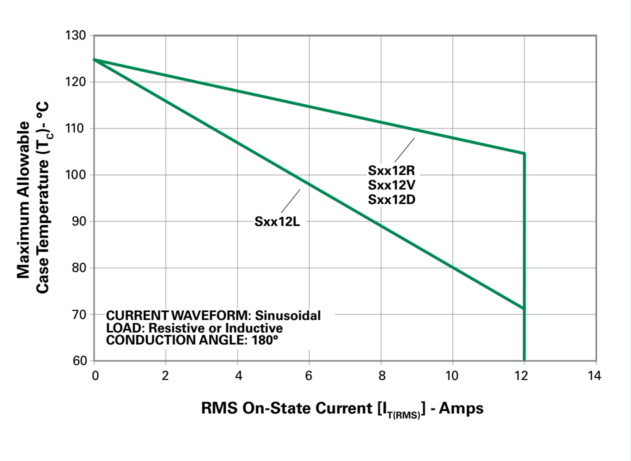


Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

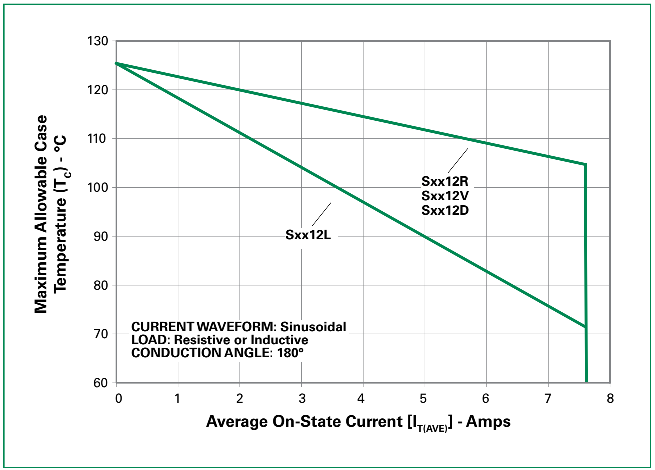
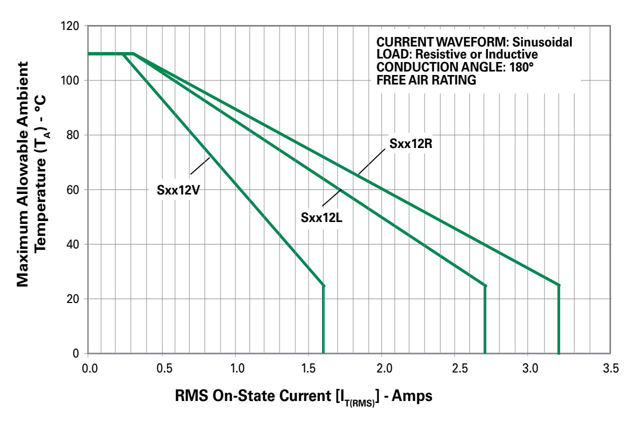


Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current



Note: xx = voltage

Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current

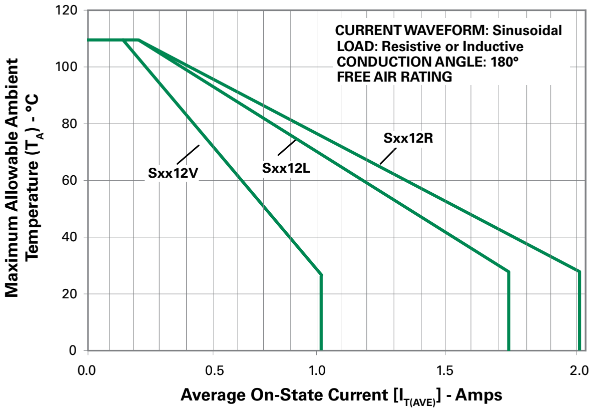


Figure 10: Peak Capacitor Discharge Current

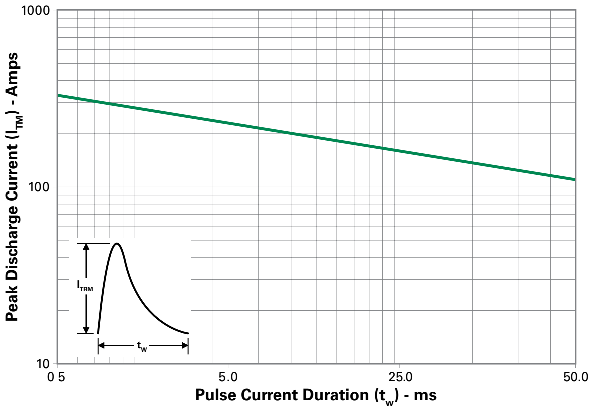


Figure 11: Peak Capacitor Discharge Current Derating

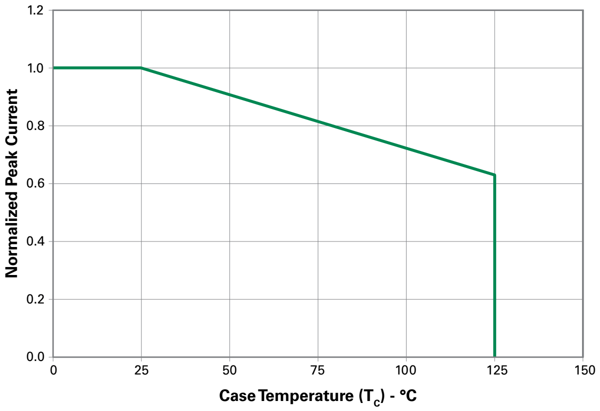
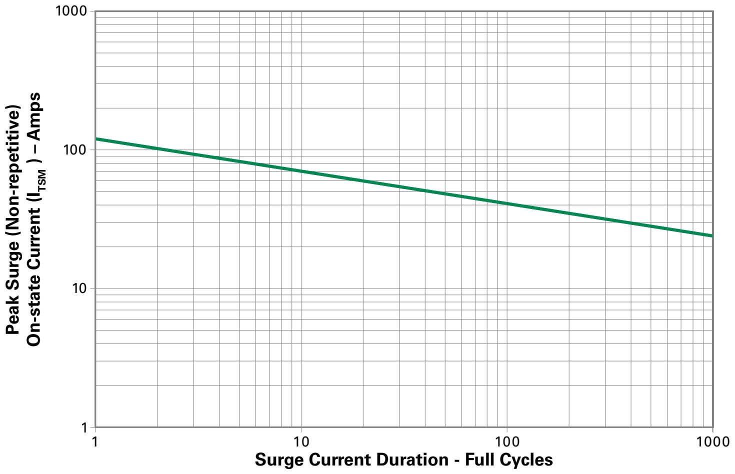


Figure 12: Surge Peak On-State Current vs. Number of Cycles



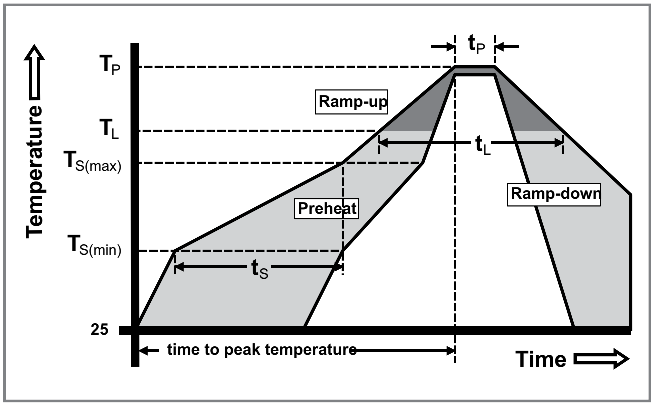
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

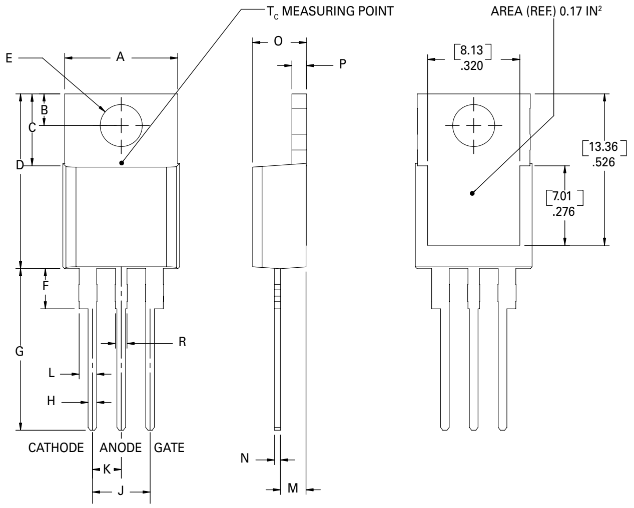
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

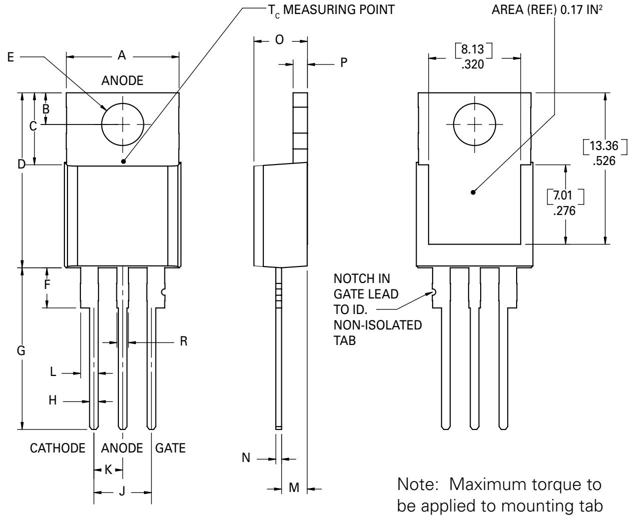
Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

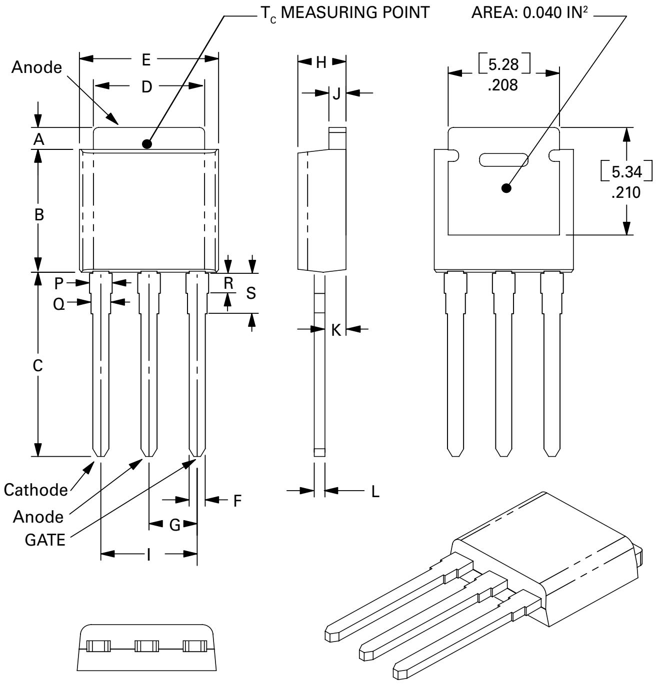
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

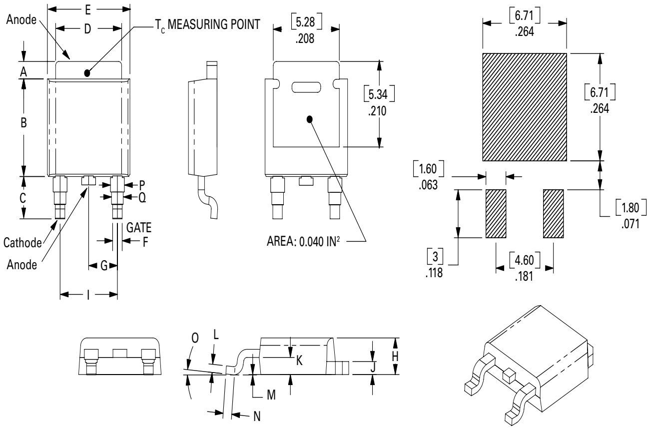
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO-251AA (V/I-Package) — V/I-PAK Through Hole



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.040	0.044	0.050	1.02	1.11	1.27
B	0.235	0.242	0.245	5.97	6.15	6.22
C	0.350	0.361	0.375	8.89	9.18	9.53
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.66	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.34	2.41
I	0.176	0.180	0.184	4.47	4.57	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.038	0.040	0.044	0.97	1.01	1.12
L	0.018	0.020	0.023	0.46	0.52	0.58
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11
R	0.034	0.039	0.044	0.86	1.00	1.11
S	0.074	0.079	0.084	1.86	2.00	2.11

Dimensions — TO-252AA (D-Package) — D-PAK Surface Mount



Dimension	Inches			Millimeters		
	Min	Typ	Max	Min	Typ	Max
A	0.040	0.043	0.050	1.02	1.09	1.27
B	0.235	0.243	0.245	5.97	6.16	6.22
C	0.106	0.108	0.113	2.69	2.74	2.87
D	0.205	0.208	0.213	5.21	5.29	5.41
E	0.255	0.262	0.265	6.48	6.65	6.73
F	0.027	0.031	0.033	0.69	0.80	0.84
G	0.087	0.090	0.093	2.21	2.28	2.36
H	0.085	0.092	0.095	2.16	2.33	2.41
I	0.176	0.179	0.184	4.47	4.55	4.67
J	0.018	0.020	0.023	0.46	0.51	0.58
K	0.038	0.040	0.044	0.97	1.02	1.12
L	0.018	0.020	0.023	0.46	0.51	0.58
M	0.000	0.000	0.004	0.00	0.00	0.10
N	0.021	0.026	0.027	0.53	0.67	0.69
O	0°	0°	5°	0°	0°	5°
P	0.042	0.047	0.052	1.06	1.20	1.32
Q	0.034	0.039	0.044	0.86	1.00	1.11

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx12L	X	X	X	X	20mA	Sensitive SCR	TO-220L
Sxx12R	X	X	X	X	20mA	Sensitive SCR	TO-220R
Sxx12V	X	X	X	X	20mA	Standard SCR	TO-251
Sxx12D	X	X	X	X	20mA	Standard SCR	TO-252

Note: xx = voltage

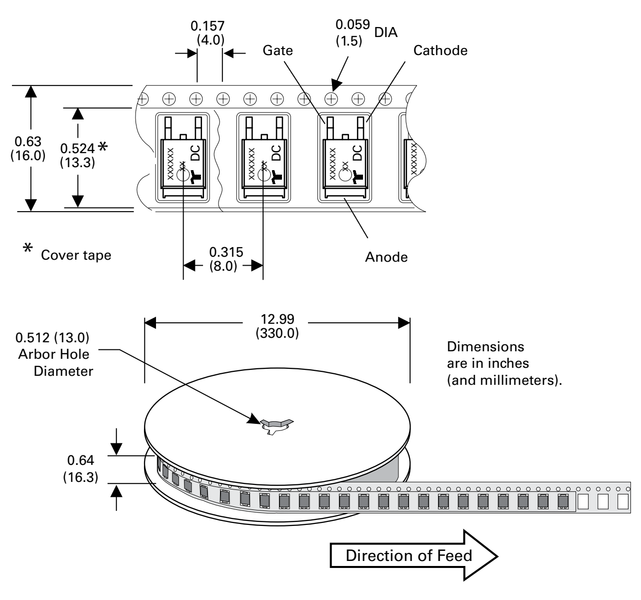
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx12LTP	Sxx12L	2.2 g	Tube	500 (50 per tube)
Sxx12R	Sxx12R	2.2 g	Bulk	500
Sxx12RTP	Sxx12R	2.2 g	Tube	500 (50 per tube)
Sxx12DTP	Sxx12D	0.3 g	Tube	750 (75 per tube)
Sxx12DRP	Sxx12D	0.3 g	Embossed Carrier	2500
Sxx12VTP	Sxx12V	0.4 g	Tube	750 (75 per tube)

Note: xx = Voltage

TO-252 Embossed Carrier Reel Pack (RP) Specifications

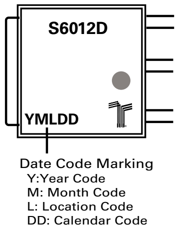
Meets all EIA-481-2 Standards



Dimensions are in inches (and millimeters).

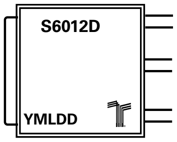
Part Marking System

TO-251AA - (V Package)

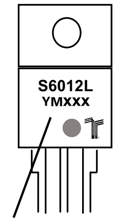


Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
DD: Calendar Code

TO-252AA - (D Package)

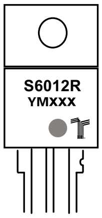


TO-220 AB - (L Package)

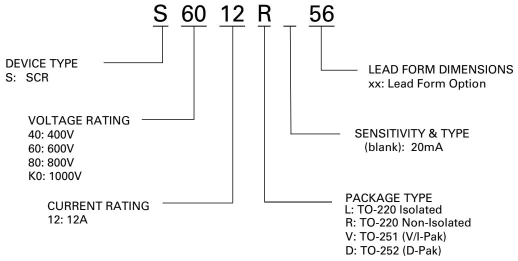


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

TO-220 AB - (R Package)



Part Numbering System



DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

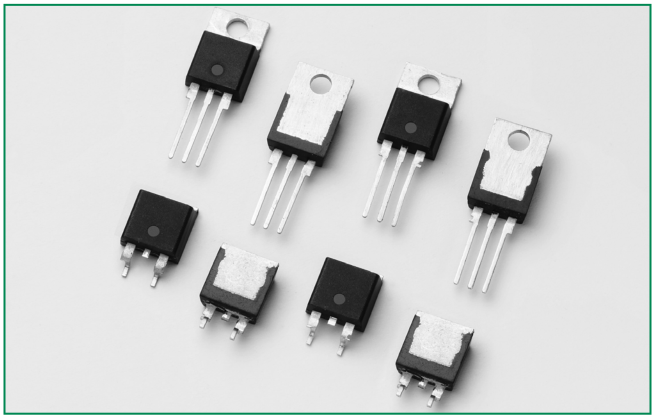
CURRENT RATING
12: 12A

LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY & TYPE
(blank): 20mA

PACKAGE TYPE
L: TO-220 Isolated
R: TO-220 Non-Isolated
V: TO-251 (V/I-Pak)
D: TO-252 (D-Pak)

Sxx15x & Sxx16x Series



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 225 A

Agency Approval

Agency	Agency File Number
UL®	L Package: E71639

Main Features

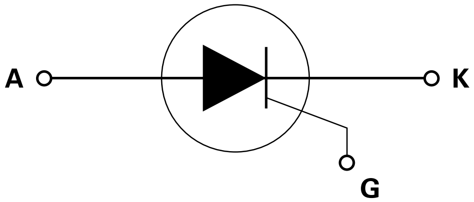
Symbol	Value	Unit
$I_{T(RMS)}$	15 & 16	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	30	mA

Applications

Typical applications are capacitive discharge systems for strobe lights, nailers, staplers and gas engine ignition. Also controls for power tools, home/brown goods and white goods appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Absolute Maximum Ratings — Standard SCRs

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx15L	T_C = 90°C	15	A
		Sxx16R Sxx16N	T_C = 110°C	16	
$I_{T(AV)}$	Average on-state current	Sxx15L	T_C = 90°C	9.5	A
		Sxx16R Sxx16N	T_C = 110°C	10.0	
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		188	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		225	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		210	A^2s
di/dt	Critical rate of rise of on-state current	f = 60 Hz ; T_J = 125°C		125	A/μs
I_{GM}	Peak gate current	T_J = 125°C		3	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.6	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Note: xx = voltage

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value Sxx15x Sxx16x	Unit
I_{GT}	V_D = 12V; R_L = 60 Ω		MAX.	30	mA
			MIN.	1	
V_{GT}			MAX.	1.5	V
dv/dt	$V_D = V_{DRM}$; gate open; T_J = 100°C	400V	MIN.	450	V/µs
		600V		425	
		800V		400	
		1000V		200	
	$V_D = V_{DRM}$; gate open; T_J = 125°C	400V		350	
		600V		325	
		800V		300	
V_{GD}	$V_D = V_{DRM}$ R_L = 3.3 kΩ T_J = 110°C		MIN.	0.2	V
I_H	I_T = 200mA (initial)		MAX.	40	mA
t_q	I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-30A/µs		MAX.	35	µs
t_{gt}	I_G = 2 x I_{GT} PW = 15µs I_T = 12A		TYP.	2	µs

Note: xx = voltage, x = package
(1) I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-30A/µs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	15A Device I_T = 30A; t_p = 380 µs			MAX.	1.6	V
	16A Device I_T = 32A; t_p = 380 µs					
I_{DRM} / I_{RRM}	$V_{DRM} = V_{RRM}$	T_J = 25°C	400 - 600V	MAX.	10	µA
			800 - 1000V		20	
		T_J = 100°C	400 - 600V		500	
			800V		1000	
			1000V		3000	
		T_J = 125°C	400 - 600V		1000	
			800V		2000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Sxx16R/ Sxx16N	1.1	°C/W
		Sxx15L	2.5	
$R_{\theta(J-A)}$	Junction to ambient	Sxx16R	40	°C/W
		Sxx15L	50	

Note: xx = voltage

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

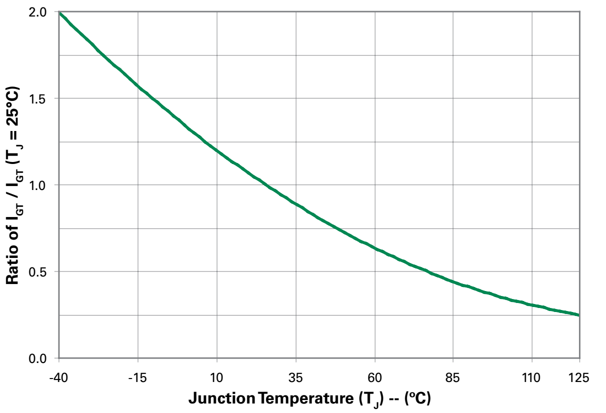


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

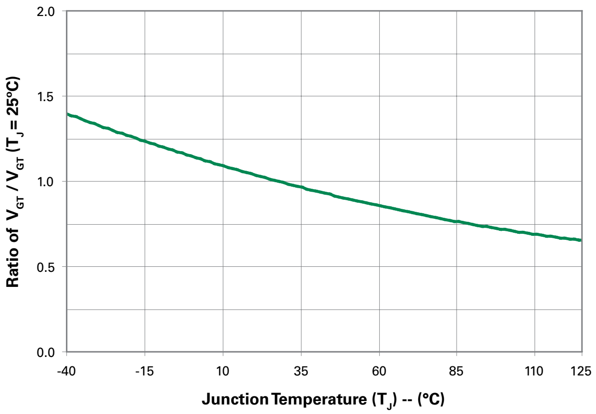


Figure 3: Normalized DC Holding Current vs. Junction Temperature

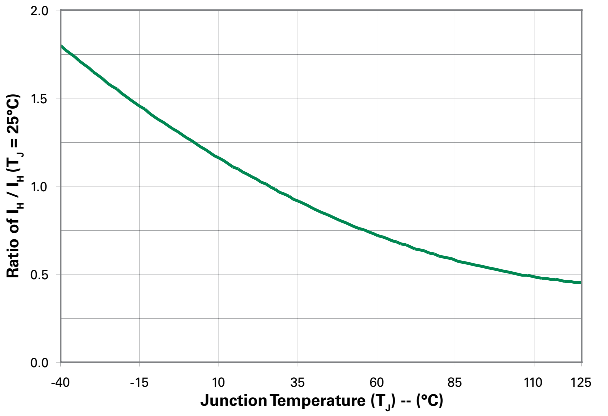


Figure 4: On-State Current vs. On-State Voltage (Typical)

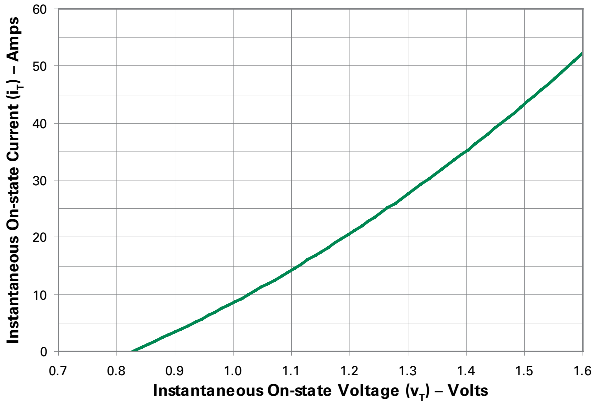


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

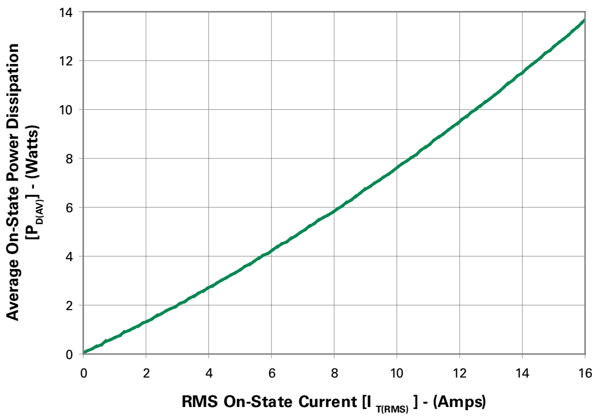


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

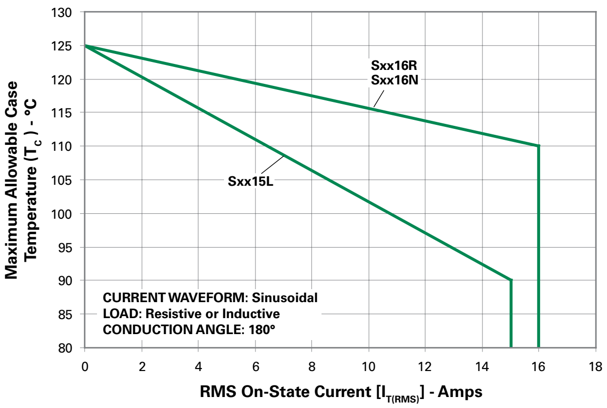


Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

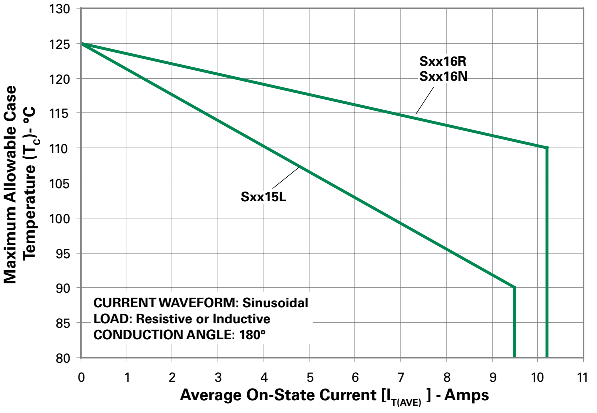


Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current

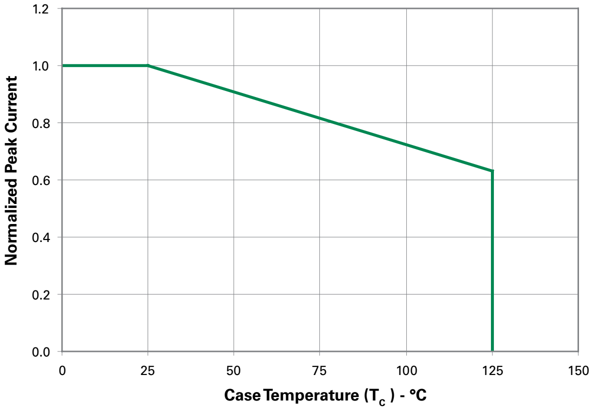
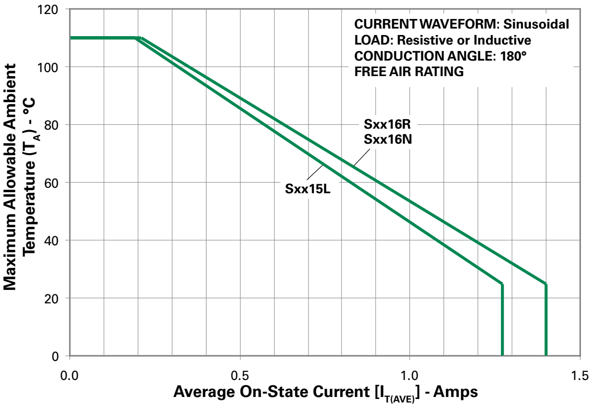


Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current



Note: xx = voltage

Figure 10: Peak Capacitor Discharge Current

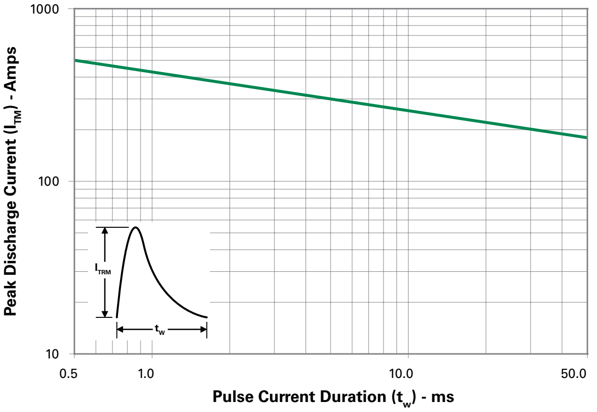


Figure 11: Peak Capacitor Discharge Current Derating

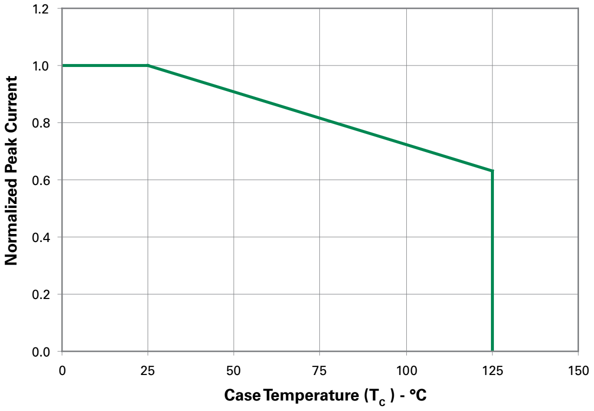
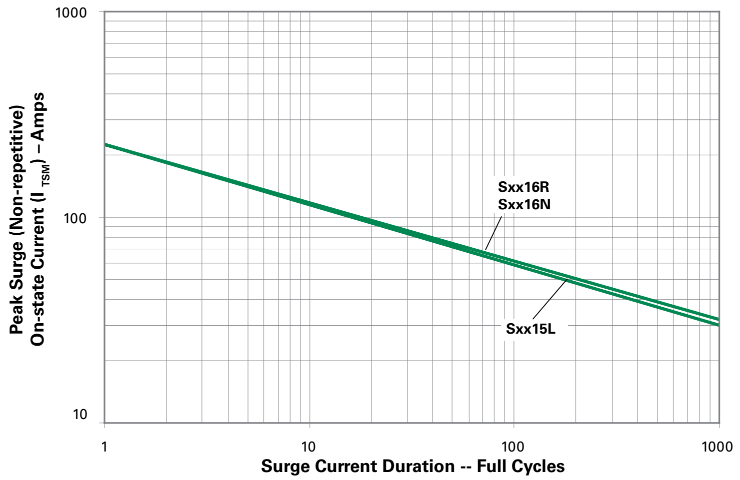


Figure 12: Surge Peak On-State Current vs. Number of Cycles

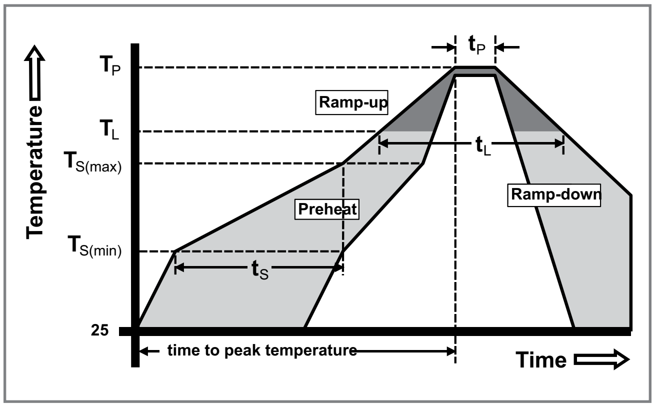


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Additional Information

Datasheet

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Samples

Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

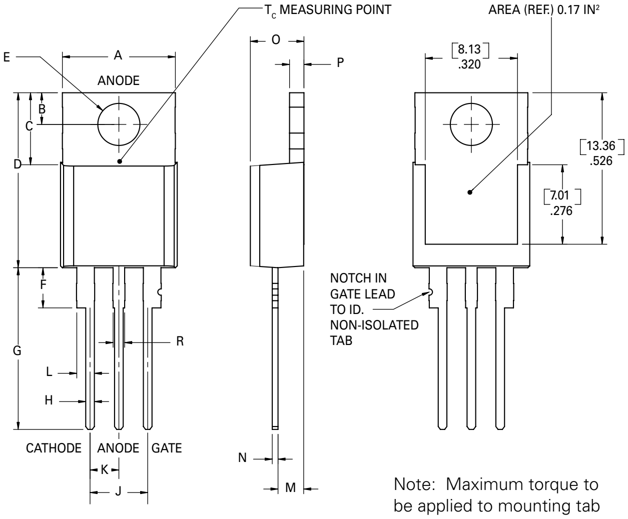
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwell-time at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

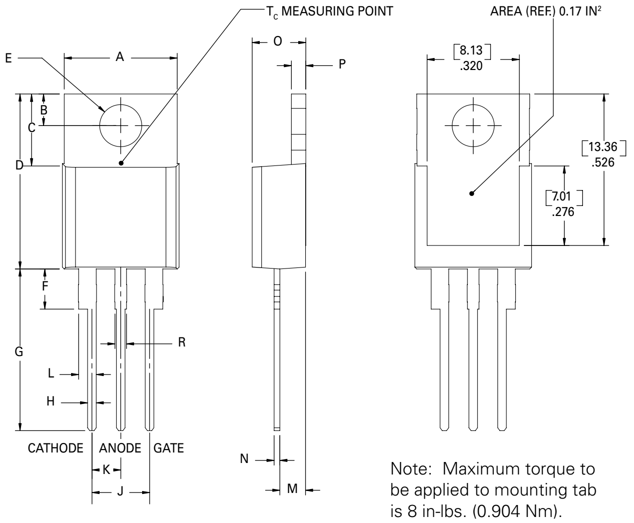
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

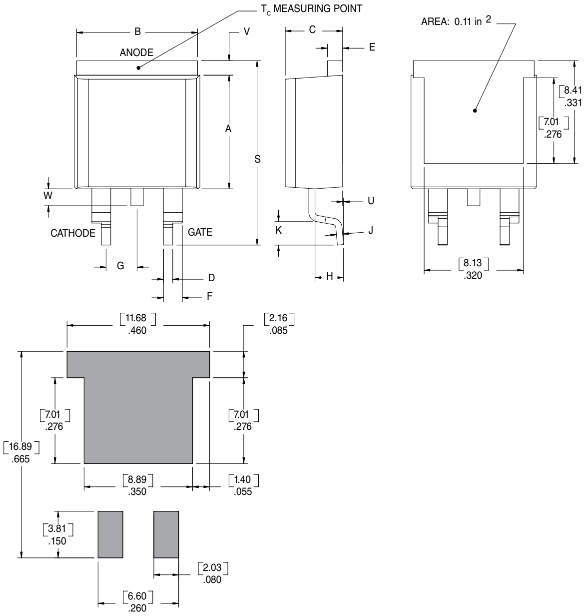
Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions — TO- 263AB (N-package) — D²-Pak Surface Mount



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx15L	X	X	X	X	30mA	Standard SCR	TO-220L
Sxx16R	X	X	X	X	30mA	Standard SCR	TO-220R
Sxx16N	X	X	X	X	30mA	Standard SCR	TO-263

Note: xx = Voltage

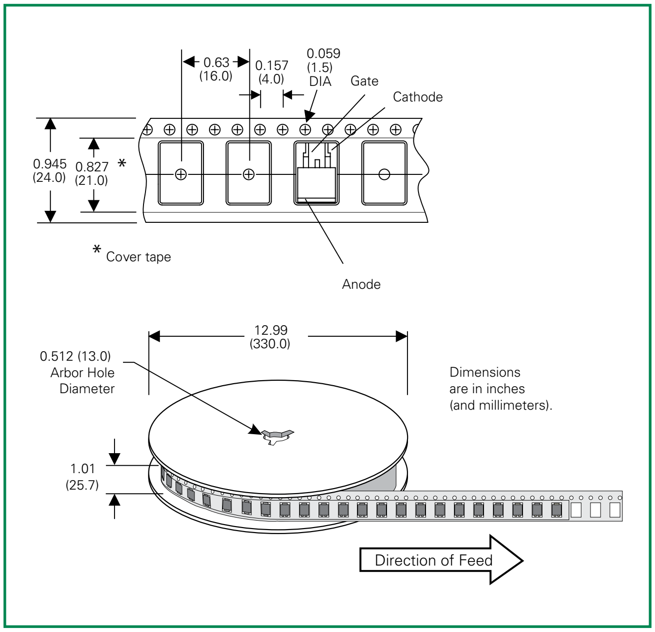
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx15L	Sxx15L	2.2 g	Bulk	500
Sxx15LTP	Sxx15L	2.2 g	Tube	500 (50 per tube)
Sxx16R	Sxx16R	2.2 g	Bulk	500
Sxx16RTP	Sxx16R	2.2 g	Tube	500 (50 per tube)
Sxx16NTP	Sxx16N	1.6 g	Tube	500 (50 per tube)
Sxx16NRP	Sxx16N	1.6 g	Embossed Carrier	500

Note: xx = Voltage

TO-263 Embossed Carrier Reel Pack (RP) Specs

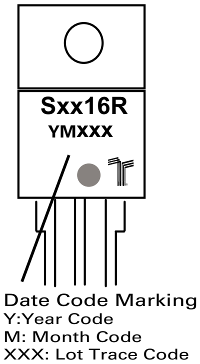
Meets all EIA-481-2 Standards



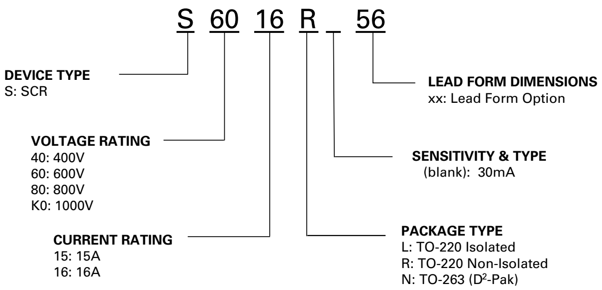
Dimensions are in inches (and millimeters).

Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)

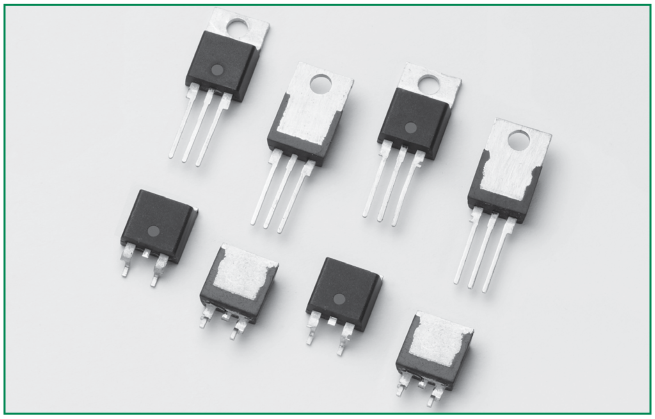


Part Numbering System



Sxx20x & Sxx25x Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 350 A

Applications

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

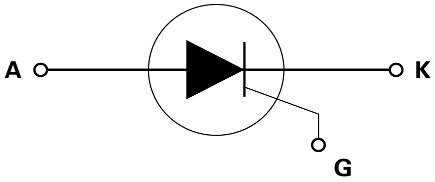
Agency Approval

Agency	Agency File Number
®ЯU	L Package: E71639

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	20 & 25	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	30 to 35	mA

Schematic Symbol



Additional Information

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Absolute Maximum Ratings — 20A SCR

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 80°C		20	A
$I_{T(AV)}$	Average on-state current	Sxx20x	T_C = 80°C	12.8	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		255	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		300	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		374	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C		125	A/μs
I_{GM}	Peak gate current	T_J = 125°C		3	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		0.6	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Absolute Maximum Ratings — 25A SCR

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx25L: T_C=75°C	25	A
		Sxx25R/Sxx25N: T_C=100°C		
$I_{T(AV)}$	Average on-state current	Sxx25L T_C = 75°C	16.0	A
		Sxx25R/Sxx25N T_C = 100°C		
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	300	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	350	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	510	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C	150	A/μs
I_{GM}	Peak gate current	T_J = 125°C	3.5	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C	0.8	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 125	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value		Unit
				Sxx20L	Sxx25x	
I_{GT}	V_D = 12V; R_L = 30Ω		MAX.	30	35	mA
			MIN.	1	1	
V_{GT}			MAX.	1.5		V
dv/dt	V_D = V_{DRM}; gate open; T_J = 100°C	400V	MIN.	450		V/μs
		600V		425		
		800V		400		
		1000V		200		
	V_D = V_{DRM}; gate open; T_J = 125°C	400V		350		
		600V		325		
		800V		300		
V_{GD}	V_D = V_{DRM}, R_L = 3.3 kΩ; T_J = 125°C		MIN.	0.2		V
I_H	I_T = 400mA (initial)		MAX.	40	50	mA
t_q	(1)		MAX.	35		μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 40A		TYP.	2		μs

Notes :
xx = voltage, x = package
(1) I_T=2A; t_p=50μs; dv/dt=5V/μs; di/dt=-30A/μs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	20A Device I_T = 40A; t_p = 380µs			MAX.	1.6	V
	25A Device I_T = 50A; t_p = 380µs					
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	400 – 600V	MAX.	10	µA
			800 – 1000V		20	
		T_J = 100°C	400 – 600V		500	
			800V		1000	
			1000V		3000	
		T_J = 125°C	400 – 600V		1000	
			800V		2000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Sxx25R / Sxx25N	1.0	°C/W
		Sxx20L	2.4	
		Sxx25L	2.35	
$R_{\theta(J-A)}$	Junction to ambient	Sxx25R	40	°C/W
		Sxx20L / Sxx25L	50	

Note: xx = voltage

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

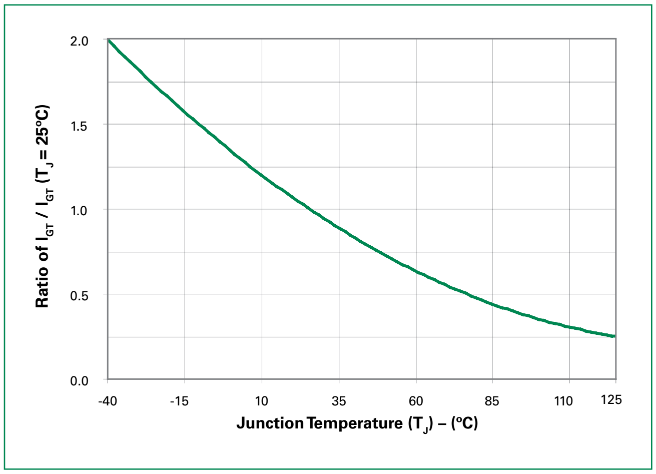


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

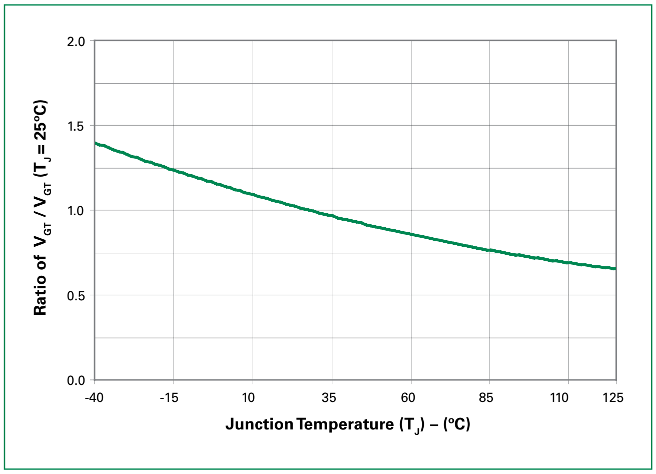


Figure 3: Normalized DC Holding Current vs. Junction Temperature

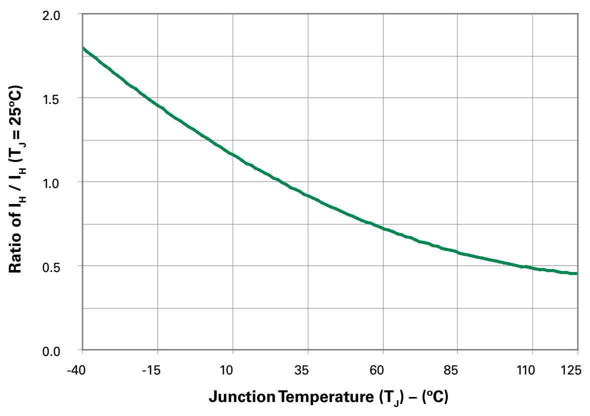


Figure 4: On-State Current vs. On-State Voltage (Typical)

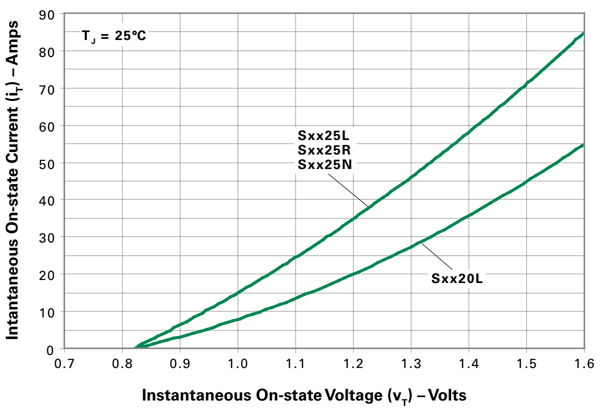


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

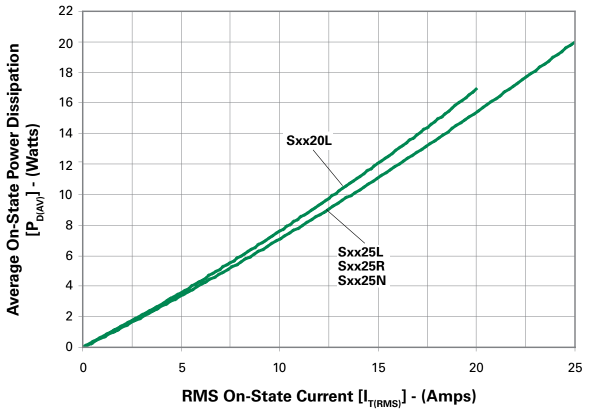


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

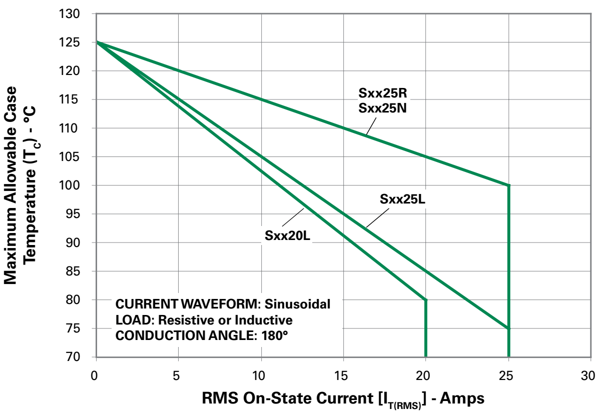


Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

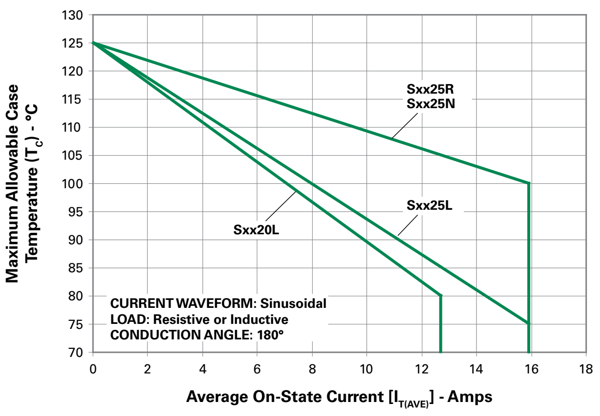


Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current

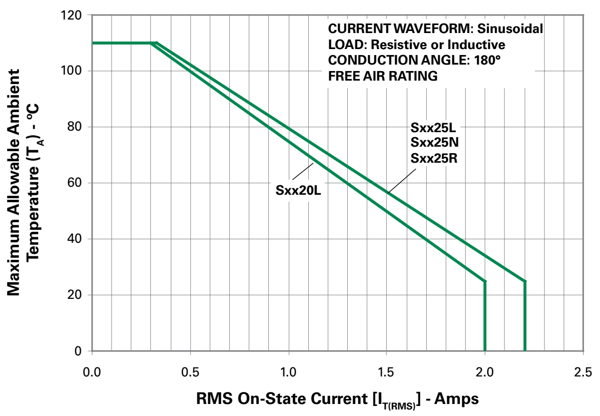
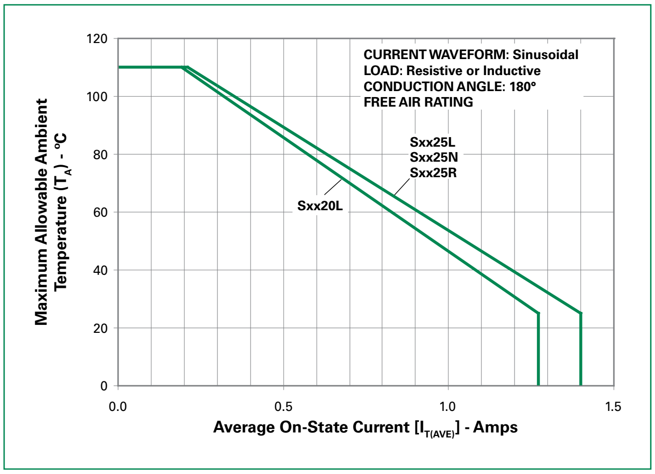


Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current



Note: xx = voltage

Figure 10: Peak Capacitor Discharge Current

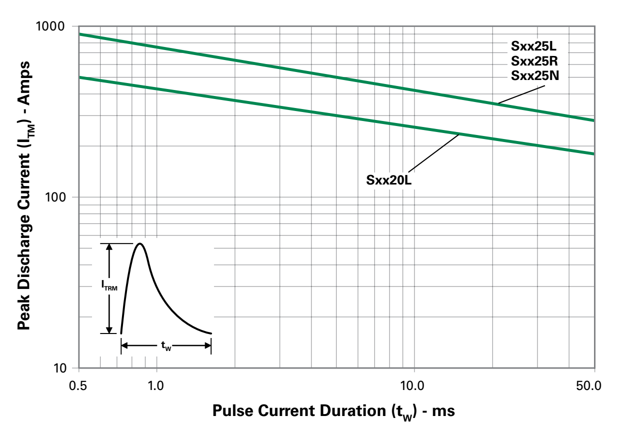


Figure 11: Peak Capacitor Discharge Current Derating

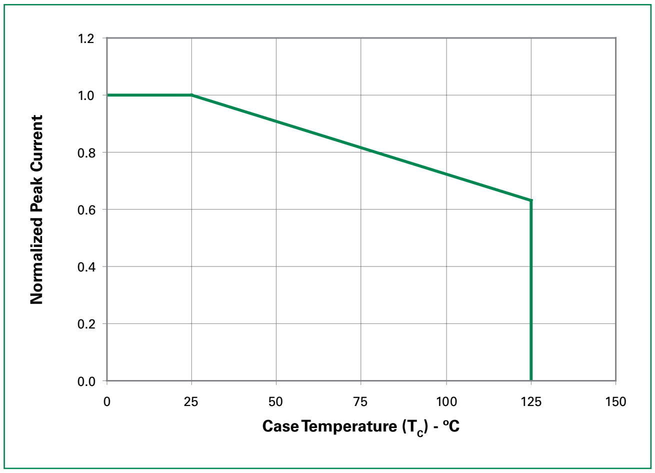
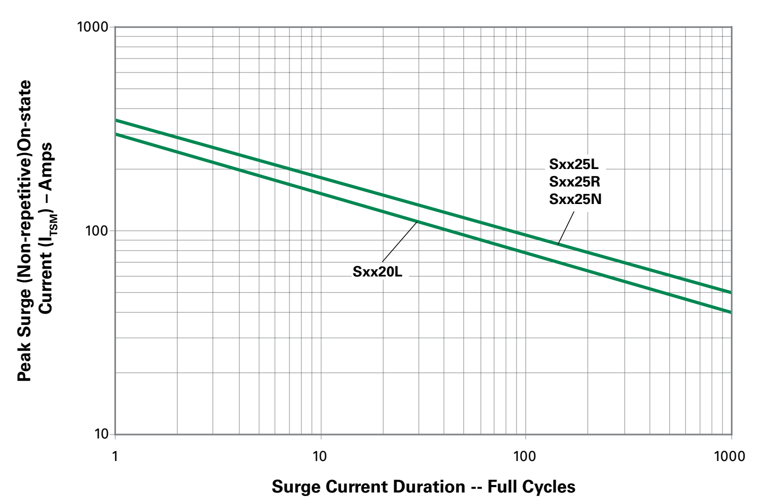


Figure 12: Surge Peak On-State Current vs. Number of Cycles

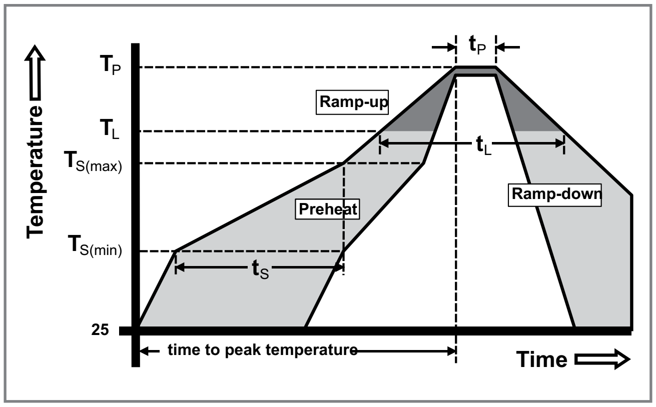


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

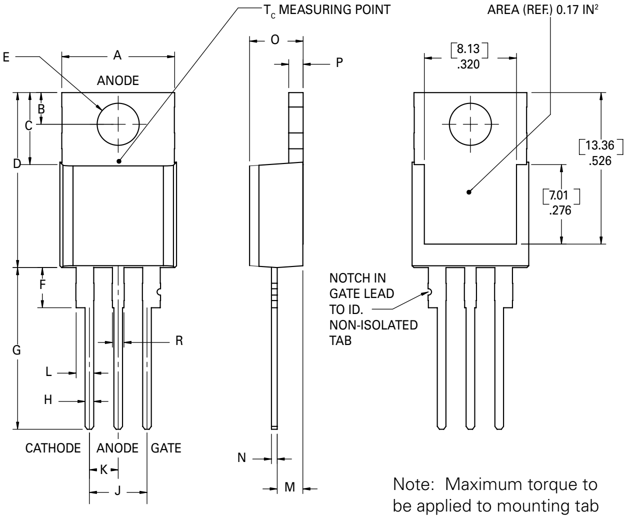
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwelltime at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

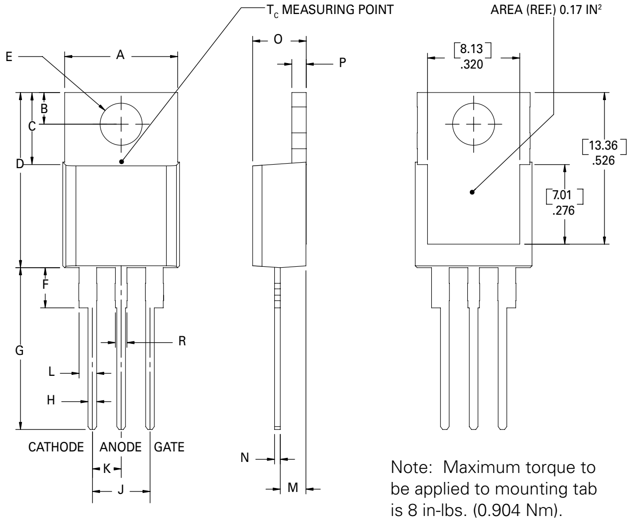
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

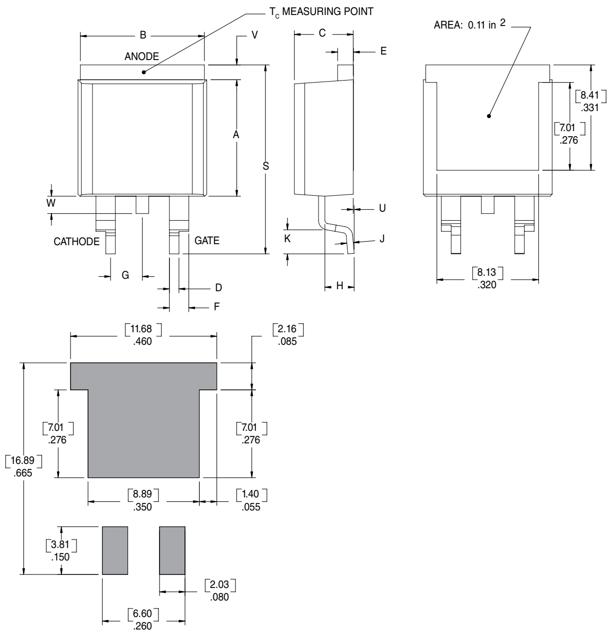
Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions –TO- 263AB (N-package) — D^2-Pak Surface Mount



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.64	0.89
E	0.045	0.060	1.14	1.52
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.092	0.102	2.34	2.59
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.88
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.016	1.78

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx20L	X	X	X	X	30mA	Standard SCR	TO-220L
Sxx25L	X	X	X	X	35mA	Standard SCR	TO-220L
Sxx25R	X	X	X	X	35mA	Standard SCR	TO-220R
Sxx25N	X	X	X	X	35mA	Standard SCR	TO-263

Note: xx = Voltage

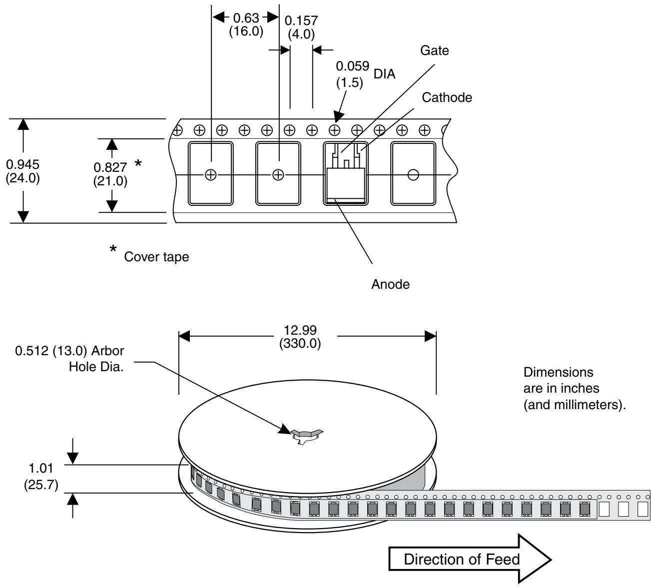
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx20L	Sxx20L	2.2g	Bulk	500
Sxx20LTP	Sxx20L	2.2g	Tube	500 (50 per tube)
Sxx25L	Sxx25L	2.2g	Bulk	500
Sxx25LTP	Sxx25L	2.2g	Tube	500 (50 per tube)
Sxx25R	Sxx25R	2.2g	Bulk	500
Sxx25RTP	Sxx25R	2.2g	Tube	500 (50 per tube)
Sxx25NTP	Sxx25N	1.6g	Tube	500 (50 per tube)
Sxx25NRP	Sxx25N	1.6g	Embossed Carrier	500

Note: xx = Voltage

TO-263 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-2 Standards



Part Numbering System

S 60 20 L _ 56

DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
20: 20A
25: 25A

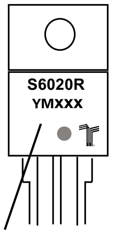
LEAD FORM DIMENSIONS
xx: Lead Form Option

SENSITIVITY & TYPE
(blank): Sxxx20L = 30mA
Sxxx25x = 35mA

PACKAGE TYPE
L: TO-220 Isolated
R: TO-220 Non-Isolated
N: TO-263 (D^2-Pak)

Part Marking System

TO-220 AB - (L and R Package)
TO-263 AB - (N Package)

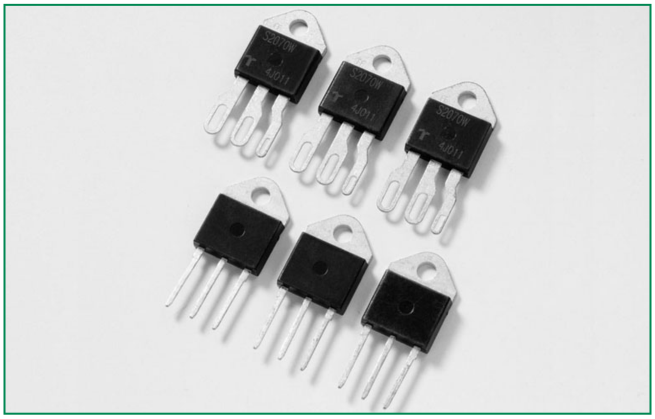


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Revised: 12/14/14

Sxx35x Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 500 A

Agency Approval

Agency	Agency File Number
®ЯU	J & K Packages: E71639

Main Features

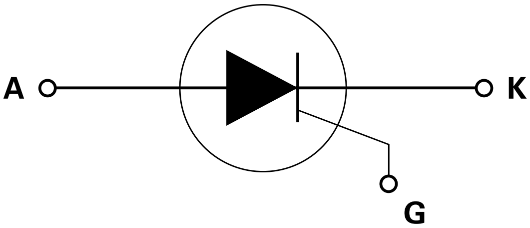
Symbol	Value	Unit
$I_{T(RMS)}$	35	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	40	mA

Applications

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 95°C	35	A
$I_{T(AV)}$	Average on-state current	T_C = 95°C	22.0	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	425	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	500	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	1035	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C	150	A/μs
I_{GM}	Peak gate current	T_J = 125°C	3.5	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C	0.8	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 125	°C

Revised: 12/14/14

Electrical Characteristics (T$_J$ = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value	Unit
I_{GT}	V_D = 12V; R_L = 30Ω		MAX.	40	mA
			MIN.	5	
V_{GT}			MAX.	1.5	V
dv/dt	V_D = V_{DRM}; gate open; T_J = 100°C	400V	MIN.	450	V/µs
		600V		425	
		800V		400	
		1000V		200	
	V_D = V_{DRM}; gate open; T_J = 125°C	400V		350	
		600V		325	
		800V		300	
V_{GD}	V_D = V_{DRM}; R_L = 3.3 kΩ; T_J = 125°C		MIN.	0.2	V
I_H	I_T = 400mA (initial)		MAX.	50	mA
t_q	(1)		MAX.	35	µs
t_{gt}	I_G = 2 x I_{GT}; PW = 15µs; I_T = 70A		TYP.	2	µs

Notes :
(1) I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-30A/µs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	I_T = 70A; t_p = 380µs			MAX.	1.8	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	400 – 600V	MAX.	10	µA
			800 – 1000V		20	
		T_J = 100°C	400 – 600V		1000	
			800V		1500	
			1000V		3000	
		T_J = 125°C	400 – 600V		2000	
			800V		3000	

Thermal Resistance

Symbol	Parameter	Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	0.7	°C/W

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

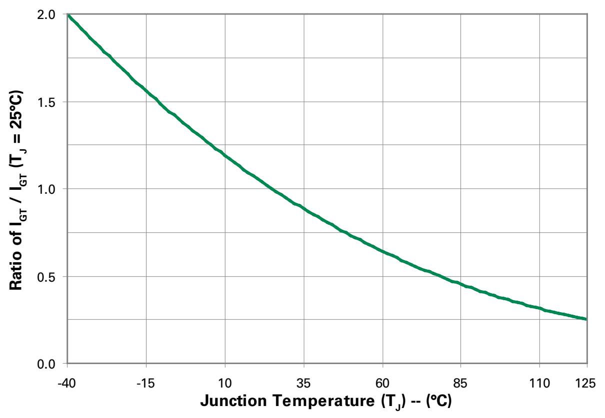


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

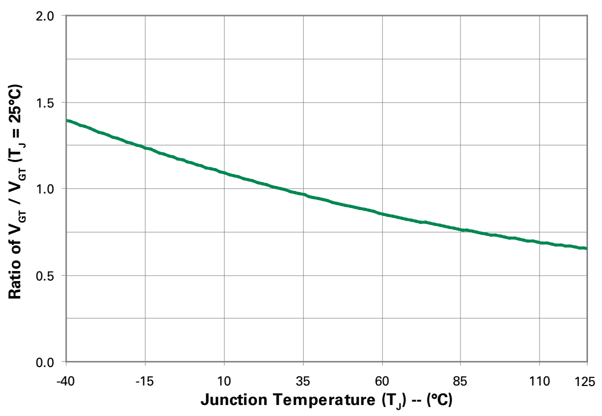


Figure 3: Normalized DC Holding Current vs. Junction Temperature

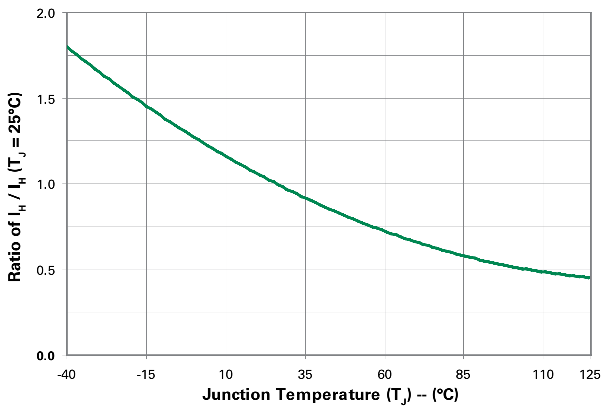


Figure 4: On-State Current vs. On-State Voltage (Typical)

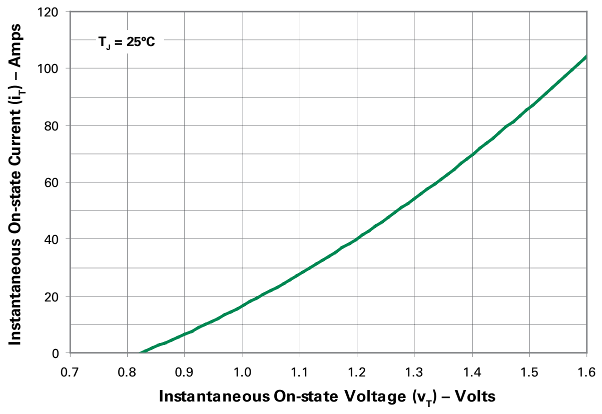


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

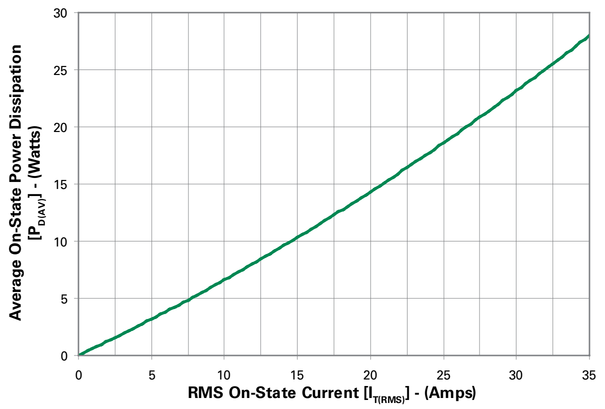
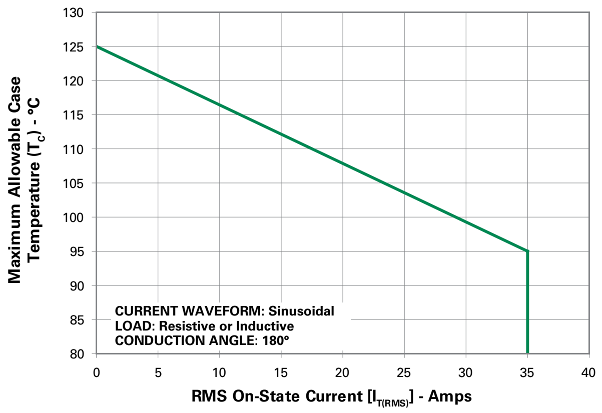


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current



CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 180°

Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

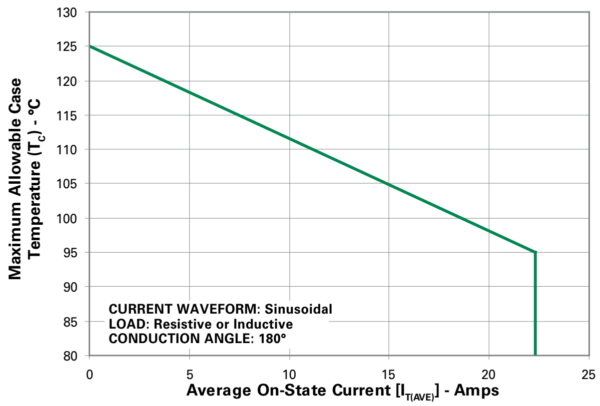


Figure 8: Peak Capacitor Discharge Current

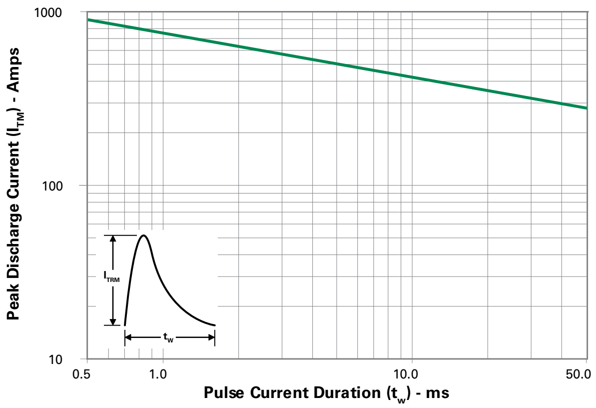


Figure 9: Peak Capacitor Discharge Current Derating

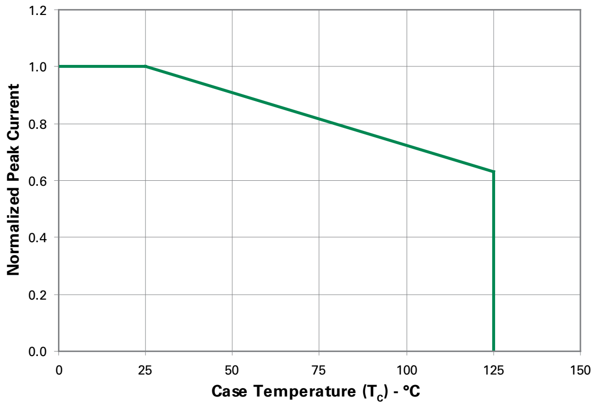
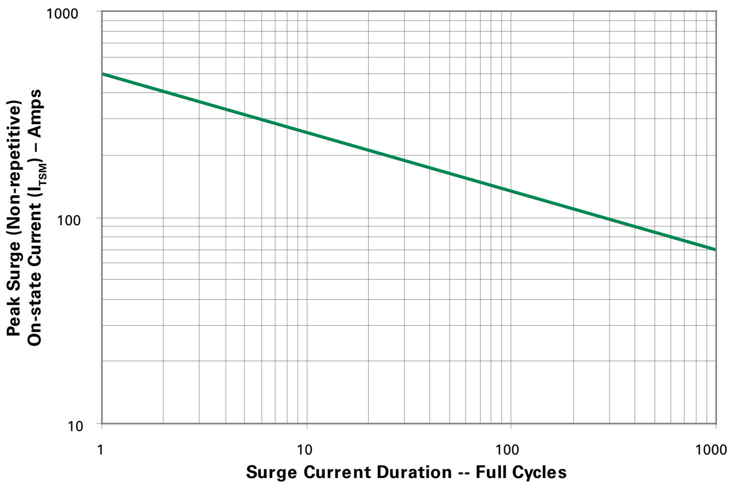


Figure 10: Surge Peak On-State Current vs. Number of Cycles



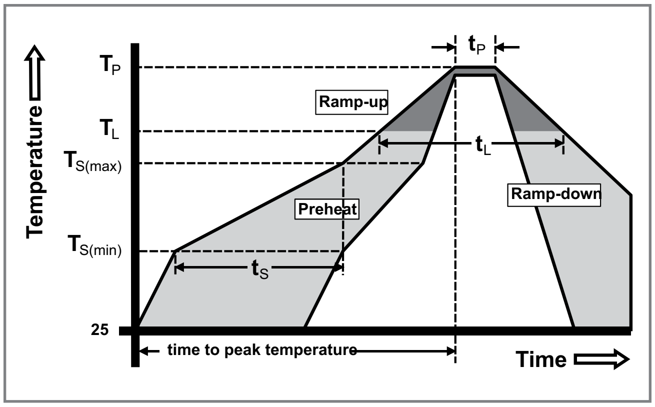
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

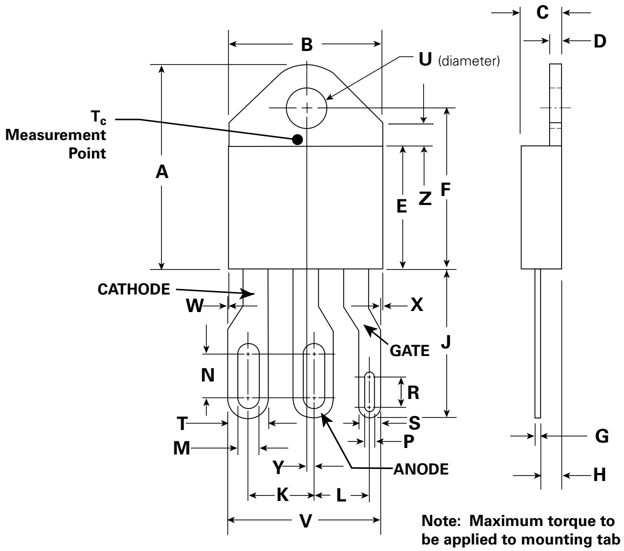
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwelltime at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

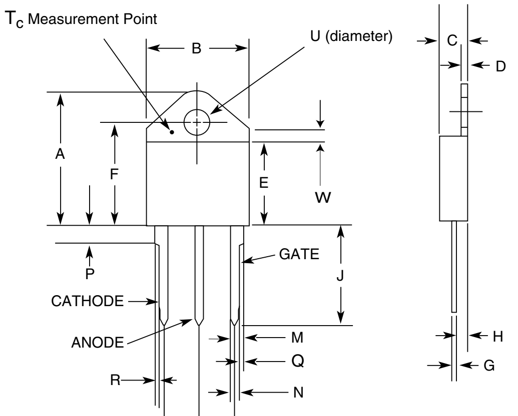
Dimensions – TO- 218X (J Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.256	0.264	6.50	6.71
L	0.220	0.228	5.58	5.79
M	0.080	0.088	2.03	2.24
N	0.169	0.177	4.29	4.49
P	0.034	0.042	0.86	1.07
R	0.113	0.121	2.87	3.07
S	0.086	0.096	2.18	2.44
T	0.156	0.166	3.96	4.22
U	0.164	0.165	4.10	4.20
V	0.603	0.618	15.31	15.70
W	0.000	0.005	0.00	0.13
X	0.003	0.012	0.07	0.30
Y	0.028	0.032	0.71	0.81
Z	0.085	0.095	2.17	2.42

Dimensions – TO- 218AC (K Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.058	0.068	1.47	1.73
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
Q	0.008	0.016	0.20	0.41
R	0.008	0.016	0.20	0.41
U	0.164	0.165	4.10	4.20
W	0.085	0.095	2.17	2.42

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx35K	X	X	X	X	40mA	Standard SCR	TO-218AC
Sxx35J	X	X	X		40mA	Standard SCR	TO-218X

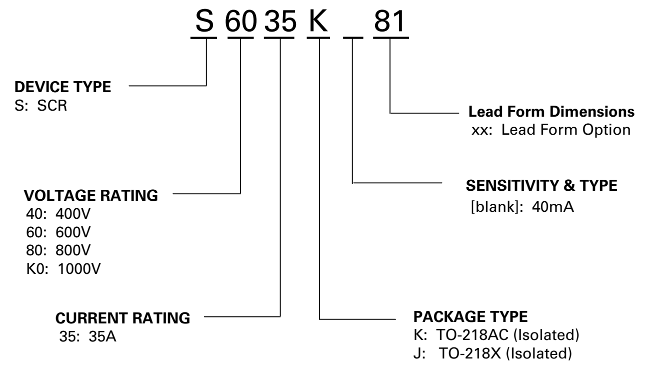
Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx35KTP	Sxx35K	4.40g	Tube	250 (25 per tube)
Sxx35JTP	Sxx35J	5.23g	Tube	250 (25 per tube)

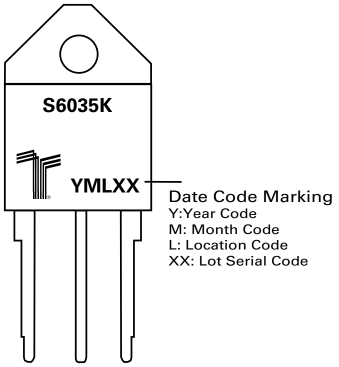
Note: xx = Voltage

Part Numbering System



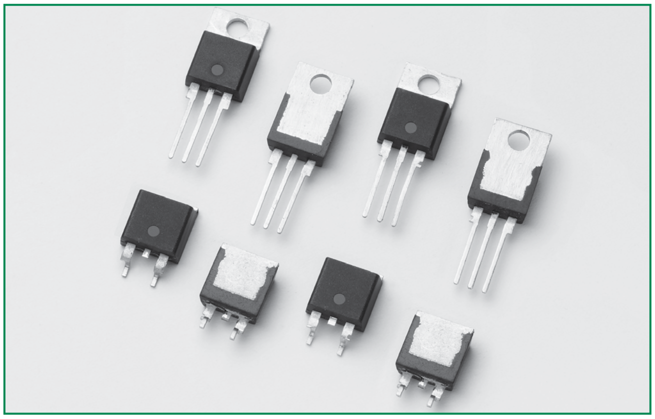
Part Marking System

TO-218 AC - (K Package)
TO-218 X - (J Package)



Sxx40x Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 520 A

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	40	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	40	mA

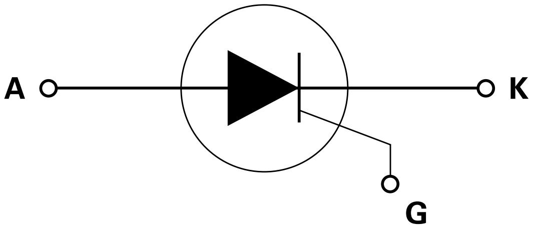
Applications

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Additional Information

Datasheet | **Resources** | **Samples**

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 100°C	40	A
$I_{T(AV)}$	Average on-state current	T_C = 100°C	25.0	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	430	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	520	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	1122	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C	175	A/μs
I_{GM}	Peak gate current	T_J = 125°C	3.5	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C	0.8	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 125	°C

Revised: 12/14/14

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value	Unit
I_{GT}	$V_D = 12V$; $R_L = 30\ \Omega$		MAX.	40	mA
			MIN.	5	
V_{GT}			MAX.	1.5	V
dv/dt	$V_D = V_{DRM}$; gate open; $T_J = 100°C$	400V	MIN.	650	V/µs
		600V		600	
		800V		500	
		1000V		250	
	$V_D = V_{DRM}$; gate open; $T_J = 125°C$	400V		550	
		600V		500	
		800V		475	
V_{GD}	$V_D = V_{DRM}$; $R_L = 3.3\ k\Omega$; $T_J = 125°C$		MIN.	0.2	V
I_H	$I_T = 400mA$ (initial)		MAX.	60	mA
t_q	(1)		MAX.	35	µs
t_{gt}	$I_G = 2 \times I_{GT}$; PW = 15µs; $I_T = 80A$		TYP.	2.5	µs

Note :
(1) I_T=2A; t_p=50µs; dv/dt=5V/µs; di/dt=-30A/µs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	$I_T = 80A$; $t_p = 380µs$			MAX.	1.8	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	$T_J = 25°C$	400 – 600V	MAX.	10	µA
			800 V		20	
			1000 V		30	
		$T_J = 100°C$	400 – 600V		1000	
			800V		1500	
			1000V		5000	
		$T_J = 125°C$	400 – 600V		2000	
			800V		3000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J\text{-}C)}$	Junction to case (AC)	Sxx40R / Sxx40N	0.6	°C/W
$R_{\theta(J\text{-}A)}$	Junction to ambient	Sxx40R	40	°C/W

Note: xx = voltage

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

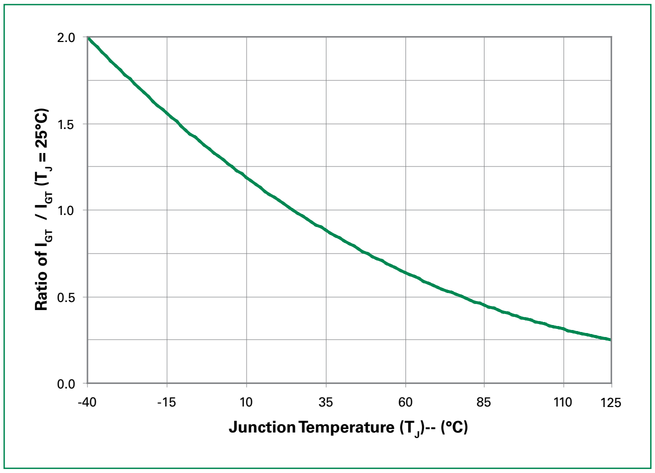


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

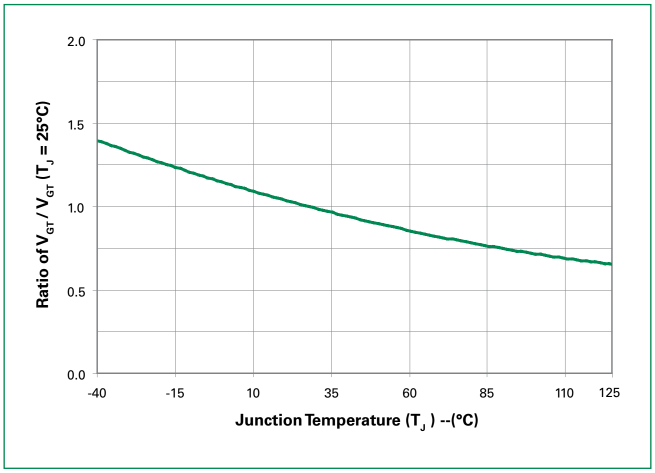


Figure 3: Normalized DC Holding Current vs. Junction Temperature

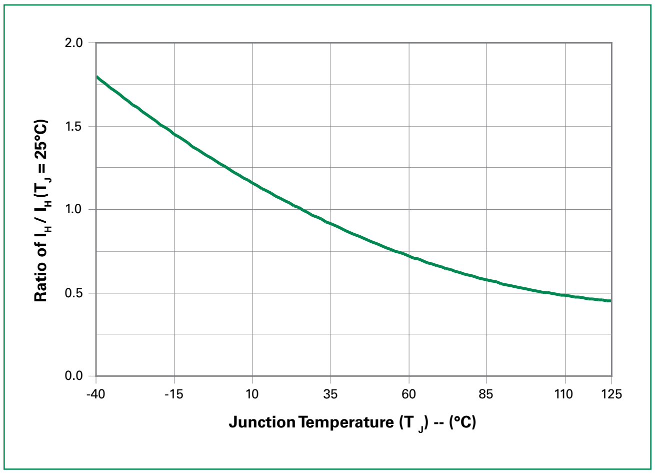


Figure 4: On-State Current vs. On-State Voltage (Typical)

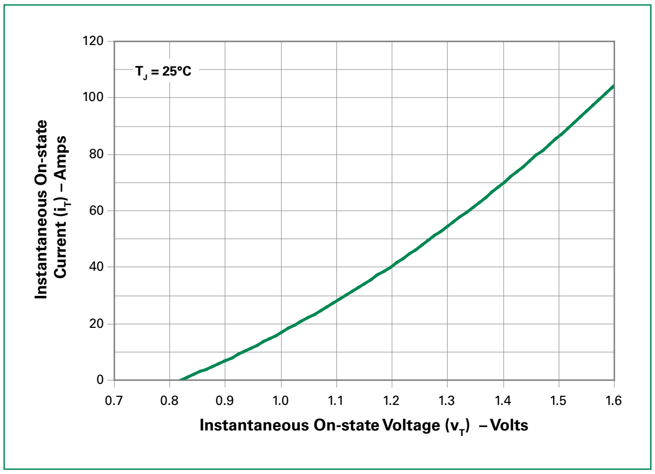


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

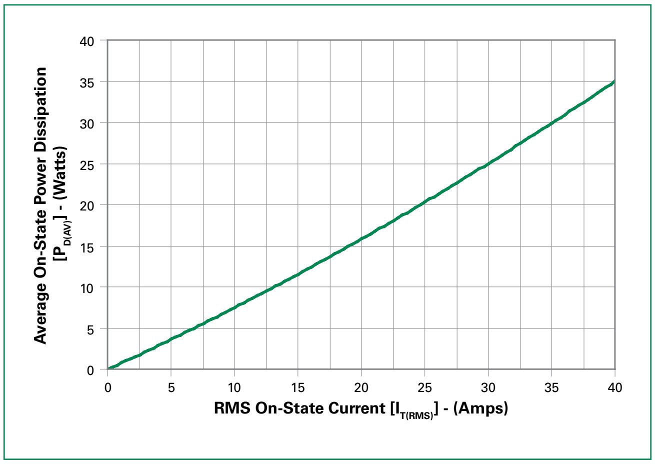
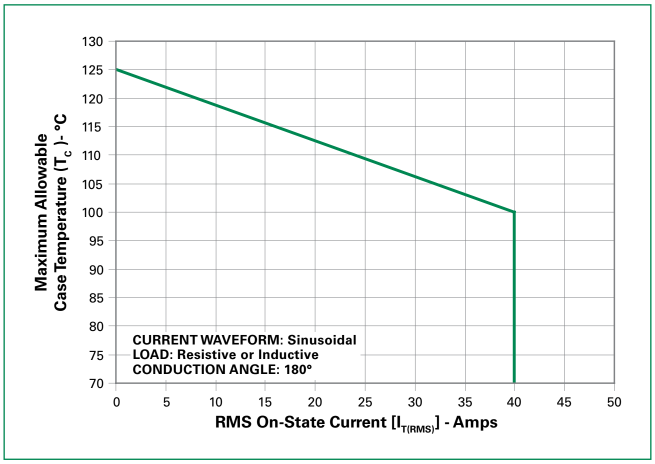


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current



Revised: 12/14/14

Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current

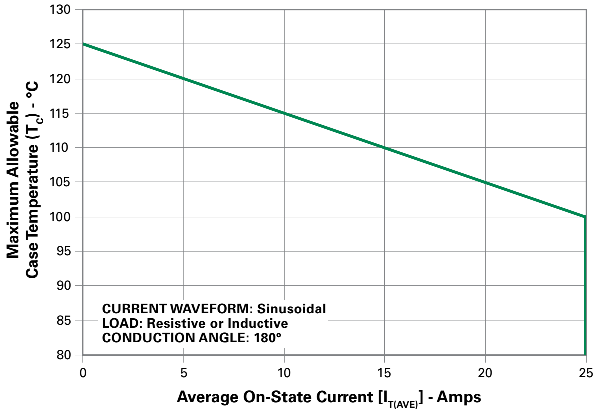


Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current

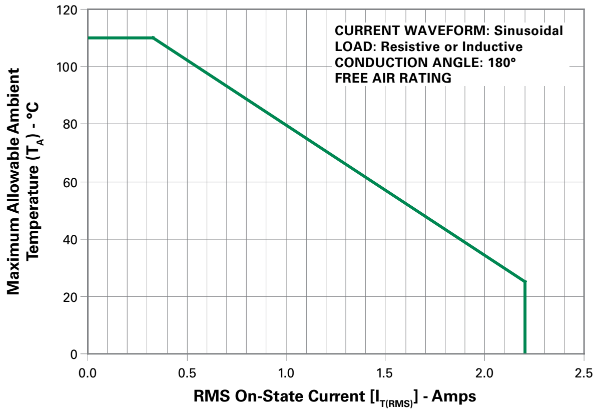


Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current

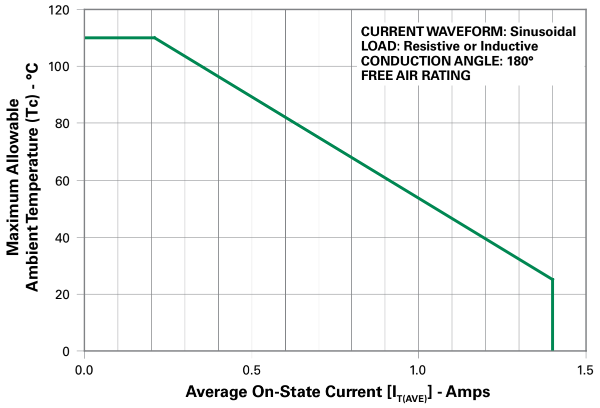


Figure 10: Peak Capacitor Discharge Current

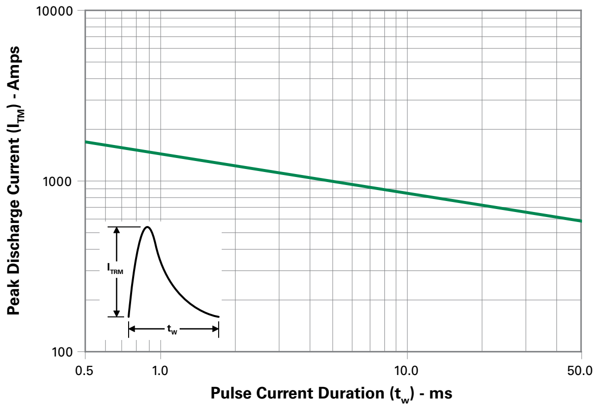


Figure 11: Peak Capacitor Discharge Current Derating

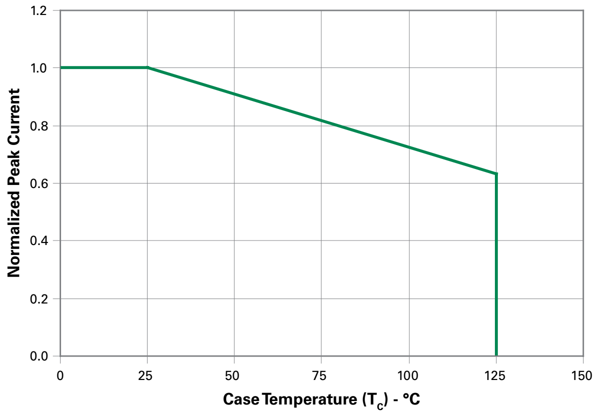
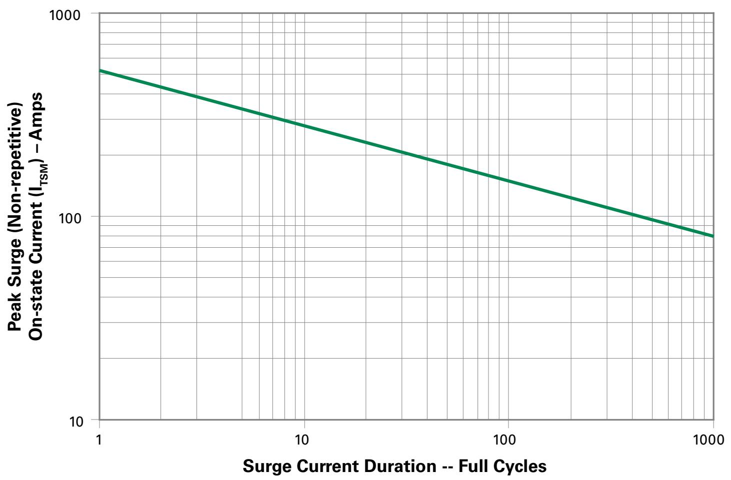


Figure 12: Surge Peak On-State Current vs. Number of Cycles



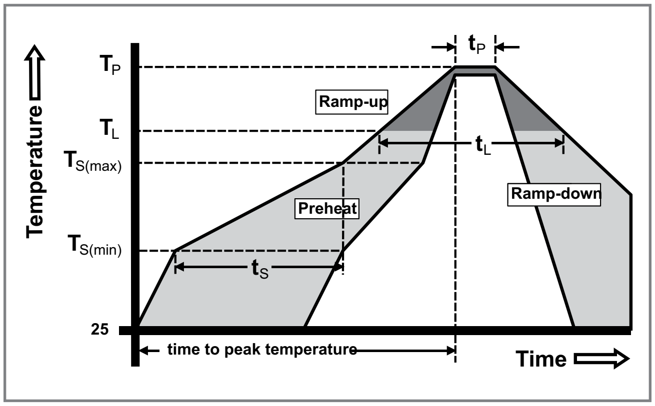
SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:

1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

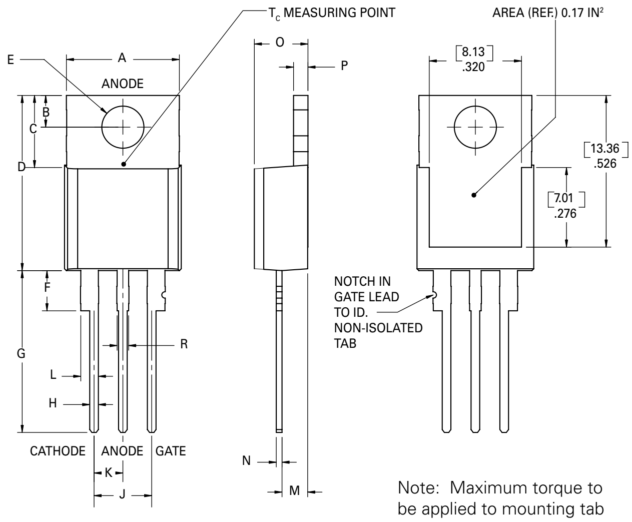
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwelltime at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

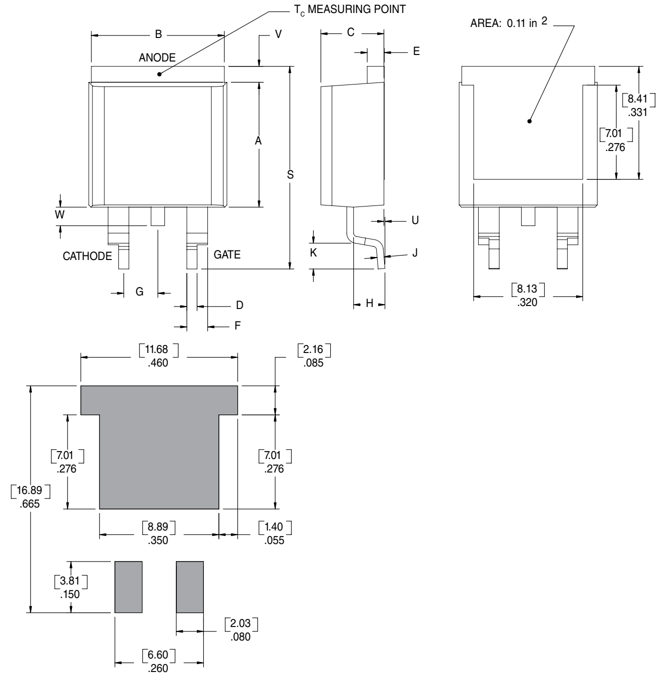
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

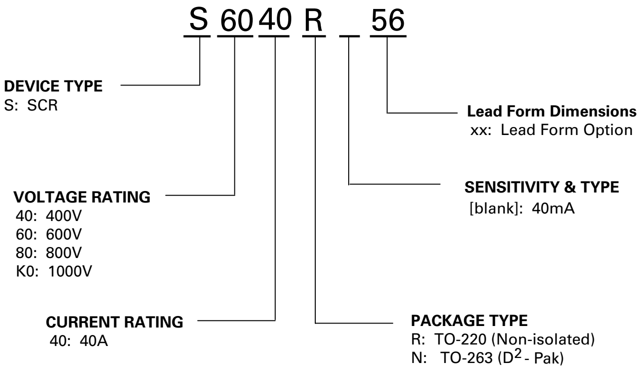
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions – TO- 263 (N-package) — D²-Pak Surface Mount



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.63	0.89
E	0.048	0.055	1.22	1.40
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.083	0.093	2.11	2.36
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.87
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

Part Numbering System



S 60 40 R _ 56

DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
40: 40A

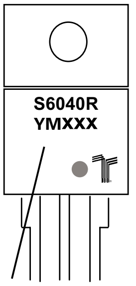
Lead Form Dimensions
xx: Lead Form Option

SENSITIVITY & TYPE
[blank]: 40mA

PACKAGE TYPE
R: TO-220 (Non-isolated)
N: TO-263 (D^2 - Pak)

Part Marking System

TO-220 AB - (R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx40R	X	X	X	X	40mA	Standard SCR	TO-220R
Sxx40N	X	X	X	X	40mA	Standard SCR	TO-263

Note: xx = Voltage

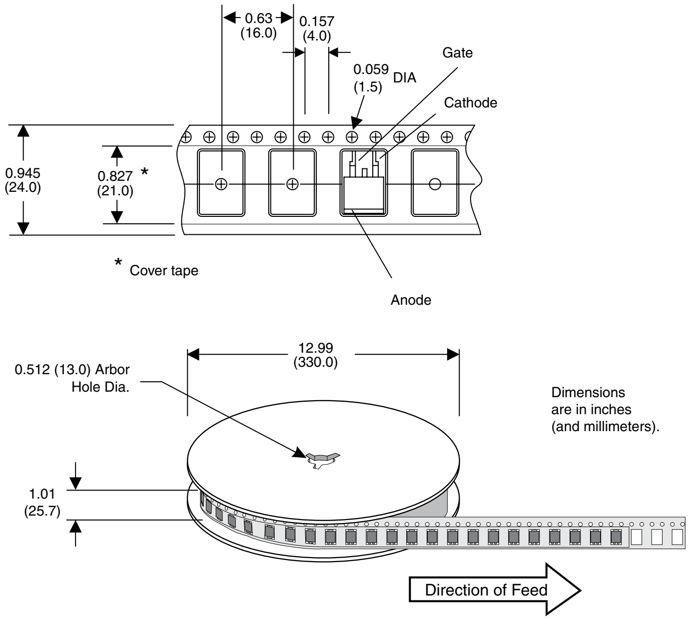
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx40R	Sxx40R	2.2g	Bulk	500
Sxx40RTP	Sxx40R	2.2g	Tube	500 (50 per tube)
Sxx40NTP	Sxx40N	1.6g	Tube	500 (50 per tube)
Sxx40NRP	Sxx40N	1.6g	Embossed Carrier	500

Note: xx = Voltage

Reel Pack (RP) for TO-263 Embossed Carrier Specifications

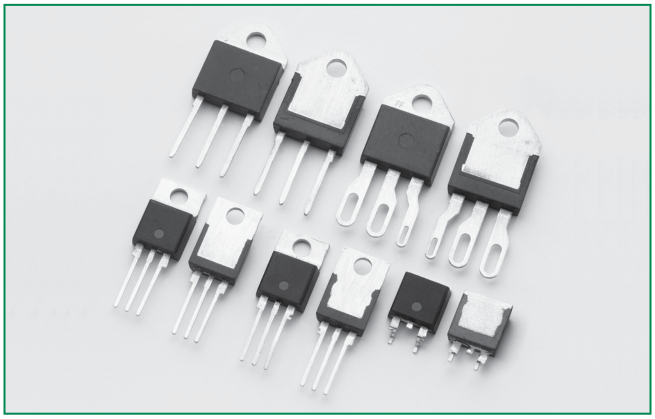
Meets all EIA-481-2 Standards



Dimensions are in inches (and millimeters).

Sxx55x Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 650 A

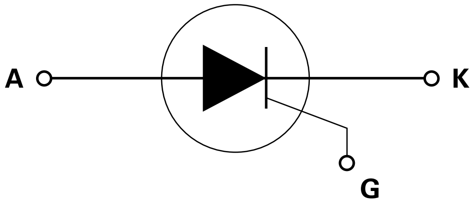
Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	55	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	40	mA

Applications

Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Schematic Symbol



Additional Information

Datasheet | **Resources** | **Samples**

Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Value	Unit
$I_{T(RMS)}$	RMS on-state current	T_C = 90°C	55	A
$I_{T(AV)}$	Average on-state current	T_C = 90°C	35.0	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	550	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	650	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	1750	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C	175	A/μs
I_{GM}	Peak gate current	T_J = 125°C P_W = 10μS	4.0	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C	0.8	W
T_{stg}	Storage temperature range		-40 to 150	°C
T_J	Operating junction temperature range		-40 to 125	°C

Revised: 12/14/14

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value	Unit
I_{GT}	V_D = 12V; R_L = 30 Ω		MAX.	40	mA
			MIN.	5	
V_{GT}			MAX.	1.5	V
dv/dt	$V_D = V_{DRM}$; gate open; T_J = 100°C	400V	MIN.	650	V/μs
		600V		600	
		800V		500	
		1000V		250	
	$V_D = V_{DRM}$; gate open; T_J = 125°C	400V		550	
		600V		500	
		800V		475	
V_{GD}	$V_D = V_{DRM}$; R_L = 3.3 kΩ; T_J = 125°C		MIN.	0.2	V
I_H	I_T = 400mA (initial)		MAX.	60	mA
t_q	(1)		MAX.	35	μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 110A		TYP.	2.5	μs

Note :
(1) I_T=2A; t_p=50μs; dv/dt=5V/μs; di/dt=-30A/μs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	I_T = 110A; t_p = 380μs			MAX.	1.8	V
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	400 – 600V	MAX.	10	μA
			800 V		20	
			1000 V		30	
		T_J = 100°C	400 – 600V		1000	
			800V		1500	
			1000V		5000	
		T_J = 125°C	400 – 600V		2000	
			800V		3000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Sxx55R Sxx55N	0.5	°C/W
		Sxx55W Sxx55M	0.53	
$R_{\theta(J-A)}$	Junction to ambient	Sxx55R	40	°C/W

Note: xx = voltage

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

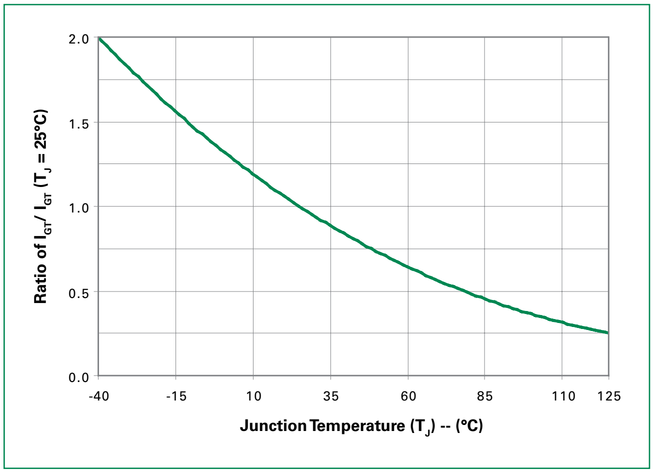


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

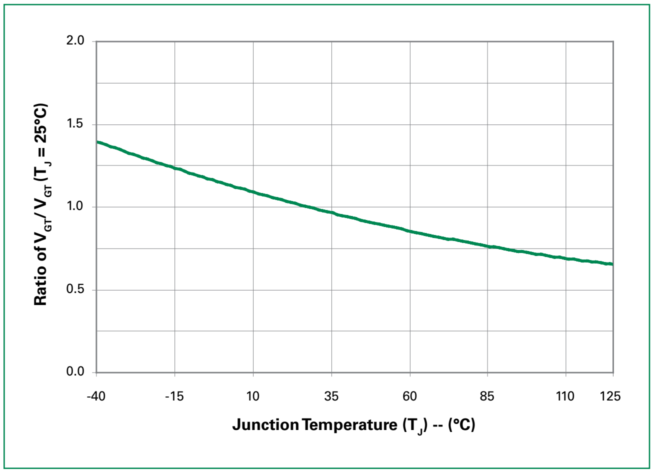


Figure 3: Normalized DC Holding Current vs. Junction Temperature

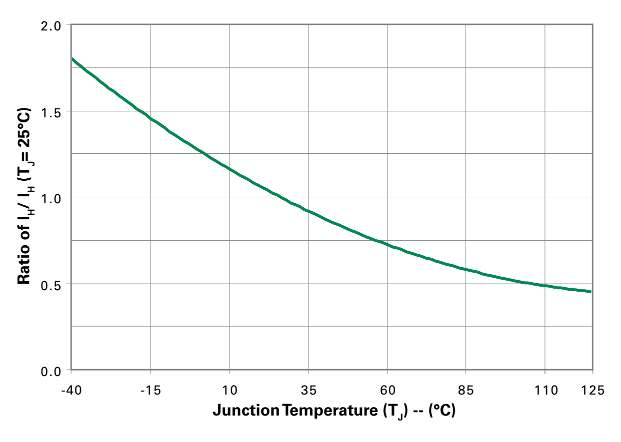


Figure 4: On-State Current vs. On-State Voltage (Typical)

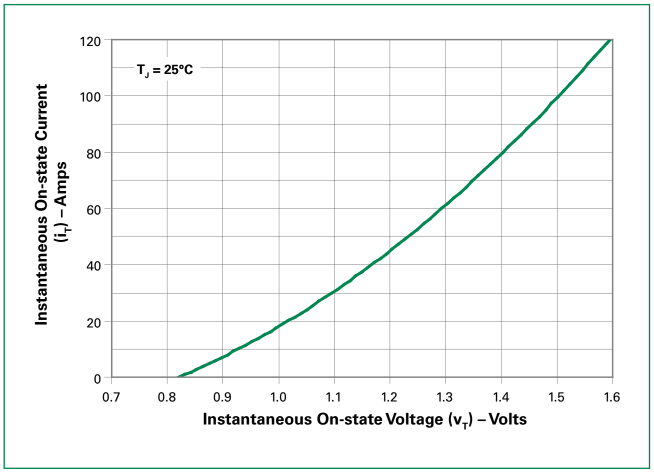


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

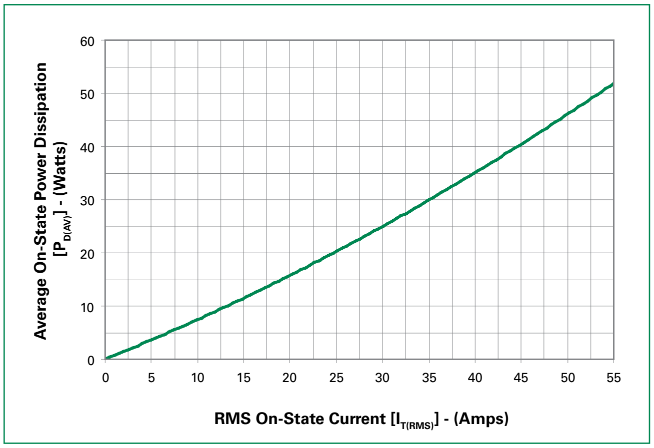
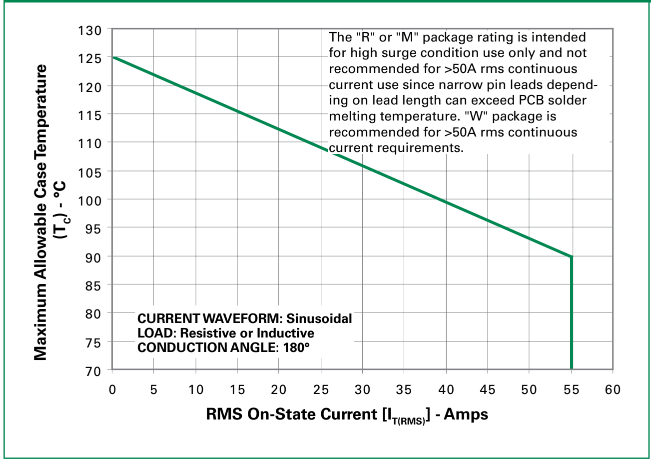


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

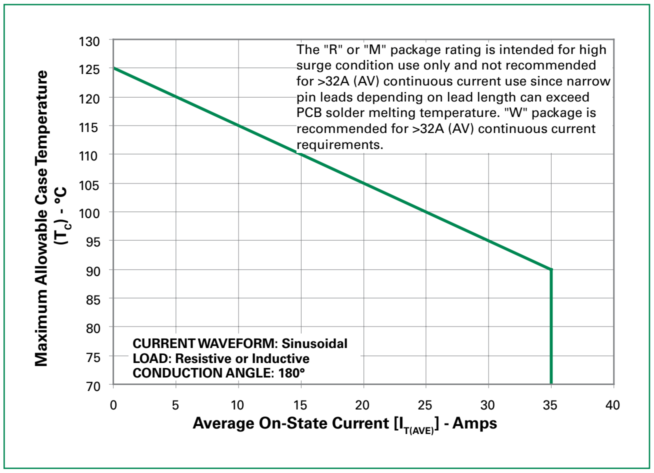


The "R" or "M" package rating is intended for high surge condition use only and not recommended for >50A rms continuous current use since narrow pin leads depending on lead length can exceed PCB solder melting temperature. "W" package is recommended for >50A rms continuous current requirements.

CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 180°

Note: xx = voltage

Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current



The "R" or "M" package rating is intended for high surge condition use only and not recommended for >32A (AV) continuous current use since narrow pin leads depending on lead length can exceed PCB solder melting temperature. "W" package is recommended for >32A (AV) continuous current requirements.

Figure 8: Maximum Allowable Ambient Temperature vs. RMS On-State Current

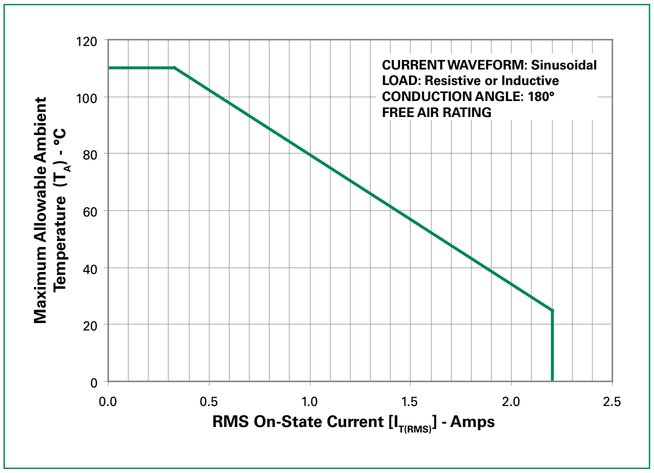


Figure 9: Maximum Allowable Ambient Temperature vs. Average On-State Current

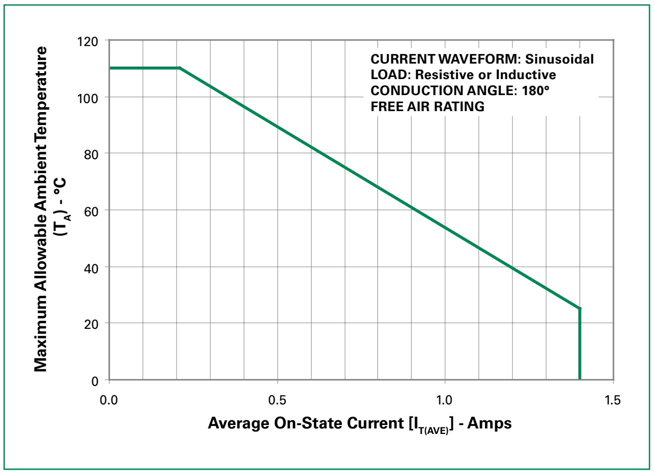


Figure 10: Peak Capacitor Discharge Current

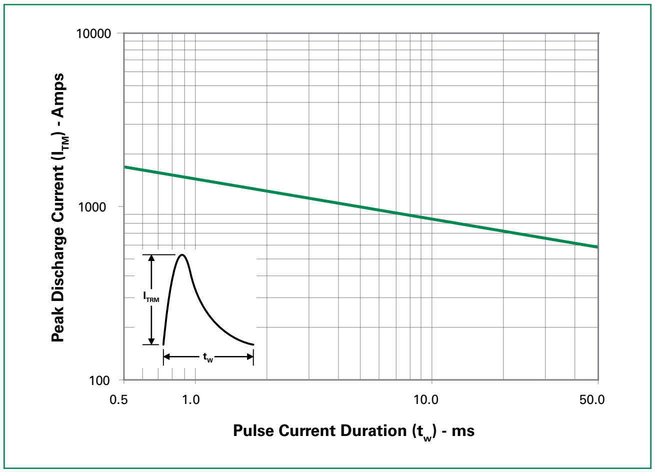
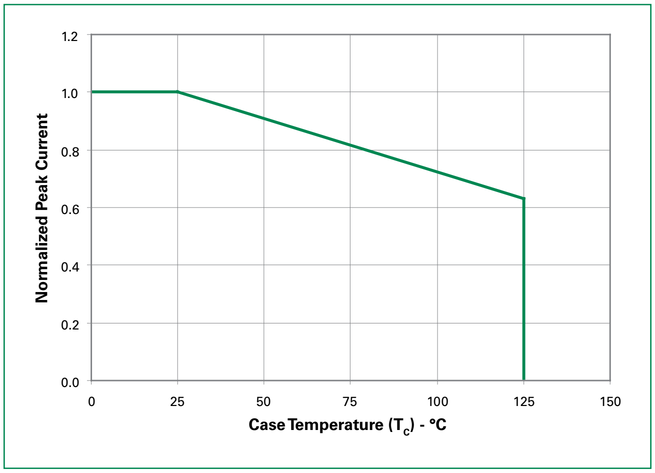
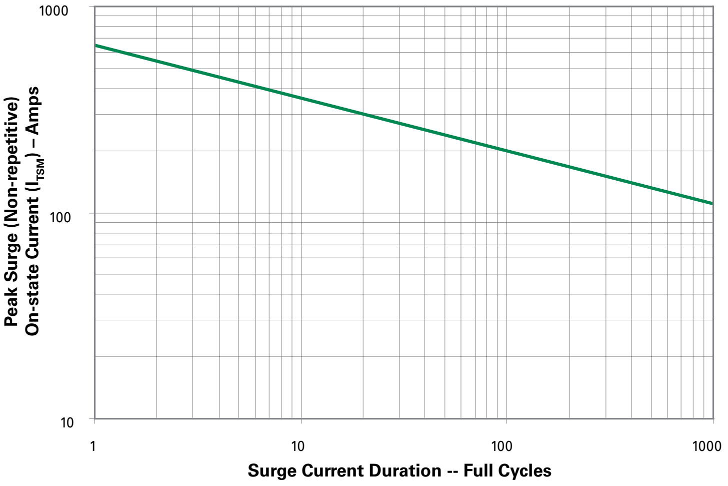


Figure 11: Peak Capacitor Discharge Current Derating



Note: xx = voltage

Figure 12: Surge Peak On-State Current vs. Number of Cycles

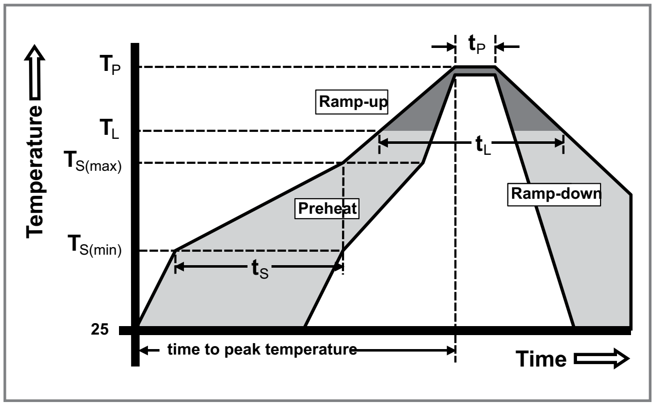


SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: [$I_{T(RMS)}$]: Maximum Rated Value at Specified Case Temperature

Notes:
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

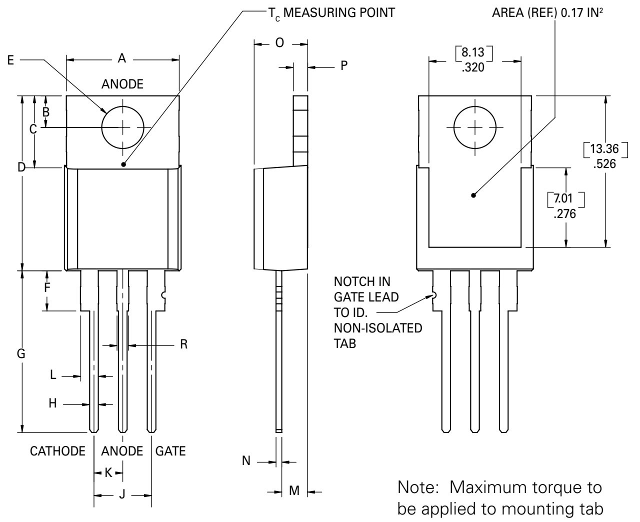
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwelltime at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

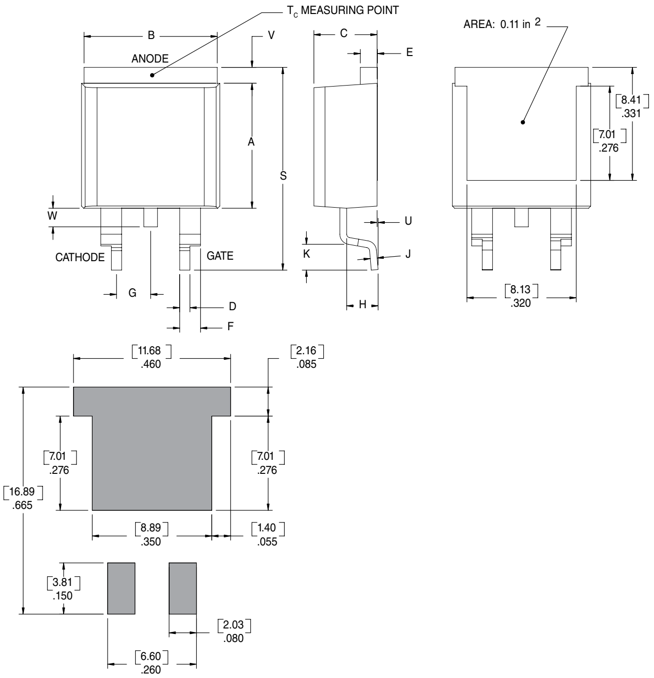
Dimensions — TO-220AB (R-Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

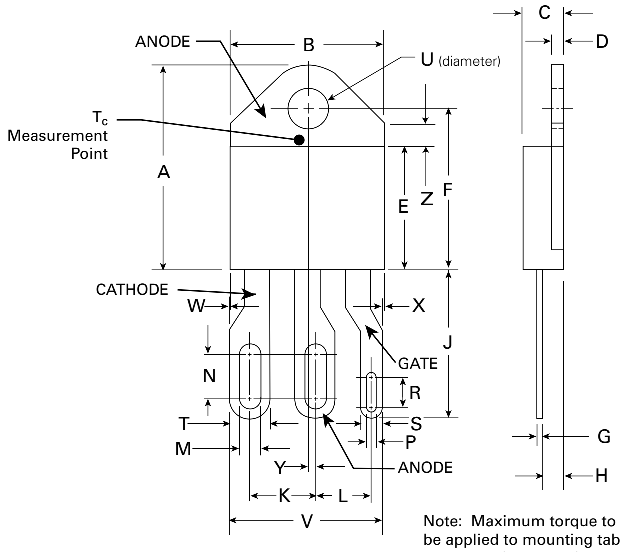
Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Dimensions – TO-263AB (N-package) — D²-Pak Surface Mount



Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.360	0.370	9.14	9.40
B	0.380	0.420	9.65	10.67
C	0.178	0.188	4.52	4.78
D	0.025	0.035	0.63	0.89
E	0.048	0.055	1.22	1.40
F	0.060	0.075	1.52	1.91
G	0.095	0.105	2.41	2.67
H	0.083	0.093	2.11	2.36
J	0.018	0.024	0.46	0.61
K	0.090	0.110	2.29	2.79
S	0.590	0.625	14.99	15.87
V	0.035	0.045	0.89	1.14
U	0.002	0.010	0.05	0.25
W	0.040	0.070	1.02	1.78

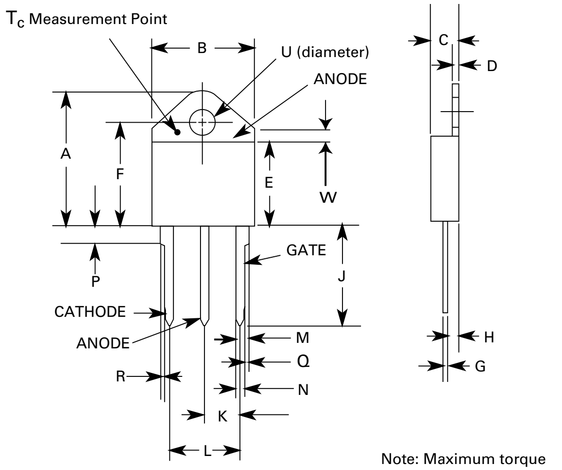
Dimensions – TO-218X (W Package) — Non-Isolated Mounting Tab Common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.256	0.264	6.50	6.71
L	0.220	0.228	5.58	5.79
M	0.080	0.088	2.03	2.24
N	0.169	0.177	4.29	4.49
P	0.034	0.042	0.86	1.07
R	0.113	0.121	2.87	3.07
S	0.086	0.096	2.18	2.44
T	0.156	0.166	3.96	4.22
U	0.164	0.165	4.10	4.20
V	0.603	0.618	15.31	15.70
W	0.000	0.005	0.00	0.13
X	0.003	0.012	0.07	0.30
Y	0.028	0.032	0.71	0.81
Z	0.085	0.095	2.17	2.42

Dimensions – TO-218AC (M Package) — Non-isolated Mounting Tab Common with Center Lead



Note: Maximum torque
to be applied to mounting
tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.058	0.068	1.47	1.73
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
Q	0.008	0.016	0.20	0.41
R	0.008	0.016	0.20	0.41
U	0.164	0.165	4.10	4.20
W	0.085	0.095	2.17	2.42

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx55R	X	X	X	X	40mA	Standard SCR	TO-220R
Sxx55N	X	X	X	X	40mA	Standard SCR	TO-263
Sxx55W	X	X	X		40mA	Standard SCR	TO-218X
Sxx55M	X	X	X	X	40mA	Standard SCR	TO-218AC

Note: xx = Voltage

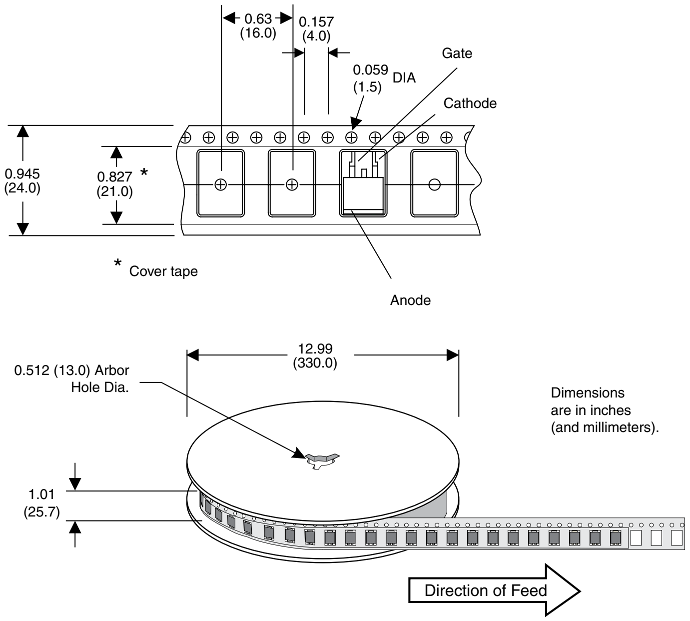
Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx55R	Sxx55R	2.2g	Bulk	500
Sxx55RTP	Sxx55R	2.2g	Tube	500 (50 per tube)
Sxx55NTP	Sxx55N	1.6g	Tube	500 (50 per tube)
Sxx55NRP	Sxx55N	1.6g	Embossed Carrier	500
Sxx55WTP	Sxx55W	5.23g	Tube	250 (25 per tube)
Sxx55MTP	Sxx55M	4.40g	Tube	250 (25 per tube)

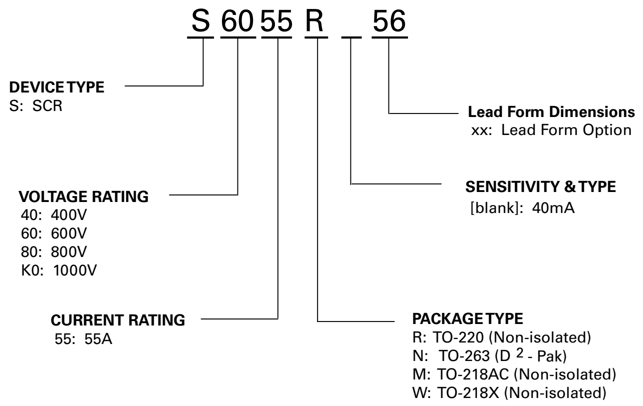
Note: xx = Voltage

TO-263 Embossed Carrier Reel Pack (RP) Specification

Meets all EIA-481-2 Standards



Part Numbering System



DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
55: 55A

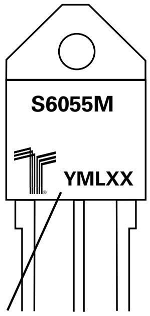
Lead Form Dimensions
xx: Lead Form Option

SENSITIVITY & TYPE
[blank]: 40mA

PACKAGE TYPE
R: TO-220 (Non-isolated)
N: TO-263 (D ^{2} - Pak)
M: TO-218AC (Non-isolated)
W: TO-218X (Non-isolated)

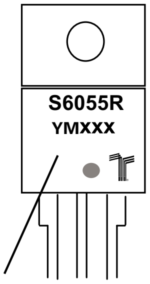
Part Marking System

TO-218AC - (M Package)
TO-218X - (W Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

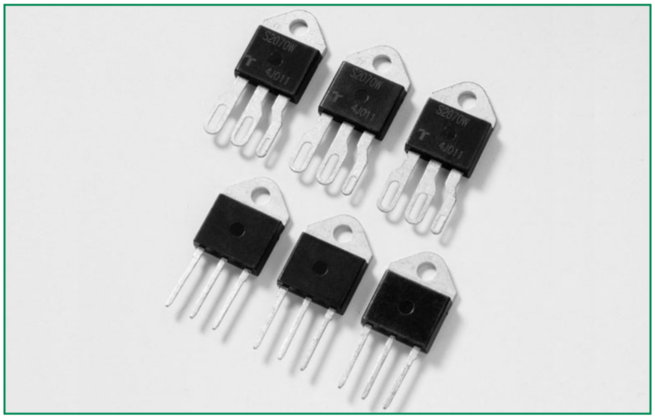
TO-220 AB - (R Package)
TO-263 AB - (N Package)



Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

Sxx65x & Sxx70x Series

RoHS



Description

Excellent unidirectional switches for phase control applications such as heating and motor speed controls.

Standard phase control SCRs are triggered with few milliamperes of current at less than 1.5V potential.

Features & Benefits

- RoHS compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 950 A

Agency Approval

Agency	Agency File Number
®	J & K Packages: E71639

Applications

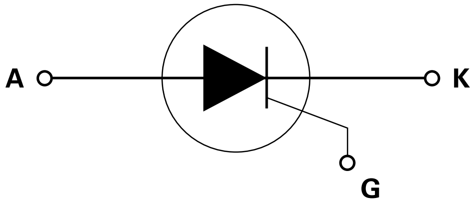
Typical applications are AC solid-state switches, industrial power tools, exercise equipment, white goods and commercial appliances.

Internally constructed isolated packages are offered for ease of heat sinking with highest isolation voltage.

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	65 & 70	A
V_{DRM}/V_{RRM}	400 to 1000	V
I_{GT}	50	mA

Schematic Symbol



Absolute Maximum Ratings

Symbol	Parameter	Test Conditions		Value	Unit
$I_{T(RMS)}$	RMS on-state current	Sxx65J Sxx65K	T_C = 75°C	65	A
		Sxx70W	T_C = 80°C	70	
$I_{T(AV)}$	Average on-state current	Sxx65J Sxx65K	TC = 75°C	41.0	A
		Sxx70W	T_C = 80°C	45.0	A
I_{TSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C		800	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C		950	
I^2t	I^2t Value for fusing	t_p = 8.3 ms		3745	A^2s
di/dt	Critical rate of rise of on-state current	f = 60Hz ; T_J = 125°C		200	A/μs
I_{GM}	Peak gate current	T_J = 125°C P_W = 15 μS Max		5.0	A
$P_{G(AV)}$	Average gate power dissipation	T_J = 125°C		1.0	W
T_{stg}	Storage temperature range			-40 to 150	°C
T_J	Operating junction temperature range			-40 to 125	°C

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Test Conditions			Value	Unit
I_{GT}	V_D = 12V; R_L = 30 Ω		MAX.	50	mA
			MIN.	5	
V_{GT}			MAX.	2.0	V
dv/dt	$V_D = V_{DRM}$; gate open; T_J = 100°C	400V	MIN.	650	V/μs
		600V		600	
		800V		500	
		1000V		250	
	$V_D = V_{DRM}$; gate open; T_J = 125°C	400V		550	
		600V		500	
		800V		475	
V_{GD}	$V_D = V_{DRM}$; R_L = 3.3 kΩ; T_J = 125°C		MIN.	0.2	V
I_H	I_T = 400mA (initial)		MAX.	80	mA
t_q	(1)		MAX.	35	μs
t_{gt}	I_G = 2 x I_{GT}; PW = 15μs; I_T = 140A		TYP.	2.5	μs

Note :
(1) I_T=2A; t_p=50μs; dv/dt=5V/μs; di/dt=-30A/μs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{TM}	65A Device I_T = 130A; t_p = 380μs			MAX.	1.8	V
	70A Device I_T = 140A; t_p = 380μs					
I_{DRM} / I_{RRM}	V_{DRM} / V_{RRM}	T_J = 25°C	400 – 800V	MAX.	20	μA
			1000 V		30	
		T_J = 100°C	400 – 600V		1500	
			800V		2000	
			1000V		5000	
		T_J = 125°C	400V – 600V		3000	
			800V		5000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Sxx65J Sxx65K	0.86	°C/W
		Sxx70W	0.6	

Note: xx = voltage

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

Figure 1: Normalized DC Gate Trigger Current vs. Junction Temperature

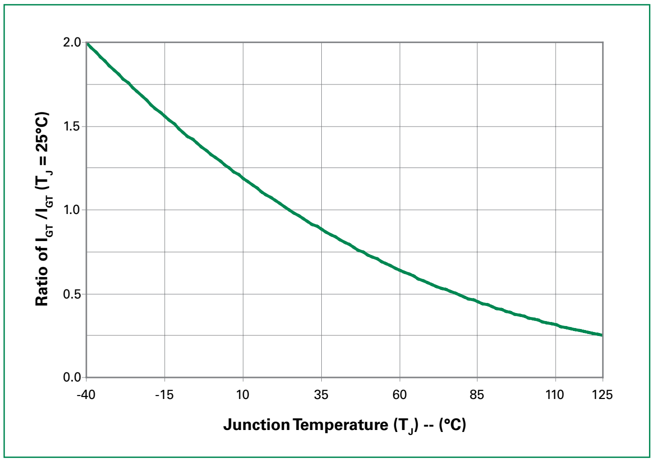


Figure 2: Normalized DC Gate Trigger Voltage vs. Junction Temperature

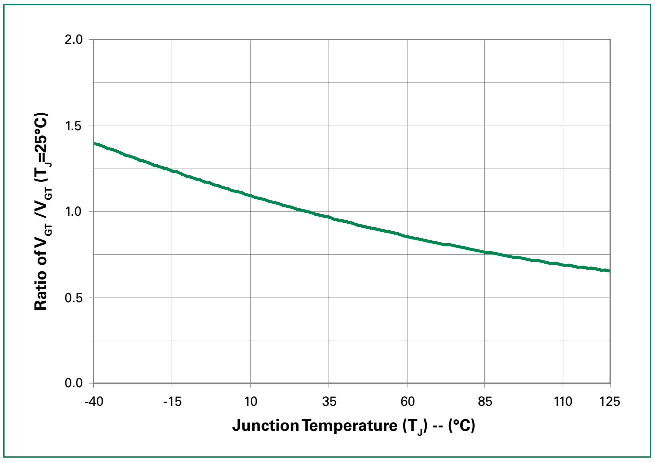


Figure 3: Normalized DC Holding Current vs. Junction Temperature

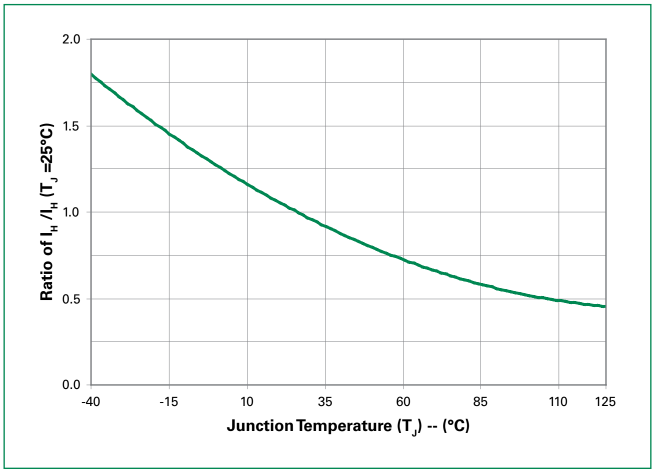


Figure 4: On-State Current vs. On-State Voltage (Typical)

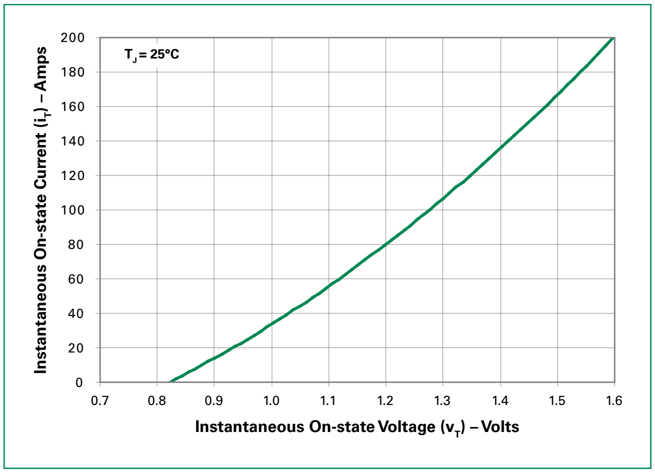


Figure 5: Power Dissipation (Typical) vs. RMS On-State Current

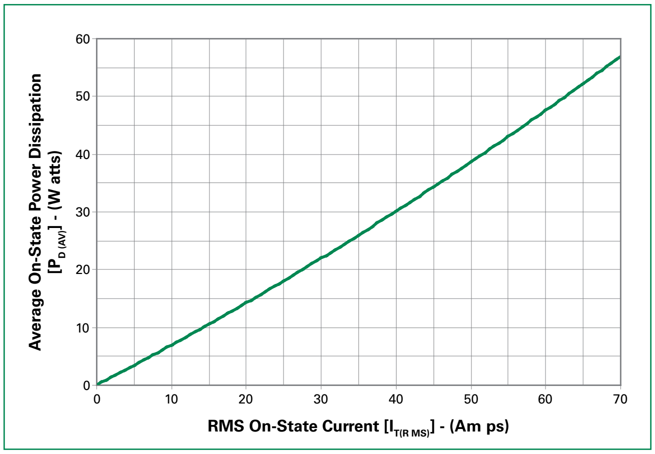
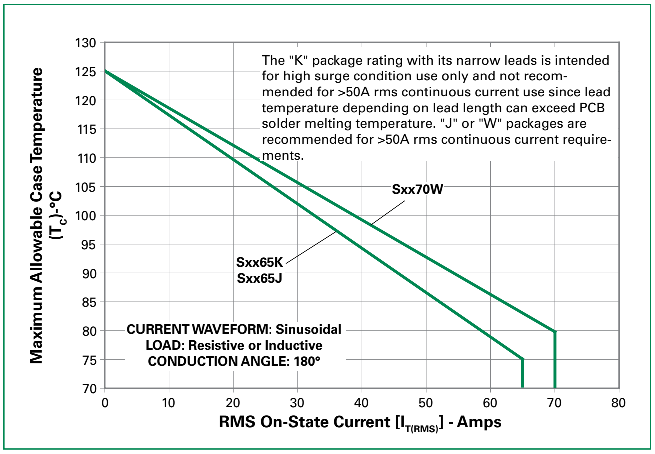


Figure 6: Maximum Allowable Case Temperature vs. RMS On-State Current

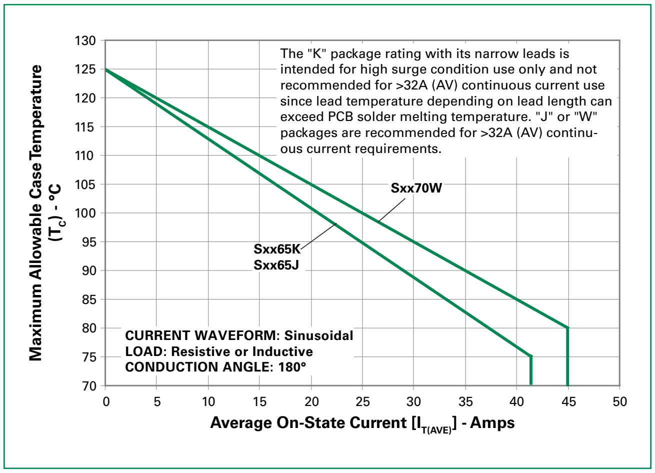


The "K" package rating with its narrow leads is intended for high surge condition use only and not recommended for >50A rms continuous current use since lead temperature depending on lead length can exceed PCB solder melting temperature. "J" or "W" packages are recommended for >50A rms continuous current requirements.

CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 180°

Note: xx = voltage

Figure 7: Maximum Allowable Case Temperature vs. Average On-State Current



The "K" package rating with its narrow leads is intended for high surge condition use only and not recommended for >32A (AV) continuous current use since lead temperature depending on lead length can exceed PCB solder melting temperature. "J" or "W" packages are recommended for >32A (AV) continuous current requirements.

CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE: 180°

Figure 8: Peak Capacitor Discharge Current

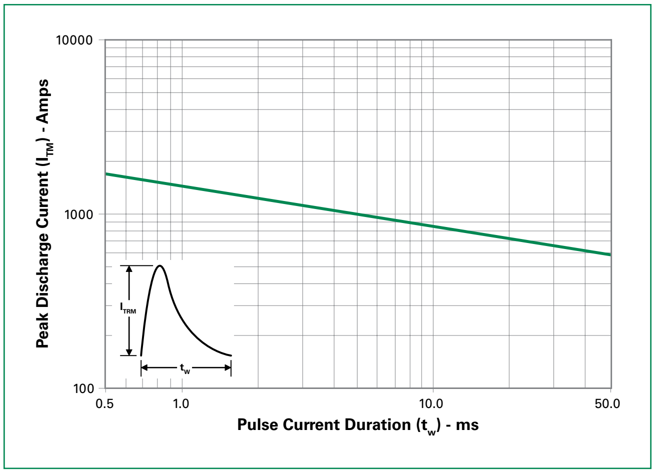


Figure 9: Peak Capacitor Discharge Current Derating

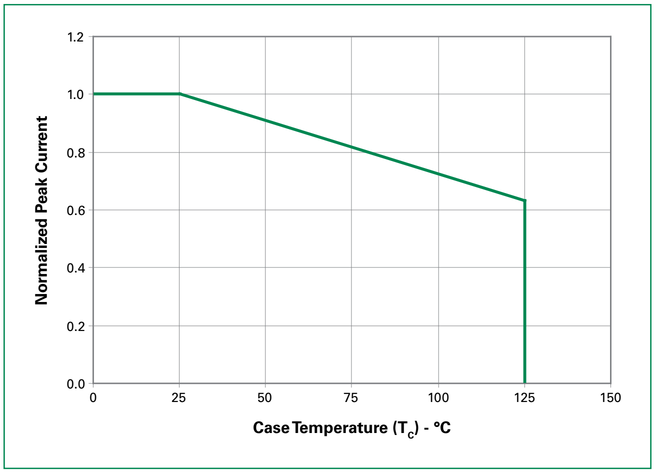
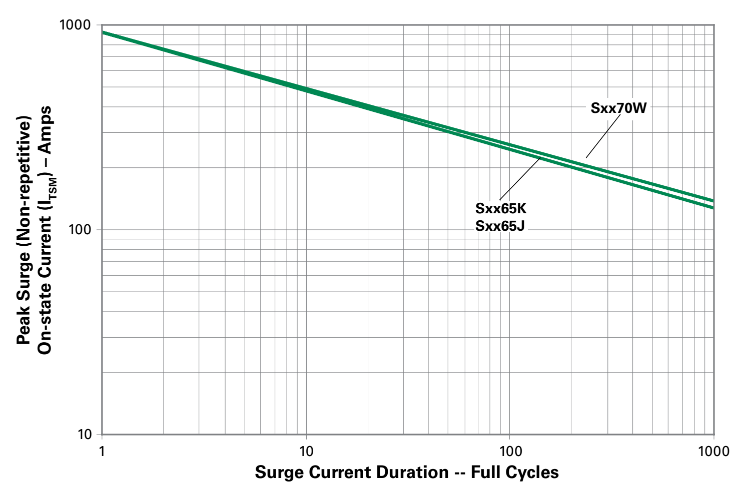


Figure 10: Surge Peak On-State Current vs. Number of Cycles



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: $[I_{T(RMS)}]$: Maximum Rated Value at Specified Case Temperature

Notes:

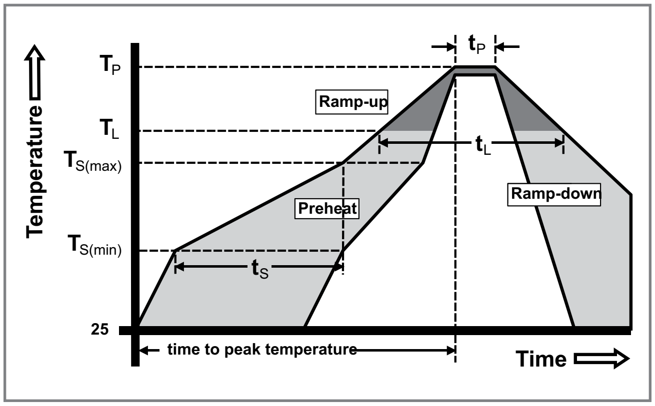
1. Gate control may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Note: xx = Voltage

Revised: 12/14/14

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin-plated
Body	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

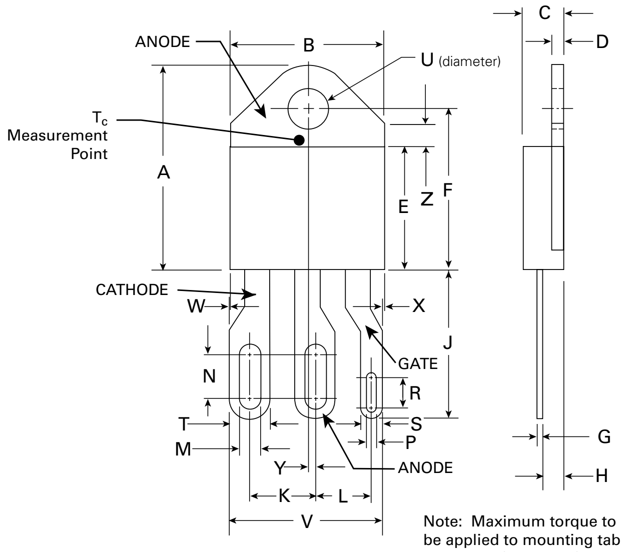
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
AC Blocking	MIL-STD-750, M-1040, Cond A Applied Peak AC voltage @ 125°C for 1008 hours
Temperature Cycling	MIL-STD-750, M-1051, 100 cycles; -40°C to +150°C; 15-min dwell-time
Temperature/ Humidity	EIA / JEDEC, JESD22-A101 1008 hours; 320V - DC: 85°C; 85% rel humidity
High Temp Storage	MIL-STD-750, M-1031, 1008 hours; 150°C
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750, M-1056 10 cycles; 0°C to 100°C; 5-min dwelltime at each temperature; 10 sec (max) transfer time between temperature
Autoclave	EIA / JEDEC, JESD22-A102 168 hours (121°C at 2 ATMs) and 100% R/H
Resistance to Solder Heat	MIL-STD-750 Method 2031
Solderability	ANSI/J-STD-002, category 3, Test A
Lead Bend	MIL-STD-750, M-2036 Cond E

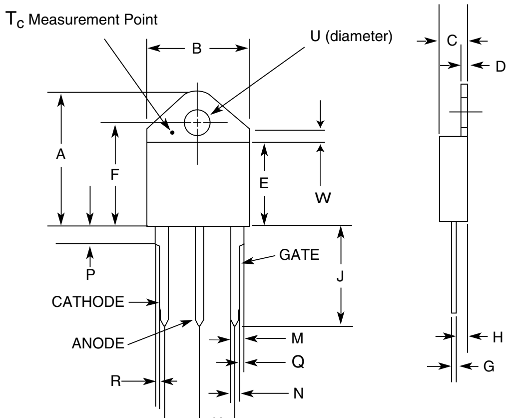
Dimensions – TO-218X (W Package) — Non-Isolated Mounting Tab common with Center Lead



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.256	0.264	6.50	6.71
L	0.220	0.228	5.58	5.79
M	0.080	0.088	2.03	2.24
N	0.169	0.177	4.29	4.49
P	0.034	0.042	0.86	1.07
R	0.113	0.121	2.87	3.07
S	0.086	0.096	2.18	2.44
T	0.156	0.166	3.96	4.22
U	0.164	0.165	4.10	4.20
V	0.603	0.618	15.31	15.70
W	0.000	0.005	0.00	0.13
X	0.003	0.012	0.07	0.30
Y	0.028	0.032	0.71	0.81
Z	0.085	0.095	2.17	2.42

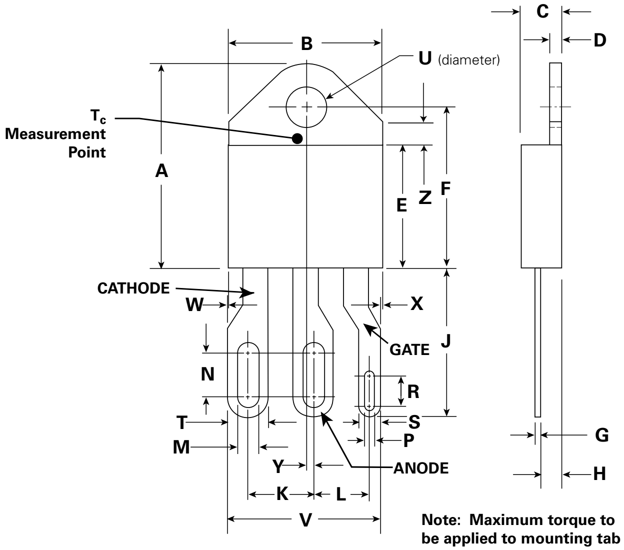
Dimensions – TO-218AC (K Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.211	0.219	5.36	5.56
L	0.422	0.437	10.72	11.10
M	0.058	0.068	1.47	1.73
N	0.045	0.055	1.14	1.40
P	0.095	0.115	2.41	2.92
Q	0.008	0.016	0.20	0.41
R	0.008	0.016	0.20	0.41
U	0.164	0.165	4.10	4.20
W	0.085	0.095	2.17	2.42

Dimensions – TO-218X (J Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.810	0.835	20.57	21.21
B	0.610	0.630	15.49	16.00
C	0.178	0.188	4.52	4.78
D	0.055	0.070	1.40	1.78
E	0.487	0.497	12.37	12.62
F	0.635	0.655	16.13	16.64
G	0.022	0.029	0.56	0.74
H	0.075	0.095	1.91	2.41
J	0.575	0.625	14.61	15.88
K	0.256	0.264	6.50	6.71
L	0.220	0.228	5.58	5.79
M	0.080	0.088	2.03	2.24
N	0.169	0.177	4.29	4.49
P	0.034	0.042	0.86	1.07
R	0.113	0.121	2.87	3.07
S	0.086	0.096	2.18	2.44
T	0.156	0.166	3.96	4.22
U	0.164	0.165	4.10	4.20
V	0.603	0.618	15.31	15.70
W	0.000	0.005	0.00	0.13
X	0.003	0.012	0.07	0.30
Y	0.028	0.032	0.71	0.81
Z	0.085	0.095	2.17	2.42

Product Selector

Part Number	Voltage				Gate Sensitivity	Type	Package
	400V	600V	800V	1000V			
Sxx65K	X	X	X	X	50mA	Standard SCR	TO-218AC
Sxx65J	X	X	X		50mA	Standard SCR	TO-218X
Sxx70W	X	X	X		50mA	Standard SCR	TO-218X

Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Sxx65KTP	Sxx65K	4.40g	Tube	250 (25 per tube)
Sxx65JTP	Sxx65J	5.23g	Tube	250 (25 per tube)
Sxx70WTP	Sxx70W	5.23g	Tube	250 (25 per tube)

Note: xx = Voltage

Part Numbering System

S 60 65 K _ 81

DEVICE TYPE
S: SCR

VOLTAGE RATING
40: 400V
60: 600V
80: 800V
K0: 1000V

CURRENT RATING
65: 65A
70: 70A

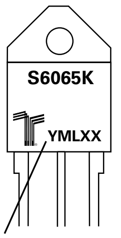
Lead Form Dimensions
xx: Lead Form Option

SENSITIVITY & TYPE
[blank]: 50mA

PACKAGE TYPE
K: TO-218AC (Isolated)
J: TO-218X (Isolated)
W: TO-218X (Non-isolated)

Part Marking System

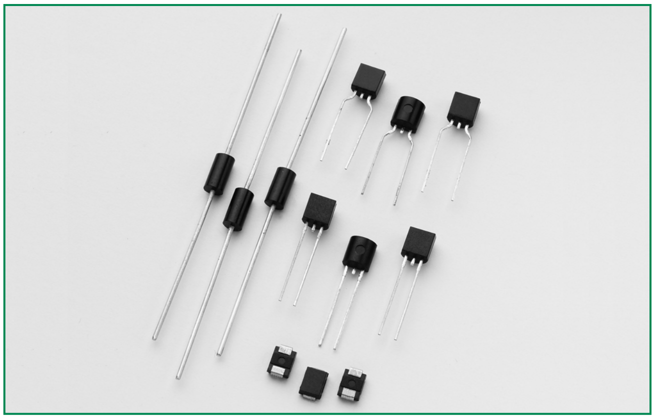
TO-218AC - (K Package)
TO-218X - (J Package)
TO-218X - (W Package)



Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

Kxxxzy SIDAC

RoHS



Description

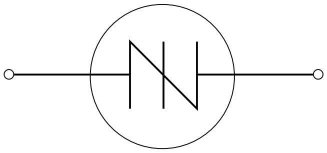
The SIDAC is a silicon bilateral voltage triggered switch. Upon application of a voltage exceeding the SIDAC breakover voltage point, the SIDAC switches on through a negative resistance region to a low on-state voltage. Conduction continues until the current is interrupted or drops below the minimum holding current of the device.

SIDACs feature glass-passivated junctions to ensure a rugged and dependable device capable of withstanding harsh environments.

Features

- AC Circuit Oriented
- Triggering Voltage of 79V to 330V
- RoHS Compliant

Schematic Symbol



Applications

Suitable for high voltage power supplies, natural gas igniters, high-pressure Sodium lamps, and Xenon flash ignition.

Electrical Specifications (T$_J$ = 25°C, unless otherwise specified)

Symbol	Parameters	Test Conditions	Min	Max	Unit
V_{BO}	Breakover/Trigger Voltage	K0900y	79	97	V
		K1050y	95	113	
		K1100y	104	118	
		K1200y	110	125	
		K1300y	120	138	
		K1400y	130	146	
		K1500y	140	170	
		K1800y	165	195	
		K200zy	190	215	
		K220zy	205	230	
		K240zy	220	250	
		K250zy	240	280	
		K300zy	270	330	
V_{DRM}	Repetitive Peak Off-state Voltage	K0900y	70		V
		K1050y	90		
		K1100y	90		
		K1200y	90		
		K1300y	90		
		K1400y	90		
		K1500y	90		
		K1800y	140		
		K200zy	180		
		K220zy	180		
		K240zy	190		
		K250zy	200		
		K300zy	200		

Note: xxx = voltage, z = circuit function, y = package

Electrical Specifications (T_J = 25°C, unless otherwise specified)

Symbol	Parameters	Test Conditions		Min	Max	Unit
$I_{T(RMS)}$	On-state RMS Current	50/60Hz, T_J < 125°C			1	A
I_{DRM}	Repetitive Peak Off-state Current	$V = V_{DRM}$ 50/60Hz Sine Wave			5	μA
V_{TM}	Peak On-state Voltage	I_T = 1A	Kxxx0y		1.5	V
			Kxxx2y		3.0	
I_H	Dynamic Holding Current	R_L = 100Ω 50/60Hz Sine Wave			150	mA
R_S	Switching Resistance, $R_S = \frac{(V_{BO} - V_S)}{(I_S - I_{BO})}$	50/60Hz Sine Wave		100		Ω
I_{BO}	Breakover Current	50/60Hz Sine Wave			10	μA
I_{TRM}	Peak Repetitive Pulse Current (refer to figure 4)	t_p = 10μs	60Hz		80	A
			5Hz		160	
I_{TSM}	Peak Non-repetitive Surge Current (refer to figure 5)	Single Cycle	60Hz		20	A
			50Hz		16.7	
di/dt	Critical Rate of Rise of On-state Current				150	A/μs
dv/dt	Critical Rate of Rise of Off-state Voltage			1500		V/μs
T_S	Storage Temperature Range			-40	150	°C
T_J	Junction Temperature Range			-40	125	°C
$R_{\theta JL}$	Thermal Resistance, Junction to Lead	DO-15			18	°C/W
		DO-214 (1)			30	
$R_{\theta JC}$	Thermal Resistance, Junction to Case	TO-92			35	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	DO-15			75	°C/W
		TO-92			95	

Notes: xxx = voltage, z = circuit function, y = package
(1) Mounted on 1 cm^2 copper foil surface; two-ounce copper foil

Additional Information

Datasheet **Resources** **Samples**

Figure 1: V-I Characteristics

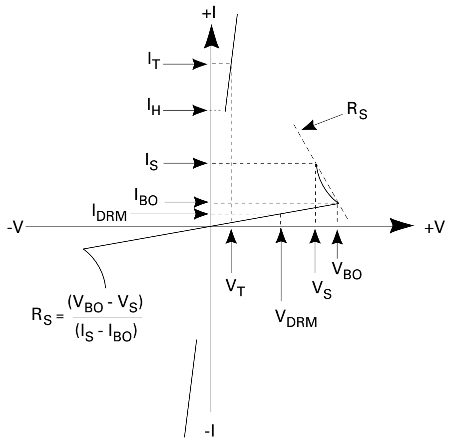


Figure 2: On-state Current vs. On-state Voltage (Typical)

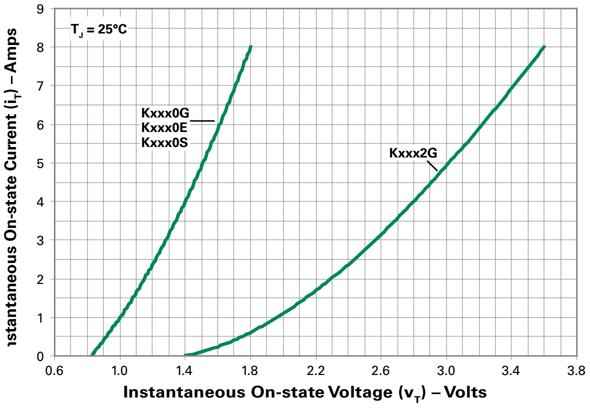


Figure 3: Power Dissipation vs. On-state Current (Typical)

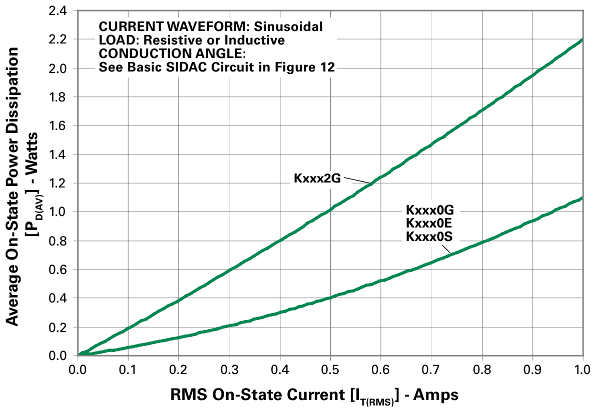


Figure 4: Repetitive Peak On-state Current (I_{TRM}) vs. Pulse Width at Various Frequencies

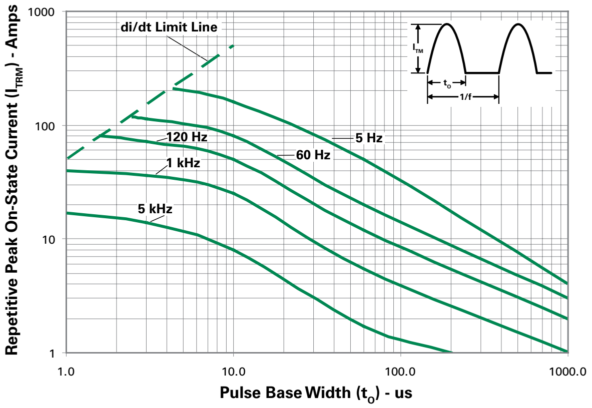


Figure 5: Peak Non-repetitive Surge Current (I_{TSM}) vs. Number of Cycles

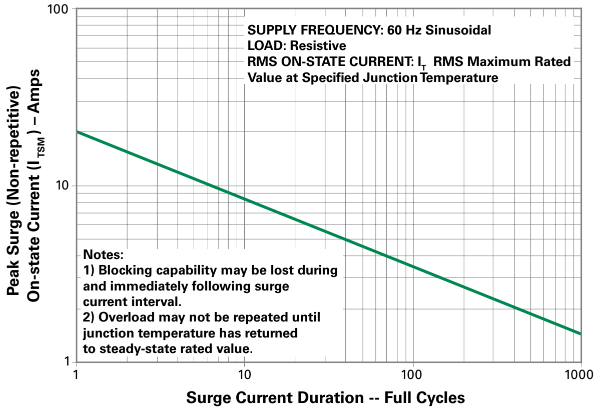


Figure 6: Normalized V_{BO} Change vs. Junction Temperature

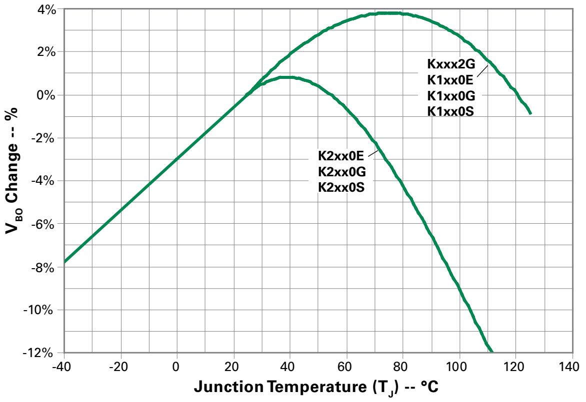


Figure 7: Normalized DC Holding Current vs. Junction Temperature

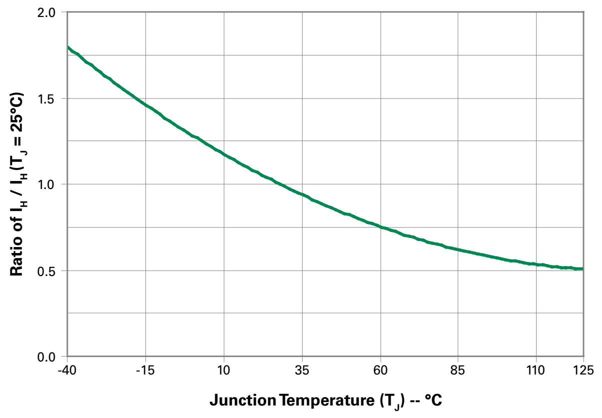


Figure 8: Maximum Allowable Case Temperature vs. RMS On-State Current

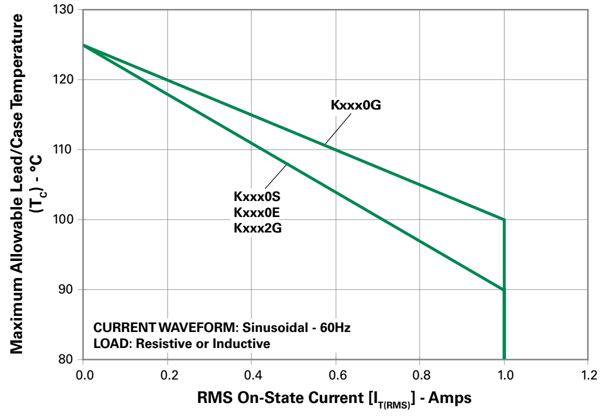


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

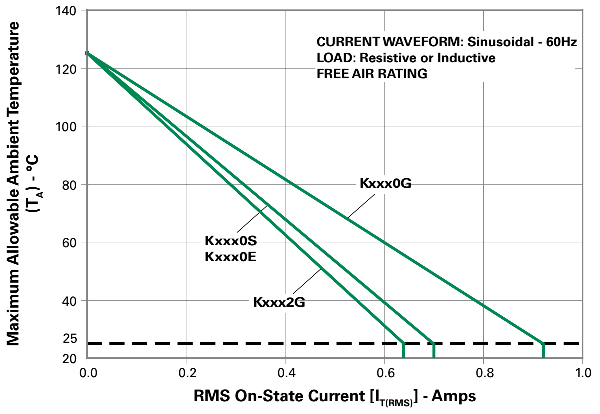


Figure 10: Normalized Repetitive Peak Breakover Current (I_{BO}) vs. Junction Temperature

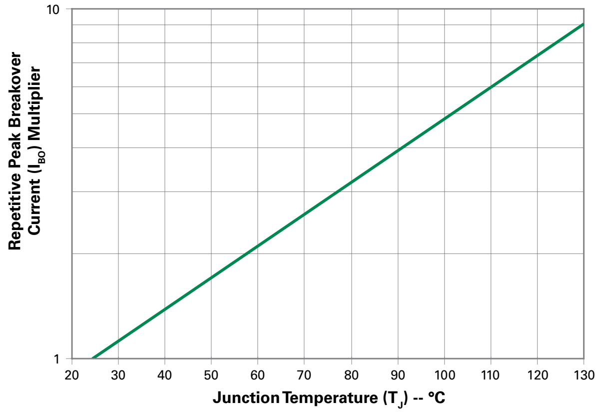


Figure 11: Dynamic Holding Current Test Circuit for SIDACs

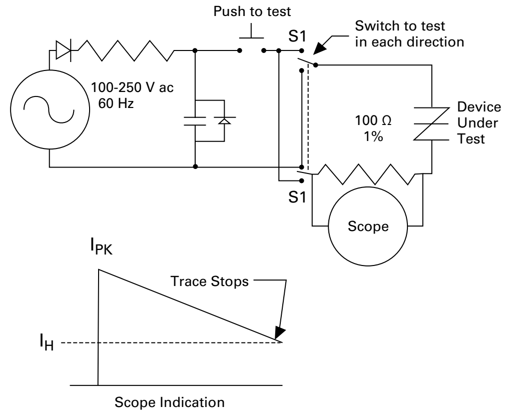


Figure 12: Basic SIDAC Circuit

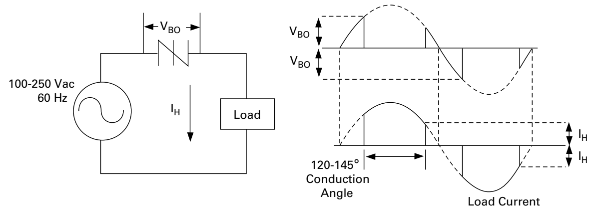


Figure 13: Relaxation Oscillator Using a SIDAC

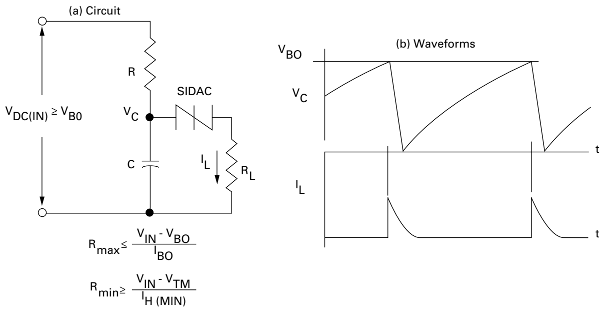


Figure 14: Low-voltage Input Circuit for Gas Ignition

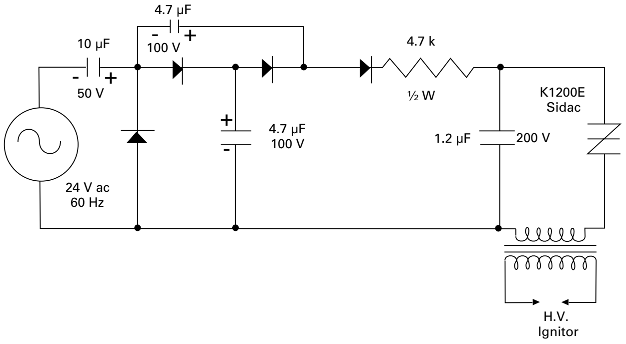


Figure 15: Comparison of SIDAC versus SCR for Gas Ignitor Circuit

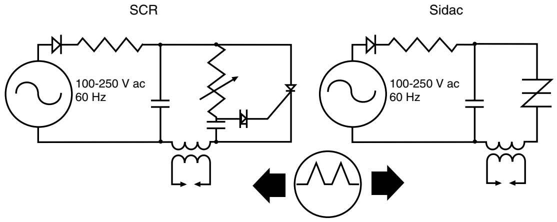


Figure 16: Xenon Lamp Flashing Circuit

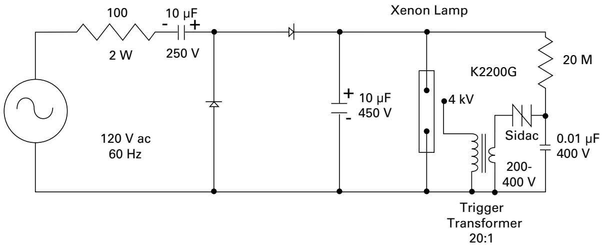
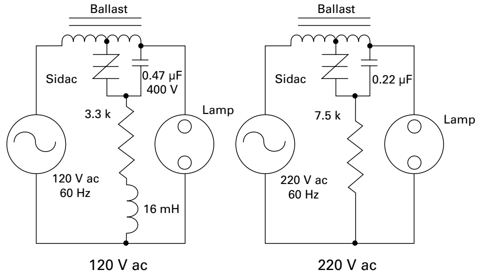
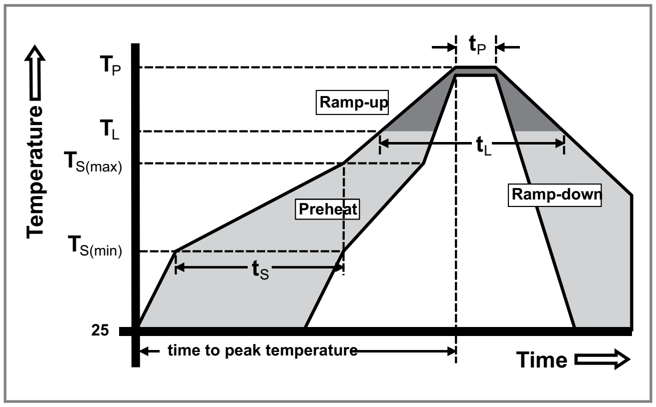


Figure 17: Typical High-pressure Sodium Lamp Firing Circuit



Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin Plated / Pb-free Solder Dipped
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

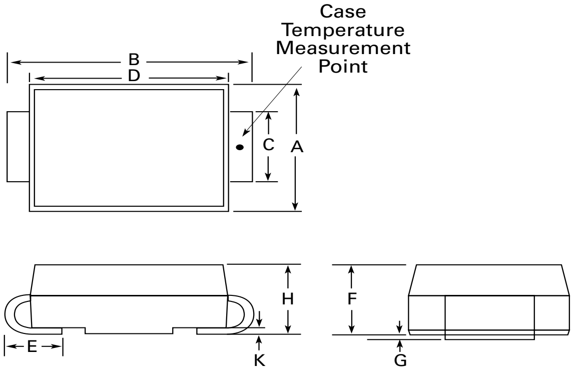
Design Considerations

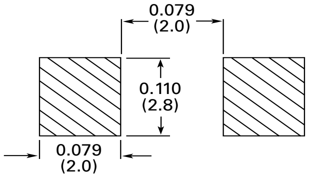
Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Overheating and surge currents are the main killers of SIDACs. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 80% min V_{BO} (V_{DC}), 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002: Category 3
Lead Bend	MIL-STD-750: Method 2036, Condition E

Dimensions — DO-214



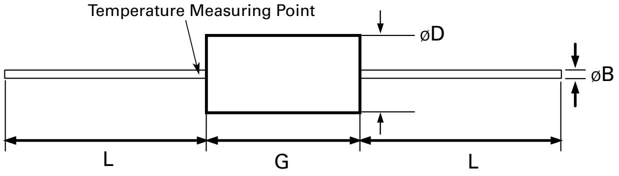


Recommended
Soldering Pad Outline

inch
(millimeter)

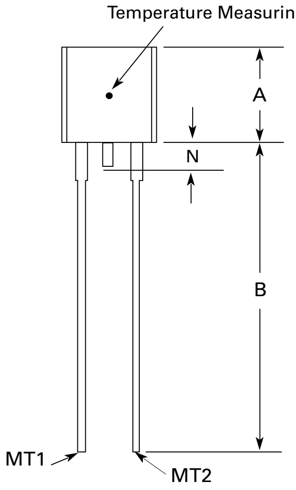
Dimension	Inches		Millimeters	
	Max	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
K	0.006	0.016	0.15	0.41

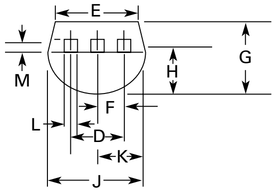
Dimensions — DO-15



Dimension	Inches		Millimeters	
	Max	Max	Min	Max
øB	0.028	0.034	0.711	0.864
øD	0.120	0.140	3.048	3.556
G	0.235	0.270	5.969	6.858
L	1.000		25.400	

Dimensions — TO-92 with Type 70 Lead Form





Dimension	Inches		Millimeters	
	Max	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500		12.70	
D	0.095	0.105	2.41	2.67
E	0.150		3.81	
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43
N		0.060		1.52

Notes:
1. Type 70 lead form as shown is standard for the E package.
2. All leads are insulated from case. Case is electrically nonconductive (rated at 16000V ac rms for one minute from leads to case over the operating temperature range.)
3. Mold flash shall not exceed 0.13 mm per side.

Product Selector

Part Number	Switching Voltage Range		Blocking Voltage	Packages		
	V_{BO} Minimum	V_{BO} Maximum	V_{DRM}	DO-15	DO-214	TO-92
K0900y	79V	97V	70V	K0900G	K0900S	K0900E70
K1050y	95V	113V	90V	K1050G	K1050S	K1050E70
K1100y	104V	118V	90V	K1100G	K1100S	K1100E70
K1200y	110V	125V	90V	K1200G	K1200S	K1200E70
K1300y	120V	138V	90V	K1300G	K1300S	K1300E70
K1400y	130V	146V	90V	K1400G	K1400S	K1400E70
K1500y	140V	170V	90V	K1500G	K1500S	K1500E70
K1800y	165V	195V	140V		K1800S	
K2000y	190V	215V	180V	K2000G	K2000S	K2000E70
K2002y	190V	215V	180V	K2002G		
K2200y	205V	230V	180V	K2200G	K2200S	K2200E70
K2202y	205V	230V	180V	K2202G		
K2400y	220V	250V	190V	K2400G	K2400S	K2400E70
K2402y	220V	250V	190V	K2402G		
K2500y	240V	280V	200V	K2500G	K2500S	K2500E70
K2502y	240V	280V	200V	K2502G		
K3002y	270V	330V	200V	K3002G		

Note: y = package

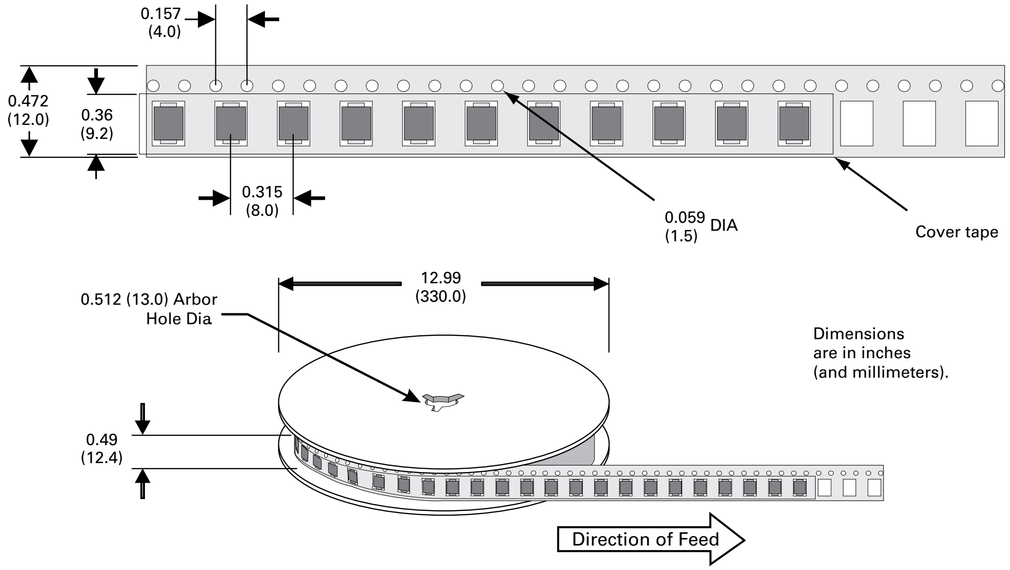
Revised: 12/14/14

Packing Options

Part Number	Marking	Weight	Packaging Mode	Base Quantity
Kxxx0G	Kxxx0G	0.38g	Bulk	1000
Kxxx0GRP	Kxxx0G	0.38g	Reel Pack	5000
Kxxx2G	Kxxx2G	0.38g	Bulk	1000
Kxxx2GRP	Kxxx2G	0.38g	Reel Pack	5000
Kxxx0SRP	KxxS	0.1g	Reel Pack	2500
Kxxx0E70	Kxxx0E	0.17g	Bulk	2000
Kxxx0E70AP	Kxxx0E	0.17g	Ammo Pack	2000
Kxxx0E70RP2	Kxxx0E	0.17g	Reel Pack	2000
Kxxx0E70RP3	Kxxx0E	0.17g	Reel Pack	2000

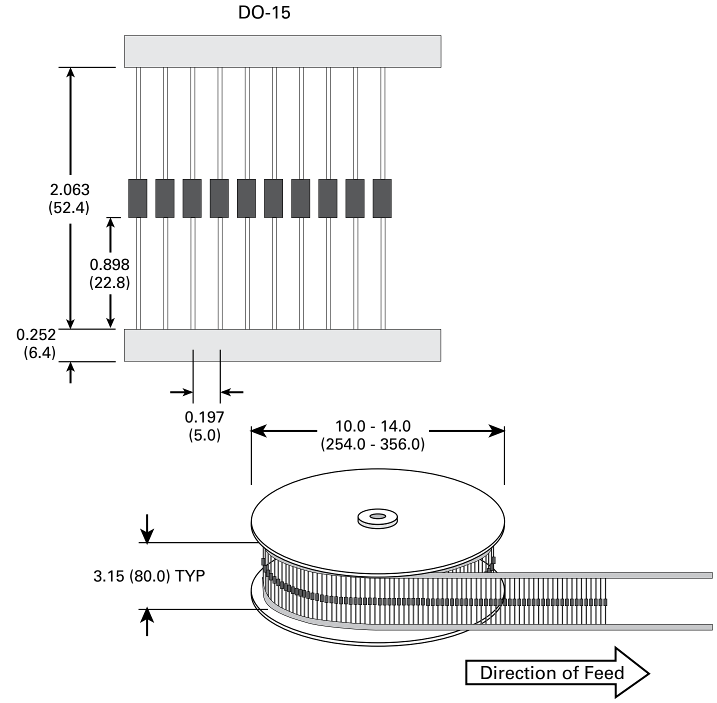
Note: xxx or xx = voltage

DO-214 Embossed Carrier Reel Pack (RP) Specifications



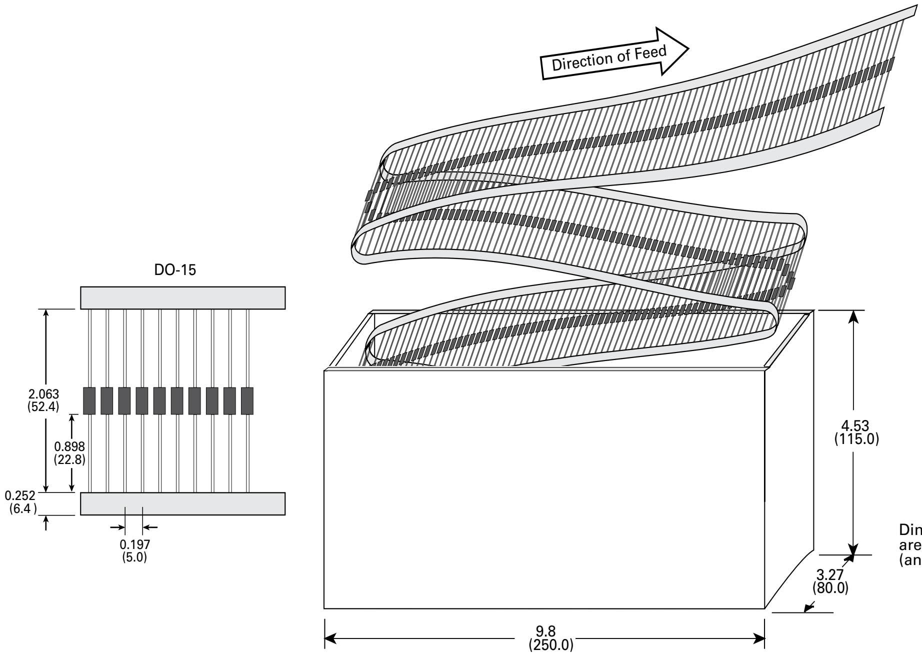
Dimensions
are in inches
(and millimeters).

DO-15 Reel Pack (RP) Specifications



Dimensions
are in inches
(and millimeters).

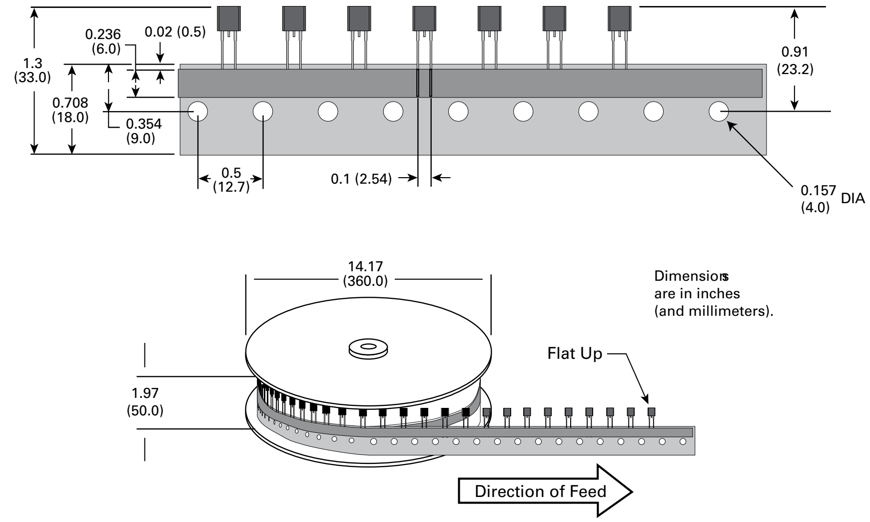
DO-15 Ammo Pack (AP) Specifications



Dimensions
are in inches
(and millimeters).

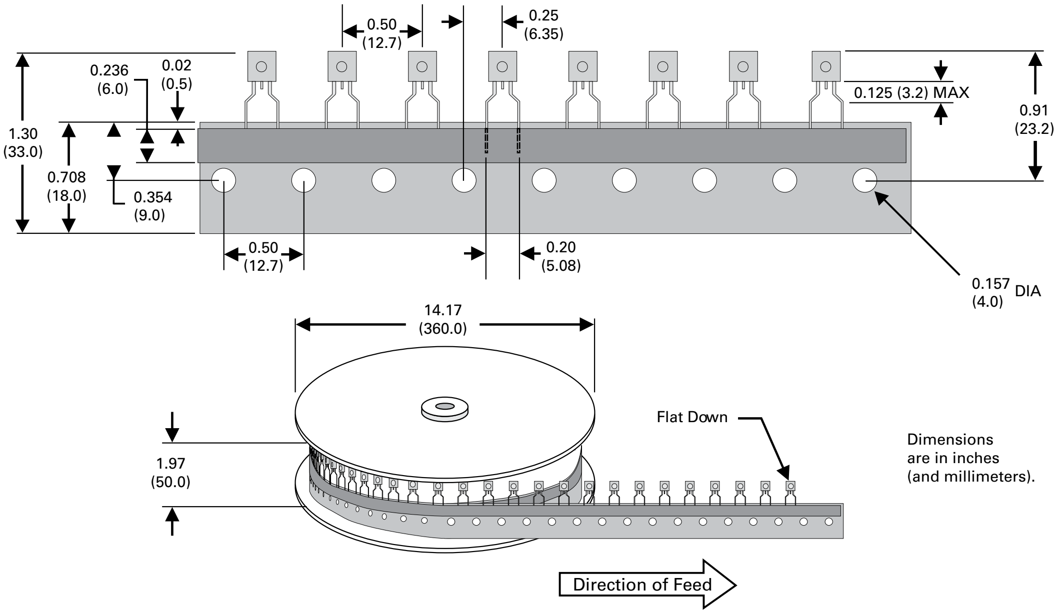
Revised: 12/14/14

TO-92 Type 70 Reel Pack (RP3) Radial Leaded Specifications



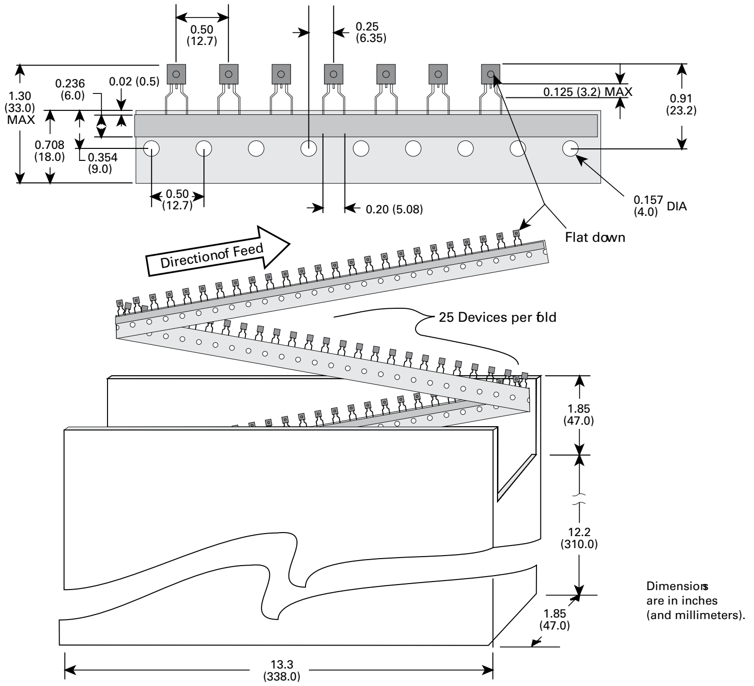
Dimensions
are in inches
(and millimeters).

TO-92 Type 70 Reel Pack (RP2) Radial Leaded Specifications



Dimensions
are in inches
(and millimeters).

TO-92 Type 70 Ammo Pack (AP) Radial Leaded Specifications



Dimensions are in inches (and millimeters).

Part Numbering System

K 240 0 E 70 RP2

DEVICE TYPE
K: Sidac

VOLTAGE RATING
090: 79 – 97V
105: 95 – 113V
110: 104 – 118V
120: 110 – 125V
130: 120 – 138V
140: 130 – 146V
150: 140 – 170V
180: 165 – 195V
200: 190 – 215V
220: 205 – 230V
240: 220 – 250V
250: 240 – 280V
300: 270 – 330V

PACKAGING OPTIONS
[blank]: Bulk
AP: Ammo(TO-92)
RP: Reel(non TO-92)
RP2: Reel(TO-92)
RP3: Reel(TO-92)

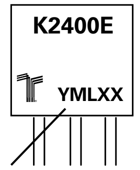
LEAD FORM DIMENSIONS
xx: Lead Form Option

PACKAGE TYPE
G: DO-15
S: DO-214
E: TO-92

CIRCUIT FUNCTION
0: Standard
2: Two Series Die

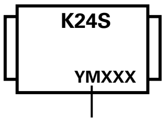
Part Marking System

TO-92



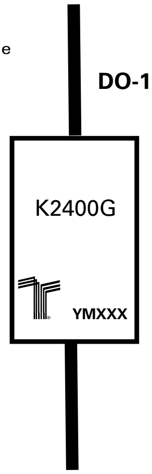
Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

DO-214AA

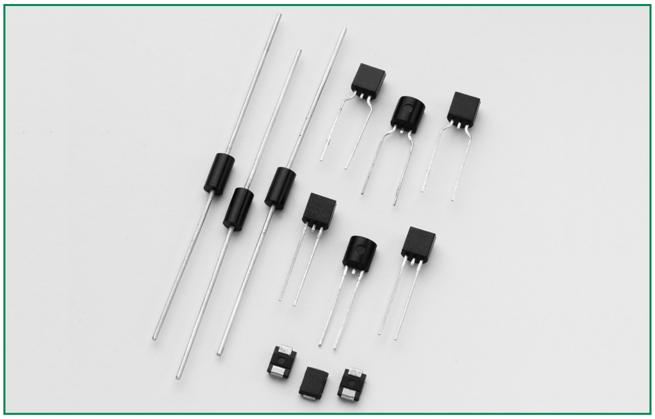


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

DO-15



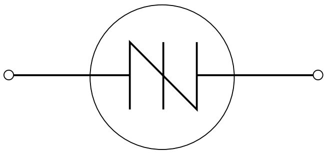
Kxxx0yH Series



Description

The new Kxxx0yH is a higher energy SIDAC switch for gas ignition applications requiring higher current pulse current especially at low repetition rate. It is offered in a DO-15 and TO-92 leaded packages as well as DO-214 surface mount package. Voltage activation of this solid state switch is accomplished with peak voltage level of 190 to 280Volts. The SIDAC is a silicon bilateral voltage triggered Thyristor switch that switches on through a negative resistance region to a low on-state voltage. Conduction will continue until current is interrupted or lowered below minimum holding current of the device.

Schematic Symbol



Features

- AC Circuit Oriented
- Triggering Voltage of 190 to 280V
- 280A Pulse Current Capability
- RoHS Compliant

Applications

Suitable for high voltage power supplies, natural gas igniters, and Xenon flash ignition.

Electrical Specifications (T_J = 25°C, unless otherwise specified)

Symbol	Parameters	Test Conditions		Min	Max	Unit
V_{BO}	Breakover/Trigger Voltage	K2000yH		190	215	V
		K2200yH		205	230	
		K2400yH		220	250	
		K2500yH		240	280	
V_{DRM}	Repetitive Peak Off-state Voltage	K2000yH		180		V
		K2200yH		180		
		K2400yH		190		
		K2500yH		200		
$I_{T(RMS)}$	On-state RMS Current	50/60Hz, T_J < 125°C			1	A
V_{TM}	Peak On-state Voltage	I_T = 1A			1.5	V
I_H	Dynamic Holding Current	R_L = 100Ω 50/60Hz Sine Wave			150	mA
R_S	Switching Resistance, $R_S = \frac{(V_{BO} - V_S)}{(I_S - I_{BO})}$	50/60Hz Sine Wave		100		Ω
I_{BO}	Breakover Current	50/60Hz Sine Wave			50	μA
I_{TRM}	Peak Repetitive Pulse Current (refer to figure 4)	t_p = 10μs	60Hz		120	A
			5Hz		280	
di/dt	Critical Rate of Rise of On-State Current				150	A/μs
dv/dt	Critical Rate of Rise of Off-State Voltage			1500		V/μs
T_S	Storage Temperature Range			-40	150	°C
T_J	Junction Temperature Range			-40	125	°C
$R_{\theta JL}$	Thermal Resistance, Junction to Lead	DO-15			18	°C/W
		DO-214			30	
$R_{\theta JC}$	Thermal Resistance, Junction to Case	TO-92			35	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	DO-15			75	°C/W
		TO-92			95	

Note: xxx - voltage, y = package

Figure 1: V-I Characteristics

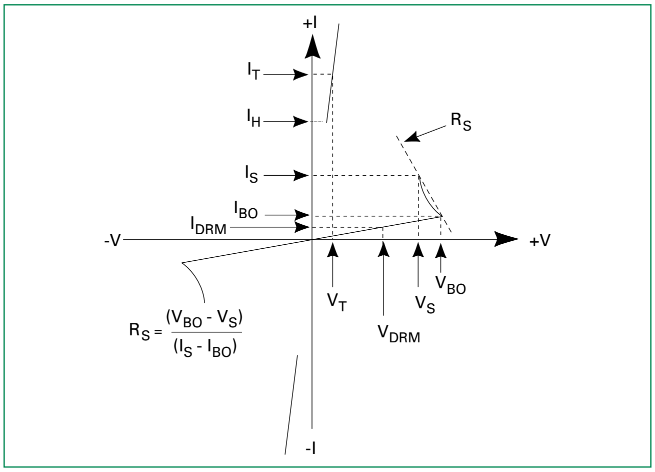


Figure 2: On-state Current vs. On-state Voltage (Typical)

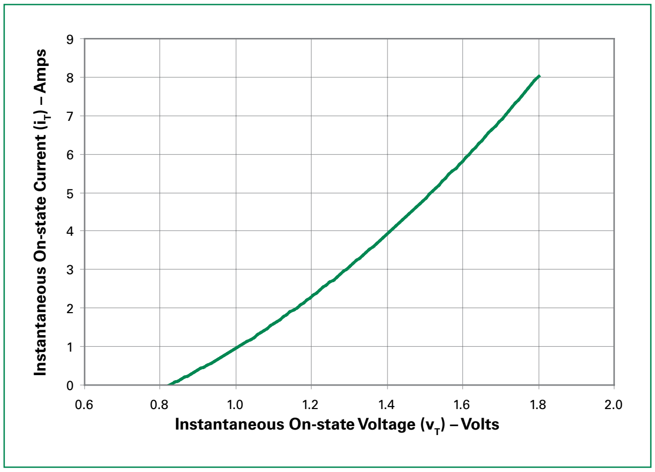
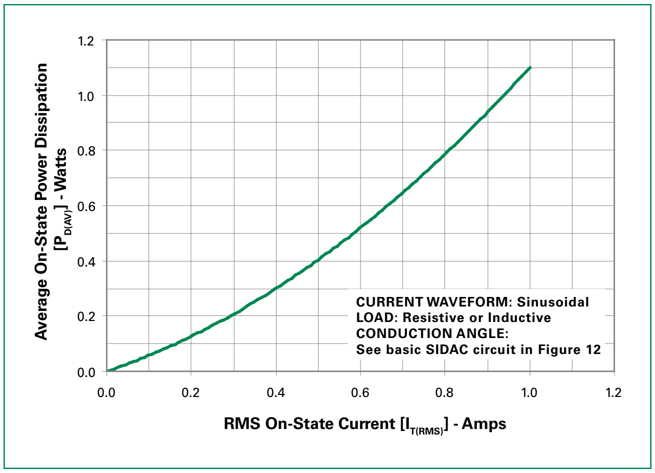


Figure 3: Power Dissipation vs. On-state Current (Typical)



CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE:
See basic SIDAC circuit in Figure 12

Figure 4: Repetitive Peak On-state Current (I_{TRM}) vs. Pulse Width at Various Frequencies

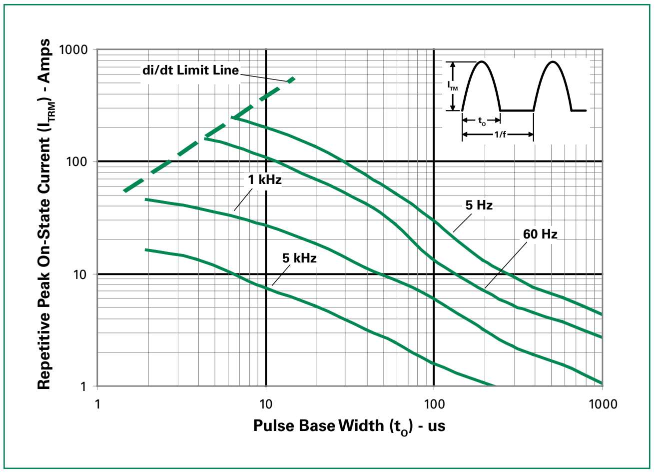
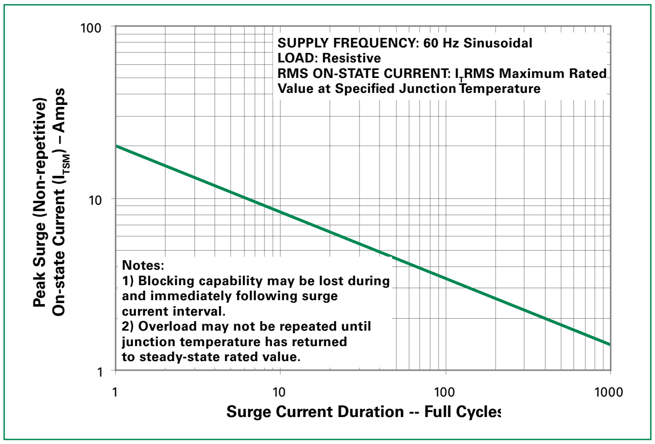


Figure 5: Surge Peak On-state Current vs. Number of Cycles



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS ON-STATE CURRENT: I_TRMS Maximum Rated Value at Specified Junction Temperature

Notes:
1) Blocking capability may be lost during and immediately following surge current interval.
2) Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 6: Normalized V_{BO} Change vs. Junction Temperature

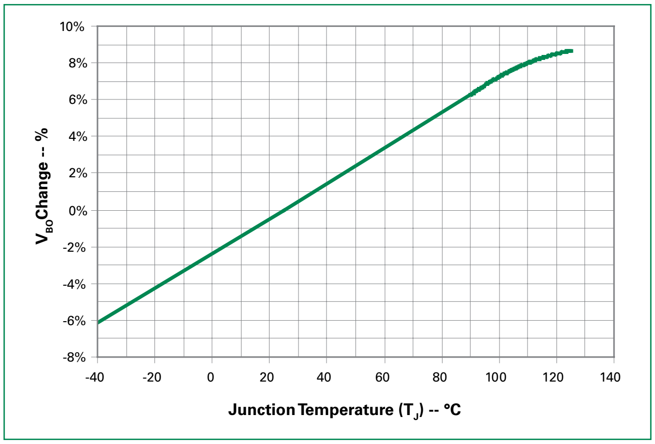


Figure 7: Normalized DC Holding Current vs. Junction Temperature

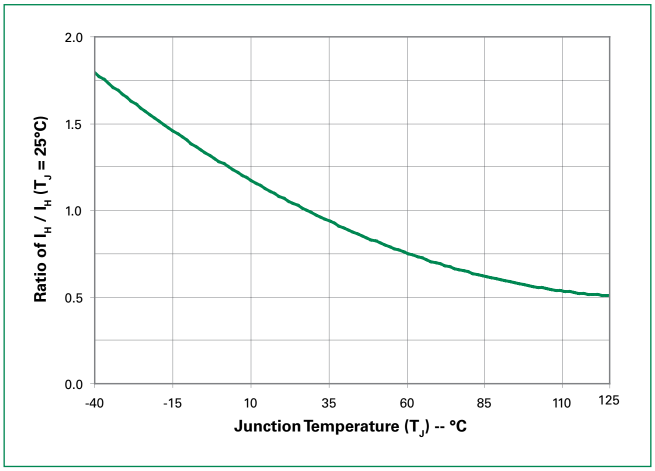


Figure 8: Maximum Allowable Case Temperature vs. RMS On-State Current

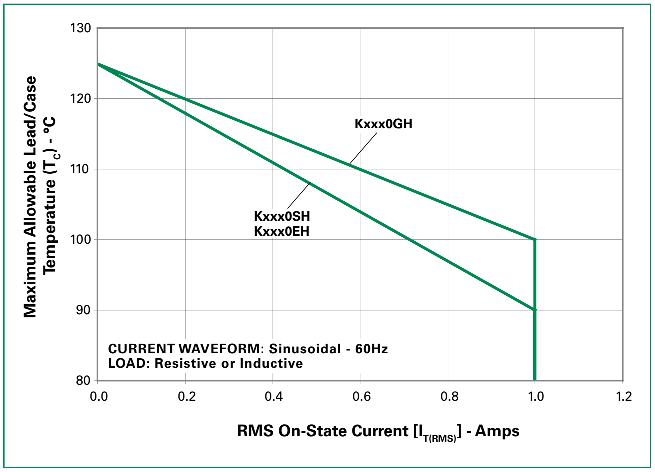


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

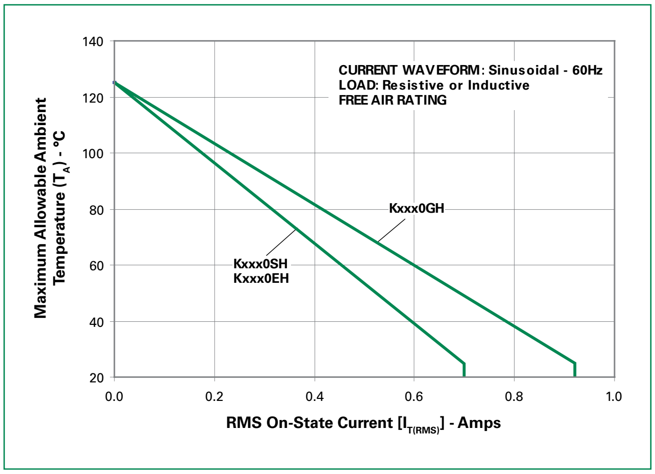


Figure 10: Normalized Repetitive Peak Breakover Current (I_{BO}) vs. Junction Temperature

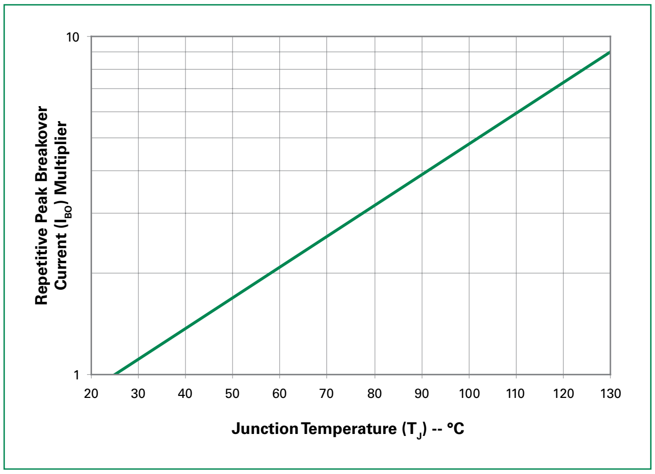


Figure 11: Dynamic Holding Current Test Circuit for SIDACs

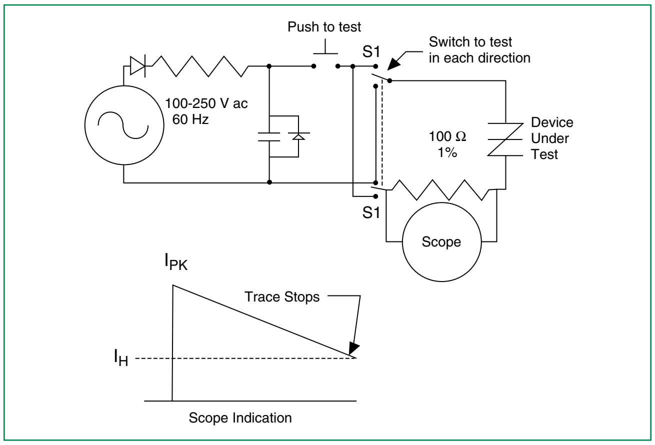


Figure 12: Basic SIDAC Circuit

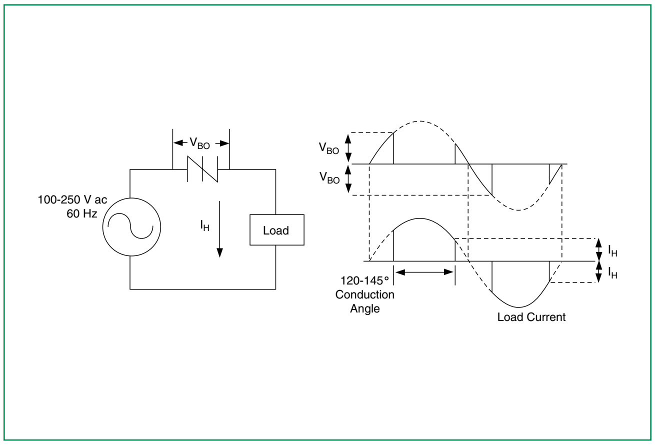


Figure 13: Relaxation Oscillator Using a SIDAC

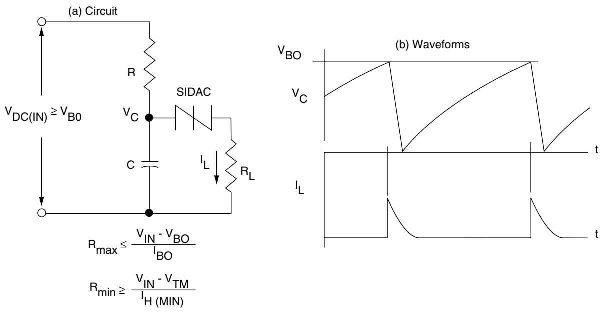
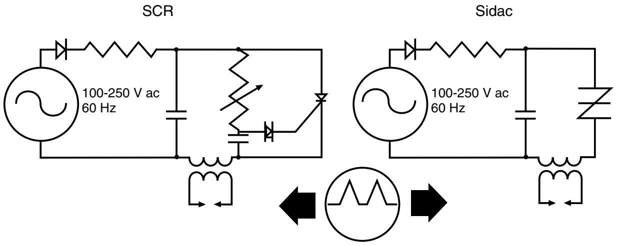
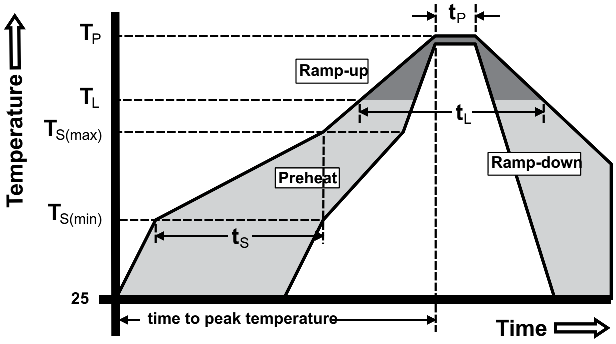


Figure 14: General Gas Ignitor Circuit



Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Additional Information

Datasheet

Resources

Samples

Physical Specifications

Terminal Material	Copper Alloy
Terminal Finish	100% Matte Tin-plated /Pb Free solder dipped.
Body Material	UL recognized epoxy meeting flammability classification 94V-0.

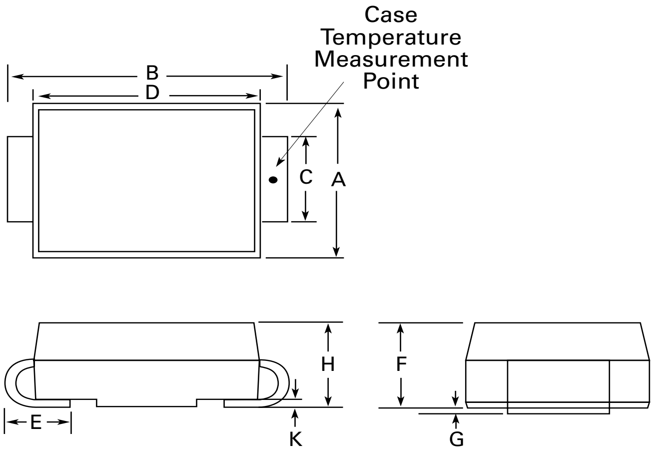
Design Considerations

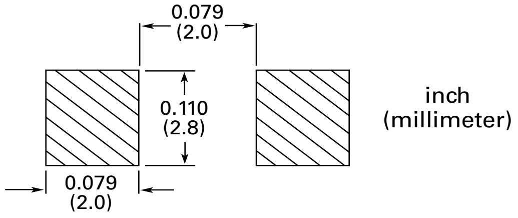
Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Overheating and surge currents are the main killers of SIDACs. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 (VDC), 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002: Category 3
Repetitive Surge Life Testing	MIL-STD-750: Method 2036, Condition E

Dimensions — DO-214

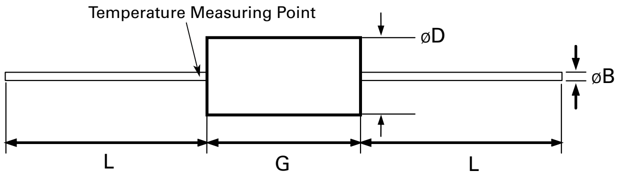




Recommended
Soldering Pad Outline

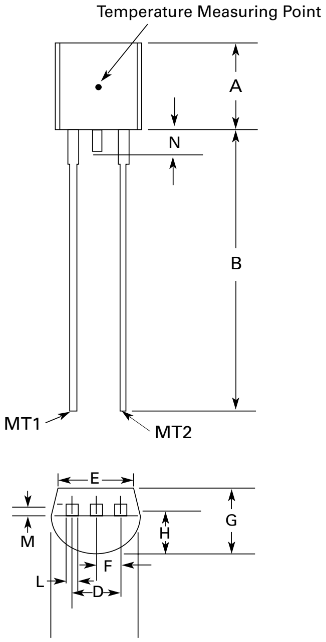
Dimension	Inches		Millimeters	
	Max	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
K	0.006	0.016	0.15	0.41

Dimensions — DO-15



Dimension	Inches		Millimeters	
	Max	Max	Min	Max
øB	0.028	0.034	0.711	0.864
øD	0.120	0.140	3.048	3.556
G	0.235	0.270	5.969	6.858
L	1.000		25.400	

Dimensions - TO-92 with Type 70 Lead Form



Dimension	Inches		Millimeters	
	Max	Max	Min	Max
A	0.176	0.196	4.47	4.98
B	0.500		12.70	
D	0.095	0.105	2.41	2.67
E	0.150		3.81	
F	0.046	0.054	1.16	1.37
G	0.135	0.145	3.43	3.68
H	0.088	0.096	2.23	2.44
J	0.176	0.186	4.47	4.73
K	0.088	0.096	2.23	2.44
L	0.013	0.019	0.33	0.48
M	0.013	0.017	0.33	0.43
N		0.060		1.52

Notes:
1. Type 70 lead form as shown is standard for the E package.
2. All leads are insulated from case. Case is electrically nonconductive (rated at 16000V ac rms for one minute from leads to case over the operating temperature range.)
3. Mold flash shall not exceed 0.13 mm per side.

Product Selector

Part Number	Switching Voltage Range		Blocking Voltage	Packages		
	V_{BO} Minimum	V_{BO} Maximum	V_{DRM}	DO-15	DO-214	TO-92
K2000yH	190V	215V	180V	K2000GH	K2000SH	K2000EH70
K2200yH	205V	230V	180V	K2200GH	K2200SH	K2200EH70
K2400yH	220V	250V	190V	K2400GH	K2400SH	K2400EH70
K2500yH	240V	280V	200V	K2500GH	K2500SH	K2500EH70

Note: y = package

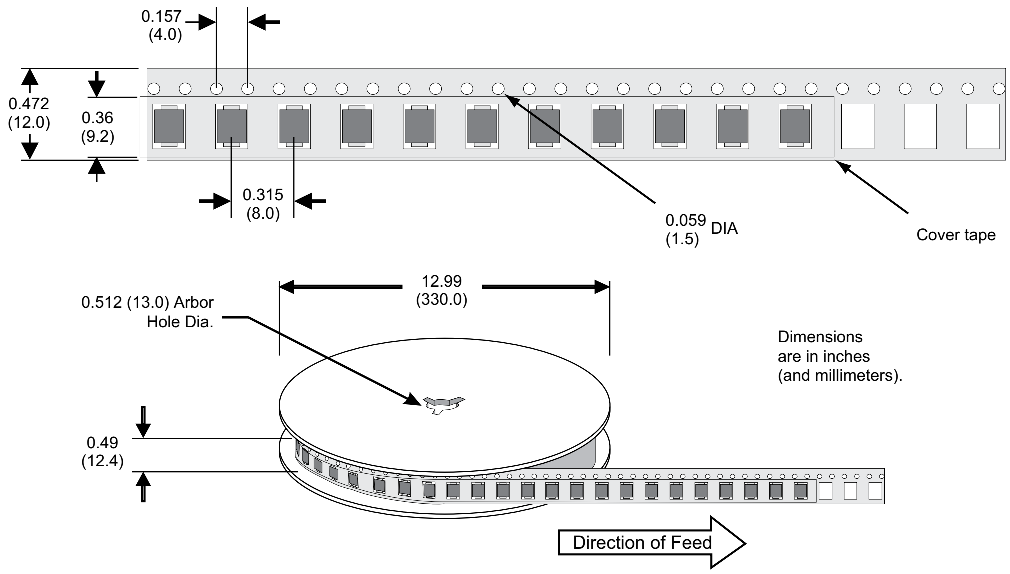
Packing Options

Part Number	Marking	Weight	Packaging Mode	Base Quantity
Kxxx0GH	Kxxx0GH	0.38g	Bulk	1000
Kxxx0GHRP	Kxxx0GH	0.38g	Reel Pack	5000
Kxxx0SHRP	KxxSH	0.1g	Reel Pack	2500
Kxxx0EH70	Kxxx0EH	0.17g	Bulk	2000
Kxxx0EH70AP	Kxxx0EH	0.17g	Ammo Pack	2000
Kxxx0EH70RP2	Kxxx0EH	0.17g	Reel Pack	2000
Kxxx0EH70RP3	Kxxx0EH	0.17g	Reel Pack	2000

Note: xxx or xx = voltage

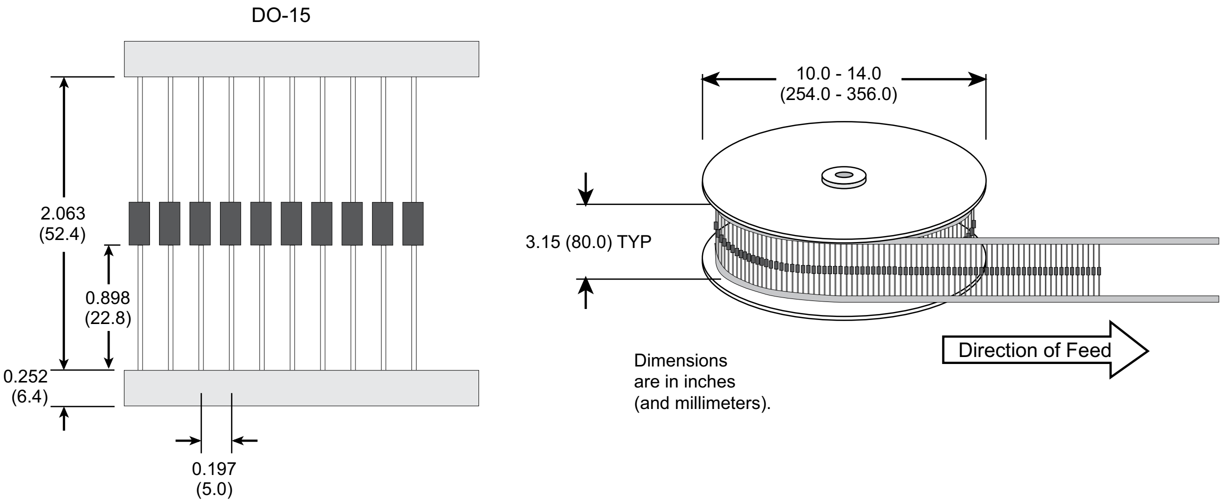
DO-214 Embossed Carrier Reel Pack (RP) Specifications

Meets all EIA-481-1 Standards



DO-15 Reel Pack (RP) Specifications

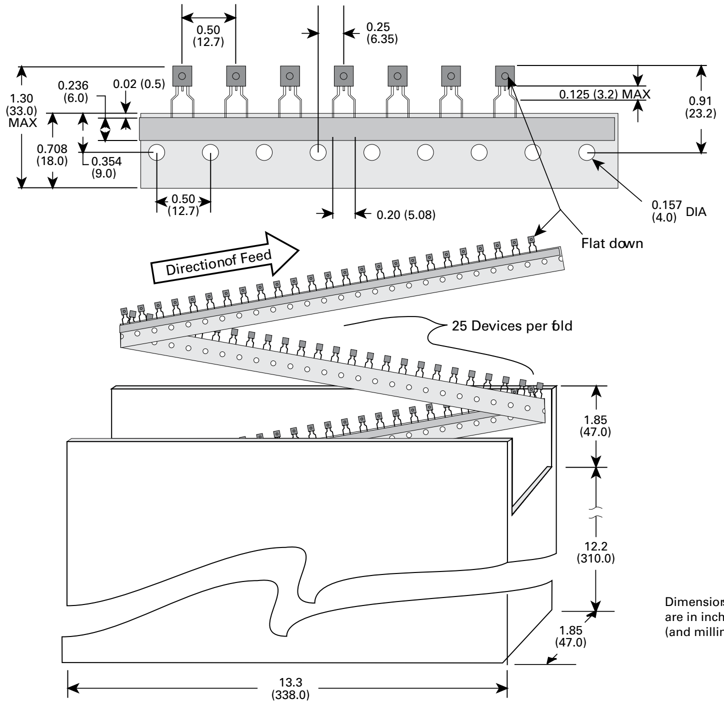
Meets all EIA RS-296 Standards



Dimensions
are in inches
(and millimeters).

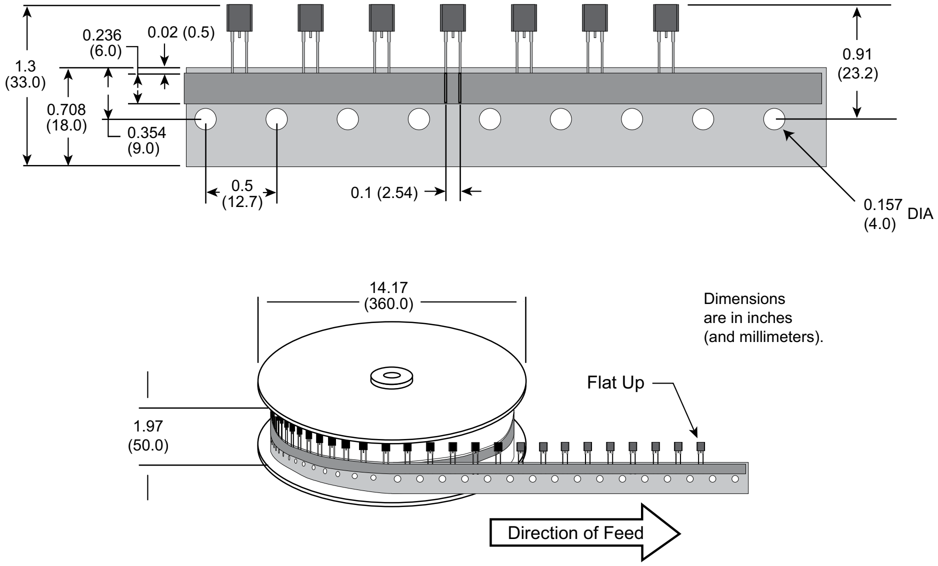
TO-92 Type 70 Ammo Pack (AP) Radial Leaded Specifications

Meets all EIA-468-C Standards



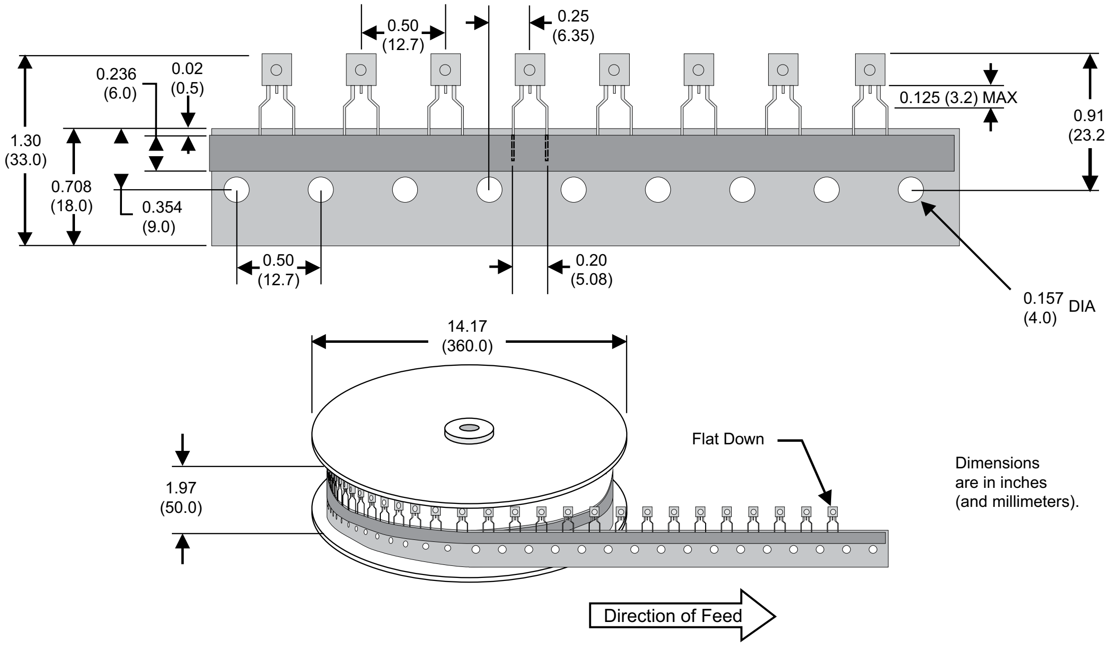
Dimensions
are in inches
(and millimeters).

TO-92 Type 70 Reel Pack (RP3) Optional Specifications



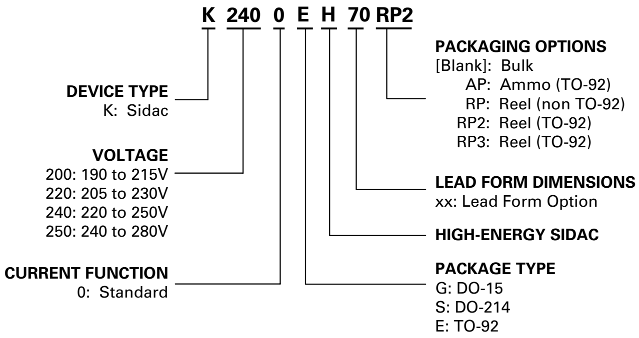
Dimensions
are in inches
(and millimeters).

TO-92 Type 70 Reel Pack (RP2) Standard Specifications



Dimensions
are in inches
(and millimeters).

Part Numbering System



DEVICE TYPE
K: Sidac

VOLTAGE
200: 190 to 215V
220: 205 to 230V
240: 220 to 250V
250: 240 to 280V

CURRENT FUNCTION
0: Standard

PACKAGING OPTIONS
[Blank]: Bulk
AP: Ammo (TO-92)
RP: Reel (non TO-92)
RP2: Reel (TO-92)
RP3: Reel (TO-92)

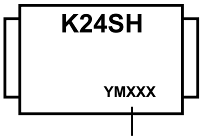
LEAD FORM DIMENSIONS
xx: Lead Form Option

HIGH-ENERGY SIDAC

PACKAGE TYPE
G: DO-15
S: DO-214
E: TO-92

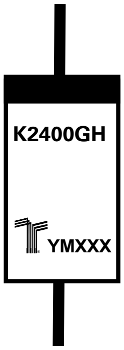
Part Marking System

DO-214AA

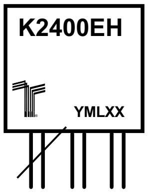


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

DO-15



TO-92

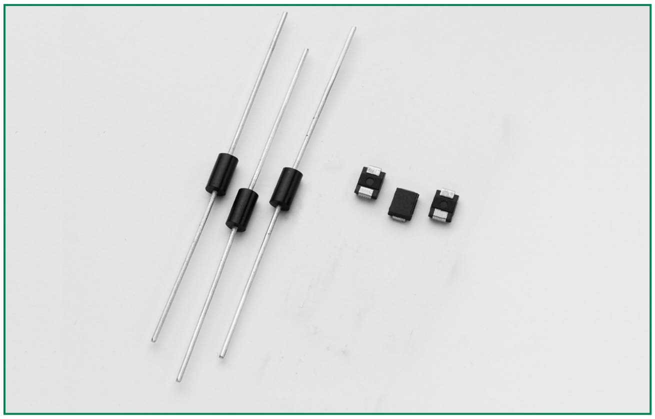


Date Code Marking
Y:Year Code
M: Month Code
L: Location Code
XX: Lot Serial Code

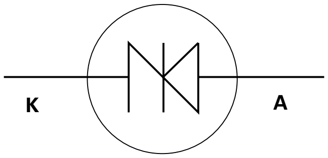
Revised: 12/14/14

K2xx0yHU Series

RoHS



Schematic Symbol



Description

The new K2xx0yHU is a higher energy SIDAC switch for gas ignition applications requiring higher current pulse current especially at low repetition rate. It is offered in a DO-15 leaded package and DO-214AA surface mount package. Voltage activation of this solid state switch is accomplished with peak voltage level of 190 to 260Volts. The SIDAC is a silicon bilateral voltage triggered Thyristor switch that switches on through a negative resistance region to a low on-state voltage. Conduction will continue until current is interrupted or lowered below minimum holding current of the device.

Features

- AC circuit oriented
- Triggering Voltage of 190 to 260V
- 280A Pulse current capability
- RoHS compliant
- Unidirectional

Applications

Suitable for high voltage power supplies, natural gas igniters, and Xenon flash ignition.

Electrical Specifications (T_J = 25°C, unless otherwise specified)

Symbol	Parameters	Test Conditions	Min	Max	Unit
V_{BO}	Breakover/Trigger Voltage	K2000yHU	190	210	V
		K2200yHU	210	230	
		K2400yHU	230	250	
		K2500yHU	240	260	
V_{DRM}	Repetitive Peak Off-state Voltage	K2000yHU	180		V
		K2200yHU	190		
		K2400yHU	210		
		K2500yHU	220		
$I_{T(RMS)}$	On-state RMS Current	50/60Hz, T_J < 125°C		1	A
V_{TM}	Peak On-state Voltage	I_T = 1A		1.5	V
I_H	Dynamic Holding Current	R_L = 100Ω 50/60Hz Sine Wave		60	mA
R_S	Switching Resistance, $R_S = \frac{(V_{BO} - V_S)}{(I_S - I_{BO})}$	50/60Hz Sine Wave	100		Ω
I_{BO}	Breakover Current	50/60Hz Sine Wave		500	µA
I_{TRM}	Peak Repetitive Pulse Current (refer to figure 4)	t_p = 10µs 60Hz		120	A
		5Hz		280	
di/dt	Critical Rate of Rise of On-State Current			220	A/µs
dv/dt	Critical Rate of Rise of Off-State Voltage		1500		V/µs
T_S	Storage Temperature Range		-40	150	°C
T_J	Junction Temperature Range		-40	125	°C
$R_{\theta JL}$	Thermal Resistance, Junction to Lead	DO-15		18	°C/W
		DO-214AA		30	
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	DO-15		75	°C/W

Note: xxx - voltage, y = package

Figure 1: V-I Characteristics

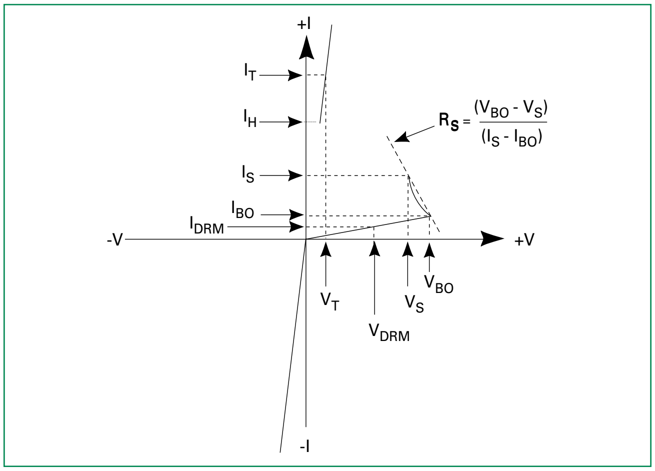


Figure 2: On-state Current vs. On-state Voltage (Typical)

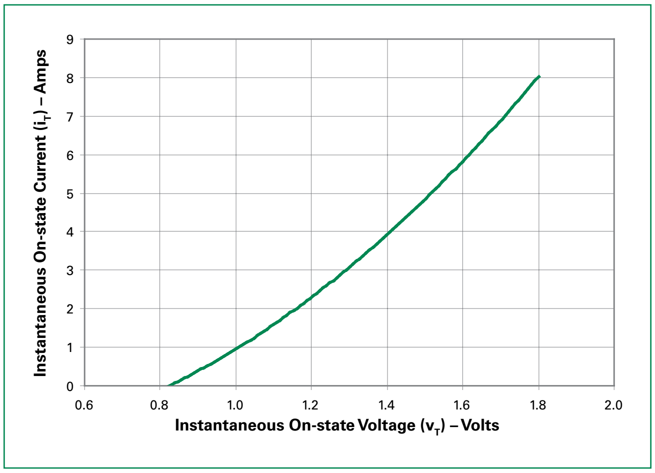
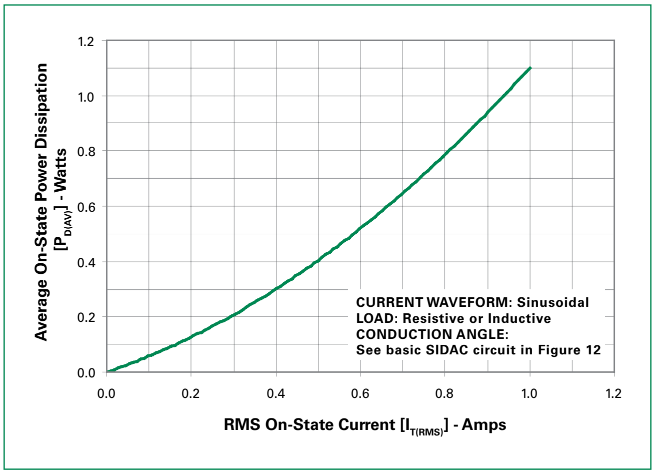


Figure 3: Power Dissipation vs. On-state Current (Typical)



CURRENT WAVEFORM: Sinusoidal
LOAD: Resistive or Inductive
CONDUCTION ANGLE:
See basic SIDAC circuit in Figure 12

Figure 4: Repetitive Peak On-state Current (I_{TRM}) vs. Pulse Width at Various Frequencies

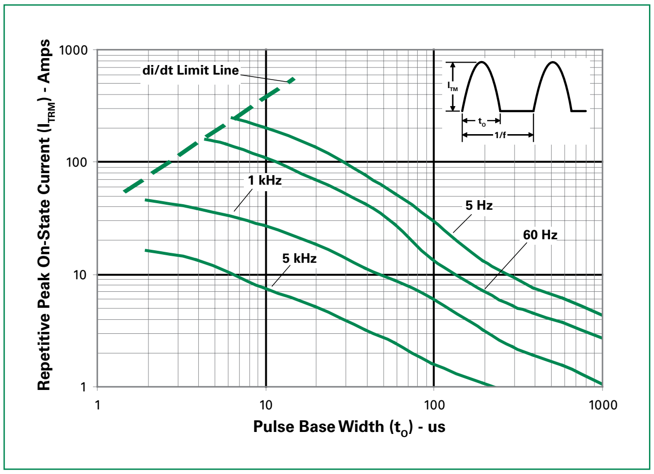
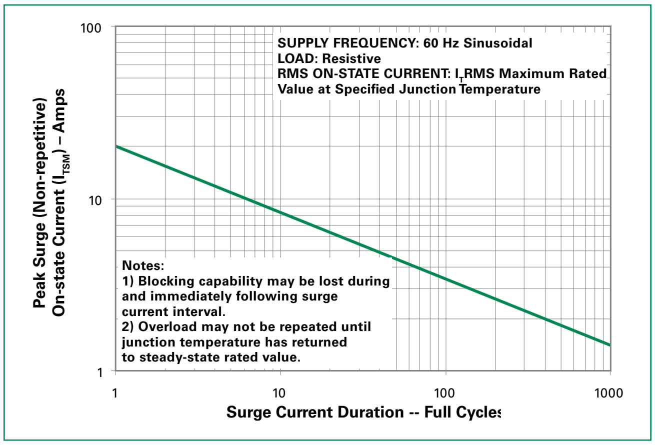


Figure 5: Surge Peak On-state Current vs. Number of Cycles



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS ON-STATE CURRENT: I_TRMS Maximum Rated Value at Specified Junction Temperature

Notes:
1) Blocking capability may be lost during and immediately following surge current interval.
2) Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 6: Normalized V_{BO} Change vs. Junction Temperature

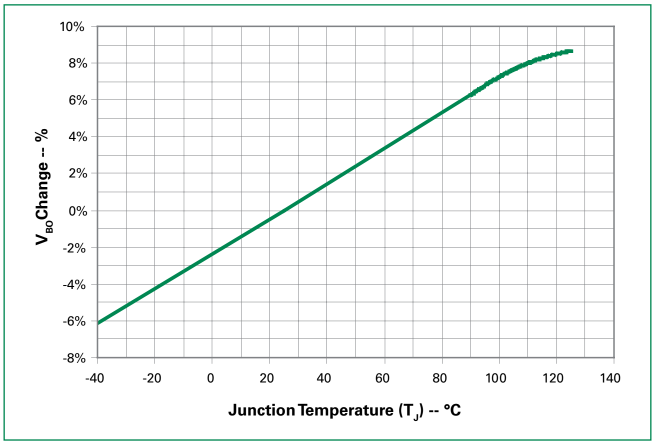


Figure 7: Normalized DC Holding Current vs. Junction Temperature

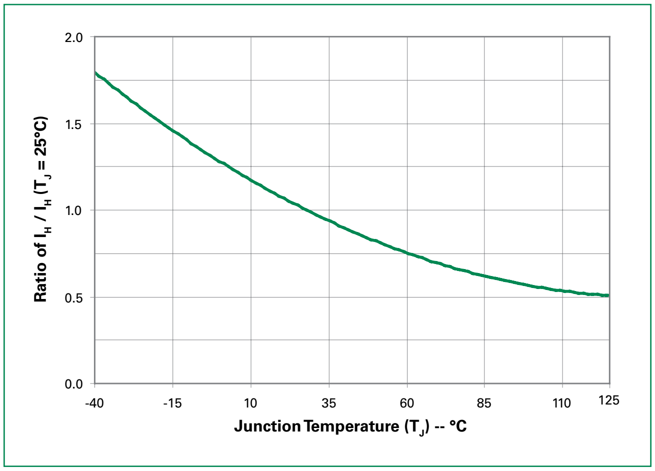


Figure 8: Maximum Allowable Case Temperature vs. RMS On-State Current

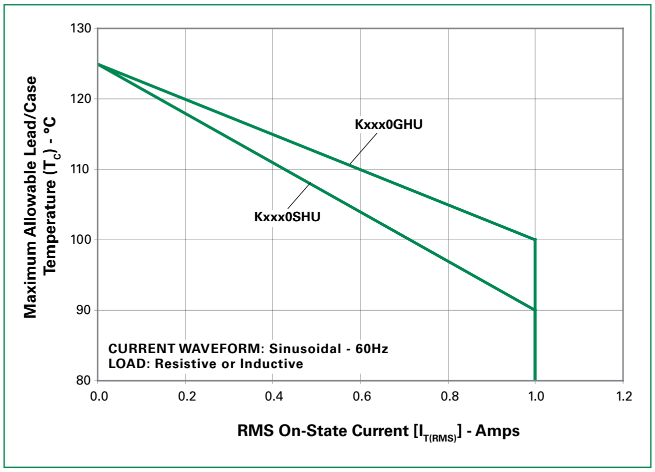


Figure 9: Maximum Allowable Ambient Temperature vs. RMS On-State Current

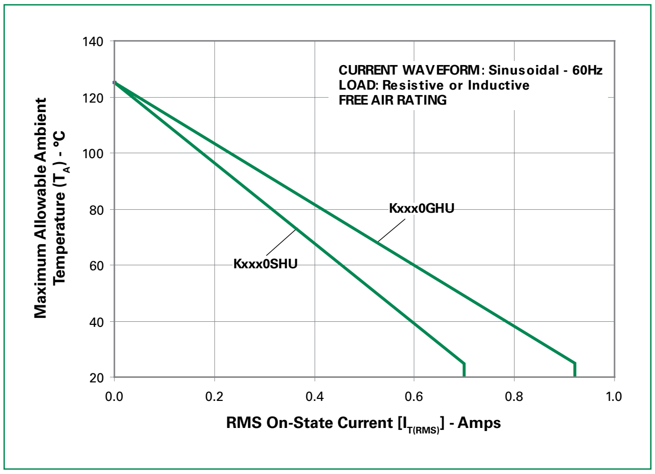


Figure 10: Normalized Repetitive Peak Breakover Current (I_{BO}) vs. Junction Temperature

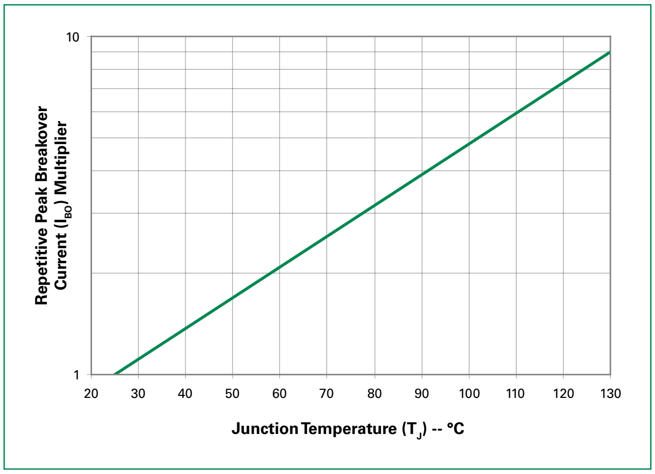
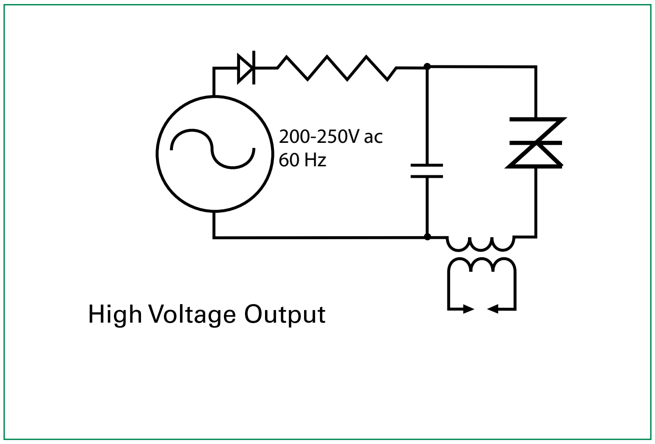


Figure 11: General Gas Ignitor Circuit



Additional Information

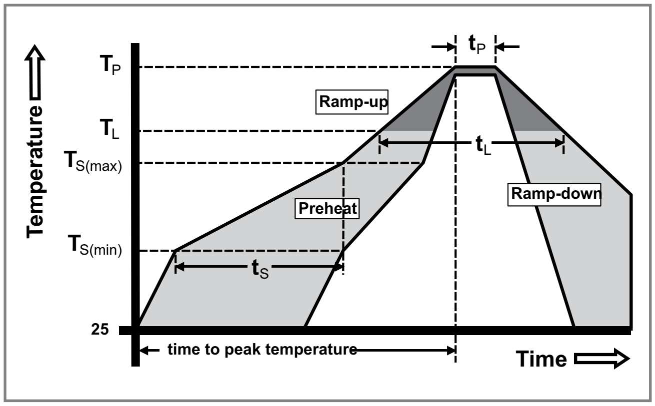
Datasheet

Resources

Samples

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Material	Copper Alloy
Terminal Finish	100% Matte Tin-plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0.

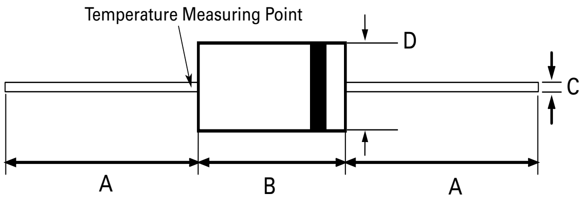
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Overheating and surge currents are the main killers of SIDACs. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

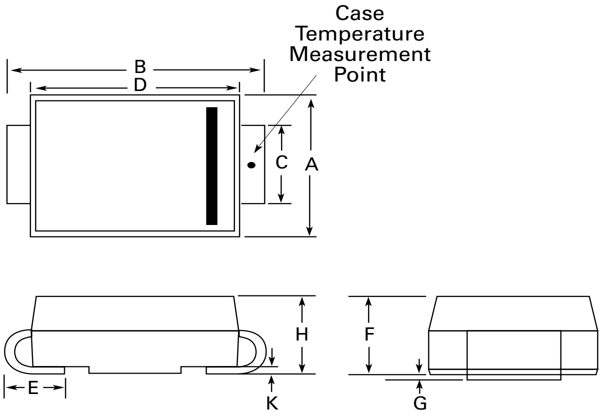
Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 (VDC), 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002: Category 3
Repetitive Surge Life Testing	MIL-STD-750: Method 2036, Condition E

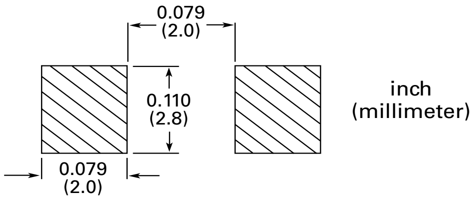
Dimensions — DO-15



Dimension	Inches		Millimeters	
	Max	Max	Min	Max
A	1.000	-	25.40	-
B	0.230	0.300	5.80	7.60
C	0.028	0.034	0.71	0.86
D	0.104	0.140	2.60	3.60

Dimensions — DO-214AA





Recommended
Soldering Pad Outline

Dimension	Inches		Millimeters	
	Max	Max	Min	Max
A	0.130	0.156	3.30	3.95
B	0.201	0.220	5.10	5.60
C	0.077	0.087	1.95	2.20
D	0.159	0.181	4.05	4.60
E	0.030	0.063	0.75	1.60
F	0.075	0.096	1.90	2.45
G	0.002	0.008	0.05	0.20
H	0.077	0.104	1.95	2.65
K	0.006	0.016	0.15	0.41

Product Selector

Part Number	Switching Voltage Range		Blocking Voltage	Packages	
	V_{BO} Minimum	V_{BO} Maximum	V_{DRM}	DO-15	DO-214AA
K2000yHU	190V	210V	180V	K2000GHU	K2000SHU
K2200yHU	210V	230V	190V	K2200GHU	K2200SHU
K2400yHU	230V	250V	210V	K2400GHU	K2400SHU
K2500yHU	240V	260V	220V	K2500GHU	K2500SHU

Note: y = package

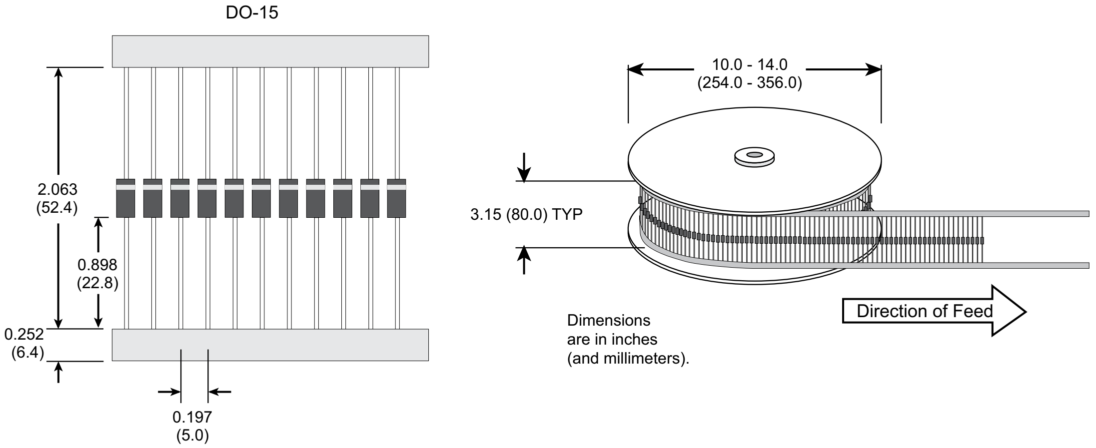
Packing Options

Part Number	Marking	Weight	Packaging Mode	Base Quantity
K2xx0GHU	K2xx0GHU	0.38g	Bulk	1000
K2xx0GHURP	K2xx0GHU	0.38g	Reel Pack	5000
K2xx0SHURP	KxxHU	0.10g	Reel Pack	2500

Note: xx = voltage

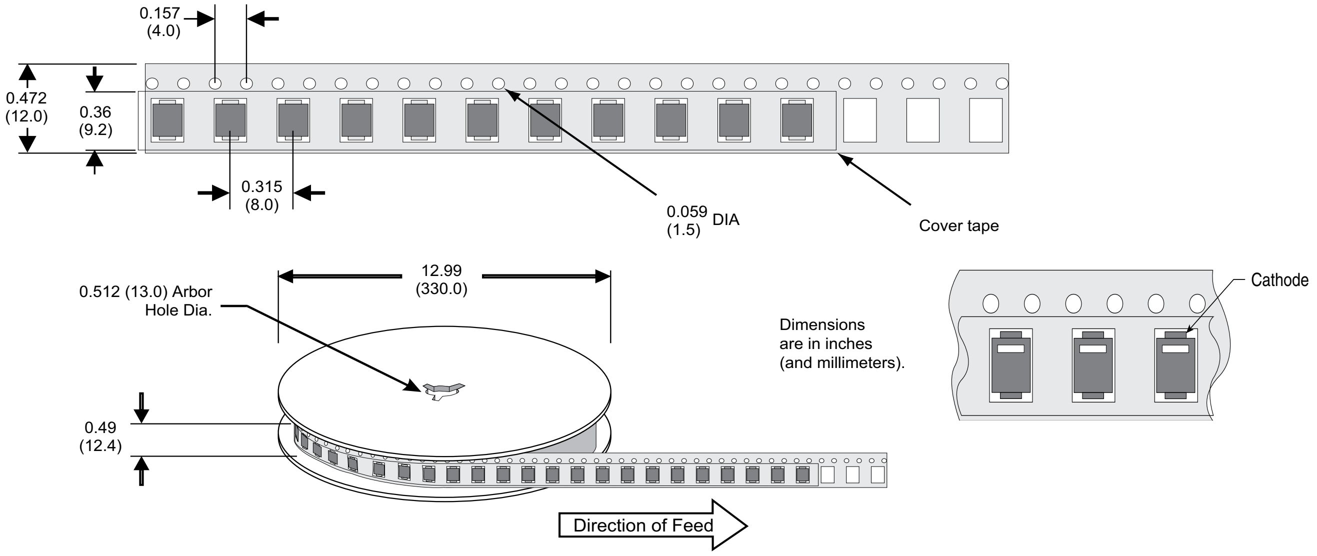
DO-15 Reel Pack (RP) Specifications

Meets all EIA RS-296 Standards

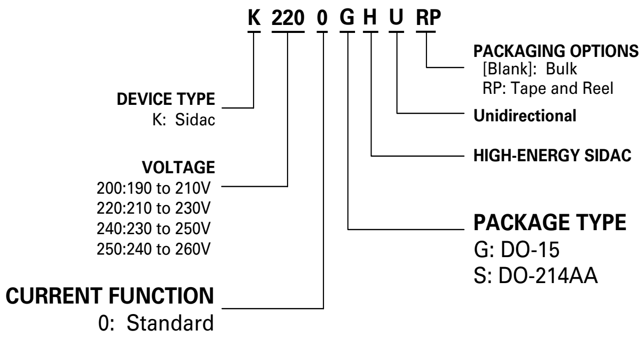


DO-214AA Embossed Carrier Reel Pack (RP) Specifications

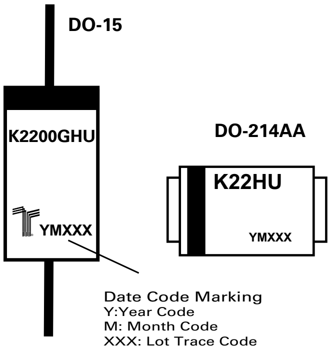
Meets all EIA-481-1 Standards



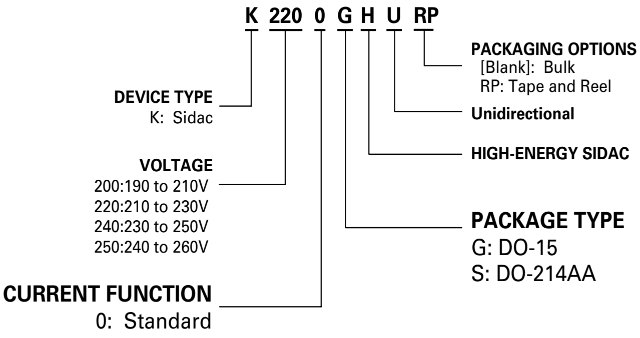
Part Numbering System



Part Marking System



Part Numbering System



DEVICE TYPE
K: Sidac

VOLTAGE
200:190 to 210V
220:210 to 230V
240:230 to 250V
250:240 to 260V

CURRENT FUNCTION
0: Standard

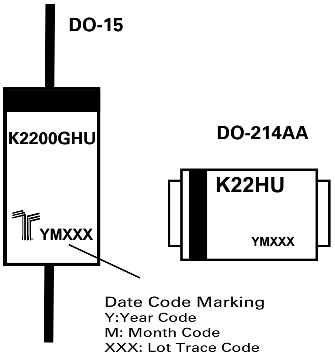
PACKAGING OPTIONS
[Blank]: Bulk
RP: Tape and Reel

Unidirectional

HIGH-ENERGY SIDAC

PACKAGE TYPE
G: DO-15
S: DO-214AA

Part Marking System

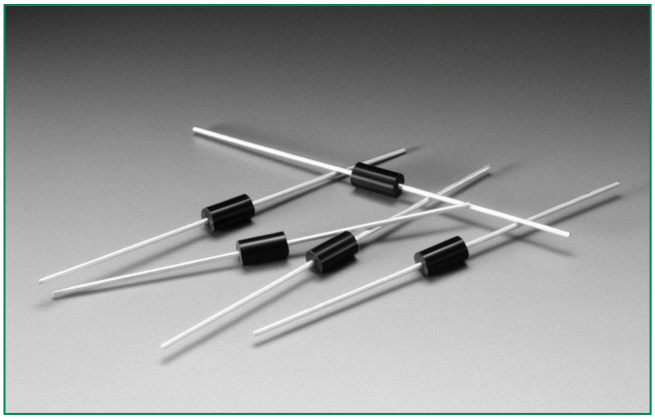


Date Code Marking
Y:Year Code
M: Month Code
XXX: Lot Trace Code

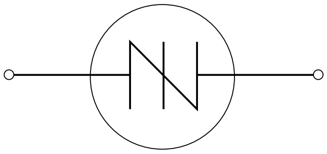
Revised: 12/14/14

Kxxx1G Series

RoHS



Schematic Symbol



Applications

Typical application circuit presented in Figure 10 of this data sheet (Typical Metal Halide Ignitor Circuit).

Description

The Multipulse™ SIDAC is a voltage switch used in Metal-Halide lamp ignition circuits as well as High Pressure Sodium lamp ignition circuits for outdoor street and area lighting. This robust solid state switch is designed to handle lamp igniter applications requiring operation at ambient temperatures up to 90°C where igniter circuit components can raise SIDAC junction temperature up to 125°C, especially when the lamp element is removed or ruptured. Its excellent commutation time (t_{COMM}) makes this robust product best suited for producing multiple pulses in each half cycle of 50/60 Hz line voltage. The Multipulse™ SIDAC is offered in DO-15 axial leaded package.

Kxxx1G SIDAC has a repetitive off-state blocking voltage (V_{DRM}) of 180V to 270V minimum depending actual device type. Blocking capability is ensured by glass passivated junctions for best reliability. Package is epoxy encapsulation with tin-plated copper alloy leads.

Features

- AC circuit oriented
- Triggering Voltage of 200 to 380V
- RoHS Compliant

Electrical Specifications

Symbol	Parameters	Test Conditions	Min	Max	Unit
V_{BO}	Breakover/Trigger Voltage	K2201G K2401G K2501G K3601G	200 220 240 340	230 250 280 380	V
V_{DRM}	Repetitive Peak Off-State Voltage	K2201G K2401G K2501G K3601G	180 190 200 270		V
$I_{T(RMS)}$	On-State RMS Current, $T_J < 125°C$	50/60Hz Sine Wave		1	A
I_H	Dynamic Holding Current, R=100 Ω	50/60Hz Sine Wave		120 TYP	mA
R_S	Switching Resistance, $R_S = \frac{(V_{BO} - V_S)}{(I_S - I_{BO})}$	50/60Hz Sine Wave	100		Ω
t_{COMM}	Commutation Time $T_J < 125°C$	See test circuit and waveform in Figure 9		100	µsec
I_{BO}	Breakover Current	50/60Hz Sine Wave		10	uA
I_{TSM}	Non-repetitive 1 cycle On-State peak value	60Hz 50Hz		20.0 16.7	A
di/dt	Critical Rate of Rise of On-State Current			150	A/µsec
dv/dt	Critical Rate of Rise of Off-State Voltage			1500	V/µsec
T_S	Storage Temperature Range		-40	+125	°C
T_J	Max Operating Junction Temperature		-40	+125	°C
$R_{\theta JL}$	Thermal Resistance	Junction to lead		18	°C/W

Figure 1: Characteristics

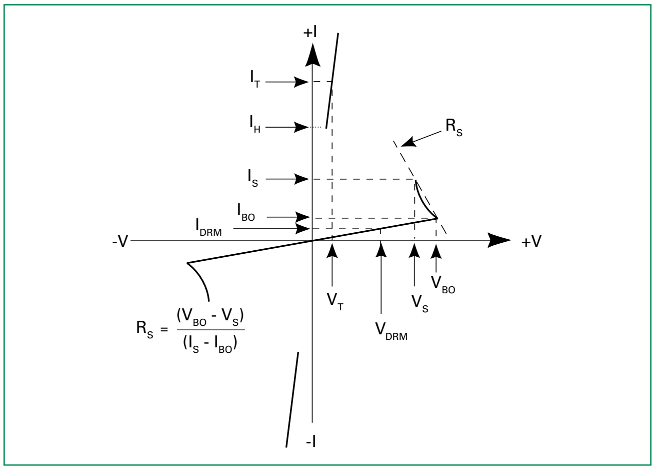


Figure 2: Maximum Allowable Lead/Tab Temperature vs. On-State Current

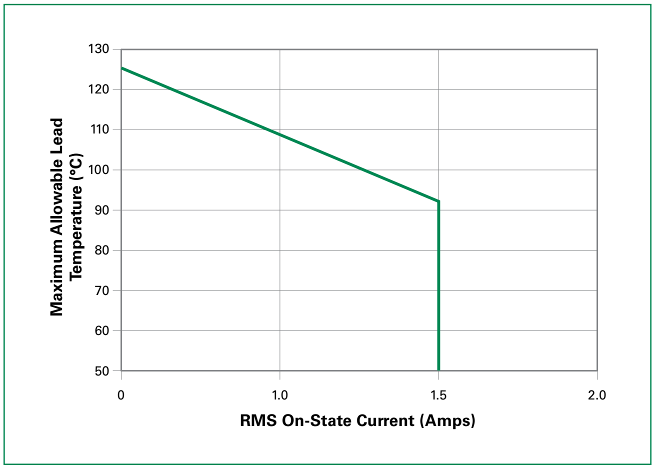


Figure 3: Power Dissipation (Typical) vs. On-State Current

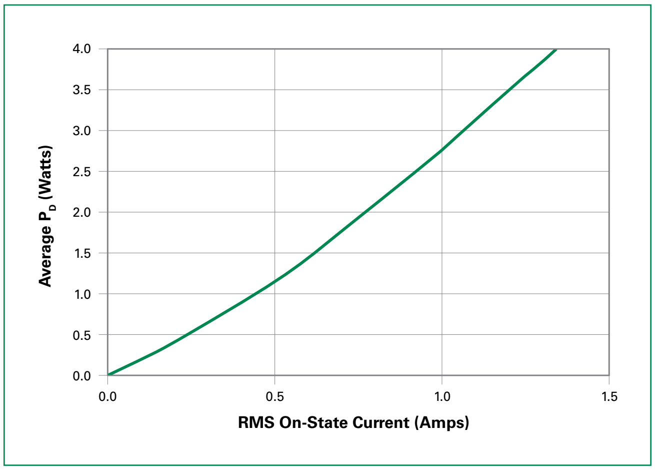


Figure 4: V_{BO} Change vs. Junction Temperature

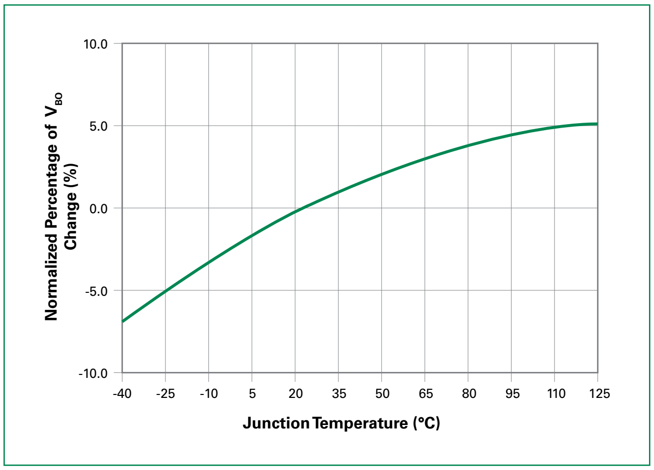


Figure 5: Pulse On-State Current Rating

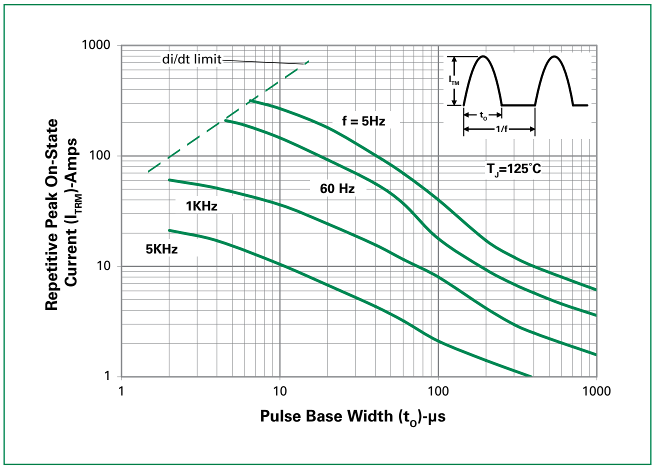


Figure 6: Maximum Allowable Ambient Temperature vs. On-State Current

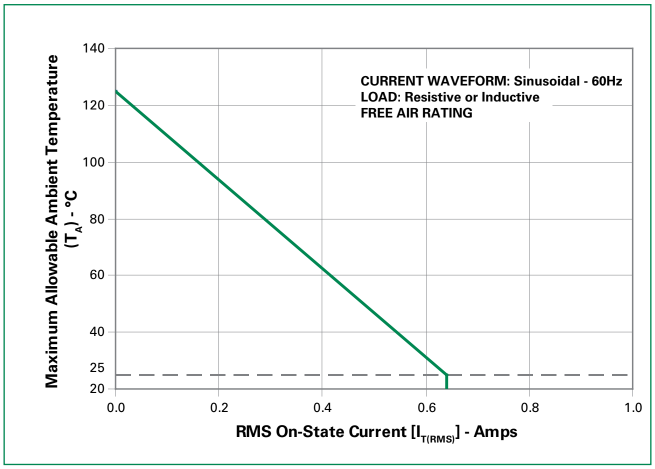
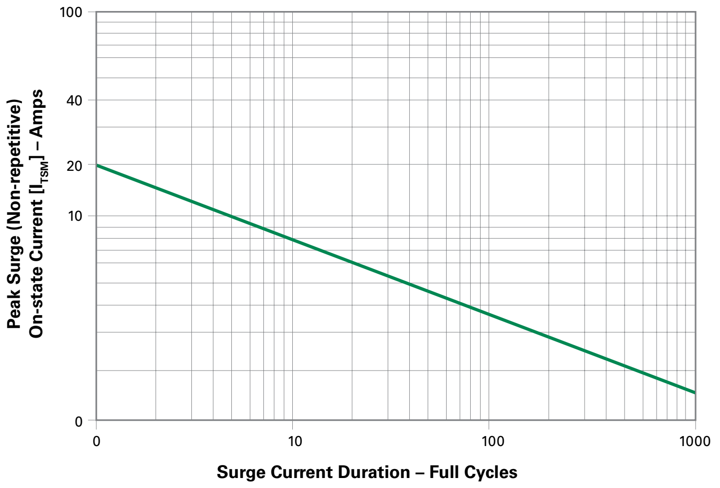


Figure 7: Peak Surge Current vs Surge Current Duration



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: I_T Maximum Rated Value at Specified Junction Temperature

Notes:

1. Blocking capability may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 8: Typical On-State Voltage vs On-State Current

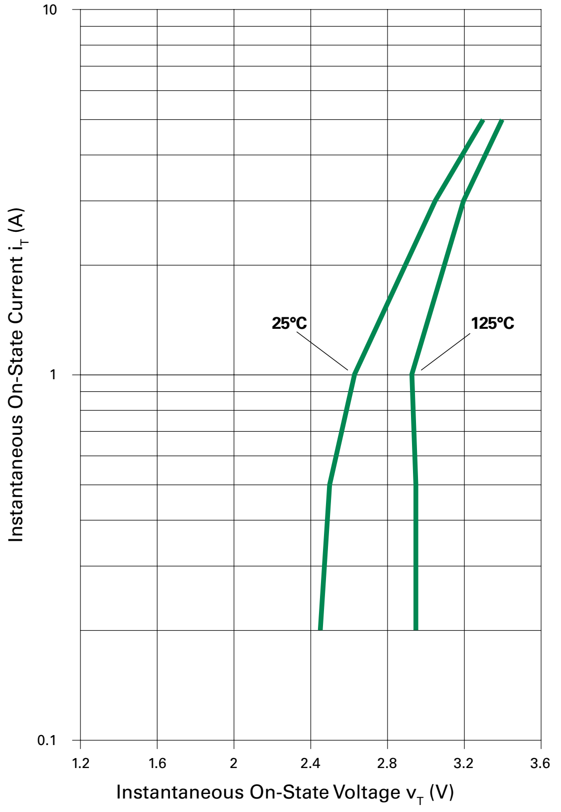
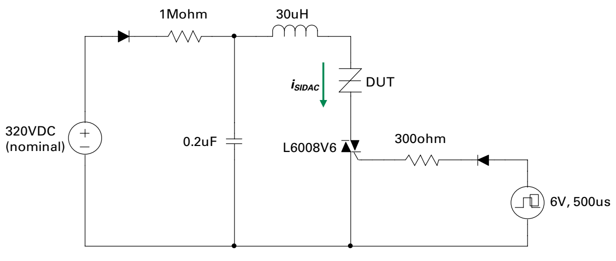
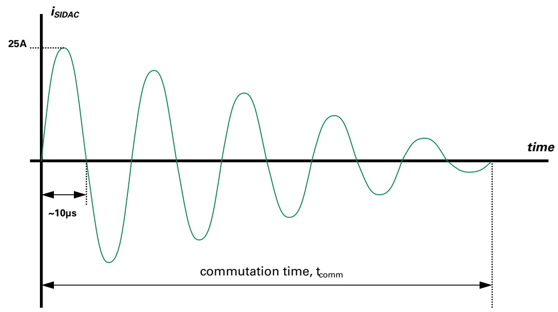


Figure 9: Multipulse™ SIDAC t_{COMM}, Commutation Time



SIDAC Commutation Time Test Circuit



SIDAC Current Response Waveform

Additional Information

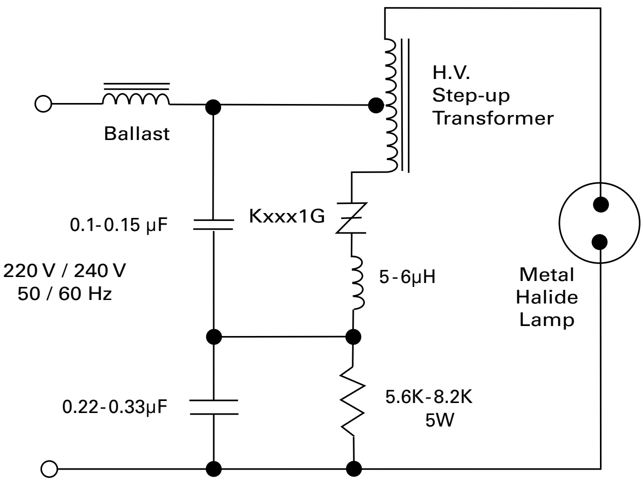
Datasheet

Resources

Samples

Revised: 12/14/14

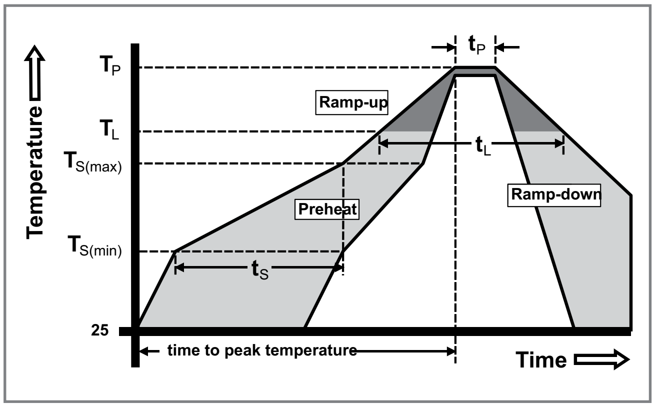
Figure 10: Typical Metal Halide Ignitor Circuit



Note: With proper component selection, this circuit will produce three pulses for ignition of metal halide lamp that requires a minimum of three pulses at 4kV magnitude and >1uSec duration each at a minimum repetition rate of 3.3kHz.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin Plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

Package	Weight / unit (mg)
DO-15	385

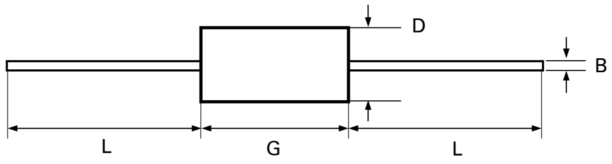
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Overheating and surge currents are the main killers of SIDACs. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051, 100 cycles; -40°C to 150°C, 15-minute dwell time
Temperature / Humidity	EIA/JEDEC: JESD22-A101 1008 hours; 160V - DC: 85°C; 85% relative humidity
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 10 cycles; 0°C to 100°C; 5-minute dwell-time at each temperature; 10-sec (max) transfer time between temperature
Autoclave	EIA/JEDEC: JESD22-A102 168 hours (121°C at 2 ATMs) and 100% RH
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002: Category 3, Test A
Repetitive Surge Life Testing	Multi firings per half cycle at 60Hz in application circuit for 168 hours minimum

Dimensions — DO-15 (G Package)



Dimension	Inches		Millimeters	
	Max	Max	Min	Max
B	0.028	0.034	0.711	0.864
D	0.120	0.140	3.048	3.556
G	0.235	0.270	5.969	6.858
L	1.000		25.400	

Product Selector

Part Number	Switching Voltage Range		Blocking Voltage	Packages
	V_{BO} Minimum	V_{BO} Maximum	V_{DRM}	
K2201G	200V	230V	180V	DO-15
K2401G	220V	250V	190V	DO-15
K2501G	240V	280V	200V	DO-15
K3601G	340V	380V	270V	DO-15

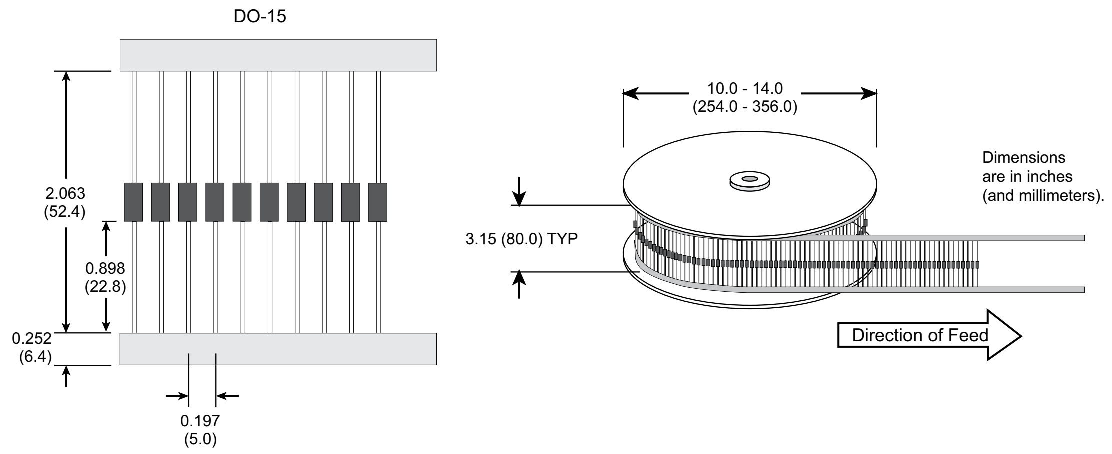
Packing Options

Part Number	Package	Packing Mode	Base Quantity
Kxxx1G	DO-15	Bulk	1000
Kxxx1GRP		Tape & Reel	5000

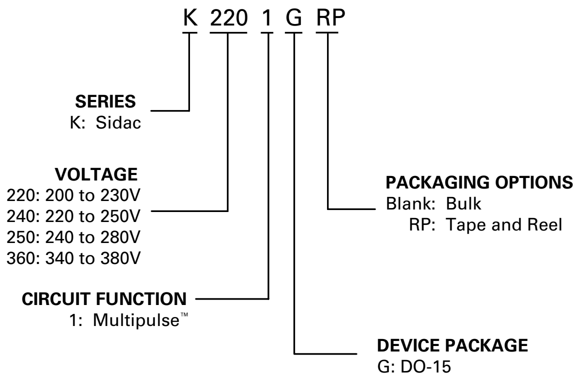
Note: xxx = voltage

DO-15 Embossed Carrier RP Specifications

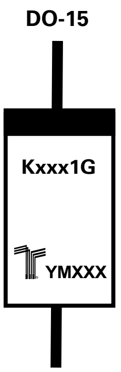
Meets all EIA RS-29-6 Standards



Part Numbering System

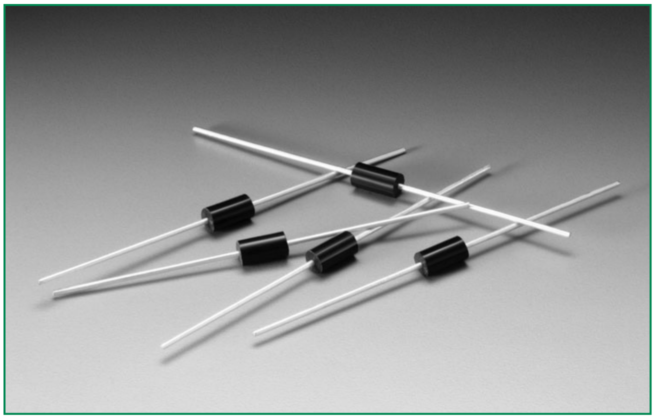


Part Marking System

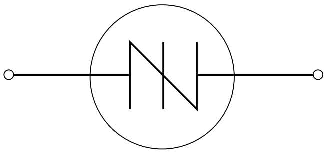


Kxxx1GL Series

RoHS



Schematic Symbol



Applications

Typical application circuit presented in Figure 10 of this data sheet (Typical Metal Halide Ignitor Circuit).

Description

The Multipulse™ SIDAC is a voltage switch used in Metal-Halide lamp ignition circuits, as well as High Pressure Sodium lamp ignition circuits for outdoor street and area lighting. This robust solid-state switch is designed to handle lamp igniter applications requiring operation at ambient temperatures up to 90°C where igniter circuit components can raise SIDAC junction temperature up to 125°C, especially when the lamp element is removed or ruptured. Its excellent commutation time (t_{COMM}) makes this robust product best suited for producing multiple pulses in each half cycle of 50/60 Hz line voltage. The Multipulse™ SIDAC is offered in a DO-15 axial leaded package.

Kxxx1GL SIDAC has a repetitive off-state blocking voltage (V_{DRM}) of 180V to 200V minimum depending actual device type. Blocking capability is ensured by glass passivated junctions for best reliability. The package is epoxy encapsulated with tin plated copper alloy leads.

Features

- AC circuit oriented
- Triggering Voltage of 200 to 265V
- RoHS Compliant

Electrical Specifications

Symbol	Parameters	Test Conditions	Min	Max	Unit
V_T	On-state Voltage	IT=1A		3	V
I_{TRM}	Peak Non-Repetitive Surge Current	TA=25 °C Pulse Wave = 10µs, Sine Wave, f=120Hz		50	A
V_{BO}	Breakover/Trigger Voltage	K2201GL K2401GL K2501GL	200 220 240	230 250 265	V
V_{DRM}	Repetitive Peak Off-State Voltage	K2201GL K2401GL K2501GL	180 190 200		V
$I_{T(RMS)}$	On-State RMS Current, T_J < 125°C	50/60Hz Sine Wave		1	A
I_H	Dynamic Holding Current, R=100 Ω	50/60Hz Sine Wave		30 TYP	mA
R_S	Switching Resistance, $R_S = \frac{(V_{BO} - V_S)}{(I_S - I_{BO})}$	50/60Hz Sine Wave	100		Ω
t_{COMM}	Commutation Time T_J < 125°C	See test circuit and waveform in Figure 9		100	µsec
I_{BO}	Breakover Current	50/60Hz Sine Wave		10	uA
I_{TSM}	Non-repetitive 1 cycle On-State peak value	60Hz 50Hz		20.0 16.7	A
di/dt	Critical Rate of Rise of On-State Current			150	A/µsec
dv/dt	Critical Rate of Rise of Off-State Voltage			1500	V/µsec
T_S	Storage Temperature Range		-40	+125	°C
T_J	Max Operating Junction Temperature		-40	+125	°C
$R_{\theta JL}$	Thermal Resistance	Junction to lead		18	°C/W

Figure 1: Characteristics

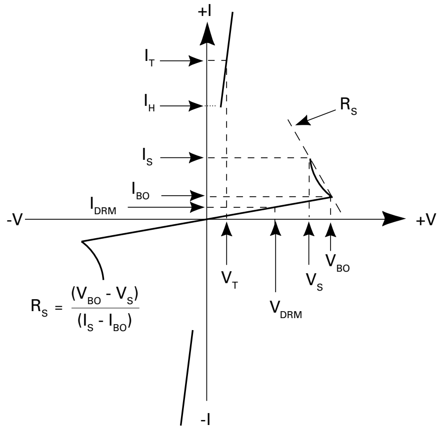


Figure 2: Maximum Allowable Lead/Tab Temperature vs. On-State Current

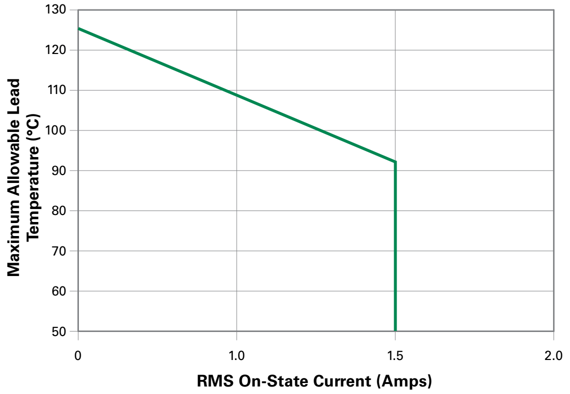


Figure 3: Power Dissipation (Typical) vs. On-State Current

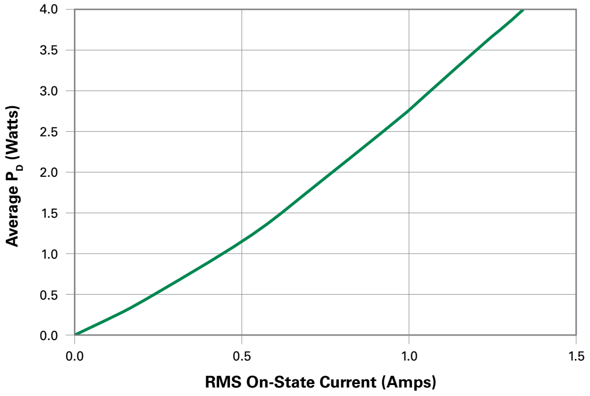


Figure 4: V_{BO} Change vs. Junction Temperature

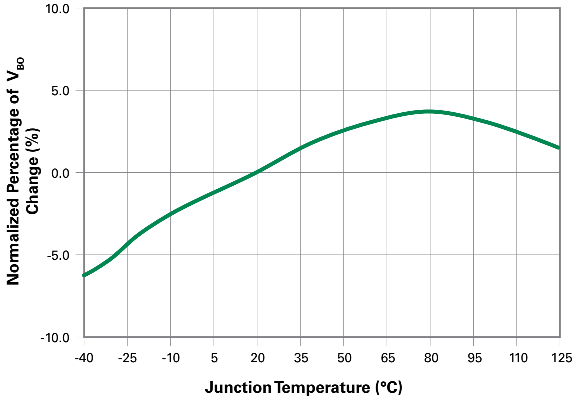


Figure 5: Pulse On-State Current Rating

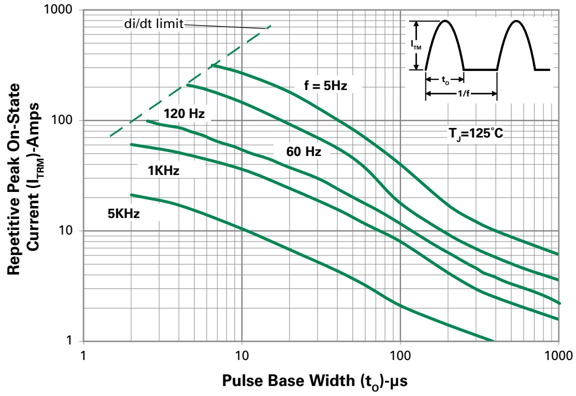


Figure 6: Maximum Allowable Ambient Temperature vs. On-State Current

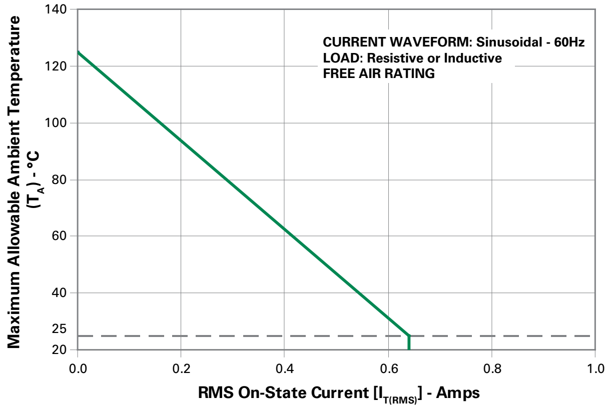
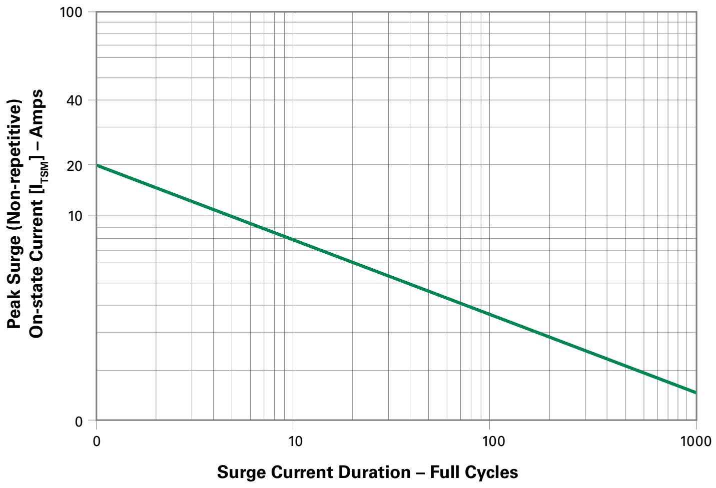


Figure 7: Peak Surge Current vs Surge Current Duration



SUPPLY FREQUENCY: 60 Hz Sinusoidal
LOAD: Resistive
RMS On-State Current: I_T Maximum Rated Value at Specified Junction Temperature

Notes:

1. Blocking capability may be lost during and immediately following surge current interval.
2. Overload may not be repeated until junction temperature has returned to steady-state rated value.

Figure 8: Typical On-State Voltage vs On-State Current

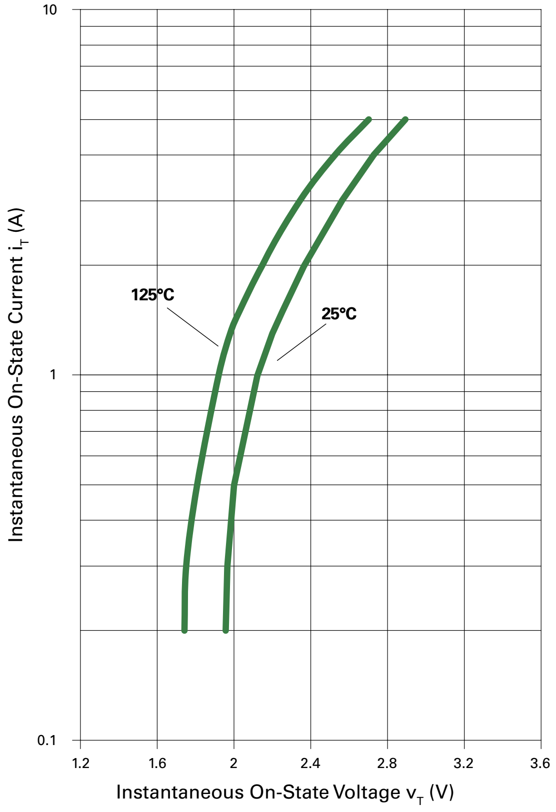
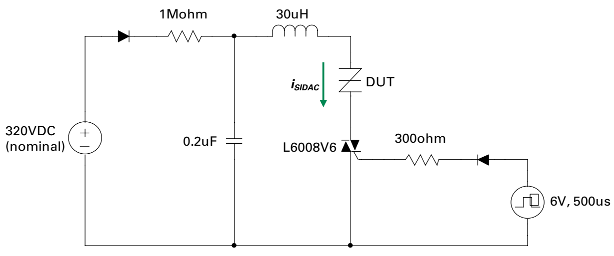
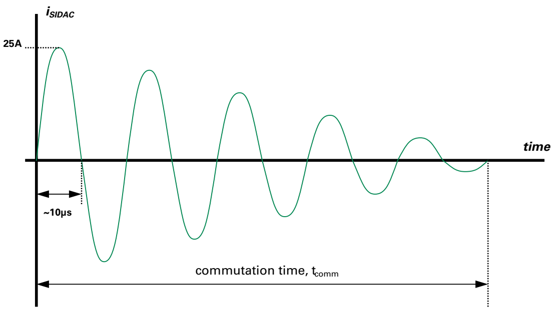


Figure 9: Multipulse™ SIDAC t_{COMM}, Commutation Time



SIDAC Commutation Time Test Circuit



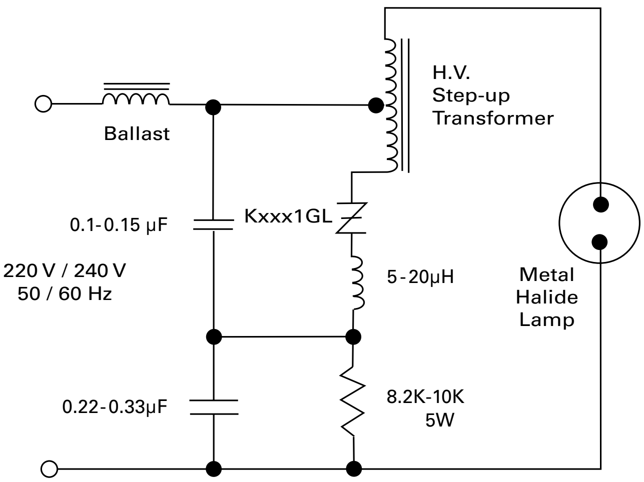
SIDAC Current Response Waveform

Additional Information

Datasheet | **Resources** | **Samples**

Revised: 12/14/14

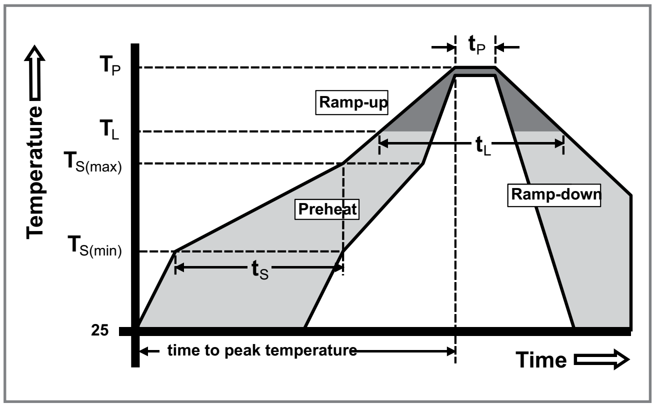
Figure 10: Typical Metal Halide Ignitor Circuit



Note: With proper component selection, this circuit will produce three pulses for ignition of metal halide lamp that requires a minimum of three pulses at 5kV magnitude and >1uSec duration each at a minimum repetition rate of 3.3kHz.

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	-Temperature Min ($T_{s(min)}$)	150°C
	-Temperature Max ($T_{s(max)}$)	200°C
	-Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	-Temperature (T_L) (Liquidus)	217°C
	-Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin Plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

Package	Weight / unit (mg)
DO-15	385

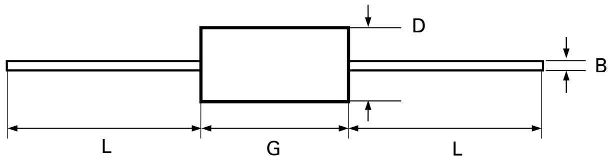
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the Thyristor. Overheating and surge currents are the main killers of SIDACs. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Reliability/Environmental Tests

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{DRM} (VAC-peak), 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051, 100 cycles; -40°C to 150°C, 15-minute dwell time
Temperature / Humidity	EIA/JEDEC: JESD22-A101 1008 hours; 160V - DC: 85°C; 85% relative humidity
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	-40°C, 1008 hours
Thermal Shock	MIL-STD-750: Method 1056 10 cycles; 0°C to 100°C; 5-minute dwell-time at each temperature; 10-sec (max) transfer time between temperature
Autoclave	EIA/JEDEC: JESD22-A102 168 hours (121°C at 2 ATMs) and 100% RH
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002: Category 3, Test A
Repetitive Surge Life Testing	Multi firings per half cycle at 60Hz in application circuit for 168 hours minimum

Dimensions — DO-15 (G Package)



Dimension	Inches		Millimeters	
	Max	Max	Min	Max
B	0.028	0.034	0.711	0.864
D	0.120	0.140	3.048	3.556
G	0.235	0.270	5.969	6.858
L	1.000		25.400	

Product Selector

Part Number	Switching Voltage Range		Blocking Voltage	Packages
	V_{BO} Minimum	V_{BO} Maximum	V_{DRM}	
K2201GL	200V	230V	180V	DO-15
K2401GL	220V	250V	190V	DO-15
K2501GL	240V	265V	200V	DO-15

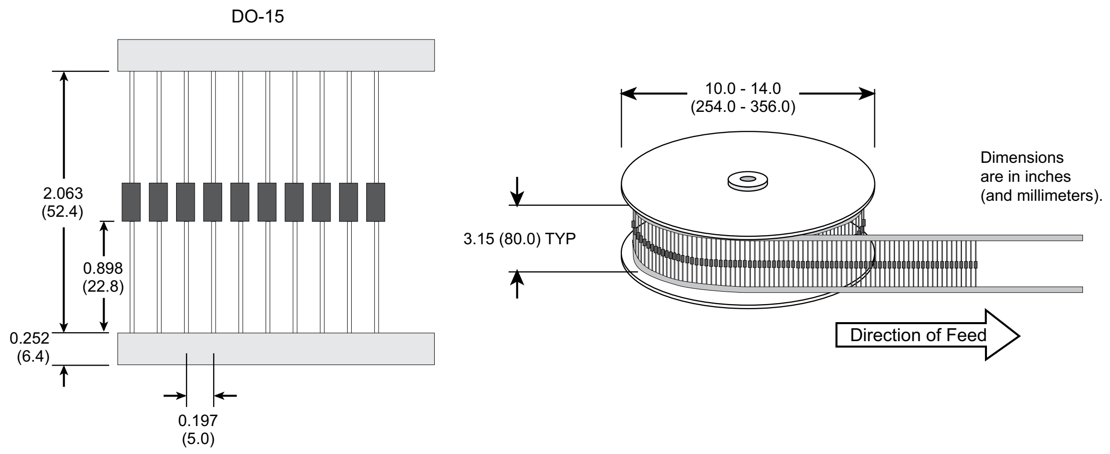
Packing Options

Part Number	Package	Packing Mode	Base Quantity
Kxxx1GL	DO-15	Bulk	1000
Kxxx1GLRP		Tape & Reel	5000

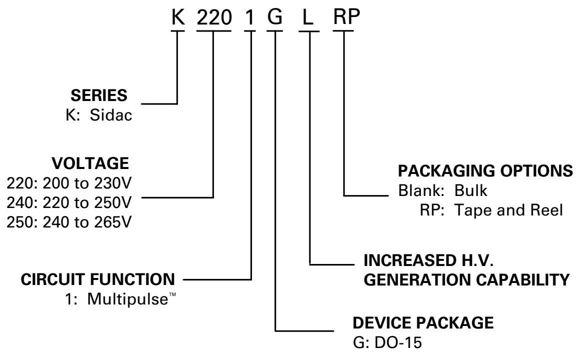
Note: xxx = voltage

DO-15 Embossed Carrier RP Specifications

Meets all EIA RS-29-6 Standards

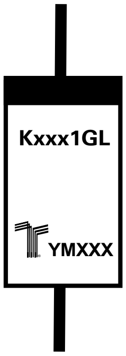


Part Numbering System



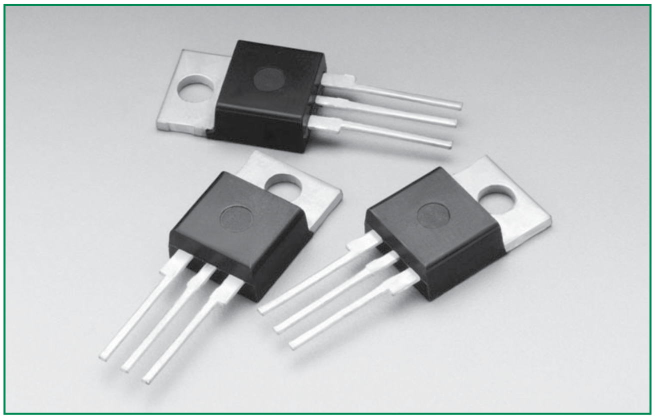
Part Marking System

DO-15



Dxx15L & Dxx20L & Dxx25L Series

RoHS



Description

Silicon rectifiers that are excellent for DC phase control applications with motor loads.

Isolated mounting tab allows for use in circuits with common anode or common cathode connections.

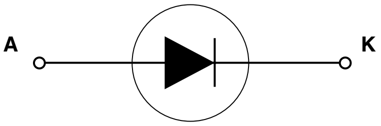
Features & Benefits

- RoHS Compliant
- Glass – passivated junctions
- Voltage capability up to 1000 V
- Surge capability up to 350 A

Agency Approval

Agency	Agency File Number
UL	L Package : E71639

Schematic Symbol



Applications

Typical applications are AC to DC solid-state switches for industrial power tools, exercise equipment, white goods, and commercial appliances.

Internally constructed isolated package is offered for ease of heat sinking with highest isolation voltage.

Main Features

Symbol	Value	Unit
$I_{T(RMS)}$	15 / 20 / 25	A
V_{RRM}	400 to 1000	V

Additional Information

Datasheet

Resources

Samples

Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Value			Unit
			Dxx15L	Dxx20L	Dxx25L	
$I_{F(RMS)}$	RMS forward current	Dxx15L: T_C = 90°C Dxx20L/Dxx25L: T_C = 80°C	15	20	25	A
$I_{F(AV)}$	Average forward current		9.5	12.7	15.9	A
I_{FSM}	Peak non-repetitive surge current	single half cycle; f = 50Hz; T_J (initial) = 25°C	188	255	300	A
		single half cycle; f = 60Hz; T_J (initial) = 25°C	225	300	350	
I^2t	I^2t Value for fusing	t_p = 8.3 ms	210	374	508	A^2s
T_{stg}	Storage temperature range		-40 to 150			°C
T_J	Operating junction temperature range		-40 to 125			°C

Note: xx = voltage

Revised: 12/14/14

Electrical Characteristics (T_J = 25°C, unless otherwise specified)

Symbol	Parameter	Test Conditions		Value	Unit
t_{rr}	Reverse-recovery Time	I_F=0.9A, I_R=1.5A	TYP.	4	µs

Static Characteristics

Symbol	Test Conditions				Value	Unit
V_{FM}	15A Device I_T = 30A; t_p = 380µs			MAX.	1.6	V
	20A Device I_T = 40A; t_p = 380µs					
	25A Device I_T = 50A; t_p = 380µs					
I_{RM}	V_{RRM}	T_J = 25°C	400-600V	MAX.	10	µA
			800-1000V		20	
		T_J = 100°C	400-800V		500	
			1000V		3000	
		T_J = 125°C	400-800V		1000	

Thermal Resistances

Symbol	Parameter		Value	Unit
$R_{\theta(J-C)}$	Junction to case (AC)	Dxx15L	2.60	°C/W
		Dxx20L	2.55	
		Dxx25L	2.50	

Note: xx = voltage

Figure 1: On-State Current vs. On-State Voltage (Typical)

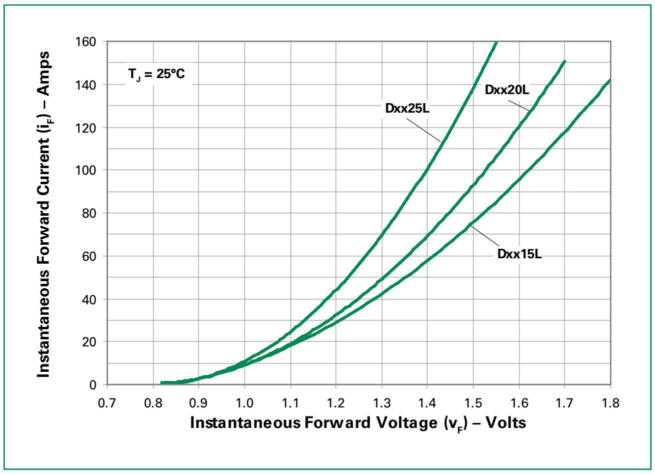


Figure 2: Power Dissipation vs. Average Forward On-State Current (Typical)

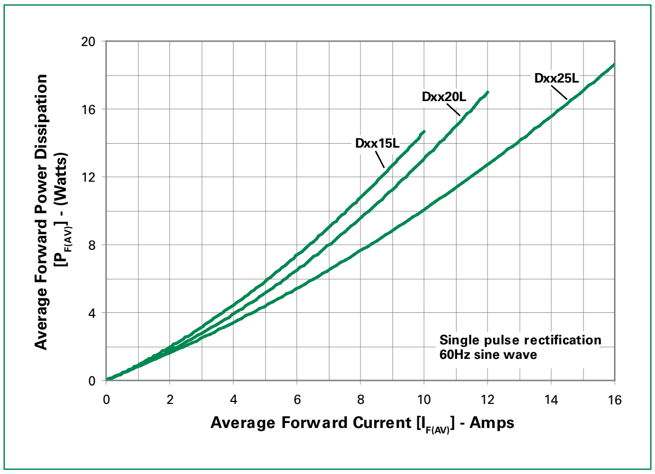
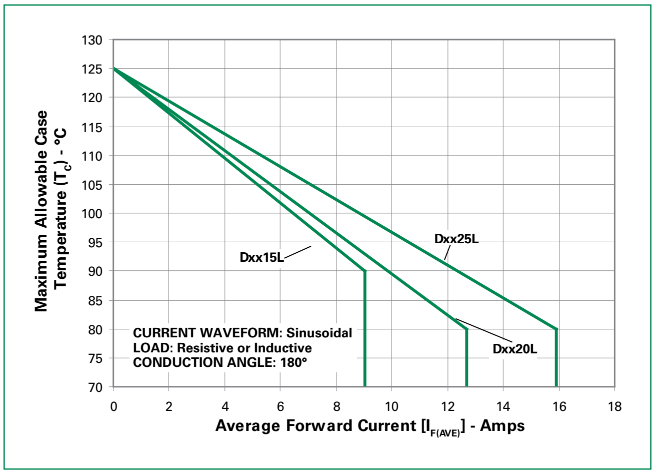
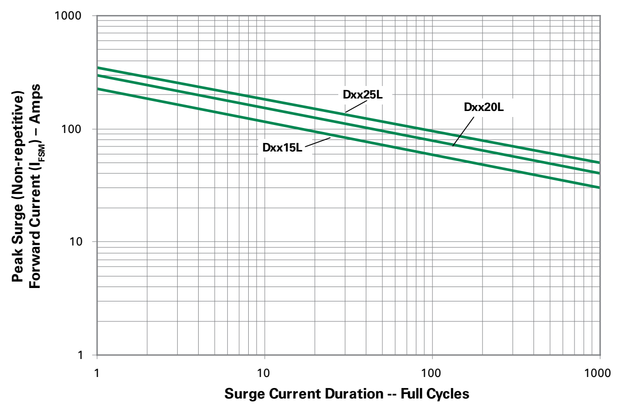


Figure 3: Maximum Allowable Case Temperature vs. Average On-State Current



Note: xx = voltage

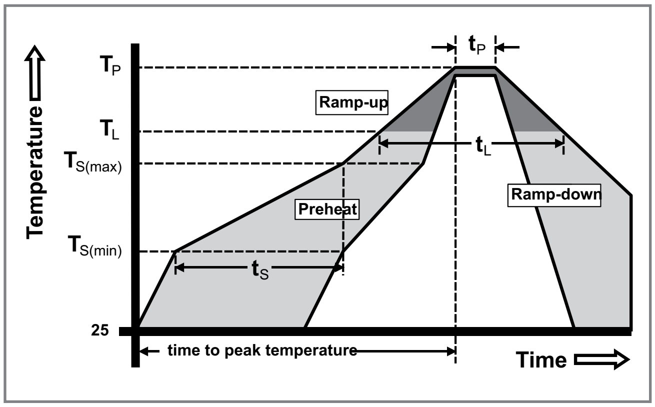
Figure 4: Surge Peak On-State Current vs. Number of Cycles



Supply Frequency: 60Hz Sinusoidal
Load: Resistive
RMS Forward Current : [$I_{T(RMS)}$]: Maximum Rated Value at Specific Case Temperature

Soldering Parameters

Reflow Condition		Pb – Free assembly
Pre Heat	- Temperature Min ($T_{s(min)}$)	150°C
	- Temperature Max ($T_{s(max)}$)	200°C
	- Time (min to max) (t_s)	60 – 180 secs
Average ramp up rate (Liquidus Temp) (T_L) to peak		5°C/second max
$T_{S(max)}$ to T_L - Ramp-up Rate		5°C/second max
Reflow	- Temperature (T_L) (Liquidus)	217°C
	- Temperature (t_L)	60 – 150 seconds
Peak Temperature (T_P)		$260^{+0/-5}$ °C
Time within 5°C of actual peak Temperature (t_p)		20 – 40 seconds
Ramp-down Rate		5°C/second max
Time 25°C to peak Temperature (T_P)		8 minutes Max.
Do not exceed		280°C



Physical Specifications

Terminal Finish	100% Matte Tin Plated
Body Material	UL recognized epoxy meeting flammability classification 94V-0
Lead Material	Copper Alloy

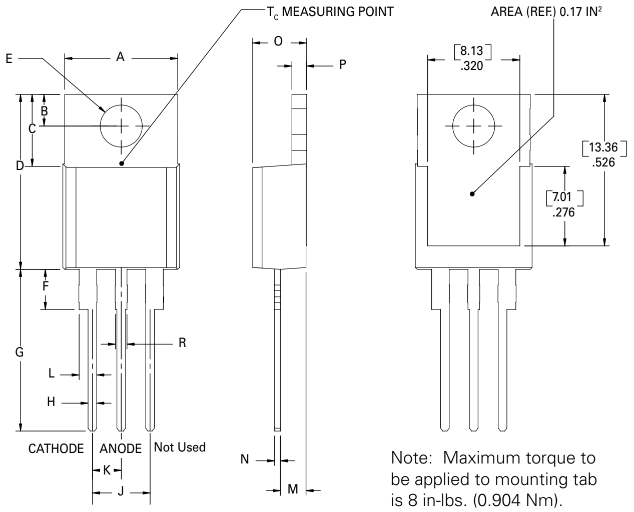
Design Considerations

Careful selection of the correct device for the application's operating parameters and environment will go a long way toward extending the operating life of the rectifier. Good design practice should limit the maximum continuous current through the main terminals to 75% of the device rating. Other ways to ensure long life for a power discrete semiconductor are proper heat sinking and selection of voltage ratings for worst case conditions. Overheating, overvoltage (including dv/dt), and surge currents are the main killers of semiconductors. Correct mounting, soldering, and forming of the leads also help protect against component damage.

Environmental Specifications

Test	Specifications and Conditions
High Temperature Voltage Blocking	MIL-STD-750: Method 1040, Condition A Rated V_{RRM}, 125°C, 1008 hours
Temperature Cycling	MIL-STD-750: Method 1051 -40°C to 150°C, 15-minute dwell, 100 cycles
Biased Temperature & Humidity	EIA/JEDEC: JESD22-A101 320VDC, 85°C, 85%RH, 1008 hours
High Temp Storage	MIL-STD-750: Method 1031 150°C, 1008 hours
Low-Temp Storage	1008 hours; -40°C
Thermal Shock	MIL-STD-750: Method 1056 0°C to 100°C, 5-minute dwell, 10-second transfer, 10 cycles
Autoclave (Pressure Cooker Test)	EIA/JEDEC: JESD22-A102 121°C, 100%RH, 2atm, 168 hours
Resistance to Solder Heat	MIL-STD-750: Method 2031 260°C, 10 seconds
Solderability	ANSI/J-STD-002, Category 3, Test A
Lead Bend	MIL-STD-750: Method 2036, Condition E

Dimensions — TO-220AB (L-Package) — Isolated Mounting Tab



Note: Maximum torque to be applied to mounting tab is 8 in-lbs. (0.904 Nm).

Dimension	Inches		Millimeters	
	Min	Max	Min	Max
A	0.380	0.420	9.65	10.67
B	0.105	0.115	2.67	2.92
C	0.230	0.250	5.84	6.35
D	0.590	0.620	14.99	15.75
E	0.142	0.147	3.61	3.73
F	0.110	0.130	2.79	3.30
G	0.540	0.575	13.72	14.61
H	0.025	0.035	0.64	0.89
J	0.195	0.205	4.95	5.21
K	0.095	0.105	2.41	2.67
L	0.060	0.075	1.52	1.91
M	0.085	0.095	2.16	2.41
N	0.018	0.024	0.46	0.61
O	0.178	0.188	4.52	4.78
P	0.045	0.060	1.14	1.52
R	0.038	0.048	0.97	1.22

Product Selector

Part Number	Voltage				Type	Package
	400V	600V	800V	1000V		
Dxx15L	X	X	X	X	Rectifier	TO-220L
Dxx20L	X	X	X	X	Rectifier	TO-220L
Dxx25L	X	X	X	X	Rectifier	TO-220L

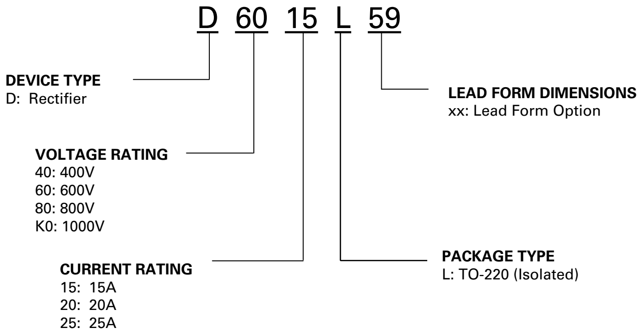
Note: xx = Voltage

Packing Options

Part Number	Marking	Weight	Packing Mode	Base Quantity
Dxx15L	Dxx15L	2.2 g	Bulk	500
Dxx15LTP	Dxx15L	2.2 g	Tube	500 (50 per tube)
Dxx20L	Dxx20L	2.2 g	Bulk	500
Dxx20LTP	Dxx20L	2.2 g	Tube	500 (50 per tube)
Dxx25L	Dxx25L	2.2 g	Bulk	500
Dxx25LTP	Dxx25L	2.2 g	Tube	500 (50 per tube)

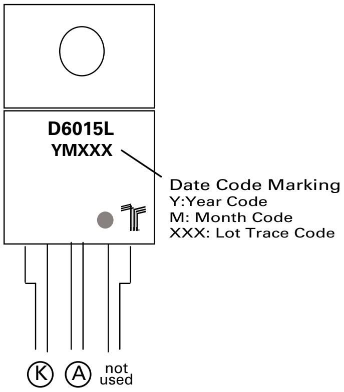
Note: xx = Voltage

Part Numbering System



Part Marking System

TO-220AB - (L Package)



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