ISO 9001 CERTIFIED BY DSCC

M.S KENNEDY CORP.

HIGH POWER OP-AMP

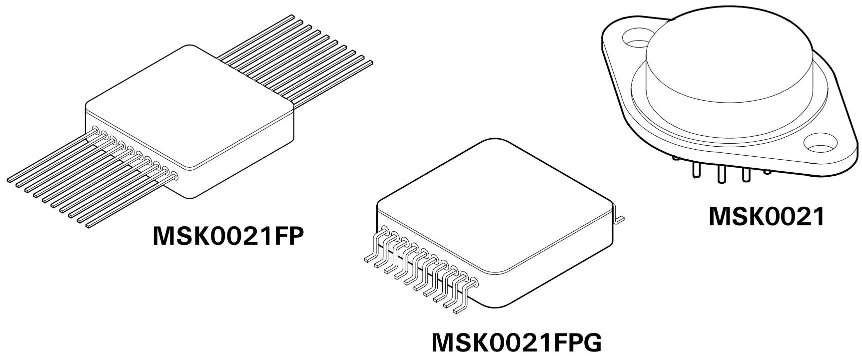
0021 SERIES

4707 Dey Road Liverpool, N.Y. 13088 (315) 701-6751

MIL-PRF-38534 QUALIFIED

FEATURES:

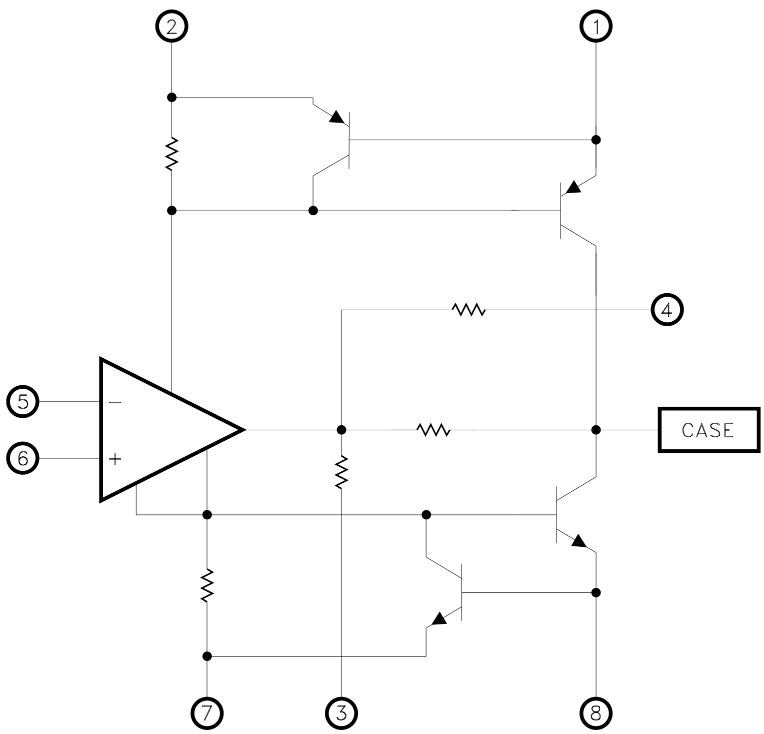
- Available as SMD #5962-8508801
- High Output Current - 2 Amps Peak
- Low Power Consumption-Class C Design
- Programmable Current Limit
- High Slew Rate
- Continuous Output Short Circuit Duration
- Replacement for LH0021



DESCRIPTION:

The MSK 0021, 0021FP and 0021FPG are general purpose Class C power operational amplifiers. These amplifiers offer large output currents, making them an excellent low cost choice for motor drive circuits. The amplifier and load can be protected from fault conditions through the use of internal current limit circuitry that can be user programmed with two external resistors. These devices are also compensated with a single external capacitor. The MSK 0021 is available in a hermetically sealed 8 pin TO-3 package. The MSK 0021FP is packaged in a 20 pin hermetic metal flatpack and the 0021FPG is lead formed by MSK.

EQUIVALENT SCHEMATIC



PIN-OUT INFORMATION

MSK0021

1 ISC+
2 +VCC
3 GND
4 Compensation
5 -Input
6 +Input
7 -VCC
8 ISC
CASE-OUTPUT

MSK0021FP/MSK0021FPG

1 ISC-	20 -VCC
2 ISC-	19 NC
3 ISC-	18 +VIN
4 VOUT	17 NC
5 VOUT	16 -VIN
6 VOUT	15 NC
7 VOUT	14 Compensation
8 ISC+	13 NC
9 ISC+	12 GND
10 ISC+	11 +VCC

CASE IS ALSO VOUT

TYPICAL APPLICATIONS

- Servo Amplifer
- Motor Driver
- Audio Amplifier
- Programmable Power Supply

ABSOLUTE MAXIMUM RATINGS

$\pm V_{CC}$	Supply Voltage	±18V
I_{OUT}	Peak Output Current	2A
V_{IN}	Differential Input Voltage	±30V
V_{IN}	Common Mode Input Voltage	±15V
R_{TH}	Thermal Resistance-Junction to Case	
	MSK 0021	2.0° C/W
	MSK 0021FP/FPG	6.0° C/W
T_{ST}	Storage Temperature Range	-65° to +150°C
T_{LD}	Lead Temperature Range (10 Seconds)	300°C
P_D	Power Dissipation (TO-3)	6W
T_J	Junction Temperature	150°C
T_C	Case Operating Temperature Range	
	Military Versions (H/B/E)	-55°C to +125°C
	Industrial Versions	-40°C to +85°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions	Group A Subgroup	Military ⑤ Min.	Military ⑤ Typ.	Military ⑤ Max.	Industrial ④ Min.	Industrial ④ Typ.	Industrial ④ Max.	Units
STATIC									
Supply Voltage Range ②		-	±12	±15	±18	±12	±15	±18	V
Quiescent Current	V_{IN} = 0V	1, 2, 3	-	±1.0	±3.5	-	±1.0	±4.0	mA
Power Consumption ②	V_{IN} = 0V	1,2,3	-	75	105	-	90	120	mW
INPUT									
Input Offset Voltage	V_{IN} = 0V	1	-	±0.5	±3.0	-	±0.5	±5.0	mV
		2, 3	-	±2.0	±5.0	-	-	-	μV/°C
Input Bias Current	V_{CM} = 0V	1	-	±100	±300	-	±150	±500	nA
	Either Input	2, 3	-	±0.4	±1.0	-	-	-	μA
Input Offset Current	V_{CM} = 0V	1	-	±2.0	±100	-	±2.0	±300	nA
		2,3	-	-	±300	-	-	-	nA
Input Capacitance ③	F=DC	-	-	3	-	-	3	-	pF
Input Resistance ②	F=DC	-	0.3	1.0	-	0.3	1.0	-	MΩ
Common Mode Rejection Ratio	F = 10Hz V_{CM} = ±10V	4	70	90	-	70	90	-	dB
		5,6	70	90	-	-	-	-	dB
Power Supply Rejection Ratio	V_{CC} = ±5V to ±15V	1	80	95	-	80	95	-	dB
		2,3	80	-	-	-	-	-	dB
Input Noise Voltage ③	F = 10Hz to 10KHz	-	-	5	-	-	5	-	μV_{RMS}
OUTPUT									
Output Voltage Swing	R_L =100Ω F =100Hz	4	±13.5	±14	-	±13.0	±14	-	V
		5,6	±13.5	±14	-	-	-	-	V
	R_L =10Ω F =100Hz	4	±11	±12	-	±10.5	±12	-	V
Output Short Circuit Current	R_{SC} = 0.5Ω V_{OUT} = MAX	4	0.8	1.2	1.6	0.7	1.2	1.7	A
	R_{SC} = 5Ω V_{OUT} = GND	4	50	150	250	50	150	250	mA
Settling Time ③	0.1% 2V step	-	-	4	-	-	4	-	μS
TRANSFER CHARACTERISTICS									
Slew Rate	V_{OUT} = ±10V R_L = 10Ω	4	1.5	3.0	-	1.2	3.0	-	V/μS
Open Loop Voltage Gain	F = 10Hz R_L = 1KΩ	4	100	105	-	100	105	-	dB
		5,6	88	96	-	-	-	-	dB
Transition Times	Rise and Fall	4	-	0.3	1.0	-	0.3	1.2	μS
Overshoot	Small Signal	4	-	5	20	-	5	20	%

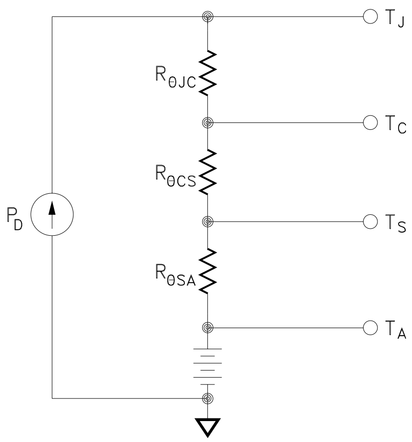
NOTES:

① Unless otherwise specified, $\pm V_{CC}$ = ±15V, C_C = 3000pF.
② Guaranteed by design but not tested.
③ Typical parameters are representative of actual device performance but are for reference only.
④ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.
⑤ Military grade devices (B/H suffix) shall be 100% tested to subgroups 1, 2, 3 and 4.
Subgroup 1, 4 T_A = T_C = +25°C
Subgroup 2, 5 T_A = T_C = +125°C
Subgroup 3, 6 T_A = T_C = -55°C
⑥ Reference DSCC SMD 5962-8508801 for electrical specifications for devices purchased as such.
⑦ Subgroup 5 and 6 testing available upon request.

HEAT SINKING

To select the correct heat sink for your application, refer to the thermal model and governing equation below.

Thermal Model:



Governing Equation:

$T_J = P_D \times (R_{\theta JC} + R_{\theta CS} + R_{\theta SA}) + T_A$

Where

T_J	=	Junction Temperature
P_D	=	Total Power Dissipation
$R_{\theta JC}$	=	Junction to Case Thermal Resistance
$R_{\theta CS}$	=	Case to Heat Sink Thermal Resistance
$R_{\theta SA}$	=	Heat Sink to Ambient Thermal Resistance
T_C	=	Case Temperature
T_A	=	Ambient Temperature
T_S	=	Sink Temperature

Example: (TO-3 PACKAGE)

In our example the amplifier application requires the output to drive a 10 volt peak sine wave across a 10 ohm load for 1 amp of output current. For a worst case analysis we will treat the 1 amp peak output current as a D.C. output current. The power supplies are ±15 VDC.

1.) Find Power Dissipation
$P_D = [(\text{quiescent current}) \times (+V_{CC} - (V_{CC}))] + [(V_S - V_O) \times I_{OUT}]$
$= (3.5\text{ mA}) \times (30V) + (5V) \times (1A)$
$= 0.1W + 6W$
$= 6.1W$
2.) For conservative design, set $T_J = +150°C$.
3.) For this example, worst case $T_A = +25°C$.
4.) $R_{\theta JC} = 2.0°C/W$ typically for the TO-3 package.
5.) Rearrange governing equation to solve for $R_{\theta SA}$:
$R_{\theta SA} = (T_J - T_A) / P_D - (R_{\theta JC}) - (R_{\theta CS})$
$= (150°C - 25°C) / 6.1W - (2.0°C/W) - (0.15°C/W)$
$= 18.5°C/W$

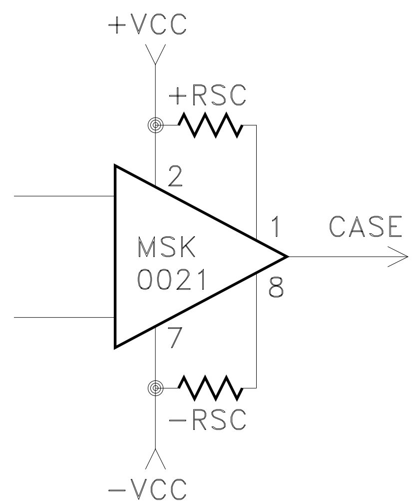
The heat sink in this example must have a thermal resistance of no more than 18.5°C/W to maintain a junction temperature of less than +150°C.

CURRENT LIMIT

The MSK 0021 has an on-board current limit scheme designed to limit the output drivers anytime output current exceeds a predetermined limit. The following formula may be used to determine the value of the current limit resistance necessary to establish the desired current limit.

$$R_{SC} = \frac{0.7}{I_{SC}}$$

Current Limit Connection



See "Application Circuits" in this data sheet for additional information on current limit connections.

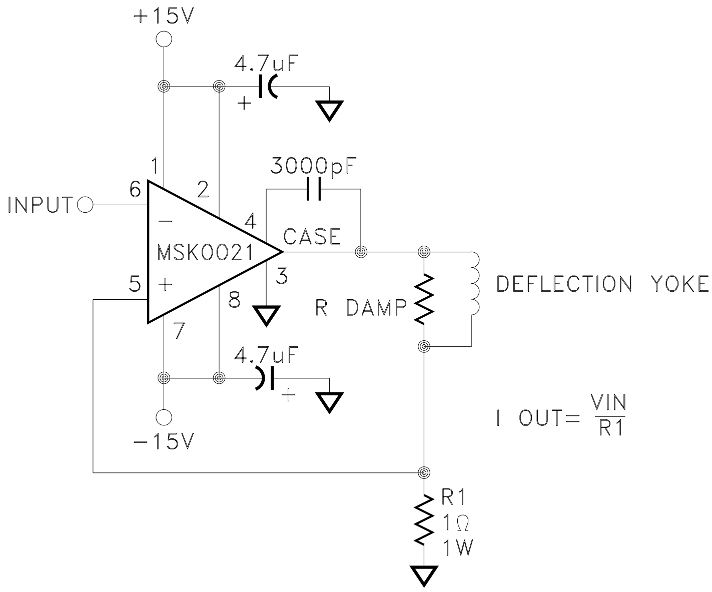
POWER SUPPLY BYPASSING

Both the negative and the positive power supplies must be effectively decoupled with a high and low frequency bypass circuit to avoid power supply induced oscillation. An effective decoupling scheme consists of a 0.1 microfarad ceramic capacitor in parallel with a 4.7 microfarad tantalum capacitor from each power supply pin to ground. It is also a good practice with high power op-amps, such as the MSK 0021, to place a 30-50 microfarad capacitor with a low effective series resistance, in parallel with the other two power supply decoupling capacitors. This capacitor will eliminate any peak output voltage clipping which may occur due to poor power supply load regulation. All power supply decoupling capacitors should be placed as close to the package power supply pins as possible.

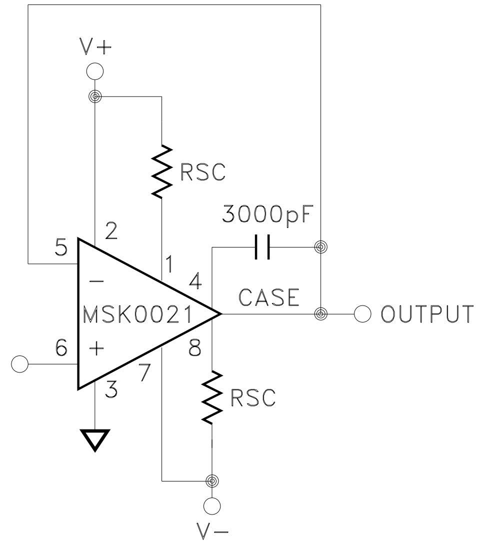
SAFE OPERATING AREA

The safe operating area curve is a graphical representation of the power handling capability of the amplifier under various conditions. The wire bond current carrying capability, transistor junction temperature and secondary breakdown limitations are all incorporated into the safe operating area curves. All applications should be checked against the S.O.A. curves to ensure high M.T.B.F.

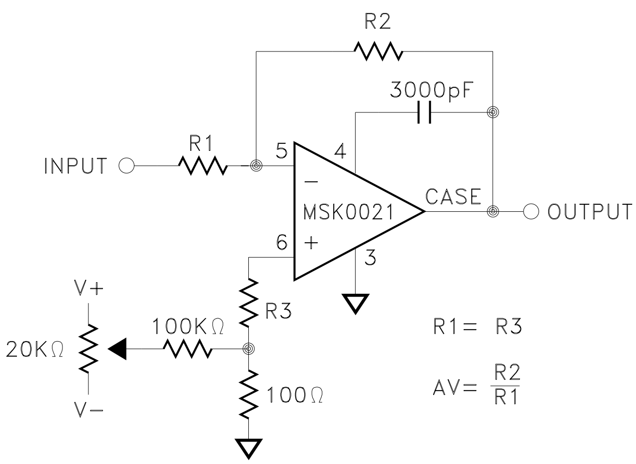
APPLICATION CIRCUITS



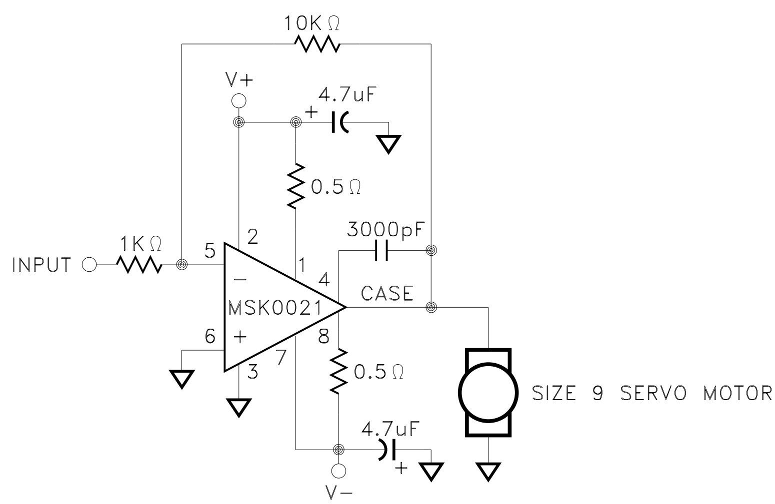
CRT DEFLECTION YOKE DRIVER



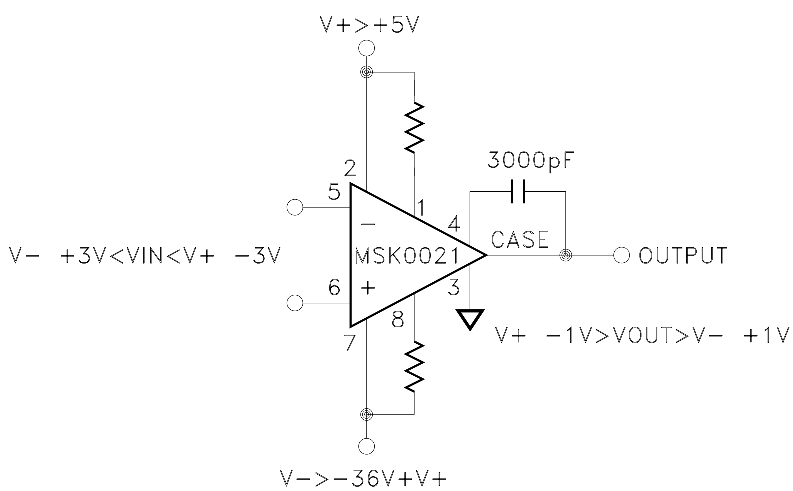
UNITY GAIN CIRCUIT WITH
SHORT CIRCUIT LIMITING



OFFSET VOLTAGE NULL CIRCUIT



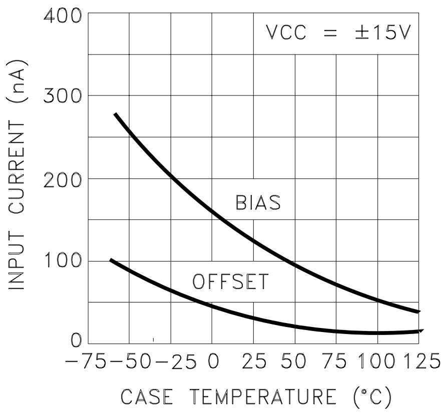
DC SERVO AMPLIFIER



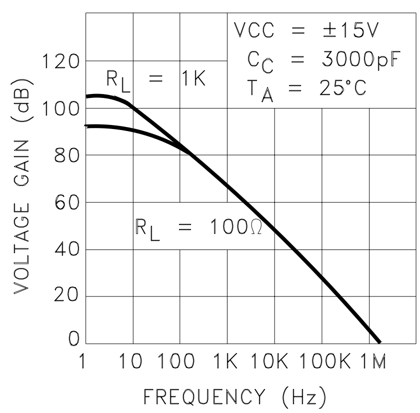
NON SYMMETRICAL SUPPLIES

TYPICAL PERFORMANCE CURVES

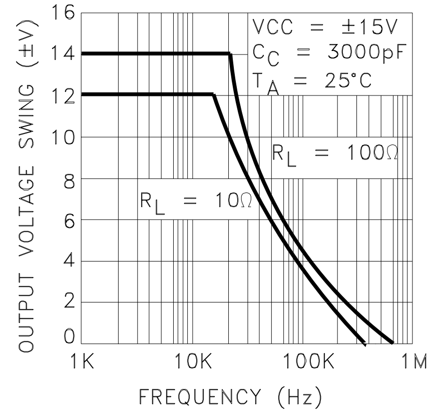
INPUT CURRENT vs TEMPERATURE



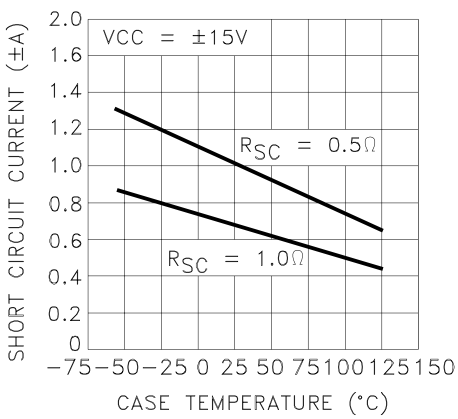
OPEN LOOP FREQUENCY RESPONSE



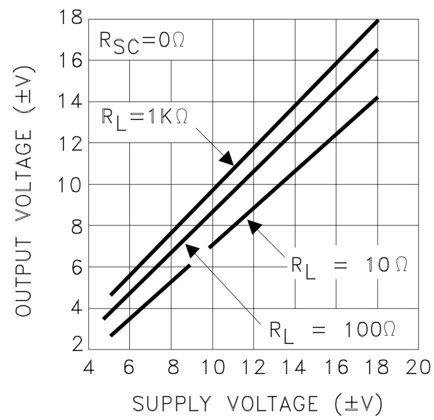
LARGE SIGNAL FREQUENCY RESPONSE



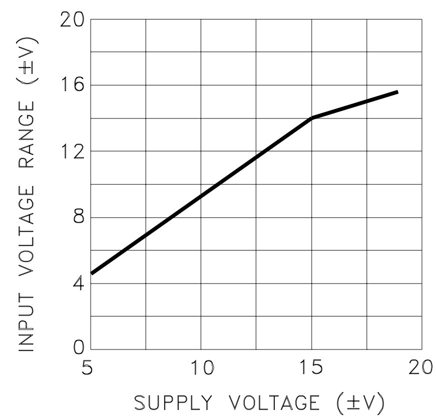
SHORT CIRCUIT CURRENT vs. TEMPERATURE MSK0021



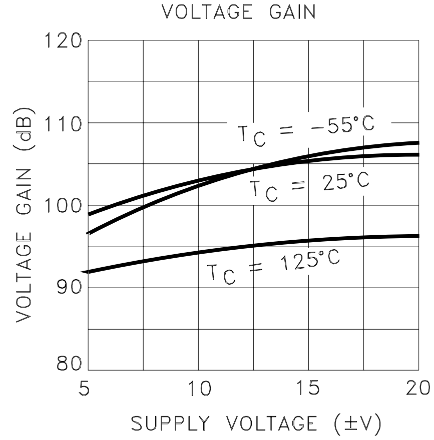
OUTPUT VOLTAGE SWING



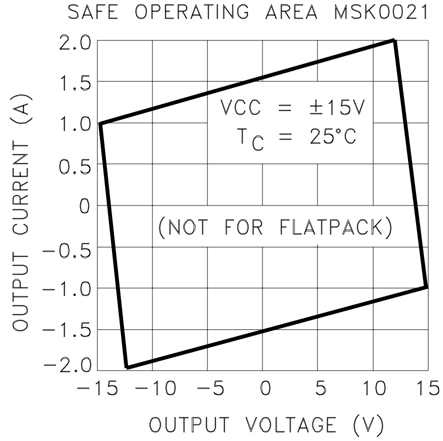
INPUT VOLTAGE RANGE



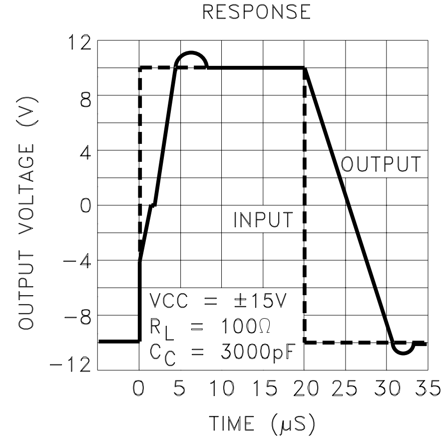
VOLTAGE GAIN



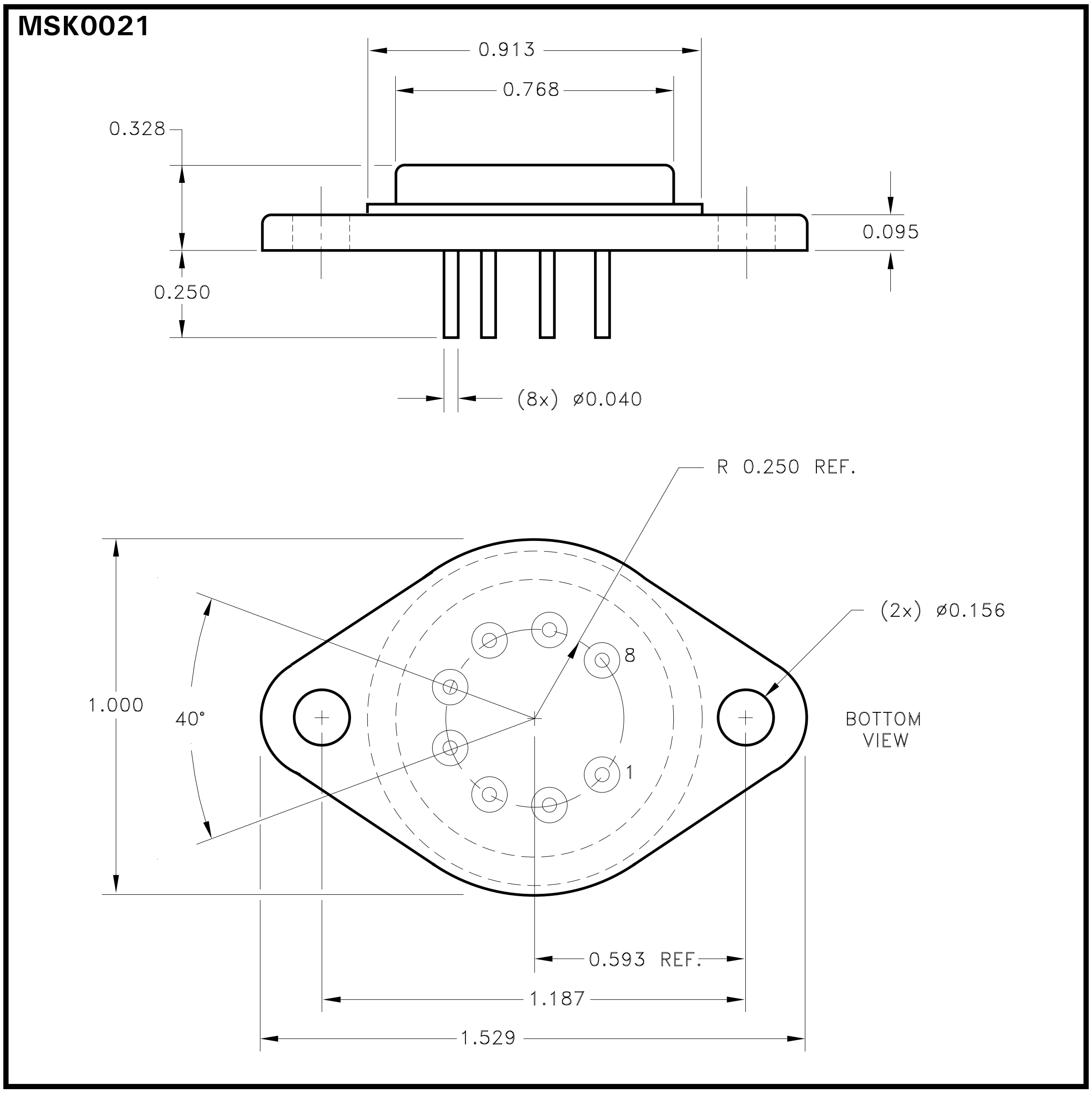
SAFE OPERATING AREA MSK0021



VOLTAGE FOLLOWER PULSE RESPONSE



MECHANICAL SPECIFICATIONS



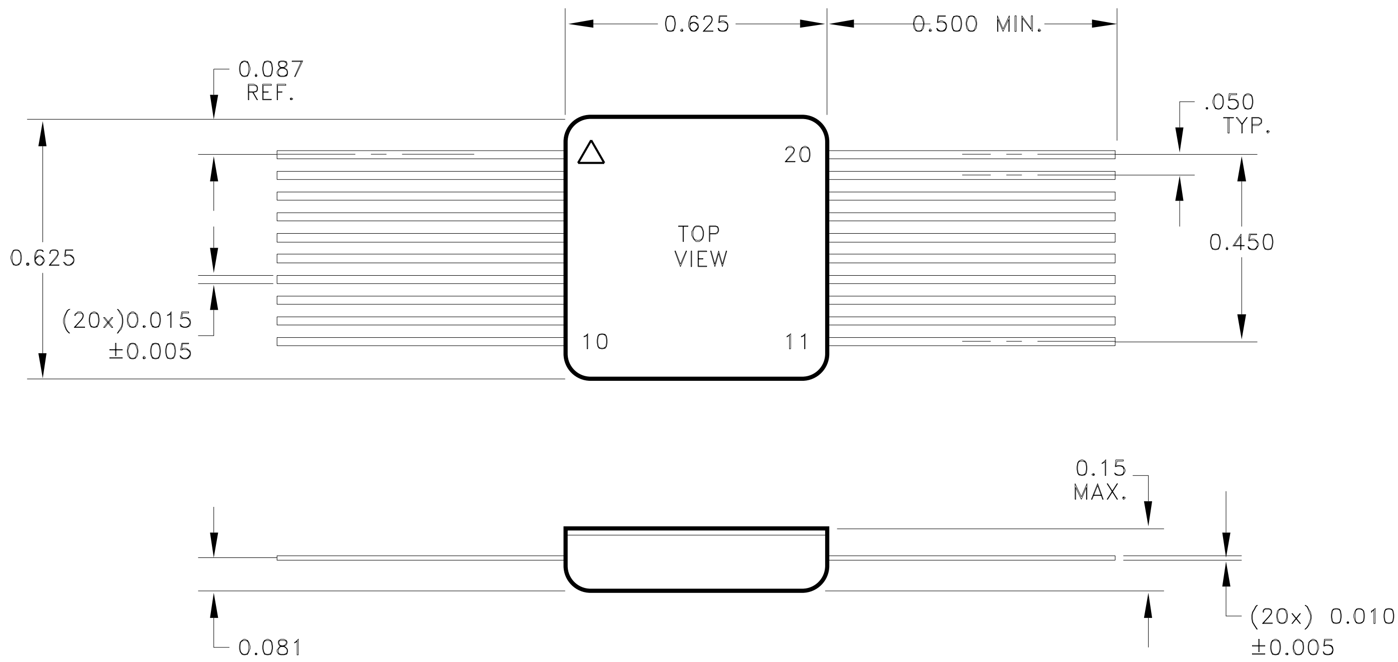
NOTE: ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED

ORDERING INFORMATION

Part Number	Screening Level
MSK 0021	Industrial
MSK 0021 B	MIL-PRF-38534 CLASS H
MSK 0021 E	EXTENDED RELIABILITY
5962-8508801X	DSCC - SMD

MECHANICAL SPECIFICATIONS CONTINUED

MSK0021FP



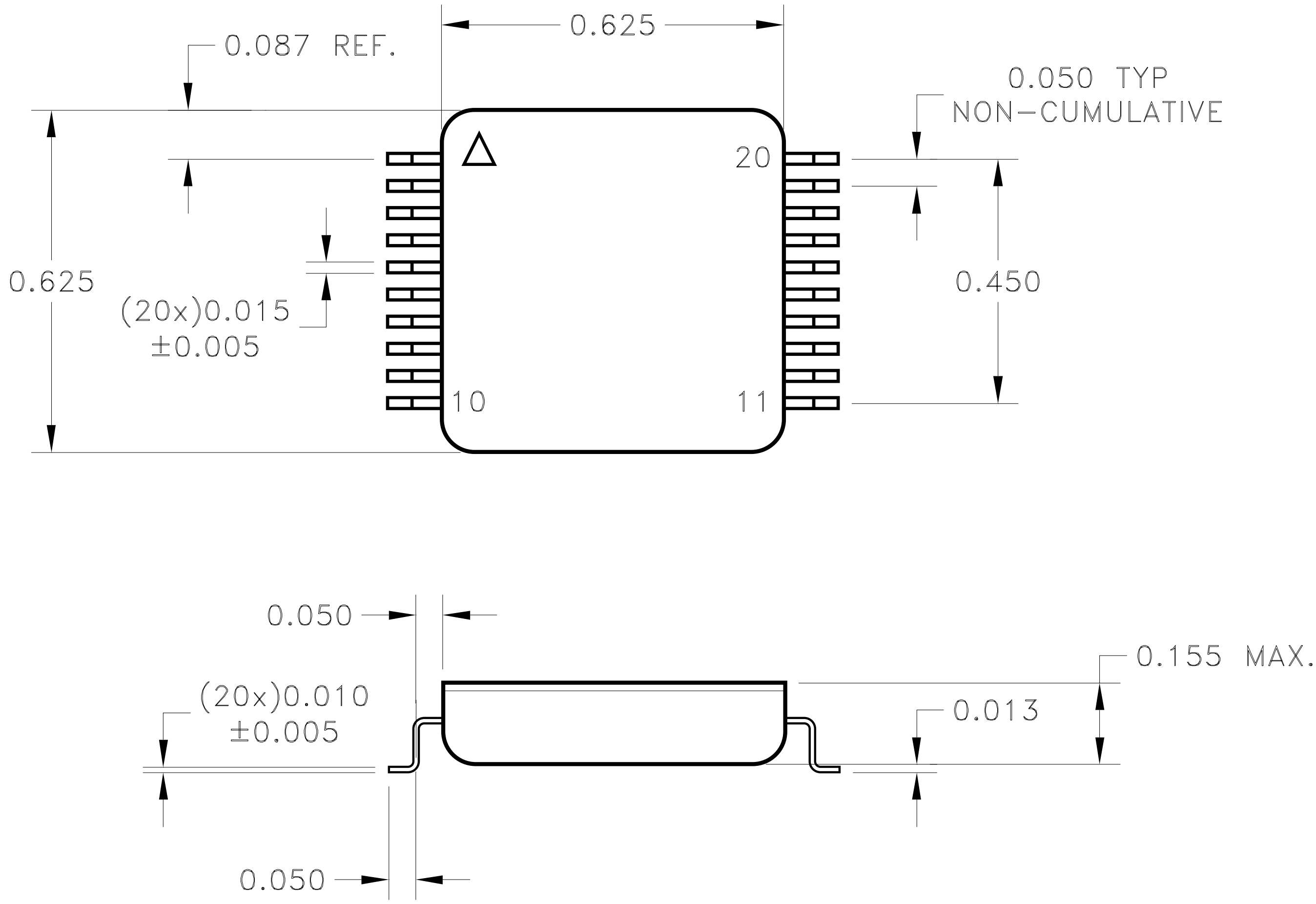
NOTE: ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.
ESD Triangle indicates pin 1.

ORDERING INFORMATION

Part Number	Screening Level
MSK 0021FP	Industrial
MSK 0021FP H	MIL-PRF-38534 CLASS H
MSK 0021FP E	EXTENDED RELIABILITY
TBD	DSCC - SMD

MECHANICAL SPECIFICATIONS CONTINUED

MSK0021FPG



NOTE: ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.
ESD Triangle indicates pin 1.

ORDERING INFORMATION

Part Number	Screening Level
MSK 0021FPG	Industrial
MSK 0021FPG H	MIL-PRF-38534 CLASS H
MSK 0021FPG E	EXTENDED RELIABILITY
TBD	DSCC - SMD

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