

120MHz, Ultra-Low Noise Precision Operational Amplifiers

June 1998

Features

- Slew Rate. 35V/μs
- Wide Gain Bandwidth ($A_v \geq 10$). 120MHz
- Low Noise $3nV/\sqrt{Hz}$ at 1kHz
- Low V_{OS} 10μV
- High CMRR 126dB
- High Gain. 1800V/mV

Applications

- High Speed Signal Conditioners
- Wide Bandwidth Instrumentation Amplifiers
- Low Level Transducer Amplifiers
- Fast, Low Level Voltage Comparators
- Highest Quality Audio Preamplifiers
- Pulse/RF Amplifiers
- For Further Design Ideas See Application Note AN553

Ordering Information

PART NUMBER (BRAND)	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
HA2-5147-2	-55 to 125	8 Pin Metal Can	T8.C
HA2-5147-5	0 to 75	8 Pin Metal Can	T8.C
HA2-5147A-2	-55 to 125	8 Pin Metal Can	T8.C
HA2-5147A-5	0 to 75	8 Pin Metal Can	T8.C
HA3-5147-5	0 to 75	8 Ld PDIP	E8.3
HA7-5147-2	-55 to 125	8 Ld Cerdip	F8.3A
HA7-5147-5	0 to 75	8 Ld Cerdip	F8.3A
HA7-5147A-2	-55 to 125	8 Ld Cerdip	F8.3A
HA7-5147A-5	0 to 75	8 Ld Cerdip	F8.3A
HA9P5147-9 (H51479)	-40 to 85	8 Ld SOIC	M8.15

The HA-5147 operational amplifier features an unparalleled combination of precision DC and wideband high speed characteristics. Utilizing the Harris D. I. technology and advanced processing techniques, this unique design unites low noise ($3nV/\sqrt{Hz}$) precision instrumentation performance with high speed ($35V/\mu s$) wideband capability.

This amplifier's impressive list of features include low V_{OS} (10mV), wide gain bandwidth (120MHz), high open loop gain (1800V/mV), and high CMRR (126dB). Additionally, this flexible device operates over a wide supply range ($\pm 5V$ to $\pm 20V$) while consuming only 140mW of power.

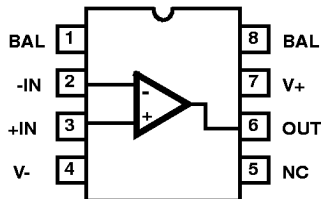
Using the HA-5147 allows designers to minimize errors while maximizing speed and bandwidth in applications requiring gains greater than ten.

This device is ideally suited for low level transducer signal amplifier circuits. Other applications which can utilize the HA-5147's qualities include instrumentation amplifiers, pulse or RF amplifiers, audio preamplifiers, and signal conditioning circuits.

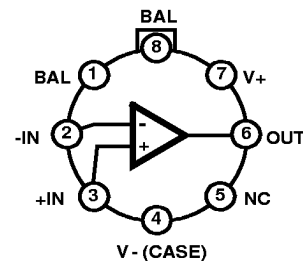
This device can easily be used as a design enhancement by directly replacing the 725, OP25, OP06, OP07, OP27 and OP37 where gains are greater than ten. For military grade product, refer to the HA-5147/883 data sheet.

Pinouts

HA-5147 (CERDIP, PDIP, SOIC)
HA-5147A (CERDIP, PDIP)
TOP VIEW



HA-5147, HA-5147A
(METAL CAN)
TOP VIEW



CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper IC Handling Procedures.

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File Number **2910.4**

HA-5147, HA-5147A

Absolute Maximum Ratings $T_A = 25^\circ\text{C}$

Voltage Between V_+ and V_- Terminals	44V
Differential Input Voltage (Note 1)	0.7V
Output Current	Full Short Circuit Protection

Operating Conditions

Temperature Range	
HA-5147/47A-2	-55°C to 125°C
HA-5147/47A-5	0°C to 75°C
HA-5147-9	-40°C to 85°C

Thermal Information

Thermal Resistance (Typical, Note 2)	θ_{JA} ($^\circ\text{C}/\text{W}$)	θ_{JC} ($^\circ\text{C}/\text{W}$)
CERDIP Package	135	50
Can Package	155	68
PDIP Package	120	N/A
SOIC Package	158	N/A
Maximum Junction Temperature (Hermetic Package)	175°C	
Maximum Junction Temperature (Plastic Package)	150°C	
Maximum Storage Temperature Range	-65°C to 150°C	
Maximum Lead Temperature (Soldering 10s)	300°C	
(SOIC - Lead Tips Only)		

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

- For differential input voltages greater than 0.7V, the input current must be limited to 25mA to protect the back-to-back input diodes.
- θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications $V_{\text{SUPPLY}} = \pm 15\text{V}$, $C_L \leq 50\text{pF}$, $R_S \leq 100\Omega$

PARAMETERS	TEST CONDITIONS	TEMP. ($^\circ\text{C}$)	HA-5147			HA-5147A			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS									
Offset Voltage		25	-	30	100	-	10	25	μV
		Full	-	70	300	-	30	60	μV
Average Offset Voltage Drift		Full	-	0.4	1.8	-	0.2	0.6	$\mu\text{V}/^\circ\text{C}$
Bias Current		25	-	15	80	-	10	40	nA
		Full	-	35	150	-	20	60	nA
Offset Current		25	-	12	75	-	7	35	nA
		Full	-	30	135	-	15	50	nA
Common Mode Range		Full	± 10.3	± 11.5	-	± 10.3	± 11.5	-	V
Differential Input Resistance (Note 3)		25	0.8	4	-	1.5	6	-	$\text{M}\Omega$
Input Noise Voltage (Note 4)	0.1Hz to 10Hz	25	-	0.09	0.25	-	0.08	0.18	$\mu\text{V}_{\text{p-p}}$
Input Noise Voltage Density (Note 5)	f = 10Hz	25	-	3.8	8.0	-	3.5	8.0	$\text{nV}/\sqrt{\text{Hz}}$
	f = 100Hz		-	3.3	4.5	-	3.1	4.5	$\text{nV}/\sqrt{\text{Hz}}$
	f = 1000Hz		-	3.2	3.8	-	3.0	3.8	$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Current Density (Note 5)	f = 10Hz	25	-	1.7	-	-	1.7	4.0	$\text{pA}/\sqrt{\text{Hz}}$
	f = 100Hz		-	1.0	-	-	1.0	2.3	$\text{pA}/\sqrt{\text{Hz}}$
	f = 1000Hz		-	0.4	0.6	-	0.4	0.6	$\text{pA}/\sqrt{\text{Hz}}$
TRANSFER CHARACTERISTICS									
Minimum Stable Gain		25	10	-	-	10	-	-	V/V
Large Signal Voltage Gain	$V_{\text{OUT}} = \pm 10\text{V}$, $R_L = 2\text{k}\Omega$	25	700	1500	-	1000	1800	-	V/mV
		Full	300	800	-	600	1200	-	V/mV
Common Mode Rejection Ratio	$V_{\text{CM}} = \pm 10\text{V}$	Full	100	120	-	114	126	-	dB

HA-5147, HA-5147A

Electrical Specifications $V_{SUPPLY} = \pm 15V$, $C_L \leq 50pF$, $R_S \leq 100\Omega$ (Continued)

PARAMETERS	TEST CONDITIONS	TEMP. (°C)	HA-5147			HA-5147A			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Gain-Bandwidth-Product	f = 10kHz	25	120	140	-	120	140	-	MHz
	f = 1MHz		-	120	-	-	120	-	MHz
OUTPUT CHARACTERISTICS									
Output Voltage Swing	$R_L = 600\Omega$	25	± 10.0	± 11.5	-	± 10.0	± 11.5	-	V
	$R_L = 2k\Omega$	Full	± 11.4	± 13.5	-	± 11.7	± 13.8	-	V
Full Power Bandwidth (Note 6)		25	445	500	-	445	500	-	kHz
Output Resistance	Open Loop	25	-	70	-	-	70	-	Ω
Output Current		25	16.5	25	-	16.5	25	-	mA
TRANSIENT RESPONSE (Note 7)									
Rise Time		25	-	22	50	-	22	50	ns
Slew Rate	$V_{OUT} = \pm 3V$	25	28	35	-	28	35	-	V/ μs
Settling Time	Note 8	25	-	400	-	-	400	-	ns
Overshoot		25	-	20	40	-	20	40	%
POWER SUPPLY CHARACTERISTICS									
Supply Current		25	-	3.5	-	-	3.5	-	mA
		Full	-	-	4.0	-	-	4.0	mA
Power Supply Rejection Ratio	$V_S = \pm 4V$ to $\pm 18V$	Full	-	16	51	-	2	4	$\mu V/V$

NOTES:

3. This parameter value is based upon design calculations.
4. Refer to Typical Performance section of the data sheet.
5. The limits for this parameter are guaranteed based on lab characterization, and reflect lot-to-lot variation.
6. Full power bandwidth guaranteed based on slew rate measurement using: $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$.
7. Refer to Test Circuits section of the data sheet.
8. Settling time is specified to 0.1% of final value for a 10V output step and $A_V = -10$.

Test Circuits and Waveforms

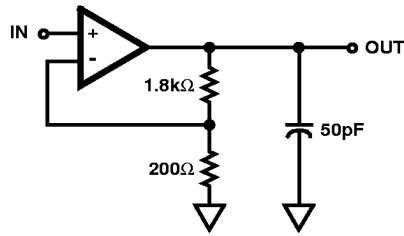
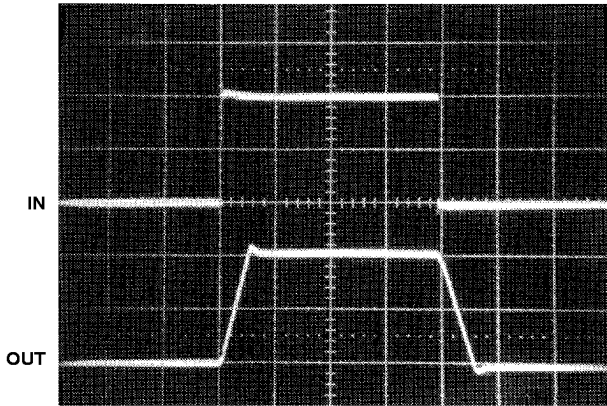
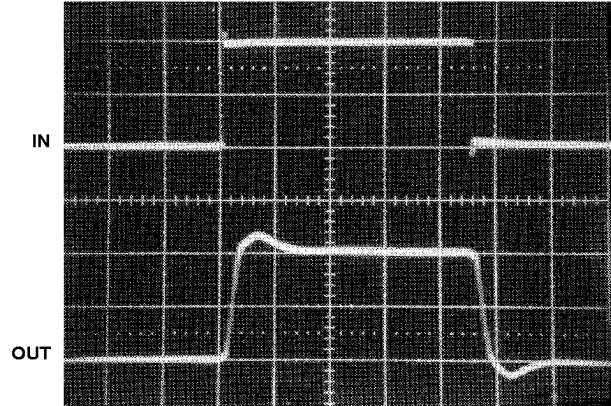


FIGURE 1. LARGE AND SMALL SIGNAL RESPONSE TEST CIRCUIT



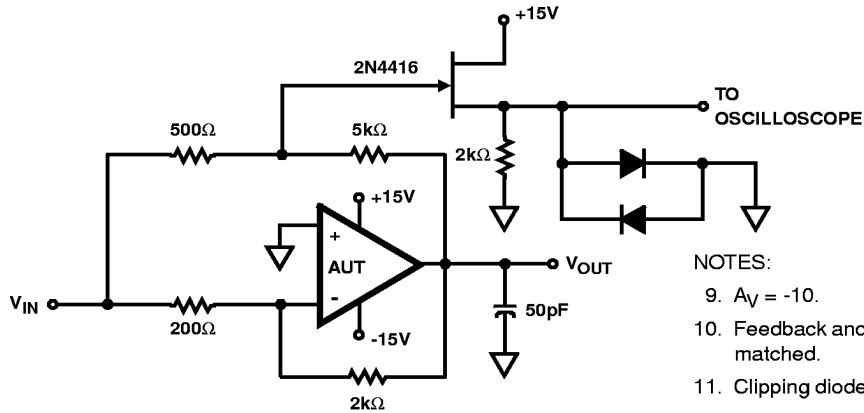
Vertical Scale: Input = 0.5V/Div.
Output = 5V/Div.
Horizontal Scale: 500ns/Div.

LARGE SIGNAL RESPONSE



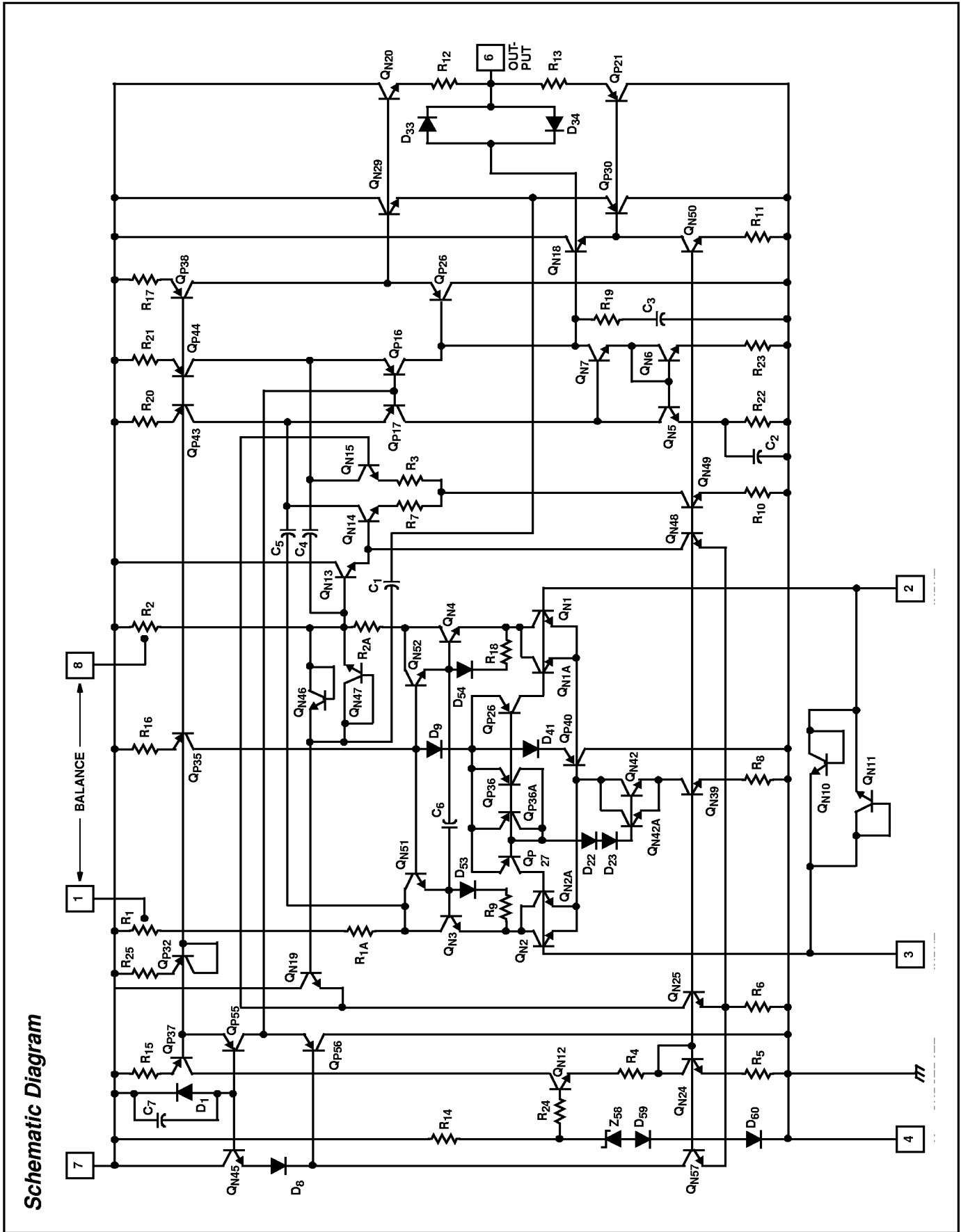
Vertical Scale: Input = 10mV/Div.
Output = 100mV/Div.
Horizontal Scale: 100ns/Div.

SMALL SIGNAL RESPONSE



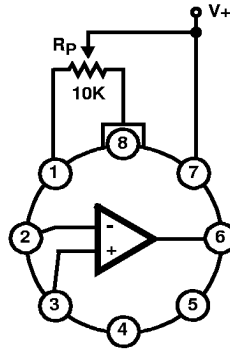
- NOTES:
9. $A_V = -10$.
 10. Feedback and summing resistors should be 0.1% matched.
 11. Clipping diodes are optional. HP5082-2810 recommended.

FIGURE 2. SETTLING TIME TEST CIRCUIT



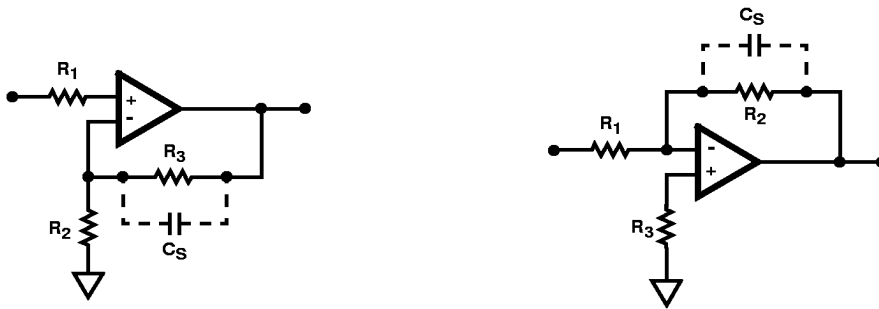
Schematic Diagram

Application Information



NOTE: Tested Offset Adjustment Range is $|V_{OS} + 1mV|$ minimum referred to output. Typical range is $\pm 4mV$ with $R_p = 10k\Omega$.

FIGURE 3. SUGGESTED OFFSET VOLTAGE ADJUSTMENT



NOTE: Low resistances are preferred for low noise applications as a $1k\Omega$ resistor has $4nV/\sqrt{Hz}$ of thermal noise. Total resistances of greater than $10k\Omega$ on either input can reduce stability. In most high resistance applications, a few picofarads of capacitance across the feedback resistor will improve stability.

FIGURE 4. SUGGESTED STABILITY CIRCUITS

Typical Performance Curves $T_A = 25^\circ C$, $V_{SUPPLY} = \pm 15V$, Unless Otherwise Specified

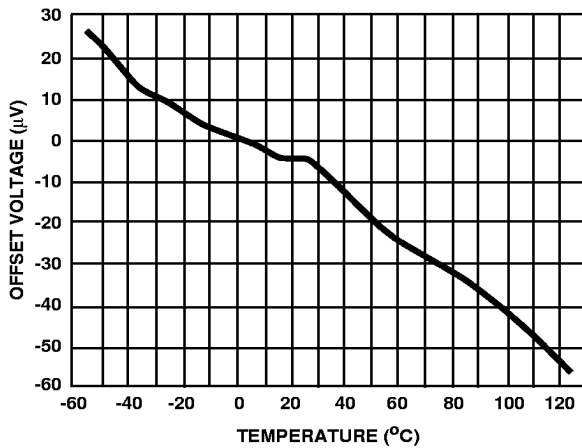


FIGURE 5. TYPICAL OFFSET VOLTAGE vs TEMPERATURE

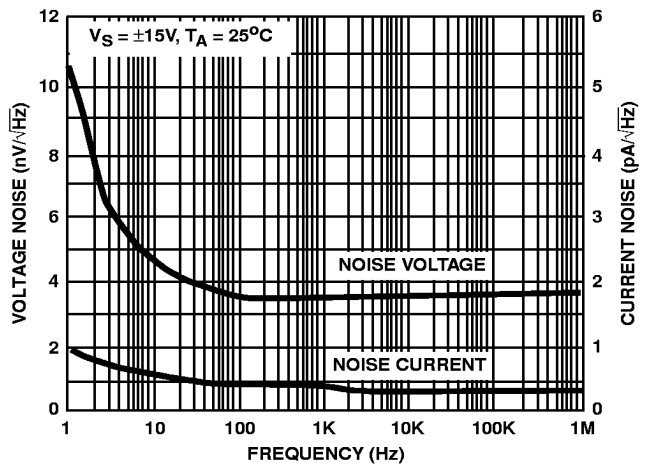


FIGURE 6. NOISE CHARACTERISTICS

HA-5147, HA-5147A

Typical Performance Curves $T_A = 25^\circ\text{C}$, $V_{\text{SUPPLY}} = \pm 15\text{V}$, Unless Otherwise Specified (Continued)

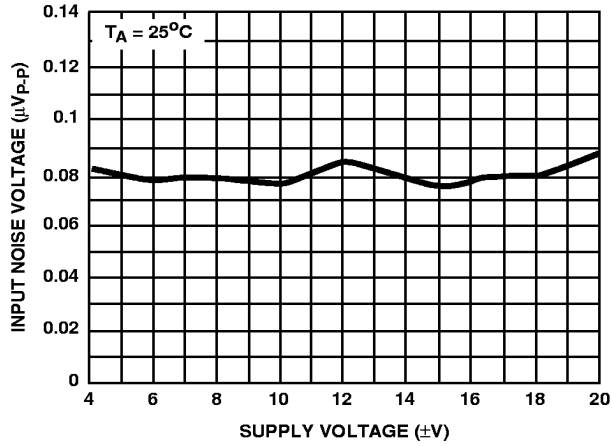


FIGURE 7. NOISE vs SUPPLY VOLTAGE

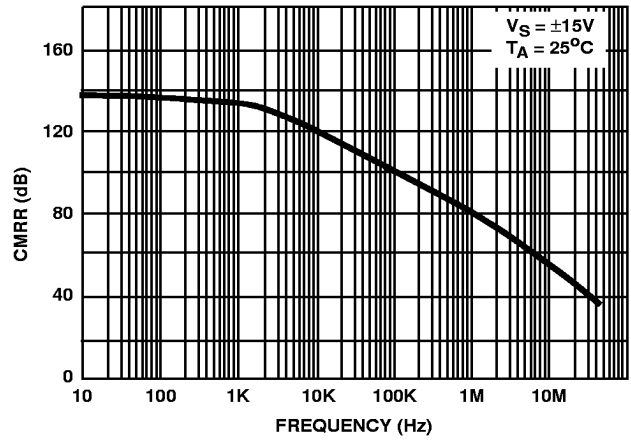


FIGURE 8. CMRR vs FREQUENCY

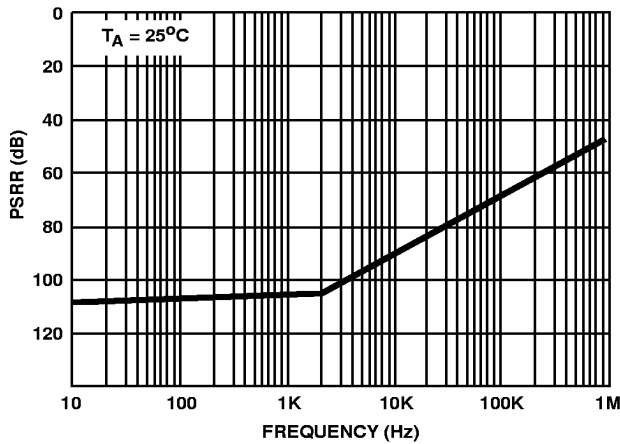


FIGURE 9. PSRR vs FREQUENCY

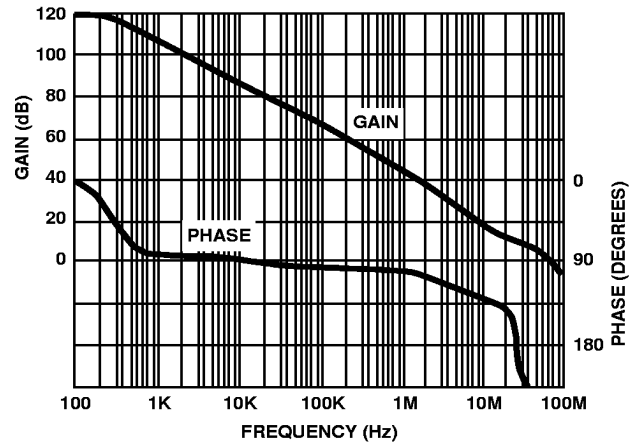


FIGURE 10. OPEN LOOP GAIN AND PHASE vs FREQUENCY

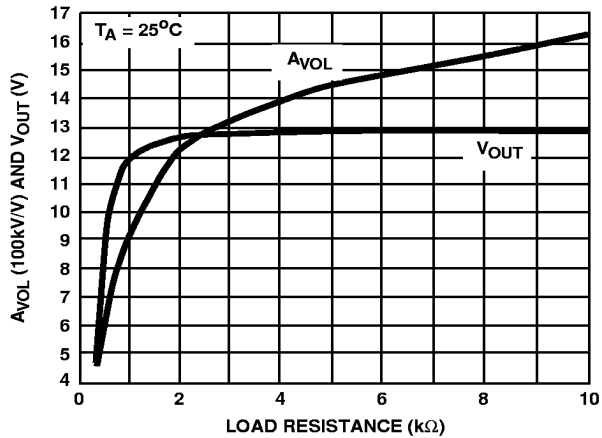


FIGURE 11. A_{VOL} AND V_{OUT} vs LOAD RESISTANCE

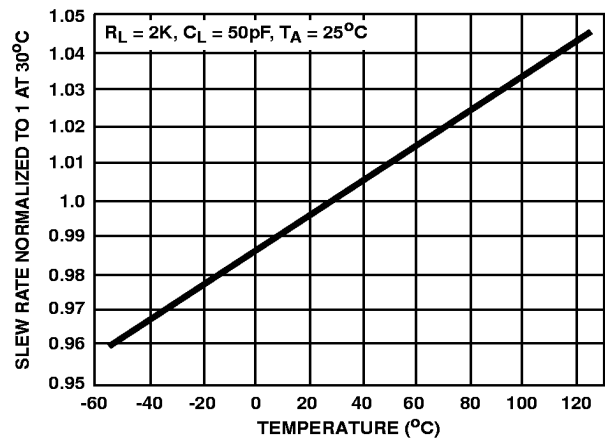


FIGURE 12. NORMALIZED SLEW RATE vs TEMPERATURE

Typical Performance Curves $T_A = 25^\circ\text{C}$, $V_{\text{SUPPLY}} = \pm 15\text{V}$, Unless Otherwise Specified (Continued)

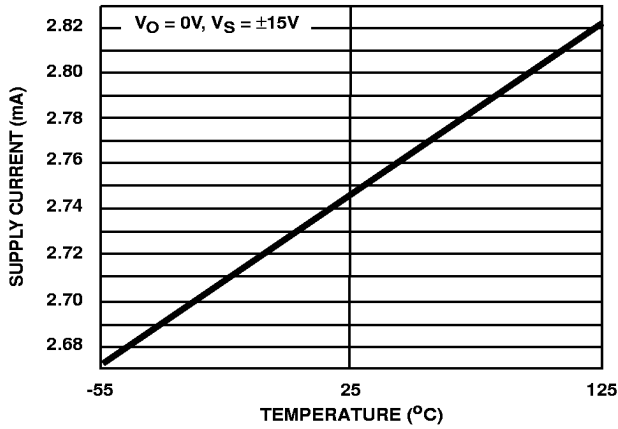


FIGURE 13. SUPPLY CURRENT vs TEMPERATURE

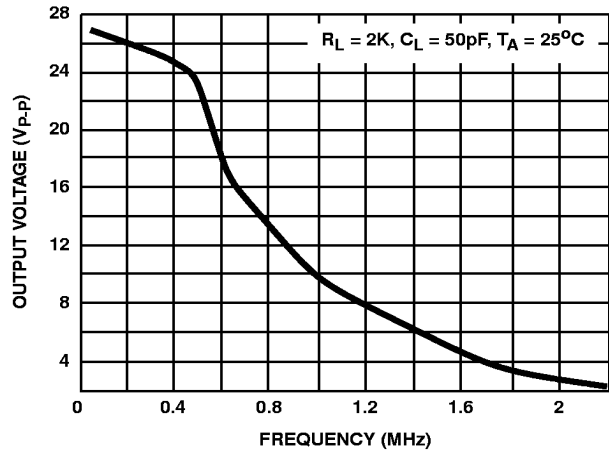


FIGURE 14. $V_{\text{OUT MAX}}$ (UNDISTORTED SINEWAVE OUTPUT) vs FREQUENCY

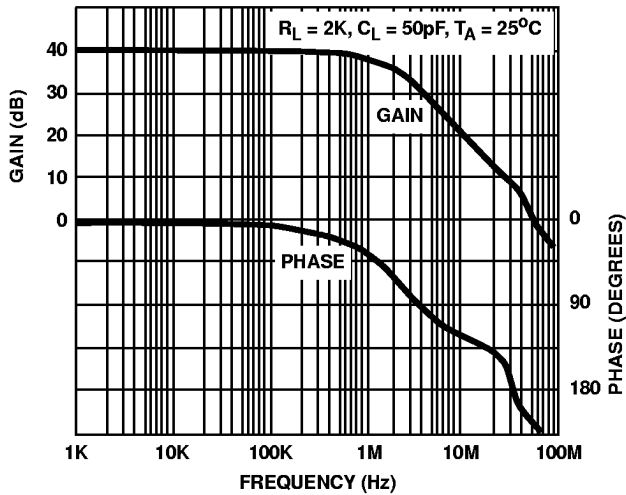
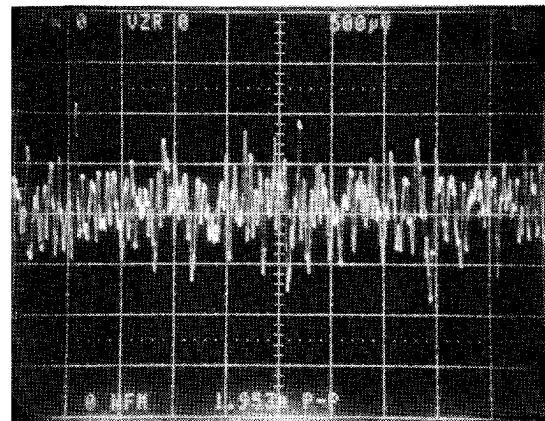


FIGURE 15. CLOSED LOOP GAIN AND PHASE vs FREQUENCY



$A_{\text{CL}} = 25,000\text{V/V}$; $E_{\text{N}} = 0.08\mu\text{V}_{\text{P-P RTI}}$
Horizontal Scale = 1s/Div.; Vertical Scale = 0.002µV/Div.

FIGURE 16. PEAK-TO-PEAK NOISE VOLTAGE (0.1Hz TO 10Hz)

HA-5147, HA-5147A

Die Characteristics

DIE DIMENSIONS:

104 mils x 65 mils x 19 mils
2650 μ m x 1650 μ m x 483 μ m

METALLIZATION:

Type: Al, 1% Cu
Thickness: 16k \AA \pm 2k \AA

SUBSTRATE POTENTIAL (Powered Up):

V-

PASSIVATION:

Type: Nitride (Si₃N₄) over Silox (SiO₂, 5% Phos.)
Silox Thickness: 12k \AA \pm 2k \AA
Nitride Thickness: 3.5k \AA \pm 1.5k \AA

TRANSISTOR COUNT:

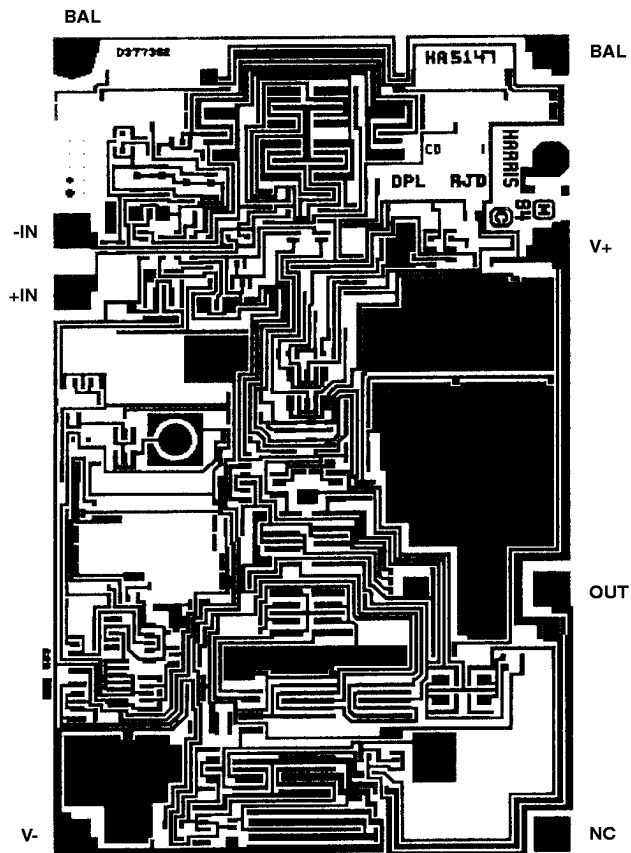
63

PROCESS:

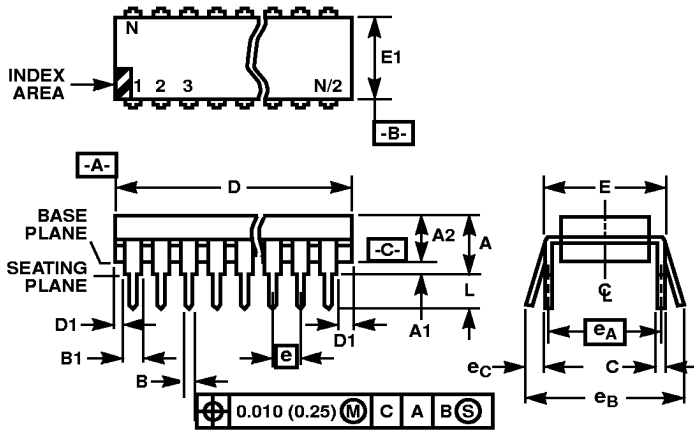
Bipolar Dielectric Isolation

Metallization Mask Layout

HA-5147



Dual-In-Line Plastic Packages (PDIP)



NOTES:

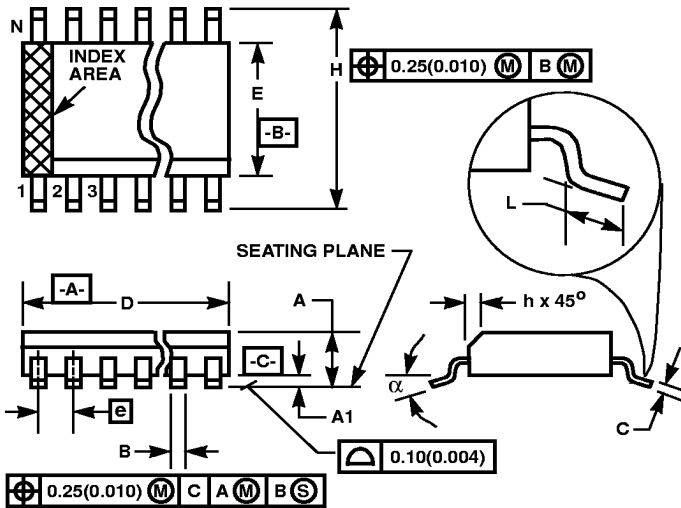
1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and e_A are measured with the leads constrained to be perpendicular to datum -C-.
7. e_B and e_C are measured at the lead tips with the leads unconstrained. e_C must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

E8.3 (JEDEC MS-001-BA ISSUE D)
8 LEAD DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.210	-	5.33	4
A1	0.015	-	0.39	-	4
A2	0.115	0.195	2.93	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.045	0.070	1.15	1.77	8, 10
C	0.008	0.014	0.204	0.355	-
D	0.355	0.400	9.01	10.16	5
D1	0.005	-	0.13	-	5
E	0.300	0.325	7.62	8.25	6
E1	0.240	0.280	6.10	7.11	5
e	0.100 BSC		2.54 BSC		-
e_A	0.300 BSC		7.62 BSC		6
e_B	-	0.430	-	10.92	7
L	0.115	0.150	2.93	3.81	4
N	8		8		9

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Small Outline Plastic Packages (SOIC)



M8.15 (JEDEC MS-012-AA ISSUE C)
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.1890	0.1968	4.80	5.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	8		8		7
α	0°	8°	0°	8°	-

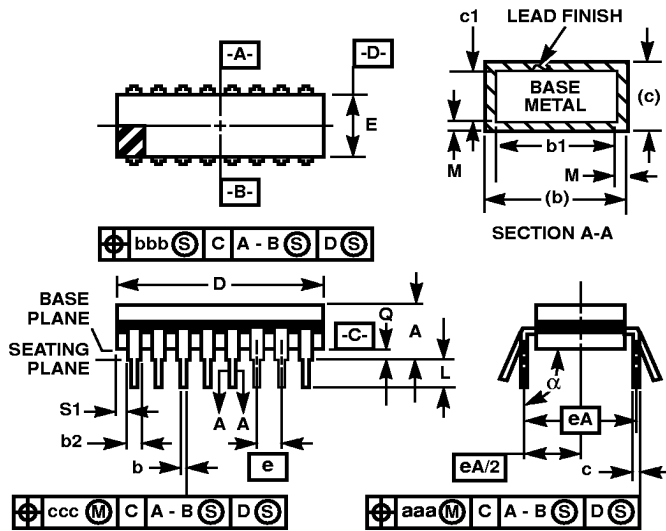
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NOTES:

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Ceramic Dual-In-Line Frit Seal Packages (CERDIP)

**F8.3A MIL-STD-1835 GDIP1-T8 (D-4, CONFIGURATION A)
8 LEAD CERAMIC DUAL-IN-LINE FRIT SEAL PACKAGE**



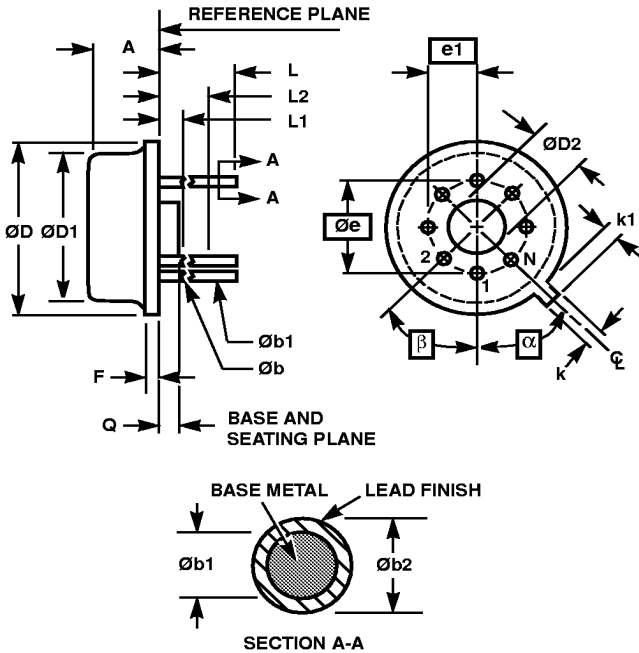
NOTES:

1. Index area: A notch or a pin one identification mark shall be located adjacent to pin one and shall be located within the shaded area shown. The manufacturer's identification shall not be used as a pin one identification mark.
2. The maximum limits of lead dimensions b and c or M shall be measured at the centroid of the finished lead surfaces, when solder dip or tin plate lead finish is applied.
3. Dimensions b1 and c1 apply to lead base metal only. Dimension M applies to lead plating and finish thickness.
4. Corner leads (1, N, N/2, and N/2+1) may be configured with a partial lead paddle. For this configuration dimension b3 replaces dimension b2.
5. This dimension allows for off-center lid, meniscus, and glass overrun.
6. Dimension Q shall be measured from the seating plane to the base plane.
7. Measure dimension S1 at all four corners.
8. N is the maximum number of terminal positions.
9. Dimensioning and tolerancing per ANSI Y14.5M - 1982.
10. Controlling dimension: INCH

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.200	-	5.08	-
b	0.014	0.026	0.36	0.66	2
b1	0.014	0.023	0.36	0.58	3
b2	0.045	0.065	1.14	1.65	-
b3	0.023	0.045	0.58	1.14	4
c	0.008	0.018	0.20	0.46	2
c1	0.008	0.015	0.20	0.38	3
D	-	0.405	-	10.29	5
E	0.220	0.310	5.59	7.87	5
e	0.100 BSC		2.54 BSC		-
eA	0.300 BSC		7.62 BSC		-
eA/2	0.150 BSC		3.81 BSC		-
L	0.125	0.200	3.18	5.08	-
Q	0.015	0.060	0.38	1.52	6
S1	0.005	-	0.13	-	7
alpha	90°	105°	90°	105°	-
aaa	-	0.015	-	0.38	-
bbb	-	0.030	-	0.76	-
ccc	-	0.010	-	0.25	-
M	-	0.0015	-	0.038	2, 3
N	8		8		8

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Metal Can Packages (Can)



**T8.C MIL-STD-1835 MACY1-X8 (A1)
8 LEAD METAL CAN PACKAGE**

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.165	0.185	4.19	4.70	-
Øb	0.016	0.019	0.41	0.48	1
Øb1	0.016	0.021	0.41	0.53	1
Øb2	0.016	0.024	0.41	0.61	-
ØD	0.335	0.375	8.51	9.40	-
ØD1	0.305	0.335	7.75	8.51	-
ØD2	0.110	0.160	2.79	4.06	-
e	0.200 BSC		5.08 BSC		-
e1	0.100 BSC		2.54 BSC		-
F	-	0.040	-	1.02	-
k	0.027	0.034	0.69	0.86	-
k1	0.027	0.045	0.69	1.14	2
L	0.500	0.750	12.70	19.05	1
L1	-	0.050	-	1.27	1
L2	0.250	-	6.35	-	1
Q	0.010	0.045	0.25	1.14	-
α	45° BSC		45° BSC		3
β	45° BSC		45° BSC		3
N	8		8		4

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NOTES:

- (All leads) Øb applies between L1 and L2. Øb1 applies between L2 and 0.500 from the reference plane. Diameter is uncontrolled in L1 and beyond 0.500 from the reference plane.
- Measured from maximum diameter of the product.
- α is the basic spacing from the centerline of the tab to terminal 1 and β is the basic spacing of each lead or lead position (N - 1 places) from α, looking at the bottom of the package.
- N is the maximum number of terminal positions.
- Dimensioning and tolerancing per ANSI Y14.5M - 1982.
- Controlling dimension: INCH.

All Harris Semiconductor products are manufactured, assembled and tested under **ISO9000** quality systems certification.

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