

# Optical M

Mike C. (sandbar w/fl)

ver. 1.0  
3-31-12

The 'Optical M' circuit card (see fig. 1 & 2) measures 25 x 50 mm and was purchased via E-be, the seller reported it as an equipment pull. No other information is available as to the source.

I did, however, reverse engineer the card completely given the data available. The 2 most important parts are the optical sensor and the op-amp. The sensor is a Hamamatsu S1223 Si PIN photodiode with a sensitivity from 400 – 1100 nm. The sensitive area is 2.4 x 2.8 mm. (see the spec sheet as part of this report).

The op-amp is a Harris HA2-5160-5 high speed **JFET** with a high slew rate in an 8 pin TO-5 can. (see the spec sheet as part of this report).

(Note: The entire pkg, schematic included, is available for download and I eventually will provide a pc layout)

## Testing:

Testing will take place upon completion of the Li-Ion battery packs. I will be using 6 each, 3 for the pos rail and 3 for the neg rail for a total of +/- 11.1 vdc.

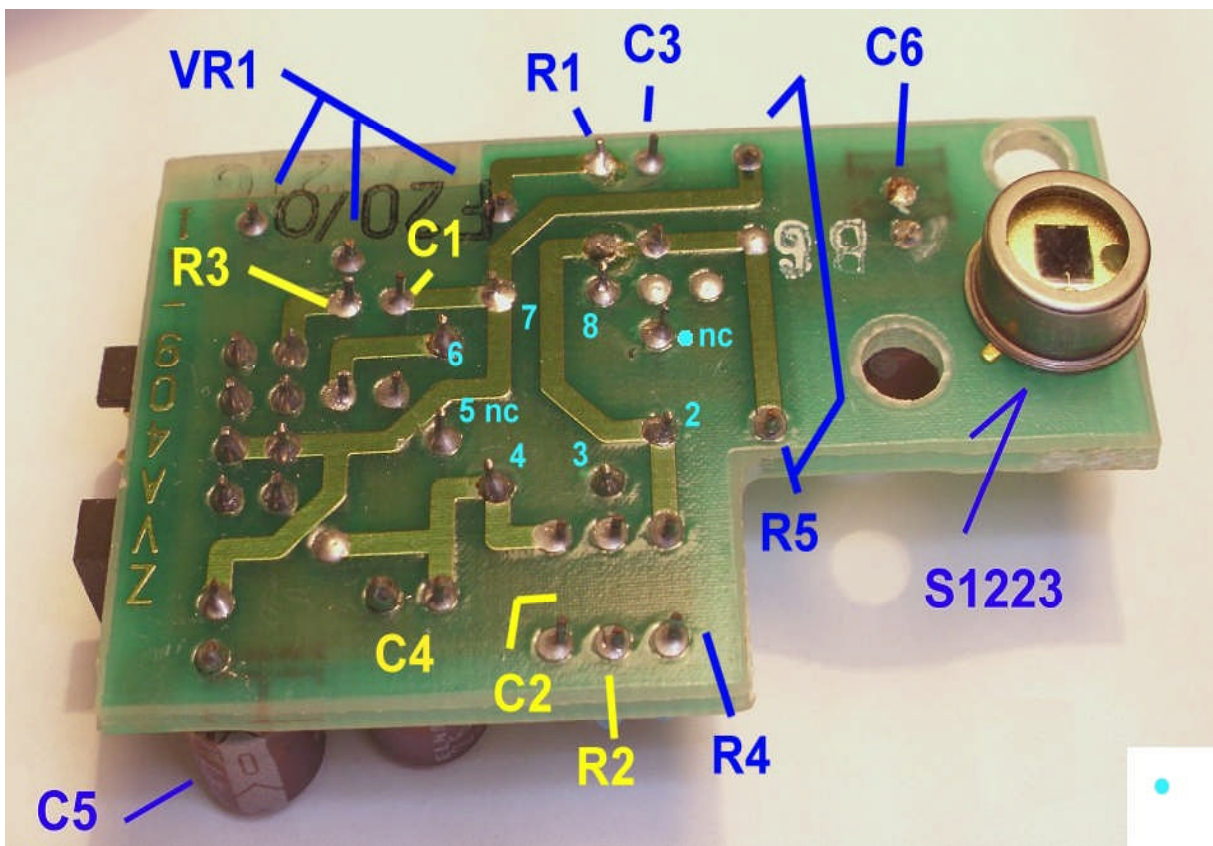
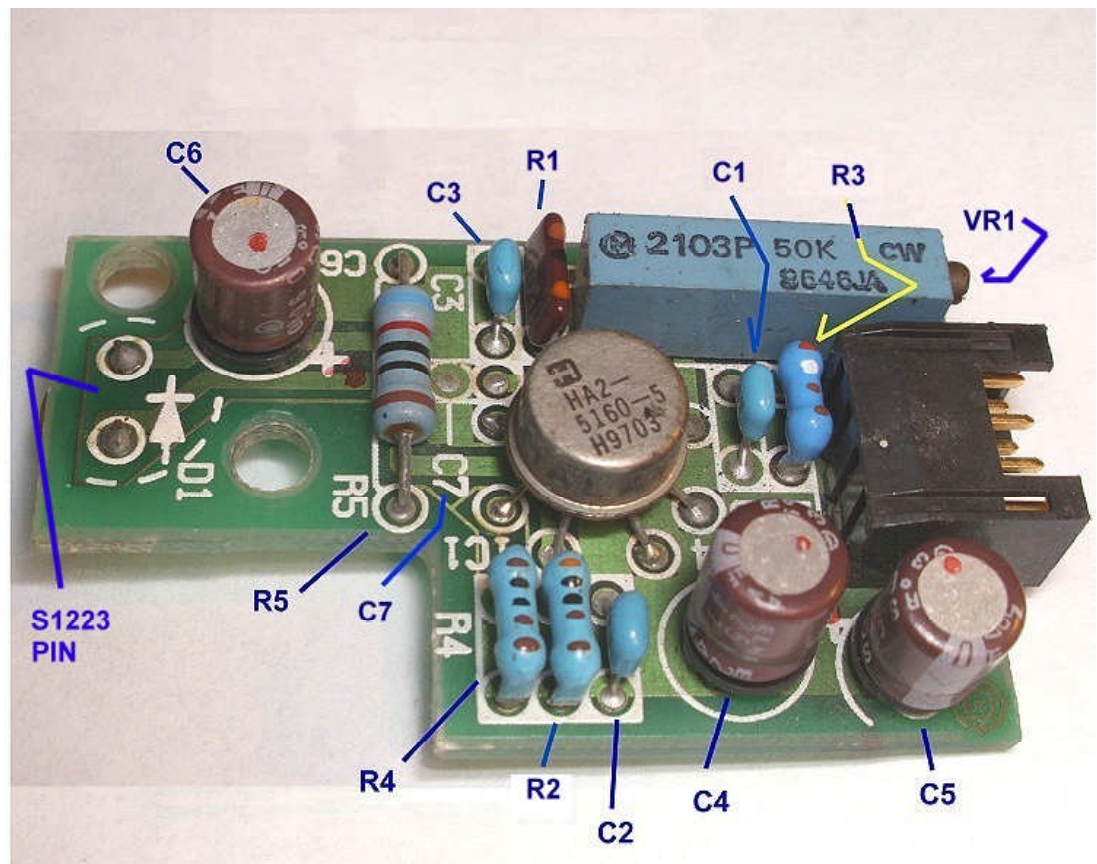


Figure 1

**R1** 10k  
**R2** 3k  
**R3** 390  
**R4** 1k  
**R5** 625  
**VR1** 50k or 100k  
  
**C1** .001  
**C2** .001  
**C3** .001  
**C4** 47uF, 25v  
**C5** 47uF, 25v  
**C6** 10uF, 63v  
**C7** 47J  
**IC** HA2-5106-5  
**D1** S1223 Pin



**Figure 2**

Figure 1 and 2 are the bottom and top of the 'Optical M' circuit. Use the figures to find components when referenced. The schematic is on page 3 (Figure 4).

### Equipment Used:

Spectran Software for analyzing signals.  
 HP Laptop running XP @ 1.6GHz processor.  
 Kenwood CS-5400 100MHz, dual channel scope.

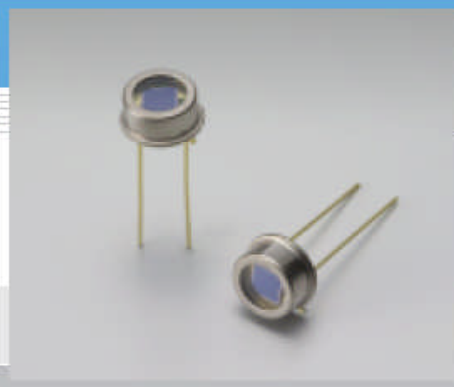


**Test Results:**

TBD:

# Si PIN photodiode S1223 series

For visible to IR, precision photometry



## Features

- High sensitivity
- High reliability
- High-speed response  
S1223:  $f_c=30$  MHz  
S1223-01:  $f_c=20$  MHz
- Low capacitance

## Applications

- Optical measurement equipment
- Analytical equipment, etc.

## General ratings

Parameter	Symbol	S1223	S1223-01	Unit
Window material	-	borosilicate glass		-
Package	-	TO-5		-
Active area size	A	2.4 × 2.8	3.6 × 3.6	mm
Effective active area	-	6.6	13	mm <sup>2</sup>

## Absolute maximum ratings

Parameter	Symbol	S1223	S1223-01	Unit
Reverse voltage	$V_R$ Max.	30		V
Power dissipation	P	100		mW
Operating temperature	$T_{opr}$	-40 to +100		°C
Storage temperature	$T_{stg}$	-55 to +125		°C

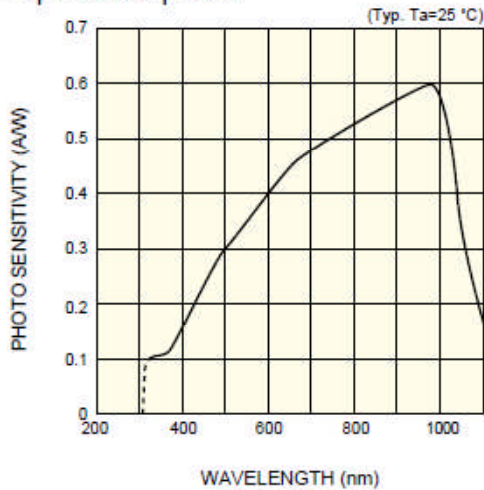
## Electrical and optical characteristics ( $T_a=25$ °C)

Parameter	Symbol	Condition	S1223			S1223-01			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range	$\lambda$		-	320 to 1100	-	-	320 to 1100	-	nm
Peak sensitivity wavelength	$\lambda_p$		-	960	-	-	960	-	nm
Photo sensitivity	S	$\lambda=\lambda_p$	-	0.6	-	-	0.6	-	A/W
		$\lambda=660$ nm	-	0.45	-	-	0.45	-	
		$\lambda=780$ nm	-	0.52	-	-	0.52	-	
		$\lambda=830$ nm	-	0.54	-	-	0.54	-	
Short circuit current	$I_{sc}$	100 lx	5	6.3	-	10	13	-	μA
Dark current	$I_D$	$V_R=20$ V	-	0.1	10	-	0.2	10	nA
Temp. coefficient of $I_D$	$T_{CID}$		-	1.15	-	-	1.15	-	times/°C
Cut-off frequency	$f_c$	$V_R=20$ V, -3 dB	-	30	-	-	20	-	MHz
Terminal capacitance	$C_t$	$V_R=20$ V, $f=1$ MHz	-	10	-	-	20	-	pF
Noise equivalent power	NEP	$V_R=20$ V, $\lambda=\lambda_p$	-	$9.4 \times 10^{-15}$	-	-	$1.3 \times 10^{-14}$	-	W/Hz <sup>1/2</sup>

**SOLID**  
**STATE** DIVISION

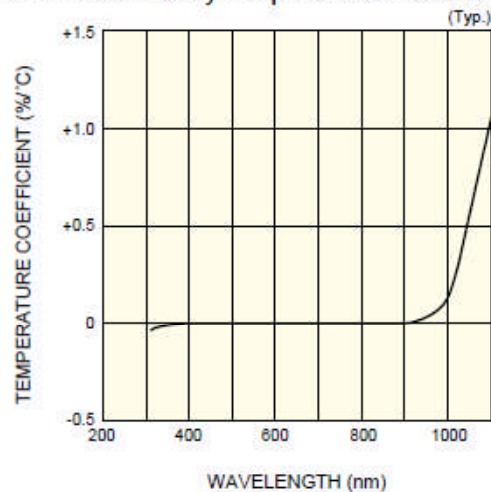


## Spectral response



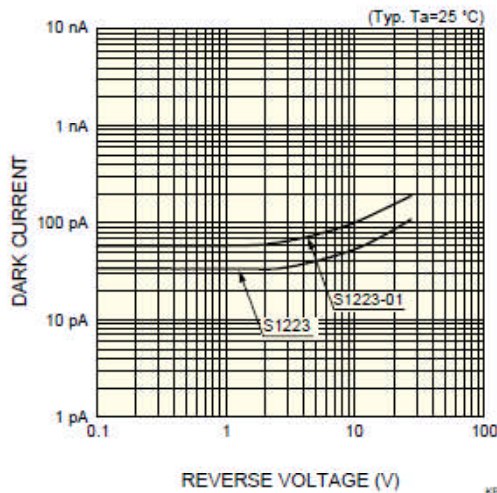
KPINB0145EA

## Photo sensitivity temperature characteristic



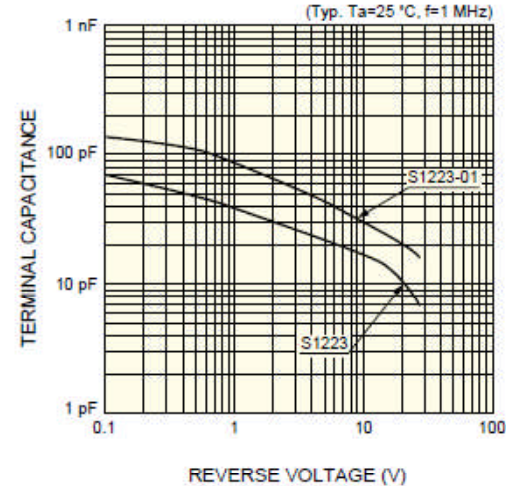
KPINB0144EA

## Dark current vs. reverse voltage



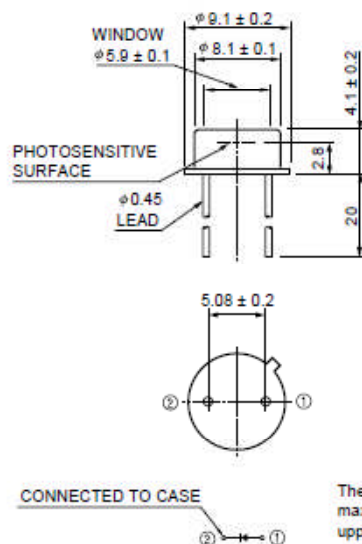
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## Terminal capacitance vs. reverse voltage



KPINB0146EA

## Dimensional outline (unit: mm)



The glass window may extend a maximum of 0.2 mm above the upper surface of the cap.

KPNA0073EA

# HAMAMATSU

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## 100MHz, JFET Input, High Slew Rate, Uncompensated, Operational Amplifier

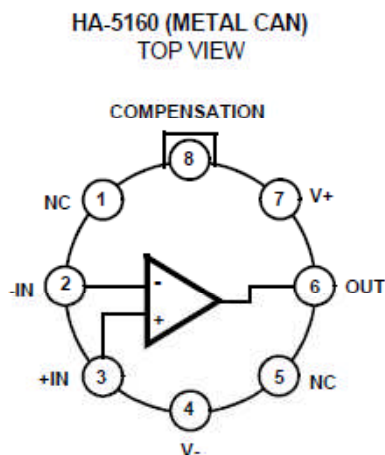
The HA-5160 is a wideband, uncompensated, operational amplifier with FET/Bipolar technologies and Dielectric Isolation. This monolithic amplifier features superior high frequency capabilities further enhanced by precision laser trimming of the input stage to provide excellent input characteristics. This device has excellent phase margin at a closed loop gain of 10 without external compensation.

The HA-5160 offers a number of important advantages over similar FET input op amps from other manufacturers. In addition to superior bandwidth and settling characteristics, the Intersil devices have nearly constant slew rate, bandwidth, and settling characteristics over the operating temperature range. This provides the user predictable performance in applications where settling time, full power bandwidth, closed loop bandwidth, or phase shift is critical. Note also that Intersil specified all parameters at ambient (rather than junction) temperature to provide the designer meaningful data to predict actual operating performance.

Complementing the HA-5160's predictable and excellent dynamic characteristics are very low input offset voltage, very low input bias current, and a very high input impedance. This ideal combination of features make these amplifiers most suitable for precision, high speed, data acquisition system designs and for a wide variety of signal conditioning applications. The HA-5160 provides excellent performance for applications which require both precision and high speed performance.

Military version (/883) data sheets are available upon request.

## Pinout



NOTE: Case connected to V-.

## Features

- Wide Gain Bandwidth ( $A_V \geq 10$ ) ..... 100MHz
- High Slew Rate ..... 120V/ $\mu$ s
- Settling Time ..... 280ns
- Power Bandwidth ..... 1.9MHz
- Offset Voltage ..... 1.0mV
- Bias Current ..... 20pA
- Compensation Pin for Unity Gain Capability

## Applications

- Video and RF Amplifiers
- Data Acquisition
- Pulse Amplifiers
- Precision Signal Generation

## Ordering Information

PART NUMBER	PART MARKING	TEMP. RANGE (°C)	PACKAGE	PKG. DWG. #
HA2-5160-5	HA2-5160-5	0 to 75	8 Pin Metal Can	T8.C



**Absolute Maximum Ratings**

Voltage Between V+ and V-	40V
Differential Input Voltage	40V
Peak Output Current	Full Short Circuit Protection

**Operating conditions**

Temperature Ranges	
HA-5160-5	0°C to 75°C
Supply Voltage Range (Typical)	±7V to ±18V

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.

**NOTE:**

1.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

**Thermal Information**

Thermal Resistance (Typical, Note 1)	$\theta_{JA}$ (°C/W)	$\theta_{JC}$ (°C/W)
Metal Can Package	155	67
Maximum Junction Temperature		175°C
Maximum Storage Temperature Range		-65°C to 150°C
Maximum Lead Temperature (Soldering 10s)		300°C

**Die Characteristics**

Number of Transistors	82
Substrate Potential (Powered Up)	Floating

**Electrical Specifications**  $V_{SUPPLY} = \pm 15V$ , Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP. (°C)	MIN	TYP	MAX	UNITS
<b>INPUT CHARACTERISTICS</b>						
Offset Voltage		25	-	1	3	mV
		Full	-	3	5	mV
Offset Voltage Average Drift		Full	-	20	-	μV/°C
Bias Current		25	-	20	50	pA
		Full	-	5	10	nA
Offset Current		25	-	2	10	pA
		Full	-	2	5	nA
Input Capacitance		25	-	5	-	pF
Input Resistance		25	-	$10^{12}$	-	Ω
Common Mode Range		Full	±10	±11	-	V
<b>TRANSFER CHARACTERISTICS</b>						
Large Signal Voltage Gain	$V_{OUT} = \pm 10V$ , $R_L = 2k\Omega$	25	75	150	-	kV/V
		Full	60	100	-	kV/V
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	Full	74	80	-	dB
Minimum Stable Gain		25	10	-	-	V/V
Gain Bandwidth Product	$A_V \geq 10$	Full	-	100	-	MHz
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage Swing	$R_L = 2k\Omega$	25	±10	±11	-	V
		Full	±10	±11	-	V
Output Current	$V_{OUT} = \pm 10V$	25	±10	±20	-	mA
Output Short Circuit Current		25	-	±35	-	mA
Full Power Bandwidth (Note 2)	$V_{OUT} = \pm 10V$ , $R_L = 2k\Omega$	25	1.6	1.9	-	MHz
Output Resistance	Open Loop	25	-	50	-	Ω
<b>TRANSIENT RESPONSE (Note 3)</b>						
Rise Time	$A_V = +10$	25	-	20	-	ns
Slew Rate	$A_V = +10$	25	100	120	-	V/μs
Settling Time (Note 4)	$A_V = -10$	25	-	280	-	ns



**Electrical Specifications**  $V_{\text{SUPPLY}} = \pm 15\text{V}$ , Unless Otherwise Specified (Continued)

PARAMETER	TEST CONDITIONS	TEMP. (°C)	MIN	TYP	MAX	UNITS
<b>POWER SUPPLY CHARACTERISTICS</b>						
Supply Current		Full	-	8	10	mA
Power Supply Rejection Ratio	$V_S = \pm 10\text{V}$ to $\pm 20\text{V}$	25	74	86	-	dB

**NOTES:**

- Full Power Bandwidth guaranteed, based on slew rate measurement using:  $\text{FPBW} = \frac{\text{Slew Rate}}{2\pi V_{\text{PEAK}}}$ .
- Refer to Test circuits section of the data sheet.
- Settling Time is measured to 0.2% of final value for a 10V output step.

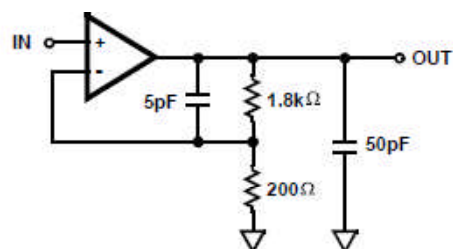
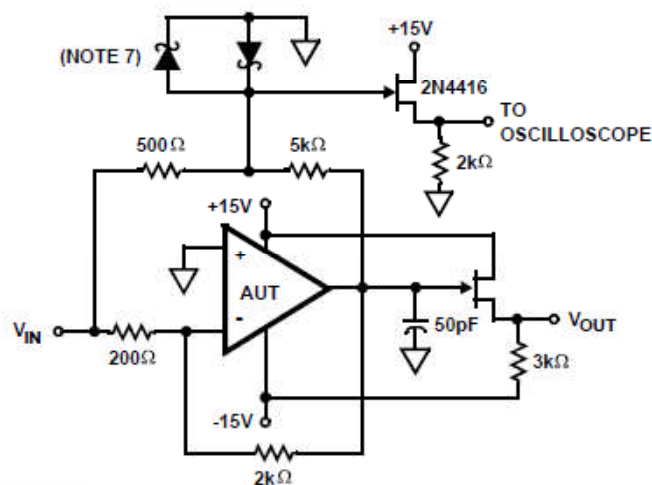
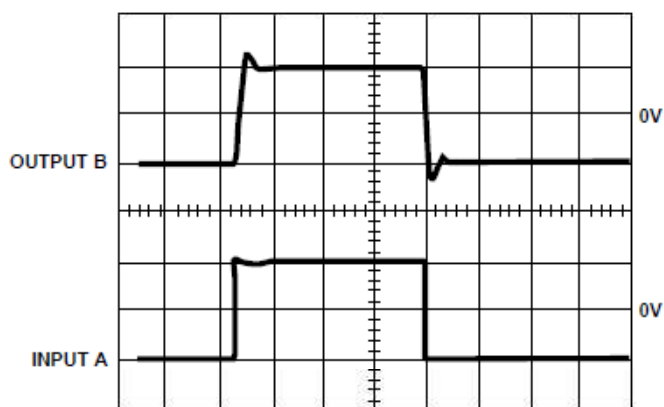
**Test Circuits and Waveforms**

FIGURE 1. LARGE AND SMALL SIGNAL RESPONSE TEST CIRCUIT

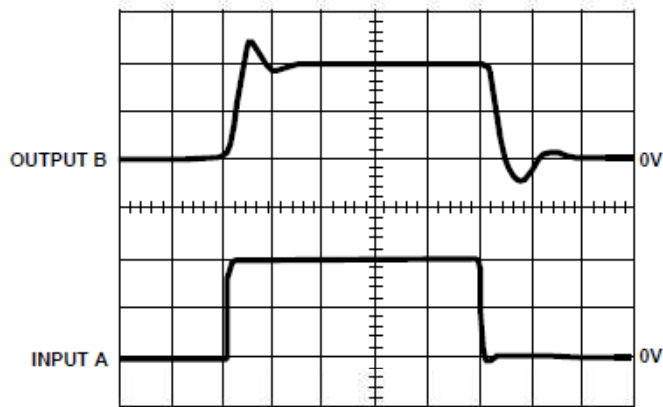
**NOTES:**

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

FIGURE 2. SETTLING TIME TEST CIRCUIT



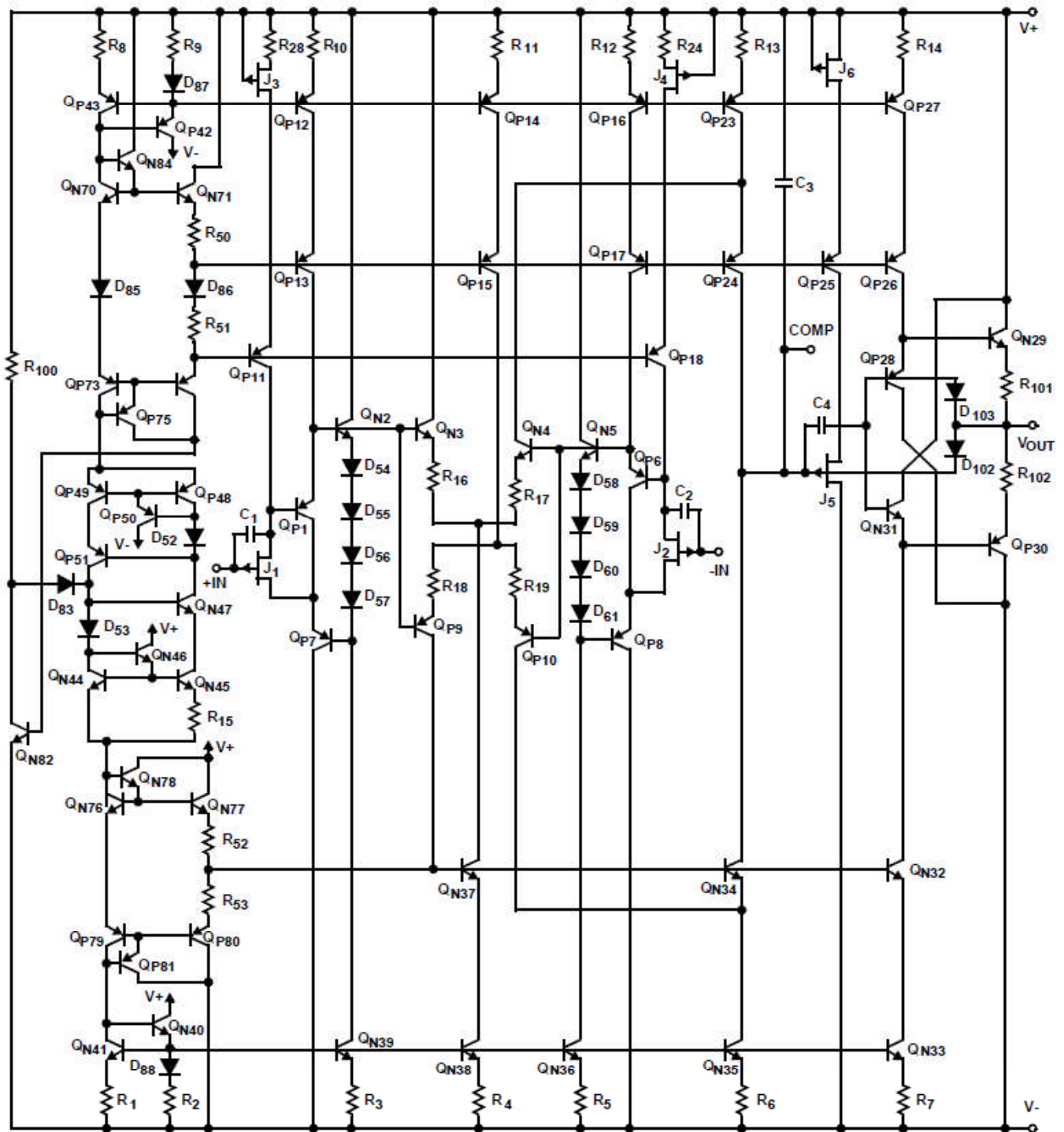
Vertical Scale: A = 0.5V/Div., B = 5V/Div.  
Horizontal Scale: 500ns/Div.

**LARGE SIGNAL RESPONSE**

Vertical Scale: A = 10mV/Div., B = 100mV/Div.  
Horizontal Scale: 100ns/Div.

**SMALL SIGNAL RESPONSE**

## Schematic Diagram



## Application Information

### Power Supply Decoupling

Although not absolutely necessary, it is recommended that all power supply lines be decoupled with  $0.01\mu\text{F}$  ceramic capacitors to ground. Decoupling capacitors should be located as near to the amplifier terminals as possible.

### Stability

The phase margin of the HA-5160 will be improved by connecting a small capacitor ( $>10\text{pF}$ ) between the output

and the inverting input of the device. This small capacitor compensates for the input capacitance of the FET.

### Capacitive Loads

When driving large capacitive loads ( $>100\text{pF}$ ), it is suggested that a small resistor ( $\approx 100\Omega$ ) be connected in series with the output of the device and inside the feedback loop.

### Power Supply Minimum

The absolute supply minimum is  $\pm 6\text{V}$  and the safe level is  $\pm 7\text{V}$ .

## Typical Applications

SUGGESTED COMPENSATION FOR UNITY GAIN STABILITY (NOTE)

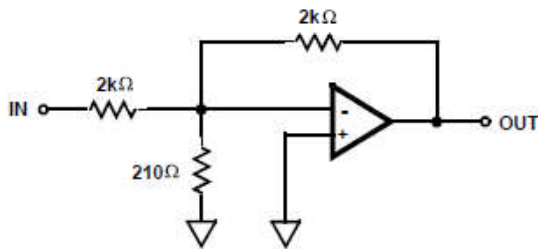
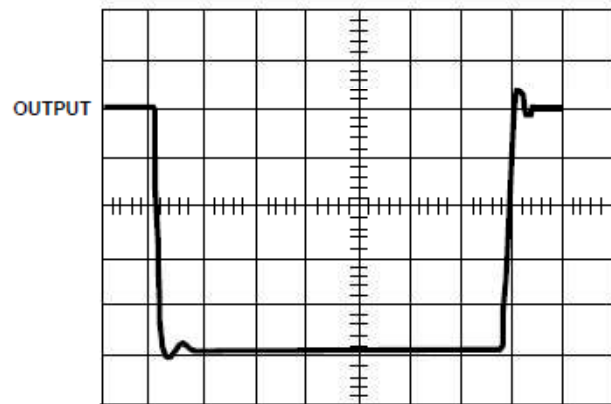


FIGURE 3A. INVERTING UNITY GAIN CIRCUIT



Vertical Scale: 2V/Div.  
Horizontal Scale: 500ns/Div.

FIGURE 3B. INVERTING UNITY GAIN PULSE RESPONSE

FIGURE 3. GAIN OF -1

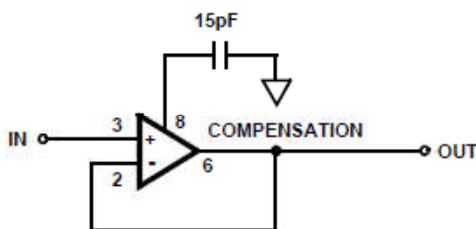
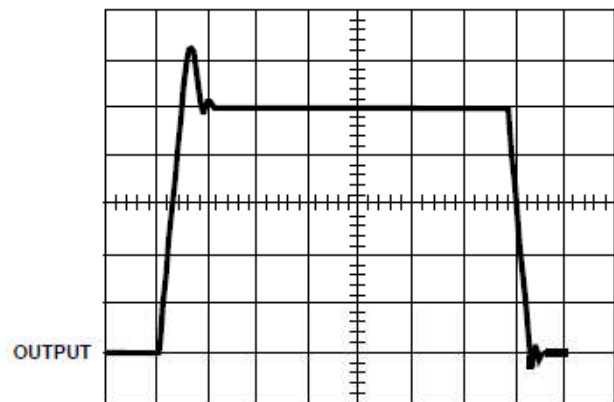


FIGURE 4A. NONINVERTING UNITY GAIN CIRCUIT



Vertical Scale: 2V/Div.  
Horizontal Scale: 500ns/Div.

FIGURE 4B. NONINVERTING UNITY GAIN PULSE RESPONSE

FIGURE 4. GAIN OF +1

NOTE: Values were determined experimentally for optimum speed and settling time.



## Typical Performance Curves

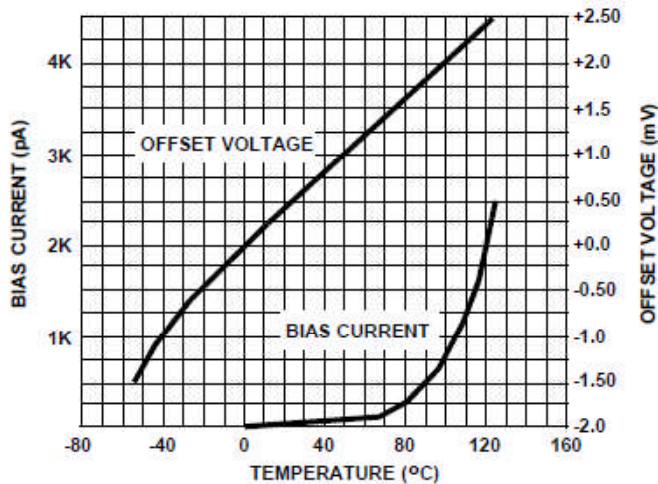


FIGURE 5. INPUT OFFSET VOLTAGE AND BIAS CURRENT vs TEMPERATURE

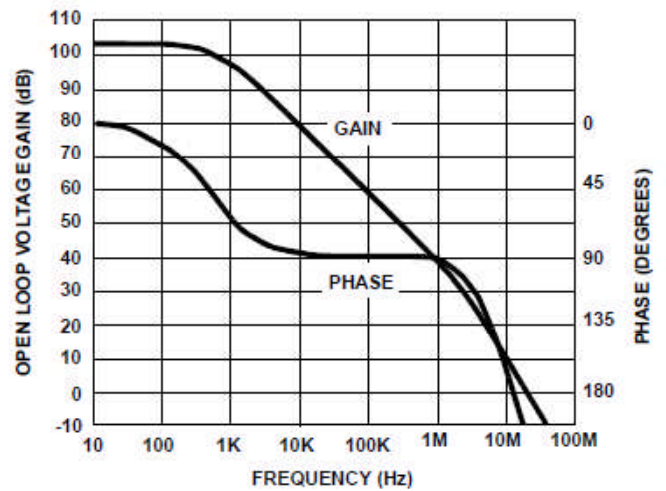


FIGURE 6. OPEN LOOP FREQUENCY RESPONSE

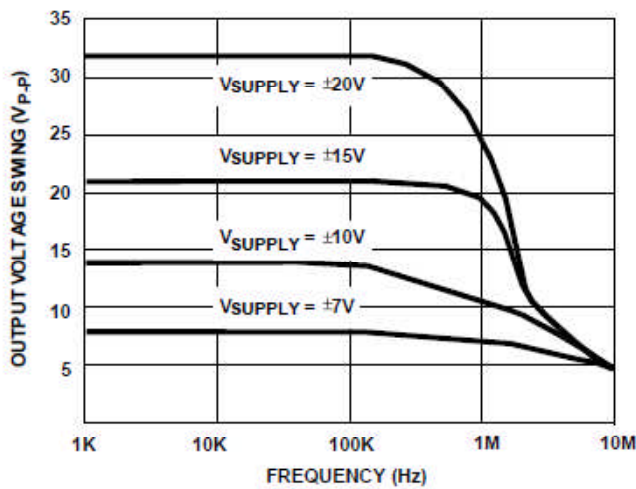


FIGURE 7. OUTPUT VOLTAGE SWING vs FREQUENCY

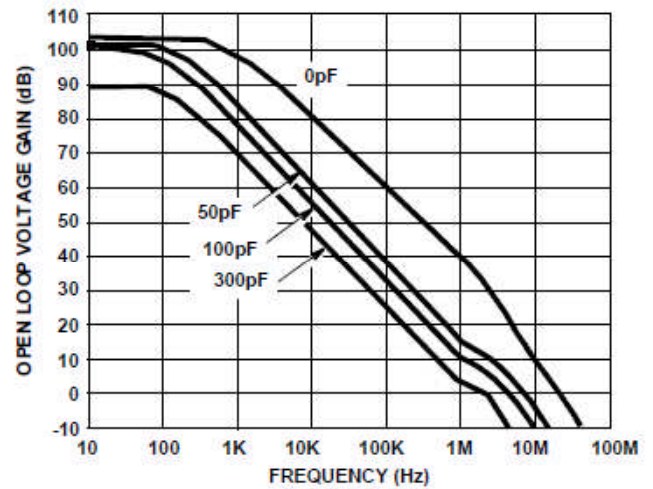


FIGURE 8. OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS COMPENSATION CAPACITANCES

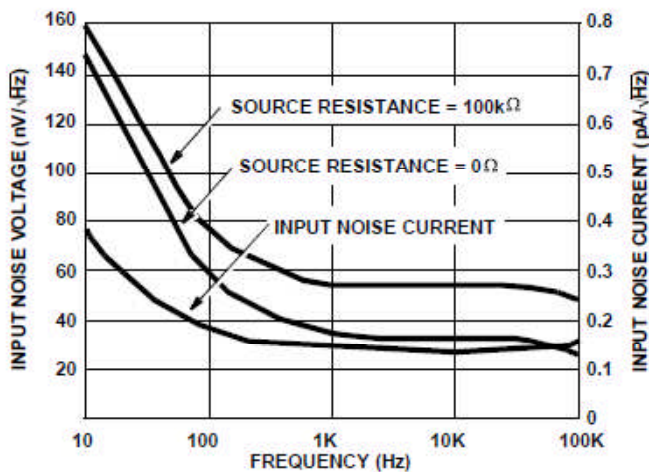


FIGURE 9. INPUT NOISE VOLTAGE AND NOISE CURRENT vs FREQUENCY

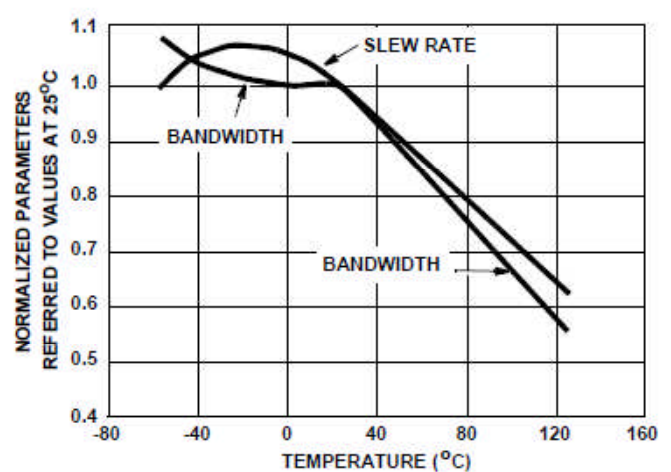


FIGURE 10. NORMALIZED AC PARAMETERS vs TEMPERATURE

# Typical Performance Curves (Continued)

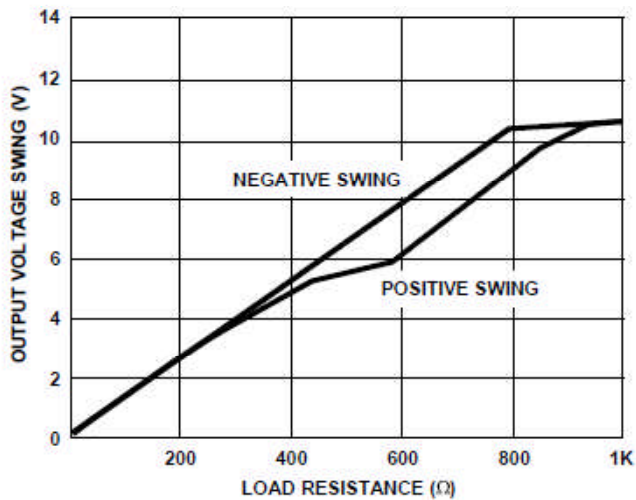


FIGURE 11. OUTPUT VOLTAGE SWING vs LOAD RESISTANCE

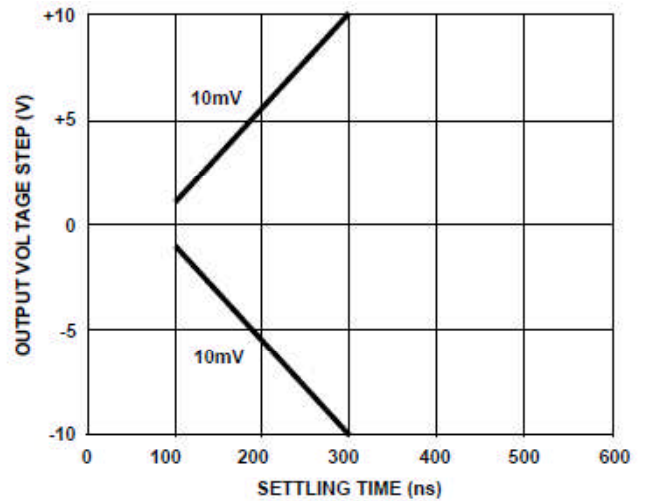


FIGURE 12. SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES

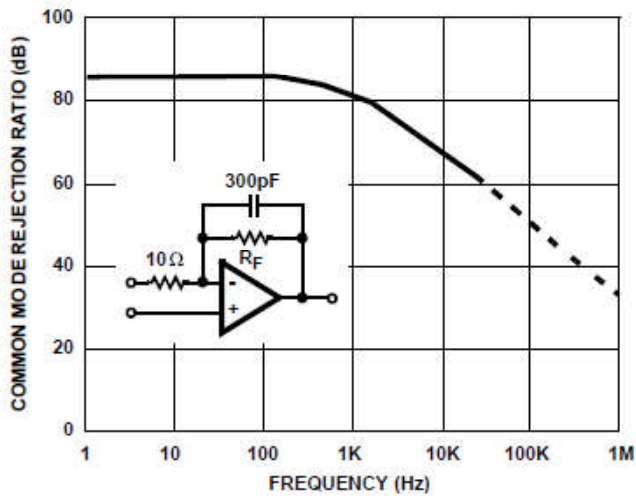


FIGURE 13. COMMON MODE REJECTION RATIO vs FREQUENCY

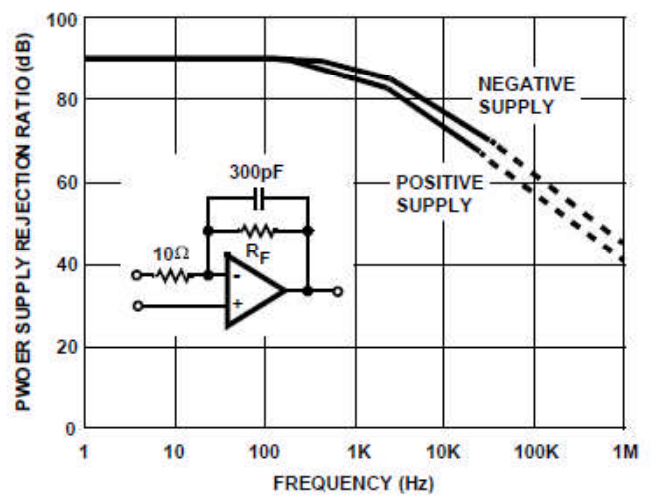


FIGURE 14. POWER SUPPLY REJECTION RATIO vs FREQUENCY

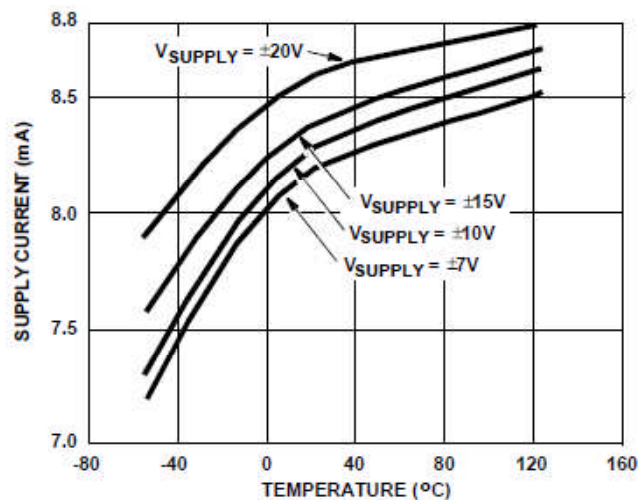
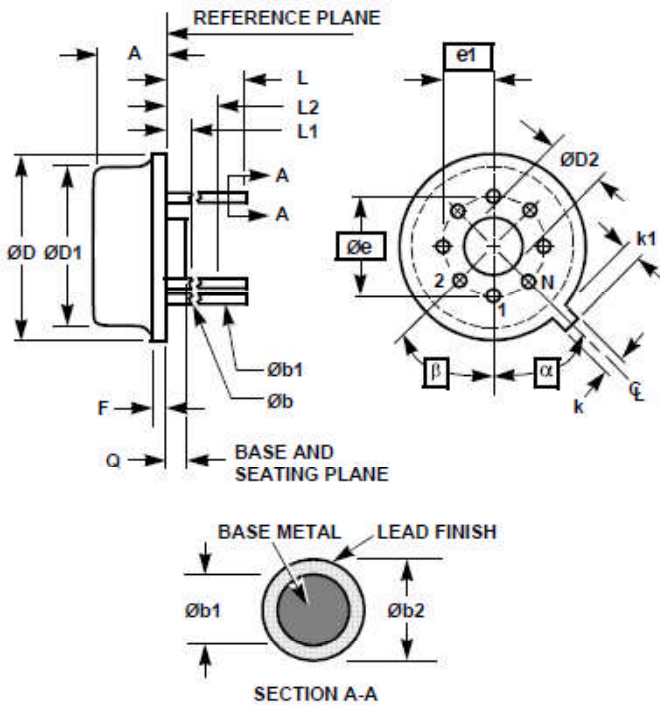


FIGURE 15. POWER SUPPLY CURRENT vs TEMPERATURE



## Metal Can Packages (Can)



### NOTES:

1. (All leads)  $\varnothing b$  applies between  $L1$  and  $L2$ .  $\varnothing b1$  applies between  $L2$  and 0.500 from the reference plane. Diameter is uncontrolled in  $L1$  and beyond 0.500 from the reference plane.
2. Measured from maximum diameter of the product.
3.  $\alpha$  is the basic spacing from the centerline of the tab to terminal 1 and  $\beta$  is the basic spacing of each lead or lead position ( $N - 1$  places) from  $\alpha$ , looking at the bottom of the package.
4.  $N$  is the maximum number of terminal positions.
5. Dimensioning and tolerancing per ANSI Y14.5M - 1982.
6. Controlling dimension: INCH.

### 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	-
$\varnothing b$	0.016	0.019	0.41	0.48	1
$\varnothing b1$	0.016	0.021	0.41	0.53	1
$\varnothing b2$	0.016	0.024	0.41	0.61	-
$\varnothing D$	0.335	0.375	8.51	9.40	-
$\varnothing D1$	0.305	0.335	7.75	8.51	-
$\varnothing D2$	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	-
$\alpha$	45° BSC		45° BSC		3
$\beta$	45° BSC		45° BSC		3
N	8		8		4

Rev. 0 5/18/94

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