

November 1996

## 2.5MHz, Precision Operational Amplifiers

### Features

- Low Offset Voltage..... **25 $\mu$ V (Max)**
- Low Offset Voltage Drift ..... **0.4 $\mu$ V/ $^{\circ}$ C**
- Low Noise..... **9nV/ $\sqrt{\text{Hz}}$**
- Open Loop Gain..... **140dB**
- Unity Gain Bandwidth ..... **2.5MHz**
- All Bipolar Construction

### Applications

- High Gain Instrumentation
- Precision Data Acquisition
- Precision Integrators
- Biomedical Amplifiers
- Precision Threshold Detectors

### Ordering Information

PART NUMBER	TEMP. RANGE ( $^{\circ}$ C)	PACKAGE	PKG. NO.
HA2-5130-5	0 to 75	8 Pin Metal Can	T8.C
HA2-5135-5	0 to 75	8 Pin Metal Can	T8.C
HA7-5130-2	-55 to 125	8 Ld CERDIP	F8.3A
HA7-5130-5	0 to 75	8 Ld CERDIP	F8.3A
HA7-5135-2	-55 to 125	8 Ld CERDIP	E8.3A
HA7-5135-5	0 to 75	8 Ld CERDIP	E8.3A

### Description

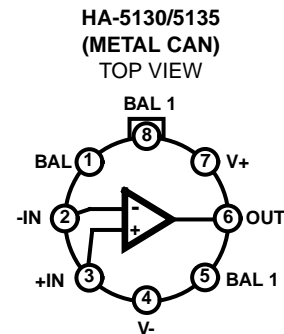
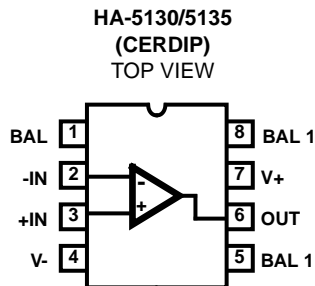
The Harris HA-5130/5135 are precision operational amplifiers manufactured using a combination of key technological advancements to provide outstanding input characteristics.

A Super Beta input stage is combined with laser trimming, dielectric isolation and matching techniques to produce 25 $\mu$ V (Maximum) input offset voltage and 0.4 $\mu$ V/ $^{\circ}$ C input offset voltage average drift. Other features enhanced by this process include 9nV/ $\sqrt{\text{Hz}}$  (Typ.) Input Noise Voltage, 1nA Input Bias Current and 140dB Open Loop Gain.

These features coupled with 120dB CMRR and PSRR make HA-5130/5135 an ideal device for precision DC instrumentation amplifiers. Excellent input characteristics in conjunction with 2.5MHz bandwidth and 0.8V/ $\mu$ s slew rate, make this amplifier extremely useful for precision integrator and biomedical amplifier designs. These amplifiers are also well suited for precision data acquisition and for accurate threshold detector applications.

HA-5130/5135 offers added features over the industry standard OP-07 in regards to bandwidth and slew rate specifications. For the military grade product, refer to the HA-5135/883 data sheet.

### Pinouts



NOTE: Both BAL 1 pins are connected together internally.

# HA-5130, HA-5135

## Absolute Maximum Ratings

Voltage Between V+ and V- Terminals .....	40V
Differential Input Voltage.....	7V
Output Short Circuit Duration.....	Indefinite

## Thermal Information

Thermal Resistance (Typical, Note 2)	$\theta_{JA}$ (°C/W)	$\theta_{JC}$ (°C/W)
CERDIP Package .....	135	50
Metal Can Package .....	165	80
Maximum Junction Temperature (Note 1) .....	175°C	
Maximum Storage Temperature Range .....	-65°C to 150°C	
Maximum Lead Temperature (Soldering 10s).....	300°C	

## Operating Conditions

Temperature Ranges	
HA-5130/5135-2 .....	-55°C to 125°C
HA-5130/5135-5 .....	0°C to 75°C

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:

1. Maximum power dissipation, including output load, must be designed to maintain the maximum junction temperature below 175°C.
2.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

## Electrical Specifications $V_{SUPPLY} = \pm 15V$

PARAMETER	TEST CONDITIONS	TEMP. (°C)	HA-5130-2/-5			HA-5135-2/-5			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
<b>INPUT CHARACTERISTICS</b>									
Offset Voltage		25	-	10	25	-	10	75	$\mu V$
		Full	-	50	60	-	50	130	$\mu V$
Average Offset Voltage Drift		Full	-	0.4	0.6	-	0.4	1.3	$\mu V/^\circ C$
Bias Current		25	-	$\pm 1$	$\pm 2$	-	$\pm 1$	$\pm 4$	nA
		Full	-	-	$\pm 4$	-	-	$\pm 6$	nA
Bias Current Average Drift		Full	-	0.02	0.04	-	0.02	0.04	nA/°C
Offset Current		25	-	-	2	-	-	4	nA
		Full	-	-	4	-	-	5.5	nA
Offset Current Average Drift		Full	-	0.02	0.04	-	0.02	0.04	nA/°C
Common Mode Range		Full	$\pm 12$	-	-	$\pm 12$	-	-	V
Differential Input Resistance		25	20	30	-	20	30	-	M $\Omega$
Input Noise Voltage (Note 3)	0.1Hz to 10Hz	25	-	-	0.6	-	-	0.6	$\mu V_{P-P}$
Input Noise Voltage Density (Note 3)	f = 10Hz	25	-	13.0	18.0	-	13.0	18.0	nV/ $\sqrt{Hz}$
	f = 100Hz		-	10.0	13.0	-	10.0	13.0	nV/ $\sqrt{Hz}$
	f = 1000Hz		-	9.0	11.0	-	9.0	11.0	nV/ $\sqrt{Hz}$
Input Noise Current (Note 3)	0.1Hz to 10Hz	25	-	15	30	-	15	30	pA $_{P-P}$
Input Noise Current Density (Note 3)	f = 10Hz	25	-	0.4	0.8	-	0.4	0.8	pA/ $\sqrt{Hz}$
	f = 100Hz		-	0.17	0.23	-	0.17	0.23	pA/ $\sqrt{Hz}$
	f = 1000Hz		-	0.14	0.17	-	0.14	0.17	pA/ $\sqrt{Hz}$
<b>TRANSFER CHARACTERISTICS</b>									
Large Signal Voltage Gain	$V_{OUT} = \pm 10V, R_L = 2k\Omega$	25	120	140	-	120	140	-	dB
		Full	120	-	-	120	-	-	dB
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	Full	110	120	-	106	120	-	dB
Closed Loop Bandwidth	$A_{VCL} = +1$	25	0.6	2.5	-	0.6	2.5	-	MHz

# HA-5130, HA-5135

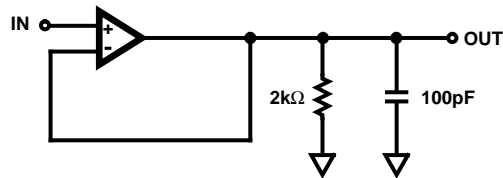
## Electrical Specifications $V_{SUPPLY} = \pm 15V$ (Continued)

PARAMETER	TEST CONDITIONS	TEMP. (°C)	HA-5130-2/-5			HA-5135-2/-5			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
<b>OUTPUT CHARACTERISTICS</b>									
Output Voltage Swing	$R_L = 600\Omega$	25	$\pm 10$	$\pm 12$	-	$\pm 10$	$\pm 12$	-	V
		Full	$\pm 10$	-	-	$\pm 10$	-	-	V
Full Power Bandwidth (Note 4)	$R_L = 2k\Omega$	25	8	10	-	8	10	-	kHz
Output Current	$V_{OUT} = 10V$	25	$\pm 15$	$\pm 20$	-	$\pm 15$	$\pm 20$	-	mA
Output Resistance	Note 5	25	-	45	-	-	45	-	$\Omega$
<b>TRANSIENT RESPONSE (Note 6)</b>									
Rise Time		25	-	340	-	-	340	-	ns
Slew Rate		25	0.5	0.8	-	0.5	0.8	-	V/ $\mu$ s
Settling Time (Note 7)		25	-	11	-	-	11	-	$\mu$ s
<b>POWER SUPPLY CHARACTERISTICS</b>									
Supply Current		Full	-	1.0	1.7	-	1.0	1.7	mA
Power Supply Rejection Ratio	$V_S = \pm 5V$ to $\pm 20V$	Full	100	130	-	94	130	-	dB

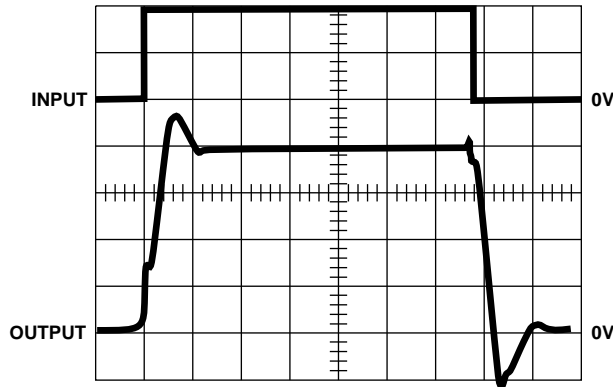
**NOTES:**

3. Not tested. 90% of units meet or exceed these specifications.
4. Full power bandwidth guaranteed based on slew rate measurement using:  $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$ .
5. Output resistance measured under open loop conditions ( $f = 100\text{Hz}$ ).
6. Refer to test circuits section of the data sheet.
7. Settling time is measured to 0.1% of final value for a 10V output step and  $A_V = -1$ .

### Test Circuits and Waveforms

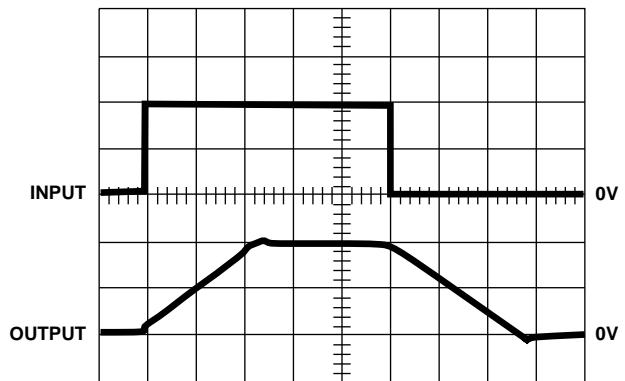


**FIGURE 1. SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT**



Vertical Scale: Input = 50mV/Div. Output = 100mV/Div.  
Horizontal Scale: 1 $\mu$ s/Div.

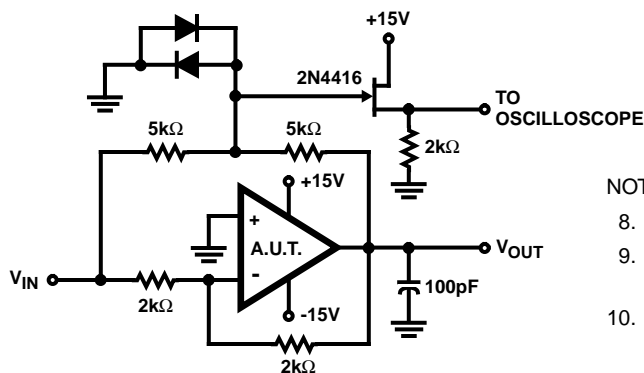
**SMALL SIGNAL RESPONSE**



Vertical Scale: 5V/Div.  
Horizontal Scale: 5 $\mu$ s/Div.

**LARGE SIGNAL RESPONSE**

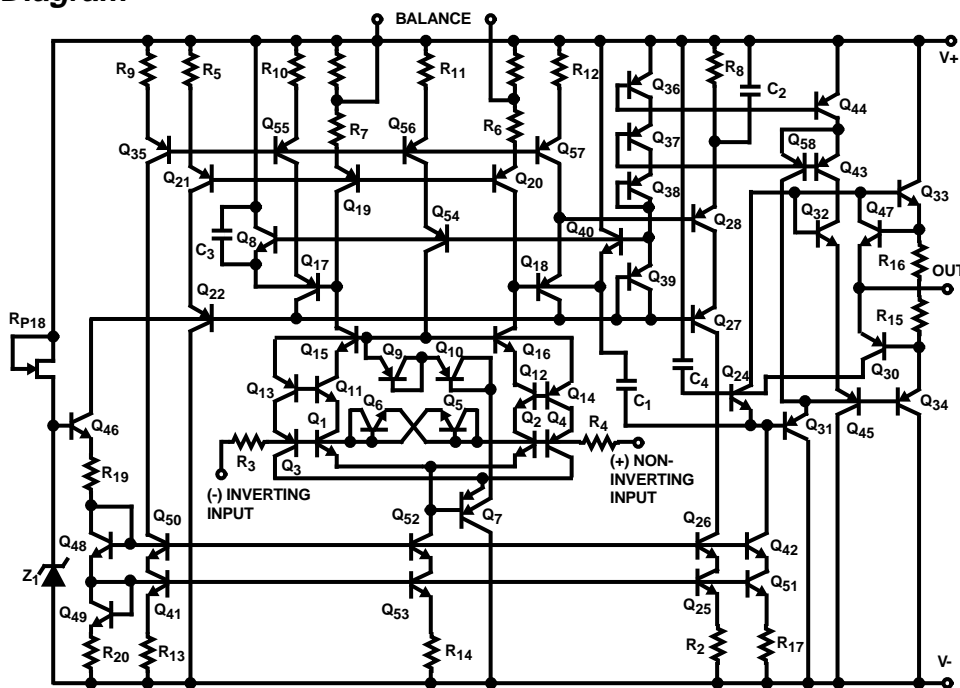
Test Circuits and Waveforms (Continued)



- NOTES:
8.  $A_V = -1$ .
  9. Feedback and summing resistors should be 0.1% matched.
  10. Clipping diodes are optional. HP5082-2810 recommended.

FIGURE 2. SETTLING TIME CIRCUIT

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.

Considerations For Prototyping:

The following list of recommendations are suggested for prototyping.

1. Resolving low level signals requires minimizing leakage currents caused by external circuitry. Use of quality insulating materials, thorough cleaning of insulating surfaces and implementation of moisture barriers when required is suggested.
2. Error voltages generated by thermocouples formed between dissimilar metals in the presence of temperature gradients

should be minimized. Isolation of low level circuitry from heat generating components is recommended.

3. Shielded cable input leads, guard rings and shield drivers are recommended for the most critical applications.

Large Capacitive Loads

When driving large capacitive loads ( $>500\text{pF}$ ), a small value resistor ( $\approx 50\Omega$ ) should be connected in series with the output and inside the feedback loop.

Offset Voltage Adjustment (See Figure 3)

A  $20\text{k}\Omega$  balance potentiometer is recommended if offset nulling is required. However, other potentiometer values such as  $10\text{k}\Omega$ ,  $50\text{k}\Omega$  and  $100\text{k}\Omega$  may be used. The minimum adjustment range for given values is  $\pm 2\text{mV}$ .  $V_{OS}$  TC of the amplifier is optimized at minimal  $V_{OS}$ . Tested Offset Adjustment is  $|V_{OS} + 1\text{mV}|$  minimum referred to output.

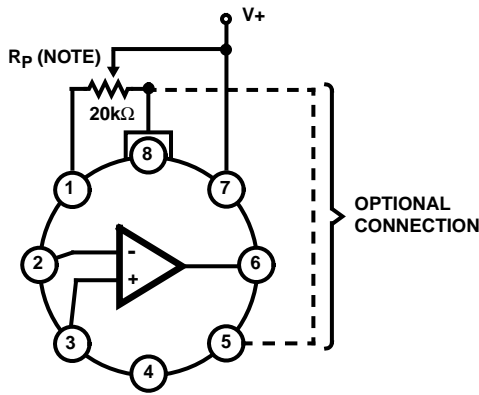


FIGURE 3. OFFSET NULLING CONNECTIONS

**Saturation Recovery**

Input and output saturation recovery time is negligible in most applications. However, care should be exercised to avoid exceeding the absolute maximum ratings of the device.

**Differential Input Voltages**

Inputs are shunted with back-to-back diodes for overvoltage protection. In applications where differential input voltages in excess of 1V are applied between the inputs, the use of limiting resistors at the inputs is recommended.

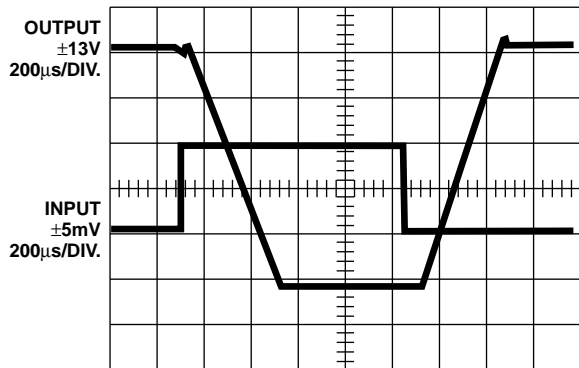


FIGURE 5. ZERO CROSSING DETECTOR

**Typical Applications**

The excellent input and gain characteristics of HA-5130 are well suited for precision integrator applications. Accurate integration over seven decades of frequency using HA-5130, virtually nullifies the need for more expensive chopper-type amplifiers.

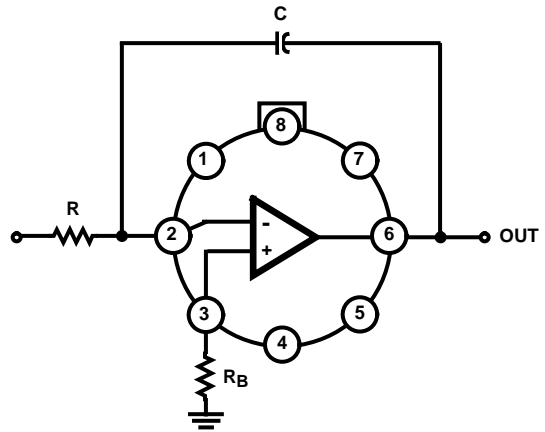


FIGURE 4. PRECISION INTEGRATOR

Low  $V_{OS}$  coupled with high open loop Gain, high CMRR and high PSRR make HA-5130 ideally suited for precision detector applications, such as the zero crossing detector shown in Figure 5.

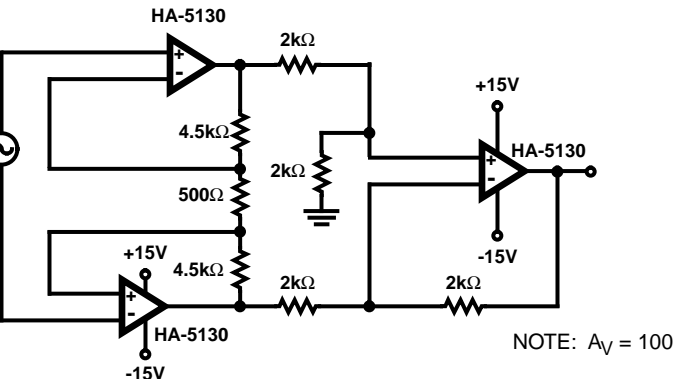
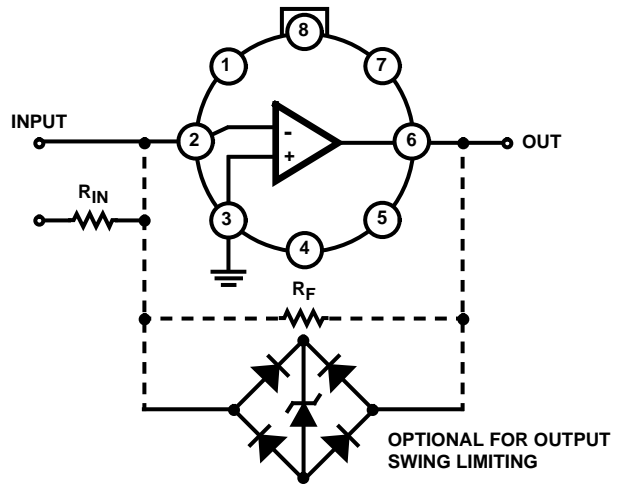


FIGURE 6. PRECISION INSTRUMENTATION AMPLIFIER

NOTE:  $A_V = 100$

Typical Performance Curves

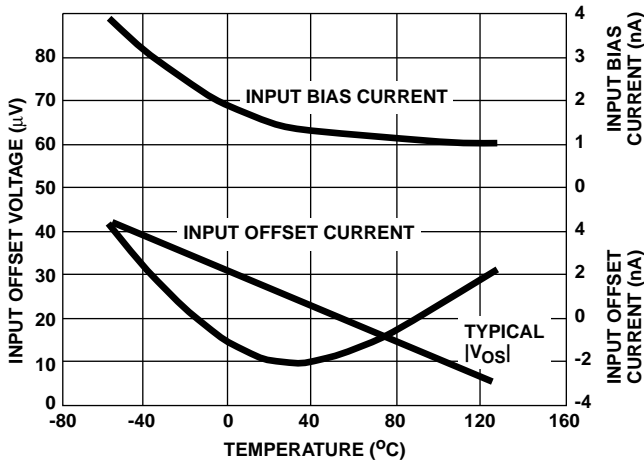


FIGURE 7. INPUT OFFSET VOLTAGE, INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE

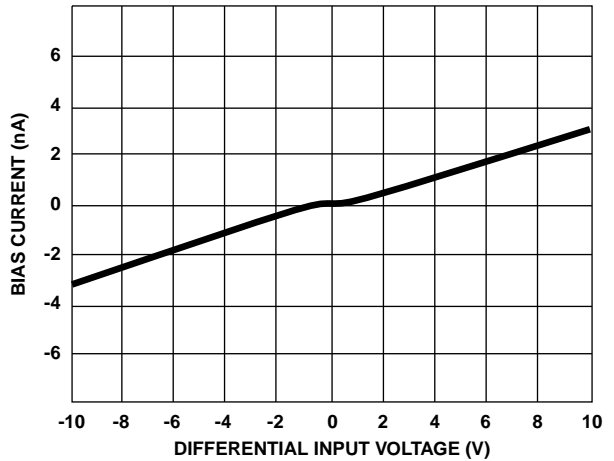


FIGURE 8. INPUT BIAS CURRENT vs DIFFERENTIAL INPUT VOLTAGE

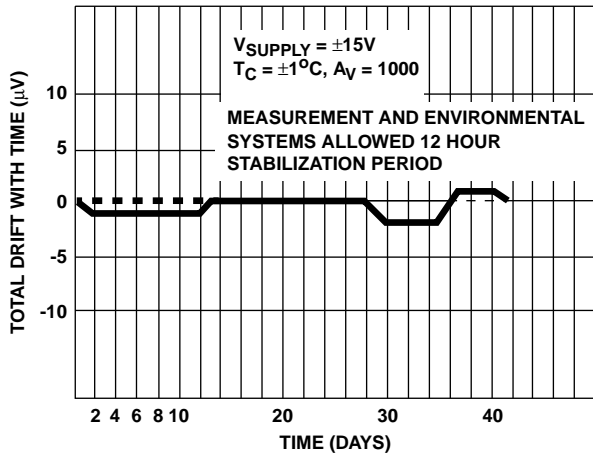


FIGURE 9. HA-5130 OFFSET VOLTAGE STABILITY vs TIME

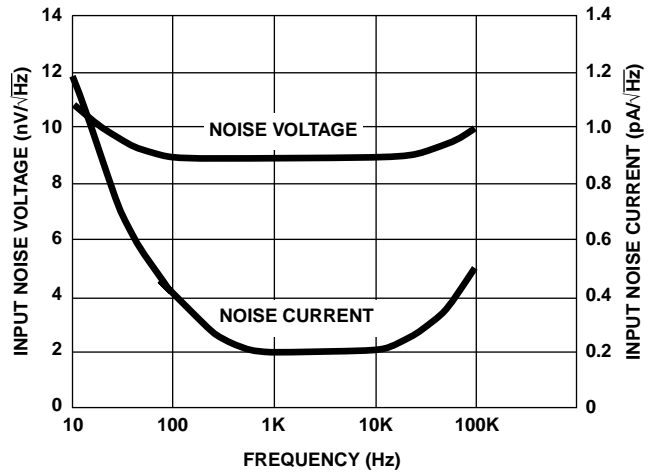


FIGURE 10. INPUT NOISE vs FREQUENCY

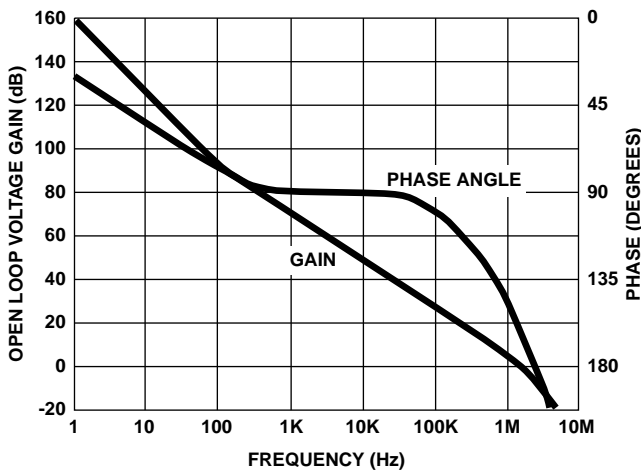


FIGURE 11. OPEN LOOP FREQUENCY RESPONSE

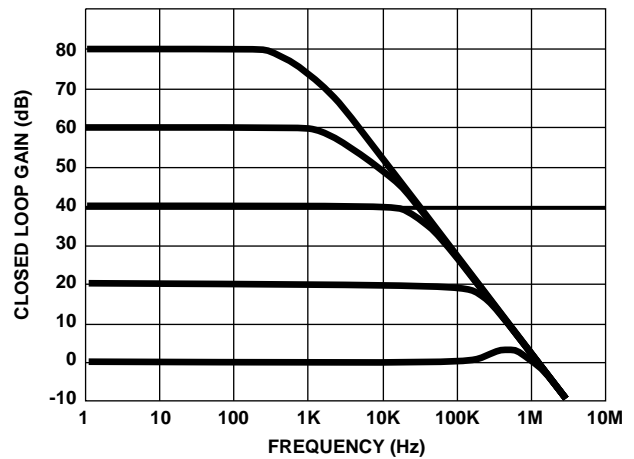


FIGURE 12. CLOSED LOOP FREQUENCY RESPONSE

Typical Performance Curves (Continued)

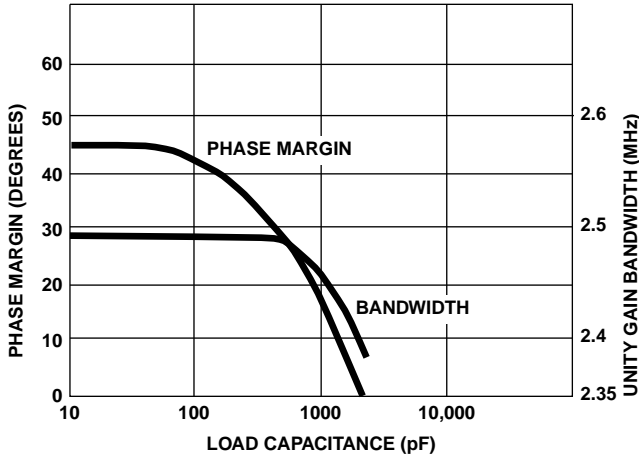


FIGURE 13. SMALL SIGNAL BANDWIDTH AND PHASE MARGIN vs LOAD CAPACITANCE

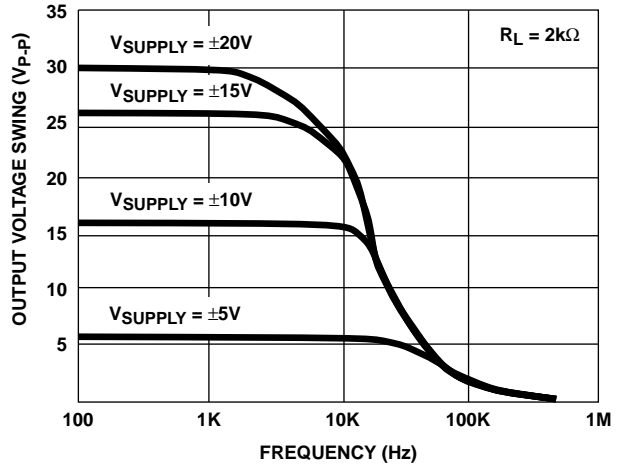


FIGURE 14. OUTPUT VOLTAGE SWING vs FREQUENCY

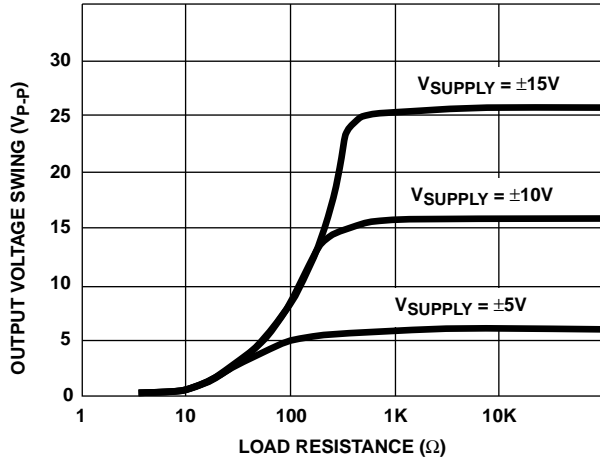


FIGURE 15. MAXIMUM OUTPUT VOLTAGE SWING vs LOAD RESISTANCE

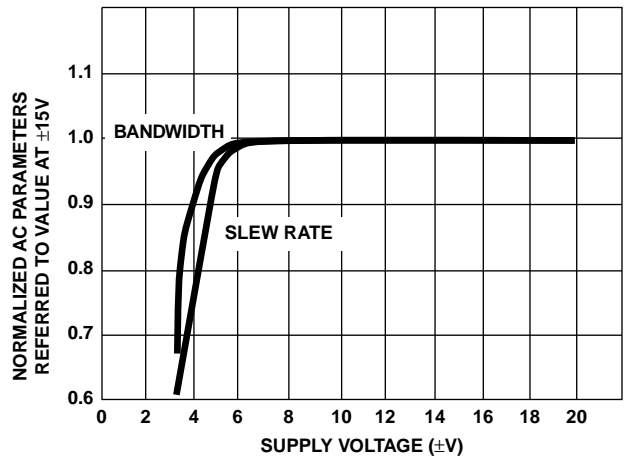


FIGURE 16. NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE

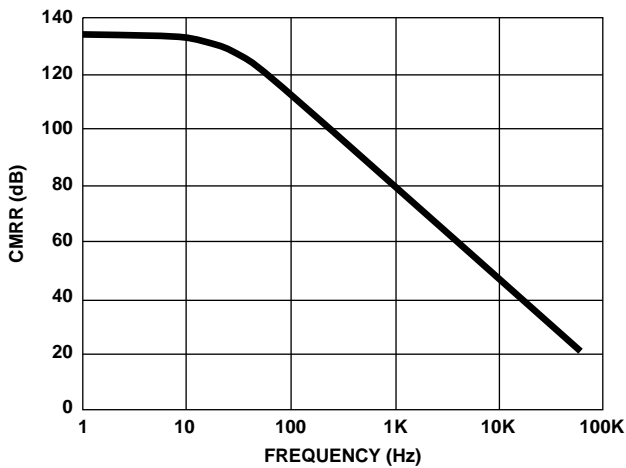


FIGURE 17. CMRR vs FREQUENCY

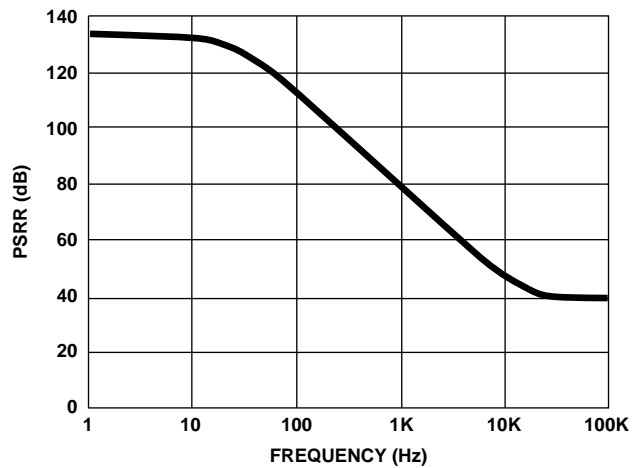


FIGURE 18. PSRR vs FREQUENCY

Typical Performance Curves (Continued)

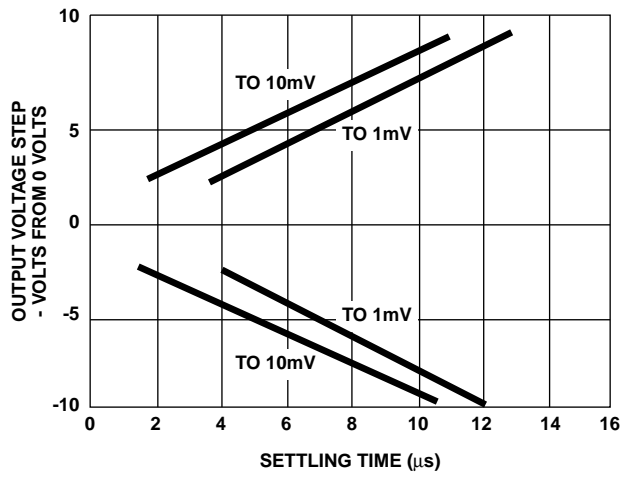


FIGURE 19. SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES

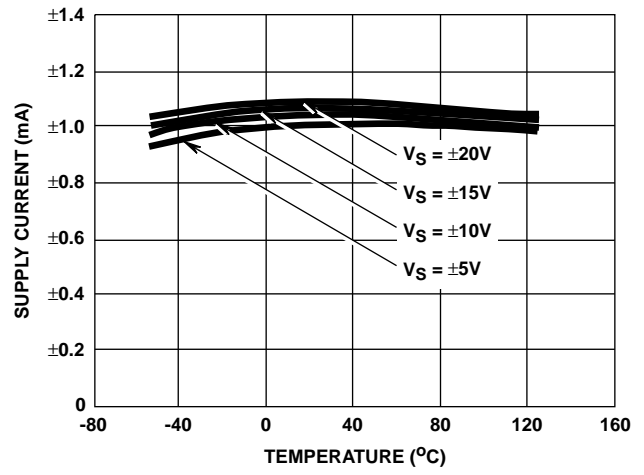


FIGURE 20. POWER SUPPLY CURRENT vs TEMPERATURE



## HA-5130, HA-5135

### Die Characteristics

#### DIE DIMENSIONS:

72 mils x 103 mils x 19 mils  
(1840 $\mu$ m x 2620 $\mu$ m x 483 $\mu$ m)

#### METALLIZATION:

Type: Al, 1% Cu  
Thickness: 16k $\text{\AA}$   $\pm$  2k $\text{\AA}$

#### SUBSTRATE POTENTIAL (Powered Up):

V-

#### PASSIVATION:

Type: Nitride (Si<sub>3</sub>N<sub>4</sub>) over Silox (SiO<sub>2</sub>, 5% Phos.)  
Silox Thickness: 12k $\text{\AA}$   $\pm$  2k $\text{\AA}$   
Nitride Thickness: 3.5k $\text{\AA}$   $\pm$  1.5k $\text{\AA}$

#### TRANSISTOR COUNT:

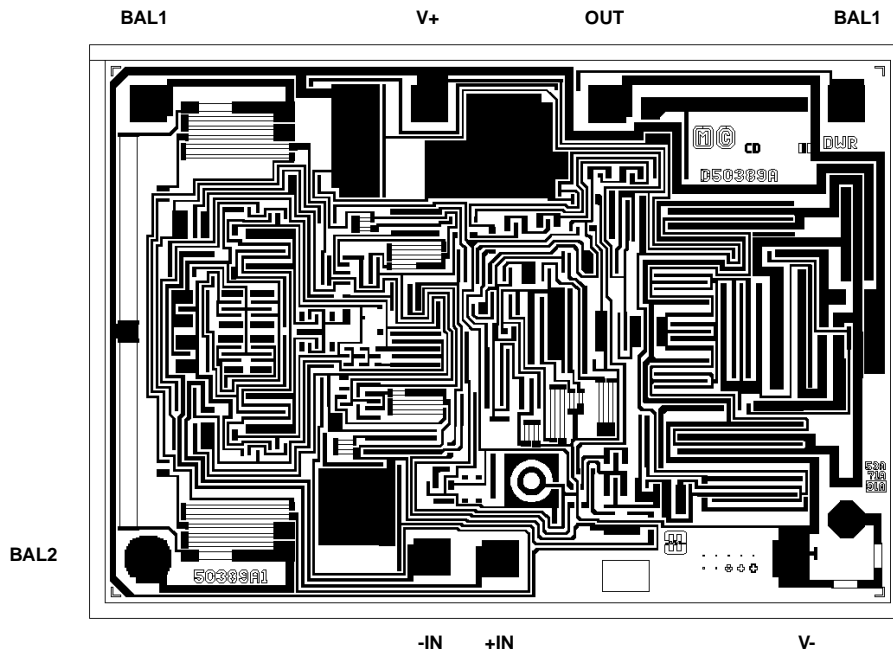
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#### PROCESS:

Bipolar Dielectric Isolation

### Metallization Mask Layout

HA-5130, HA-5135



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#### EUROPE

Harris Semiconductor  
Mercure Center  
100, Rue de la Fusee  
1130 Brussels, Belgium  
TEL: (32) 2.724.2111  
FAX: (32) 2.724.22.05

#### ASIA

Harris Semiconductor PTE Ltd.  
No. 1 Tannery Road  
Cencon 1, #09-01  
Singapore 1334  
TEL: (65) 748-4200  
FAX: (65) 748-0400

