

**OBSOLETE PRODUCT  
POSSIBLE SUBSTITUTE PRODUCT  
HA-5104**

**4MHz, Precision, Quad Operational Amplifier**

The HA-5134 is a precision quad operational amplifier that is pin compatible with the OP-400, LT1014, OP11, RM4156, and LM148 as well as the HA-4741. Each amplifier features guaranteed maximum values for offset voltage of 200μV, offset voltage drift of 2μV/°C, and offset current of 75nA over the full temperature range while CMRR/PSRR is guaranteed greater than 94dB and A<sub>VOL</sub> is guaranteed above 500kV/V over the full temperature range.

Precision performance of the HA-5134 is enhanced by a noise voltage density of 7nV/√Hz at 1kHz, noise current density of 1pA/√Hz at 1kHz and channel separation of 120dB. Each unity-gain stable quad amplifier is fabricated using the dielectric isolation process to assure performance in the most demanding applications.

The HA-5134 is ideal for compact circuits such as instrumentation amplifiers, state-variable filters, and low-level transducer amplifiers. Other applications include precision data acquisition, precision integrators, and accurate threshold detectors in designs where board space is a limitation.

For military grade product, refer to the HA-5134/883 data sheet.

**Part Number Information**

PART NUMBER	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
HA1-5134-5	0 to 75	14 Ld CERDIP	F14.3

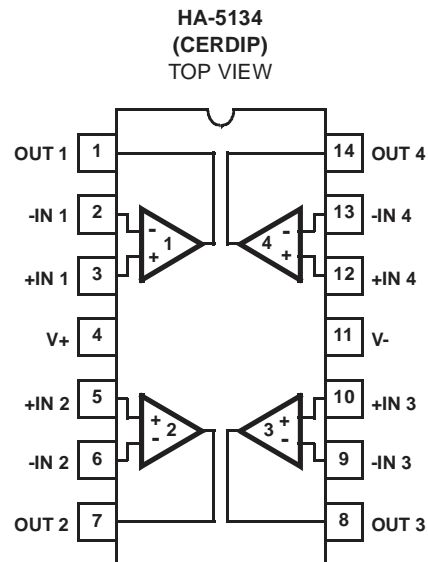
**Features**

- Low Offset Voltage . . . . . 200μV (Max)
- Low Offset Voltage Drift . . . . . 2μV/°C (Max)
- High Channel Separation . . . . . 120dB
- Low Noise . . . . . 7nV/√Hz
- Unity Gain Bandwidth. . . . . 4MHz
- High CMRR/PSRR . . . . . 120dB (Typ)

**Applications**

- Instrumentation Amplifiers
- State-Variable Filters
- Precision Integrators
- Threshold Detectors
- Precision Data Acquisition Systems
- Low-Level Transducer Amplifiers

**Pinout**



**Absolute Maximum Ratings**

Voltage Between V+ and V- Terminals . . . . . 40V  
 Differential Input Voltage (Note 2) . . . . . 6V  
 Output Current . . . . . Full Short Circuit Protection

**Thermal Information**

Thermal Resistance (Typical, Note 1)  $\theta_{JA}$  (°C/W)  $\theta_{JC}$  (°C/W)  
 CERDIP Package . . . . . 80 30  
 Maximum Junction Temperature (Note 3) . . . . . 175°C  
 Maximum Storage Temperature Range . . . . . -65°C to 150°C  
 Maximum Lead Temperature (Soldering 10s) . . . . . 300°C

**Operating Conditions**

Temperature Range  
 HA-5134-5 . . . . . 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.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.
2. For differential input voltages greater than 6V, the input current must be limited to 25mA to protect the back-to-back input diodes.
3. Maximum power dissipation, including output load, must be designed to maintain the maximum junction temperature below 175°C.

**Electrical Specifications**  $V_{SUPPLY} = \pm 15V, R_L = 2k\Omega, C_L = 50pF, R_S \leq 100\Omega$ , Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP (°C)	HA-5134-5			UNITS
			MIN	TYP	MAX	
<b>INPUT CHARACTERISTICS</b>						
Offset Voltage		25	-	50	200	$\mu V$
		Full	-	75	350	$\mu V$
Average Offset Voltage Drift		Full	-	0.3	2	$\mu V/^\circ C$
Bias Current		25	-	$\pm 10$	$\pm 50$	nA
		Full	-	$\pm 20$	$\pm 75$	nA
Offset Current		25	-	10	50	nA
		Full	-	15	75	nA
Average Offset Current Drift		Full	-	0.05	-	nA/°C
Common Mode Range		Full	$\pm 10$	-	-	V
Differential Input Resistance		25	-	30	-	M $\Omega$
Input Noise Voltage	0.1Hz to 10Hz	25	-	0.2	-	$\mu V_{p-p}$
Input Noise Voltage Density	f = 10Hz	25	-	10	-	nV/ $\sqrt{Hz}$
	f = 100Hz		-	7.5	-	nV/ $\sqrt{Hz}$
	f = 1kHz		-	7	-	nV/ $\sqrt{Hz}$
Input Noise Current Density	f = 10Hz	25	-	3	-	pA/ $\sqrt{Hz}$
	f = 100Hz		-	1.5	-	pA/ $\sqrt{Hz}$
	f = 1kHz		-	1	-	pA/ $\sqrt{Hz}$
<b>TRANSFER CHARACTERISTICS</b>						
Large Signal Voltage Gain	$V_{OUT} = \pm 10V$	25	800	1200	-	kV/V
		Full	500	750	-	kV/V
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	25	100	120	-	dB
		Full	94	115	-	dB
Minimum Stable Gain		25	1	-	-	V/V
Unity-Gain Bandwidth		25	-	4	-	MHz
<b>OUTPUT CHARACTERISTICS</b>						
Output Voltage Swing		Full	12	13.5	-	V
Output Current		25	-	20	-	mA

**Electrical Specifications**  $V_{SUPPLY} = \pm 15V, R_L = 2k\Omega, C_L = 50pF, R_S \leq 100\Omega$ , Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	HA-5134-5			UNITS
			MIN	TYP	MAX	
Full Power Bandwidth (Note 4)		25	12	16	-	kHz
Channel Separation (Note 7)	$V_{OUT} = \pm 10V$	25	120	136	-	dB
<b>TRANSIENT RESPONSE</b> (Note 5)						
Rise Time	$A_V = +1, V_{OUT} = 200mV$	25	-	200	400	ns
Slew Rate	$A_V = +1$	25	0.75	1.0	-	V/ $\mu s$
Overshoot	$A_V = +1$	25	-	20	40	%
Settling Time (Note 6)		25	-	13	-	$\mu s$
<b>POWER SUPPLY CHARACTERISTICS</b>						
Supply Current	All Amps	Full	-	6.5	8	mA
Power Supply Rejection Ratio	$V_S = \pm 5V$ to $\pm 18V$	25	100	120	-	dB
		Full	94	115	-	dB

NOTES:

4. Full power bandwidth guaranteed based on slew rate measurement using:  $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$ ;  $V_{PEAK} = 10V$ .
5. Refer to Test Circuits section of the data sheet.
6. Specified to 0.01% of a 10V step,  $A_V = -1$ .
7. Guaranteed but not tested.

**Test Circuits and Waveforms**

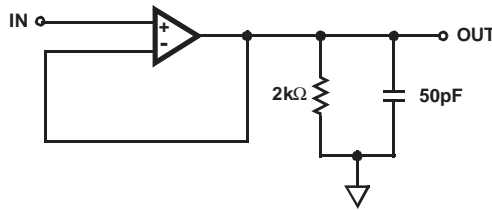
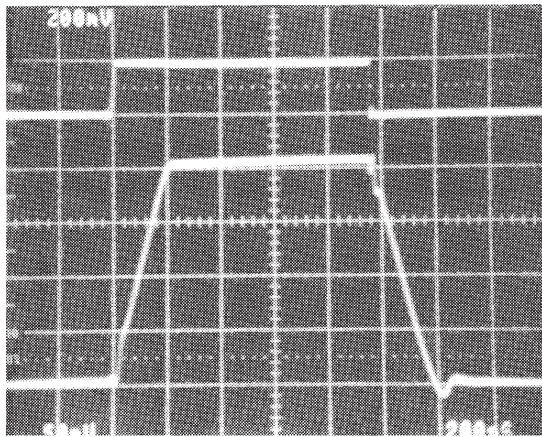
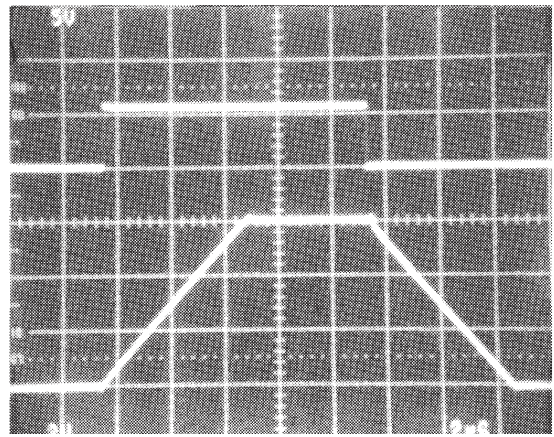


FIGURE 1. SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT



Vertical: 50mV/Div., Horizontal: 200ns/Div.  
 $T_A = 25^\circ C, V_S = \pm 15V, A_V = +1, R_L = 2k\Omega, C_L = 50pF$

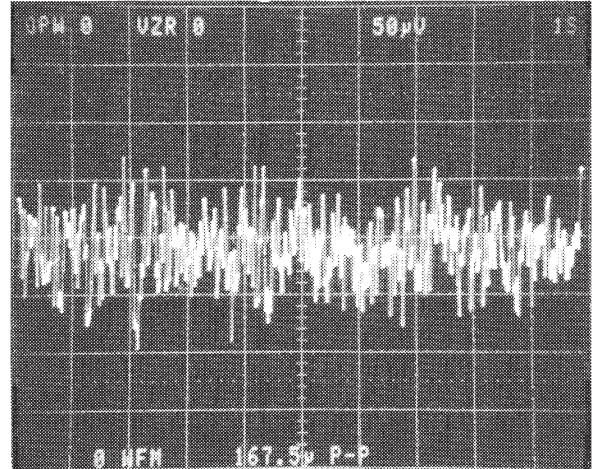
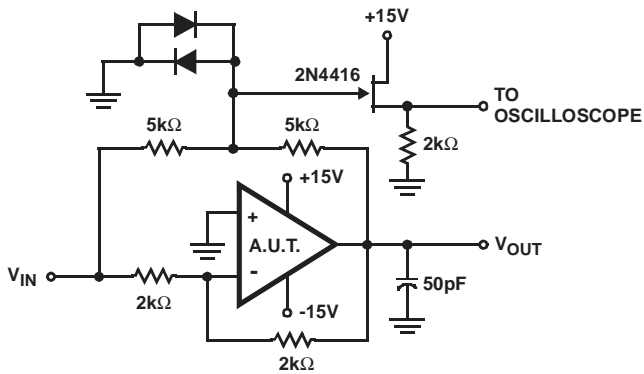
**SMALL SIGNAL RESPONSE**



Vertical: 2V/Div., Horizontal: 2 $\mu s$ /Div.  
 $T_A = 25^\circ C, V_S = \pm 15V, A_V = +1, R_L = 2k\Omega, C_L = 50pF$

**LARGE SIGNAL RESPONSE**

Test Circuits and Waveforms (Continued)



NOTES:

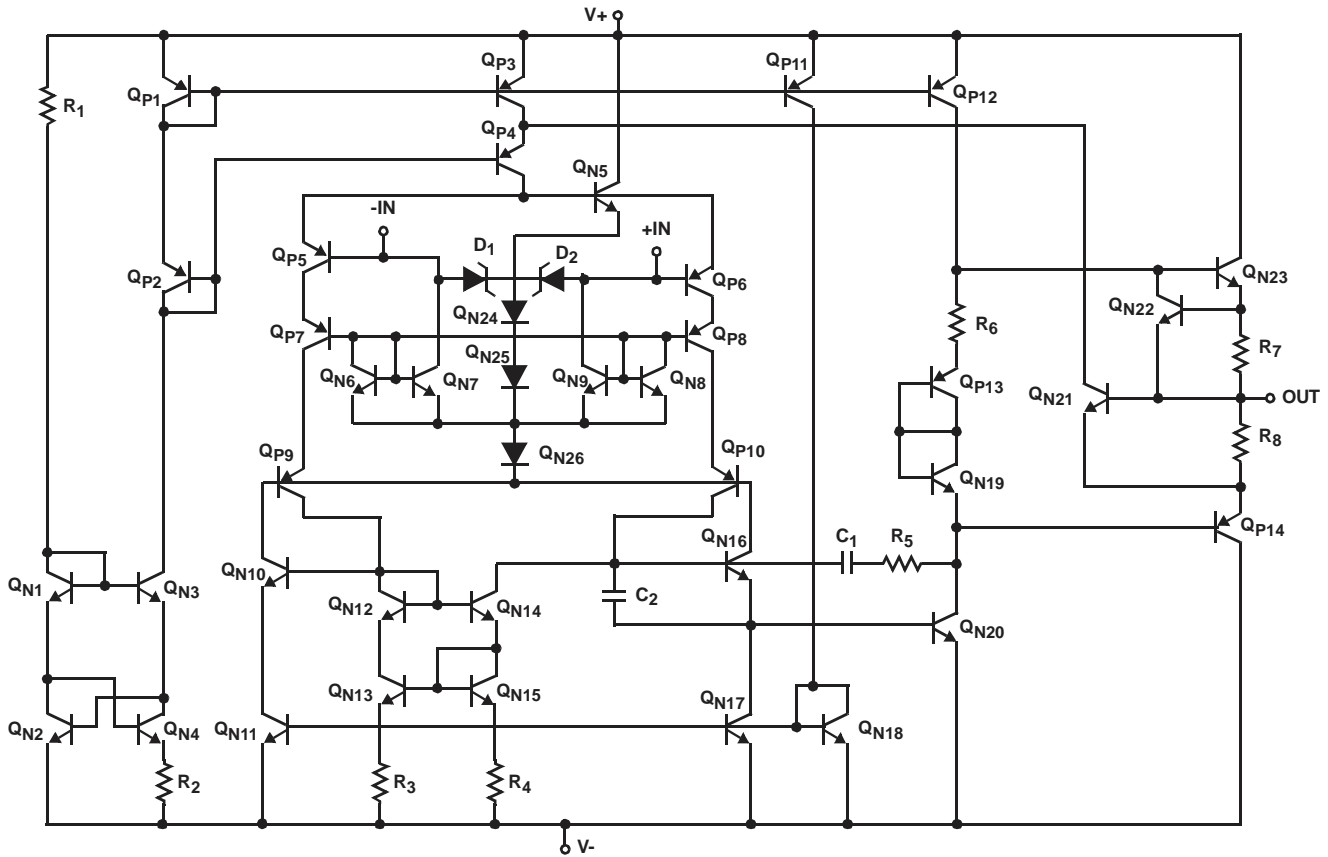
- 8.  $A_V = -1$ .
- 9. Feedback and summing resistors should be 0.1% matched.
- 10. Clipping diodes are optional. HP5082-2810 recommended.

FIGURE 2. SETTLING TIME CIRCUIT

$T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ ,  $A_V = 1000$   
 $e_n = 0.167\mu\text{V}_{\text{P-P}}$   
 $0.05\mu\text{V}/\text{Div.}, 1\text{s}/\text{Div.}$

PEAK-TO-PEAK NOISE 0.1Hz TO 10Hz

Schematic Diagram (Each Amplifier)



**Application Information**

**Power Supply Decoupling**

Although not absolutely necessary, it is recommended that all power supply lines be decoupled with 0.01μF ceramic capacitors to ground. Decoupling capacitors should be located as near to the amplifier terminals as possible.

**Considerations For Prototyping**

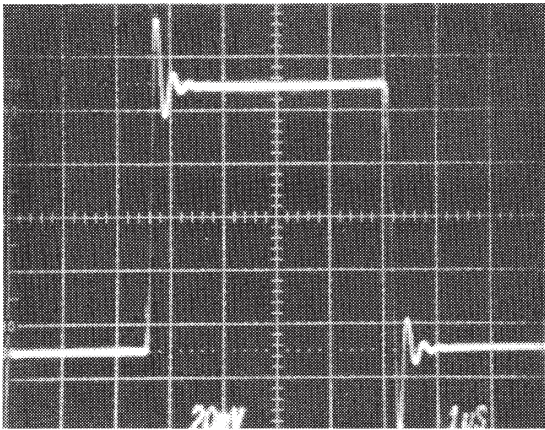
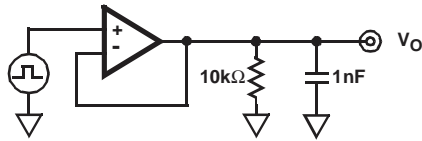
The following list of recommendations are suggested for prototyping.

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.

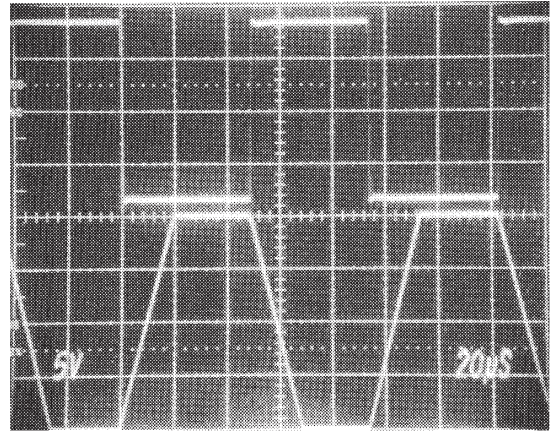
2. Error voltages generated by thermocouples formed between dissimilar metals in the presence of temperature gradients should be minimized. Isolation of low level circuitry from heat generating components is recommended.
3. Shielded cable input leads, guard rings and shield drivers are recommended for the most critical applications.

**Typical Applications**



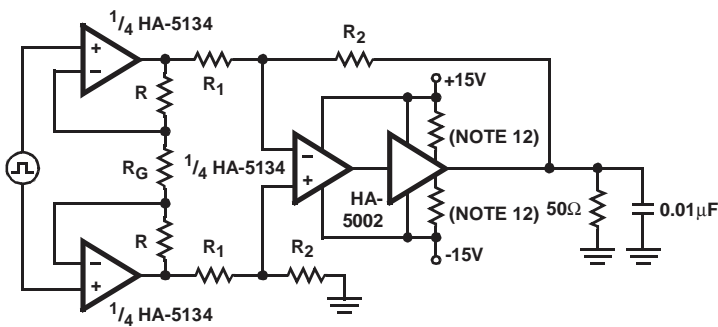
$T_A = 25^\circ\text{C}$ ,  $V_S = \pm 15\text{V}$ ,  $A_V = 1$ ,  $R_L = 10\text{k}\Omega$   
20mV/Div., 1μs/Div.

**FIGURE 3. SMALL SIGNAL TRANSIENT RESPONSE**  
( $C_{LOAD} = 1\text{nF}$ )



$V_{OUT} = \pm 10\text{V}$ ,  $R_{LOAD} = 50\Omega$ ,  $C_{LOAD} = 0.01\mu\text{F}$ ,  $A_V = 3$ ,  $V_S = \pm 15\text{V}$   
Top: Input, 2V/Div., 20μs/Div. Bottom: Output, 5V/Div, 20μs/Div.

**TRANSIENT RESPONSE OF APPLICATION CIRCUIT #1**

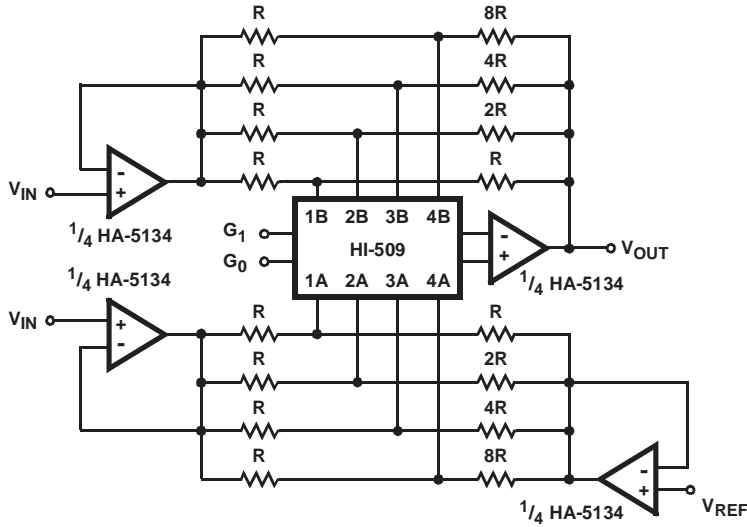


**FIGURE 4. APPLICATION CIRCUIT #1: INSTRUMENTATION AMPLIFIER WITH POWER OUTPUT**

NOTES:

11.  $-A_V = \left(1 + \frac{2R}{R_G}\right) \left(\frac{R_2}{R_1}\right)$ .
12. 10Ω - 100Ω recommended for short circuit limiting.
13. When driving heavy loads the HA-5002 may contribute to thermal errors. Proper thermal shielding is recommended.

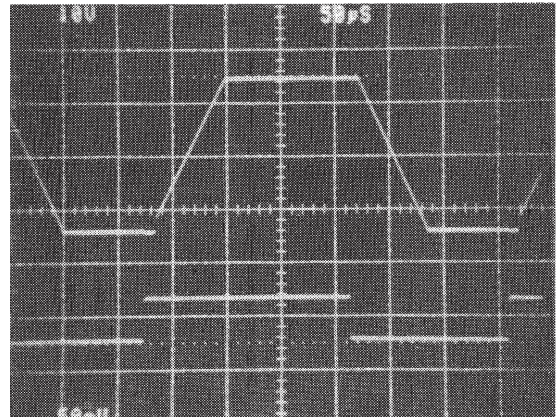
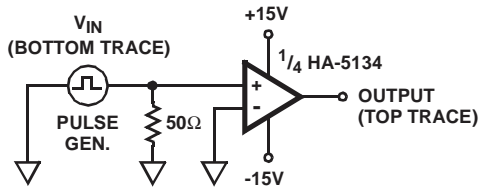
Typical Applications (Continued)



$G_1$	$G_0$	$A_V$
0	0	-1
0	1	-2
1	0	-4
1	1	-8

High  $A_{VOL}$  of HA-5134 reduces gain error.  
Gain Error  $\cong 0.004\%$  at  $A_V = 8$ .

FIGURE 5. APPLICATION CIRCUIT #2: PROGRAMMABLE GAIN AMPLIFIER



Horizontal:  $50\mu s/Div.$   
 $V_{IN} = \pm 25mV, V_{OUT} = \pm 14V$

NOTE: If differential input voltages greater than 6V are present, input current must be limited to less than 25mA.

FIGURE 6. APPLICATION CIRCUIT #3: PRECISION COMPARATOR

Typical Performance Curves

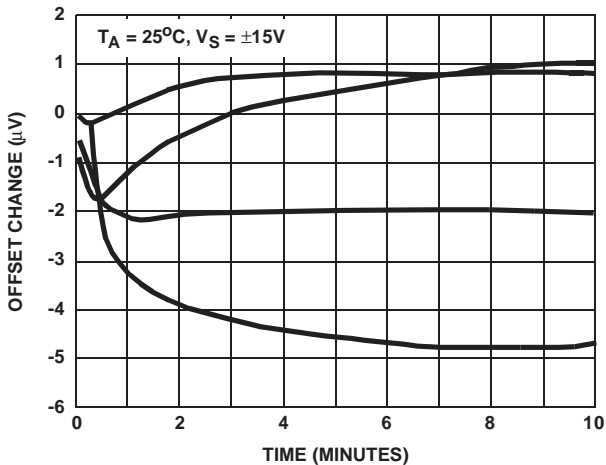


FIGURE 7.  $V_{IO}$  WARM-UP DRIFT

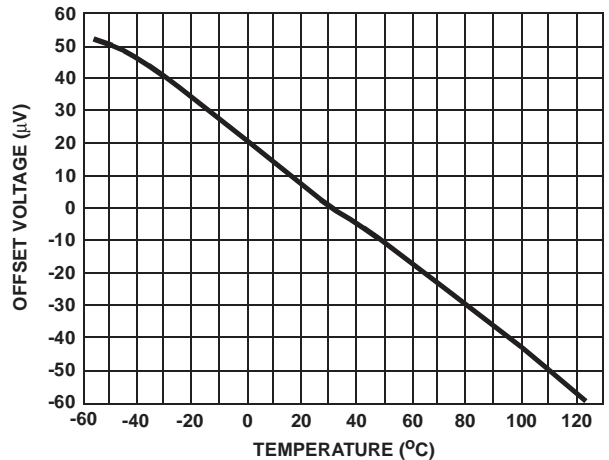


FIGURE 8. INPUT OFFSET VOLTAGE vs TEMPERATURE

Typical Performance Curves (Continued)

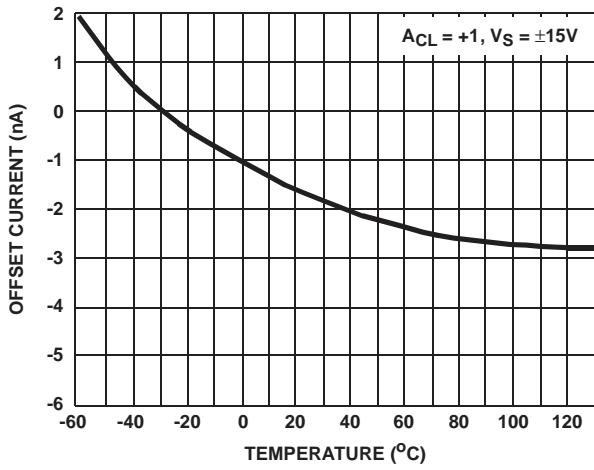


FIGURE 9. OFFSET CURRENT vs TEMPERATURE

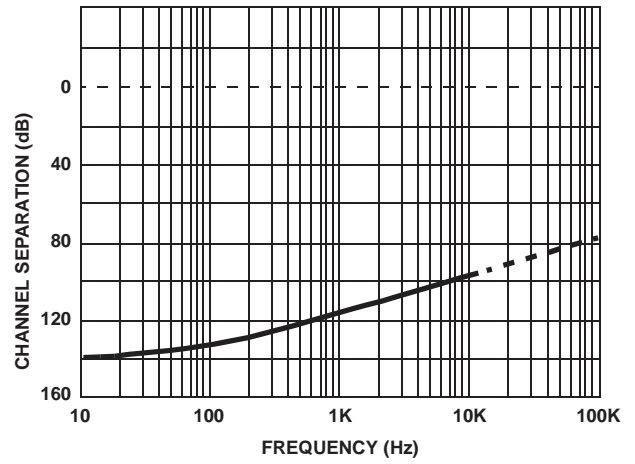


FIGURE 10. CHANNEL SEPARATION vs FREQUENCY

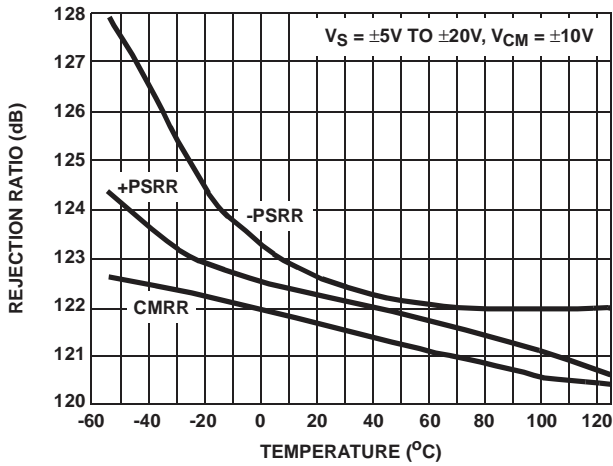


FIGURE 11. REJECTION RATIOS vs TEMPERATURE

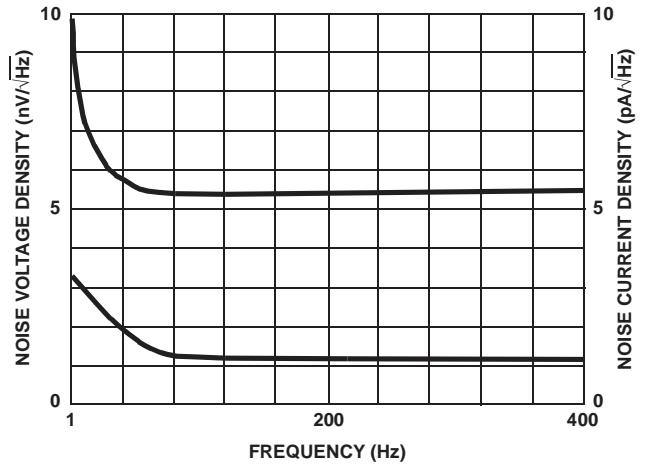


FIGURE 12. NOISE DENSITY vs FREQUENCY

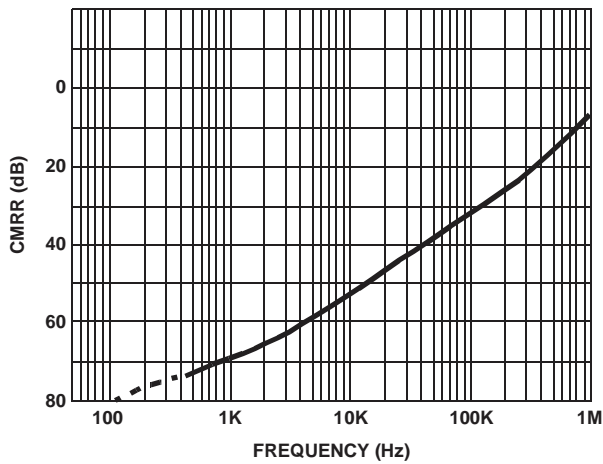


FIGURE 13. CMRR vs FREQUENCY

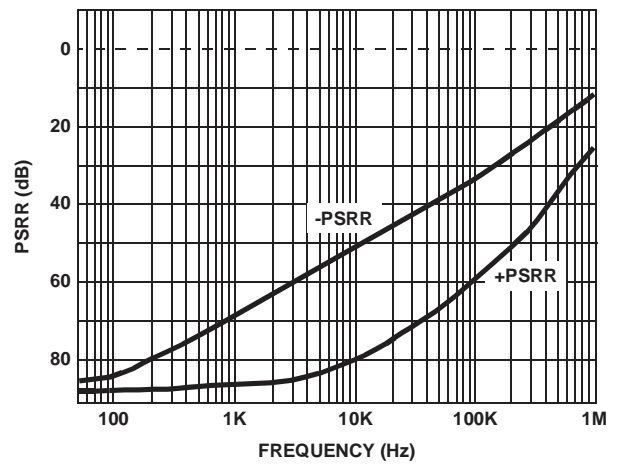


FIGURE 14. PSRR vs FREQUENCY

Typical Performance Curves (Continued)

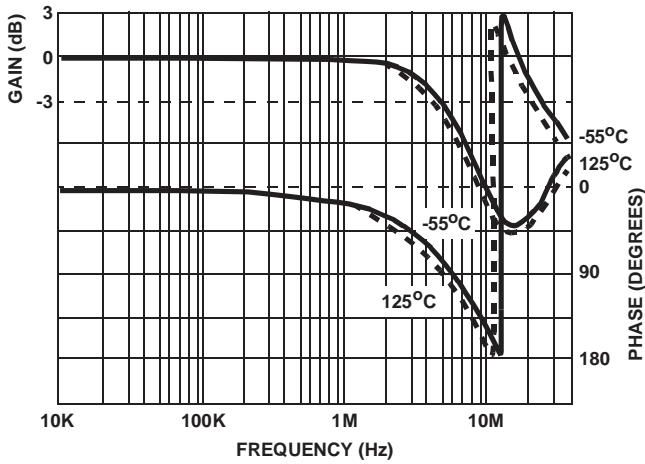


FIGURE 15. CLOSED LOOP FREQUENCY RESPONSE

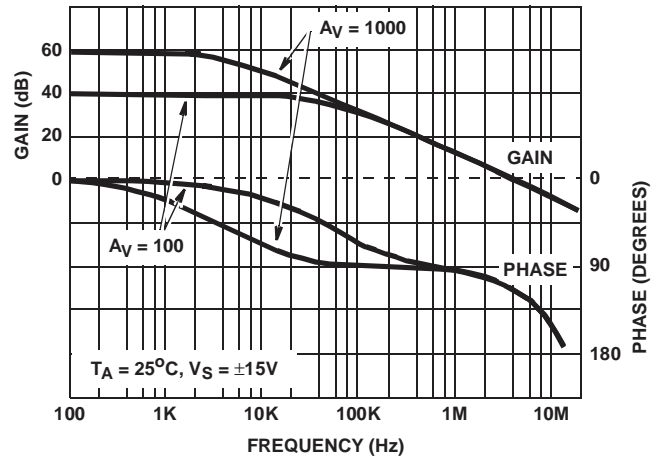


FIGURE 16. CLOSED LOOP GAIN/PHASE vs FREQUENCY

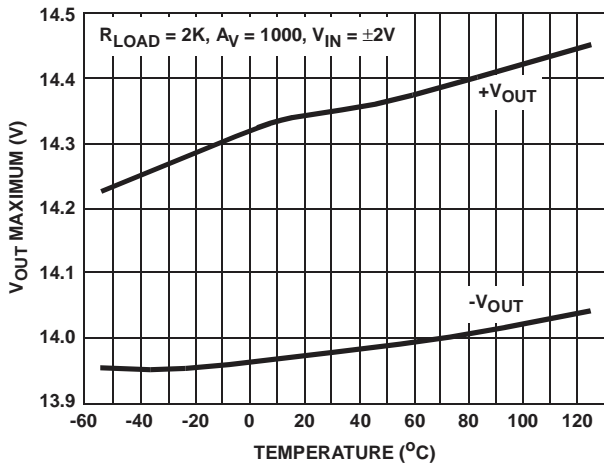


FIGURE 17. MAXIMUM OUTPUT VOLTAGE vs TEMPERATURE

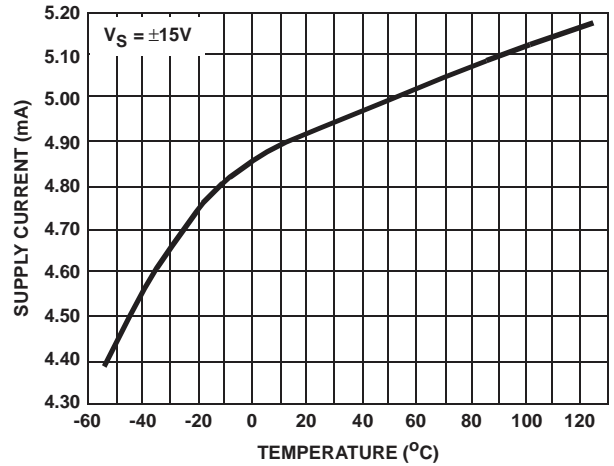


FIGURE 18. SUPPLY CURRENT vs TEMPERATURE

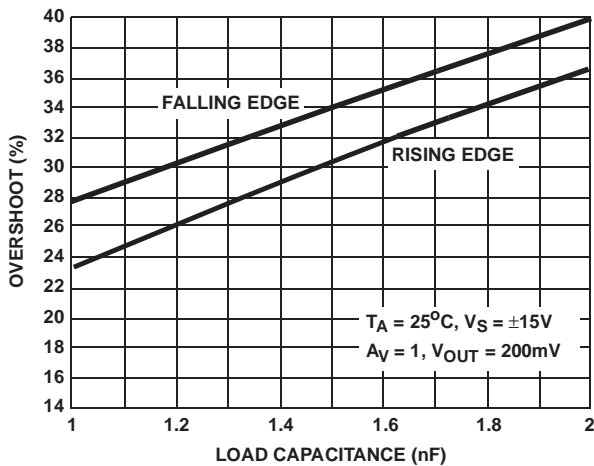


FIGURE 19. OVERSHOOT vs  $C_{LOAD}$

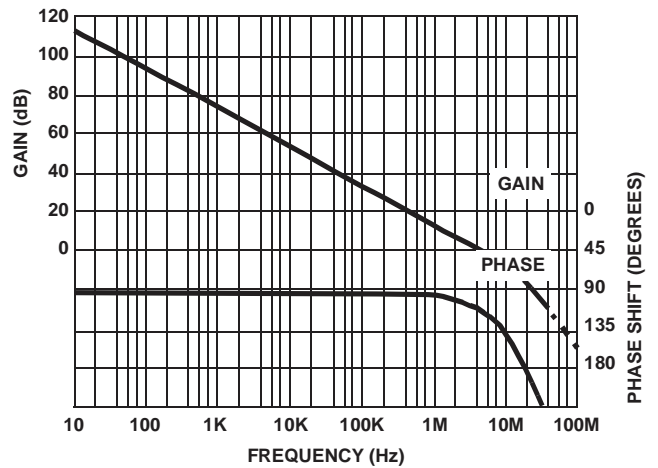


FIGURE 20. OPEN LOOP GAIN AND PHASE vs FREQUENCY



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