HARRIS SEMICONDUCTOR

HA-5127

Ultra-Low Noise Precision Operational Amplifier

March 1993

Features

- **High Speed 10V/µs**
- **Wide Unity Gain Bandwidth 8.5MHz**
- **Low Noise .... 3nV/√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**

Ordering Information

PART NUMBER	TEMPERATURE RANGE	PACKAGE
HA2-5127-2	-55°C to +125°C	8 Pin CAN
HA2-5127-5	0°C to +75°C	8 Pin CAN
HA2-5127A-2	-55°C to +125°C	8 Pin CAN
HA2-5127A-5	0°C to +75°C	8 Pin CAN
HA3-5127A-5	0°C to +75°C	8 Lead Plastic DIP
HA7-5127-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5127-5	0°C to +75°C	8 Lead Ceramic DIP
HA7-5127A-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5127A-5	0°C to +75°C	8 Lead Ceramic DIP
HA9P5127-5	0°C to +75°C	8 Lead SOIC

Description

The HA-5127 monolithic 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/√Hz) precision instrumentation performance with high speed (10V/µs) wideband capability.

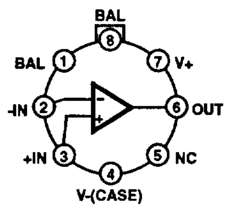
This amplifier's impressive list of features include low V_{OS} (10µV), wide unity gain-bandwidth (8.5MHz), high open loop gain (1800V/mV), and high CMRR (126dB). Additionally, this flexible device operates over a wide supply range (±5V to ±20V) while consuming only 140mW of power.

Using the HA-5127 allows designers to minimize errors while maximizing speed and bandwidth.

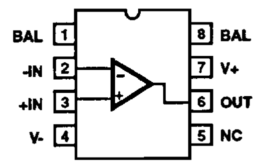
This device is ideally suited for low level transducer signal amplifier circuits. Other applications which can utilize the HA-5127's qualities include instrumentation amplifiers, pulse amplifiers, audio preamplifiers, and signal conditioning circuits. This device can easily be used as a design enhancement by directly replacing the 725, OP25, OP06, OP07, OP27 and OP37. For the military grade product, refer to the HA-5127/883 data sheet.

Pinouts

HA-5127
(TO-99 METAL CAN)
TOP VIEW



HA-5127
(PDIP, CDIP, SOIC)
TOP VIEW



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

File Number **2906.1**

Absolute Maximum Ratings (Note 1)

T_A = +25°C Unless Otherwise Stated
Supply Voltage Between V+ and V- Terminals 44V
Differential Input Voltage (Note 2)........................0.7V
Output Current .... Full Short Circuit Protection
Junction Temperature (Note 13)...................... +175°C
Junction Temperature (Plastic Package) .... +150°C
Lead Temperature (Soldering 10 Sec.)................. +300°C

Operating Conditions

Operating Temperature Range
HA-5127/27A-2 .... -55°C ≤ T_A ≤ +125°C
HA5127/27A-5.......................... 0°C ≤ T_A ≤ +75°C
Storage Temperature Range............... -65°C ≤ T_A ≤ +150°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.

Electrical Specifications V+ = 15V, V- = -15V, C_L < 50pF, R_S < 100Ω

PARAMETER	TEMP	HA-5127A			HA-5127			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS								
Offset Voltage	+25°C	-	10	25	-	30	100	µV
	Full	-	30	60	-	70	300	µV
Average Offset Voltage Drift	Full	-	0.2	0.6	-	0.4	1.8	µV/°C
Bias Current	+25°C	-	±10	±40	-	±15	±80	nA
	Full	-	±20	±60	-	±35	±150	nA
Offset Current	+25°C	-	7	35	-	12	75	nA
	Full	-	15	50	-	30	135	nA
Common Mode Range	Full	±10.3	±11.5	-	±10.3	±11.5	-	V
Differential Input Resistance (Note 3)	+25°C	1.5	6	-	0.8	4	-	MΩ
Input Noise Voltage 0.1Hz to 10Hz (Note 4)	+25°C	-	0.08	0.18	-	0.09	0.25	μV_{P-P}
Input Noise Voltage Density (Note 5)								
f = 10Hz	+25°C	-	3.5	5.5	-	3.8	8.0	nV/√Hz
f = 100Hz		-	3.1	4.5	-	3.3	5.6	nV/√Hz
f = 1000Hz		-	3.0	3.8	-	3.2	4.5	nV/√Hz
Input Noise Current Density (Note 5)								
f = 10Hz	+25°C	-	1.7	4.0	-	1.7	-	pA/√Hz
f = 100Hz		-	1.0	2.3	-	1.0	-	pA/√Hz
f = 1000Hz		-	0.4	0.6	-	0.4	0.6	pA/√Hz
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Note 6)	+25°C	1000	1800	-	700	1500	-	V/mV
	Full	600	1200	-	300	800	-	V/mV
Common Mode Rejection Ratio (Note 7)	Full	114	126	-	100	120	-	dB
Minimum Stable Gain	+25°C	1	-	-	1	-	-	V/V
Unity-Gain-Bandwidth	+25°C	5	8.5	-	5	8.5	-	MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing								
R_L = 600Ω	+25°C	±10.0	±11.5	-	±10.0	±11.5	-	V
R_L = 2kΩ	Full	±11.7	±13.8	-	±11.5	±13.5	-	V

Electrical Specifications $V+ = 15V$, $V- = -15V$, $C_L < 50pF$, $R_S < 100\Omega$ **(Continued)**

PARAMETER	TEMP	HA-5127A			HA-5127			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
Full Power Bandwidth (Note 8)	+25°C	111	160	-	111	160	-	kHz
Output Resistance, Open Loop	+25°C	-	70	-	-	70	-	Ω
Output Current	+25°C	16.5	25	-	16.5	25	-	mA
TRANSIENT RESPONSE (Note 9)								
Rise Time	+25°C	-	-	150	-	-	150	ns
Slew Rate (Note 11)	+25°C	7	10	-	7	10	-	V/µs
Settling Time (Note 10)	+25°C	-	1.5	-	-	1.5	-	µs
Overshoot	+25°C	-	20	40	-	20	40	%
POWER SUPPLY CHARACTERISTICS								
Supply Current	+25°C	-	3.5	-	-	3.5	-	mA
	Full	-	-	4.0	-	-	4.0	mA
Power Supply Rejection Ratio (Note 12)	Full	-	2	4	-	16	51	µV/V

NOTES:

1. Absolute maximum ratings are limiting values, applied individually, beyond which the serviceability of the circuit may be impaired. Functional operability under any of these conditions is not necessarily implied.
2. For differential input voltages greater than 0.7V, the input current must be limited to 25mA to protect the back-to-back input diodes.
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. $V_{OUT} = \pm 10V$, $R_L = 2k\Omega$
7. $V_{CM} = \pm 10V$
8. Full power bandwidth guaranteed based on slew rate measurement using: $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$.
9. Refer to Test Circuits section of the data sheet.
10. Settling time is specified to 0.1% of final value for a 10V output step and $A_V = -1$.
11. $V_{OUT} = 10V$ Step
12. $V_S = \pm 4.5V$ to $\pm 18V$
13. See Thermal Constants in "Die Characteristics" section.

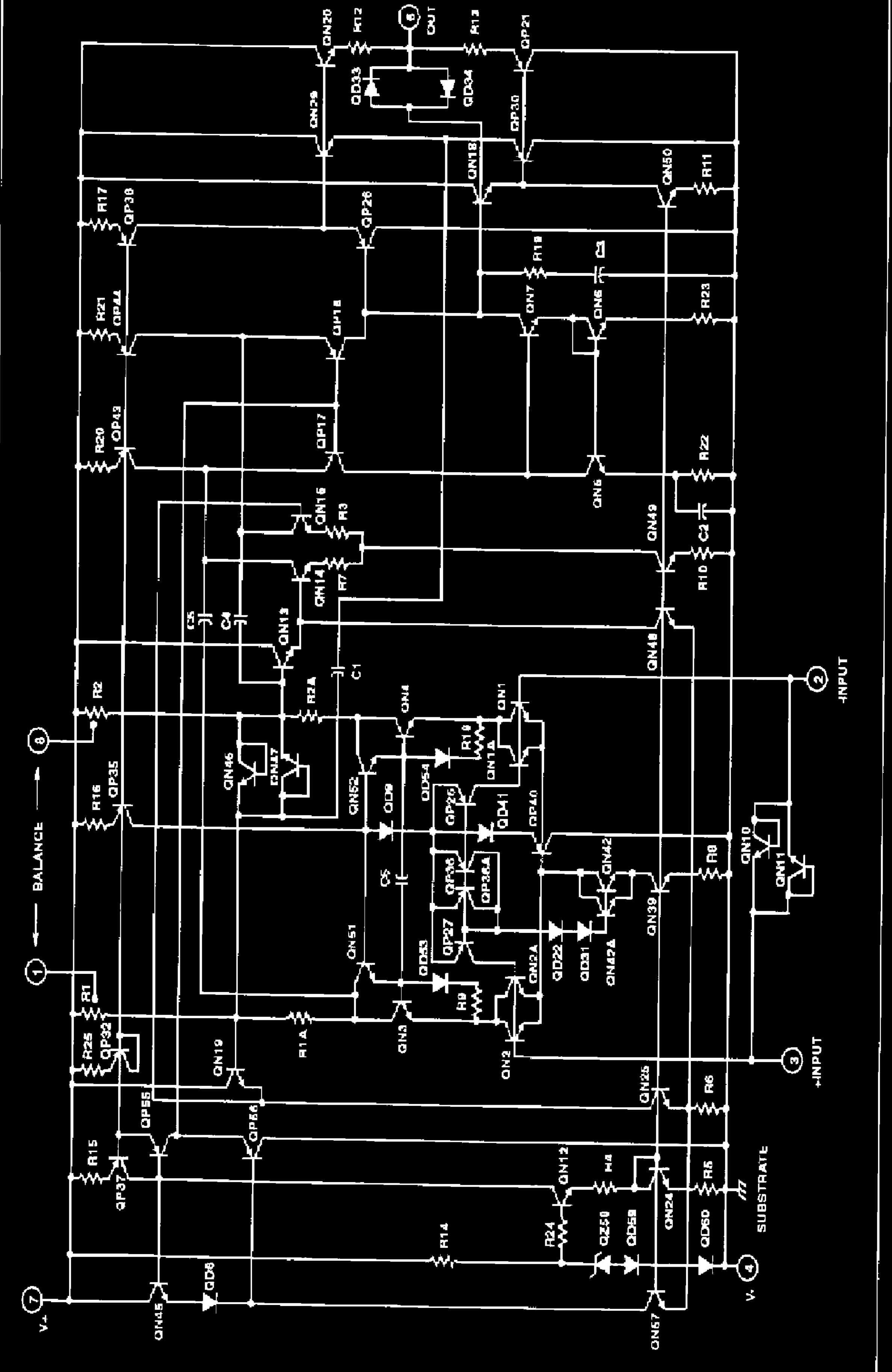
Die Characteristics

Transistor Count 63
Die Dimensions . . . . 65 x 104.3 x 19 mils
(1700µm x 2600µm x 480µm)
Substrate Potential* . . . . V-
Process. . . . . Bipolar-DI

* The substrate may be left floating (Insulating Die Mount) or it may be mounted on a conductor at V- potential.

Thermal Constants (°C/W)	θ_{JA}	θ_{JC}
Ceramic Mini-DIP	114	34
TO-99 Metal Can	108	33
Plastic DIP	92	30
SOIC	157	43

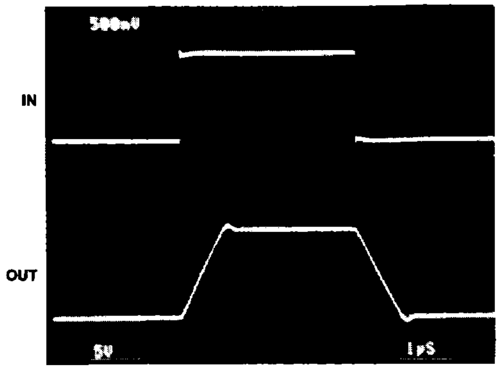
Schematic Diagram



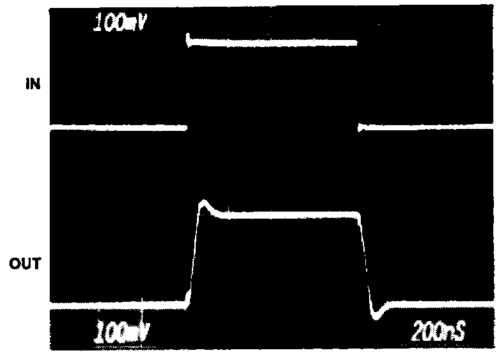
Test Circuits

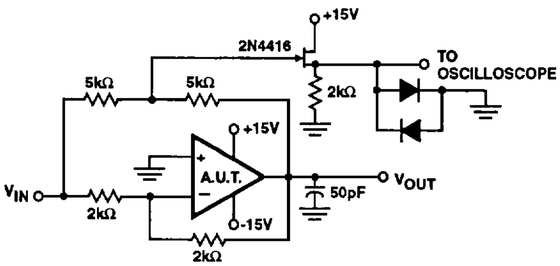
FIGURE 1. LARGE AND SMALL SIGNAL RESPONSE TEST CIRCUITS

LARGE SIGNAL RESPONSE
Vertical Scale: (Volts: Input = 0.5V/Div.)
(Output = 5V/Div.)
Horizontal Scale: (Time = 1µs/Div.)



SMALL SIGNAL RESPONSE
Vertical Scale: (Volts: 100mV/Div.)
Horizontal Scale: (200ns/Div.)





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

FIGURE 2. SETTLING TIME TEST CIRCUIT

Typical Performance Curves Unless Otherwise Specified: T_A = +25°C, V_{SUPPLY} = ±15V

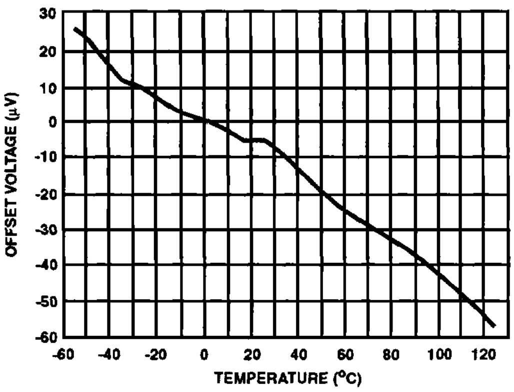


FIGURE 3. TYPICAL OFFSET VOLTAGE DRIFT vs TEMPERATURE

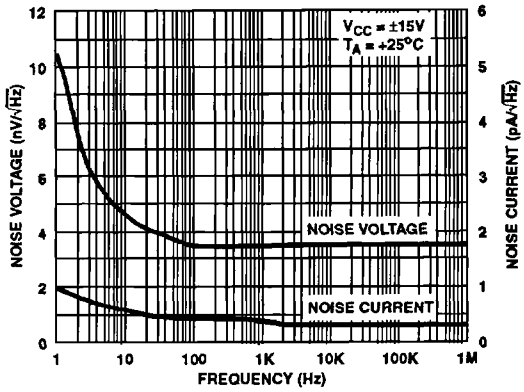


FIGURE 4. NOISE CHARACTERISTICS

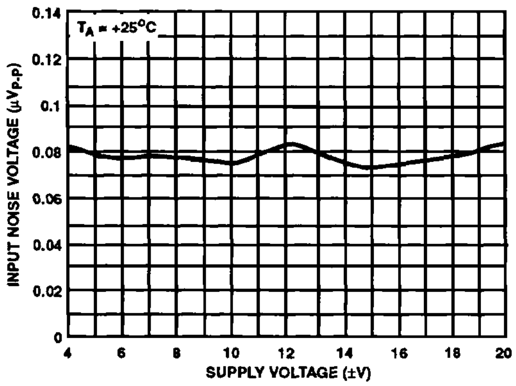


FIGURE 5. NOISE vs SUPPLY VOLTAGE

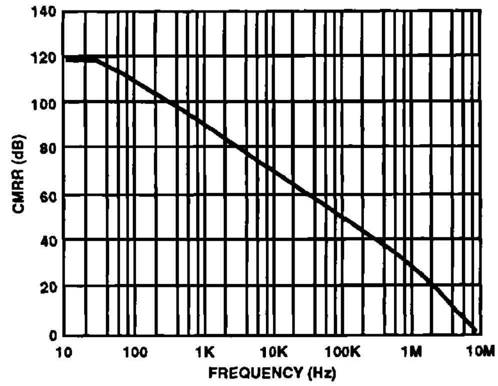


FIGURE 6. CMRR vs FREQUENCY

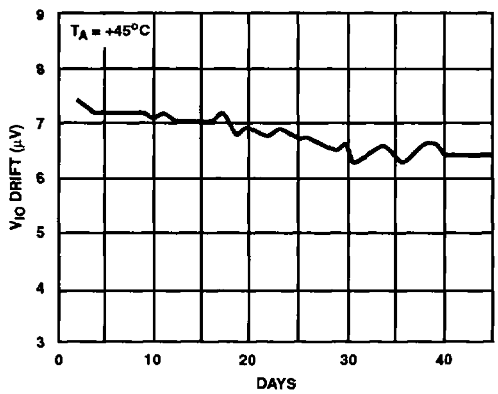


FIGURE 7. OFFSET VOLTAGE DRIFT vs TIME

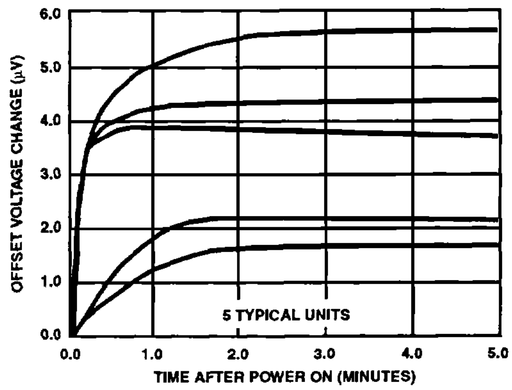


FIGURE 8. OFFSET VOLTAGE WARM UP DRIFT

Typical Performance Curves Unless Otherwise Specified: $T_A = +25^oC$, $V_{SUPPLY} = \pm15V$ (Continued)

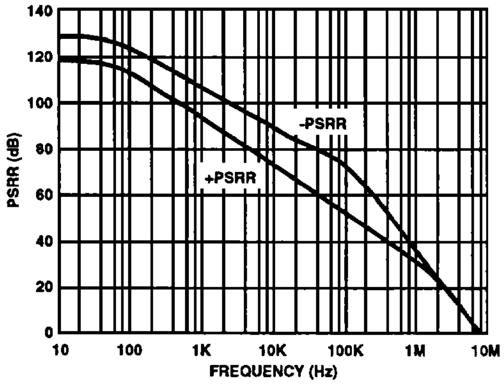


FIGURE 9. PSRR vs FREQUENCY

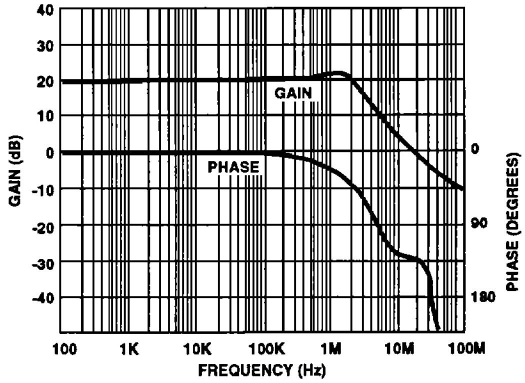


FIGURE 10. CLOSED LOOP GAIN AND PHASE vs FREQUENCY

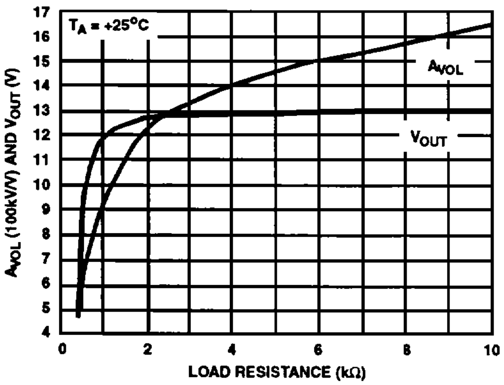


FIGURE 11. A_{VOL} AND V_{OUT} vs LOAD RESISTANCE

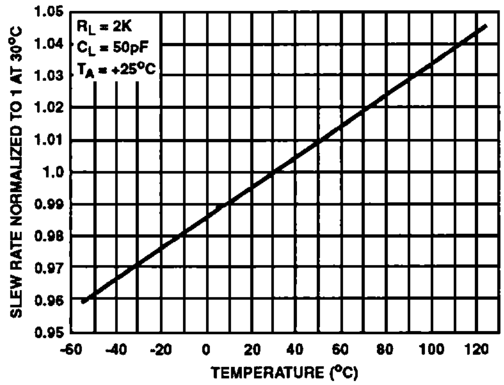


FIGURE 12. NORMALIZED SLEW RATE vs TEMPERATURE

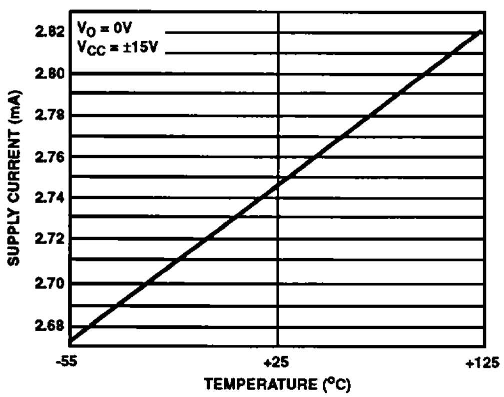


FIGURE 13. SUPPLY CURRENT vs TEMPERATURE

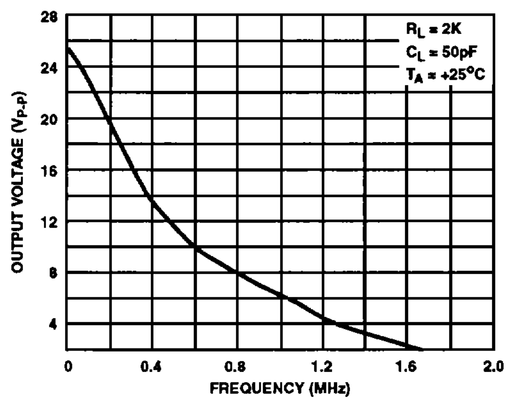


FIGURE 14. MAX UNDISTORTED SINEWAVE OUTPUT vs FREQUENCY

Typical Performance Curves Unless Otherwise Specified: T_A = +25°C, V_{SUPPLY} = ±15V **(Continued)**

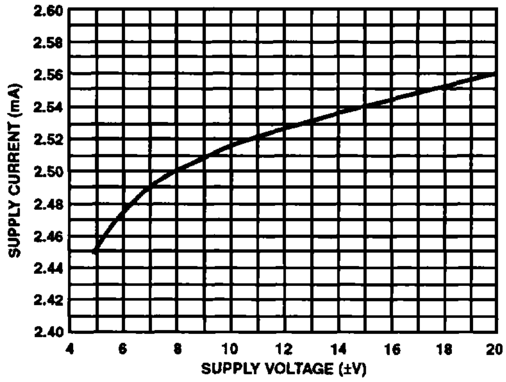


FIGURE 15. SUPPLY CURRENT vs SUPPLY VOLTAGE

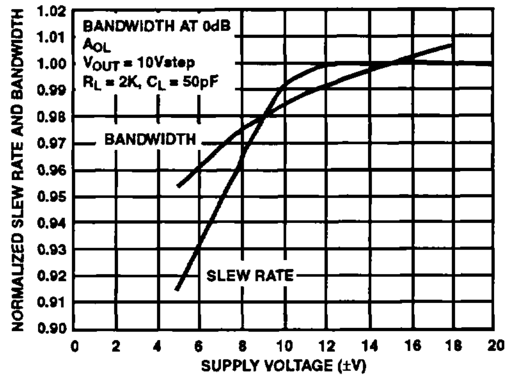


FIGURE 16. BANDWIDTH AND SLEW RATE vs SUPPLY VOLTAGE

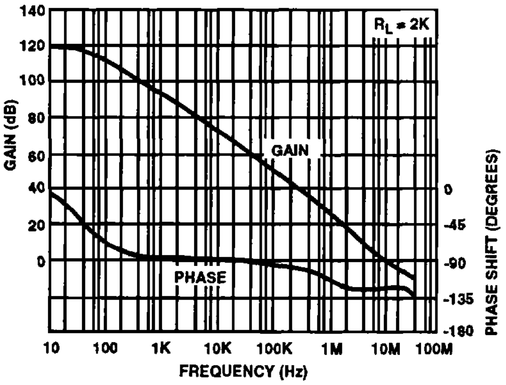


FIGURE 17. OPEN LOOP GAIN AND PHASE vs FREQUENCY

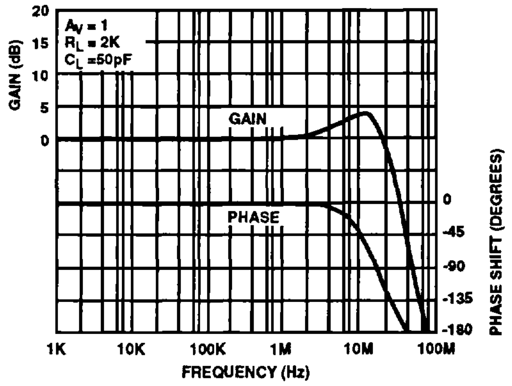


FIGURE 18. CLOSED LOOP GAIN AND PHASE vs FREQUENCY

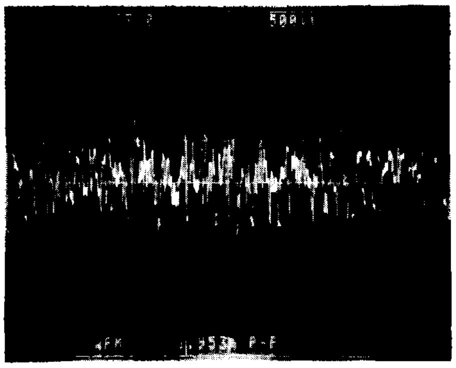
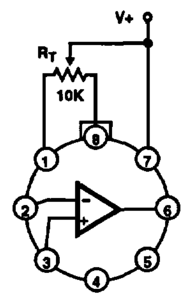


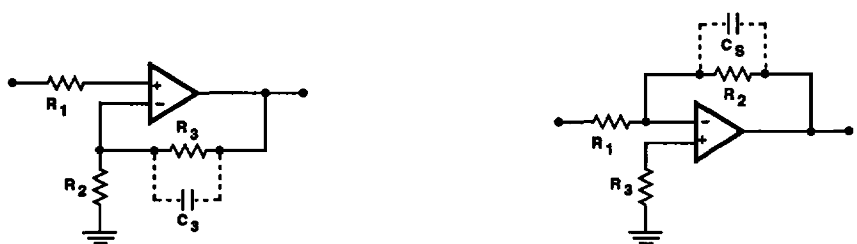
FIGURE 19. PEAK-TO-PEAK NOISE VOLTAGE (0.1Hz TO 10Hz)
Horizontal Scale = 1sec/Div.
Vertical Scale = 0.002µV/Div.
A_{CL} = 25,000V/V, E_N = 0.08µV_{P-P} RTI

Application Information



Tested Offset Adjustment Range is $|V_{OS} + 1mV|$ minimum referred to output. Typical range is ±4mV with R_T = 10kΩ.

FIGURE 20. SUGGESTED OFFSET VOLTAGE ADJUSTMENT



Low resistances are preferred for low noise applications as a 1kΩ resistor has 4nV/√Hz of thermal noise. Total resistances of greater than 10kΩ on either input can reduce stability. In most high resistance applications, a few picofarads of capacitance across the feedback resistor will improve stability.

FIGURE 21. SUGGESTED STABILITY CIRCUITS