HA-5177

Ultra-Low Offset Voltage Operational Amplifier

January 1989

Features

- Low Offset Voltage 10μV
- Low Offset Voltage Drift ..... 0.1μV/°C
- High Voltage Gain 150dB
- High CMRR 140dB
- High PSRR 135dB
- Low Noise ..... 3.8nV/$\sqrt{Hz}$
- Low Power Consumption ..... 51mW Max.

Applications

- High Gain Instrumentation Amplifiers
- Precision Control Systems
- Precision Integrators
- High Resolution Data Converters
- Precision Threshold Detectors
- Low Level Transducer Amplifiers

Description

The HA-5177 is a monolithic, all bipolar, precision operational amplifier, utilizing Harris dielectric isolation and advance processing techniques. This design features a combination of precision input characteristics, wide bandwidth (2MHz) and high speed (0.8V/μs).

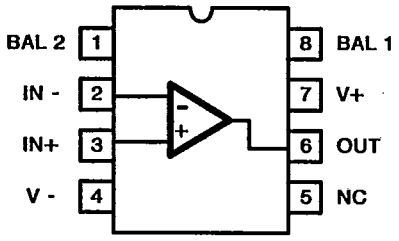
The HA-5177 uses advanced matching techniques and laser trimming to produce low offset voltage (10μV) and low offset voltage drift (0.1μV/°C). This design also features low voltage noise (3.8nV/$\sqrt{Hz}$), low current noise (0.32pA/$\sqrt{Hz}$), nanoamp input currents, and 120dB minimum gain.

These outstanding features along with high CMRR (140dB) and high PSRR (135dB) make this unity gain stable amplifier ideal for high resolution data acquisition systems, precision integrators, and low level transducer amplifiers.

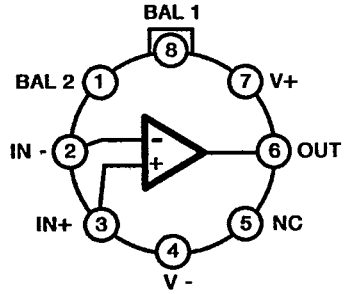
The HA-5177 can be used as a direct replacement for the OP05, OP07, and OP77 while offering higher bandwidth and slew rate. The HA-5177 is packaged in a 8 pin (TO-99) Metal Can and Ceramic 8 pin Mini-DIP and is pin compatible with many existing op amps. See the HA-5177/883 data sheet for military grade parts and LCC package.

Pinouts

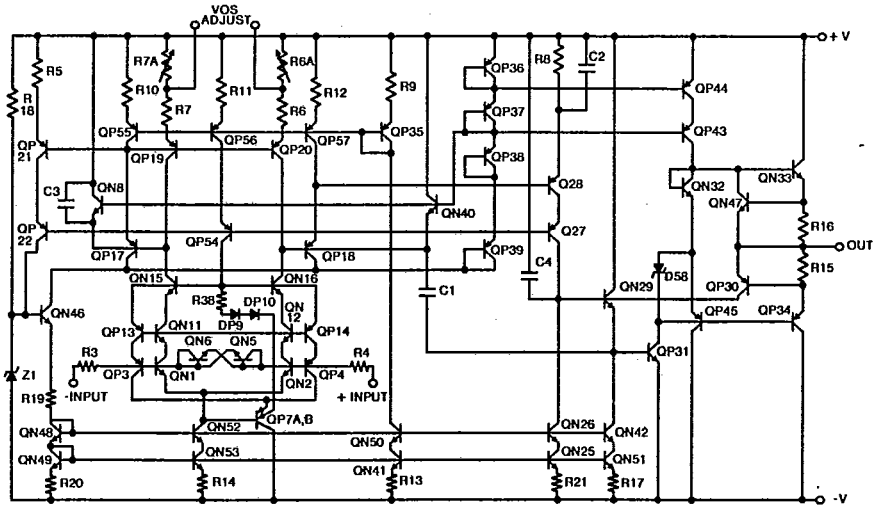
HA7-5177 (CERAMIC MINI-DIP)
TOP VIEW



HA2-5177 (TO-99 METAL CAN)
TOP VIEW



Schematic



CAUTION: These devices are sensitive to electrostatic discharge. Proper I.C. handling procedures should be followed.

Specifications HA-5177

Absolute Maximum Ratings (Note 1)

Voltage Between V+ and V- Terminals 44V
Differential Input Voltage ..... ±15V
Output Current ..... Short Circuit Protected

Operating Temperature Ranges

HA-5177A/5177-2 ..... $-55^oC \leq T_A \leq +125^oC$
HA-5177A/5177-5 ..... $0^oC < T_A \leq +75^oC$
Storage Temperature Range ..... $-65^oC \leq T_A \leq +150^oC$
Maximum Junction Temperature ..... $+175^oC$

Electrical Specifications V+ = +15V, V- = -15V, Unless Otherwise Specified

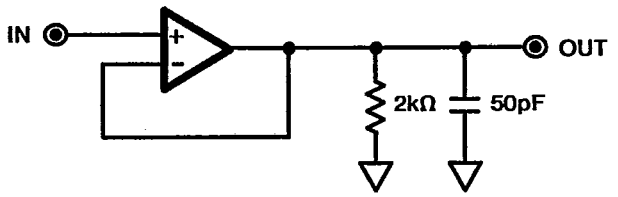
PARAMETER	TEMP	HA-5177A MIN	HA-5177A TYP	HA-5177A MAX	HA-5177 MIN	HA-5177 TYP	HA-5177 MAX	UNITS
INPUT CHARACTERISTICS								
Offset Voltage	+25°C	-	10	25	-	20	60	µV
	Full	-	25	60	-	40	100	µV
Average Offset Voltage Drift	Full	-	0.1	0.3	-	0.2	0.6	µV/°C
Bias Current	+25°C	-	1.2	2	-	1.2	6	nA
	Full	-	2.4	4	-	2.4	8	nA
Bias Current Average Drift	Full	-	8	25	-	15	35	pA/°C
Offset Current	+25°C	-	0.6	2	-	0.6	6	nA
	Full	-	1.0	4	-	1.0	8	nA
Offset Current Average Drift	Full	-	1.5	25	-	1.5	50	pA/°C
Common Mode Range	Full	±12	-	-	±12	-	-	V
Differential Input Resistance	+25°C	-	47	-	-	47	-	MΩ
Input Noise Voltage 0.1Hz to 10Hz	+25°C	-	0.35	0.6	-	0.35	0.6	μV_{p-p}
Input Noise Voltage Density								
f_O = 10Hz	+25°C	-	13	18	-	13	18	$nV/\sqrt{Hz}$
f_O = 100Hz	+25°C	-	10	13	-	10	13	$nV/\sqrt{Hz}$
f_O = 1000Hz	+25°C	-	9	11	-	9	11	$nV/\sqrt{Hz}$
Input Noise Current 0.1Hz to 10Hz	+25°C	-	14	45	-	14	45	pA_{p-p}
Input Noise Current Density								
f_O = 10Hz	+25°C	-	1.1	4	-	7.1	10	$pA/\sqrt{Hz}$
f_O = 100Hz	+25°C	-	0.55	2.3	-	3.3	5	$pA/\sqrt{Hz}$
f_O = 1000Hz	+25°C	-	0.32	1	-	1.2	2	$pA/\sqrt{Hz}$
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Note 2)	+25°C	134	150	-	126	150	-	dB
	Full	126	140	-	120	140	-	dB
Common Mode Rejection Ratio (Note 3)	Full	120	140	-	110	140	-	dB
Closed Loop Bandwidth (A_{VCL} = +1)	+25°C	0.6	2	-	0.6	2	-	MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing R_L = 600Ω	+25°C	±10	±12.5	-	±10	±12.5	-	V
R_L = 2K	+25°C	±12	±13	-	±12	±13	-	V
R_L = 2K	Full	±12	±12.5	-	±12	±12.5	-	V
Full Power Bandwidth (Note 5)	+25°C	8	10	-	8	10	-	kHz
Output Current (Note 6)	+25°C	15	20	-	15	20	-	mA
Output Resistance	+25°C	-	60	-	-	60	-	Ω
TRANSIENT RESPONSE								
Rise Time (Note 10)	+25°C	-	310	420	-	310	420	ns
Slew Rate (Note 11)	+25°C	0.5	0.8	-	0.5	0.8	-	V/µs
Settling Time (Notes 7, 8)	+25°C	-	14	-	-	14	-	µs
Overshoot (Note 10)	+25°C	-	10	40	-	10	40	%
POWER SUPPLY CHARACTERISTICS								
Supply Current	Full	-	1.2	1.7	-	1.2	1.7	mA
Power Supply Rejection Ratio (Note 9)	Full	110	135	-	110	135	-	dB

NOTES:

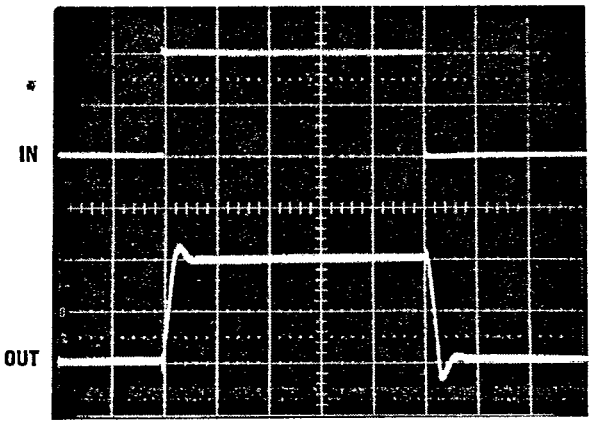
1. Absolute maximum ratings are limiting values, applied individually beyond which the serviceability of the circuit may be impaired. Functional operability under any of these conditions is not necessarily implied.
2. V_{OUT} = ±10V, R_L = 2kΩ
3. ΔV_{CM} = ±10V D.C.
4. R_L = 2K
5. Full power bandwidth guaranteed based on slew rate measurement using $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$, V_{PEAK} = 10V.
6. V_{OUT} = ±10.
7. Refer to test circuits section of the data sheet.
8. Settling time is measured to 0.1% of final value for a 10V output step and A_V = +1.
9. ΔV_{SUPPLY} = ±10V D.C. to ±20V D.C.
10. A_V = 1, R_L = 2K, V_{OUT} = ±200mV
11. A_V = 1, R_L = 2K, V_{OUT} = 0 to ±3V

Test Circuits

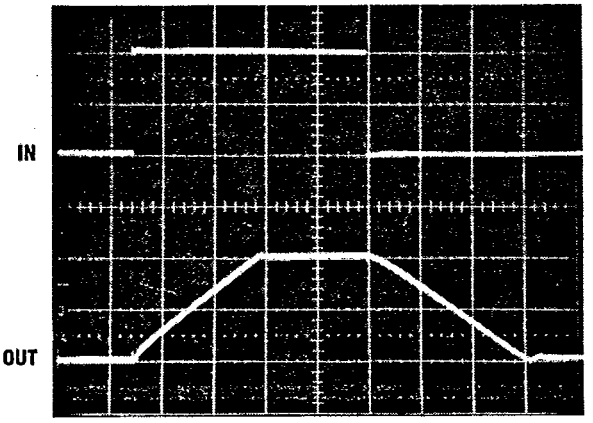
SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT



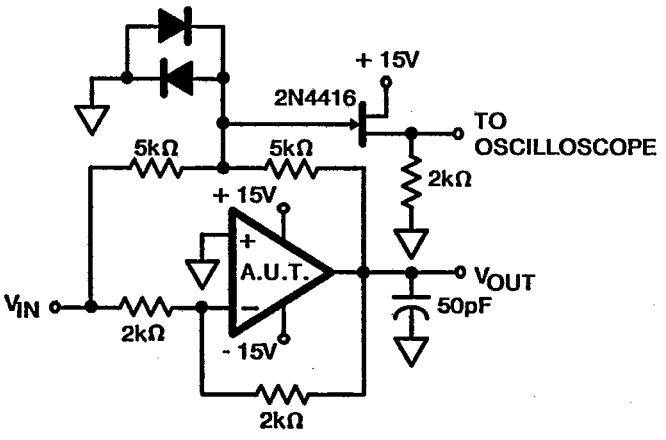
SMALL SIGNAL RESPONSE
Vertical Scale: (Volts: 100mV/Div.)
Horizontal Scale: (Time: 2μs/Div.)



LARGE SIGNAL RESPONSE
Vertical Scale: (Volts: 5V/Div.)
Horizontal Scale: (Time: 5μs/Div.)



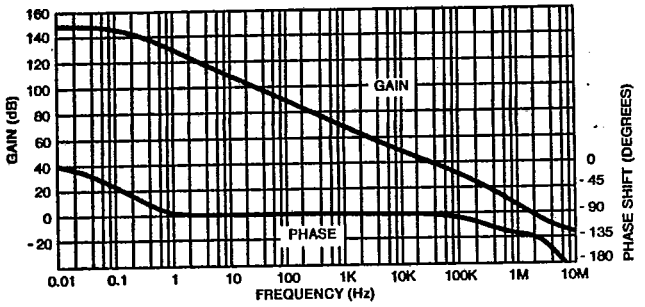
SETTLING TIME CIRCUIT



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

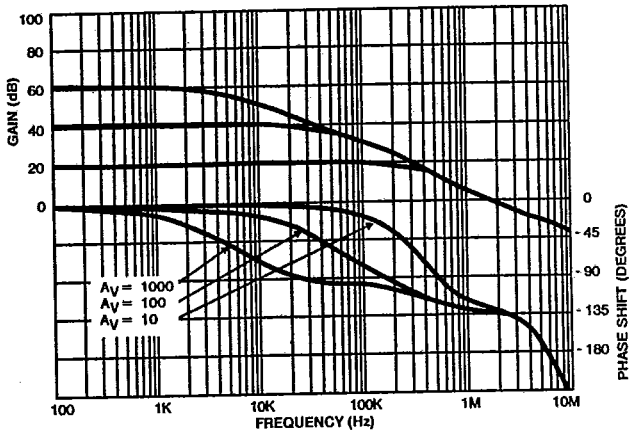
Typical Performance Curves $V_S = \pm 15V, T_A = +25^oC$

OPEN LOOP GAIN AND PHASE vs. FREQUENCY

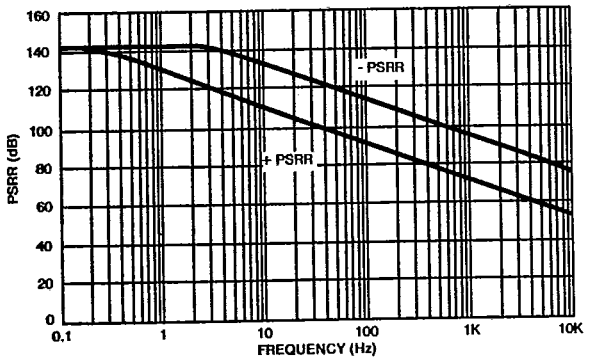


VARIOUS CLOSED LOOP GAINS vs. FREQUENCY

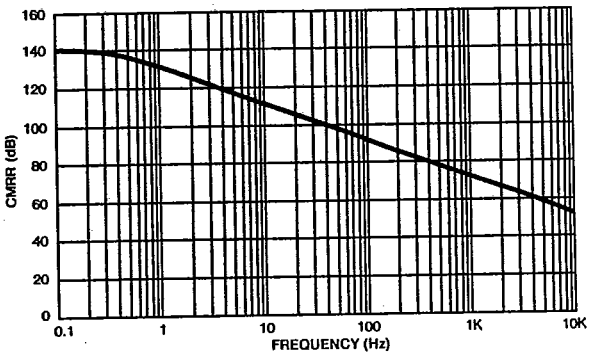
$R_L = 2K, C_L = 50pF$



PSRR vs. FREQUENCY

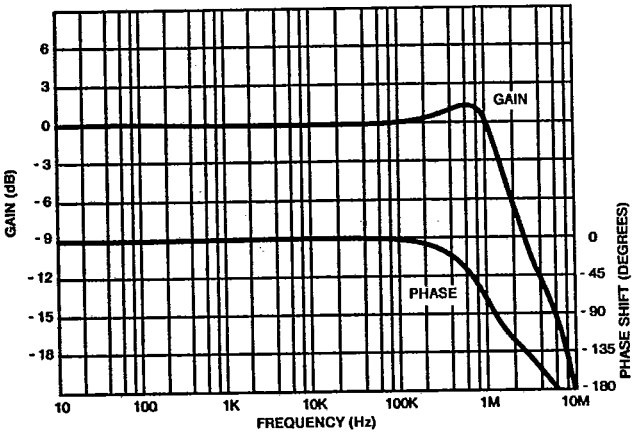


CMRR vs. FREQUENCY



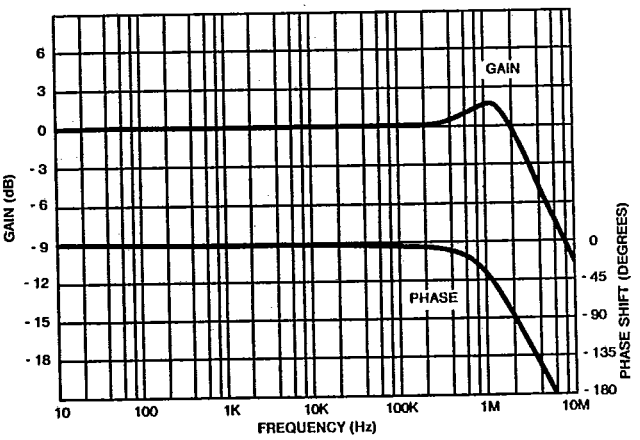
CLOSED LOOP GAIN AND PHASE vs. FREQUENCY

$A_V = -1, R_L = 2K, C_L = 50pF$



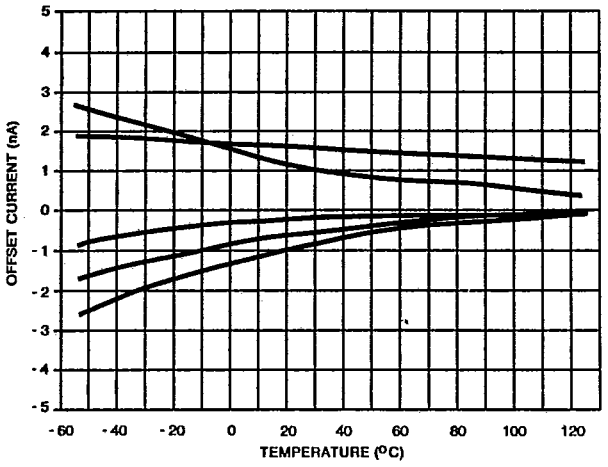
CLOSED LOOP GAIN AND PHASE vs. FREQUENCY

$A_V = +1, R_L = 2K, C_L = 50pF$

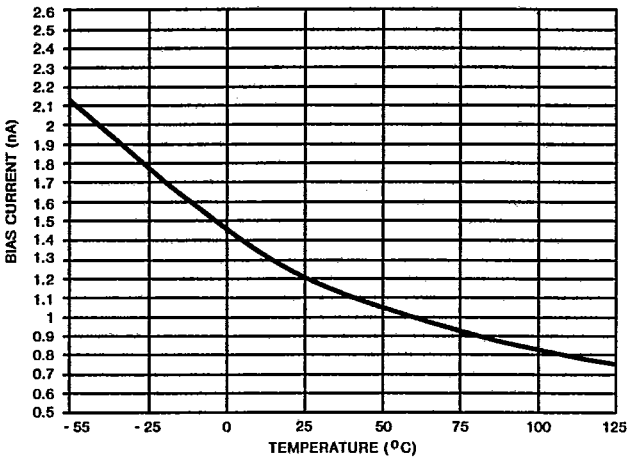


Typical Performance Curves $V_S = \pm 15V$, $T_A = +25^oC$

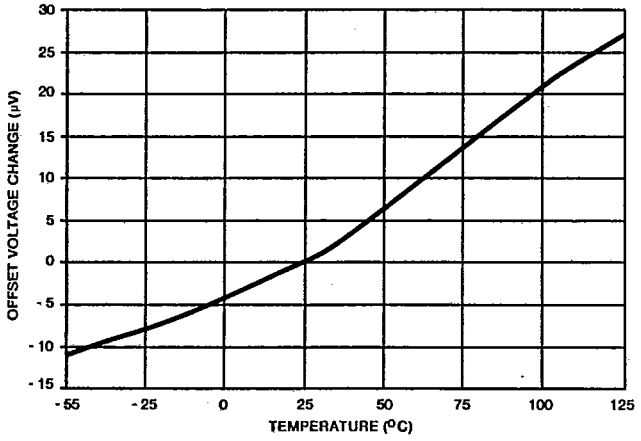
OFFSET CURRENT vs. TEMPERATURE
Five Representative Units



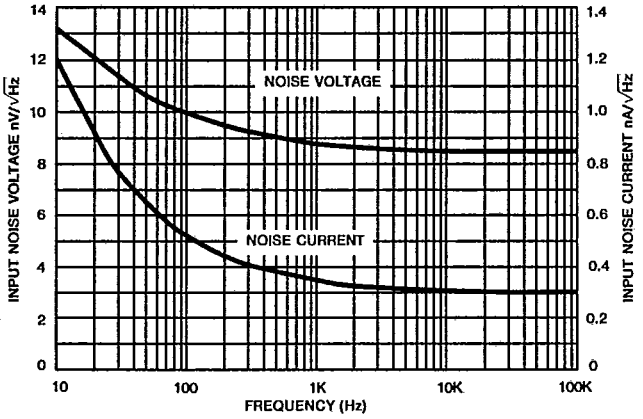
BIAS CURRENT vs. TEMPERATURE



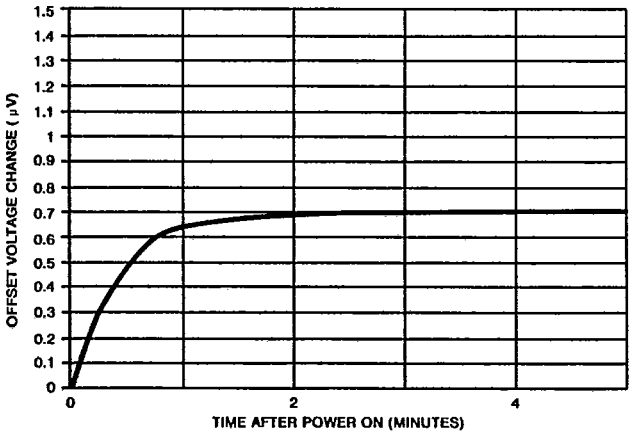
OFFSET VOLTAGE vs. TEMPERATURE



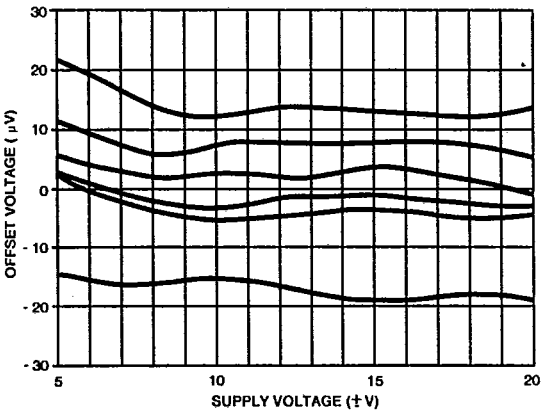
INPUT NOISE vs. FREQUENCY



OFFSET VOLTAGE WARM-UP DRIFT

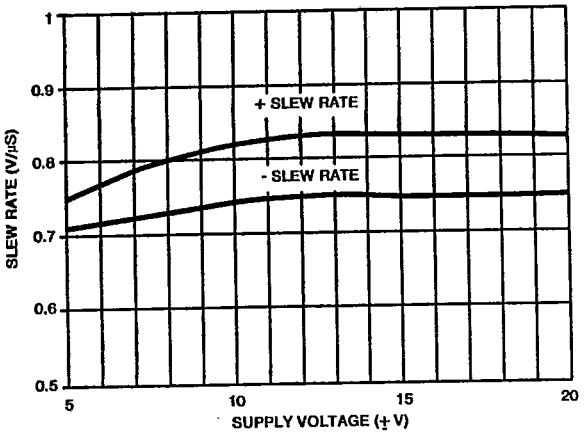


OFFSET VOLTAGE vs. SUPPLY VOLTAGE
Six Representative Units

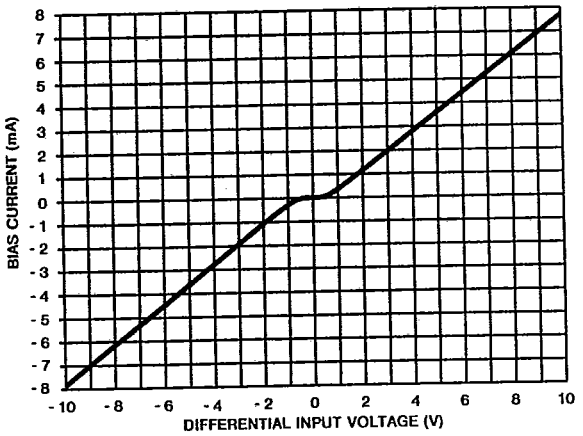


Typical Performance Curves $V_S = \pm 15V$, $T_A = +25^oC$

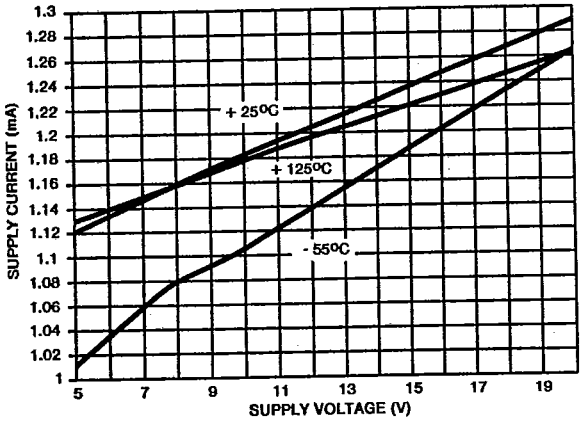
SLEW RATE vs. SUPPLY VOLTAGE
$A_V = -1$, $R_L = 2K$, $C_L = 50pF$



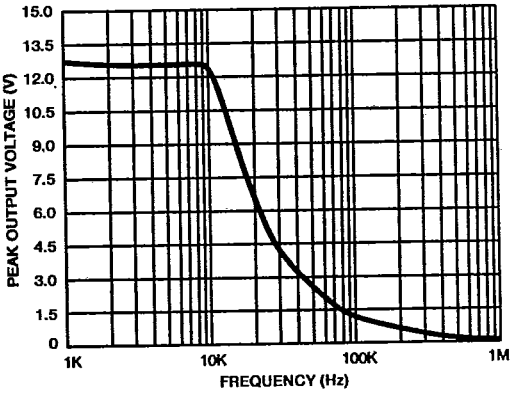
BIAS CURRENT vs. DIFFERENTIAL INPUT VOLTAGE



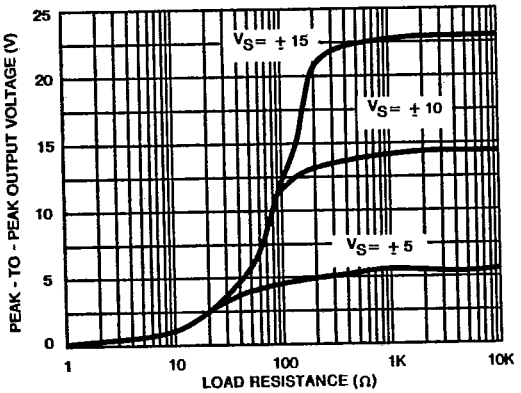
SUPPLY CURRENT vs. SUPPLY VOLTAGE



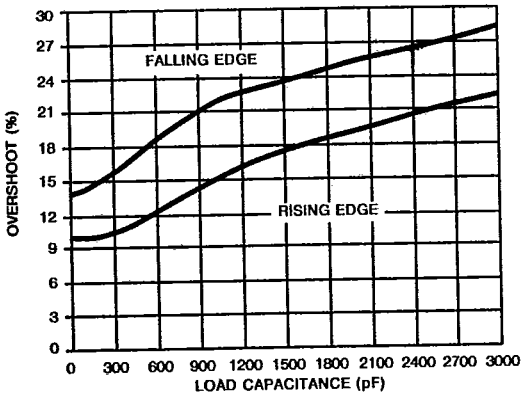
OUTPUT VOLTAGE vs. FREQUENCY
$A_V = -1$, $R_L = 2K$, $C_L = 50pF$



OUTPUT VOLTAGE vs. LOAD RESISTANCE
$A_V = -1$, $V_{IN} = 100Hz$, $C_L = 50pF$

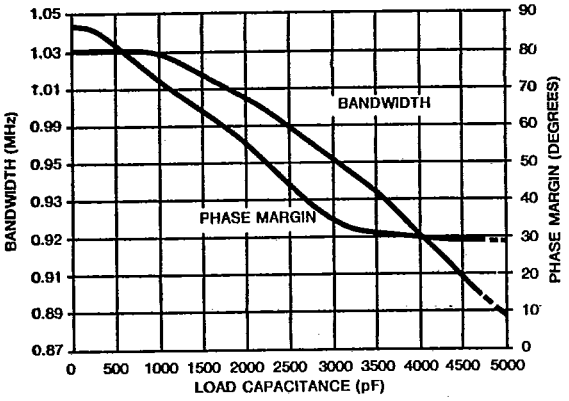


OVERSHOOT vs. LOAD CAPACITANCE
$V_S = \pm 15V$, $A_V = +1$, $V_{OUT} = \pm 200mV$

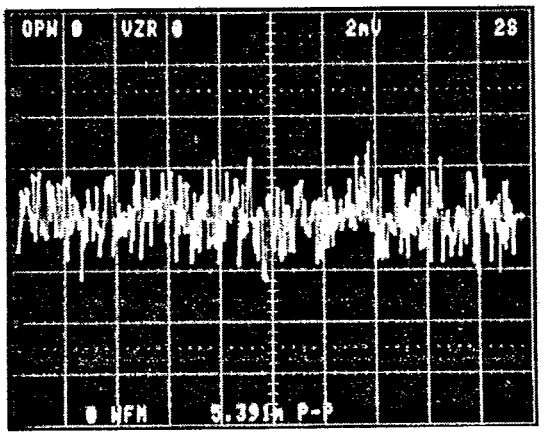


Typical Performance Curves $V_S = \pm 15V$, $T_A = +25^oC$

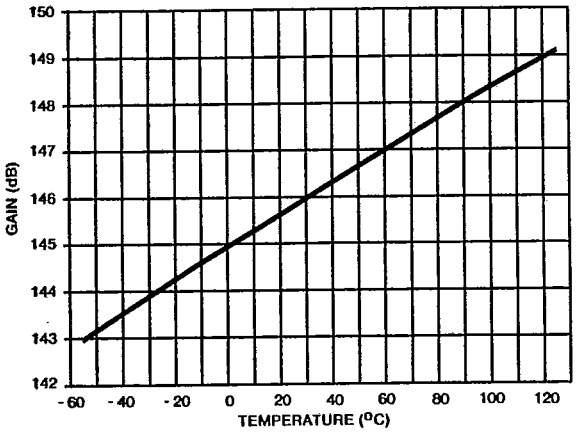
SMALL SIGNAL BANDWIDTH AND PHASE MARGIN vs. LOAD CAPACITANCE
$A_V = +1$



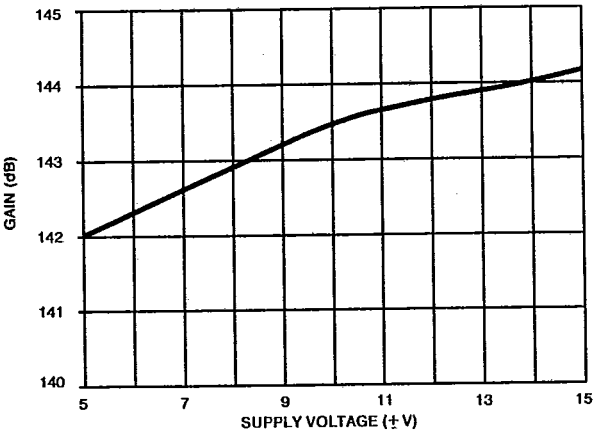
PEAK-TO-PEAK NOISE 0.1Hz TO 10Hz
$A_V = 25{,}000$, $0.22\mu V_{p-p}$ RTI



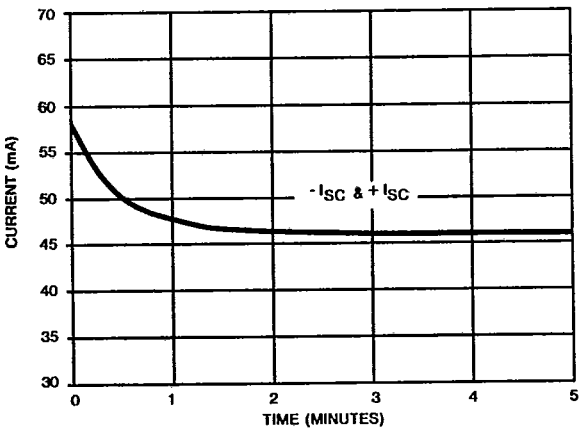
OPEN LOOP GAIN vs. TEMPERATURE



OPEN LOOP GAIN vs. SUPPLY VOLTAGE



OUTPUT SHORT CIRCUIT CURRENT vs. TIME
$V_{IN} = \pm 10V$, $A_V = -1$



Applications Information

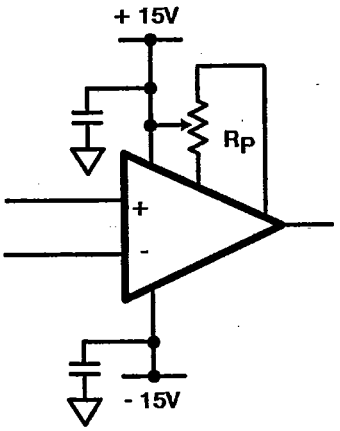
Operation Below ±5V Supply

The HA-5177 performs well down to ±5V supplies.

At ±5V supplies there is a slight degradation of slew rate and open loop gain. There is very little change in bias currents and offset voltage.

Offset Adjustment

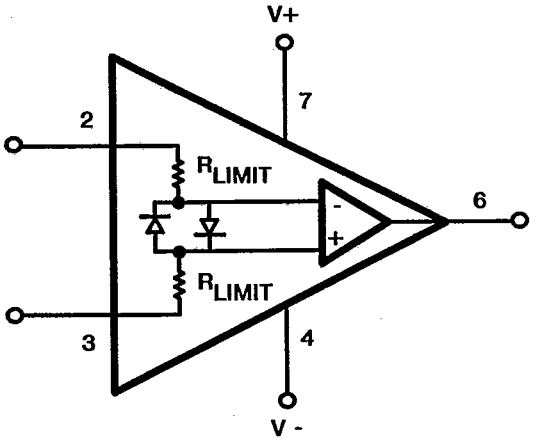
The following is the recommended V_{IO} adjust configuration:



Setting R_P = 20K will give an adjustment range of ±2.6mV.

Input Protection

The HA-5177 input stage has built in back-to-back protection diodes with series current limiting resistors.



The Bias currents will increase when a differential voltage of 0.7 volts is exceeded.

The internal current limiting resistors sufficiently limit current therefore, no external resistors are required.

Refer to the "Bias Current vs. Differential Input Voltage" curve in the Typical Performance Curves section.

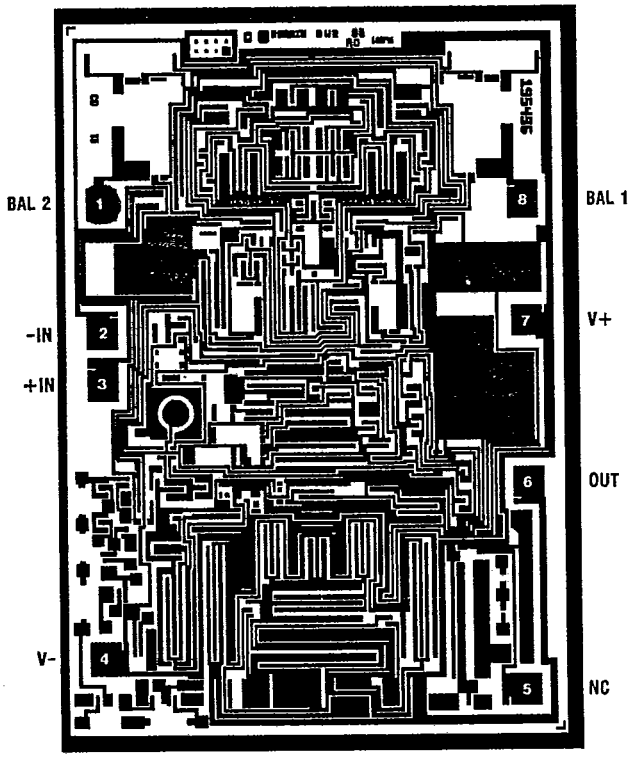
Die Characteristics

Transistor Count	71
Die Dimensions	102 x 71.7 x 19 mils (2590 x 1820 x 485µm)
Substrate Potential*	V-
Process	High Frequency Bipolar DI
Passivation	Silox

Thermal Constants (°C/W)	θ_{ja}	θ_{jc}
Ceramic Mini-DIP, HA7-5177	154	74
Metal Can TO-99, HA2-5177	124	38

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

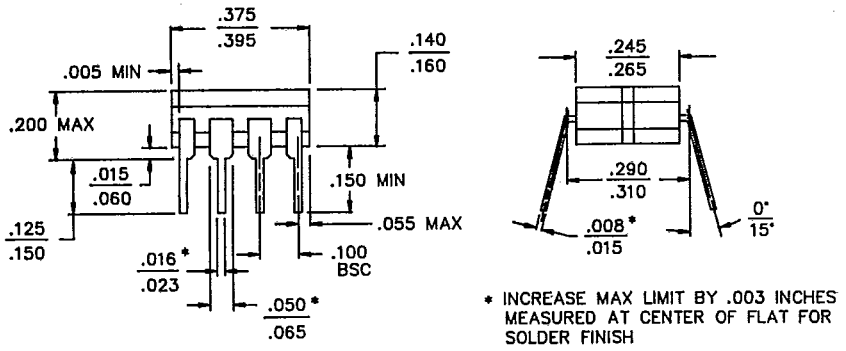
Chip



NOTE: Pad Numbers Indicate 8 Pin Mini-DIP and Metal Can Package Layout.

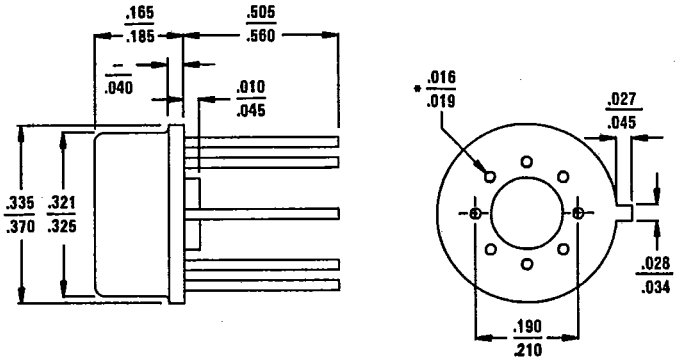
Packaging

8 PIN CERAMIC DIP



* INCREASE MAX LIMIT BY .003 INCHES MEASURED AT CENTER OF FLAT FOR SOLDER FINISH

8 PIN TO-99 METAL CAN



*Dimension Maximum Limits Are Increased by 0.003 inches for Solder Dip Finish

NOTE: All Dimensions are $\frac{\text{Min.}}{\text{Max.}}$, Dimensions are in inches.

Ordering Information (See HA-5177/883 Data Sheet for Military Grade Product)

MODEL NUMBER	OPERATING TEMPERATURE RANGE	PACKAGE DESCRIPTION
HA2-5177-2 HA2-5177A-2 HA7-5177-2 HA7-5177A-2	-55°C to +125°C	8 Lead Metal Can (TO-99) 8 Lead Ceramic Mini-DIP
HA2-5177-7 HA2-5177A-7 HA7-5177-7 HA7-5177A-7	0°C to +75°C	8 Lead Metal Can (TO-99) With Burn-In 8 Lead Ceramic Mini-DIP With Burn-In
HA2-5177-5 HA2-5177A-5 HA7-5177-5 HA7-5177A-5	0°C to +75°C	8 Lead Metal Can (TO-99) 8 Lead Ceramic Mini-DIP

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