HARRIS SEMICONDUCTOR

HA-5177

Ultra-Low Offset Voltage Operational Amplifier

March 1993

Features

- **Low Offset Voltage. 20µV**
- **Low Offset Voltage Drift . . . . 0.2µV/°C**
- **High Voltage Gain 150dB**
- **High CMRR. 140dB**
- **High PSRR 135dB**
- **Low Noise. . . . . 9.0nV/√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 (20µV) and low offset voltage drift (0.2µV/°C). This design also features low voltage noise (9.0nV/√Hz), low current noise (1.2pA/√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.

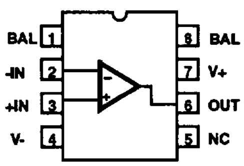
The HA-5177 can be used as a direct replacement for the OP05, OP07, and OP77 while offering higher bandwidth and slew rate. See the HA-5177/883 data sheet for military grade parts and LCC package.

Ordering Information

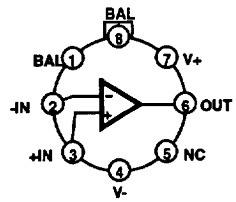
PART NUMBER	TEMPERATURE RANGE	PACKAGE
HA2-5177-2	-55°C to +125°C	8 Pin CAN
HA2-5177-5	0°C to +75°C	8 Pin CAN
HA3-5177-5	0°C to +75°C	8 Lead Plastic DIP
HA7-5177-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5177-5	0°C to +75°C	8 Lead Ceramic DIP
HA9P5177-5	0°C to +75°C	8 Lead SOIC

Pinouts

HA-5177
(PDIP, CDIP, SOIC)
TOP VIEW



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



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

File Number **2913.1**

Absolute Maximum Ratings (Note 1)

Supply Voltage Between V+ and V- Terminals. 44V
Differential Input Voltage. 7V
Output Current . . . . Short Circuit Protected
Junction Temperature. . . . . +175°C
Junction Temperature (Plastic Package) . . . . +150°C
Lead Temperature (Soldering 10 Sec.). . . . . +300°C

Operating Conditions

Operating Temperature Range
HA-5177-2. . . . . $-55°C \le T_A \le +125°C$
HA-5177-5. . . . . $0°C \le T_A \le +75°C$
Storage Temperature Range. . . . . $-65°C \le T_A \le +150°C$

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, Unless Otherwise Specified

PARAMETER	TEMP	HA-5177			UNITS
		MIN	TYP	MAX	
INPUT CHARACTERISTICS					
Offset Voltage	+25°C	-	20	60	µV
	Full	-	40	100	µV
Average Offset Voltage Drift	Full	-	0.2	0.6	µV/°C
Bias Current	+25°C	-	1.2	6	nA
	Full	-	2.4	8	nA
Bias Current Average Drift	Full	-	15	35	pA/°C
Offset Current	+25°C	-	0.6	6	nA
	Full	-	1.0	8	nA
Offset Current Average Drift	Full	-	1.5	50	pA/°C
Common Mode Range	Full	±12	-	-	V
Differential Input Resistance	+25°C	-	47	-	MΩ
Input Noise Voltage 0.1Hz to 10Hz	+25°C	-	0.35	0.6	μV_{P-P}
Input Noise Voltage Density					
f_O = 10Hz	+25°C	-	13	18	$nV/\sqrt{Hz}$
f_O = 100Hz	+25°C	-	10	13	$nV/\sqrt{Hz}$
f_O = 1000Hz	+25°C	-	9	11	$nV/\sqrt{Hz}$
Input Noise Current 0.1Hz to 10Hz	+25°C	-	14	45	pA_{P-P}
Input Noise Current Density					
f_O = 10Hz	+25°C	-	7.1	10	$pA/\sqrt{Hz}$
f_O = 100Hz	+25°C	-	3.3	5	$pA/\sqrt{Hz}$
f_O = 1000Hz	+25°C	-	1.2	2	$pA/\sqrt{Hz}$
TRANSFER CHARACTERISTICS					
Large Signal Voltage Gain (Note 2)	+25°C	126	150	-	dB
	Full	120	140	-	dB
Common Mode Rejection Ratio (Note 3)	Full	110	140	-	dB
Closed Loop Bandwidth (A_{VCL} = +1)	+25°C	0.6	2	-	MHz

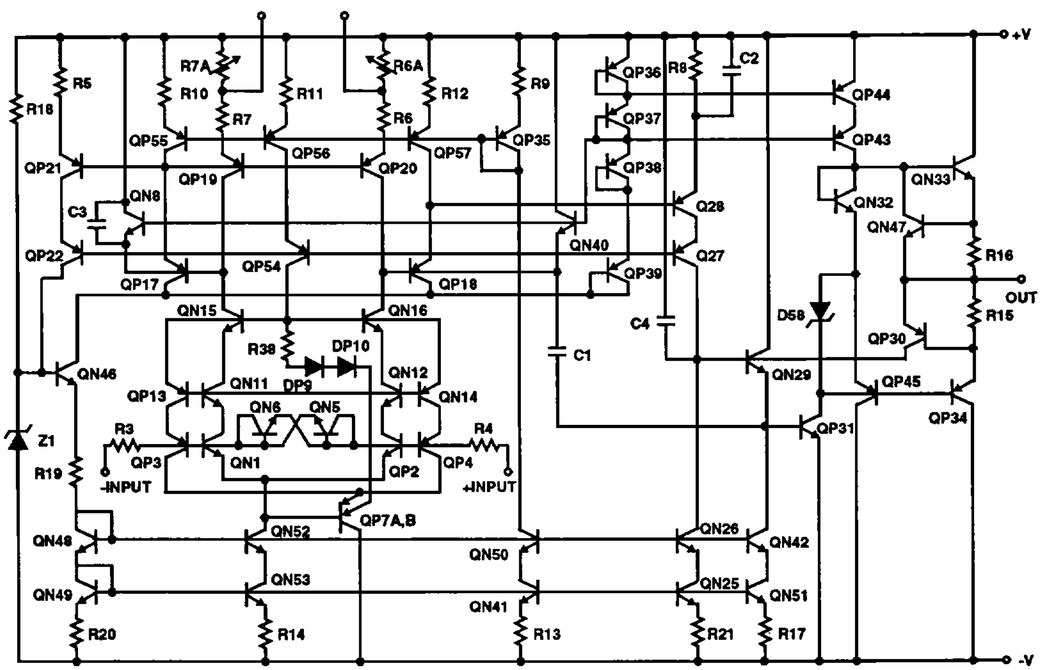
Electrical Specifications V+ = +15V, V- = -15V, Unless Otherwise Specified **(Continued)**

PARAMETER	TEMP	HA-5177 MIN	TYP	MAX	UNITS
OUTPUT CHARACTERISTICS					
Output Voltage Swing					
R_L = 600Ω	+25°C	±10	±12.5	-	V
R_L = 2kΩ	+25°C	±12	±13	-	V
R_L = 2kΩ	Full	±12	±12.5	-	V
Full Power Bandwidth (Note 5)	+25°C	8	10	-	kHz
Output Current (Note 6)	+25°C	15	20	-	mA
Output Resistance	+25°C	-	60	-	Ω
TRANSIENT RESPONSE					
Rise Time (Note 10)	+25°C	-	310	420	ns
Slew Rate (Note 11)	+25°C	0.5	0.8	-	V/µs
Settling Time (Notes 7, 8)	+25°C	-	14	-	µs
Overshoot (Note 10)	+25°C	-	10	40	%
POWER SUPPLY CHARACTERISTICS					
Supply Current	Full	-	1.2	1.7	mA
Power Supply Rejection Ratio (Note 9)	Full	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 = 2kΩ.
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} = ±10V.
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 = 2kΩ, V_{OUT} = ±200mV.
11. A_V = 1, R_L = 2kΩ, V_{OUT} = 0 to ±3V.

Schematic Diagram



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	113	34
TO-99 Metal Can	124	38
Plastic Mini DIP	92	30
SOIC	157	42

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

Test Circuits

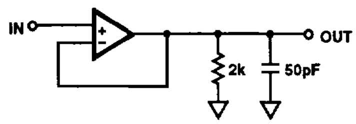


FIGURE 1. SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT

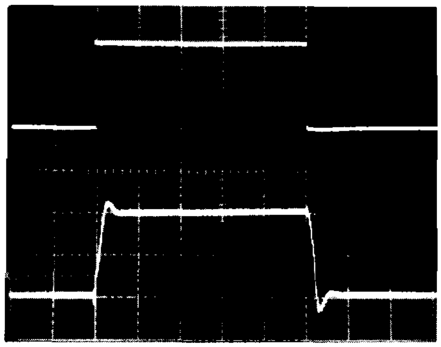


FIGURE 2. SMALL SIGNAL RESPONSE
Vertical Scale: (Volts: 100mV/Div.)
Horizontal Scale: (Time: 2µs/Div.)

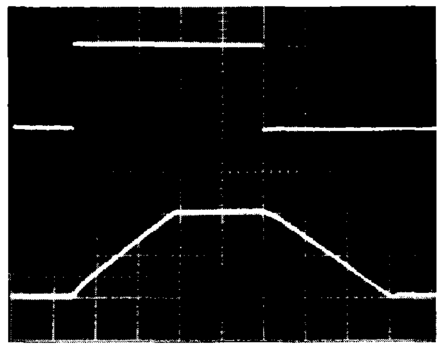
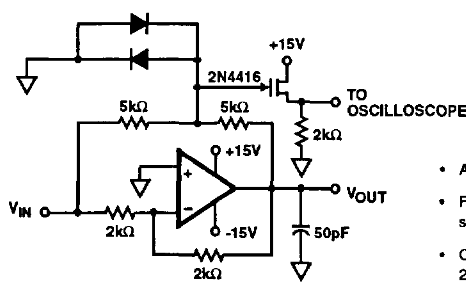


FIGURE 3. LARGE SIGNAL RESPONSE
Vertical Scale: (Volts: 5V/Div.)
Horizontal Scale: (Time: 5µs/Div.)



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

FIGURE 4. SETTLING TIME CIRCUIT

Typical Performance Curves $V_S = \pm15V$, $T_A = +25^oC$

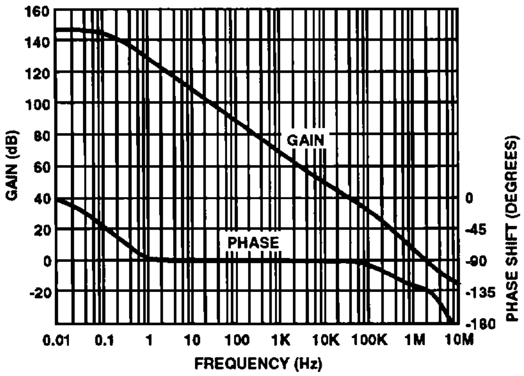


FIGURE 5. OPEN LOOP GAIN AND PHASE vs FREQUENCY

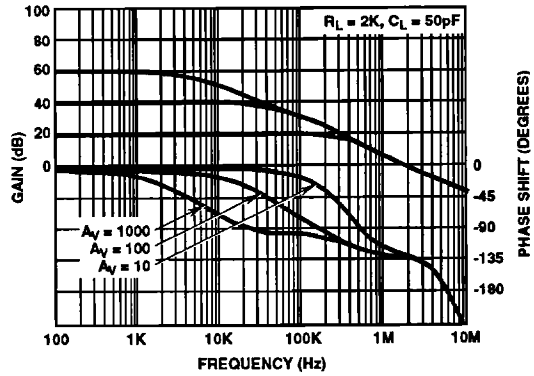


FIGURE 6. VARIOUS CLOSED LOOP GAINS vs FREQUENCY

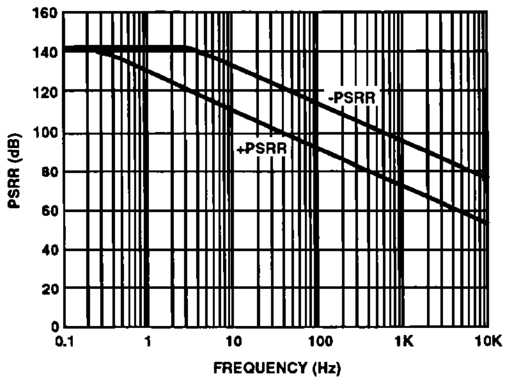


FIGURE 7. PSRR vs FREQUENCY

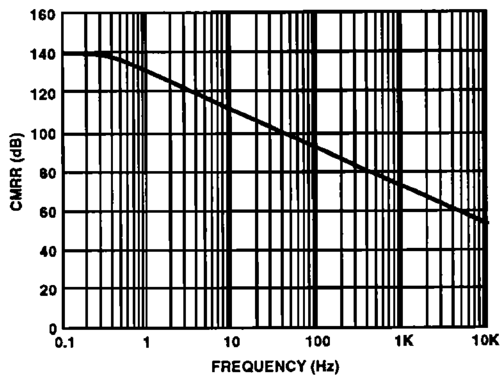


FIGURE 8. CMRR vs. FREQUENCY

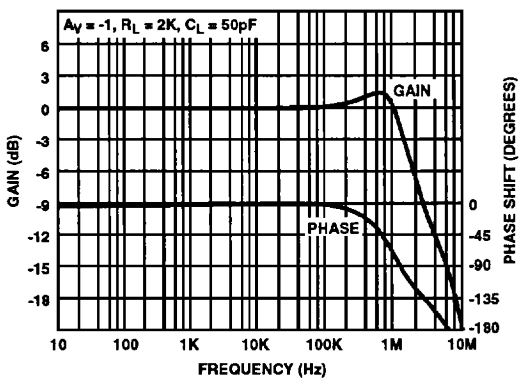


FIGURE 9. CLOSED LOOP GAIN AND PHASE vs. FREQUENCY

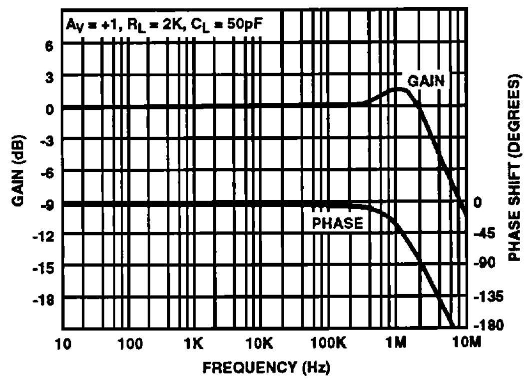


FIGURE 10. CLOSED LOOP GAIN AND PHASE vs. FREQUENCY

Typical Performance Curves $V_S = \pm15V$, $T_A = +25^oC$ (Continued)

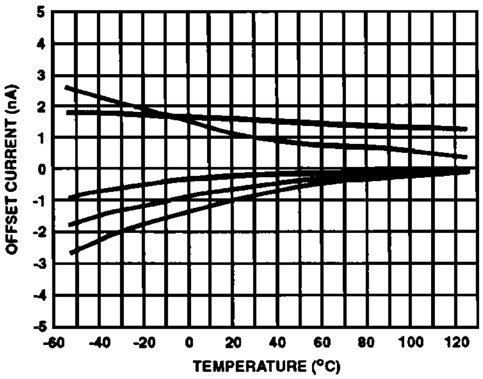


FIGURE 11. OFFSET CURRENT vs TEMPERATURE
Five Representative Units

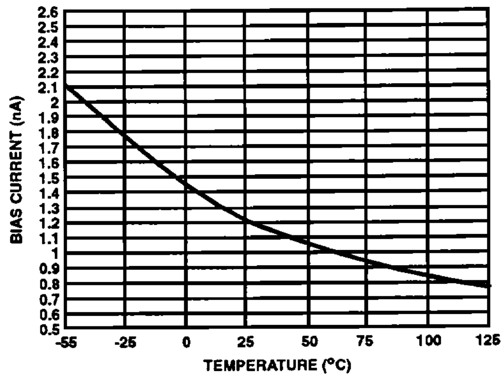


FIGURE 12. BIAS CURRENT vs TEMPERATURE

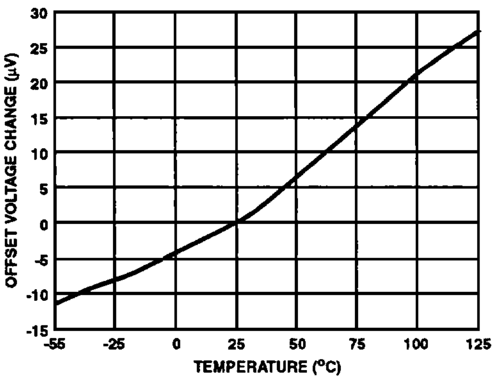


FIGURE 13. OFFSET VOLTAGE vs TEMPERATURE

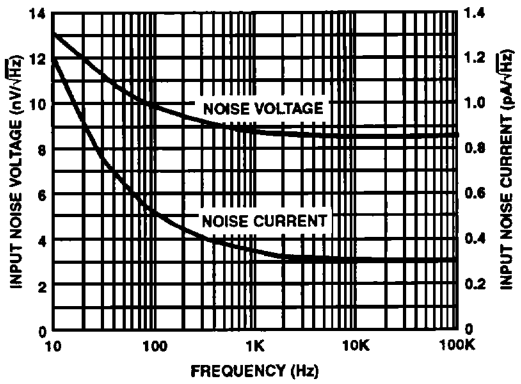


FIGURE 14. INPUT NOISE vs FREQUENCY

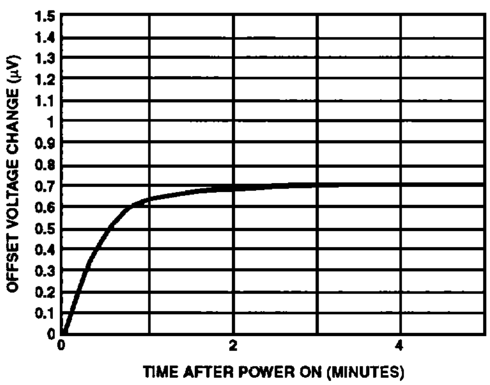


FIGURE 15. OFFSET VOLTAGE WARM-UP DRIFT

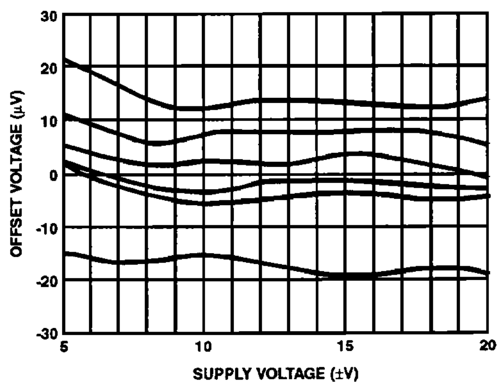


FIGURE 16. OFFSET VOLTAGE vs SUPPLY VOLTAGE
Six Representative Units

Typical Performance Curves $V_S = \pm15V$, $T_A = +25^oC$ (Continued)

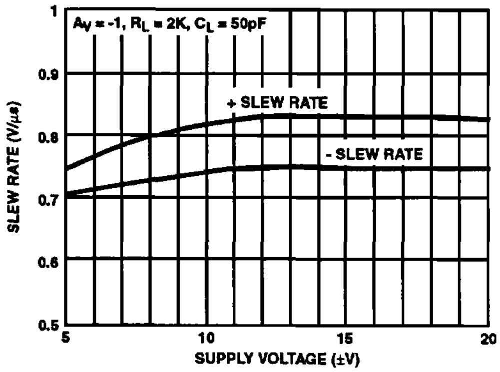


FIGURE 17. SLEW RATE vs. SUPPLY VOLTAGE

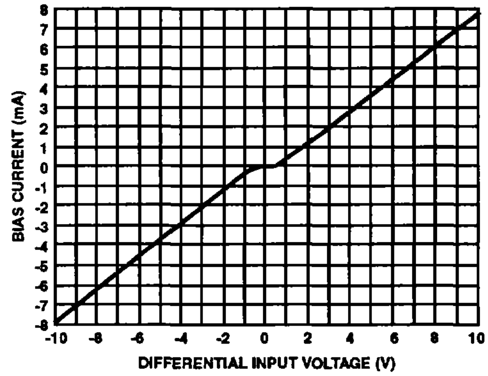


FIGURE 18. BIAS CURRENT vs DIFFERENTIAL INPUT VOLTAGE

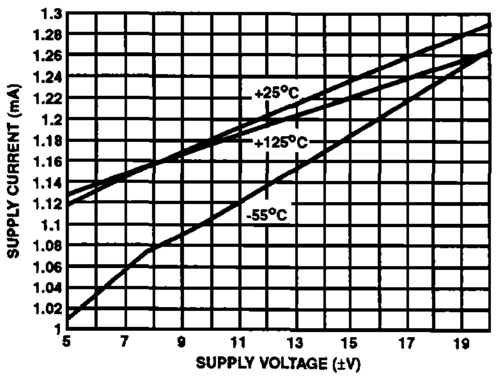


FIGURE 19. SUPPLY CURRENT vs SUPPLY VOLTAGE

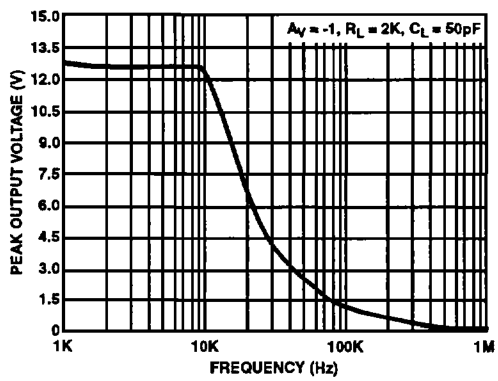


FIGURE 20. OUTPUT VOLTAGE vs FREQUENCY

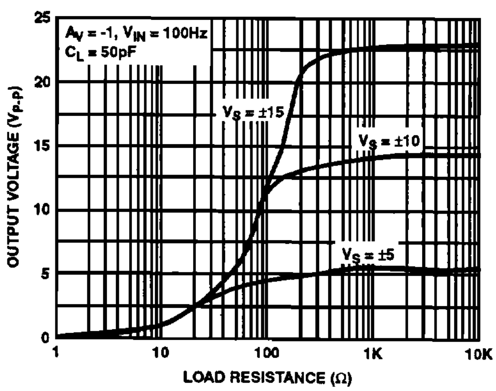


FIGURE 21. OUTPUT VOLTAGE vs LOAD RESISTANCE

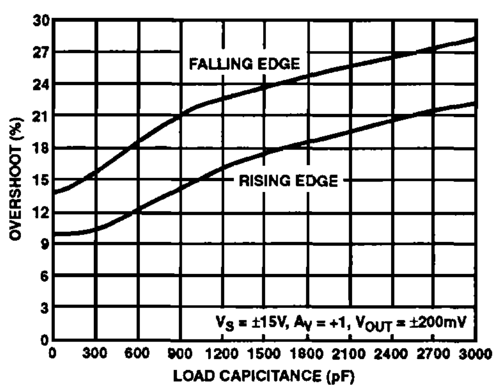


FIGURE 22. OVERSHOOT vs LOAD CAPACITANCE

Typical Performance Curves $V_S = \pm15V$, $T_A = +25^oC$ (Continued)

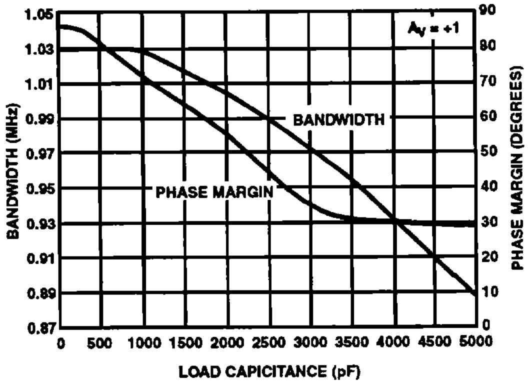


FIGURE 23. SMALL SIGNAL BANDWIDTH AND PHASE MARGIN

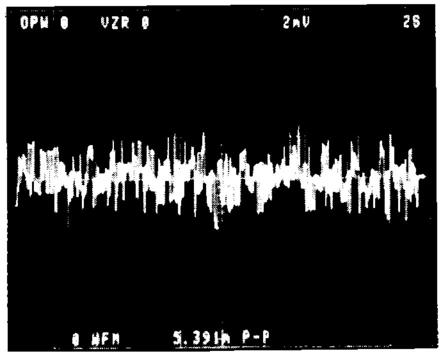


FIGURE 24. PEAK-TO-PEAK NOISE (0.1Hz TO 10Hz)
$A_V = 25,000$, $E_N = 0.22\mu V_{P-P}$ RTI

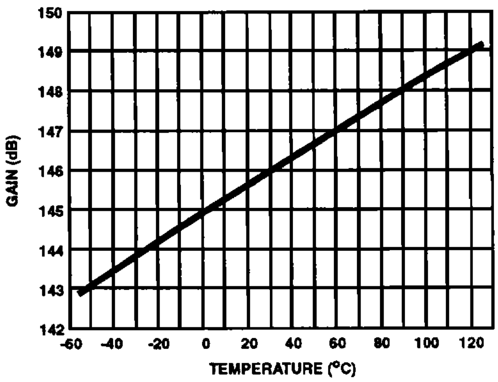


FIGURE 25. OPEN LOOP GAIN vs TEMPERATURE

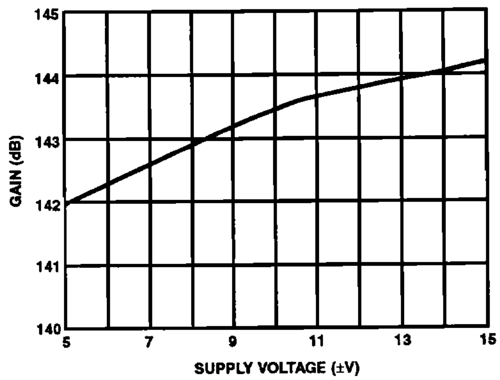


FIGURE 26. OPEN LOOP GAIN vs SUPPLY VOLTAGE

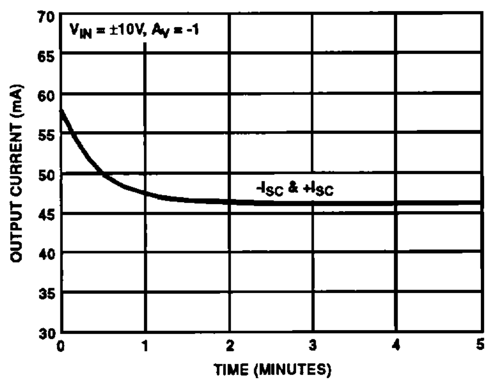


FIGURE 27. OUTPUT SHORT CIRCUIT CURRENT vs TIME

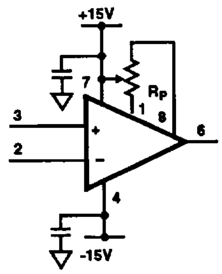
Applications Information

Operation Below 15V 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

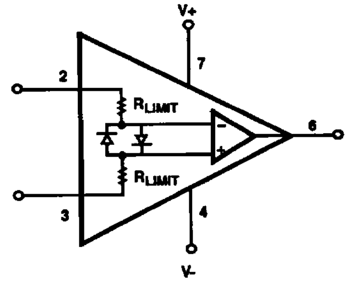
The following is the recommended V_{IO} adjust configuration:



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

2

OPERATIONAL AMPLIFIERS