HARRIS SEMICONDUCTOR

HA-5130, HA-5135

April 1993

Precision Operational Amplifiers

Features

- **Low Offset Voltage....................... 25µV Max**
- **Low Offset Voltage Drift .... 0.4µV/°C**
- **Low Noise............................. 9nV/√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	PACKAGE
HA2-5130-2	-55°C to +125°C	8 Pin Can
HA2-5130-5	0°C to +75°C	8 Pin Can
HA2-5135-2	-55°C to +125°C	8 Pin Can
HA2-5135-5	0°C to +75°C	8 Pin Can
HA7-5130-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5130-5	0°C to +75°C	8 Lead Ceramic DIP
HA7-5135-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5135-5	0°C to +75°C	8 Lead Ceramic DIP

Description

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

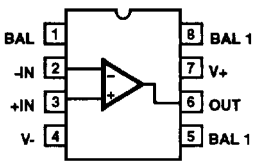
A Super Beta input stage is combined with laser trimming, dielectric isolation and matching techniques to produce 25µV (Maximum) input offset voltage and 0.4µV/°C input offset voltage average drift. Other features enhanced by this process include 9nV/√Hz (Typ.) Input Noise Voltage, 1nA Input Bias Current 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/µs 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.

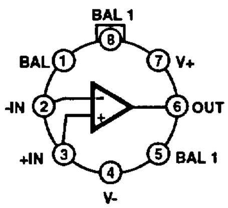
HA-5130/5135 offers added features over the industry standard OP-07 in regards to bandwidth and slew rate specifications. For the military grade product, refer to the HA-5135/883 data sheet.

Pinouts

HA-5130/5135 (CDIP)
TOP VIEW

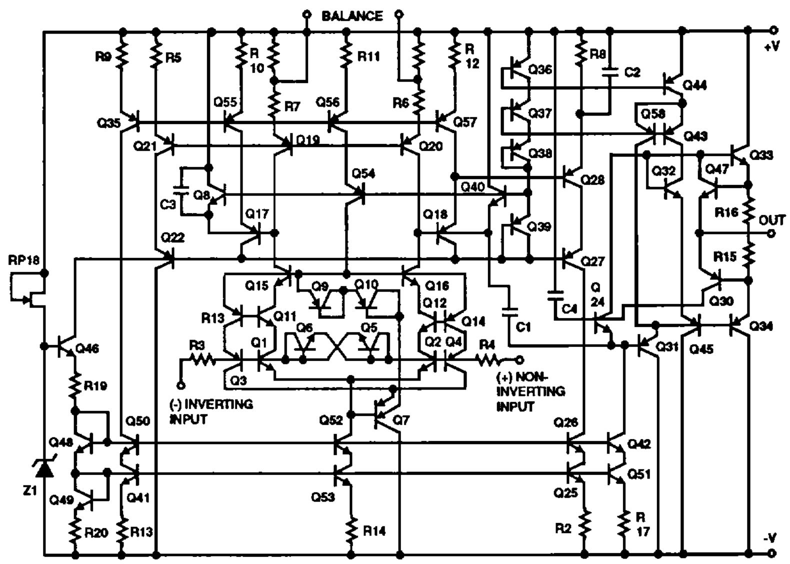


HA-5130/5135 (TO-99 CAN)
TOP VIEW



(Both BAL 1 pins are connected together internally)

Schematic Diagram



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

File Number **2907.1**

Absolute Maximum Ratings

T_A = +25°C Unless Otherwise Stated

Voltage Between V+ and V- Terminals 40.0V
Differential Input Voltage 7V
Output Short Circuit Duration .... Indefinite
Junction Temperature (Note 1) .... +175°C
Lead Temperature (Soldering 10 Sec.) .... 300°C

Operating Conditions

Operating Temperature Ranges
HA-5130/5135-2 .... -55°C ≤ T_A ≤ +125°C
HA-5130/5135-5 .... 0°C ≤ T_A ≤ +75°C
Storage Temperature Range .... -65°C ≤ T_A ≤ +150°C

Thermal Resistance (°C/W)	θ_{JA}	θ_{JC}
Ceramic DIP Package	113	34
TO-99 Metal Can	108	33

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

PARAMETER	TEMP	HA-5130-2/-5			HA-5135-2/-5			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS								
Offset Voltage	+25°C	-	10	25	-	10	75	µV
	Full	-	50	60	-	50	130	µV
Average Offset Voltage Drift	Full	-	0.4	0.6	-	0.4	1.3	µV/°C
Bias Current	+25°C	-	±1	±2	-	±1	±4	nA
	Full	-	-	±4	-	-	±6	nA
Bias Current Average Drift	Full	-	0.02	0.04	-	0.02	0.04	nA/°C
Offset Current	+25°C	-	-	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	±12	-	-	±12	-	-	V
Differential Input Resistance	+25°C	20	30	-	20	30	-	MΩ
Input Noise Voltage 0.1Hz to 10Hz (Note 2)	+25°C	-	-	0.6	-	-	0.6	μV_{P-P}
Input Noise Voltage Density (Note 2)								
f = 10Hz	+25°C	-	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 0.1Hz to 10Hz (Note 2)	+25°C	-	15	30	-	15	30	pA_{P-P}
Input Noise Current Density (Note 2)								
f = 10Hz	+25°C	-	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	$pA/\sqrt{Hz}$
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Note 3)	+25°C	120	140	-	120	140	-	dB
	Full	120	-	-	120	-	-	dB
Common Mode Rejection Ratio (Note 4)	Full	110	120	-	106	120	-	dB
Closed Loop Bandwidth (A_{VCL} = +1)	+25°C	0.6	2.5	-	0.6	2.5	-	MHz

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

PARAMETER	TEMP	HA-5130-2/-5 MIN	HA-5130-2/-5 TYP	HA-5130-2/-5 MAX	HA-5135-2/-5 MIN	HA-5135-2/-5 TYP	HA-5135-2/-5 MAX	UNITS
OUTPUT CHARACTERISTICS								
Output Voltage Swing (Note 5)	+25°C	±10	±12	-	±10	±12	-	V
	Full	±10	-	-	±10	-	-	V
Full Power Bandwidth (Note 6)	+25°C	8	10	-	8	10	-	kHz
Output Current (Note 7)	+25°C	±15	±20	-	±15	±20	-	mA
Output Resistance (Note 8)	+25°C	-	45	-	-	45	-	Ω
TRANSIENT RESPONSE (Note 9)								
Rise Time	+25°C	-	340	-	-	340	-	ns
Slew Rate	+25°C	0.5	0.8	-	0.5	0.8	-	V/µs
Settling Time (Note 10)	+25°C	-	11	-	-	11	-	µs
POWER SUPPLY CHARACTERISTICS								
Supply Current	Full	-	1.0	1.7	-	1.0	1.7	mA
Power Supply Rejection Ratio (Note 11)	Full	100	130	-	94	130	-	dB

NOTES:

1. Maximum power dissipation, including output load, must be designed to maintain the maximum junction temperature below +175°C.
2. Not tested. 90% of units meet or exceed these specifications.
3. V_{OUT} = ±10V; R_L = 2K. Gain dB = 20 $\log_{10} A_V$.
   ∴ 120dB = 1MV/V
   140dB = 10MV/V
4. V_{CM} = ±10V DC
5. R_L = 600Ω.
6. R_L = 2K; Full power bandwidth guaranteed based on slew rate measurement using $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$
7. V_{OUT} = 10V
8. Output resistance measured under open loop conditions (f = 100Hz).
9. Refer to test circuits section of the data sheet.
10. Settling time is measured to 0.1% of final value for a 10V output step and A_V = -1.
11. V_{SUPPLY} = ±5V DC to ±20V DC.

Test Circuits

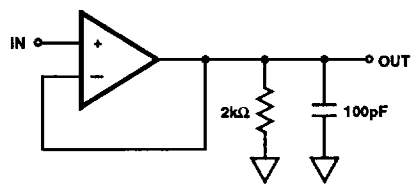


FIGURE 1. SLEW RATE AND TRANSIENT RESPONSE TEST CIRCUIT

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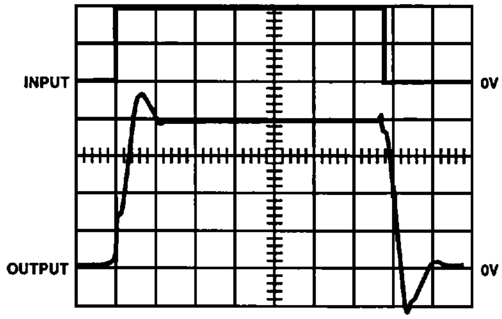
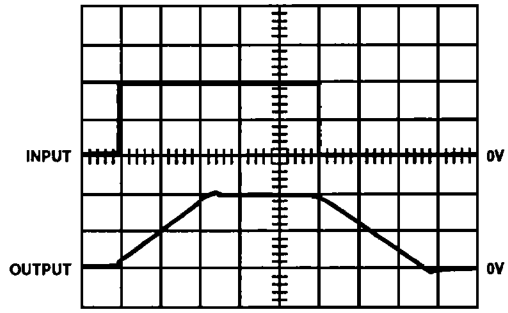
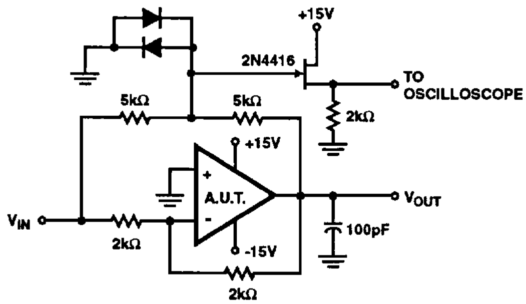
Test Circuits (Continued)

SMALL SIGNAL RESPONSE
Vertical Scale: Volts: 50mV/Div. Output
Volts: 100mV/Div. Input
Horizontal Scale: Time: 1µs/Div.



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 2. SETTLING TIME CIRCUIT

Typical Performance Curves

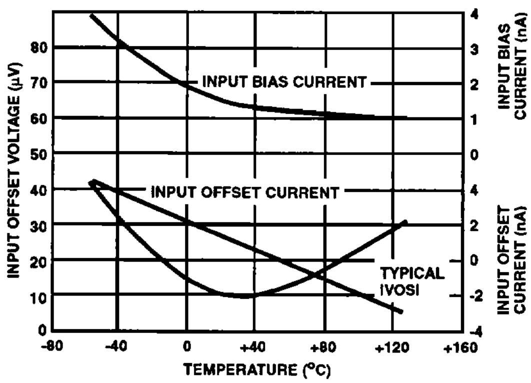


FIGURE 3. INPUT OFFSET VOLTAGE INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE

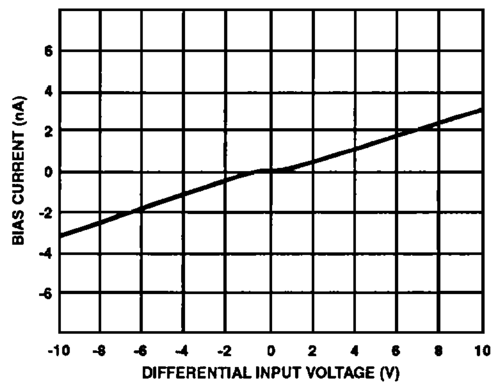


FIGURE 4. INPUT BIAS CURRENT vs DIFFERENTIAL INPUT VOLTAGE

Typical Performance Curves (Continued)

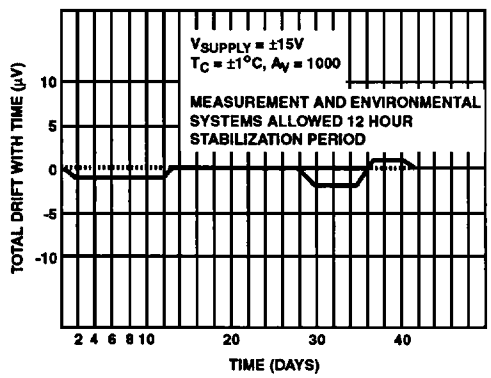


FIGURE 5. HA-5130 OFFSET VOLTAGE STABILITY vs TIME

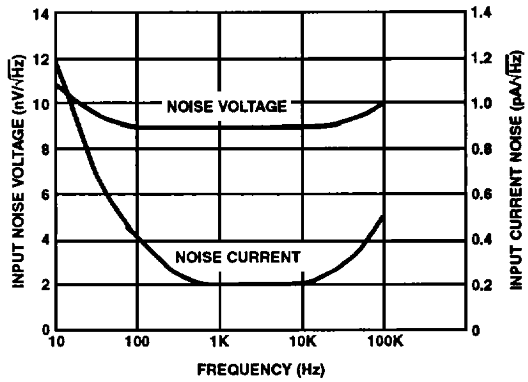


FIGURE 6. INPUT NOISE vs FREQUENCY

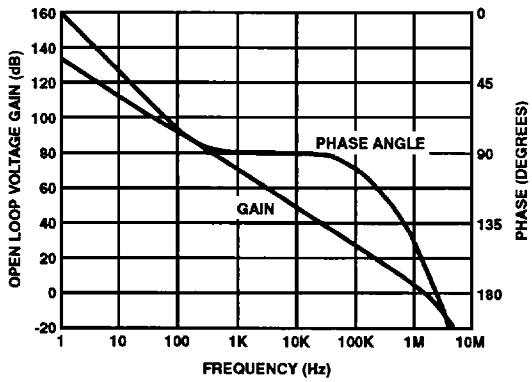


FIGURE 7. OPEN LOOP FREQUENCY RESPONSE

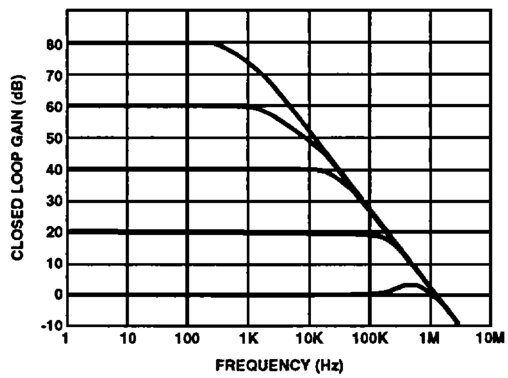


FIGURE 8. CLOSED LOOP FREQUENCY RESPONSE FOR VARIOUS CLOSED LOOP GAINS

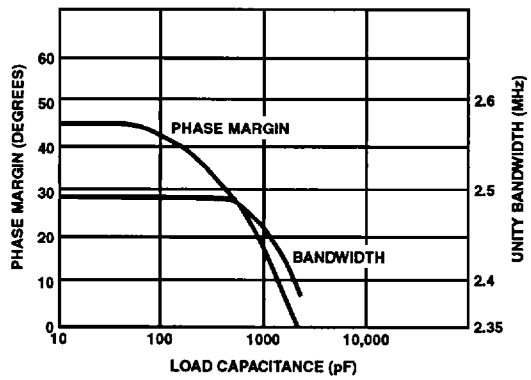


FIGURE 9. SMALL SIGNAL BANDWIDTH AND PHASE MARGIN vs LOAD CAPACITANCE

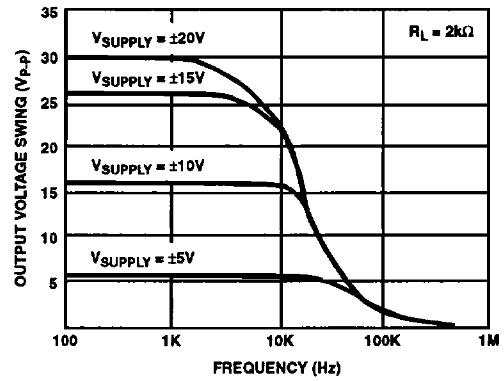


FIGURE 10. OUTPUT VOLTAGE SWING vs FREQUENCY AND SUPPLY VOLTAGE

Typical Performance Curves (Continued)

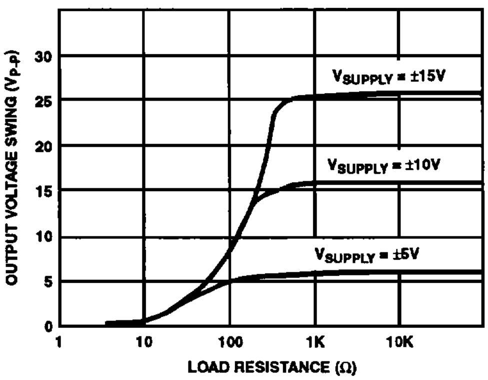


FIGURE 11. MAXIMUM OUTPUT VOLTAGE SWING vs LOAD RESISTANCE AND SUPPLY VOLTAGE

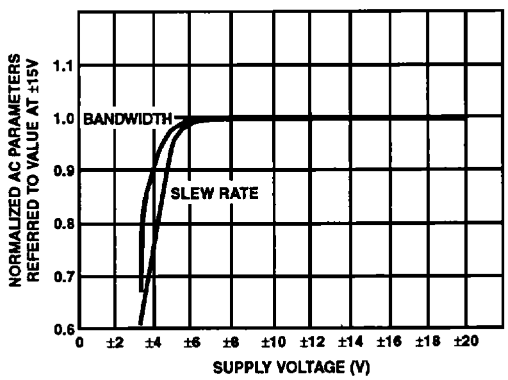


FIGURE 12. NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE

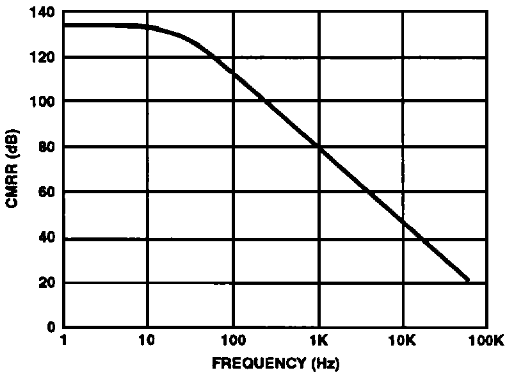


FIGURE 13. CMRR vs FREQUENCY

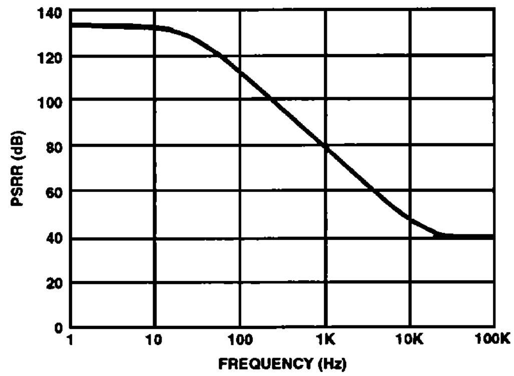


FIGURE 14. PSRR vs FREQUENCY

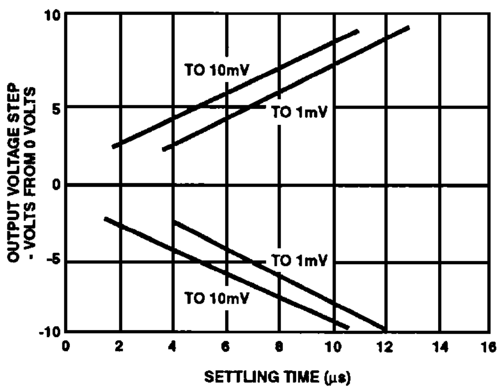


FIGURE 15. SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES

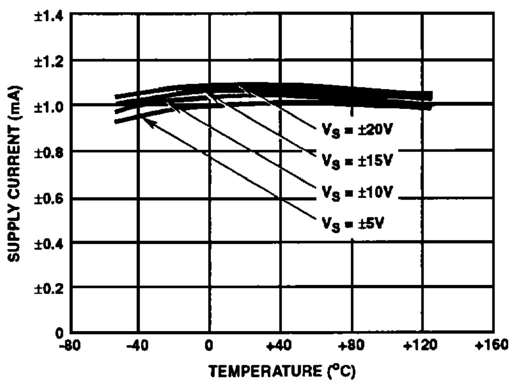


FIGURE 16. POWER SUPPLY CURRENT vs TEMPERATURE AND SUPPLY VOLTAGE

Applying the HA-5130, HA-5135 Operational Amplifiers

1. 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.

2. CONSIDERATIONS FOR PROTOTYPING: The following list of recommendations are suggested for prototyping.

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

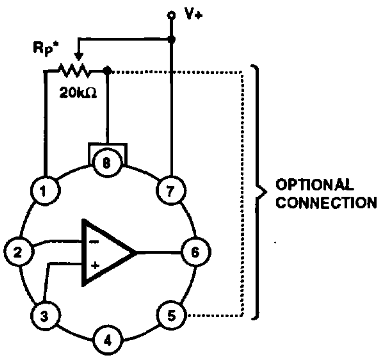
3. When driving large capacitive loads (> 500pF), a small value resistor (≈50Ω) should be connected in series with the output and inside the feedback loop.

4. OFFSET VOLTAGE ADJUSTMENT: A 20kΩ balance potentiometer is recommended if offset nulling is required. However, other potentiometer values such as 10kΩ, 50kΩ and 100kΩ may be used. The minimum adjustment range for given values is ±2mV.

5. 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.

6. 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.

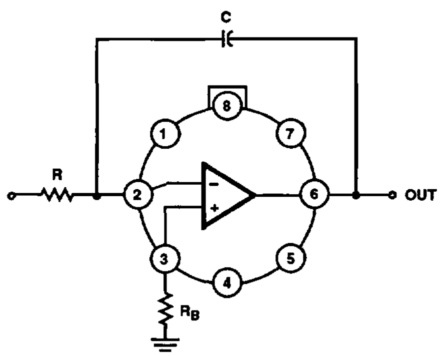
Applications



* Although R_P is shown equal to 20kΩ, other values such as 50kΩ, 100kΩ and 1kΩ may be used. Range of adjustment is approximately ±2.5mV. V_{OS} TC of the amplifier is optimized at minimal V_{OS}.

Tested Offset Adjustment is $|V_{OS} + 1mV|$ minimum referred to output.

FIGURE 17. OFFSET NULLING CONNECTIONS

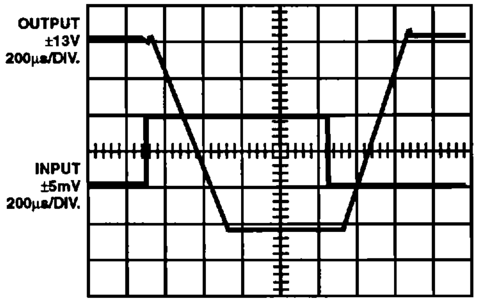


The excellent input and gain characteristics of HA-5130 are well suited for precision integrator applications. Accurate integration over seven decades of frequency using HA-5130, virtually nullifies the need for more expensive chopper-type amplifiers.

FIGURE 18. PRECISION INTEGRATOR

2
OPERATIONAL AMPLIFIERS

Applications (Continued)



Low V_{OS} coupled with high open loop Gain, high CMRR and high PSRR make HA-5130 ideally suited for precision detector applications.

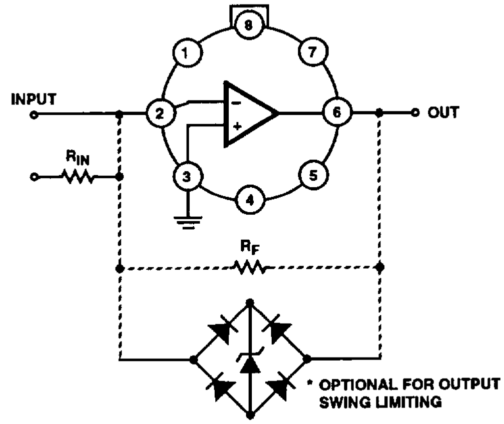


FIGURE 19. ZERO CROSSING DETECTOR

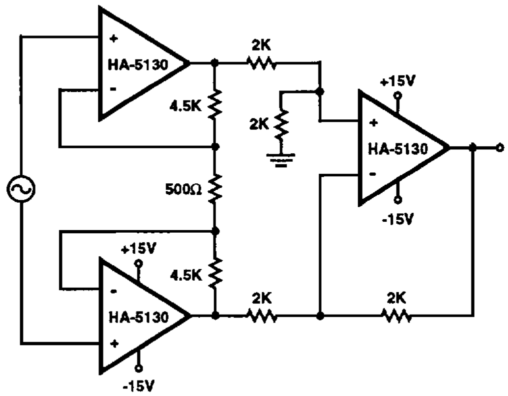


FIGURE 20. PRECISION INSTRUMENTATION AMPLIFIER (A_V = 100)