



**Optical Electronics  
Incorporated**

**AH0013**

DATA AND SPECIFICATIONS  
DESCRIPTION AND INSTRUCTIONS

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## LINEAR LOW-NOISE FET INPUT WIDEBAND PRE-AMPLIFIER

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### FEATURES

- HIGH CONTROLLED GAIN: 35dB Typ
- VERY LOW NOISE:  $2 \text{ nV}/\sqrt{\text{Hz}}$
- HIGH SPEED:  $400 \text{ V}/\mu\text{sec}$  Typ
- WIDE BANDWIDTH: 100 MHz
- LOW SUPPLY CURRENT: +10mA @ gain 30
- FET INPUT:  $10^{11} \Omega$
- SINGLE POWER SUPPLY: +15V nominal

### APPLICATIONS

- INFRARED DETECTION
- LOW NOISE AMPLIFICATION
- ANALOG TO DIGITAL CONVERSION
- SONAR APPLICATION
- AUDIO PREAMPLIFIERS
- ULTRASONIC APPLICATIONS

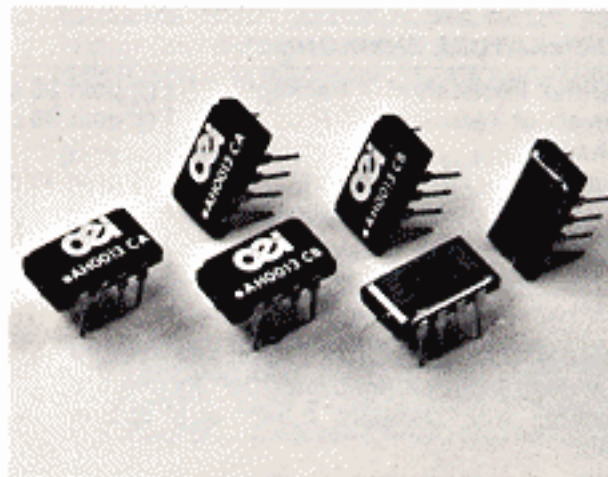
### DESCRIPTION

The AH0013 is a linear wideband preamplifier with a very low noise characteristic. Its typical noise voltage spectral density is  $800 \text{ pV}/\sqrt{\text{Hz}}$  measured at an operating frequency of 1 MHz. With proper external component selection the AH0013 has a usable bandwidth in excess of 100 MHz.

Only two standard, and therefore easily obtainable capacitors, are required to set lower and upper frequency rolloff. Simple RL, RC or LC circuits connected externally allow the use of the unit as a tuned amplifier with narrow to wide bandwidths, as active low, high, or bandpass filter or as an inverting amplifier. Its high speed allows applications in the digital design area as well.

These features have been made possible by the hybrid design which employs a very low noise FET coupled to a unity gain amplifier.

The standard 8-pin mini-dip package allows easy application of the amplifier for low noise requirements in commercial and military sonar devices. Audio preamplifiers, where low noise coupled with high usable gain and frequency



field, (sonar imaging) where frequencies in the range of 2 to 10 MHz are required, can take advantage of all main features of the device.

Further applications offer themselves in the areas of infrared detection, where extremely small temperature differentials must be detected over a wide frequency range, and in commercial as well as in military communications equipment. The low noise and high speed of the AH0013 also make it useful in digital applications for example

response are required, present a large applications area. Ultrasonic equipment in the medical

for low noise amplification and level setting for analog to digital (A/D) converters.

## SPECIFICATIONS

### ELECTRICAL

Specifications at  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = \pm 15\text{VDC}$  unless otherwise noted.

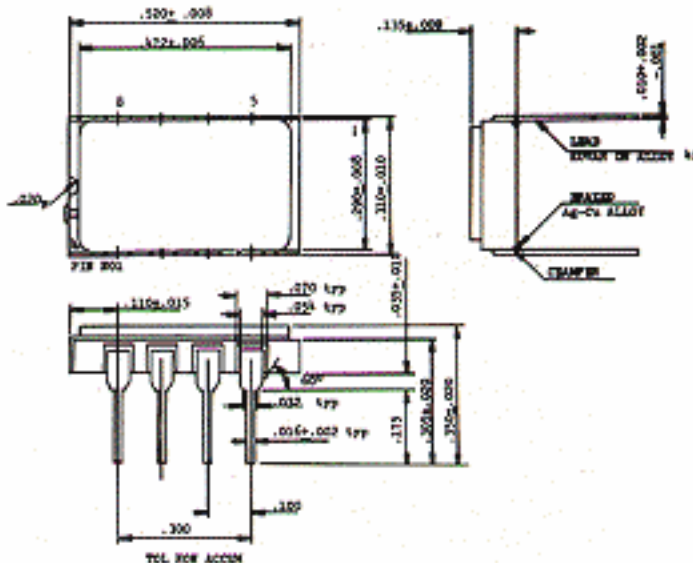
MODEL		AH0013			
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
<b>VOLTAGE GAIN</b>					
		0	35		dB
<b>INPUT</b>					
Resistance			$10^{11}$		$\Omega$
Voltage	@ gain 30 dB		$\pm 1$		V
Bias Current	@ gain 30 dB		+50		pA
Noise Spectral Density					
Noise Voltage AH0013CA/MA	SEE GRAPH FOR NOISE VS FREQUENCY & FIGURE 7 FOR TEST CIRCUIT		1.5	2	$\text{nV}/\sqrt{\text{Hz}}$
AH0013CB/MB			2.5	3	$\text{nV}/\sqrt{\text{Hz}}$
Noise Current			10		$\text{fA}/\sqrt{\text{Hz}}$
Capacitance			4		pF
<b>OUTPUT</b>					
Voltage Swing	@ gain 30 dB		3		V(P-P)
Load Resistance				50	$\Omega$
Load Current			5	7.5	mA
Output Resistance			50		$\Omega$
Load Capacitance				10	nF
<b>FREQUENCY RESPONSE</b>					
Slewing Rate	@ gain 30 dB	350	400		$\text{V}/\mu\text{sec}$
Full Output Frequency			20		MHz
Overload Recovery Time			100		ns
Gain Bandwidth Product			100		MHz
<b>TEMPERATURE ENVIRONMENT</b>					
Thermal Resistance of Package	@ gain 30 dB			65	$^\circ\text{C}/\text{W}$
Quiescent Temperature Rise	@ gain 30 dB		13		$^\circ\text{C}$
Voltage		+6	+15	+18	V
Quiescent Supply Current	@ gain 30 dB		10		mA
Quiescent Power Dissipation			150		mW
Socket	8 pin dual inline standard				
MTBF-per-MIL-HDBK-217C-GF	692,000 hrs.				

**MECHANICAL DESCRIPTION:** The AH0013 is a standard 8-pin, ceramic mini-DIP. Its pins are compatible with standard 0.3-in. dual in-line sockets.

AH0013MA and AH0013MB are rated at  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  and are sealed with metal lids.

AH0013CA and AH0013CB are rated at  $0^\circ\text{C}$  to  $+70^\circ\text{C}$  and are epoxy sealed with ceramic lids.

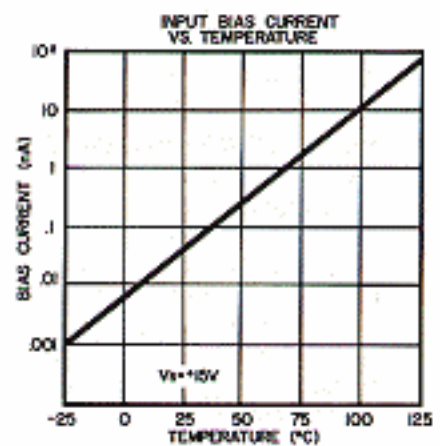
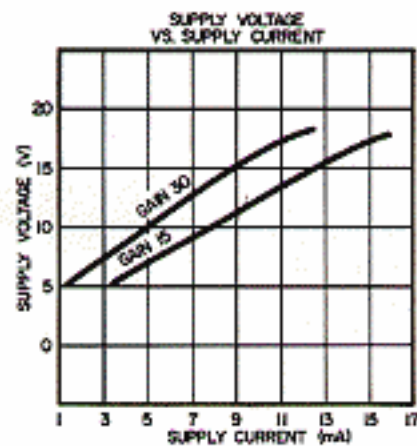
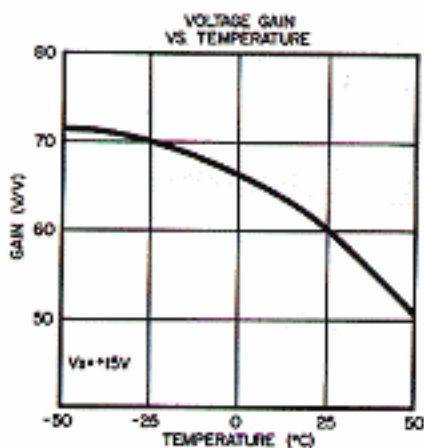
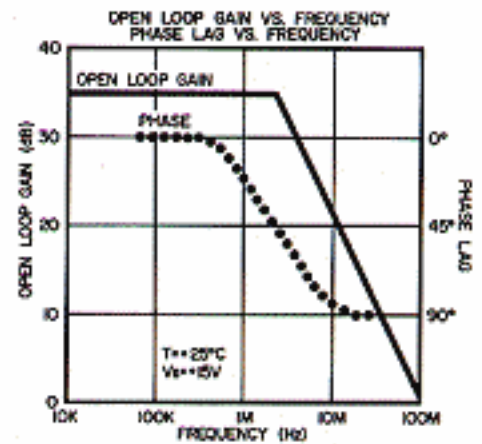
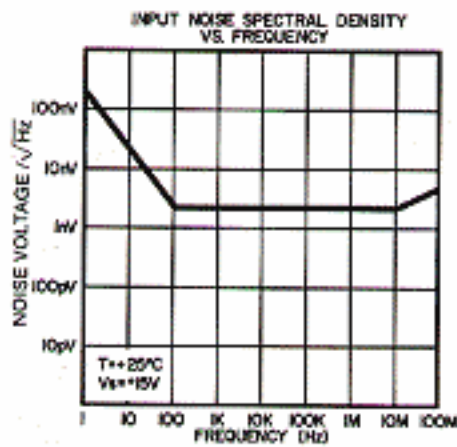
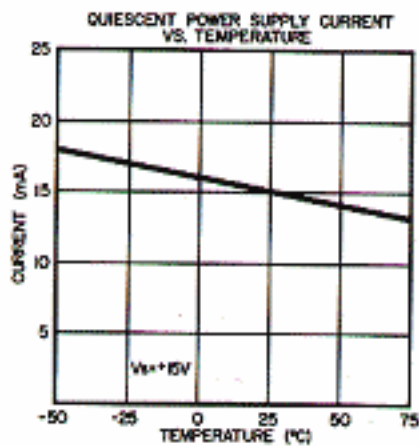
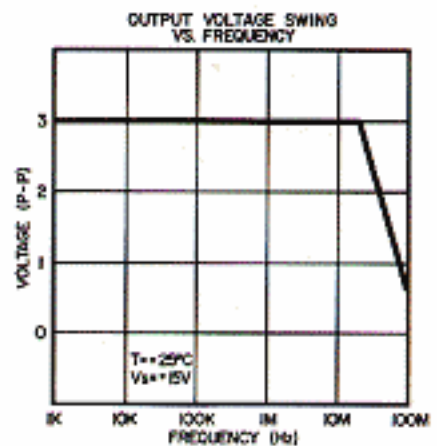
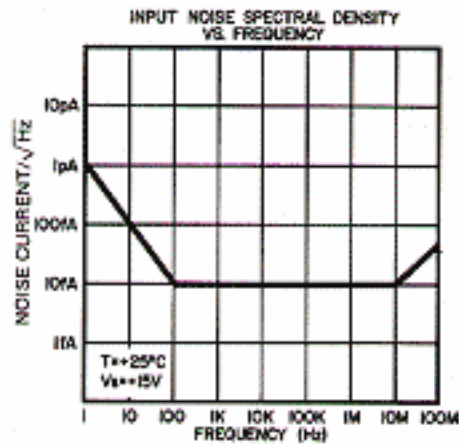
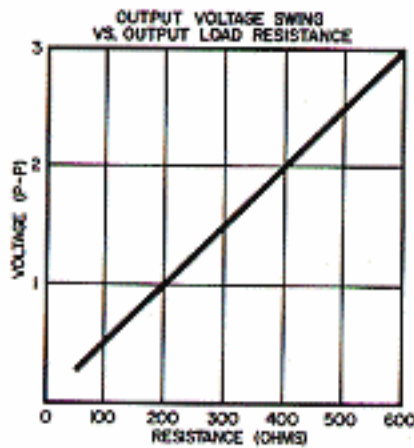
PIN CONNECTIONS	
1	DECOUPLE
2	GAIN ELEMENT
3	INPUT
4	COMMON
5	BYPASS
6	OUTPUT
7	SUPPLY
8	NO CONNECTIONS





# AH0013 TYPICAL PERFORMANCE CURVES

( $T_A = +25^\circ\text{C}$ ,  $V_{CC} = \pm 15\text{VDC}$  unless otherwise noted)



The information in this publication has been carefully checked and is believed to be reliable; however, no responsibility is assumed for possible inaccuracies or omissions. Prices and

specifications are subject to change without notice. No patent rights are granted to any of the circuits described herein.

## GENERAL, Typical Applications

Basic connections for the AH0013 are shown in figure 1.

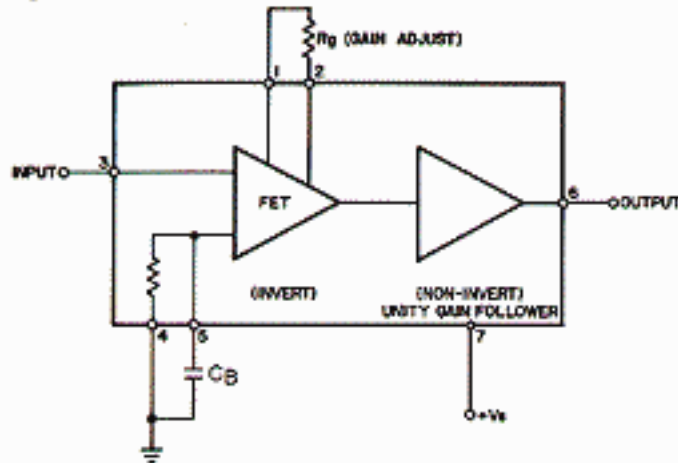


FIGURE 1: BASIC CONNECTIONS

The diagram for a general application of the AH0013 is presented in figure 2. As can be seen only a +15 VDC (nominal) power supply is required. In order to keep noise input at its lowest the power supply ripple should not be more than 250 $\mu$ V. Additionally three capacitors are connected to pin 7. Typically a 15 $\mu$ F tantalum, a 0.1 $\mu$ F ceramic, and 330 pF silver mica (or glass composition) capacitor should be connected together to provide most effective supply noise suppression. These capacitors together with the common mode rejection of the device itself should provide sufficient filtering. Capacitors, as all other external components, should be mounted as closely as possible to the device.

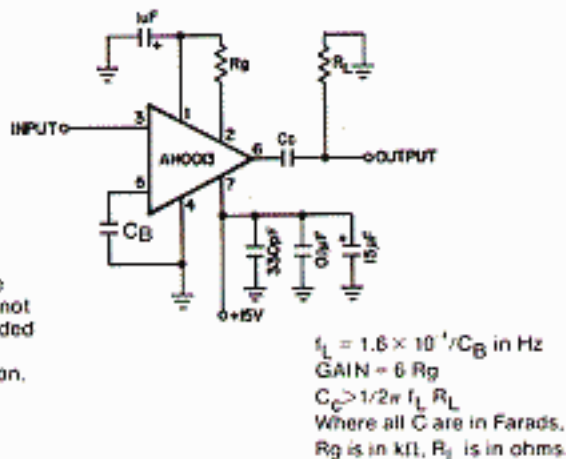


FIGURE 2: TYPICAL APPLICATION

The input line must be shielded up to the pin and kept as short as possible to minimize noise pickup from external sources. The output line and

$R_G$  between pins 1 and 2. If  $R_G$  were chosen to be 5.1k $\Omega$  the resulting gain would be in the order of 28 to 32 (approximately 30 dB) with a linear frequency response to 7 MHz. The lower frequency rolloff point will be discussed below.  $R_G$  is series connected to a device internal resistor in a voltage divider arrangement and thus determines essentially the current into the device. An increase in  $R_G$  will result in an increase in gain of the AH0013. Since this will cause a smaller current the output voltage swing will drop as dictated by the two voltage divider resistors mentioned above. A bypass capacitor between pin 1 and ground will help retain the noise characteristics of the device.

The decrease in output voltage swing could, of course, be countered by appropriate biasing. This is, however, not recommended because biasing the device will unnecessarily introduce additional noise which is not desirable for the applications for which the AH0013 is intended. Further, it should be remembered the increased  $R_G$  values will also introduce additional Johnson noise. The recommended procedure is to make a tradeoff between gain and allowable noise and follow the AH0013 with an additional low noise stage of amplification with a device, that would also provide the necessary drive for other stages or signal processing.

To take full advantage of the low noise characteristics of the device, metal film resistors and capacitors of the kind mentioned above should be employed. Also, a metal housing should be considered, to electromagnetically shield the complete stage from the environment, thus preserving the low noise characteristic of the device.

Although the AH0013 is essentially DC coupled and can be used in such applications, the useful noise figures are somewhat higher at the low end of the frequency range. Therefore, employment of the AH0013 as an AC coupled device is recommended. The lower rolloff frequency is determined by capacitor  $C_B$  connected between pins 4 and 5 (5 and ground). The equations for this frequency  $f_L$  (-3 dB point), the gain and the output coupling capacitor are given in figure 2. Since there is a small bias current into the front end of the AH0013 the source must provide DC continuity or the input must be designed to provide this current.

## LOW LEVEL LIGHT SENSOR

The AH0013 is shown here in an application that requires a high gain coupled with a wide band-

the associated passive devices are more noise immune (depending on output impedance of course) and can thus be treated with somewhat less care (see typical PC board layout pg. 8). However, overall performance of a system will depend on each of its stages. The gain of the AH0013 is determined by the value of the resistor

requires a high gain coupled with a wide bandwidth for a fast response such as photo diode or photo multiplier outputs demand. The circuit is also usable in this form for pulsed laser receivers, fast signal conditioners for A/D converter inputs, and other areas where low signal levels must be amplified with very small noise figures.



The input device in this case is a current source. Since the AH0013 is to be considered a voltage amplifier the source should provide the very small bias current required.

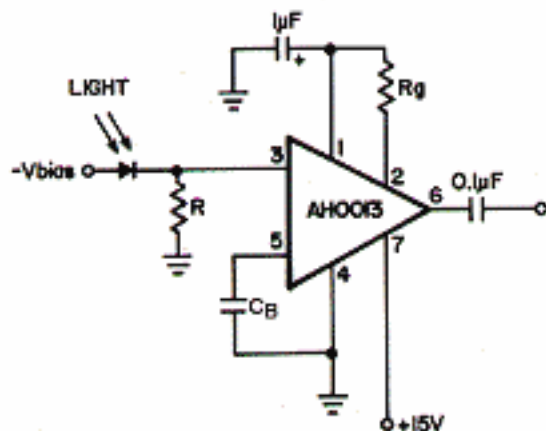
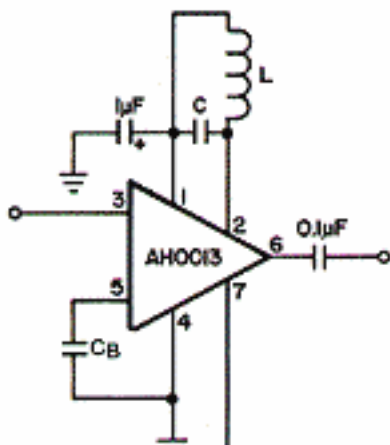


FIGURE 3: LOW LEVEL LIGHT SENSOR

The source current is "converted" to a voltage with the input resistor R. The remainder of the circuit is designed as has been discussed above. R<sub>G</sub>, connected between pins 1 and 2, sets the gain. The capacitor between pin 1 and ground provides, together with the capacitors on pin 7 (not shown), power supply decoupling and the capacitor between pins 4 and 5 determines the lower rolloff frequency. Should it be desirable to roll off an upper frequency, an additional capacitor can be connected between pin 2 and ground. With this arrangement linearity within ¼dB is obtainable over the whole required frequency range. Shielding and mounting precautions mentioned above must be observed to preserve the inherent ultra low noise characteristic of the AH0013.

### SHARP FREQUENCY RESPONSE

In some applications it is desirable to design for a peak gain at a given frequency or a peak gain over a narrow frequency range. These features are easily obtainable with the AH0013 as is shown in the following two diagrams.



pending on the Q of the tank circuit in the feedback loop of the AH0013 (pins 1 and 2), very sharp resonance can be obtained with equally sharp rolloff. Damping the LC circuit will, of course, also widen the overall frequency response. For an even broader response the capacitor can be replaced by a resistor. This circuit is then usable as a bandpass filter. The upper frequency rolloff can still be adjusted by use of a capacitor between pin 2 and ground.

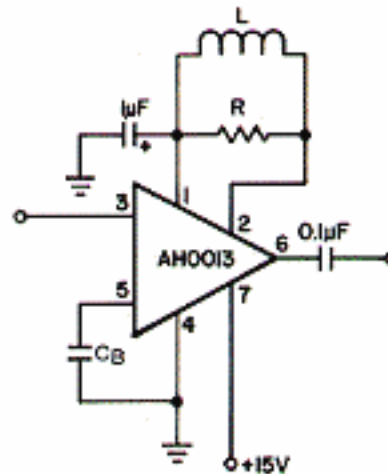
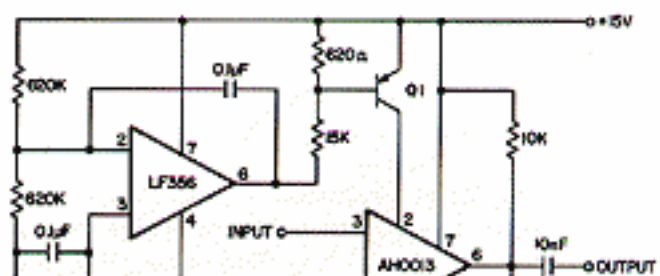


FIGURE 5: TUNED CIRCUIT FOR ULTRASONIC APPLICATIONS

The lower limit can be set with C<sub>B</sub> between pin 5 and ground as has previously been discussed. In any applications involving inductive elements, special care must be taken to shield these parts from the electromagnetic environment to prevent noise pickup detrimental to the overall performance of the device in the circuit. Power supply decoupling, although not shown in either diagram, is also mandatory for the same reasons.

### ACTIVE GAIN ELEMENT, GAIN 100

To obtain large gain figures, a reasonable output voltage swing and frequency range at low noise figures and without having to resort to biasing, the following application shows the use of a "rivet" circuit. The diagram depicts an active gain element for a very low noise audio amplifier with approximately 40dB of gain. This gain is achieved by use of a combination of a level setting integrator circuit and the AH0013 as follows:



$\bar{=}$  0 +15V

FIGURE 4: LC GAIN ELEMENTS FOR SHARP  
RESONANT FREQUENCY RESPONSE

The first one could be used in an active filter design where a peak and a sharp rolloff on either side of the design frequency is required. De-

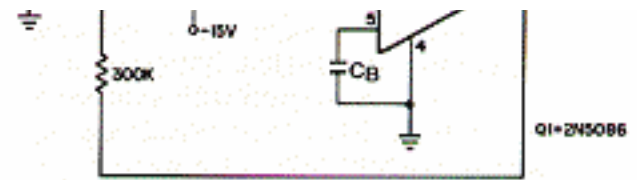


FIGURE 6: ACTIVE GAIN ELEMENT FOR AUDIO  
PREAMPLIFIER WITH APPROX. 100 GAIN



A low noise LF356 is used in an integrator circuit. The two 620k $\Omega$  resistors between +15V and ground together with the 0.1 $\mu$ F capacitor in the feedback loop (inverting input) will cause the LF356 to settle to a given DC voltage after a few time constants.

The output at pin 6 of this integrator becomes at this time a stable DC voltage as well. This voltage together with the 15k $\Omega$  and the 620 $\Omega$  resistor between pin 6 and the +15 volt supply voltage determines the bias on the transistor Q. Q is typically chosen to be a 2N5086 or an equivalent transistor.

The current, set by this base bias and multiplied by the gain of Q, is then the current into pin 2 of the AH0013 which in essence sets the gain of this stage.

The output of the AH0013 (pin 6) is taken and fed back to the non-inverting input of the LF356 via the 300k $\Omega$  resistor. Putting a capacitor between pin 3 of the LF356 and grounding the non-inverting input will help stabilize the LF356. Thus the current will be set by the first stage transistor Q. Stabilization of that current over frequency then results in a very stable gain figure over frequency of the complete preamplifier stage.

It should be noted that the stage is intended for amplification of small signals. Large signals will tend to compress the output and gain figures of 100 can no longer be achieved.

Also, of course, the usual power supply bypass and the shielding precautions mentioned earlier must be observed. The lower rolloff frequency is still determinable by  $C_B$ . A typical capacitor of 1.5 $\mu$ F will result in a 6dB/octave frequency rolloff point of 400 Hz. The output coupling capacitor and the capacitors in the integrator stage have little effect on the frequency.

## NOISE PERFORMANCE MEASUREMENTS

Measurements of noise performance, noise figures and other noise related measurements are generally difficult to perform. Additionally, different measurement methodologies will yield different results and can lead to misunderstandings. For this reason, OEI has developed a schematic diagram in order to perform these measurements.

The diagram below shows how the various components are connected together. Metal film resistors and tantalum, silver mica or glass composition capacitors should be used close to the devices. The circuit is not critical but should not be directly exposed to strong external electromagnetic fields to prevent noise pickup.

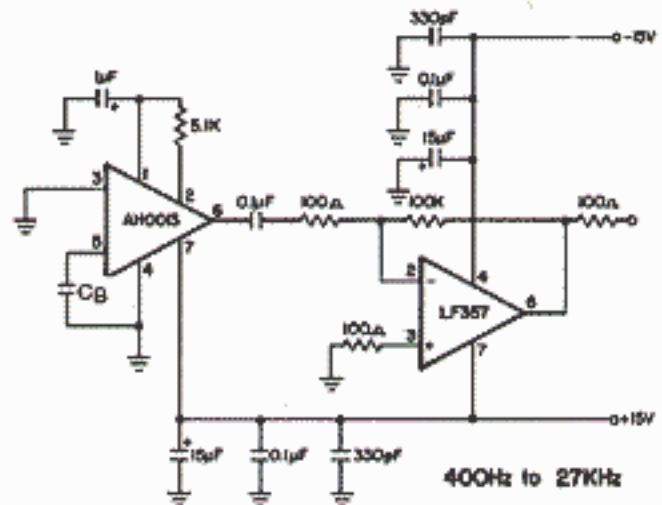


FIGURE 7: AH0013 TEST FOR NOISE

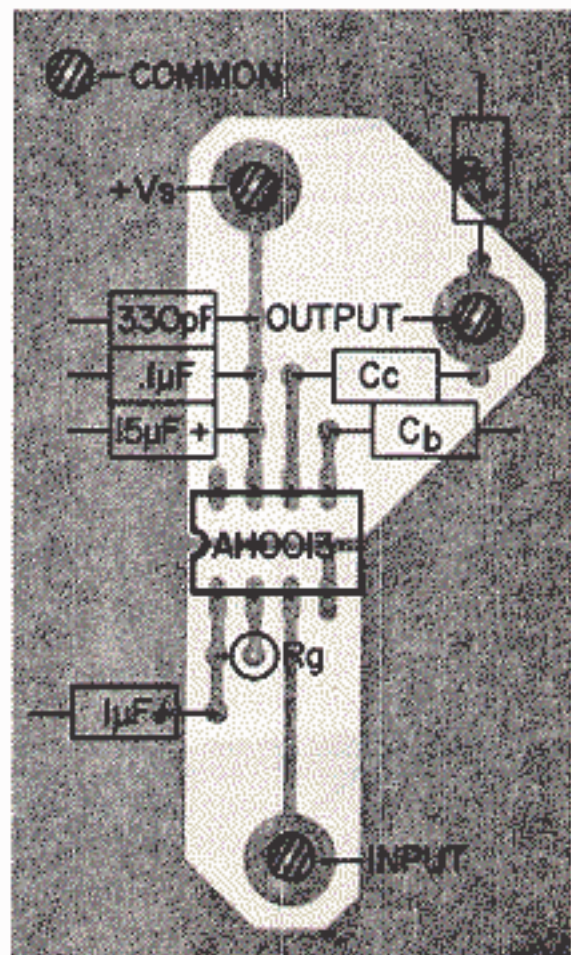


FIGURE 8: TYPICAL BOARD LAYOUT