a HEICO company

ANALOG MODULES, INC.

Specialists in Analog and Laser Electronics

MODEL 311/341 SERIES AMPLIFIERS
APPLICATION/OPERATING NOTES

CIRCUIT DESCRIPTION

The Model 311 series of low-noise amplifiers comprise three stages:

1. A transimpedance virtual ground preamplifier
2. A non-inverting amplifier
3. A selectable inverting or non-inverting current output stage

Each stage has negative feedback to ensure high accuracy. This arrangement is ideal for converting a peak current source such as a photo-detector into an amplified voltage output.

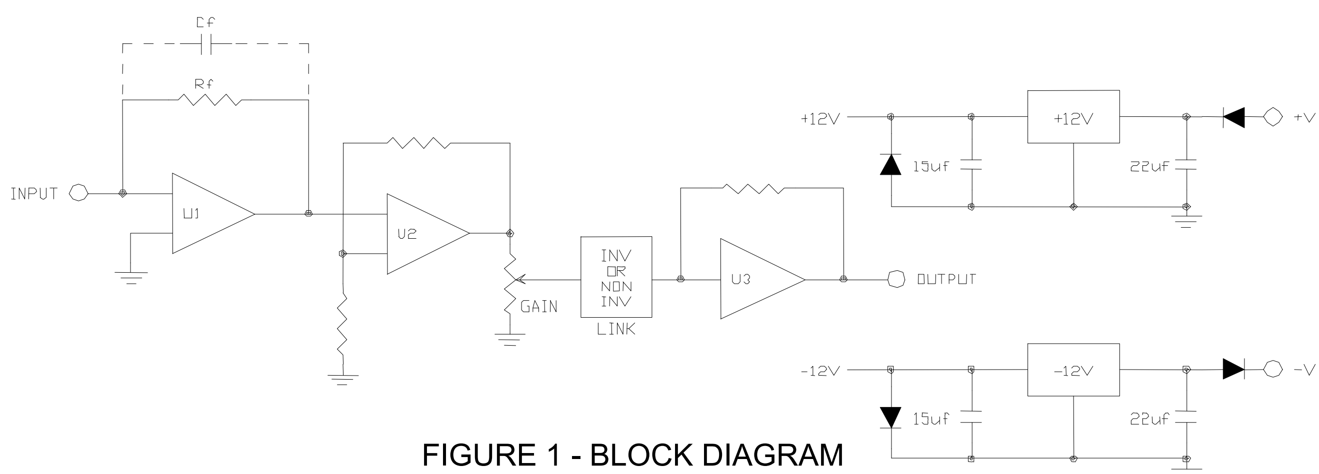


FIGURE 1 - BLOCK DIAGRAM

The components used in the different models are selected for voltage and current noise to provide an optimum combination of noise, gain and bandwidth.

Models ending in -1 and -2 do not have the middle gain stage because of high preamplifier gain. The 341 Models are dc coupled throughout. Model 311 has 34µF, 6V non-polarized capacitor in series with the output, and a 1µF, 50V ceramic capacitor in series with the input.

CONNECTIONS

A ± 15 volt supply is recommended with a common ground return connected to the ground lug at the power input pin/filter. The power leads should be lightly twisted as a triple from the amplifiers to the power supply.

126 BAYWOOD AVENUE ♦ LONGWOOD, FL 32750-3426 ♦ USA
(407) 339-4355 ♦ FAX (407) 834-3806 ♦ E-mail: ami@analogmodules.com
www.analogmodules.com

Series and shunt diodes are used to protect the electronics from reversed power connections. No current will be drawn in such an event. The positive and negative power supplies should be applied simultaneously. In a few cases, regulator latch-up can occur on misapplication of power. AMI has fitted low conductance diodes across the regulator outputs to prevent this, but it is good practice to apply both power supplies simultaneously.

If lower voltage power supplies are applied, generally the amplifier will work, but with reduced output swing. The regulators will saturate resulting in less rejection of noise from the power lines, and the dc offset adjustments may not be valid. High supply voltages result in increased regulator dissipation inside the amplifier box and may result in a thermal shutdown if continuously high output currents are being driven into the load. The simplest solution is to add 15 volts pre-regulators to power the amplifier.

INPUT

These amplifiers are designed to be used with current inputs. It is possible to convert them into a voltage amplifier by adding a series resistor to the input. Generally, lower noise will be achieved from voltage sources by selecting the 320 or 350 range of amplifiers.

Input connections are critical to the performance of any amplifier and useful hints are published in our Application/Operating Note 300-1.

The main problems concerning current input amplifiers are those of capacitance and source leakage.

Input Capacitance

Capacitance across the input of these virtual ground amplifiers causes a midband frequency boost and loss of bandwidth. The frequency boost can be cancelled by adding a small capacitor C_f across the feedback resistor of U1, R_f. The noise also increases at high frequencies due to current flow in the input capacitance caused by the input voltage noise of the amplifier. It is important to minimize input capacitance for the best performance and AMI fits a low-capacitance input feedthrough pin as standard. BNC or SMA connectors may be fitted on request at the time of ordering, but add about 5pf to the input capacitance. Graphs of noise and bandwidth performance versus input capacitance are given on the data sheet.

Input DC Current (Model 341)

The leakage or dc current flow of the source affects the interfacing of the amplifier input. With the dc coupled amplifiers (341), the maximum input current is the peak output voltage swing divided by the transimpedance gain in ohms. Exceeding this current will cause output saturation. Possible solutions to this problem are to specially reduce the gain, or to draw current away from the input in an opposite sense to that from the sensor to back off the input current to the amplifier. This may be done with a high value resistor to a voltage source (Figure 2a) or with an active current source (Figure 2b). Using high value resistors results in less thermal (Johnson) current noise, at the expense of dissipation and a higher voltage reference. Metal film type resistors should be used with a quite and well-decoupled voltage reference. Active current sources may be made from a transistor with emitter resistor. The current is set by the base voltage. Low-noise, low-capacitance devices are necessary with the highest possible emitter resistor and well-decoupled base voltage.

Input DC Current (Model 311-3)

The 311 series is fitted with a 1μF 50V blocking capacitor. Current sources with biasing arrangements, which provide a bias current return and do not exceed ± 50V may be directly connected to the 311 (Figure 2c). Higher voltages require the input capacitor rating be increased. Remove the four screws securing the lid and change the 1μF, 50V capacitor wired to the input pin.

If a photoconductive photodiode with dc leakage or background light is connected to the input, the blocking capacitor will charge up and gradually reduce the bias across the detector. Two alternative connections are possible. If the input leakage or light dc currents are below the values specified below, then the input capacitor may be removed and replaced with a short circuit (Figure 2d). These currents are based on a 4V loss in peak swing at the output due to dc offsets in the amplifier chain. The offset trimpot adjustment may be set to minimize the loss of swing.

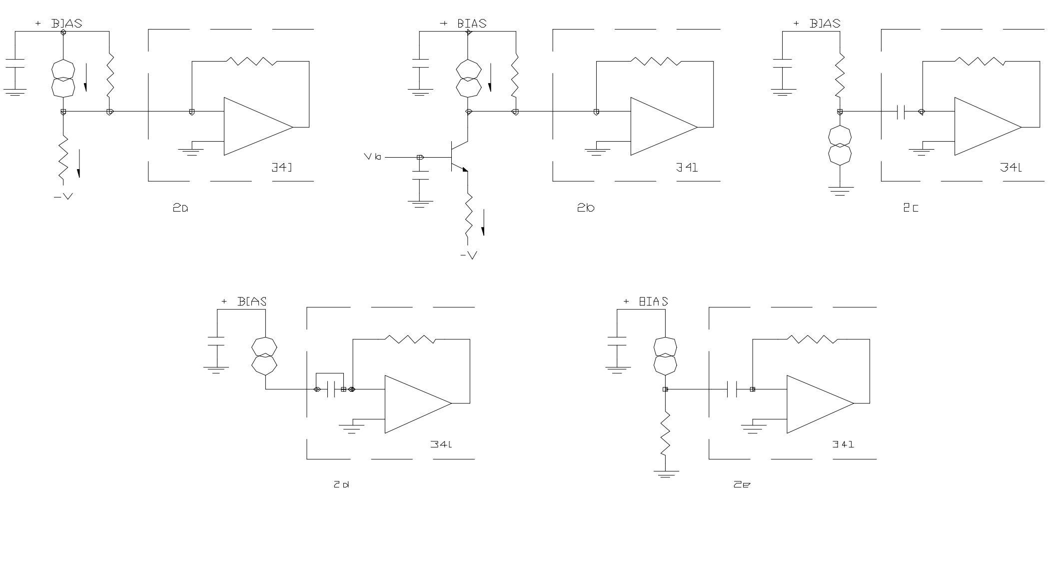
Maximum Input dc Current with Input Capacitor Shorted

Model	311-2(10M)	311-2(100M)
Input dc Current	0.4μA	40nA

If a capacitor is fitted in series with the input to the mid stage, then these currents may be increased by ten times. Consult factory.

Where higher leakage or light-induced currents are present, then the input capacitor can remain and a shunt resistor must be fitted between the input pin and the input ground pin. Its value is set by:

$$R = \frac{\text{maximum acceptable loss of bias volts}}{\text{maximum leakage / dc light current}}$$



FIGURES 2a, 2b, 2c, 2d and 2e

The noise will be increased by two times if a 150V and 33K is used to parallel the input of the 341-3. Lower values may be necessary for high dc current flow in the detector. Shot noise caused by this flow will also be a factor. Low-noise metal film resistors should be used.

OUTPUT

A low impedance output driver stage is designed to drive loads of 50 ohms or greater. When longer shielded cables are used, it is desirable to correctly terminate the cable to avoid line reflections causing signal distortion. This is more important with the higher bandwidth models. With very long lines (i.e., >30 meters), it may be desirable, in addition, to add a resistor value equal to the line impedance in series with the amplifier output. This will cause a gain loss of 6dB, but will reverse terminate the line to minimize reflection. Do not short circuit the output as large currents will flow possibly damaging the output stage. Keep the output leads as short as possible and away from the input. Avoid an output ground loop to the input wires or sensor as this may cause oscillation.

DYNAMIC RANGE

The dynamic range of the amplifier is usually specified in dB's as peak output voltage divided by rms noise at the output. Clearly, low noise and large output swing is desirable to maximize dynamic range. The higher the gain of the amplifier, the less the dynamic range since the output noise is greater.

A good rule is to set the amplifier gain so that the output noise is just at the minimum of the working range of the instrument or device following the amplifier. Dynamic range can also be increased by limiting the amplifier bandwidth to that required, since the noise is reduced by the square root of the bandwidth.