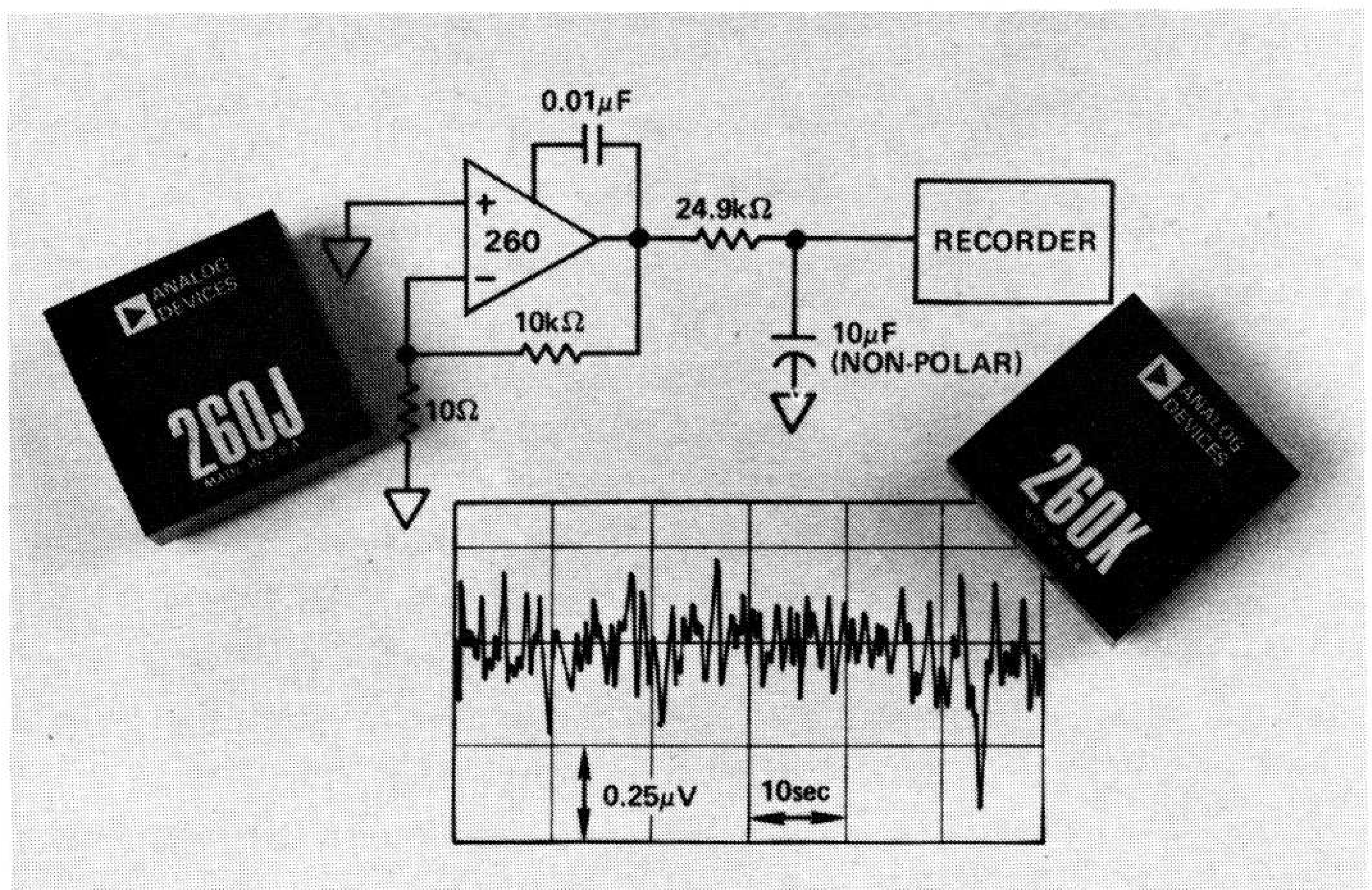
ANALOG DEVICES

Low Noise Non-Inverting Chopper Amplifier

MODEL 260

FEATURES
Non-Inverting Input
$10^9\,\Omega$ Common Mode Impedance
Protected MOSFET Chopper
Ultra Low Drift 0.1µV/°C, max (260K)
Low Voltage Noise of 0.4µV p-p (0.01 to 1Hz)
Low Current Noise of 4pA p-p (0.01 to 1Hz)
Low Cost

APPLICATIONS
Microvolt & Millivolt Measurements
Meter & Recorder Preamplifier
Semiconductor Strain Gage Amplifier
Biological Sensors
Potentiometer Buffer



0.01–1Hz p-p NOISE, AND MEASUREMENT CIRCUIT

GENERAL DESCRIPTION

Model 260 is a low cost non-inverting chopper amplifier featuring ultra low drift of 0.1µV/°C (261K), open loop gain of greater than 5 million V/V and low noise performance of 0.4µV p-p in a 0.01 to 1Hz bandwidth. It is ideally suited for low level pre-amplifier applications where high input impedance and low noise are essential.

NON-INVERTING VS. INVERTING OPERATION

The major limitation of the standard inverting type chopper stabilized amplifier is due to the practical limit on input impedance resulting from input bias current characteristics. If one attempts to obtain 10^7 ohms input impedance by usir - a 10^7 ohm input resistor with an inverting amplifier, this resistor will convert input current drifts of 0.5pA/°C into equivalent voltage drifts of 5µV/°C. It will also add Johnson Noise of 2.5µV p-p/$\sqrt{\text{Hz}}$ to the amplifier's input. These results negate the advantage of selecting the chopper-stabilized amplifier in the first place. Noise current will similarly increase the input uncertainty: inverting amplifier input noise currents of 10pA become 100µV noise voltages (referred to input). Furthermore, uncompensated initial bias currents of 50pA cause additional offsets of 500µV. Due to the non-inverting configuration of the model 260, these limitations are avoided. The input bias current (with its drift and noise) flows only through the signal source impedance, effectively eliminating the multiplication of drift and noise and offset caused by the input resistor in the inverting configuration.

CHOPPER VS. CHOPPER-STABILIZED

Most conventional ultra-stable amplifiers are chopper-stabilized to achieve low drift. In these units, the higher frequency signal components are separated and directly amplified, while the low frequency and dc components are separately chopped, amplified, demodulated, and then summed with the high frequency components in an output stage. This method provides wide bandwidth and excellent performance at the expense of increased cost and complexity. Since many requirements for ultra-low drift amplification involve only dc and low frequency signals, the additional high frequency amplifier stage found in most chopper-stabilized amplifiers has been eliminated from the model 260. This design approach has made it possible to achieve a practical non-inverting configuration, which retains the advantages of low cost and small size. The input stage of the model 260 chops the signal at a 500Hz rate, resulting in a maximum useful –3dB bandwidth of about 100Hz. For increased flexibility in meeting specific design requirements, terminals are provided for an external compensation capacitor, which determines the amplifier's gain-bandwidth product.

INPUT IMPEDANCE

One of the prime advantages of the non-inverting amplifier is the capability of bootstrapping the input impedance up to the level of the common mode impedance. For the model 260, this means that the 80kΩ open loop input resistance will be multiplied by the open loop gain times the feedback factor. With a typical open loop gain of 20×10^6, closed loop gains of up to 1600 will allow the user to realize $10^9\,\Omega$ input resistance. Even at a gain of 10,000, the effective input resistance will be over 100 megohms. (i.e.,) $(80\text{k}\Omega)\,\dfrac{20 \times 10^6}{10^4} = 160\text{M}\Omega$

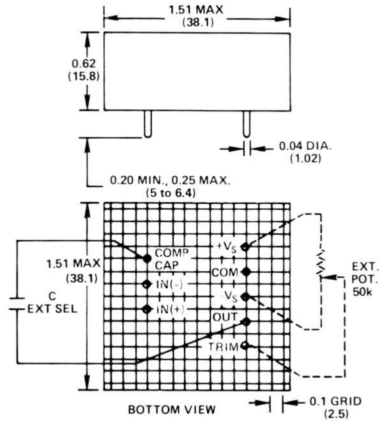
SPECIFICATIONS (typical @ +25°C and ±15V dc unless otherwise noted)

Model	260J	260K
OPEN LOOP GAIN		
DC rated load	5×10^6 min	
RATED OUTPUT		
Voltage	±10V min	*
Current	±5mA min	*
Load Capacitance Range	0 to 0.001μF	*
FREQUENCY RESPONSE[1]		
Small Signal, -3dB	100Hz	*
Full Power Response	2-50Hz min	*
Slewing Rate	100V/sec min	*
Overload Recovery	300ms	*
INPUT OFFSET VOLTAGE		
External Trim Pot[2]	50kΩ	*
Initial Offset, +25°C	±25μV max	*
Avg vs Temp (0 to +70°C)	±0.3μV/°C max	±0.1μV/°C max
Supply Voltage	±0.1μV/%	*
Time	±½μV/month	*
Warm-up Drift	<3μV in 20 minutes	*
INPUT BIAS CURRENT		
Initial Bias, +25°C, + Input	±300pA max	*
Avg vs Temp (0 to +70°C)	±10pA/°C max	*
Initial Bias, +25°C, – Input	±3nA max	*
Avg vs Supply Voltage	±3pA/%	*
INPUT IMPEDANCE		
Differential	80kΩ‖0.01μF	*
Common Mode	10^9Ω‖0.02μF	*
INPUT NOISE		
Voltage, 0.01 to 1Hz, p-p	0.4μV	*
0.01 to 10Hz, p-p	1.0μV	*
Current, 0.01 to 1Hz, p-p	4pA	*
0.01 to 10Hz, p-p	10pA	*
INPUT VOLTAGE RANGE		
Common Mode Voltage	±0.33V min	±1.0V min
Common Mode Rejection	300,000	*
Max Safe Differential Voltage	±20V	*
Max Safe Common Mode Voltage	±20V	*
POWER SUPPLY[3]		
Voltage, Rated Specification	±(14 to 16)V	*
Voltage, Operating	±(13 to 18)V	*
Current, Quiescent	±7mA	*
TEMPERATURE RANGE		
Rated Specifications	0 to +70°C	*
Operating	-25°C to +85°C	*
Storage	-55°C to +125°C	*
MECHANICAL		
Case Size	1.5" x 1.5" x 0.62"	*
Mating Socket	AC1022	*
Weight	1.75 oz. (50g)	*

[1] See selectable bandwidth, and Figure 1 and Figure 2.
[2] Ground trim terminal if trim potentiometer is not used.
[3] Recommended power supply, ADI model 904, ±15V @ 50mA output
*Specifications same as for model 260J.
Specifications subject to change without notice.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



SELECTABLE BANDWIDTH

The model 260 uses an external compensation capacitor to determine the gain-bandwidth product. Its value may be chosen to allow the use of the maximum 100Hz -3dB bandwidth, at any given value of closed loop gain. By using a larger value of compensation capacitance, the bandwidth can be limited to any desired value below 100Hz. The minimum value of the required compensation capacitor, in μF, is 1000/GB, where G is the desired closed-loop dc gain, and B is the -3dB bandwidth. For example, the minimum value of recommended capacitance (for 100Hz bandwidth to -3dB) is 10/G. Shown in Figure 1 are curves of the amplifier's response for various closed loop gains while using values of capacitance appropriate for maintaining 100Hz (-3dB) bandwidth. Figure 2 illustrates the model 260's open loop response with various values of the compensation capacitor. It is recommended that the capacitor be polycarbonate, mylar, mica, glass or polystyrene.

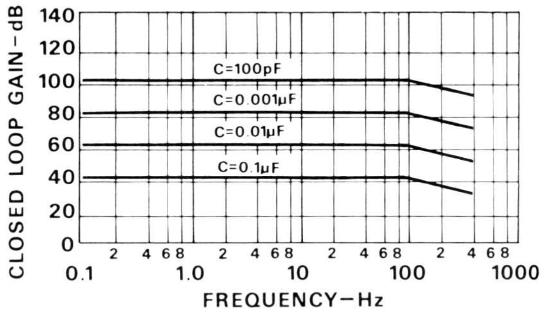


Figure 1. Compensation vs. Gain for 100Hz Bandwidth

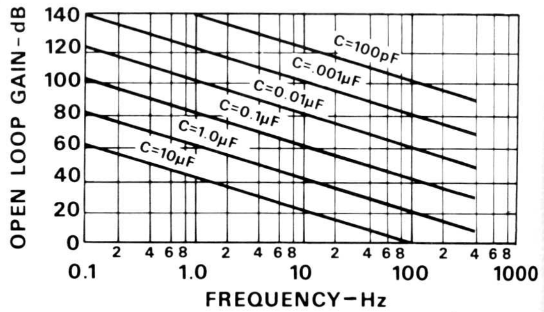


Figure 2. Open Loop Response vs. Compensation