

5 Femtoampere Bias Current Operational Amplifiers

1702

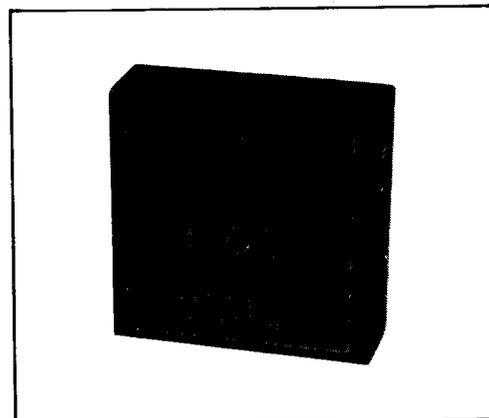
The Teledyne Philbrick 1702, with 5 femtoamp ($5 \times 10^{-15}A$) maximum bias current, is designed to be used in circuits where extremes in low error currents, low current noise, high input impedance, high common mode voltage and high common mode rejection ratio are critical design requirements. Philbrick was the first to use the parametric technology in designing operational amplifiers and has continued research and development to achieve higher performance with smaller size and lower cost.

The 1702 uses a number of Philbrick's proprietary developments in circuit design and packaging. Features include a full output frequency response of 40Hz, common mode voltage of 100V, CMRR of 100dB and offset voltage drift of $30\mu V/^{\circ}C$ max. These features are complemented by the 1702's small size (1.5 inches square by 0.6 inches high) and epoxy encapsulation for reliability in areas of shock and vibration. The epoxy also forms an isothermal environment for protection against thermal spikes. The unit is totally enclosed by a metal cup for protection against spurious signals from associated circuitry.

Input bias current of the 1702 is measured as a maximum into either input. Therefore, the 1702 can be used for inverting, non-inverting, and differential applications. For dc applications where the initial voltage offset may affect performance, an optional $50k\Omega$ pot will zero this voltage. Complete short circuit protection of the input and output circuitry is provided for added reliability.

Applications for the 1702 include electrometers, low-level integrators, photo-diode amplifiers, charge amplifiers, low frequency high impedance amplifiers, femtoammeters, sensitive differentiators, and pH meters. The 1702-01 is electrically identical to the 1702 except for a $10\mu V/^{\circ}C$ maximum offset voltage temperature coefficient. This characteristic is vital in the design of ultra sensitive pH meters.

As an example of errors caused by leakage currents, consider the case where there is a 10^{14} ohm path from a 15 volt power supply terminal to the inverting input. The leakage current across this path will be 150 femtoamperes. This is 75 times the actual bias current of the 1702.



FEATURES

- $\pm 5fA$ Maximum Bias Current
- $\pm 2fA/^{\circ}C$ Maximum Bias Drift
- $\pm 100V$ CMV
- $\pm 300V$ Differential
- 100dB CMRR
- 100dB Open Loop Gain

APPLICATIONS

- Electrometers
- Photo-Diode Amplifiers
- pH Meters
- Long Term Integrators
- Charge Amplifiers
- Femto-Ammeters



1702

SPECIFICATIONS @ 25°C, V_{CC} = ±15 V unless otherwise indicated

	Typical	Guaranteed
OUTPUT RANGE		
Voltage (Peak)	----	±10 V
Current	----	±5 mA
VOLTAGE GAIN (dc Open Loop)		
Rated Load	----	100 dB
FREQUENCY RESPONSE (Inverting)		
Small Signal (Unity Gain, Open Loop)	500 Hz	----
Gain @ 5 Hz	----	37 dB
Large Signal Full Output (Undistorted)	40 Hz	20 Hz
Large Signal Full Output (Peak to Peak)	50 Hz	----
Slew Rate	2.5 V/msec	----
Max Capacitive Load without Instability	0.1 μF	----
INPUT VOLTAGE RANGE		
Common Mode dc Linear Operation ⊙	----	±100 V
Common Mode Fault	----	±200 V
Differential (Between Inputs)	±300 V	----
Common Mode Rejection Ratio	----	100 dB
INPUT VOLTAGE OFFSET		
Initial (without external trim) @ 25°C	----	±5 mV
Zero Adjustment (optional)	50 kΩ pot	----
V _s Temperature (avg 0°C to +70°C)(1702)	----	±30 μV/°C
V _s Temperature (avg 0°C to +70°C)(1702-01)	----	±10 μV/°C
NOISE		
Flicker (0.016 to 1.6 Hz)	7 μV _{p-p}	----
Midband (1 Hz to 100 Hz)	10 μV rms	----
INPUT BIAS CURRENT		
Initial at 25°C	±0.002 pA	±0.005 pA
V _s Temperature (avg 0°C to +70°C)	±0.001 pA/°C	±0.002 pA/°C
V _s Power Supply	±0.0005 pA/V	----
INPUT IMPEDANCE		
Differential	3 X 10 ¹¹ Ω 15 pF	----
Common Mode (Either Input to Common)	10 ¹⁴ Ω	----
POWER REQUIREMENTS		
Nominal Supply Voltage	±15 V	----
Voltage Range	±12 to ±18 V	----
Current (Quiescent)	----	+13 mA, -8 mA
TEMPERATURE RANGE		
Operating (Rated)	----	0°C to +70°C
Operating (Derated)	-25°C to +85°C	----
Storage	----	-55°C to +125°C

⊙ The 1702 can operate with ±100 V of common mode voltage when V_{CC} = ±12 V.

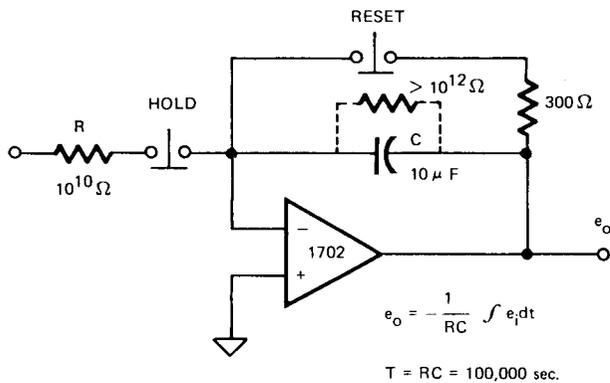
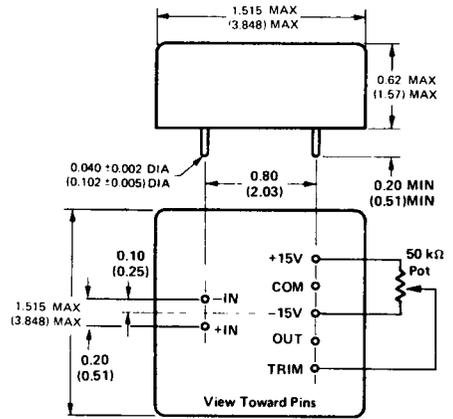


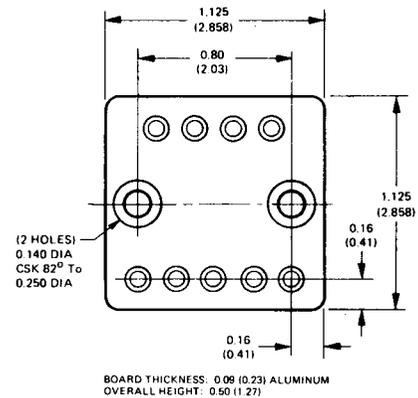
Figure 1. Long Term Integrator



±0.01 Non-cumulative tolerance between pins
±0.02 Tolerance from case edge to center of pin

DIMENSIONS IN PARENTHESES ARE EXPRESSED IN CENTIMETERS

Optional Socket: 6123



BOARD THICKNESS: 0.09 (0.23) ALUMINUM
OVERALL HEIGHT: 0.50 (1.27)

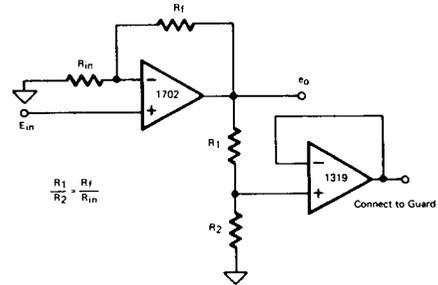


Figure 2. Follower With Gain-Guard Drive

To minimize errors caused by leakage currents, a "foil guard" should be put around the input pins. The guard conductor should be connected to a potential that is very close to or equal to the voltage being applied to the input. In this manner any stray leakage currents will be intercepted before they reach the inputs, and since the guard is at approximately the same potential as the inputs, no leakage currents will be generated.

Connect the guard to ground for inverters or I to V's, to the output for unity gain followers, and to a buffered attenuator (see Figure 2) for follower with gain.

For additional application information, request AN-3.

Teledyne Philbrick makes no representation that use of its modules in the circuits described herein, or use of other technical information contained herein will not infringe on existing or future patent rights nor do the descriptions contained herein imply the granting of licenses to make, use, or sell equipment constructed in accordance therewith.



Allied Drive @ Rte. 128, Dedham, Massachusetts 02026
Tel: (617) 329-1600, TWX: (710) 348-6726, Tlx: 92-4439