

### FEATURES

**Low Nonlinearity:**  $\pm 0.012\%$  max (289L)  
**Frequency Response:**  $(-3\text{dB})$  dc to 20kHz  
 (Full Power) dc to 5kHz  
**Gain Adjustable** 1 to 100V/V, Single Resistor  
**3-Port Isolation:**  $\pm 2500\text{V}$  CMV Isolation Input/Output  
**Low Gain Drift:**  $\pm 0.005\%$   $^{\circ}\text{C}$  max  
**Floating Power Output:**  $\pm 15\text{V}$  @  $\pm 5\text{mA}$   
**120dB CMR** at 60Hz: Fully Shielded Input Stage  
**Meets UL Std. 544 Leakage:**  $2\mu\text{A}$  rms max, @ 115V ac, 60Hz

### APPLICATIONS

**Multi-Channel Data Acquisition Systems**  
**Current Shunt Measurements**  
**Process Signal Isolator**  
**High Voltage Instrumentation Amplifier**  
**SCR Motor Control**

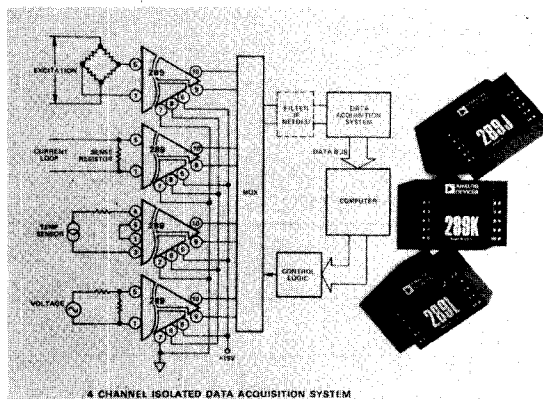
### GENERAL DESCRIPTION

Model 289 is a wideband, accurate, low cost isolation amplifier designed for instrumentation and industrial applications. Three accuracy selections are available offering guaranteed gain nonlinearity error at 10V p-p output:  $\pm 0.012\%$  max (289L),  $\pm 0.025\%$  max (289K),  $\pm 0.05\%$  max (289J). All versions of the 289 provide a small signal frequency response from dc to 20kHz  $(-3\text{dB})$  and a large signal response from dc to 5kHz (full power) at a gain of 1V/V. This new design offers true 3-port isolation,  $\pm 2500\text{V}$  dc between inputs and outputs (or power inputs), as well as 240V rms between power supply inputs and signal outputs. Using carrier modulation techniques with transformer isolation, model 289 interrupts ground loops and leakage paths and minimizes the effect of high voltage transients. It provides 120dB Common Mode Rejection between input and output common. The high CMV and CMR ratings of the model 289 facilitate accurate measurements in the presence of noisy electrical equipment such as motors and relays.

### WHERE TO USE THE MODEL 289

The model 289 is designed to interface single and multichannel data acquisition systems with dc sensors such as thermocouples, strain gauges and other low level signals in harsh industrial environments. Providing high accuracy with complete galvanic isolation, and protection from line transients of fault voltages, model 289's performance is suitable for applications such as process controllers, current loop receivers, weighing systems, high CMV instrumentation and computer interface systems.

Use the model 289 when data must be acquired from floating transducers in computerized process control systems. The photograph above shows a typical multichannel application allowing potential differences or interrupting ground loops, among transducers, or between transducers and local ground.



### DESIGN FEATURES AND USER BENEFITS

**Isolated Power:** The floating power supply section provides isolated  $\pm 15\text{V}$  outputs @  $\pm 5\text{mA}$ . Isolated power is regulated to within  $\pm 5\%$ . This feature permits model 289 to excite floating signal conditioners, front-end buffer amplifiers and remote transducers such as thermistors or bridges, eliminating the need for a separate isolated dc/dc converter.

**Adjustable Gain:** A single external resistor adjusts the model 289's gain from 1V/V to 100V/V for applications in high and low level transducer interfacing.

**Synchronized:** The model 289 provides a synchronization terminal for use in multichannel applications. Connecting the synchronization terminals of model 289s synchronizes their internal oscillators, thereby eliminating the problem of oscillator "beat frequency" interference that sometimes occurs when isolation amplifiers are closely mounted.

**Internal Voltage Regulator:** Improves power supply rejection and helps prevent carrier oscillator spikes from being broadcast via the isolator power terminal to the rest of the system.

**Buffered Output:** Prevents gain errors when an isolation amplifier is followed by a resistive load of low impedance. Model 289 can drive a  $2\text{k}\Omega$  load.

**Three-Port Isolation:** Provides true galvanic isolation between input, output and power supply ports. Eliminates need for power supply and output ports being returned through a common terminal.

**Reliability:** Model 289 is conservatively designed to be capable of reliable operation in harsh environments. Model 289 has a calculated MTBF of 271,835 hours. In addition, the model 289 meets UL Std. 544 leakage,  $2\mu\text{A}$  rms @ 115V ac, 60Hz.

# SPECIFICATIONS

(typical @ +25°C and  $V_S = +14.4V$  to +25V dc unless otherwise noted)

Model	289J	289K	289L
<b>GAIN (NONINVERTING)</b>			
Range	1 to 100V/V		
Formula	$G = 1 + \frac{10k\Omega}{R_G(k\Omega)}$		
Deviation from Formula	±1.5% max		
vs. Temperature (0 to +70°C) <sup>1</sup>	15ppm/°C typ (50ppm/°C max)		
Nonlinearity, (±5V Swing) <sup>2,3</sup>	±0.05% max	±0.025% max	±0.012% max
<b>INPUT VOLTAGE RATINGS</b>			
Linear Differential Range (G = 1V/V)	±10V min		
Max Safe Differential Input			
Continuous	120V rms		
1 Minute	240V rms		
Max CMV (Inputs to Outputs)			
Continuous ac or dc	±2500V peak max		
ac, 60Hz, 1 Minute Duration	2500V rms		
CMR, Inputs to Outputs 60Hz			
R <sub>S</sub> ≤ 1kΩ, Balanced Source Impedance	120dB		
R <sub>S</sub> ≤ 1kΩ, HI IN Lead Only	104dB min		
Max Leakage Current, Input to Output @ 115V rms, 60Hz ac	2μA rms max		
<b>INPUT IMPEDANCE</b>			
Differential	33pF  10 <sup>8</sup> Ω		
Overload	100kΩ		
Common Mode	20pF  5 × 10 <sup>10</sup> Ω		
<b>INPUT DIFFERENCE CURRENT</b>			
Initial @ +25°C	10nA (75nA max)		
vs. Temperature (0 to 70°C)	0.15nA/°C		
<b>INPUT NOISE (GAIN = 100V/V)</b>			
Voltage			
0.05Hz to 100Hz	8μV p-p		
10Hz to 1kHz	3μV rms		
Current			
0.05Hz to 100Hz	3pA rms		
<b>FREQUENCY RESPONSE</b>			
Small Signal -3dB			
G = 1V/V	20kHz		
G = 100V/V	5kHz		
Full Power, 10V p-p Output			
G = 1V/V	5kHz		
G = 100V/V	3.5kHz		
Full Power, 20V p-p Output			
G = 1V/V	2.3kHz		
G = 100V/V	2.3kHz		
Slew Rate	0.14V/μs		
Settling Time <sup>4</sup> ±0.05%, ±10V Step	400μs		
<b>OFFSET VOLTAGE, REFERRED TO INPUT</b>			
Initial, @ +25°C	±5 ± $\frac{10}{G}$ mV max		
vs. Temperature (0 to +70°C)	±20 ± $\frac{200}{G}$ max	±15 ± $\frac{100}{G}$ max	±10 ± $\frac{50}{G}$ μV/°C max
vs. Supply Voltage (+15V to +20V change)	±2 ± $\frac{10}{G}$ μV/V		
<b>RATED OUTPUT</b>			
Voltage, 2kΩ Load	±10V min		
Output Impedance	<1Ω(dc to 100Hz)		
Output Ripple, 0.1MHz Bandwidth			
No Signal IN	5mV p-p		
+10V <sub>IN</sub>	50mV p-p		
<b>ISOLATED POWER SUPPLY</b>			
Voltage	±15V dc		
Accuracy	±10%		
Current	±5mA, min		
Regulation No Load to Full Load	±5%		
Ripple, 0.1MHz Bandwidth, No Load	25mV p-p		
Full Load	75mV p-p		
<b>POWER SUPPLY, SINGLE POLARITY<sup>5</sup></b>			
Voltage, Rated Performance	+14.4V to +25V		
Voltage, Operating	+8.5V to +25V		
Current, Quiescent (@ V <sub>S</sub> = +15V)	+25mA		
<b>TEMPERATURE RANGE</b>			
Rated Performance	0 to +70°C		
Operating	-15°C to +75°C		
Storage	-55°C to +85°C		
<b>CASE DIMENSIONS</b>			
	1.5" X 2.0" X 0.75"		

## NOTES

<sup>1</sup> Gain temperature drift is specified as a percentage of output signal level.

<sup>2</sup> Gain nonlinearity is specified as a percentage of 10V pk-pk output span.

<sup>3</sup> When isolated power output is used, nonlinearity increases by +0.002%/mA of current drawn.

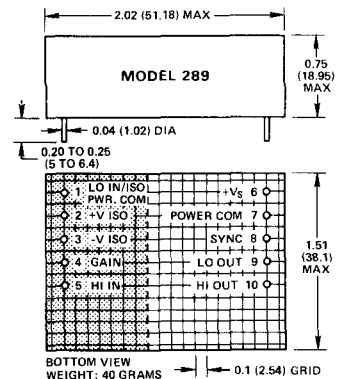
<sup>4</sup>  $G = 1V/V$ , with 2-pole, 5kHz output filter.

<sup>5</sup> Recommended power supply, ADI model 904, ±15V @ 50nA output.

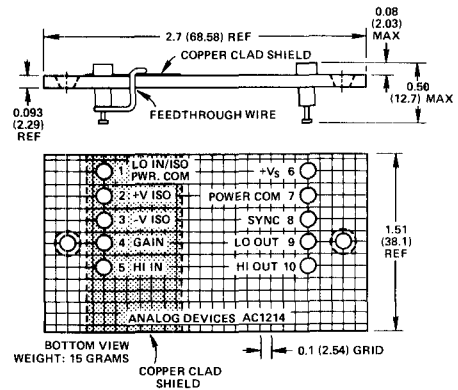
Specifications subject to change without notice.

## OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



## SHIELDED MATING SOCKET AC1214



## INTERCONNECTIONS AND SHIELDING TECHNIQUE

To preserve the high CMR performance of model 289, care must be taken to keep the capacitance balanced about the input terminals. A shield should be provided on the printed circuit board under model 289 as illustrated in the outline drawing above (screened area). The LO IN/ISO PWR COM (pin 1) must be connected to this shield. This shield is provided with the mounting socket, model AC1214 (solder feedthrough wire to the socket pin 1 and copper foil surface). A recommended shielding technique using model AC1214 is illustrated in Figure 1.

Best CMR performance will be achieved by using twisted, shielded cable for the input signal to reduce inductive and capacitive pickup. To further reduce effective cable capacitance, the cable shield should be connected to the common mode signal source as close to signal low as possible (see Figure 1).

# Understanding the Isolation Amplifier Performance

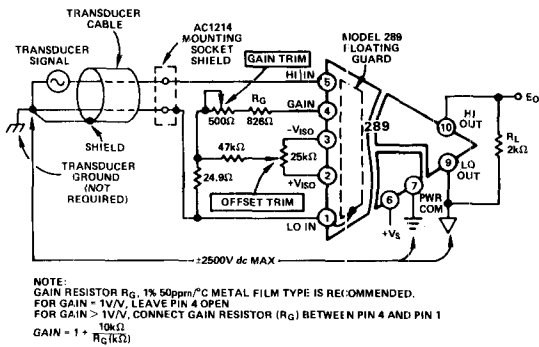


Figure 1. Basic Isolator Interconnection

## THEORY OF OPERATION

The remarkable performance of the model 289 is derived from the carrier isolation technique used to transfer both signal and power between the amplifier's input stage and the rest of the circuitry. A block diagram is shown in Figure 2.

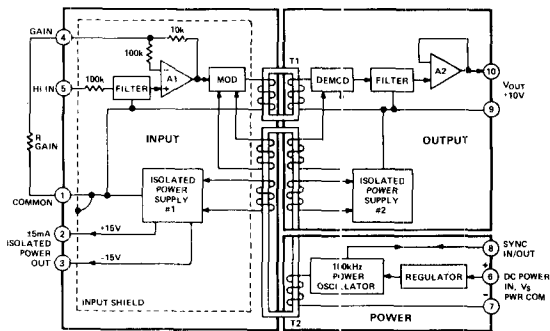


Figure 2. Model 289 Block Diagram

The input signal is filtered and appears at the input of the non-inverting amplifier, A1. This signal is amplified by A1, with its gain determined by the value of resistance connected externally between the gain terminal and the input common terminal. The output of A1 is modulated, carried across the isolation barrier by signal transformer T1, and demodulated. The demodulated voltage is filtered, amplified and buffered by amplifier A2, and applied to the output terminal. The voltage applied to the  $V_S$  terminal is set by the regulator to +12V which powers the 100kHz symmetrical square wave power oscillator. The oscillator drives the primary winding of transformer T2. The secondary windings of T2 energize both input and output power supplies, and drives both the modulator and demodulator.

## INTERELECTRODE CAPACITANCE AND TERMINAL RATINGS

**Capacitance:** Interelectrode terminal capacitance, arising from stray coupling capacitance effects between the input terminals and the signal output terminals, are each shunted by leakage resistance values exceeding 50GΩ. Figure 3 illustrates model 289's capacitance, between terminals.

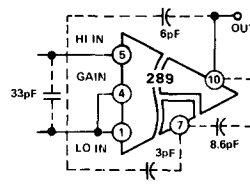


Figure 3. Model 289 Terminal Capacitance

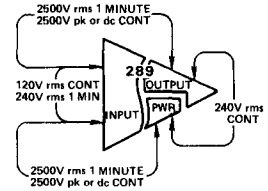


Figure 4. Model 289 Terminal Ratings

**Terminal Ratings:** CMV performance is given in both peak pulse and continuous ac, or dc peak ratings. Continuous peak ratings apply from dc up to the normal full power response frequencies. Figure 4 illustrates model 289 ratings between terminals.

## GAIN AND OFFSET TRIM PROCEDURE

The following procedure illustrates a calibration technique which can be used to minimize output error. In this example, the output span is +5V to -5V and Gain = 10V/V.

1. Apply  $E_{IN} = 0$  volts and adjust  $R_O$  for  $E_O = 0$  volts.
2. Apply  $E_{IN} = +0.500V$  dc and adjust  $R_G$  for  $E_O = +5.000V$  dc.
3. Apply  $E_{IN} = -0.500V$  dc and measure the output error (see curve a).
4. Adjust  $R_G$  until the output error is one-half that measured in step 3 (see curve b).
5. Apply  $-0.500V$  dc and adjust  $R_O$  until the output error is one-half that measured in step 4 (see curve c).

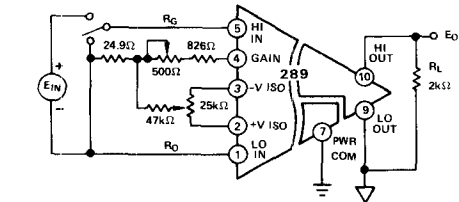
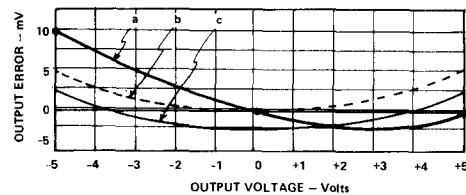


Figure 5a. Recommended Offset and Gain Adjustment for Gains > 1

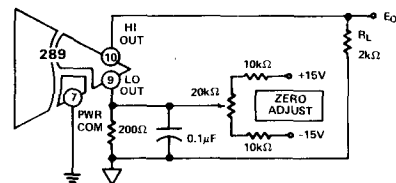


Figure 5b. Recommended Offset Adjustment for  $G = 1V/V$

## PERFORMANCE CHARACTERISTICS

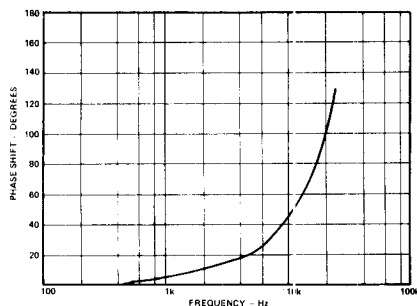


Figure 6. Typical 289 Phase vs. Frequency

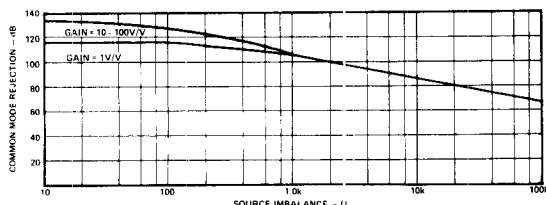


Figure 7. Typical 289 Common Mode Rejection vs. Source Impedance

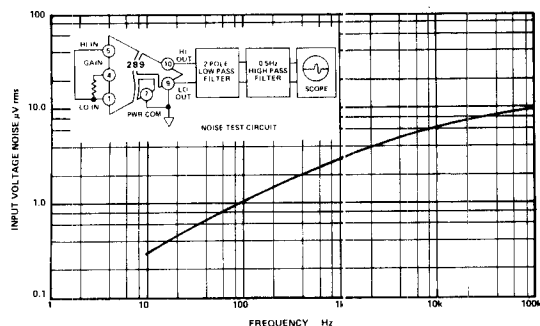


Figure 8. Typical Input Voltage Noise vs. Bandwidth

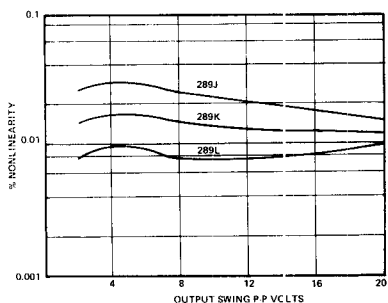


Figure 9. Typical Gain Nonlinearity vs. Output Swing

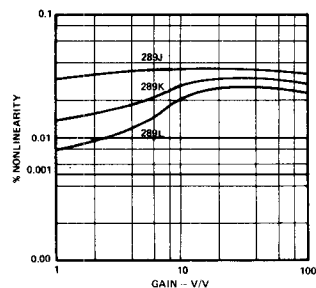


Figure 10. Typical Gain Nonlinearity vs. Gain

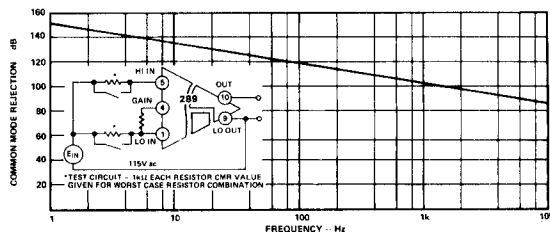


Figure 11. Typical Common Mode Rejection vs. Frequency at a Gain of 1V/V, CMR is typically 6dB Lower than at a Gain of 100V/V

## MULTICHANNEL APPLICATIONS

Isolation amplifiers containing internal oscillators may exhibit a slowly varying offset voltage at the output when used in multichannel applications. This offset voltage is the result of adjacent internal oscillators beating together. For example, if two adjacent isolation amplifiers have oscillator frequencies of 100.0kHz and 100.1kHz respectively, a portion of the difference frequency may appear as a slowly varying output offset voltage error. Model 289 eliminates this problem by offering a synchronization terminal (pin 8). When this terminal is interconnected with other model 289 synchronization terminals, the units are synchronized. Alternately, one or more units may be synchronized to an external 100kHz  $\pm 2\%$  square-wave generator by the connection of synchronization terminal(s) to that generator. The generator output should be 2.5V–5.0V p-p with 1k $\Omega$  source impedance to each unit. Use an external oscillator when you need to sync to an external 100kHz source, such as a sub-multiple of a microprocessor clock. A differential line driver, such as SN75158, can be used to drive large clusters of model 289. When using the synchronization pin, keep leads as short as possible and do not use shielded wire. These precautions are necessary to avoid capacitance from the synchronization terminal to other points. It should be noted that units synchronized must share the same power common to ensure a return path.