Intronics Power ®

Precision Isolation Amplifier
High CMV/CMR, ±15V Floating Power

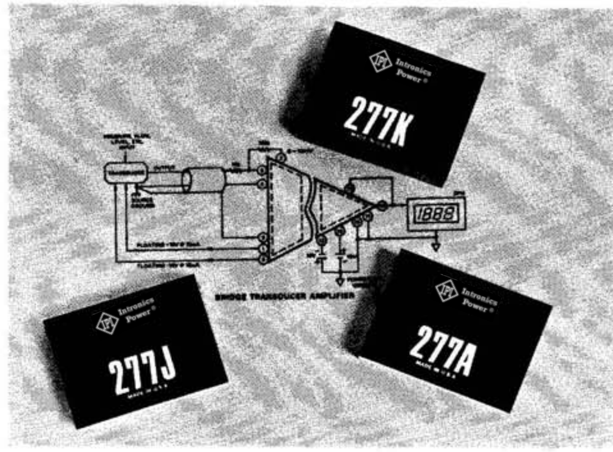
MODEL 277

FEATURES

- **Versatile Op Amp Front End: Inverting, Non-Inverting, Differential Applications**
- **Low Nonlinearity: 0.025% max, Model 277K**
- **Low Input Offset Voltage Drift: 1μV/°C max, Model 277K**
- **Floating Power Output: ±15V @ ±15mA**
- **High CMR: 160dB min @ dc**
- **High CMV: 3500V$_{rms}$**

APPLICATIONS

- **Programmable Gain Isolated Amplifier**
- **Isolated Power Source and Amplifier for Bridge Measurements**
- **Instrumentation Amplifier**
- **Instrumentation Grade Process Signal Isolator**
- **Current Shunt Measurements**



GENERAL DESCRIPTION

Model 277 is a versatile isolation amplifier which combines a high-performance, uncommitted operational amplifier front end with a precision, isolated output stage and a floating power supply section. This configuration, shown in Figure 1, makes the 277 ideally suited to instrumentation applications where the need for various forms of signal conditioning, high CMV protection and isolated transducer power requirements are encountered.

The input stage is a low drift (±1μV/°C max, model 277K) differential op amp that may be connected for use in inverting, non-inverting and differential configurations. The circuitry employed around the operational amplifier input stage can be designed by the user to suit each application's particular signal processing needs. A full ±10V signal range is available at the output of the front end amplifier.

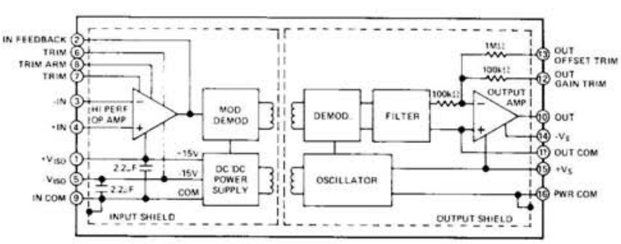


Figure 1. Model 277 Functional Block Diagram

The isolated output stage includes a special modulator/demodulator technique which provides the 277 with 160dB minimum DC common mode rejection between input and output common and an input-to-output CMV rating of 3500V$_{rms}$. When combined with the output stage's low nonlinearity (0.05%, models 277J/A and 0.025% model 277K), these high CMR and CMV ratings facilitate accurate measurements in the presence of noisy electrical equipment such as motors and relays. In addition, model 277A offers a -25°C to +85°C rated operating temperature range. All versions of model 277 have a ±10 volt output range.

The floating power supply section provides isolated ±15 volt outputs capable of delivering currents up to ±15mA. This feature permits model 277 to power transducers and auxilliary isolated circuitry, thereby eliminating the need for a separate isolated DC/DC converter.

All of the features of the model 277 isolation amplifier are packaged in a compact (3″ x 2.2″ x 0.59″) module. As an assurance of high performance reliability, every model 277 is factory tested for CMV rating by application of 3500V$_{rms}$ (±4900V peak) between input and output common terminals for one minute (meets NEMA and CSA requirements for 660V$_{rms}$ service.) In addition, the 277 has a calculated MTBF of 133,000 hours.

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

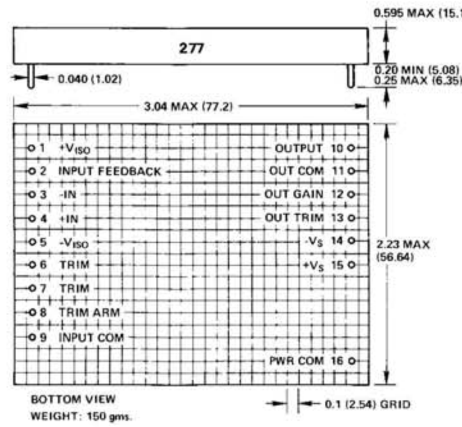
MODEL	277J	277K	277A
INPUT STAGE PERFORMANCE [1,2]			
OPEN LOOP GAIN	106dB min	•	•
INPUT OFFSET VOLTAGE			
Initial, @ +25°C (Adjustable to Zero)	±1.5mV max	•	•
vs. Temperature			
Offset Untrimmed	±5μV/°C max	•	±5μV/°C
Offset Trimmed to Zero	±3μV/°C max	±1μV/°C max	•
vs. Supply Voltage	±30μV/V	•	•
vs. Time	±3.5μV/mo	•	•
INPUT BIAS CURRENT			
Initial, @ +25°C	±20nA max	•	•
vs. Temperature	±50pA/°C	•	•
vs. Supply Voltage	±100pA/V	•	•
INPUT DIFFERENCE CURRENT			
Initial, @ +25°C	±6nA	•	•
vs. Supply Voltage	±50pA/V	•	•
INPUT IMPEDANCE			
Differential	4MΩ	•	•
Common Mode [3]	100MΩ‖4pF	•	•
INPUT NOISE			
Voltage, 0.01Hz to 10Hz	1μV p-p	•	•
10Hz to 1kHz	3μV rms	•	•
Current, 0.01Hz to 10Hz	35pA p-p	•	•
INPUT VOLTAGE RANGE			
Common Mode Voltage [3]	±10V min	•	•
Common Mode Rejection [3], CMV = ±10V, 60Hz	100dB	•	•
Max Safe Differential Voltage	±13V	•	•
ISOLATED POWER OUTPUT [4]			
Voltage/Current [2]	±15V @ ±15mA max	•	•
Load Regulation (No Load – Full Load)	+0, -6%	•	•
Line Regulation	1V/V	•	•
Ripple, Full Load	30mV p-p @ 70kHz	•	•
OUTPUT STAGE PERFORMANCE			
GAIN	1V/V	•	•
Gain Error	±0.5% max	•	•
vs. Temperature	±50ppm/°C max	•	•
Nonlinearity, ±10V Output	±0.05% max	±0.025% max	•
VOLTAGE RATINGS [5]			
Max CMV, Output Com/Input Com			
AC, 60Hz, 1 Minute	3500V_{rms} max	•	•
Nonrecurring Spike (<1 Second)	±5000V pk max	•	•
Peak AC or DC, Continuous	±2500V max	•	•
CMR, Output Com/Input Com [5]			
DC	160dB min	•	•
60Hz	120dB min	•	•
Leak. Cur., Input/Output 115V_{rms}, 60Hz	1μA rms max	•	•
ISOLATION IMPEDANCE [5]			
Input Com/Output Com	10^{12}Ω‖16pF	•	•
OUTPUT OFFSET VOLTAGE			
Initial, @ +25°C (Adjustable to Zero)	±10mV max	•	•
vs. Temperature	±100μV/°C max	±50μV/°C max	±100μV/°C max
vs. Supply Voltage	±1mV/V	•	•
vs. Time	±100μV/mo	•	•
FREQUENCY RESPONSE			
Small Signal, -3dB	2.5kHz	•	•
Full Power, 20V p-p Output	1.5kHz	•	•
Settling Time ±10V Step to 0.1%	1ms	•	•
RATED OUTPUT			
Voltage/Current	±10V min @ ±5mA min	•	•
OUTPUT NOISE			
Voltage, 0.01Hz to 10Hz	7μV p-p	•	•
10Hz to 1kHz	25μV rms	•	•
POWER SUPPLY			
Voltage, Rated Performance	±15VDC	•	•
Voltage, Operating	±(14 to 16)VDC	•	•
Current, Quiescent	+35, -5mA	•	•
TEMPERATURE RANGE			
Rated Performance	0 to +70°C	•	-25°C to +85°C
Operating	-25°C to +85°C	•	•
Storage	-55°C to +85°C	•	•
CASE SIZE	3.0" x 2.2" x 0.59"	•	•

NOTES:
[1] Current drawn from INPUT FEEDBACK terminal must be ≤5mA.
[2] Total current drawn from IN FEEDBACK and either $+V_{ISO}$ or $-V_{ISO}$ must be ≤15mA.
[3] Input common mode specifications are measured at +IN and -IN terminals with respect to INPUT COM.
[4] Protected for momentary shorts to IN COM.
[5] Isolation specifications are measured at INPUT COM with respect to OUT COM and PWR COM.

•Specifications same as model 277J.
Specifications subject to change without notice.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm)



MATING SOCKET – AC1053

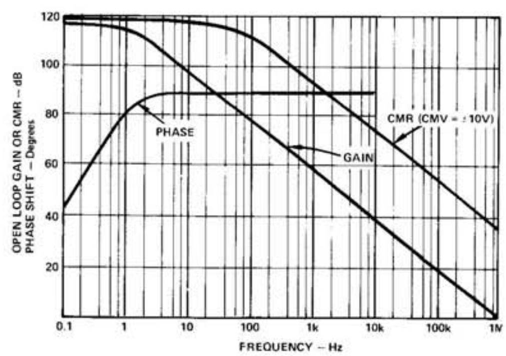


Figure 2. Input Stage Gain, CMR and Phase vs. Frequency

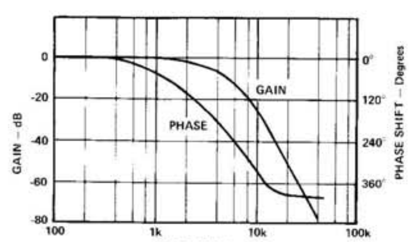


Figure 3. Output Stage Gain and Phase vs. Frequency

PERFORMANCE CHARACTERISTICS

Gain Nonlinearity: Nonlinearity error is expressed as a % of peak-to-peak output voltage span; e.g. ±0.05% @ 10V p-p output = ±5mV max RTO nonlinearity error. Model 277 is available in two maximum nonlinearity grades – ±0.05% (277J/A), ±0.025% (277K).

The nonlinearity of model 277 is virtually independent of output voltage swing. Therefore, the 277 can be used at any level of gain and output signal range up to ±10V while maintaining its excellent linearity characteristics.

Output Voltage Noise: Peak-to-peak output voltage noise is dependent on bandwidth, as shown in Figure 4. The graph shows RTO noise, that is, output noise for a gain of 1V/V through the isolator. For lowest noise performance, a low pass filter at the output can be used to roll-off noise and undesired signal frequencies beyond the bandwidth of interest. As gain increases, voltage noise referred-to-input decreases, resulting in higher input signal to noise ratios. The next section demonstrates how voltage noise, referred-to-input, can be calculated.

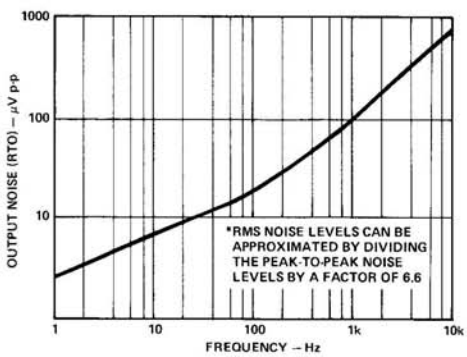


Figure 4. Output Voltage Noise vs. Bandwidth

RTI Offset Voltage, Drift and Noise: Offset voltage, referred to input (RTI) for model 277 may be computed by treating the isolator as two cascaded amplifier stages. The input stage has variable gain G_1 while the output isolation stage has a fixed gain of 1. RTI offset is given by:

$$E_{OS}\ (RTI) = E_{OS_1} + E_{OS_2}/G_1$$

where: E_{OS_1} = total input stage offset voltage
E_{OS_2} = output stage offset voltage
G_1 = input stage gain

Offset voltage drift, RTI, may be calculated in the same manner.

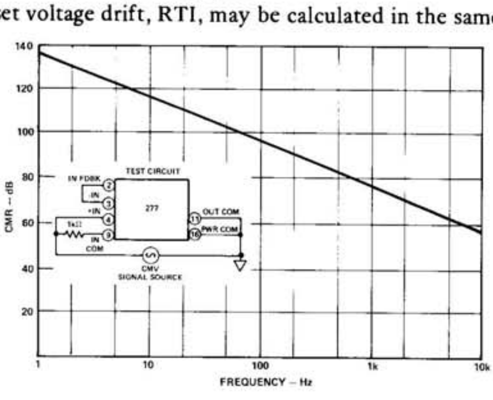


Figure 5. Input-to-Output CMR vs. Frequency with 1kΩ Source Imbalance

RTI noise, in a given bandwidth, (for Figure 8a) may be calculated as follows:

$$E_N\ (rms, RTI) = \sqrt{E_{N_1}{}^2 + (E_{N_2}/G_1)^2}$$

where: E_{N_1} = total rms input stage voltage noise
E_{N_2} = rms output voltage noise (RTO)

Common Mode Rejection: A 160dB rejection of potential differences between input and output common is achieved in model 277 by maintaining low coupling capacitance between the input and output stages. Input-to-output rejection is a function of frequency as shown in Figure 5 under the adverse condition of 1kΩ in series with IN COM. CMR versus frequency for the input stage is shown in Figure 2.

The section on GUARDING TECHNIQUES & INTERCONNECTION demonstrates how to calculate total CMR error for the isolator and indicates the precautions to be taken to preserve the model 277's inherently excellent CMR performance.

GUARDING TECHNIQUES & INTERCONNECTION

Model 277 CMR performance is best preserved by using shielded signal cable with the shield connected as close as possible to signal low and IN COM to reduce pickup (see Figure 6).

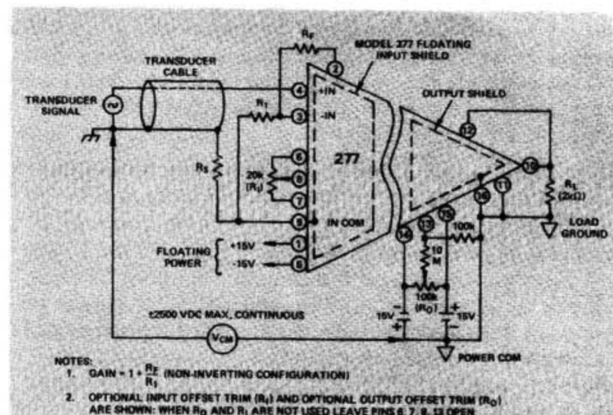


Figure 6. Transducer, Power, Gain Resistors, and Shielding Interconnection

Overall CMR error at the output (e_{err}) is due to the CMR of the input amplifier and the CMR between input and output stages and is given by:

$$e_{err} = \frac{e_{cm}}{CMR_{IN}}(G_1) + \frac{e_{IO}}{CMR_{IO}}$$

where: e_{cm} = input amp CMV with respect to IN COM
e_{IO} = CMV between OUT COM and signal ground
CMR_{IN} = CMR of the input op amp
CMR_{IO} = CMR from input IN COM to OUT COM
G_1 = input stage gain

To preserve CMR_{IN}, amplifier source impedances should be balanced with respect to IN COM. Components connected to the input should be enclosed by a shield tied to IN COM to reduce CMR_{IO} degradation due to unguarded capacitance to ground.

High CMR_{IO} is maintained with low capacitance between IN COM and OUT COM. For best CMR performance, printed circuit layouts should minimize stray capacitance between input and output stages. *Do not run a ground plane under the isolator since this increases input-output coupling.* CMR_{IO} also degrades at high frequencies by resistance (R_S) between IN COM and signal ground. Voltage between OUT COM and source ground divides between this resistance (generally wire resistance) and the input-to-output capacitance resulting in an input error signal. If R_S becomes excessive, a capacitor from +IN to OUT COM will help compensate for its effect on CMR. The capacitor must withstand the isolation voltages encountered.

ADJUSTMENT PROCEDURE

The input and output offset voltage of model 277 can be trimmed as shown below with the isolator set up in the desired circuit configuration.

(1) Refer to Figure 6 for terminal and component designations.
(2) Connect IN COM to OUT COM and set input signal to zero.
(3) Place floating DVM across IN FDBK and OUTPUT terminals.
(4) Null DVM reading using output offset trim potentiometer R_O.
(5) Disconnect IN COM from OUT COM.
(6) Place DVM across IN FDBK and IN COM terminals.
(7) Adjust input offset trim potentiometer, R_I, until DVM reads zero volts.

The overall gain of the isolator may be increased over a limited range (5%) with a 5kΩ potentiometer connected between pins 10 and 12.

APPLICATIONS

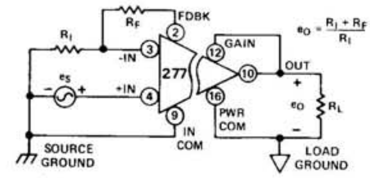
Programmable Gain Bridge Transducer Amplifier: The versatility of model 277 is shown by the programmable gain bridge transducer amplifier application of Figure 7. In this circuit the 277's uncommitted front end and floating voltage output permit both bridge excitation and signal gain conditioning to be provided by the isolation amplifier.

Control switches are driven by TTL inputs which are isolated from source ground by the opto-isolators in the control switch. Control signals operate the CMOS switch network to establish the gains shown in the table in Figure 7. The CMOS switch network is operated in a manner that causes the resistance of the switches only to be in series with the negative input of the isolator and not in series with the gain setting resistors. With this arrangement the switch resistance does not affect gain accuracy. A resistor, R_B, should be in series with -IN to reduce errors due to bias current drift.

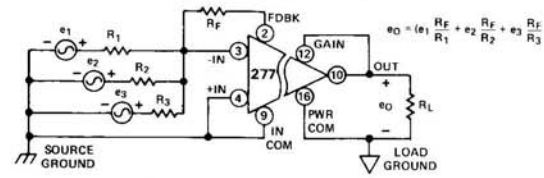
With this circuit the isolator gain can be remotely set at a value that optimizes input signal-to-noise ratio and eliminates the need for high quality post-amplifiers at the isolator output. This network is extremely useful in wide dynamic range measurements such as flow, level or pressure where auto-gain ranging would be a desirable system instrumentation feature.

INPUT CONFIGURATION

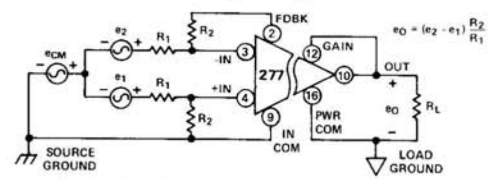
Model 277's input stage is an isolated, uncommitted operational amplifier that may be configured to suit a variety of applications. Model 277 may be used in the same way as any op amp except that the feedback is taken from the FDBK terminal rather than the OUTPUT pin. Figure 8 shows four typical input configurations for interfacing with a wide range of signal sources.



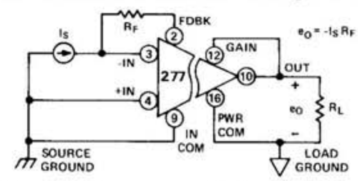
(a) Non-Inverting Configuration



(b) Summing Configuration

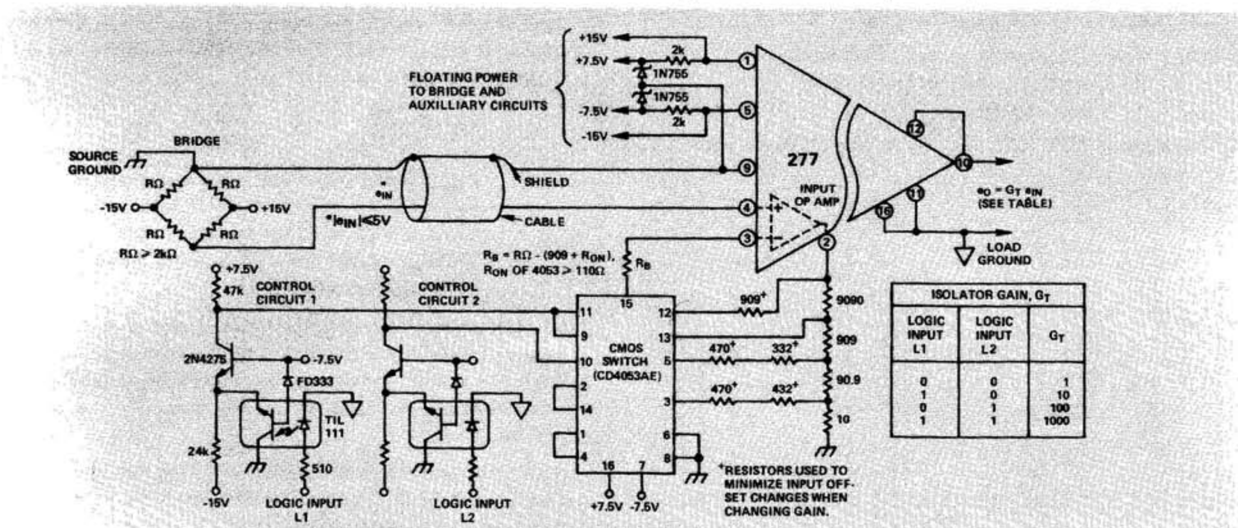


(c) Isolated Differential Configuration



(d) Current Source Amplifier Configuration

Figure 8. Model 277 Input Amplifier Configurations



ISOLATOR GAIN, G_T		
LOGIC INPUT L1	LOGIC INPUT L2	G_T
0	0	1
1	0	10
0	1	100
1	1	1000

Figure 7. Programmable Gain Bridge Transducer Amplifier

Intronics Power ®

High CMV, High Performance Isolation Amplifiers

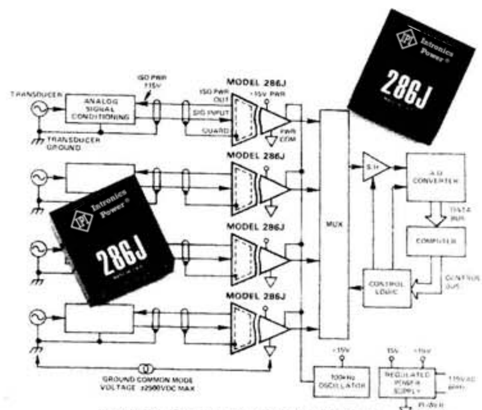
MODELS 284J, 286J, 281

FEATURES

High CMV Isolation: ±5000V pk, 10ms Pulse; ±2500V dc Continuous
High CMR: 110dB min with 5kΩ Imbalance
Low Nonlinearity: 0.05% @ 10V pk-pk Output
High Gain Stability: ±0.0075%/°C, ±0.001%/1000 hours
Low Input Offset Voltage Drift: 10μV/°C, G = 100V/V (Model 286J)
Resistor Programmed Gain: 1 to 10V/V (284J)
1 to 100V/V (286J)
Isolated Power Supply: ±8.5V dc @ ±5mA (284J)
±15V dc @ ±15mA (286J)
Meets IEEE Std 472: Transient Protection (SWC)
Meets UL Std 544 Leakage @ 115V ac, 60Hz:
2.0μA max (284J)
2.5μA max (286J)

APPLICATIONS

Fetal Heartbeat Monitoring
Multi-Channel ECG Recording
Ground Loop Elimination in Industrial and Process Control
High Voltage Protection in Data Acquisition Systems
4-20mA Isolated Current Loop Receiver



4 CHANNEL ISOLATED DATA ACQUISITION SYSTEM

GENERAL DESCRIPTION

The models 284J, 286J are low cost, high performance isolation amplifiers designed for high CMV isolation and low leakage in biomedical, industrial and data acquisition systems. Using modulation techniques with reliable transformer isolation, the models 284J, 286J protect both patients and ultrasensitive equipment from high CMV transients up to ±5000V pk (10ms pulse) or 2500V dc continuous, high CMR of 110dB (5kΩ imbalance) and feature maximum leakage current of less than 3μA rms, @ 115V ac, 60Hz (inputs to power common).

The model 284J is a self-contained isolation amplifier for single channel applications. For multi-channel applications, the model 286J combined with an external synchronizing oscillator such as the model 281 may be used; up to 16 model 286J amplifiers can be driven from 1 model 281 oscillator. Additional channels may be obtained by configuring an unlimited number of 284Js with several ganged 281 oscillators.

Both models also provide resistor-programmable gain of 1 to 10V/V (284J) or 1 to 100V/V (286J), high gain stability of 0.0075%/°C, low nonlinearity of 0.05% @ 10V pk-pk output and isolated power supply outputs of ±15V dc @ ±15mA (286J) or ±8.5V dc @ ±5mA (284J).

WHERE TO USE MODELS 284J, 286J

Industrial Applications: In data acquisition systems, computer interface systems, process signal isolators and high CMV instrumentation, models 284J, 286J offer complete galvanic isolation and protection against damage from transients and fault voltages. High level transducer interface capability is afforded with model 286J's 20V pk-pk or model 284J's 10V pk-pk input signal range at a gain of 1V/V operation. In portable field designs, single supply, wide range operation (+8V to +16V) offers simple battery operation.

Medical Applications: In biomedical and patient monitoring equipment such as multi-channel VCG, ECG, and polygraph recorders, models 284J, 286J offer protection from lethal ground fault currents as well as 5kV defibrillator pulse inputs. Low level bioelectric signal recording is achieved with low input noise (8μV pk-pk @ G = max gain) and high CMR (110dB, min @ 60Hz).

DESIGN FEATURES AND USER BENEFITS

High Reliability: Models 284J, 286J are conservatively designed, compact modules, capable of reliable operation in harsh environments. Models 284J, 286J have calculated MTBF of over 390,000 hours and are designed to meet MIL-STD-202E environmental testing as well as the IEEE Standard for Transient Voltage Protection (472-1974: Surge Withstand Capability).

Isolated Power Supply: Dual regulated supplies, completely isolated from the input power terminals (±2500V dc isolation), provides the capability to excite floating signal conditioners, front end buffer amplifiers as well as remote transducers such as thermistors or bridges.

Adjustable Gain: A single external resistor enables gain adjustment from 1V/V to 100V/V (286J) or 1V/V to 10V/V (284J) providing the flexibility of applying models 284J, 286J in both high-level transducer interfacing as well as low-level sensor measurements.

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

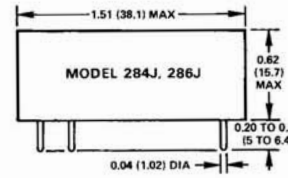
MODEL	284J	286J[1]
GAIN (NON-INVERTING)		
Range (50kΩ Load)	1 to 10V/V	1 to 100V/V
Formula	Gain = $[1 + \frac{100k\Omega}{10.7k\Omega + R_i(k\Omega)}]$	Gain = $[1 + \frac{100k\Omega}{1k\Omega + R_i(k\Omega)}]$
Deviation from Formula	±3%	±4%
vs. Time	±0.001%/1000 Hours	*
vs. Temperature (0 to +70°C)[2]	±0.0075%/°C	*
Nonlinearity, 10V pk-pk Output[2]	±0.05%	*
INPUT VOLTAGE RATINGS		
Linear Differential Range, G = 1V/V	±5V min	±10V min
Max Safe Differential Input		
Continuous	$240V_{rms}$	*
Pulse, 10ms duration, 1 pulse/10 sec[3]	$\pm 6500V_{pk}$ max	*
Max CMV, Inputs to Outputs		
AC, 60Hz, 1 minute duration	$2500V_{rms}$	*
Pulse, 10ms duration, 1 pulse/10 sec[3]	$\pm 2500V_{pk}$ max	*
With 510kΩ in series with Guard	$\pm 5000V_{pk}$ max	*
Continuous, AC or DC	$\pm 2500V_{pk}$	*
CMR, Inputs to Outputs, 60Hz, $R_S \leq 5k\Omega$		
Balanced Source Impedance	114dB	*
5kΩ Source Impedance Imbalance	110dB min	*
CMR, Inputs to Guard, 60Hz		
1kΩ Source Impedance Imbalance	78dB	*
Max Leakage Current, Inputs to Power Common @ 115VAC, 60Hz	2.0μA rms max	2.5μA rms max
INPUT IMPEDANCE		
Differential	$10^8\Omega \| 70pF$	$10^8\Omega \| 150pF$
Overload	300kΩ	*
Common Mode	$5 \times 10^{10}\Omega \| 20pF$	*
INPUT DIFFERENCE CURRENT		
Initial, @ +25°C	±7nA max	*
vs. Temperature (0 to +70°C)	±0.1nA/°C	*
INPUT NOISE		
Voltage[4]		
0.05Hz to 100Hz	8μV pk-pk	*
10Hz to 1kHz	10μV rms	3μV rms
Current		
0.05Hz to 100Hz	5pA pk-pk	*
FREQUENCY RESPONSE		
Small Signal, -3dB	1kHz	*
Slew Rate	25mV/μs	*
Full Power, 10V p-p Output	200Hz	900Hz
Full Power, 20V p-p Output	N/A	400Hz
Recovery Time, to ±100μV after Application of $\pm 6500V_{pk}$ Differential Input Pulse[3]	200ms	*
OFFSET VOLTAGE REFERRED TO INPUT		
Initial, @ +25°C, Adjustable to Zero	±(5 + 20/G)mV	±(5 + 45/G)mV
vs. Temperature (0 to +70°C)	±(1 + 150/G)μV/°C	±(7 + 250/G)μV/°C
vs. Supply Voltage	±1mV/%	*
RATED OUTPUT		
Voltage, 50kΩ Load	±5V min	±10V min
Output Impedance	1kΩ	*
Output Ripple, 1MHz Bandwidth	5mV pk-pk	20mV pk-pk
ISOLATED POWER OUTPUTS		
Voltage, ±5mA Load	±8.5V dc	±15V dc
Accuracy	±5%	0, -6%
Current	±5mA min	±15mA min
Regulation, No Load to Full Load	+0, -15%	+0, -10%
Ripple, 100kHz Bandwidth	100mV pk-pk	200mV pk-pk
POWER SUPPLY, SINGLE POLARITY[5]		
Voltage, Rated Performance	+15V dc	*
Voltage Operating	+(8 to 15.5)V dc	*
Current, Quiescent	+10mA	+13mA
TEMPERATURE RANGE		
Rated Performance	0 to +70°C	*
Operating	-25°C to +85°C	*
Storage	-55°C to +85°C	*
CASE DIMENSIONS[6]	1.5" x 1.5" x 0.62"	*

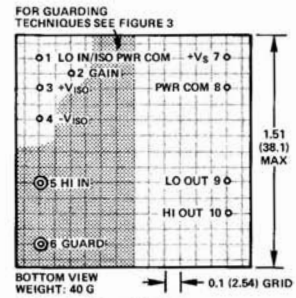
NOTES
*Specifications same as model 284J.
[1] Specifications for model 286J apply when driven by ADI model 281 oscillator.
[2] Gain temperature drift and gain nonlinearity are specified as a percentage of output signal level.
[3] Rise time of pulse must be >10μs.
[4] Model 284J: Gain = 10V/V; Model 286J: Gain = 100V/V.
[5] Recommened power supply, ADI model 904, ±15V @ 50mA.
[6] Recommended mounting sockets – model 284J: ADI Part Number AC1049; model 286J: ADI Part Number AC1054.

Specifications subject to change without notice.

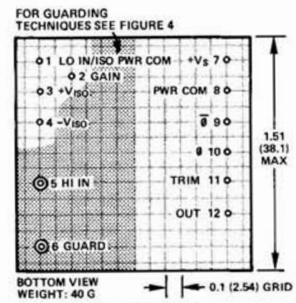
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).





Model 284J



Model 286J

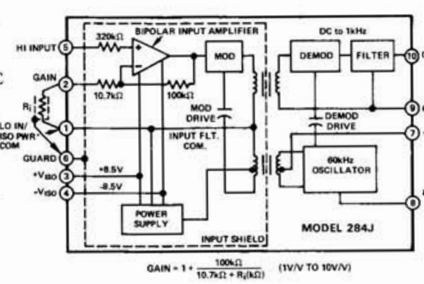


Figure 1. Block Diagram – Model 284J

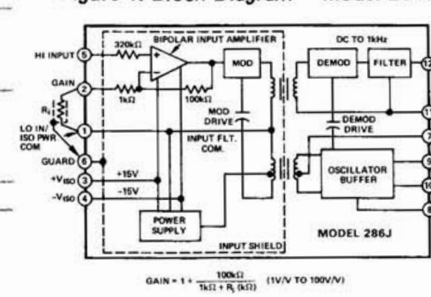
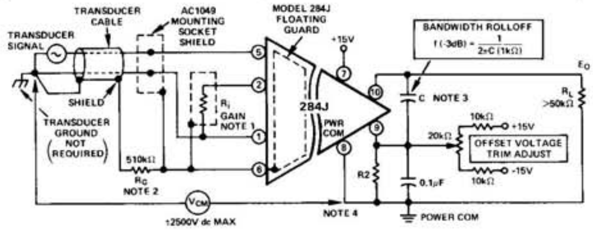


Figure 2. Block Diagram – Model 286J

INTERCONNECTION AND GUARDING TECHNIQUES

Models 284J, 286J can be applied directly to achieve rated performance as shown in Figures 3 and 4. To preserve the high



NOTE 1. GAIN RESISTOR, R_i, 1%, 50ppm/°C METAL FILM TYPE IS RECOMMENDED.
FOR GAIN = 1V/V, LEAVE TERMINAL 2 OPEN.
FOR GAIN = 10V/V, SHORT TERMINAL 2 TO TERMINAL 1

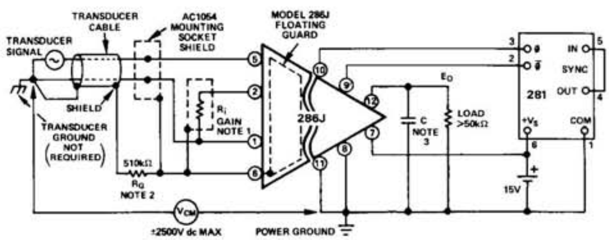
$$GAIN = 1 + \frac{100k\Omega}{10.7k\Omega + R_i(k\Omega)}$$

NOTE 2. GUARD RESISTOR, R_G, REQUIRED ONLY FOR CMV > ±2500V_{PK} (±5kV_{PK} MAX). R_G MAY BE MOUNTED ON AC1049 MOUNTING SOCKET USING STANDOFF PROVIDED. (USE ¼ WATT, 5%, CARBON COMPOSITION TYPE; ALLEN BRADLEY RECOMMENDED).

NOTE 3. OUTPUT FILTER CAPACITOR, C. SELECT TO ROLLOFF NOISE AND OUTPUT RIPPLE: (e.g. SELECT C = 1.5µF FOR dc TO 100Hz BANDWIDTH).

NOTE 4. R2 ~ 200Ω, G = 1; R2 ~ 2kΩ, G>1

Figure 3. Model 284J Basic Isolator Interconnection



NOTE 1. GAIN RESISTOR, R_i, USE 50ppm/°C, METAL FILM TYPE.
FOR GAIN = 1V/V, LEAVE TERMINAL 2 OPEN.
FOR GAIN = 100V/V, SHORT TERMINAL 2 TO TERMINAL 1
FOR GAINS FROM 1V/V TO 100V/V:

$$GAIN = 1 + \frac{100k\Omega}{1k\Omega + R_1\ (k\Omega)}$$

NOTE 2. OPTIONAL GUARD RESISTOR, R_G, REQUIRED ONLY FOR CMV > ±2500V_{PK}. R_G MAY BE CONVENIENTLY MOUNTED ON AC1054 MOUNTING SOCKET USING THE STANDOFF PROVIDED (R_G). USE 1/4 WATT, 5% CARBON COMPOSITION TYPE; (ALLEN BRADLEY RECOMMENDED).

NOTE 3. OUTPUT FILTER CAPACITOR C. SELECT TO ROLL-OFF NOISE AND OUTPUT RIPPLE: (e.g. SELECT C=1.5µF FOR dc TO 100Hz BANDWIDTH)

$$F\ (-3dB) = \frac{1}{2\pi C\ (1k\Omega)}$$

Figure 4. Model 286J Basic Isolator Interconnection

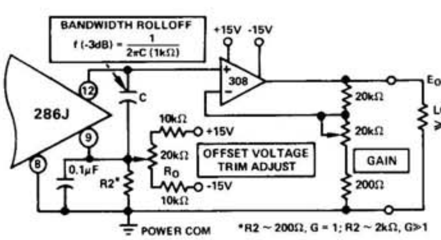


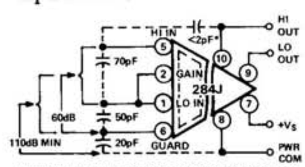
Figure 5. Model 286J Optional Connection: Offset Voltage Trim Adjust, Bandwidth (–3dB) Rolloff and Gain Adjust (G>100V/V)

CMR performance, 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 284J or 286J. The GUARD (Pin 6) should be connected to this shield. The guard-shield is provided with the mounting socket. To reduce effective cable capacitance, cable shield should be connected to the common mode signal source by connecting the shield as close as possible to the signal low.

Offset Voltage Trim Adjust: The trim adjust circuits shown in Figures 3 and 5 can be used to zero the output offset voltage over the specified gain range. The output terminals, HI OUT and LO OUT, can be floated with respect to PWR COM up to ±50V_{pk} max, offering three-port isolation. A 0.1µF capacitor is required from LO OUT to PWR COM whenever the output terminals are floated with respect to PWR COM. LO OUT can be connected directly to PWR COM when output offset trimming is not required.

INTERELECTRODE CAPACITANCE, TERMINAL RATINGS AND LEAKAGE CURRENTS LIMITS

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 50kMΩ. Figures 6 and 8 illustrate the CMR ratings at 60Hz and 5kΩ source imbalance between signal input/output terminals, along with their respective capacitance.



*WHEN GUARD TIED TO INPUT COMMON MODE SOURCE

Figure 6. Model 284J Terminal Capacitance and CMR Ratings

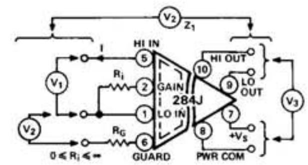
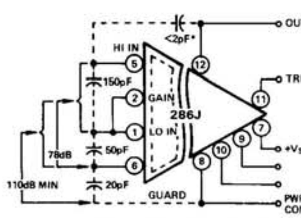


Figure 7. Model 284J Terminal Ratings



*WHEN GUARD TIED TO INPUT COMMON MODE SOURCE

Figure 8. Model 286J Terminal Capacitance and CMR Ratings

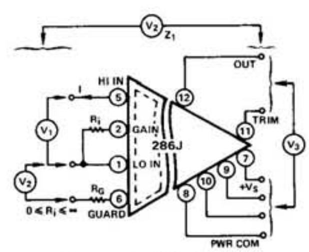


Figure 9. Model 286J Terminal Ratings

Terminal Ratings: CMV performance is given in both peak pulse and continuous ac or dc peak ratings. Pulse ratings are intended to support defibrillator and other transient voltages. Continuous peak ratings apply from dc up to the normal full power response frequencies. Figures 7 and 9 and Table I illustrate models 284J, 286J ratings between terminals.

SYMBOL	RATING	REMARKS
V1 (pulse)*	±6500V_{PK} (10ms)	Withstand Voltage, Defibrillator
V1 (cont.)	±240V_{RMS}	Withstand Voltage, Steady State
V2 (pulse)*	±2500V_{PK} (10ms) R_G = 0	Transient
V2 (pulse)*	±5000V_{PK} (10ms) R_G = 510kΩ	Isolation, Defibrillator
V2 (cont.)	±2500V_{PK}	Isolation, Steady State
V3 (cont.)	±50V_{PK}	Isolation, dc
Z1	50kMΩ‖20pF	Isolation Impedance
I (286J)	50µA rms	Input Fault Limit, dc to 200kHz
I (284J	35µA rms	Input Fault Limit, dc to 60kHz

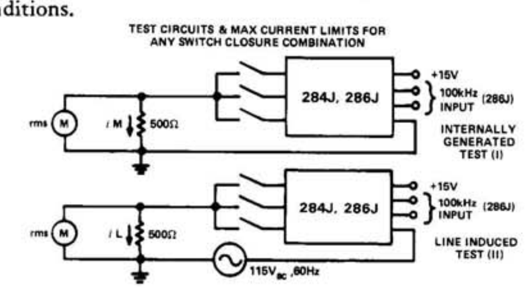
*Rise time of pulse must be >10µs.

Table I. Isolation Ratings Between Terminals

Leakage Current Limits: The low coupling capacitance between inputs and output yields a ground leakage current of less than 2.0μA rms (284J) and 2.5μA rms (286J) at 115V ac, 60Hz (or 0.02μA/V ac). As shown in Figures 10 and 11, the transformer coupled modulator signal, through stray coupling, also creates an internally generated leakage current. Line frequency leakage current levels are unaffected by the power on or off condition of models 284J, 286J.

For medical applications, models 284Jand 286J are designed to improve on patient safety current limits proposed by F.D.A., U.L., A.A.M.I. and other regulatory agencies (e.g., model 286J complies with leakage requirements for the Underwriters Laboratory STANDARD FOR SAFETY, MEDICAL AND DENTAL EQUIPMENT as established under UL544 for type A and B patient connected equipment – reference *Leakage Current,* paragraph 27.5).

In patient monitoring equipment, such as ECG recorders, models 284J, 286J will provide adequate isolation without exposing the patient to potentially lethal microshock hazards. Using passive components for input protection, this design limits input fault currents even under amplifier failure conditions.



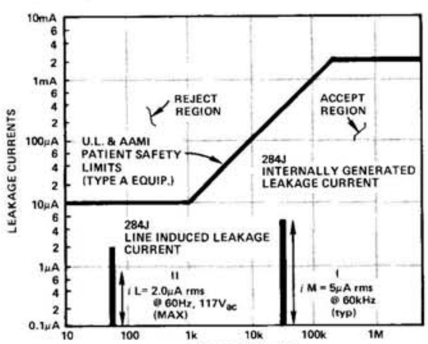


Figure10. Model 284J Leakage Current Performance from Line Induced and Internally Generated (Modulator) Operating Conditions

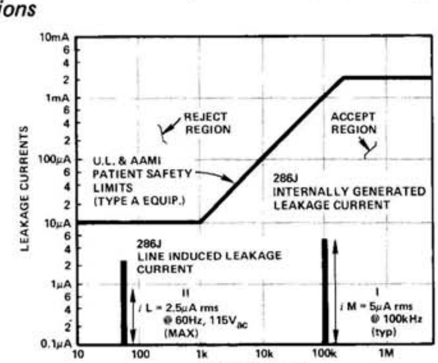


Figure 11. Model 286J Leakage Current Performance from Line Induced and Internally Generated (Modulator) Operating Conditions

GAIN AND OFFSET TRIM PROCEDURE, MODEL 284J

1. Apply e_{IN} = 0 volts and adjust R_O for e_O = 0 volts.
2. Apply e_{IN} = +1.000V dc and adjust R_G for e_O = +5.000V dc.
3. Apply e_{IN} = –1.000V 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 e_{IN} = +1.000V dc and adjust R_O until the output error is one half that measured in step 4 (see curve c).

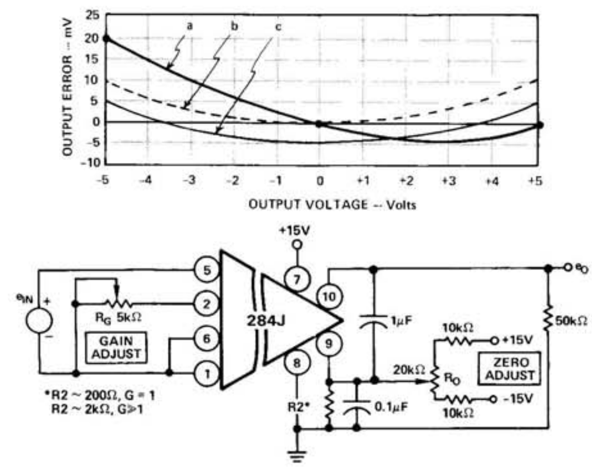


Figure 12. Gain and Offset Adjustment

GAIN AND OFFSET TRIM PROCEDURE, MODEL 286J

In applying the isolation amplifier, highest accuracy is achieved by adjustment of gain and offset voltage to minimize the peak error encountered over the selected output voltage span. 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 operation at Gain = 10V/V is desired.

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).

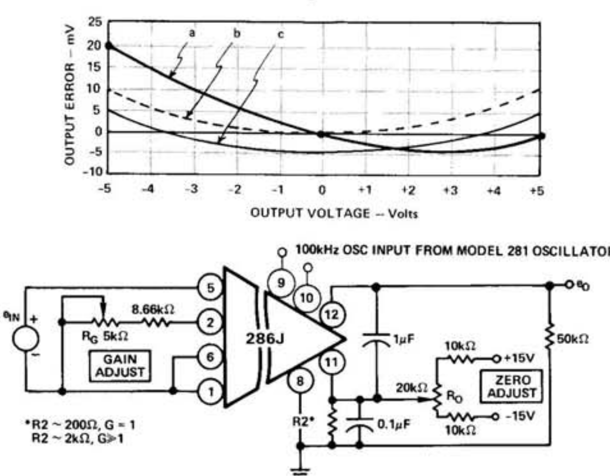


Figure 13. Gain and Offset Adjustment

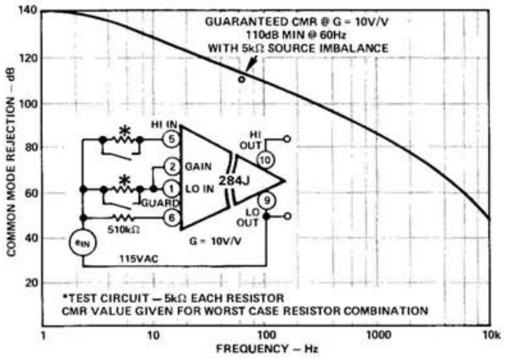


Figure 14. Model 284J Common Mode Rejection vs. Frequency

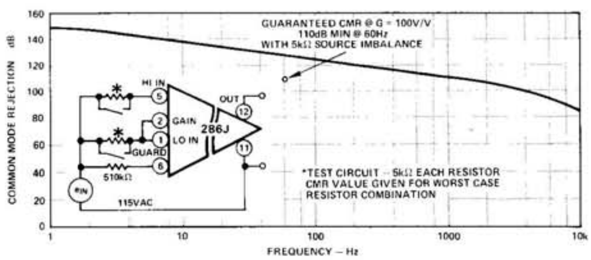


Figure 15. Model 286J Common Mode Rejection vs. Frequency

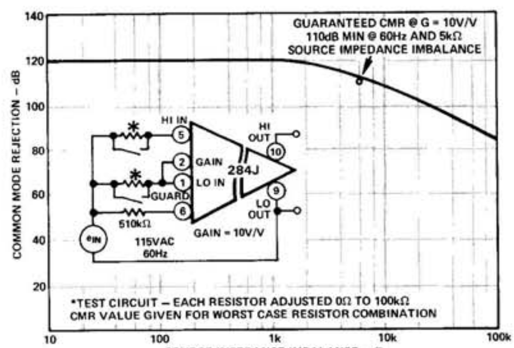


Figure 16. Model 284J Common Mode Rejection vs. Source Impedance Imbalance

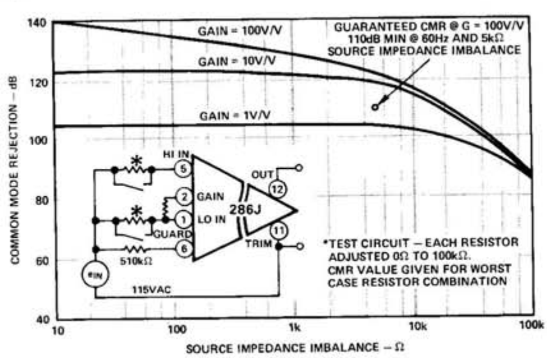


Figure 17. Model 286J Common Mode Rejection vs. Source Impedance Imbalance

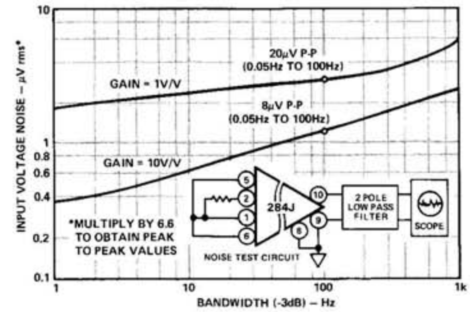


Figure 18. Model 284J Input Voltage Noise vs. Bandwidth

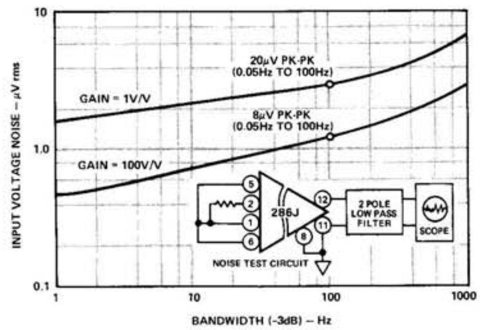


Figure 19. Model 286J Input Voltage Noise vs. Bandwidth

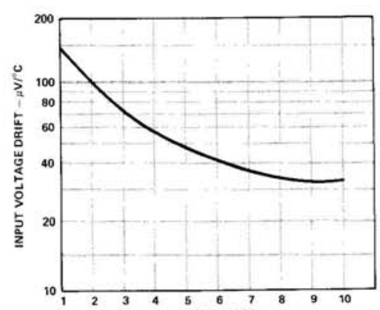


Figure 20. Model 284J Input Offset Voltage Drift vs. Gain

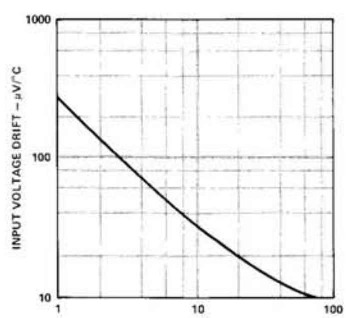


Figure 21. Model 286J Input Offset Voltage Drift vs. Gain

Applying the Multi-Channel Isolation Amplifier

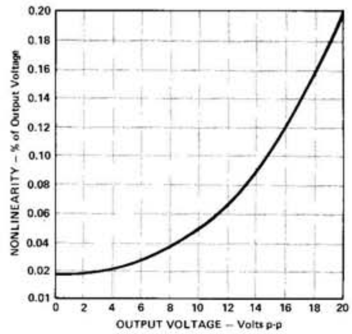


Figure 22. Model 286J Gain Nonlinearity vs. Output Voltage

REFERENCE EXCITATION OSCILLATOR*

When applying model 286J, the user has the option of building a low cost 100kHz excitation oscillator, as shown in Figure 23, or purchasing a module from Analog Devices – model 281.

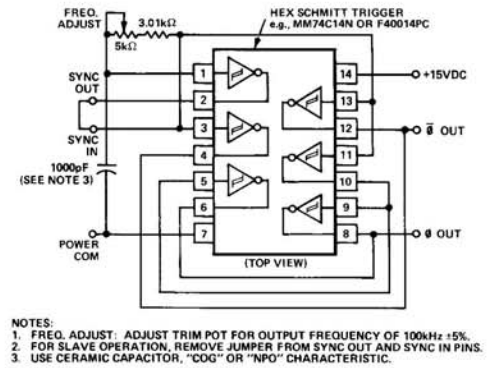


Figure 23. Model 281 100kHz Oscillator – Logic and Interconnection Diagram

The block diagram of model 281 is shown in Figure 24. An internal +12V dc regulator is provided to permit the user the option of operating over two, pin selectable, power input ranges; terminal 6 offers a range of +14V dc to +28V dc; terminal 7 offers an input range of +8V dc to +14V dc.

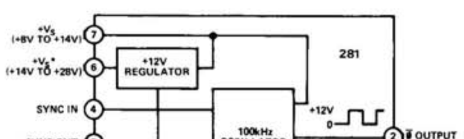


Figure 24. Model 281 Block Diagram

Model 281 oscillator is capable of driving up to 16 model 286Js as shown in Figure 25. An additional model 281 may be driven in a slave-mode, as shown in Figure 26 to expand the total system channels from 16 to 32. By adding additional model 281's in this manner, systems of over 1000 channels may be easily configured.

EXTERNAL OSCILLATOR INTERCONNECTION

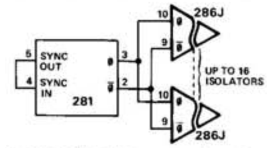


Figure 25. Model 281/286 Connection for Driving from 1 to 16 Isolators

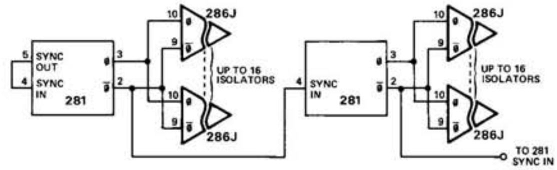


Figure 26. Model 281/286 Connection for Driving > 16 Isolators

SPECIFICATIONS

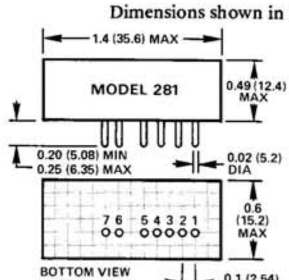
(typical @ +25°C and V_S = +15V dc unless otherwise noted)

MODEL	281*
OUTPUT	
Frequency	100kHz ±5%
Waveform	Squarewave
Voltage (ϕ and $\bar{\phi}$ terminals)	0 to +12V pk
Fan-Out[1,2]	16 max
POWER SUPPLY RANGE[3]	
High Input, Pin 6	+(14 to 28)V dc
Quiescent Current, N.L.	+5mA
F.L.	+16mA
Low Input, Pin 7	+(8 to 14)V dc
Quiescent Current, N.L.	+12mA
F.L.	+33mA
TEMPERATURE	
Rated Performance	0 to +70°C
Storage	-55°C to +85°C
MECHANICAL	
Case Size	1.4" x 0.6" x 0.49"
Weight	10 grams

NOTES
[1] Model 286J oscillator drive input represents unity oscillator load.
[2] For applications requiring more than 16 286Js, additional 281s may be used in a master/slave mode. Refer to Figure 26.
[3] Full load consists of 16 model 286Js and 281 oscillator slave.
Specifications subject to change without notice.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



PIN TERMINAL IDENTIFICATION
1 POWER COMMON
2 $\bar{\phi}$ OUTPUT
3 ϕ OUTPUT
4 SYNC INPUT
5 SYNC OUTPUT
6 $+V_S$: HIGH RANGE +(14 to 28)V_{dc}
7 $+V_S$: LOW RANGE +(8 to 14)V_{dc}

MATING SOCKET: Cinch #16 DIP or Equivalent

***CAUTION:**

ESD(Electro-static-discharge) sensitive device. Permanent damage may occur on unconnected devices subjected to high-energy electrostatic fields. Unused devices must be stored in conductive foam or shunts. The protective foam should be discharged to the destination socket before devices are removed.

Intronics Power ®

Precision, Wide Bandwidth, Synchronized Isolation Amplifier

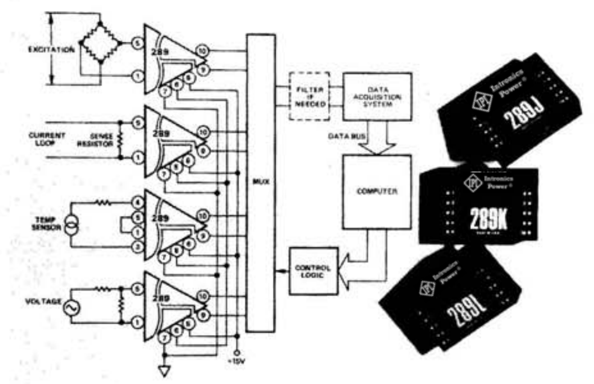
MODEL 289

FEATURES

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

APPLICATIONS

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



4 CHANNEL ISOLATED DATA ACQUISITION SYSTEM

GENERAL DESCRIPTION

Model 289 is a wide-band, 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: ±0.012% max (289L), ±0.025% max (289K), ±0.05% max (289J). All versions of the 289 provide a small signal frequency response from dc to 20kHz (–3dB) 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, ±2500V 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 ±15V outputs @ ±5mA. Isolated power is regulated to within ±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 2kΩ 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, 2μA rms @ 115V ac, 60Hz.

1400 PROVIDENCE HIGHWAY • BUILDING 2 NORWOOD, MASSACHUSETTS 02062-5015
PHONE: 781-551-5500 FAX: 781-551-5555

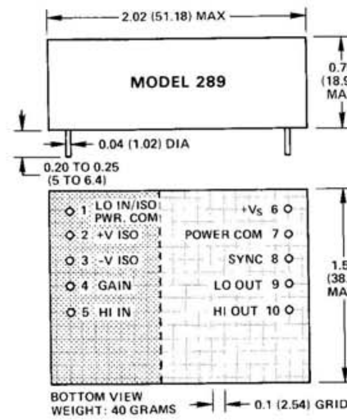
SPECIFICATIONS (typical @ +25°C and V_S = +14.4V to +25V dc unless otherwise noted)

Model	289J	289K	289L
GAIN (NONINVERTING)			
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)[1]		15ppm/°C typ (50ppm/°C max)	
Nonlinearity, (±5V Swing)[2,3]	±0.05% max	±0.025% max	±0.012% max
INPUT VOLTAGE RATINGS			
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			
$R_S \leq 1k\Omega$, Balanced Source Impedance		120dB	
$R_S \leq 1k\Omega$, HI IN Lead Only		104dB min	
Max Leakage Current, Input to Output @ 115V rms, 60Hz ac		2μA rms max	
INPUT IMPEDANCE			
Differential		$33pF \parallel 10^8\Omega$	
Overload		100kΩ	
Common Mode		$20pF \parallel 5 \times 10^{10}\Omega$	
INPUT DIFFERENCE CURRENT			
Initial @ +25°C		10nA (75nA max)	
vs. Temperature (0 to 70°C)		0.15nA/°C	
INPUT NOISE (GAIN = 100V/V)			
Voltage			
0.05Hz to 100Hz		8μV p-p	
10Hz to 1kHz		3μV rms	
Current			
0.05Hz to 100Hz		3pA rms	
FREQUENCY RESPONSE			
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[4] ±0.05%, ±10V Step		400μs	
OFFSET VOLTAGE, REFERRED TO INPUT			
Initial, @ +25°C		$\pm 5 \pm \frac{10}{G}$ mV max	
vs. Temperature (0 to +70°C)	$\pm 20 \pm \frac{200}{G}$ max	$\pm 15 \pm \frac{100}{G}$ max	$\pm 10 \pm \frac{50}{G}$ μV/°C max
vs. Supply Voltage (+15V to +20V change)		$\pm 2 \pm \frac{10}{G}$ μV/V	
RATED OUTPUT			
Voltage, 2kΩ Load		±10V min	
Output Impedance		<1Ω(dc to 100Hz)	
Output Ripple, 0.1MHz Bandwidth			
No Signal IN		5mV p-p	
$+10V_{IN}$		50mV p-p	
ISOLATED POWER SUPPLY			
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	
POWER SUPPLY, SINGLE POLARITY[5]			
Voltage, Rated Performance		+14.4V to +25V	
Voltage, Operating		+8.5V to +25V	
Current, Quiescent (@ V_S = +15V)		+25mA	
TEMPERATURE RANGE			
Rated Performance		0 to +70°C	
Operating		-15°C to +75°C	
Storage		-55°C to +85°C	
CASE DIMENSIONS		1.5" X 2.0" X 0.75"	

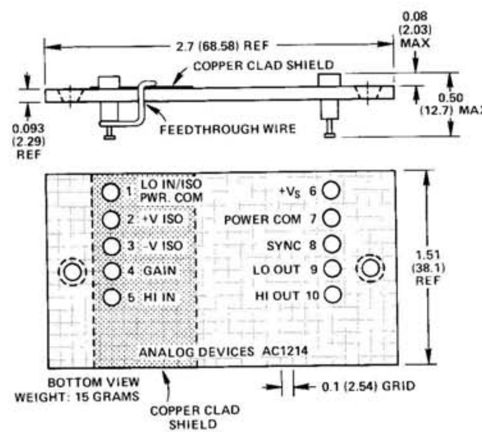
NOTES:
[1] Gain temperature drift is specified as a percentage of output signal level.
[2] Gain nonlinearity is specified as a percentage of 10V pk-pk output span.
[3] When isolated power output is used, nonlinearity increases by ±0.002%/mA of current drawn.
[4] G = 1V/V; with 2-pole, 5kHz output filter (see Figure 13).
[5] Recommended power supply, ADI model 904, ±15V @ 50mA output.
Specifications subject to change without notice.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



SHIELDED MATING SOCKET AC1214

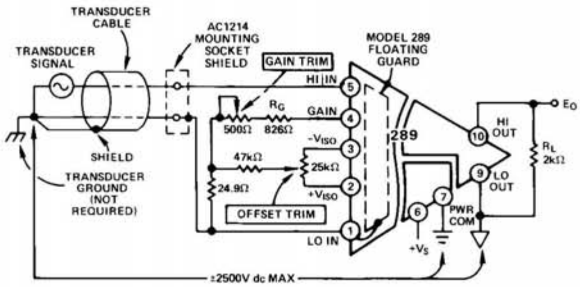


INTERCONNECTIONS AND SHIELDING TECHNIQUE

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



NOTE:
GAIN RESISTOR R_G, 1% 50ppm/°C METAL FILM TYPE IS RECOMMENDED.
FOR GAIN = 1V/V, LEAVE PIN 4 OPEN
FOR GAIN > 1V/V, CONNECT GAIN RESISTOR (R_G) BETWEEN PIN 4 AND PIN 1

$$GAIN = 1 + \frac{10k\Omega}{R_G(k\Omega)}$$

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.

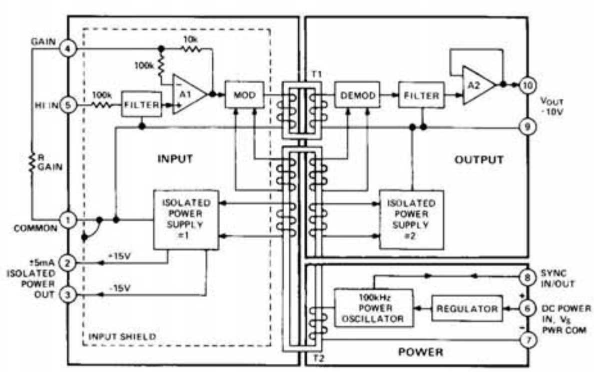


Figure 2. Model 289 Block Diagram

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.

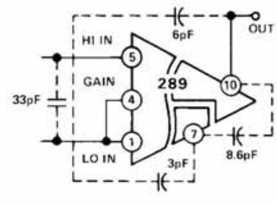


Figure 3. Model 289 Terminal Capacitance

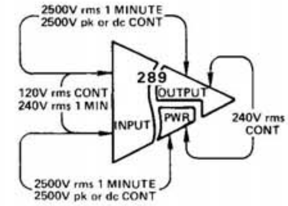


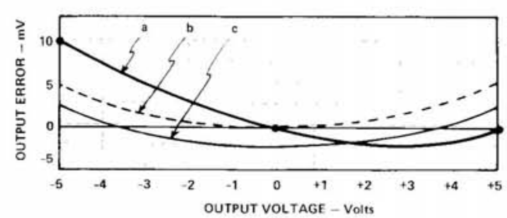
Figure 4. Model 289 Terminal Ratings

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).



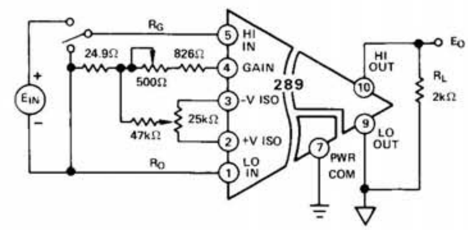


Figure 5a. Recommended Offset and Gain Adjustment for Gains > 1

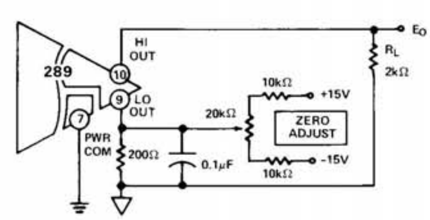


Figure 5b. Recommended Offset Adjustment for G = 1V/V

PERFORMANCE CHARACTERISTICS

Figure 6 shows the phase shift vs. frequency. The low phase shift and wide bandwidth of the model 289 make it suitable for use in SCR Motor Controller and other high frequency applications.

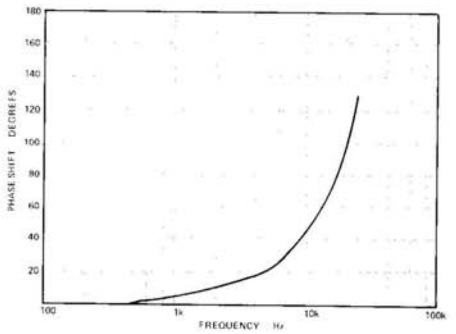


Figure 6. Typical 289 Phase vs. Frequency

Figure 7 illustrates the effect of source impedance imbalance on CMR performance at 60Hz for gains of 1V/V, 10V/V, and 100V/V. CMR is typically 120dB at 60Hz and a balanced source impedance. CMR is >60dB for source impedance imbalances up to 100kΩ.

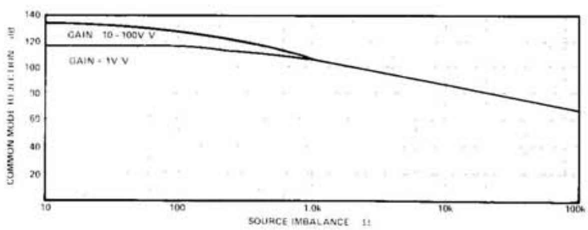


Figure 7. Typical 289 Common Mode Rejection vs. Source Impedance

Input Voltage Noise: Voltage noise, referred to input, is dependent on gain and bandwidth. Figure 8 shows rms voltage noise in a bandwidth from 0.05Hz to the frequency shown on the horizontal axis. The noise in a bandwidth from 0.05Hz to 100Hz is 8μV pk-pk at a gain of 100V/V. The peak-to-peak value is derived by multiplying the rms value at F = 100Hz (1.2μV rms) by 6.6.

For best noise performance in particular applications, a low pass filter at the output should be used to selectively roll-off noise and undesired signal frequencies beyond the bandwidth of interest. Increasing gain will also reduce the noise, referred to input.

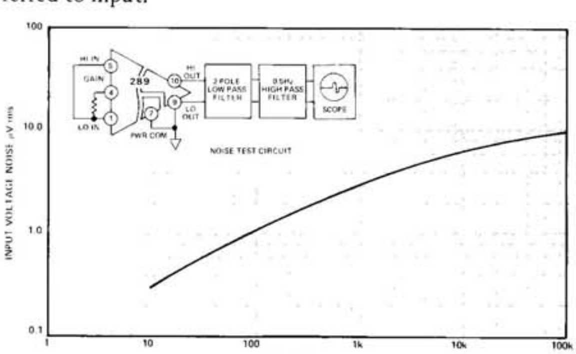


Figure 8. Typical Input Voltage Noise vs. Bandwidth

Gain Nonlinearity: Linearity error is defined as the deviation of the output voltage from the best straight line and is specified as a % peak-to-peak output voltage span; e.g., nonlinearity of model 289J operating at an output span of 10V pk-pk (±5V) is ±0.05% or ±5mV. Figure 9 illustrates gain nonlinearity for any output span to 20V pk-pk (±10V). Figure 10 shows the effect of gain vs. gain nonlinearity.

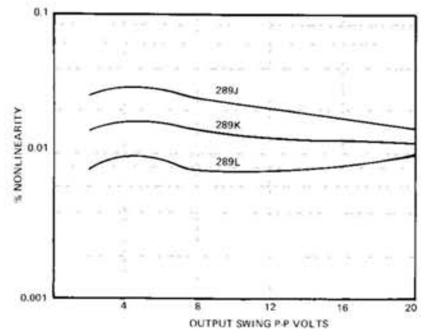


Figure 9. Typical Gain Nonlinearity vs. Output Swing

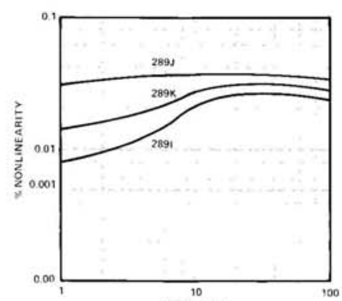


Figure 10. Typical Gain Nonlinearity vs. Gain

Common Mode Rejection: Input-to-output CMR is dependent on source impedance imbalance, signal frequency and amplifier gain. CMR is rated at 115V ac, 60Hz and 1kΩ balanced source at a gain of 100V/V. Figure 11 illustrates CMR performance as a function of signal frequency. CMR approaches 156dB at dc with source imbalance as high as 1kΩ. As gain is decreased, CMR is reduced. At a gain of 1V/V, CMR is typically 6dB lower than at a gain of 100V/V.

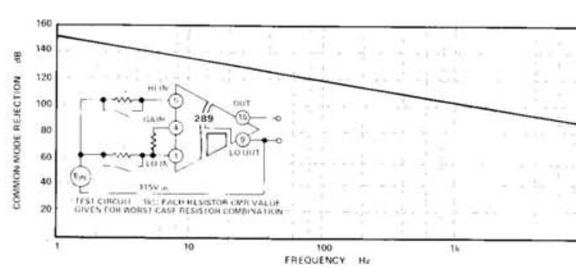


Figure 11. Typical Common Mode Rejection vs. Frequency

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 ±2% squarewave generator by the connection of synchronization terminal(s) to that generator. The generator output should be 2.5V–5.0V p-p with 1kΩ 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.

APPLICATIONS IN INDUSTRIAL MEASUREMENT AND CONTROL SYSTEMS

Isolated DAS: In data acquisition systems where multiple transducers are powered by a single supply and the magnitude of that supply is low enough for a multiplexer to handle the voltages on all the transducers, it is economical to multiplex ahead of an isolator. The fast settling time of the model 289 makes this configuration practical where slower isolators would not be usable.

Figure 12 shows an application where the difference in voltage between any two terminals of any of the transducers does not exceed 30 volts. Though the input of the model 289 is protected against line voltage, its power terminals are not; neither is the multiplexer so protected. This circuit will not, therefore, withstand the differential application of line voltage.

Multiplexer addressing is binary, an enable providing selection of the circuit shown as a signal source. Optical isolation is provided for digital signals. When several of these circuits are used for several groups of transducers, the model 289's should be synchronized.

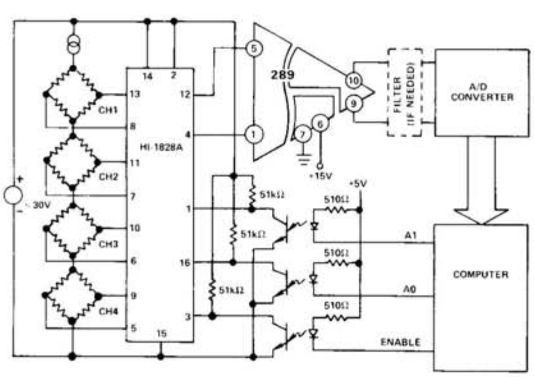


Figure 12. DAS with MUX Ahead of Isolator

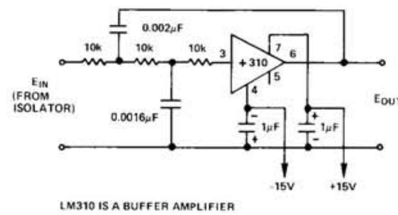


Figure 13. 2-Pole, 5kHz Active Filter

Noise Reduction in Data Acquisition Systems: Transformer coupled isolators must have a carrier to pass dc signals through their signal transformers. Inevitably some carrier frequency ripple passes through to the isolator output. As the bandwidth of an isolator becomes a larger fraction of its carrier frequency, this ripple becomes more difficult to control. Despite this difficulty, the model 289 produces very low ripple; therefore, additional filtration will usually be unnecessary. However, in some applications, particularly where a fast analog-to-digital converter is used following the isolator, it may be desirable to add filtration; otherwise, ripple may cause inaccurate conversions. The 2-pole low-pass shown in Figure 13 limits isolator bandwidth to 5kHz, which is the full power bandwidth of the model 289. Carrier ripple is much reduced. Another beneficial effect of an output filter is smoothing of discontinuous high frequency waveforms.

Motor Control and AC Load Control: Phase shift and bandwidth are important considerations for motor control and ac load control applications. The model 289 possesses sufficient bandwidth and acceptable phase shift for such tasks.

Figure 14 shows two model 289's sensing the armature voltage and current of a motor. Faithful replicas of the waveforms of these variables are applied to the motor control. A1 operates at unity gain from divided R1–R3 to deliver an output that is 1/100 of the armature voltage of the motor. A2 operates at a gain of 100V/V to deliver a voltage 100 times that developed across the current sensing shunt.

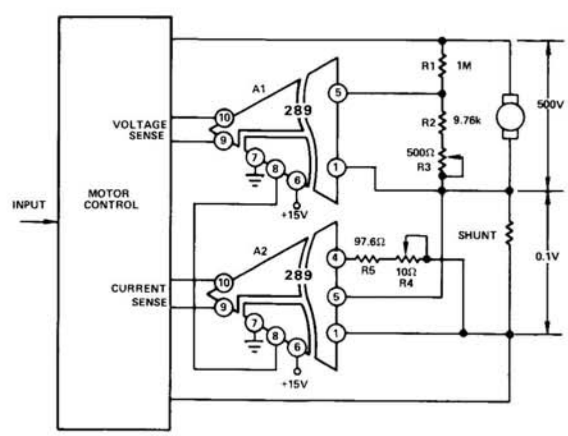


Figure 14. Isolating a Motor Controller

Figure 15 shows three model 289's sensing the voltages on the three phases of an ac load. The Y network shown divides the voltages of the three phases and creates a neutral for the input commons of the isolators. The output of each isolator is a faithful replica of the phase of the waveform it senses. The isolator outputs provide the feedback necessary for the trigger control to correctly fire the triacs. In other applications, the outputs of the isolators might have been fed to rms-to-dc converters.

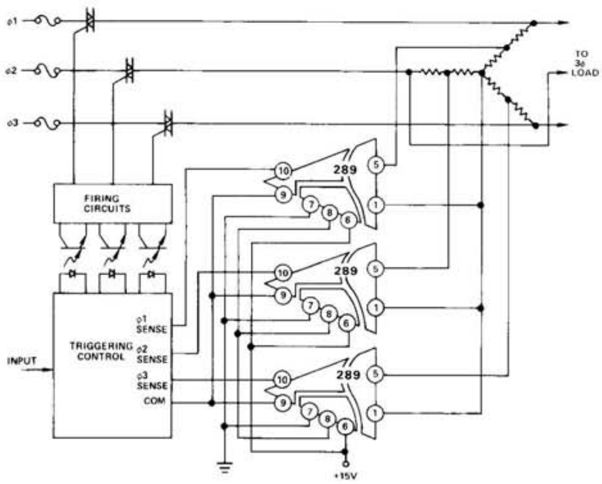


Figure 15. Isolating a 3 Phase Load Controller

Isolated DACs: Figure 16 shows a 12-bit DAC with ±5V isolated output. A buffered −5V reference voltage is provided to the DAC by A1a, A1b and associated circuitry. The digital input causes a proportion of DAC current to flow into OUT1 of the DAC. The remaining DAC current flows into OUT2. Current flowing into OUT1 causes positive voltage at the output of A1c. Current flowing into OUT2 causes a positive voltage at the output of A1d, which in turn causes a negative voltage at the output of A1c. Voltage appearing at the output of A1c is reproduced at the output of the model 289. R5 and R8 must be adjusted to produce less than 0.5mV at OUT1 and OUT2 of the DAC respectively. R15 may be used to adjust gain and R11 to adjust offset with the binary code 1000 0000 0000 to zero.

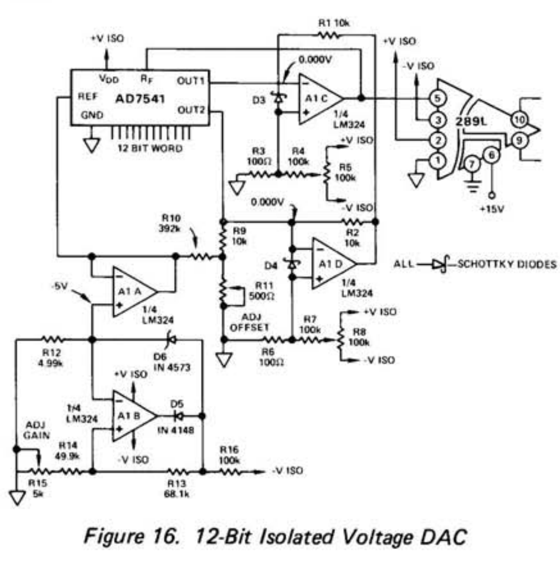


Figure 16. 12-Bit Isolated Voltage DAC

Figure 17 shows the model 289 providing an isolated 4-to-20mA output from a 12-bit DAC. A1a provides a −4V reference to the DAC. The digital input causes a portion of DAC current to flow into OUT1, causing a positive voltage at the output of A1d. A1b produces a voltage across R4 proportional to DAC current. A1c and associated circuitry sink a current which is one-fourth of the full scale current of the DAC, causing a positive voltage of 1 volt at the output of A1d. With the code 1111 1111 1111, +5 volts appears at the output of A1d. Operation is unipolar with a positive offset. The output voltage of A1d is reproduced at the output of the isolator, where the circuitry shown converts it into a 4-to-20mA current which may be applied to the load R_L.

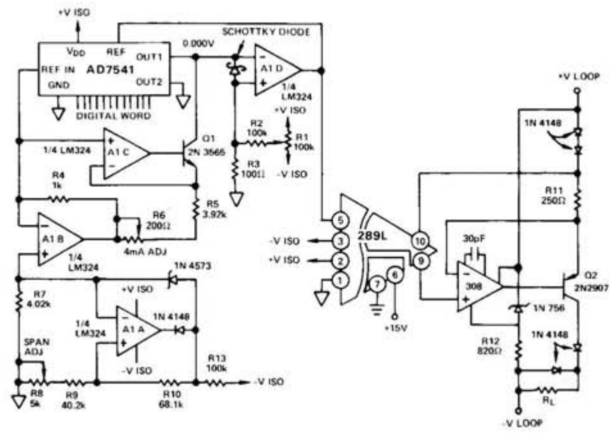


Figure 17. 12-Bit Isolated Process Current DAC

Temperature Measurement: Figure 18 shows the model 289 providing a ground-referred output in an application measuring the temperature of an object floating at a high common mode voltage. The AD590 temperature sensor sinks a current of −1μA/K. This current flows into the gain terminal of the model 289, developing +10mV/K across the internal feedback resistor. This voltage also appears at the output of the model 289.

The circuitry shown connected by a dotted line may be useful if an output of 10mV/°C is desired. A current of +273μA is sourced through the 8.66k resistor and the potentiometer cancelling the AD590 current at 0°C (273K), resulting in 0mV at the output at 0°C.

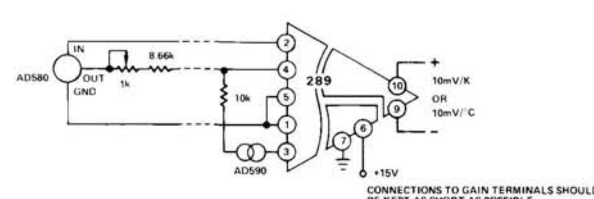


Figure 18. Isolated Temperature Measurement

Intronics Power ®

Low Cost, Single and Multichannel Isolation Amplifier

MODEL 290A, 292A

FEATURES
Low Cost
Multichannel Capability Using External Oscillator (292A)
Isolated Power Supply: ±13V dc @ ±5mA (290A) or ±15mA (292A)
Low Nonlinearity: 0.1% @ 10V pk-pk Output
High Gain Stability: 0.001%/1000 Hours; 0.01%/°C
Small Size: 1.5" X 1.5" X 0.62"
Low Input Offset Voltage Drift: 10µV/°C (Gain = 100V/V)
Wide Input/Output Dynamic Range: 20V pk-pk
High CMV Isolation: 1500V dc, Continuous
Wide Gain Range: 1 to 100V/V

APPLICATIONS
Ground Loop Elimination in Industrial and Process Control
High Voltage Protection in Data Acquisition Systems
Fetal Heart Biomedical and Monitoring Instrumentation
Off-Ground Signal Measurements

GENERAL DESCRIPTION
Models 290A and 292A are low cost, compact, isolation amplifiers that are optimized for single and multichannel industrial applications, respectively. The model 290A has a self-contained oscillator and is intended for single channel applications. A single external synchronizing oscillator can drive up to 16 model 292A's or, a virtually limitless number of model 292A's can be configured using multiple oscillators. The user can supply the external oscillator circuit or specify model 281 oscillator module, which includes a voltage regulator for operation over a wide single supply voltage range of +8V to +28V.

Models 290A and 292A design features include: adjustable gain, from 1 to 100V/V, dual isolated power, ±13V dc, ±1500V dc off ground isolation, 100dB minimum CMR at 60Hz, 1kΩ source imbalance, in a compact 1.5" X 1.5" X 0.6" module. Models 290A and 292A achieve low input noise of 1µV pk-pk (10Hz bandwidth, G = 100V/V), nonlinearity of ±0.1% @ 10V pk-pk output, and an input/output dynamic range of 20V pk-pk.

Using modulation techniques with reliable transformer isolation, models 290A and 292A will interrupt ground loops, leakage paths, and voltage transients, while providing dc to 2kHz (−3dB) response.

WHERE TO USE MODELS 290A AND 292A
Industrial Applications: In data acquisition systems, computer interface systems, process signal isolators and high CMV instrumentation, models 290A and 292A offer complete galvanic isolation and protection against damage from transients and fault voltages. High level transducer interface capability is afforded with 20V pk-pk input signal range at a gain of 1V/V operation. In portable single or multichannel designs, single power supply operation (+8V to +16V) enables battery operation.

DESIGN FEATURES AND USER BENEFITS
Isolated Power: Dual ±13V dc output, completely isolated from the input power terminals (±1500V dc isolation), provides the capability to excite floating signal conditioners, front end buffer amplifiers and remote transducers such as thermistors or bridges.

Adjustable Gain: Models 290A and 292A adjustable gain offers compatibility with a wide class of input signals. A single external resistor enables gain adjustment from 1V/V to 100V/V providing flexibility in both high level transducer interfacing as well as low level sensor measurement applications.

Floating, Guarded Front-End: The input stage of models 290A and 292A can directly accept floating differential signals or it may be configured as a high performance instrumentation front-end to accept signals having CMV with respect to input power common.

High Reliability: Models 290A and 292A are conservatively designed, compact modules, capable of reliable operation in harsh environments. They have a calculated MTBF of over 400,000 hours and are designed to meet MIL-STD-202E environmental testing as well as the IEEE Standard for Transient Voltage Protection (472-1974: Surge Withstand Capability).

1400 PROVIDENCE HIGHWAY • BUILDING 2 NORWOOD, MASSACHUSETTS 02062-5015
PHONE: 781-551-5500 FAX: 781-551-5555

SPECIFICATIONS (typical @ +25°C; G = 100V/V and V_S = +15V dc, unless otherwise noted)

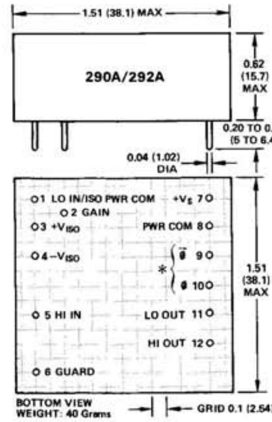
MODEL	290A		292A
GAIN (NONINVERTING)			
Range (50kΩ Load)		1 to 100V/V	
Formula		$Gain = \left[1 + \frac{100k\Omega}{1k\Omega + R_i (k\Omega)}\right]$	
Deviation from Formula		±3%	
vs. Time		±0.001%/1000 Hours	
vs. Temperature (-25°C to +85°C)[1]		±0.0075%/°C	
Nonlinearity, G = 1V/V to 100V/V[2]		±0.1% (±0.25%)[3]	
INPUT VOLTAGE RATINGS			
Linear Differential Range, G = 1V/V		±5V min (±10V min)[3]	
Max Safe Differential Input			
Continuous, 1 min		110V rms	
Max CMV, Inputs to Outputs			
ac, 60Hz, 1 Minute Duration		1500V rms max	
Continuous, ac		±1000V pk max	
Continuous, dc		±1500V pk max	
CMR, Inputs to Outputs, 60Hz, $R_S \leq 1k\Omega$			
Balanced Source Impedance		106dB	
1kΩ Hi In Lead Only		100dB min	
Max Leakage Current, Inputs to Power Common			
@ 115V ac, 60Hz		10µA rms max	
INPUT IMPEDANCE			
Differential		$10^8 \Omega \| 70pF$	
Overload		100kΩ	
Common Mode		$5 \times 10^{10} \Omega \| 100pF$	
INPUT DIFFERENCE CURRENT			
Initial, @ +25°C		+3nA	
vs. Temperature (-25°C to +85°C)		±0.1nA/°C	
INPUT NOISE			
Voltage, G = 100V/V			
0.01Hz to 10Hz		1µV p-p	
10Hz to 1kHz		1.5µV rms	
Current			
0.05Hz to 100Hz		5pA p-p	
FREQUENCY RESPONSE			
Small Signal, -3dB, G = 1V/V		2.5kHz	
Slew Rate		50mV/µs	
Full Power, 10V p-p Output			
Gain - 1V/V thru 100V/V	2.0kHz(1.0kHz)[3]		3.0kHz(1.0kHz)[3]
OFFSET VOLTAGE REFERRED TO INPUT			
Initial, @ +25°C, Adjustable to Zero		±(5 + 50/G)mV	
vs. Temperature (-25°C to +85°C)	±(10 + 150/G)µV/°C		±(8 + 250/G)µV/°C
vs. Supply Voltage		±1mV/%	
RATED OUTPUT			
Voltage, 50k Load		±5V min (±10V min)[3]	
Output Impedance		1kΩ	
Output Ripple, 1MHz Bandwidth		10mV pk-pk	
OSCILLATOR DRIVE INPUT			
Input Voltage	N/A		8 to 16V pk-pk
Input Frequency	N/A		100kHz ±5%, max
ISOLATED POWER OUTPUTS			
Voltage Full Load		±13V dc	
Accuracy		±5%	
Current[4]	±5mA min		±15mA min
Regulation, No Load to Full Load		+0, -15%	
Ripple, 100kHz Bandwidth	200mV p-p		250mV p-p
POWER SUPPLY, SINGLE POLARITY			
Voltage, Rated Performance		+15V dc	
Voltage, Operating		+8V dc to +15.5V dc	
Current, Quiescent		+20mA	
TEMPERATURE RANGE			
Rated Performance		-25°C to +85°C	
Storage		-55°C to +85°C	
CASE DIMENSIONS		1.5" × 1.5" × 0.62"	

[1] Gain temperature drift is specified as a percentage of output signal level.
[2] Gain nonlinearity is specified as a percentage of 10V pk-pk output span.
[3] These specs apply for a 20V pk-pk output span.
[4] Do not load V_{ISO} when operating at output spans greater than 10V pk-pk.

Specifications subject to change without notice.

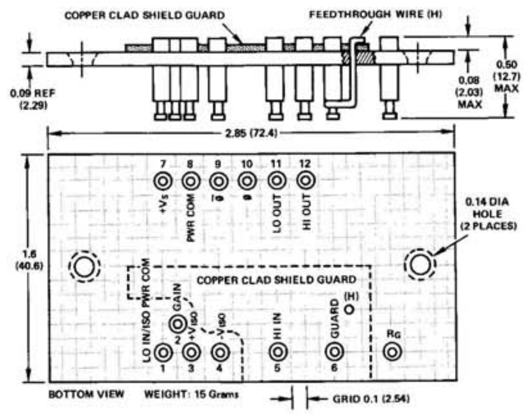
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



*PINS 9 AND 10 NOT PRESENT ON 290A

SHIELDED MOUNTING SOCKET AC1054



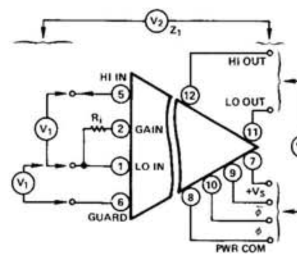


Figure 1. Model 290A and 292A Terminal Ratings

Symbol	Rating	Remarks
V_1	±110V rms (cont.)	Withstand Voltage, Steady State
V_2	±1000V pk (cont.)	Isolation, Steady State, ac
V_2	±1500V pk (cont.)	Isolation, Steady State, dc
V_2	±1500V rms (1 min)	Isolation, ac, 60Hz
V_3	±50V pk (cont.)	Isolation, dc
Z_1	50GΩ‖20pF	Isolation Impedance

Table 1. Isolation Ratings Between Terminals

THEORY OF OPERATION

The remarkable performance of models 290A and 292A are derived from the carrier isolation technique which is used to transfer both signal and power between the amplifier's guarded input stage and the rest of the circuitry. The block diagram for both models is shown in Figure 2 below.

The bipolar input preamplifier operates single-ended (non-inverting). Only a difference bias current flows with zero net bias current. A third wire return path for input bias current is not required. Gain can be set from 1V/V to 100V/V by changing the gain resistor, R_i. *To preserve high CMR, the gain resistor must be guarded.* Best performance is achieved by shorting terminal 2 to terminal 1 and operating the isolator at a gain of 100V/V.

For powering floating input circuitry such as buffer amplifiers, instrumentation amplifiers, calibration signals and transducers, dual isolated power is provided. High CMV isolation is achieved by the low-leakage transformer coupling between the input preamplifier, modulator section and the output circuitry. Only the 10pF leakage capacitance between the floating input section and the rest of the circuitry keeps the CMR from being infinite.

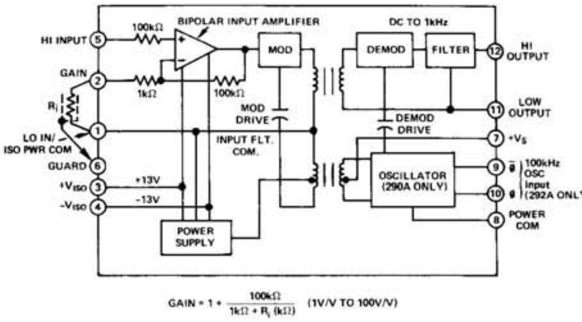


Figure 2. Block Diagram – Models 290A and 292A

GUIDELINES ON EFFECTIVE SHEILDING & GROUNDING PRACTICES

- Use twisted shielded cable to reduce inductive and capacitive pickup.
- Drive the transducer cable shield, S, with the common mode signal source, E_G, to reduce the effective cable capacitance as shown in Figure 3. This is accomplished by connecting the shield point S, as close as possible to the transducer signal low point B. This may not always be possible. In some cases the shield may be separated from signal low by a portion of the medium being measured (e.g. pressure transducer). This will cause a common mode signal, E_M, to be generated by the medium between the shield and the signal low. The 86dB CMR capability of both models between the input terminals (HI IN and LO IN) and GUARD, will work to suppress the common mode signal, E_M.
- Dress unshielded leads short at the connection terminals and reduce the area formed by these leads to minimize inductive pickup.

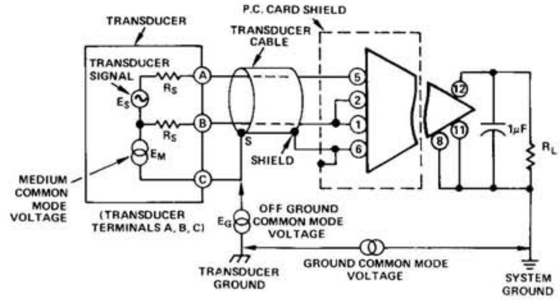
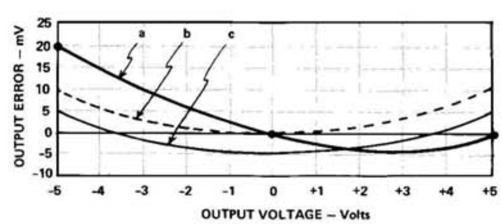


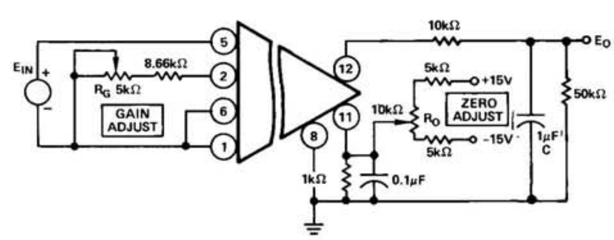
Figure 3. Transducer – Amplifier Interface

GAIN AND OFFSET TRIM PROCEDURE

In applying the isolation amplifier, highest accuracy is achieved by adjustment of gain and offset voltage to minimize the peak error encountered over the selected output voltage span. 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 operation at Gain = 10V/V is desired.

1. Apply E_{IN} = 0 volts and adjust R_O for E_O = 0 volts.
2. Apply E_{IN} = +0.5V dc and adjust R_G for E_O = +5.0V dc.
3. Apply E_{IN} = −0.5V 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 +0.5V dc and adjust R_O until the output error is one half that measured in step 4 (see curve c).





GAIN RESISTOR, R_i, 1%, 50ppm/°C METAL FILM TYPE IS RECOMMENDED.
FOR GAIN = 1V/V, LEAVE TERMINAL 2 OPEN.
FOR GAIN = 100V/V, SHORT TERMINAL 2 TO TERMINAL 1

$$GAIN = 1 + \frac{100k\Omega}{1k\Omega + R_i(k\Omega)}$$

OUTPUT FILTER, 10kΩ RESISTOR AND CAPACITOR, C.
SELECT C TO ROLL-OFF NOISE AND OUTPUT RIPPLE:

$$f = (-3dB) = \frac{1}{2\pi C\,(11k\Omega)}$$

Figure 4. Gain and Offset Adjustment

SELECTING BANDWIDTH

In low frequency signal measurements, such as thermocouple temperature measurements, strain gage measurements and geophysical instrumentation, an external filter is used to select bandwidth and minimize output noise.

When used with a buffer amplifier as shown in Figure 5a below, a series resistor (R_S) is used to lower the effective value of the filter capacitor required to achieve very low frequency (under 200Hz) noise filtering.

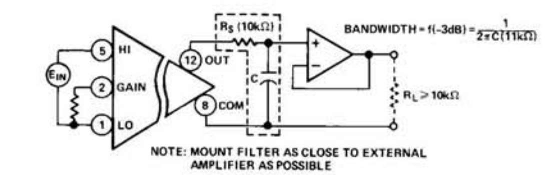


Figure 5a. Selecting Bandwidth with External Capacitor and Buffer

An active filter, as illustrated in Figure 5b will significantly improve 60Hz noise reduction at the output by providing a sharp roll-off characteristic. The 5Hz 3-pole active filter design illustrated in Figure 5b, will increase the 60Hz noise reduction by 50dB. Overall CMR performance of models 290 and 292 and the 5Hz active filter approaches 150dB @ 60Hz and 1kΩ imbalance.

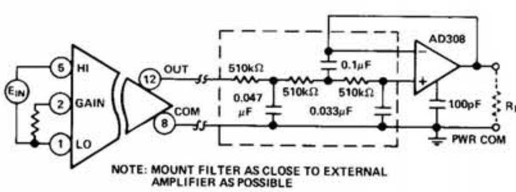


Figure 5b. Selecting Bandwidth with a 3-Pole 5Hz Active Filter

PERFORMANCE CHARACTERISTICS

Common Mode Rejection: Input-to-Output CMR is dependent on source impedance imbalance, signal frequency and amplifier gain. CMR is rated at 115V ac, 60Hz and 1kΩ imbalance at a gain of 100V/V. Figure 6 illustrates CMR performance as a function of signal frequency. CMR approaches 130dB at dc with source imbalances as high as 1kΩ. As gain is decreased, CMR is reduced. At a gain of 1V/V, CMR is typically 12dB lower than at a gain of 100V/V.

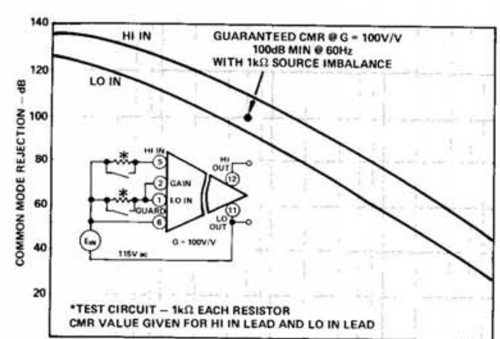


Figure 6. Typical Common Mode Rejection vs. Frequency

Figure 7 illustrates the effect of source imbalance on CMR performance at 60Hz and Gain = 100V/V. CMR is typically 110dB at 60Hz and a balanced source. CMR is maintained greater than 70dB for source imbalances up to 100kΩ.

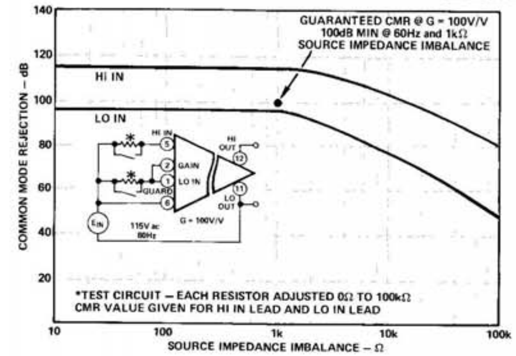


Figure 7. Typical Common Mode Rejection vs. Source Impedance Imbalance

Gain Nonlinearity: Linearity error is defined as the deviation of the output voltage from the best straight line and is specified as a % of peak-to-peak output voltage span; e.g., nonlinearity of models 290A and 292A operating at an output span of 10V pk-pk (±5V) is ±0.1% or ±10mV. Figure 8 illustrates gain nonlinearity for any output span to 20V pk-pk (±10V).

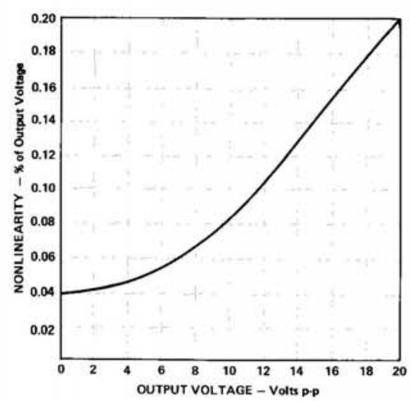


Figure 8. Typical Gain Nonlinearity vs. Output Voltage

Input Voltage Noise: Voltage noise, referred to input, is dependent on gain and bandwidth as illustrated in Figure 9. RMS voltage noise is shown in a bandwidth from 0.01Hz to the frequency shown on the horizontal axis. The noise in a bandwidth from 0.01Hz to 10Hz is 1µV pk-pk at a gain of 100V/V. This value is derived by multiplying the rms value at f = 10Hz shown in Figure 9 by 6.6.

For best noise performance in particular applications, a low pass filter at the output should be used to selectively roll-off noise and undesired signal frequencies beyond the bandwidth of interest. Increasing gain will also reduce the input noise.

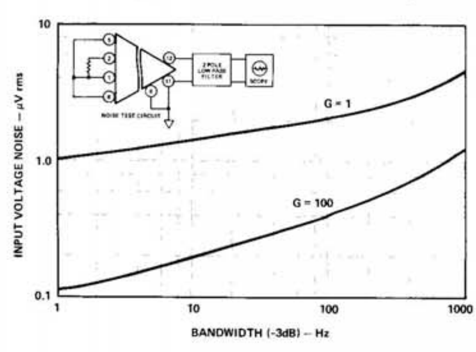


Figure 9. Typical Input Voltage Noise vs. Bandwidth

Input Offset Voltage Drift: Total input drift is composed of two sources, input and output stage drifts and is gain dependent. The curve of Figure 10 illustrates total input drift over the gain range of 1 to 100V/V.

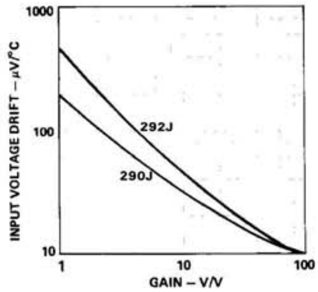
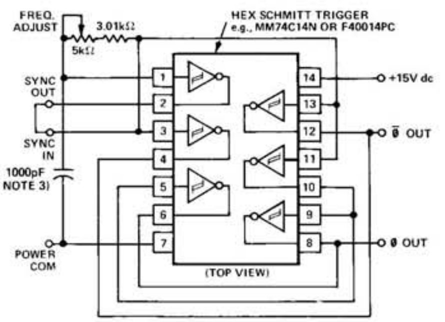


Figure 10. Typical Input Offset Voltage Drift vs. Gain

REFERENCE EXCITATION OSCILLATOR, MODEL 281

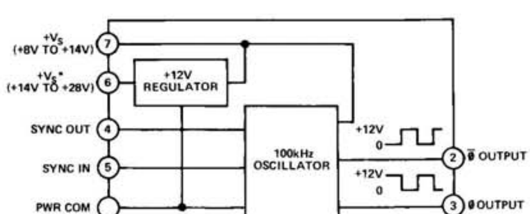
When applying model 292A, the user has the option of building a low cost 100kHz excitation oscillator, as shown in Figure 11, or purchasing a module from Analog Devices—model 281.



NOTES:
1. FREQ. ADJUST: ADJUST TRIM POT FOR OUTPUT FREQUENCY OF 100kHz ±5%.
2. FOR SLAVE OPERATION, REMOVE JUMPER FROM SYNC OUT AND SYNC IN PINS.
3. USE CERAMIC CAPACITOR, "COG" OR "NPO" CHARACTERISTIC.

Figure 11. 100kHz Oscillator Interconnection Diagram

The block diagram of model 281 is shown in Figure 12. An internal +12V dc regulator is provided to permit the user the option of operating over two, pin selectable, power input ranges; terminal 6 offers a range of +14V dc to +28V dc; terminal 7 offers an input range of +8V dc to +14V dc.



*LEAVE TERMINAL 6 OPEN, WHEN POWER IS APPLIED TO TERMINAL 7.

Figure 12. Model 281 Block Diagram

Model 281 oscillator is capable of driving up to 16 model 292A's. As shown in Figure 13, an additional model 281 may be driven in a slave-mode to expand the total system channels from 16 to 32. By adding additional model 281's in this manner, systems of over 1000 channels may be easily configured.

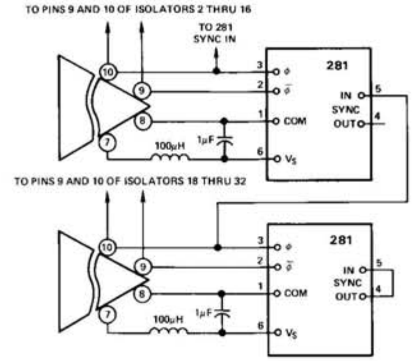


Figure 13. External Oscillator Interconnection

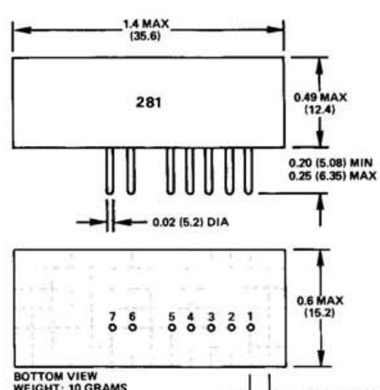
SPECIFICATIONS
(typical @ +25°C and V_S = +15V dc unless otherwise noted)

MODEL	281
OUTPUT	
Frequency	100kHz ±5%
Waveform	Squarewave
Voltage (φ and φ̄ terminals)	0 to +12V pk
Fan-Out[1,2]	16 max
POWER SUPPLY RANGE[3]	
High Input, Pin 6	+(14 to 28)V dc
Quiescent Current, N.L.	+5mA
F.L.	+16mA
Low Input, Pin 7	+(8 to 14)V dc
Quiescent Current, N.L.	+12mA
F.L.	+33mA
TEMPERATURE	
Rated Performance	0 to +70°C
Storage	-55°C to +85°C

[1] Model 292A oscillator drive input represents unity oscillator load.
[2] For applications requiring more than 16 292A's, additional 281's may be used in a master/slave mode. Refer to Figure 13.
[3] Full load consists of 16 model 292A's and 281 oscillator slave.

Specifications subject to change without notice.

OUTLINE DIMENSIONS
Dimensions shown in inches and (mm).



PIN TERMINAL IDENTIFICATION
1 POWER COMMON
2 φ̄ OUTPUT
3 φ OUTPUT
4 SYNC OUTPUT
5 SYNC INPUT
6 $+V_S$: HIGH RANGE +(14 to 28)V dc
7 $+V_S$: LOW RANGE +(8 to 14)V dc

MATING SOCKET:
CINCH #16 DIP OR EQUIVALENT

APPLICATIONS IN INDUSTRIAL MEASUREMENT AND CONTROL SYSTEMS

Remote Sensor Interface: In chemical, nuclear and metal processing industries, models 290A and 292A can be applied to measure and control off-ground millivolt signals in the presence ±1500V dc CMV signals. In interface applications such as pH control systems or on-line process measurement systems such as pollution monitoring, models 290A and 292A offer complete galvanic isolation to eliminate troublesome ground loop problems. Isolated power outputs and adjustable gain add to the application flexibility of these models.

Figure 14 illustrates how model 290A or 292A can be combined with a low drift, 1μV/°C front-end amplifier, model AD517L, to interface low level transducer signals. Both products provide isolated ±13V dc power and front-end guard in addition to eliminating ground loops and preserving high CMR (100dB @ 60Hz).

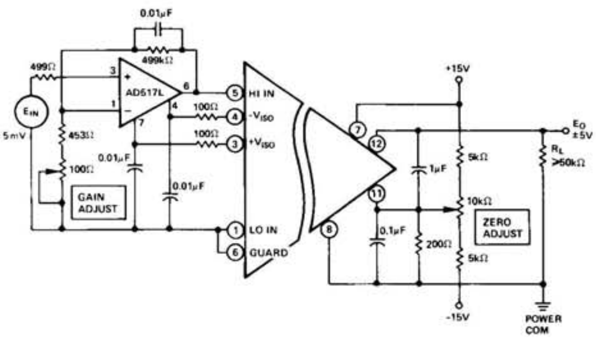


Figure 14. Input Signal Conditioning Using Isolated Power for Transducer Buffer Amplifier

Instrumentation Amplifier: Models 290A and 292A provide a floating guarded input stage capable of directly accepting isolated differential signals. The noninverting, single-ended input stage offers simple two wire interconnection with floating input signals.

In applications where the isolated power is applied to transducers such as bridges which generate differential input signals with common mode voltages measured with respect to the isolated power common, models 290A and 292A can be connected as shown in Figure 15. To achieve high CMR with respect to the ISO PWR COM, the following trim procedure is recommended.

CMR Trim Procedure

1) Connect a 1V pk-pk oscillator between the +IN/–IN and IN COM terminals as shown in Figure 15.
2) Set the input frequency at 0.5Hz and adjust R1 for minimum E_O.
3) Set the input frequency at 60Hz and adjust R2 for minimum E_O.
4) Repeat steps 2 and 3 for best CMR performance.

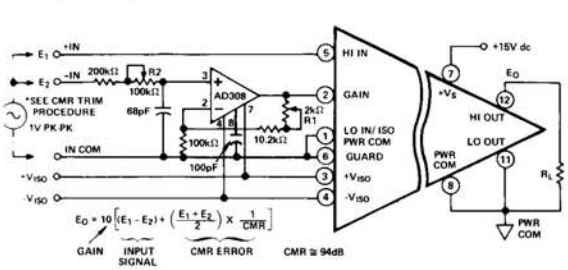


Figure 15. Application of 290A as Instrumentation Amplifier

Isolated Temperature Measurements: Industrial temperature measurements are often performed in harsh environments where line voltages or transients can sometimes be impressed on the temperature sensor. To provide protection for the delicate recording instrumentation, models 290A and 292A can be applied as shown in Figure 16. The Analog Devices' AC2626 probe is a temperature sensor whose output is a current directly proportional to absolute temperature. The isolation amplifier provides the isolated power (+13V dc) as well as the input/output isolation. Zero calibration is performed by placing the AC2626 probe in a zero temperature bath and adjusting R_O for E_O to 0 volts. Full scale output adjustment is performed by placing the AC2626 probe in boiling water (100°C) and adjusting R_S for 1.000V output.

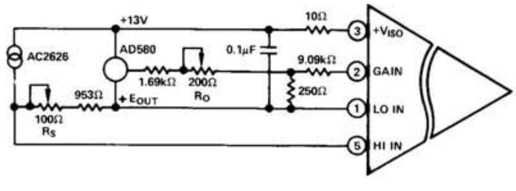


Figure 16. Isolated Temperature Measurements

Current Loop Receiver: Model 290A and 292A can be applied to measurement of analog quantities transmitted via 4-20mA current loops over substantial distances through harsh environments. Figure 17 shows an application of model 290A or 292A as a current loop receiver. A 25Ω resistor converts the 4-20mA current input from a remote loop to a 100–500mV differential voltage input, which the isolator amplifies, isolates, and translates to a 0 to +5V output level at local system ground.

Among the most-helpful characteristics of the isolator in this kind of measurement are the high common-mode rejection (100dB minimum at 60Hz with 1kΩ source unbalance) and the high common-mode rating (±1500 volts dc). The former means low noise pickup; the latter means excellent isolation and protection against large transients. The high common-mode rejection, permitting relatively low input voltage to be used (0.4V span, in this case), permits the use of a low current-metering resistance, which in turn results in low compliance-voltage loading on the current loop, and therefore permits insertion into existing loops without encountering overrange problems. The gain of 12.5 provides a substantial output span, and the floating output permits biasing to a 0 to 5V range.

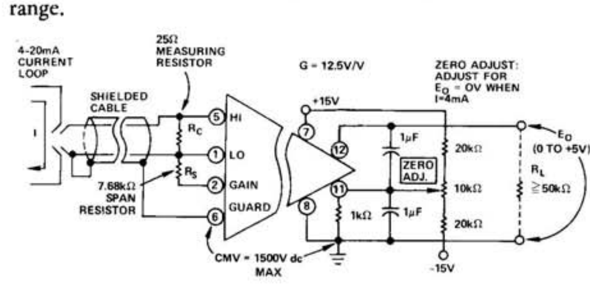


Figure 17. Isolated Analog Interface; 4 to 20mA is Converted to 0 to +5V at the Output, with Up to ±1500V of Isolation

Intronics Power ®

High Resolution 14-Bit Sample and Hold Amplifier

SHA1144

FEATURES
- ±10V min Input/Output Range
- 50ns Aperture Delay
- 0.5ns Aperture Jitter
- 6μs Settling Time
- ±0.001% Max Gain Linearity Error
- Complete with Input Buffer

APPLICATIONS
- Track and Hold
- Peak Measurement Systems
- Data Acquisition Systems
- Simultaneous Sample-and-Hold

GENERAL DESCRIPTION

The SHA1144 is a fast sample-hold amplifier module with accuracy and dynamic performance appropriate for applications with fast 14-bit A/D converters. In the "sample" mode, it acts as a fast amplifier, tracking the input signal. When switched to the "hold" mode, the output is held at a level corresponding to the input signal voltage at the instant of switching. The droop rate in "hold" is appropriate to allow accurate conversion by 14-bit A/D converters having conversion times of up to 150μs.

DYNAMIC PERFORMANCE

The SHA1144 was designed to be compatible with fast 14-bit A/D converters such as the Analog Devices' ADC1130 and ADC1131 series, which convert 14 bits in 25μs and 12μs, respectively. Maximum acquisition time of 8μs for the SHA1144 permits high sampling rates for 14-bit conversions. The SHA1144 is guaranteed to have a maximum gain nonlinearity of ±0.001% of full scale to insure 1/2LSB accuracy in 14-bit systems. When in the "hold" mode, the droop rate is 1μV/μs, so the SHA1144 will hold an input signal to ±0.003% of full scale (20V p-p) for over 600μs.

PRINCIPLE OF OPERATION

The SHA1144 consists basically of two high speed operational amplifiers, a storage capacitor, and a digitally controlled switch. It differs from typical sample-and-hold modules in one important respect; application versatility. The user completes the SHA1144 feedback circuit external to the module. Therefore, the module may be used in inverting or noninverting configurations and can easily be arranged to provide circuit gain of more than unity to simplify signal conditioning in a subsystem.

FEEDBACK CONNECTIONS

A block diagram of the SHA1144 is shown in Figure 1. The input section acts as a voltage-to-current converter, providing the current needed to charge the "hold" capacitor. The output amplifier isolates the "hold" capacitor and provides low output impedance for driving the load. Since feedback is not hardwired in the module, both inverting and noninverting input terminals are available, and the SHA1144 can be connected as a follower with unity gain or potentiometric gain, as well as inverter or even a differential amplifier. Since the unity gain follower mode will be the most frequent application, performance data listed in the specification table is based on this operating mode.

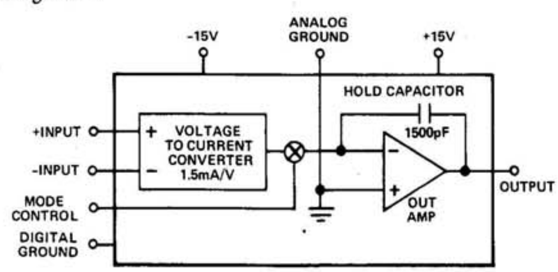


Figure 1. Block Diagram – SHA1144

1400 PROVIDENCE HIGHWAY • BUILDING 2 NORWOOD, MASSACHUSETTS 02062-5015
PHONE: 781-551-5500 FAX: 781-551-5555

SPECIFICATIONS (typical @ +25°C, gain = +1V/V and nominal supply voltages unless otherwise noted)

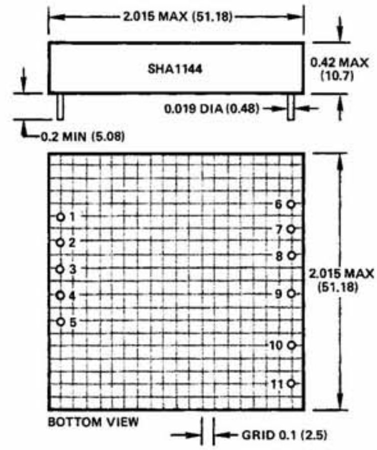
MODEL		SHA1144
ACCURACY		
Gain		+1V/V
Gain Error		±0.005%
Gain Nonlinearity		±0.0005% (±0.001% max)
Gain Temperature Coefficient (0 to +70°C)		±1ppm/°C (±2ppm/°C max)
INPUT CHARACTERISTICS		
Input Voltage Range		±10V
Impedance		10^{11} Ω ‖ 10pF
Bias Current		0.5nA max
Initial Offset Voltage		Adjustable to Zero
Offset vs. Temperature (0 to +70°C)		±30µV/°C max
OUTPUT CHARACTERISTICS		
Voltage		±10V min
Current		±20mA min
Resistance		<1Ω
Capacitive load		350pF
Noise @ 100kHz Bandwidth		70µV p-p
@ 1MHz Bandwidth		175µV p-p
SAMPLE MODE DYNAMICS		
Frequency Response		
Small Signal (-3dB)		1MHz
Full Power		50kHz
Slew Rate		3V/µs
SAMPLE-TO-HOLD SWITCHING		
Aperture Delay Time		50ns
Aperture Uncertainty		0.5ns
Offset Step		1mV
Offset Nonlinearity		160µV
Switching Transient		
Amplitude		50mV
Settling Time to ±0.003%		1µs
HOLD MODE DYNAMICS		
Droop Rate		1µV/µs (2µV/µs max)
Variation with Temperature		double every +10°C
Feedthrough (for 20V p-p Input @ 1kHz)		-80dB
HOLD-TO-SAMPLE SWITCHING		
Acquisition Time to ±0.003%	(20V Step)	6µs (8µs max)
	(10V Step)	5µs
±0.01%	(20V Step)	5µs
	(10V Step)	4µs
DIGITAL INPUT		
Sample Mode (Logic "1")		+2V<Logic "1" <+5.5V @ 15nA max
Hold Mode (Logic "0")		0V<Logic "0" <+0.8V @ 5µA (20µA max)
POWER REQUIRED[1]		+15V ±3% @ 60mA -15V ±3% @ 45mA
TEMPERATURE RANGE		
Operating		0 to +70°C
Storage		-55°C to +85°C

[1] Recommended Power Supply ADI Model 902-2, ±15V @ ±100mA output.

Specifications subject to change without notice.

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).



PIN DESIGNATIONS

1. TRIM
2. TRIM
3. +INPUT
4. -INPUT
5. TRIM
6. +15V
7. ANALOG GROUND
8. -15V
9. ANALOG OUTPUT
10. MODE CONTROL
11. DIGITAL GROUND

OFFSET ZERO ADJUST (OPTIONAL)

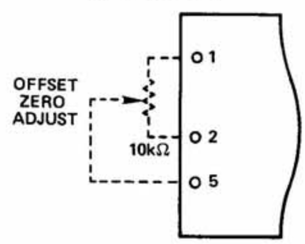


Figure 2 shows feedback connections to the SHA1144 for the unity gain follower mode. Output (pin 9) is connected to input (pin 4). Input signal is applied to pin 3.

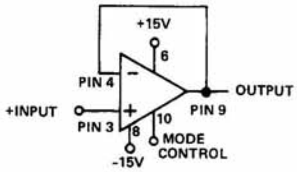


Figure 2. Unity Gain Follower

Figure 3 shows feedback connections for noninverting operation with potentiometric gain. When the indicated values are installed, gain will be +5. As in all operational amplifiers, gain-bandwidth product is a constant for a given sample-and-hold. Effective 3dB bandwidth will be inversely proportional to gain.

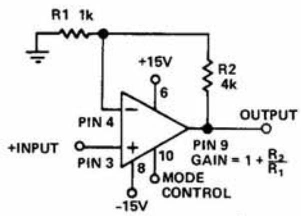


Figure 3. Noninverting Operation

By using conventional operational amplifier feedback connections, the SHA1144 can be connected for use as an inverter, with various gains (as determined by the R_F/R_1 ratio), or as a differential amplifier.

DATA ACQUISITION APPLICATION

Successive-approximation A/D converters can generate substantial linearity errors if the analog input varies during the period of conversion; even the fast 14-bit models available cannot tolerate input signal frequencies of greater than a few Hz. For this reason, sample-and-hold amplifiers like the SHA1144 are connected between the A/D and its signal source to hold the analog input constant during conversion.

When the SHA1144 is connected to an A/D, its aperture time uncertainty, rather than the A/D's conversion time, is the factor which limits the allowable input signal frequency. The SHA1144, with a typical aperture delay time of 50ns and an uncertainty of 0.5ns, will change from the sample mode to the hold mode 50 to 50.5ns after the "1" to "0" transition of the mode control input. If the system timing is so arranged as to initiate the mode control signal 50ns early, then switching will actually occur within 0.5ns of the desired time as shown below.

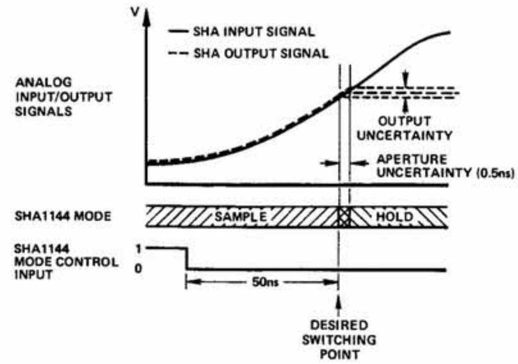


Figure 4. Aperture Uncertainty

The maximum allowable slew rate will thus equal the quotient of the maximum allowable voltage uncertainty and the 0.5ns aperture uncertainty. For sinewave inputs, the corresponding maximum frequency is expressed by:

$$f_{max} = \left(\frac{\Delta E}{E_{FS}}\right)\left(\frac{1}{2\pi\Delta t}\right) \cong 3.18 \times 10^{8} \left(\frac{\Delta E}{E_{FS}}\right)$$

where: ΔE = the allowable voltage uncertainty
E_{FS} = the sinewave magnitude

For a system containing a SHA1144 and a 14-bit A/D with ±10V input signals and an allowable input uncertainty of ±1/2LSB (±620μV), the maximum allowable signal frequency will be 19.7kHz.

POWER SUPPLY AND GROUNDING CONNECTIONS

The proper power supply and grounding connections are shown shown below in Figure 5.

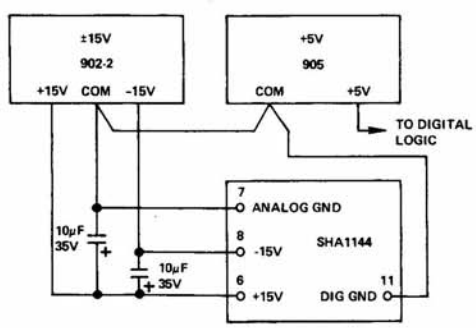


Figure 5. Power Supply and Grounding Connections

The ±15V power supplies must be externally bypassed as shown. The capacitors should be tantalum types and should be installed as close to the module pins as possible. The analog and digital ground lines should be run separately to their respective power supply commons to prevent coupling of digital switching noise to the sensitive analog circuit section.

OPERATION WITH AN A/D CONVERTER

Figure 6 below shows the appropriate connections between the SHA1144 and a successive approximation A/D converter in block diagram form.

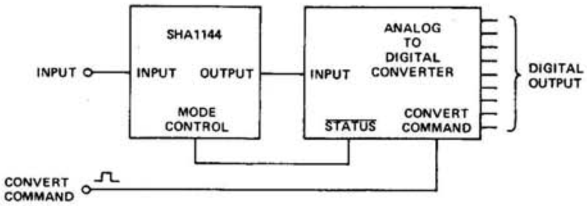


Figure 6. SHA1144 and A/D Connections

The resulting timing sequence at the start of conversion is illustrated in Figure 7.

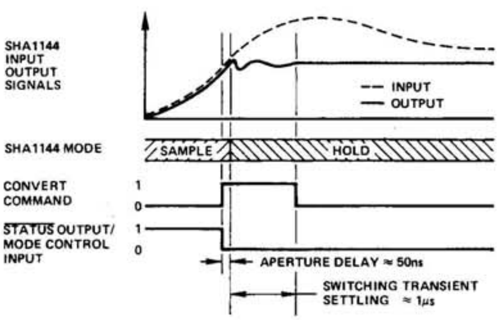


Figure 7. A/D and SHA Timing at Start of Conversion

Note that the leading edge of the convert command pulse causes the converter's STATUS output to go to Logic "0" which in turn switches the SHA1144 from sample to hold. As discussed previously, the typical SHA1144 actually changes modes 50 to 50.5ns after the "1" to "0" transition of the mode control input. This mode switching causes a transient on the output terminal which decays to within 0.003% of the final value in approximately 1μs. Once the transient has settled, the convert command input is returned to Logic "0" and the conversion proceeds. As shown in Figure 8, the STATUS signal returns to Logic "1" and the SHA1144 returns to the sample mode at the end of conversion. Within 6μs, it will have acquired the input signal to 0.003% accuracy and a new conversion cycle may be started.

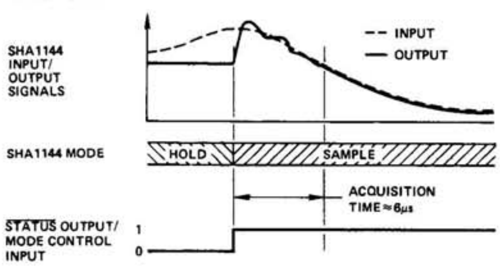


Figure 8. A/D and SHA Timing at End of Conversion

OPERATION WITH AN A/D AND MULTIPLEXER

The subsystem of Figure 9 may also be connected to a multiplexer like the Harris HI508A as shown below.

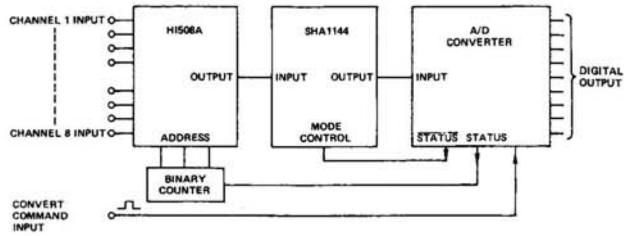


Figure 9. A/D, SHA, and MPX Connections

The leading edge of the convert command pulse sets the STATUS output to Logic "0" thereby switching the SHA1144 to "hold"; the corresponding change to Logic "1" of the STATUS output increments the binary counter and changes the multiplexer address. Since the SHA1144's aperture time is small with respect to the multiplexer switching time, it will have switched to the hold mode before the multiplexer actually changes channels. The multiplexer switching transients will settle out long before the SHA returns to "sample" at the end of conversion. The timing sequence described above is illustrated in Figure 10.

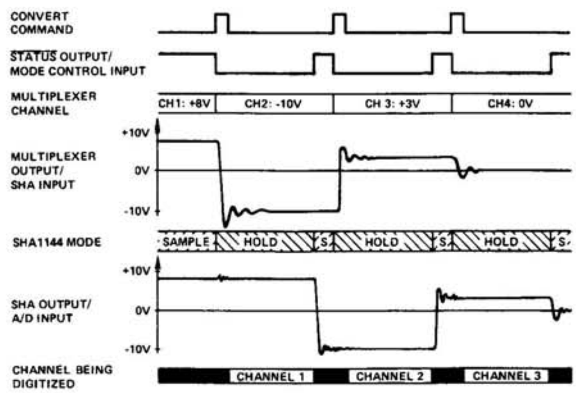


Figure 10. A/D, SHA, and MPX Timing

This method of sequencing the multiplexer may be altered to permit random addressing or addressing in a preset pattern. The timing of the multiplexer address changes may also be altered but consideration should be given to the effects of feedthrough in the SHA1144. Feedthrough is the coupling of analog input signals to the output terminal while the SHA is in "hold". Large multiplexer switching transients occuring during A/D conversion may introduce an error.

GENERAL DESCRIPTION

High resolution, high speed data acquisition demands that considerable thought be given to wiring connections, even when simply evaluating the unit in a temporary laboratory bench set-up. To assist with such evaluations, an AC1580 is available. This 4 1/2" X 6" printed circuit card has sockets that allow a SHA1144 and ADC1130 or ADC1131 to be plugged directly onto it. It also has provisions for two optional Harris HI508A multiplexers. This card includes gain and offset adjustment potentiometers and power supply bypass capacitors. It mates with a Cinch 251-22-30-160 (or equivalent) edge connector (P1) and Cinch 251-06-30-160 (or equivalent) edge connector (P2) which are supplied with every card.

To use the AC1580, program as shown in the wiring chart of Table 1, by installing the appropriate jumpers. An outline drawing and schematic are provided for reference.

Calibration Procedure

Set up the SHA1144 for the desired gain per the wiring chart of Table 1. Short W9 which drives the SHA MODE CONTROL with the STATUS of the ADC. Calibrate offset and gain in the manner described below. When calibration is completed W9 may be removed and the SHA MODE CONTROL may be driven in accordance with the option chart.

Offset Calibration

For the 0 to +10V unipolar range set the input voltage precisely to +0.0003V. Adjust the zero potentiometer until the converter is just on the verge of switching from 00. . . . . 0 to 00. . . . . 1.

For the +5V bipolar range, set the input voltage precisely to -4.9997V; for ±10V units set it to -9.9994V. Adjust the zero potentiometer until offset binary coded units are just on the verge of switching from 00 . . . . . 0 to 00 . . . . . 1 and two's complement coded units are just on the verge of switching from 100 . . . . 0 to 100 . . . . . 1.

Gain Calibration

Set the input voltage precisely to +9.9991V for 0 to +10V units, +4.9991V for ±5V units or +9.9982V for ±10V units. Note that these values are 1 1/2LSB's less than the nominal full scale. Adjust the gain potentiometer until binary and offset binary coded units are just on the verge of switching from 11 . . . . 0 to 11 . . . . 1 and two's complement coded units are just on the verge of switching from 011 . . . 10 to 011 . . . 11.

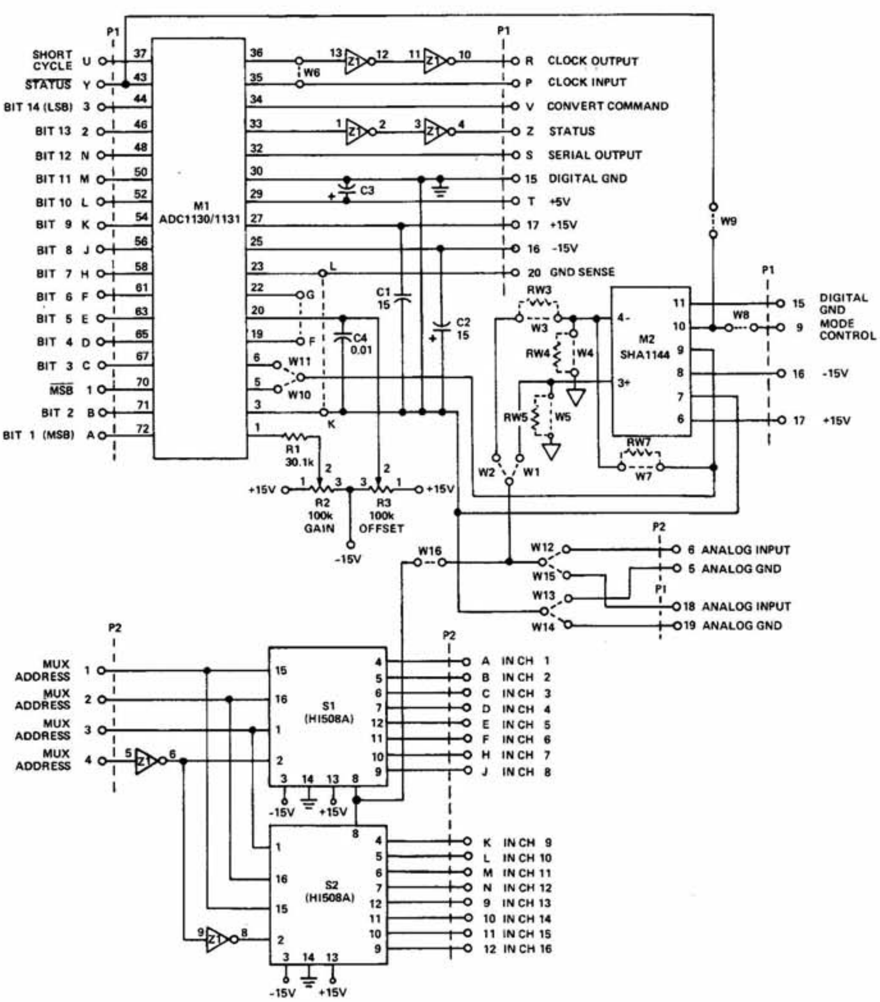


Figure 11. Schematic and Pin Designations

OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

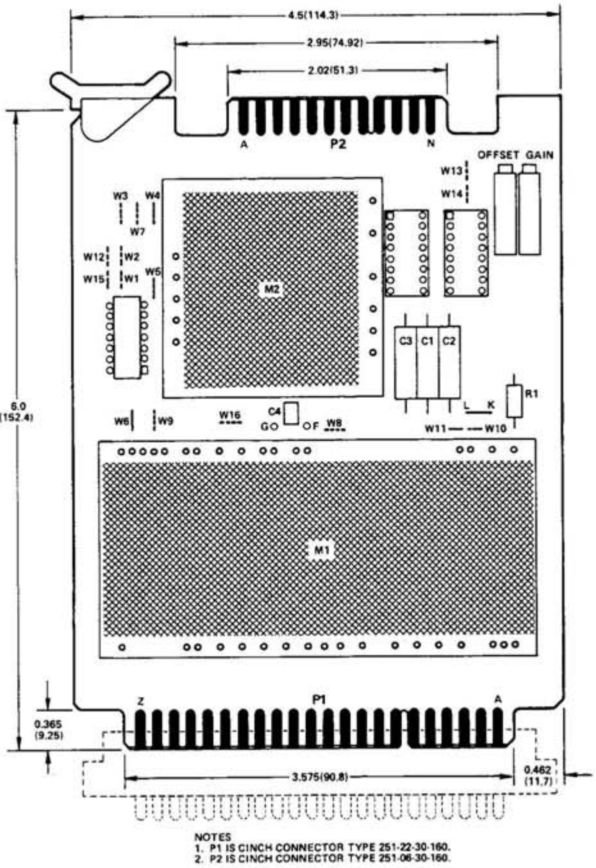


Figure 12. AC1580 Mounting Board

A to D Converter Options

Range	Jumpers
0V to 10V	Jumper W11
±5V	Jumper W11 and Jumper G to F on Board
±10V	Jumper W10 and Jumper G to F on Board
	SHA Options
SHA Unity Gain (+1)	Jumper W1 and Jumper W7
SHA with Gain[1,3]	Jumper W1 and Install RW4 and RW7 in W4 and W7 Locations[3]
SHA as an Inverter[2,3]	Jumper W2 and Jumper W5 and Install RW3 and RW7 in W3 and W7 Locations[3]

SHA Mode Control

Internal (Driven from Status of the ADC)	Jumper W9
External (Apply External Signal to Pin 9 of Connector P1)	Jumper W8

Multiplexer Option

When Using Multiplexers	Jumper W16

INPUT OPTIONS

Inputs	From Connector P1	From Connector P2
Analog Input	Jumper W15	Jumper W12
Analog Ground	Jumper W14	Jumper W13

NOTES

[1] $G = 1 + \frac{RW7}{RW4}$ [2] $G = -\frac{RW7}{RW3}$

[3] See Figure 11 for appropriate gain setting resistor locations (RW3, RW4, RW7)

Table 1. Option Chart

"ON" Channel	1	2	3	4
1	L	L	L	L
2	L	L	H	L
3	L	H	L	L
4	L	H	H	L
5	H	L	L	L
6	H	L	H	L
7	H	H	L	L
8	H	H	H	L
9	L	L	L	H
10	L	L	H	H
11	L	H	L	H
12	L	H	H	H
13	H	L	L	H
14	H	L	H	H
15	H	H	L	H
16	H	H	H	H

L = TTL Logic "0" (0V ≤ "0" ≤ +0.8V)

H = TTL Logic "1" (+2V ≤ "1" ≤ +5.5V)

Table 2. Multiplexer Address