THE NEW GENERATION OF ISOLATION AMPLIFIERS

What Can You do with a Wideband, Ultralinear Low-Drift, 3-Port Synchronizable Isolation Amplifier?

by Frank Goodenough

*An isolation amplifier (or isolator) has an input circuit that is galvanically isolated from the power supply and the output circuit. The power supply and the output may also be isolated from one another, in varying degrees. Isolators are intended for applications which need: safe, accurate measurement of voltage and current at frequencies from dc to the audio range in the presence of high common-mode voltage (to thousands of volts) with good common-mode rejection; line-receiving of signals transmitted at high impedance in noisy environments; and/or safety in general-purpose measurements where dc and line-frequency leakage must be maintained at levels well below certain mandated minima. Principal applications occur in electrical environments of the kind associated with medical equipment, power plants, automatic test equipment, and industrial process-control systems.**

WHAT IS MODEL 289?

Model 289 is a three-port synchronizable isolator, with low output impedance and functionally usable gains up to 100V/V. It is capable of handling low-frequency signals with 12-bit accuracy, with linearity to within 0.012%, gain stability of 0.005%/°C, and input offset drift of 15μV/°C. Dynamically, it has small-signal bandwidth of 20kHz, full-power bandwidth of 5kHz, and settling time of 200μs to within 0.1%. And this performance is available in a small, 1.5″ X 2″ X 0.75″ (38.1 X 51 X 19.1mm^3), package at low cost, $59 in small quantity (J version).

WHAT DOES THREE-PORT ISOLATION MEAN?

Figure 1 is a greatly simplified diagram of the 289, showing its external connections. It is divided into input, output, and power sections, separated from each other by isolation barriers. DC current cannot cross these barriers. As with all Analog Devices isolators currently available, energy and signals are transferred across the barrier by inductive coupling, using a high-frequency carrier and transformers.

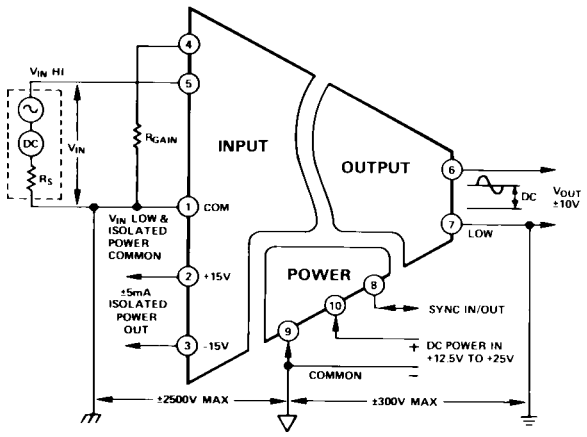

Figure 1. Three-port isolation.

The barrier between the input section and the output and power sections can withstand ±2500 volts applied between any pins of the input section and any pins elsewhere on the device. In addition, ±300V can be applied between any pins of the output section and any pins of the power section without damage.

What does this mean to the user? As with any 2- or 3-port isolator, a fault or large common-mode voltage on the input side of the barrier cannot hurt signals, people, or equipment on the output or the power sides; conversely, a fault or CMV on the output or the power side cannot cause harm to similar entities on the input side. The advantages afforded by the third port are more subtle. Here are a few:

- No ground-loop problems between output and power ground.
- Either output pin can be connected to either side of the load; this permits the user to choose the output polarity or phase.
- A fault on the power input will not damage users or equipment (people or computers) connected to the output.

WHY SYNCHRONIZE? HOW?

If two or more carrier-coupled isolators are located in close proximity, small amounts of carrier crossfeed can, in some cases, cause low-frequency or dc-offset errors due to the generation of difference (beat) frequencies. Of course, shielding and good wiring practice help, but where high resolution is important, synchronization of all the oscillators may be the most practical solution.

Among the synchronizable isolators that Analog Devices manufactures, there are several approaches to synchronization. In the approach used for Model 289, no external oscillator is required. The synchronization terminals provided are "soft"; hence, they can be simply connected together, and the devices will agree upon a stable common frequency.

HOW DOES THE ISOLATOR WORK?

Figure 2 is a simplified view of the inner workings of Model 289. Two transformers straddle the isolation barriers between the three sections. DC power (25mA at 14.4V to 25V), connected to pins 9 and 10, is applied to a regulator which drives the 100kHz synchronizable power oscillator, which in turn drives winding *a* of power transformer T2. Isolated ac power is induced into windings b, c, d, and e. The output of winding *b* is rectified and filtered to furnish power to input amplifier A1 and, via terminals 2 and 3, to external circuitry (such as low-level preamplifiers) needing isolated power; up to 5mA at ±15V is available.

The input signal is applied between pins 5 and 1 (isolated common) to follower-connected op amp, A1. The user connects gain resistor, R_G, externally to set the gain. Gain values

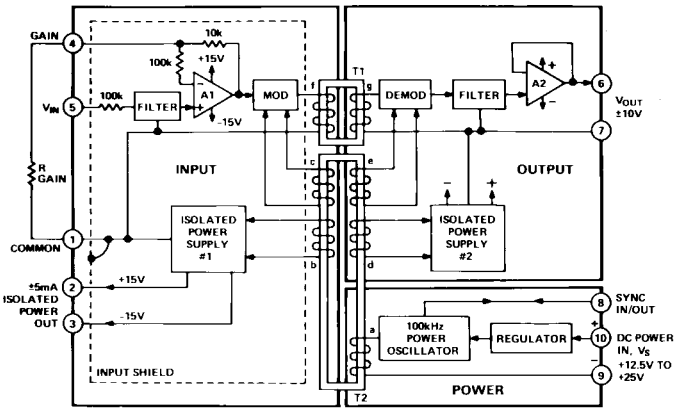

Figure 2. Block diagram of model 289.

up to 1000V/V can be set; but specified performance is available only for gains to 100. 100kΩ resistors protect the input from differential voltages as high as 230V rms. A1's output is chopped into winding *f*, and the resulting waveform is coupled to the output section via winding *g*, synchronously demodulated, filtered, and buffered by follower-connected output amplifier A2. A2 receives its isolated power from isolated power supply #2, which in turn is excited by winding *d*. The isolated ±10V output appears between pins 6 and 7 and may be connected for either polarity.

The input power regulator serves a number of useful purposes:

- Acting as a filter, it minimizes both conduction of electromagnetic interference to the power source and the effect of input-power ripple on the output signal.
- Since it is current-limited, indefinite shorting of the floating power will not destroy the 289.
- A short-circuit-type failure of the 289 will not pull down or blow the fuse of the input power source.

APPLICATIONS

Figure 3 shows a *portmanteau* application that demonstrates ways in which the extended bandwidth and three-port isolation of Model 289 can be useful in a single test setup. It represents a hypothetical test facility for large electrical machinery. The environment is alive with electrical and mechanical noise of all types and probably is not very clean. High voltage, transient and continuous, abounds. The system of Figure 3 shows a few of the measurements that might be made for which an isolator with Model 289's speed and accuracy would be a natural choice.

Temperature. (1) An essential test is to determine the hot-spot temperatures at various points inside the machine, since these affect the machine's life and a variety of design parameters, such as insulation, size, cooling, lubrication, and cost. As Figure 3 shows, AD590F current-output temperature sensors are indicated. They are a logical choice because of their small size, low cost, fast response, and easy signal conditioning, including multiplexing.* Since they are *current* sources, with current in microamperes numerically equal to absolute temperature (K), no errors are caused by line drops, contact resistance, or contact potentials at terminals, switches, or slip rings.

The CMOS multiplexer and its sequencing circuitry, as well as the AD590s, are excited by the isolated front-end power; the

*Useful information about such applications can be found in the AD590 data sheet and ANALOG DIALOGUE 12-2.

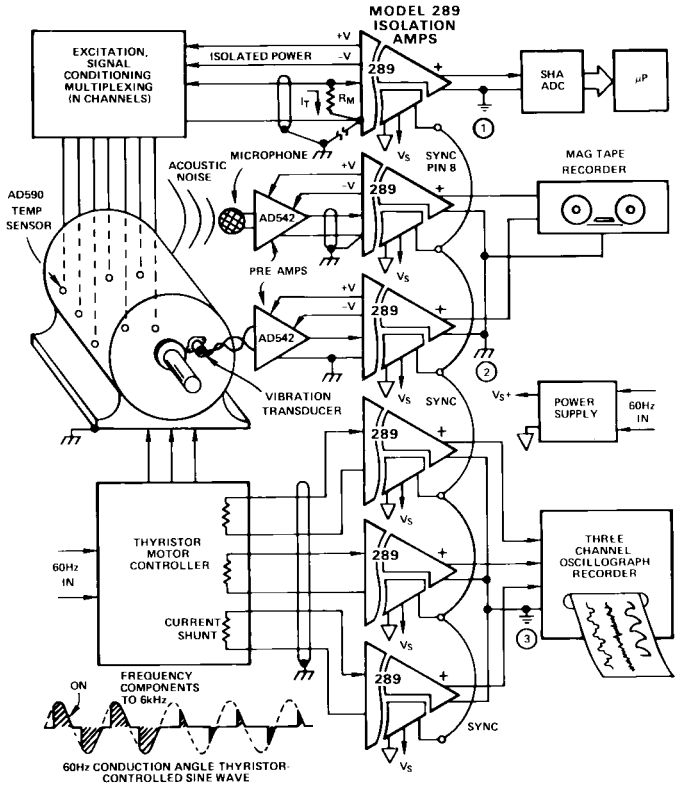

Figure 3. Test system illustrating possible applications for 3-port isolators.

output current from the selected device flows through a resistor at the 289's input, which measures the voltage, proportional to current, directly. Because of its 5kHz large-signal bandwidth and settling time of 200μs, the 289 can follow a rapid sequence of measurements, even at 500Hz. The 289 isolates the 590's (and-any potentials between the test machine and the instrumentation panel) from the data-acquisition system to which they are connected. The three-port isolation permits a choice of output polarity, converting K to °C by adding voltage in series, and elimination of common-mode errors between the 289 output and the input of the data-acquisition system.

Noise and Vibration. (2) The audio-band response of the 289 permits isolation of acoustic noise measurements (symbolized by the microphone), lamination noise, and detection of noise due to arcing, corona discharge, etc. Vibration pickups may be used to detect problems with bearings, mountings, etc.; they can be installed in locations thought to be susceptible in large machines. In each case, the ±15V floating power from the 289 can power a preamplifier (such as the AD542 FET-input op amp) or other signal-conditioning circuits.

Electrical Instrumentation. (3) Isolation amplifiers can be used to monitor electrical waveforms, such as current, when sensed by resistive shunts at high common-mode voltage. For accurate observation of electrical noise or thyristor waveforms, with frequency components up to and beyond 10kHz, the wide bandwidth of the 289 is especially useful.

The measurements discussed above are just a few for which isolation would be useful in the testing of large electrical machines. And electrical-machine testing is a small subset of the application potential of the versatile synchronizable three-port Model 289 isolator. ▶▶▶