Application Briefs

Good Circuit Practice Gets Best Results from Isolation Amplifiers

Analog Devices recently introduced Model 272*, a modular low-cost unity-gain isolation amplifier designed to protect hospital patients from both macro- and microshock, by isolating the outputs of patient-connected transducers from the instrumentation system. It also facilitates measurements in the presence of common-mode signals by providing 120dB CMR at 60Hz. The internal transformer-coupled shielded isolation system of the 272 is shown schematically in Figure 1.

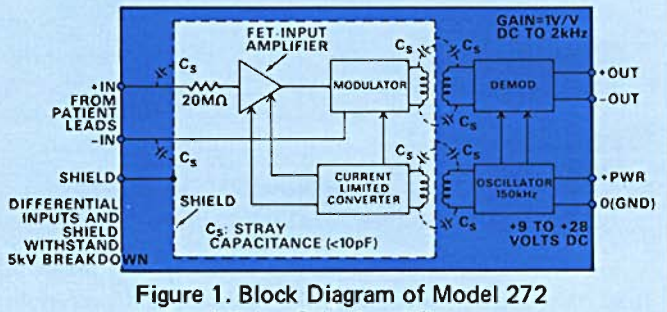

Figure 1. Block Diagram of Model 272 Isolated Unity-Gain Amplifier

SHIELDING AND GROUNDING

A major source of "noise" in instrumentation systems is the coupling of common-mode voltages and currents into the input circuit. This can occur in many ways: through ground potential differences ("ground loops"); electrostatic (i.e., capacitive) coupling from power lines and other high-frequency sources; electro-magnetic induction in closed conductive loops; unbalanced loading of the signal leads, etc.

The 272 allows a number of these sources of common-mode error to be minimized. By connecting its floating guard shield to the cable shield, one can in effect totally enclose the differential signal leads, thus protecting them from electrostatic pickup. With the shield connected at only one point (i.e. at a point representative of the common-mode potential): it acts as a guard to minimize unbalanced capacitive loading; it minimizes magnetic pickup; and it avoids introducing ground difference potentials into the instrumentation system.

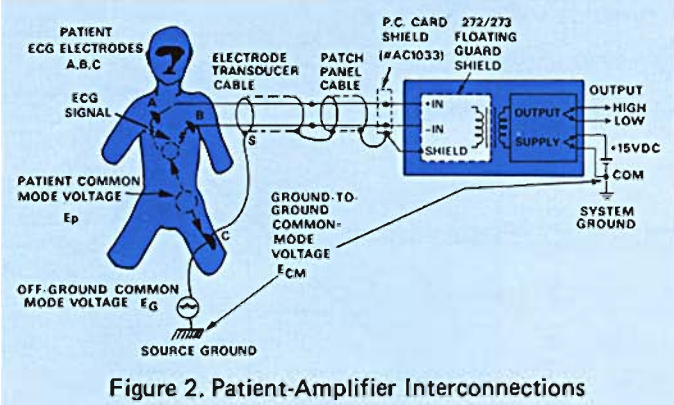

Figure 2. Patient-Amplifier Interconnections

To derive full benefit from the 272's ability to reject noise and "float" input signals, one should employ good shielding practice, as shown in the example of Figure 2. Although a medical application is shown, it is representative of other applications pertaining to guarding millivolt signals in hostile environments, such as voltages developed in current shunts in "heavy industrial" plants.

GUIDELINES

- Use twisted shielded cable to reduce inductive and capacitive pickup.
- Drive the shield(S) with the common-mode signal source (E_G) to reduce effective cable capacitance significantly. This is accomplished by connecting shield point(S) as closely as possible to the signal "low"(B). Often, a "right leg" electrode connection establishes a patient "ground"(C).
- The common-mode rejection of the 272 between the differential inputs and the shield will suppress the effects of common-mode voltages generated within the patient's body (E_P).
- To avoid ground loops and excessive power-frequency "hum," signal low(B) or the cable shield(S) should never be grounded at more than one point.
- Dress unshielded leads short at the connection terminals and reduce the area formed by these leads to minimize inductive pickup.

AC COUPLING

In addition to the common mode, biological signals often include a differential (i.e., "normal mode") offset voltage, caused by an electrochemical bias (i.e., "contact") potential, at the patient-electrode interface, subject to polarity and magnitude variations as the pressure and position of the probes change. Its magnitude is typically in the hundreds of millivolts.

It is the presence of this potential that accounts for the initial choice of design of the 272 as a unity-gain dc follower. The contact potential is usually larger than the signal being measured – therefore built-in gain would produce saturation with limited amplification. If ac components (usually 0.05 to 100Hz) are the signals of interest, an arbitrary choice of characteristics (bandwidth, recovery time, capacitor stand-off voltage) would leave many applications unsatisfied; also it would cost more and might sacrifice CMR or protective capability.

A good solution nowadays is for a general-purpose isolation amplifier to transmit the signal essentially unchanged, allowing the circuit designer to determine the type and degree of signal conditioning to be used in the circuits that follow. Figure 3 shows an example of ac coupling and adjustable gain.

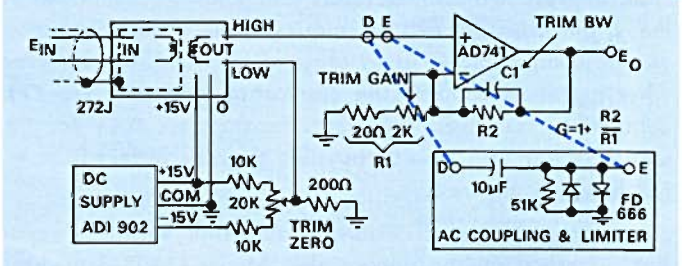

Figure 3. DC Isolation Amplifier with Adjustable Gain and AC Coupling Option

*See *Dialogue*, Vol. 5, No. 2. For further information on Model 272, use the reply card. Circle C10