Application Brief

Fast-Recovery AC Coupling and Galvo Driver

TYPICAL CIRCUIT TECHNIQUES THAT CAN BE USED WITH OUTPUTS FROM THE MODEL 272 MEDICAL ISOLATION AMPLIFIER

Model 272* and some of its applications have been described in the two most recent issues of *Analog Dialogue.*† Briefly, Model 272 is a unity-gain amplifier with FET-input circuit isolated from both the output and the dc supply. It is specifically designed to protect hospital patients from both macro- and microshock, by isolating the outputs of patient-connected transducers from the instrumentation system. It will withstand 5kV defibrillation pulses, and can operate in the presence of 1,000VCM. Its common-mode rejection at 60Hz is 120dB with 5kΩ source unbalance. It is a potted module costing well below $100 in quantity. These few of its characteristics offer some hint as to its potential applicability in both medicine and industrial OEM applications calling for high isolation voltage.

We will discuss here some of the circuit techniques for dealing with its output signal in the context of a typical application family: electrocardiography.

AC COUPLING

The ecg signals transmitted by the 272 at unity gain have amplitudes typically of the order of a few millivolts. However, dc contact potentials at the electrodes add a normal mode signal of several hundred millivolts. In general, this dc potential is not constant, and thus cannot be conveniently biased out. For this reason, ac coupling to the preamplifier is used almost universally, to provide high signal gain without allowing the dc level to cause amplifier saturation. Unfortunately, ac coupling, using time constants long enough to pass ecg waveforms with reasonable fidelity, has a glaring weakness: Large transient signals can cause the preamplifier to "block" and the coupling capacitor to charge to a large potential, which must be discharged over a period of several heartbeats, during which time the ecg information is unavailable. Sources of transients include artifacts caused by patient motion, de-fibrillator pulses, and pacemaker pulses. An obvious approach to ameliorating this situation is to reduce the amount of charge acquired by the capacitor. This can be done using a pair of diodes back-to-back (Figure 1). For small signals, the diode's resistance is very large compared to that of the 62kΩ resistor. For large signals, the diodes will soft-limit in the neighborhood of 600mV. When the transient is removed, recovery to the 10mV region occurs within about 4.1 time constants, or 2.5 seconds. While this helps with infrequently-applied transients, it is of little value if the transient is an 80–100mV pacemaker pulse applied for 10–20ms at every heartbeat.

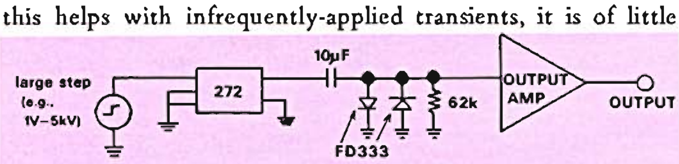

Figure 1. AC Coupling with Limit Protection

To solve this problem, we can make use of the fact that the timing of the pacemaker pulse is known. Thus, suitably delayed and tailored, it can be applied to a clamp circuit that briefly "holds" the output during the interval that the pacemaker pulse is expected to appear on the electrocardiogram. One way of accomplishing this is shown in Figure 2.

There are a variety of other approaches in use, including one in which the signal is measured, processed, and compared with a reference level. A capacitor-shorting relay permits ac operation only if the signal is not excessive

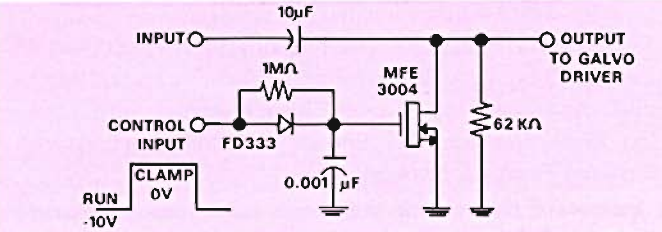

Figure 2. Circuit to Clamp Output During Pacemaker Pulse

GALVANOMETER DRIVER

Galvanometer coils respond most readily to current input. Therefore, following the input and its preamplifier, there is usually a voltage-to-current converter having sufficient output current available to drive the pens. Figure 3 shows a fairly conventional approach to such a circuit, using an op amp plus booster circuitry, and adjustable voltage feedback from a current-sensing resistor R3, to set the appropriate transconductance. C1 and C2 may be needed to stabilize the circuit by allowing feedback to bypass the high-frequency rolloff of the galvanometer and its driver. Shaping networks may be desirable in the feedback loop to compensate for the galvanometer's response characteristic.

Most commercially-available galvanometers are supplied (often optionally) with built-in amplifiers having appropriate characteristics. The "do-it-yourself" approach is best suited to those needing (or wishing) to save money at the expense of design time.

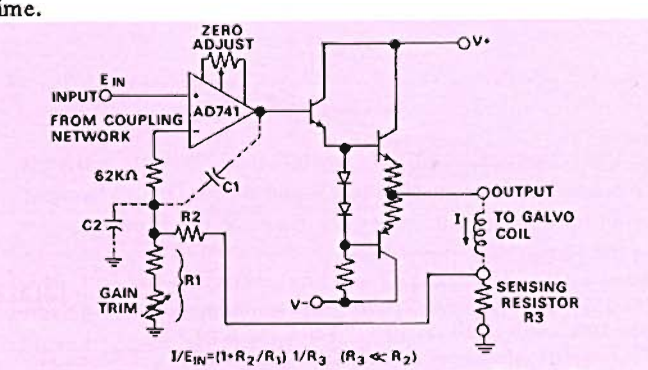

Figure 3. Typical Form of Galvanometer-Driver-Current-Boost Circuit

*For technical data on Model 272, use reply card. Circle D11

†See "Medical Isolation Amplifier," Vol. 5, No. 2, page 10, and "Good Circuit Practice Gets Best Results from Isolation Amplifiers" Vol. 5, No. 3, page 12