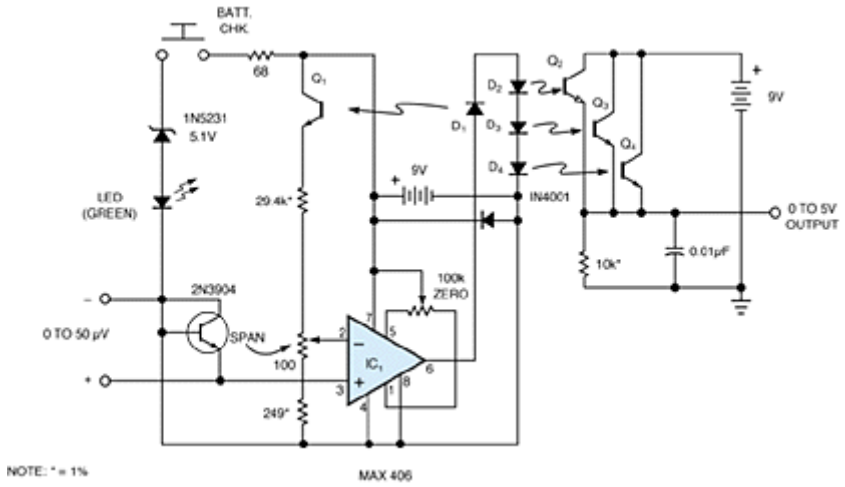
Battery-powered amplifier has optical isolation

Stephen Woodward - June 06, 1996

When you interconnect scientific instruments, especially older ones, you often need both gain and galvanic isolation for the analog interface functions. The amplifier in **Figure 1** runs from 9V batteries and fulfills both these requirements. The overall gain is 100, and the optical coupling withstands several kilovolts and offers greater than 1-GV isolation. The power consumption is proportional to the signal amplitude; current drain ranges from approximately 1 to 500 µA. This consumption rate yields greater than 1000 hours of battery life when signals are present and years of battery life in standby mode.



The input side of the amplifier uses the micropower op amp IC_1. IC_1 servos the drive applied to LED D_1 such that the feedback that Q_1 generates nulls the input voltage. A 50-mV full-scale input results in 133-µA current in Q_1. The series connection of LEDs results in drive current identical to the current in D_1/Q_1 for the D_2/Q_2, D_3/Q_3, and D_4/Q_4 pairs. This matching, combined with the efficient intrachannel, coupled gain-tracking characteristic of the PS2501-4 optoisolator and the similar bias levels applied to all four phototransistors, yields less than 1% transfer-function nonlinearity.

With suitable adjustment of the Span potentiometer, a 50-mV input produces a net Q_2, Q_3, Q_4 composite current of 500 µA and 5V output voltage, ideal for direct input to a typical A/D converter. Note that operation of the optoisolator at such low current levels is unconventional and invites low coupled gain in the optical pairs. The high loop-gain feedback from IC_1 overcomes this low gain and thereby ensures linear operation. The low speed of the anorexic MAX406 op amp limits frequency response to a less than blazing figure, but the circuit is nonetheless capable of operating at 1 kHz, a speed that's adequate for many applications.

Although the battery life expectancy is long, it is finite; so, you need a reliable criterion for battery

replacement. The Batt Chk pushbutton provides this indication by inserting a 5.1V zener diode, a 2V green LED, and a current-limiting resistor in series across the input-side battery. Battery voltage lower than approximately 7V fails to light the LED, thus giving notice that you'll soon need a fresh battery. You need test only the input-side battery, because calculations show a somewhat higher average current drain in the input side. You can, thus, take the input-side result as a conservative indicator for the state of both batteries. (DI #1878)