Application Note AN48

Shaft Encoder Drives Multiple XICOR Digitally Controlled Potentiontiometers (XDCPs)

by Applications Staff

Suppose a circuit design requires the sprinkling around of a significant number of control potentiometers, but there is only enough room on the front panel for one knob. Or, for aesthetic reasons or other design considerations, it is only desired to have one control for a number of seldom adjusted, but essential control functions. A shaft encoder, some simple circuitry, and Xicor XDCPs can provide a versatile and unique solution for these types of issues.

Shaft angle encoders are available at low cost from a number of manufacturers. Many of these devices can output two signals in phase quadrature (90 degrees) with typically from 1 to 10,000 pulses available per revolution. By counting the number of transitions on both phases, the shaft angle of the control can be electronically resolved. By using one of the phases as a reference, the direction that the shaft was turned can also be resolved.

The particular shaft encoder shown in Figure 1 is capable of encoding 16 positions per revolution, though other encoders can be selected with different angular resolutions. Each channel of the encoder has four electrical cycles per revolution. In other words, the electrical phase goes through 360 degrees for every 90 degrees of mechanical rotation. In any complete rotation of the shaft, there are a combined total of 16 level transitions (8 transitions per phase).

In Figure 1, U7A and U7B are used as Schmitt-trigger buffers for the two phase channels out of the Grayhill shaft encoder. The XOR gate (U6B) essentially adds these two phases to produce an 8- cycle per revolution signal. U6C along with delay network R1/C2 form a one-shot which produces one pulse for every HIGH to LOW or LOW to HIGH transition from U6B. There are now 16 position pulses per revolution, with only the direction of the shaft rotation to be determined. This is accomplished by U6A and delay network R7/C4. If the shaft were being rotated at a constant velocity, say by a motor, the R7/C4 delay network would not be required since the U6A output would always be in a defined direction- indicating state, on the LOW going edge of the one-shot output formed by U6C. Since the shaft is going to be rotated by hand, and erratic direction changes could take place, there exists the possibility for direction ambiguity. This is solved by the delay network R7/C4 which stores the direction that the shaft was going at the time that the one-shot pulse was produced. Notice that the time constant for the direction delay is much longer than the one-shot time, ensuring that the direction will be valid on the falling edge of the increment pulse coming from the output of U6C.

Because the XDCPs should remember the last setting on power-down, it is required that $\overline{\text{INC}}$ be HIGH before $\overline{\text{CS}}$ goes HIGH. This is ensured by two timing networks consisting of the increment-invert network (CR2, R12, C7, U10A, U10B, and U10C), and the chip-select network (CR1, R2, C6, and U6D). The increment-invert circuit is essentially an increment pulse detector that holds U10B in the non-inverting state whenever an increment pulse is detected. The non-invert period is approximately ten times as long as an increment pulse. This allows the $\overline{\text{INC}}$ input on the selected XDCP to return to a HIGH state after the last falling pulse edge has incremented the pot. Since the time constant of the chip-select network is even longer, the $\overline{\text{CS}}$ input on the pot will be the last to return to a HIGH state after the increment pulse, thereby ensuring that the pots'current wiper setting is stored. Close inspection reveals that U10B is a follower when an increment pulse is present or recently received, but becomes an inverter after the increment pulse is gone, thus returning $\overline{INC}$ to a HIGH state.

A 4-bit shift register is formed by U8 and U9 which is clocked by the pushbutton switch included in the Gray-hill shaft encoder. The shift register is preset on power-up by U7D with "1000," this selects the first XDCP. Whenever a $\overline{CS}$ pulse is generated by U6D, it is NANDed with the output of the shift register by U5and determines which pot will be selected. Subsequent button pushes on the shaft encoder will select the next pot in the sequence. The length of the shift register can be extended as desired. Naturally, a variety of shift register schemes will work as well as the one shown, the only problem being the ability to determine which pot is active. Here, the use of the four LEDs serves as a simple index pointer to indicate the active pot.

The schematic shows an application using four X9C103 type XDCPs. Also notice that the Vh and Vl pot terminals are connected to supply and ground merely for the purpose of this application, however these terminals be connected to any voltage levels, as long as the maximum are not exceeded.

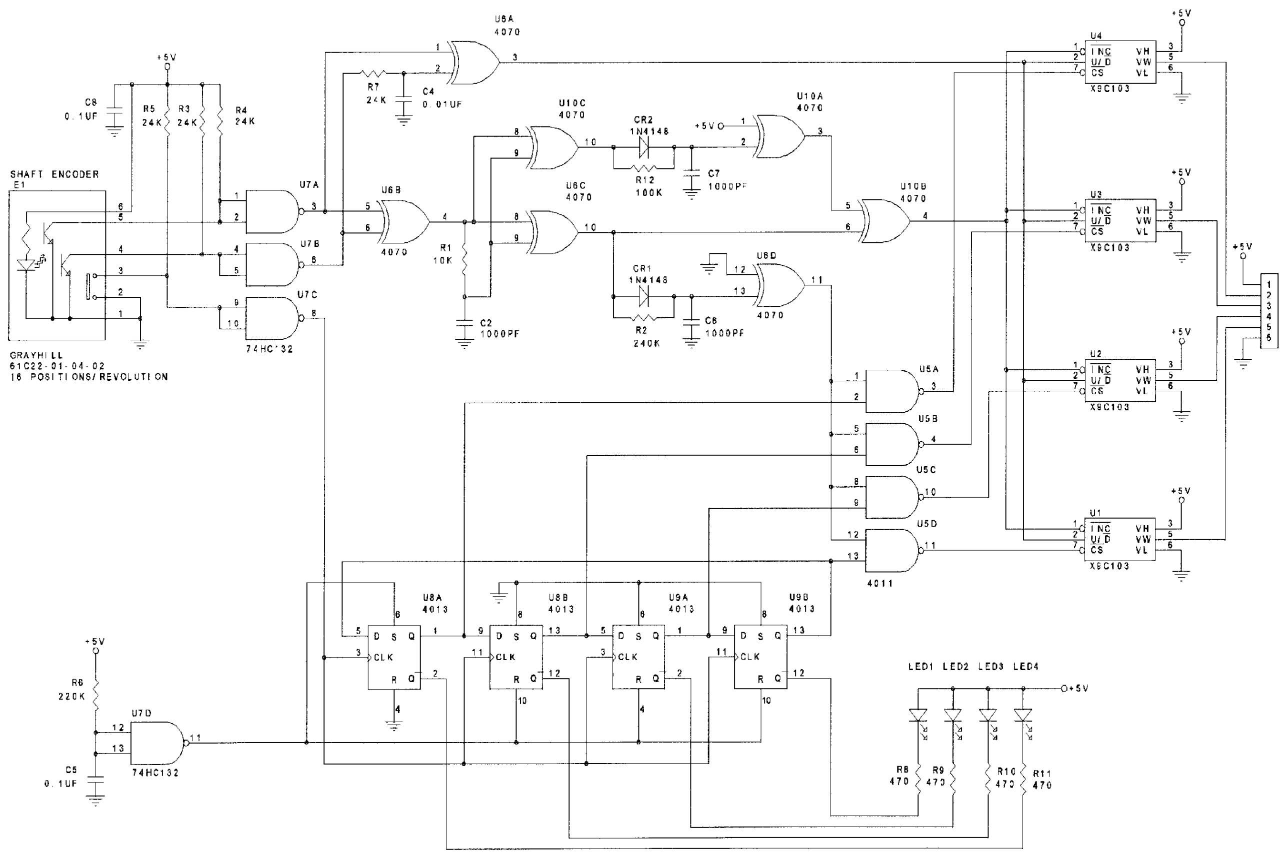

Figure 1. Shaft Encoder Driving Multiple XDCPs