Shaft Encoder Drives Multiple Renesas Digitally Controlled Potentiometers (XDCPs)

Introduction

Renesas XDCPs, combined with a shaft encoder and simple circuitry, provide a versatile solution for designs that require multiple control potentiometers or a single control to adjust multiple functions for aesthetic or other design considerations.

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1. Shaft Angle Encoder

Shaft angle encoders are available at low-cost from a number of manufacturers. Most can output two signals in phase quadrature (90°) with 1 to 10,000 pulses available per revolution. Count the number of transitions on both phases to electronically resolve the shaft angle of the control. Resolve the direction that the shaft turns using one of the phases as a reference.

The particular shaft encoder shown in Figure 1 encodes 16 positions per revolution, but other encoders offer different angular resolutions. Each channel of the encoder has four electrical cycles per revolution. This means the electrical phase goes through 360° for every 90° of mechanical rotation. There is a total of 16 level transitions (eight transitions per phase) in a complete shaft rotation.

In Figure 1, U7A and U7B are Schmitt-trigger buffers for the two phase channels out of the Grayhill shaft encoder. The XOR gate (U6B) adds these two phases to produce an 8-cycle per revolution signal. U6C along with delay network R1/C2 form a one-shot that produces one pulse for every HIGH to LOW or LOW to HIGH transition from U6B with 16 position pulses per revolution. The U6A and delay network R7/C4 determine the direction of the shaft rotation. If a motor rotates the shaft at a constant velocity, the R7/C4 do not require delay network because the U6A output is in a defined direction-indicating state, on the LOW going edge of the one-shot output formed by U6C. Direction ambiguity and erratic direction changes can happen if the shaft is rotated by hand. The delay network R7/C4 stores the direction the shaft was going and produces a one-shot pulse to solve this. The time constant for the direction delay is longer than the one-shot time, ensuring the direction is valid on the falling edge of the increment pulse coming from the output of U6C.

The $\overline{INC}$ must be HIGH before $\overline{CS}$ goes HIGH, because the XDCPs remember the last setting on power-down. 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) ensure this process. The increment-invert circuit is an increment pulse detector that holds U10B in the non-inverting state whenever it detects an increment pulse. The non-invert period is approximately ten-times as long as an increment pulse. This allows the $\overline{INC}$ input on the selected XDCP to return to a HIGH state after the last falling pulse edge increments the pot. The $\overline{CS}$ input on the pot is the last to return to a HIGH state after the increment pulse because the time constant of the chip-select network is longer, ensuring to store the pots' current wiper setting. 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, therefore returning $\overline{INC}$ to a HIGH state.

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U8 and U9 form a 4-bit shift register clocked by the push-button switch included in the Grayhill shaft encoder. The shift register presets on power-up by U7D with 1000, this selects the first XDCP. When U6D generates a $\overline{CS}$ pulse, it is NANDed with the output of the shift register by U5 and determines which pot to select. Each subsequent press of the shaft encoder button selects the next potentiometer in the sequence. The length of the shift register can be extended as required. Different shift register schemes work as the one presented, the only difference is the ability to determine which pot is active. The use of the four LEDs serves as a simple index pointer to indicate the active pot.

Figure 1 shows an application using four X9C103 type XDCPs. The Vh and Vl pot terminals connect to supply and ground for the purpose of this application; however, these terminals can connect to any voltage levels not exceeding maximum.

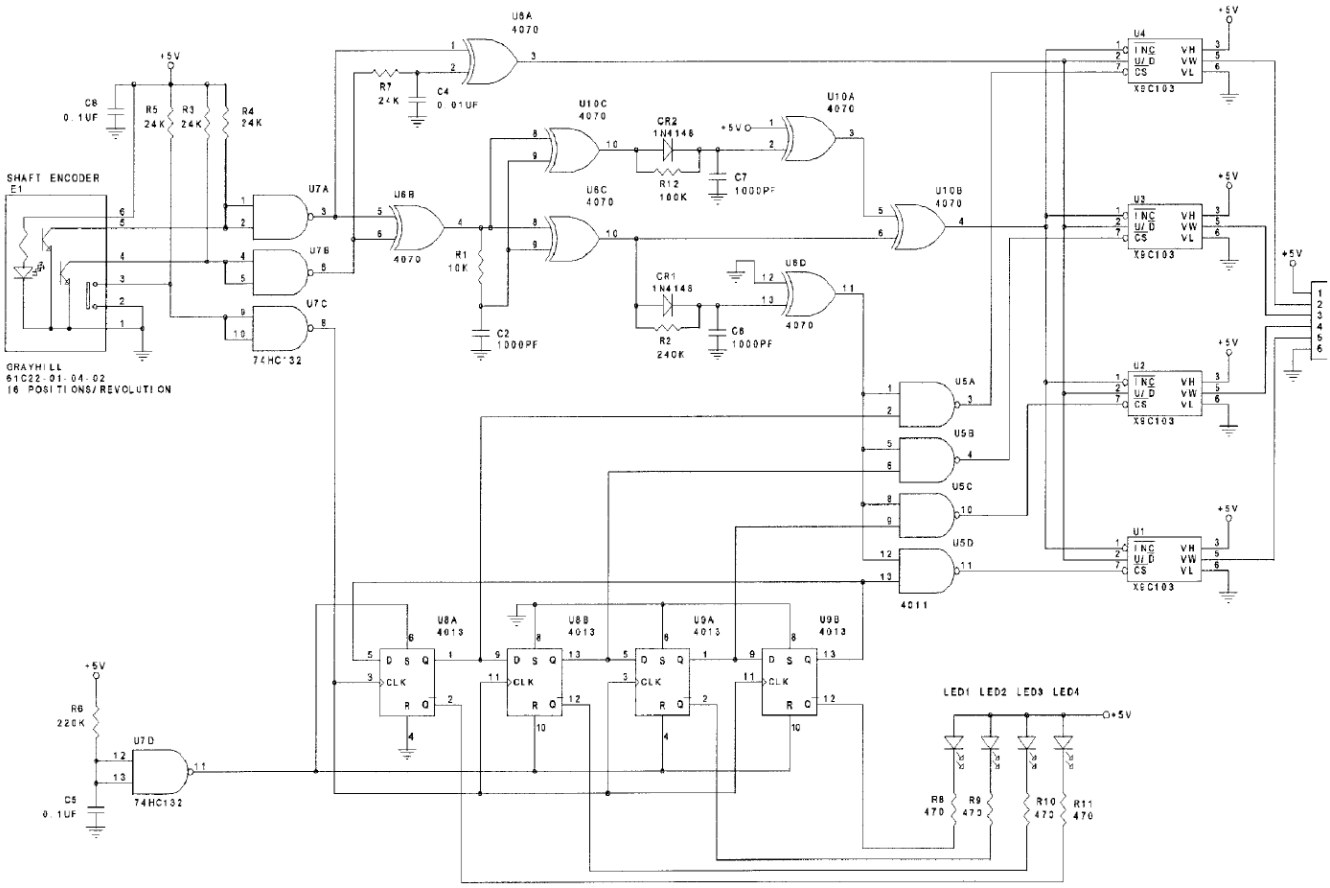


Figure 1. Shaft Encoder Driving Multiple XDCPs

2. Revision History

Revision	Date	Description
1.00	Nov 5, 2026	▪ Applied latest template ▪ Added Revision History section
0.00	Apr 27, 2005	Initial release

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