

Shaft Encoder Drives Multiple Intersil Digitally Controlled Potentiometers (XDCPs)

AN1155
Rev 0.00
April 27, 2005

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 Intersil 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 $\overline{INC}$ be HIGH before $\overline{CS}$ 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 $\overline{INC}$ 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 $\overline{CS}$ 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 Grayhill 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 U5 and 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 VI 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.

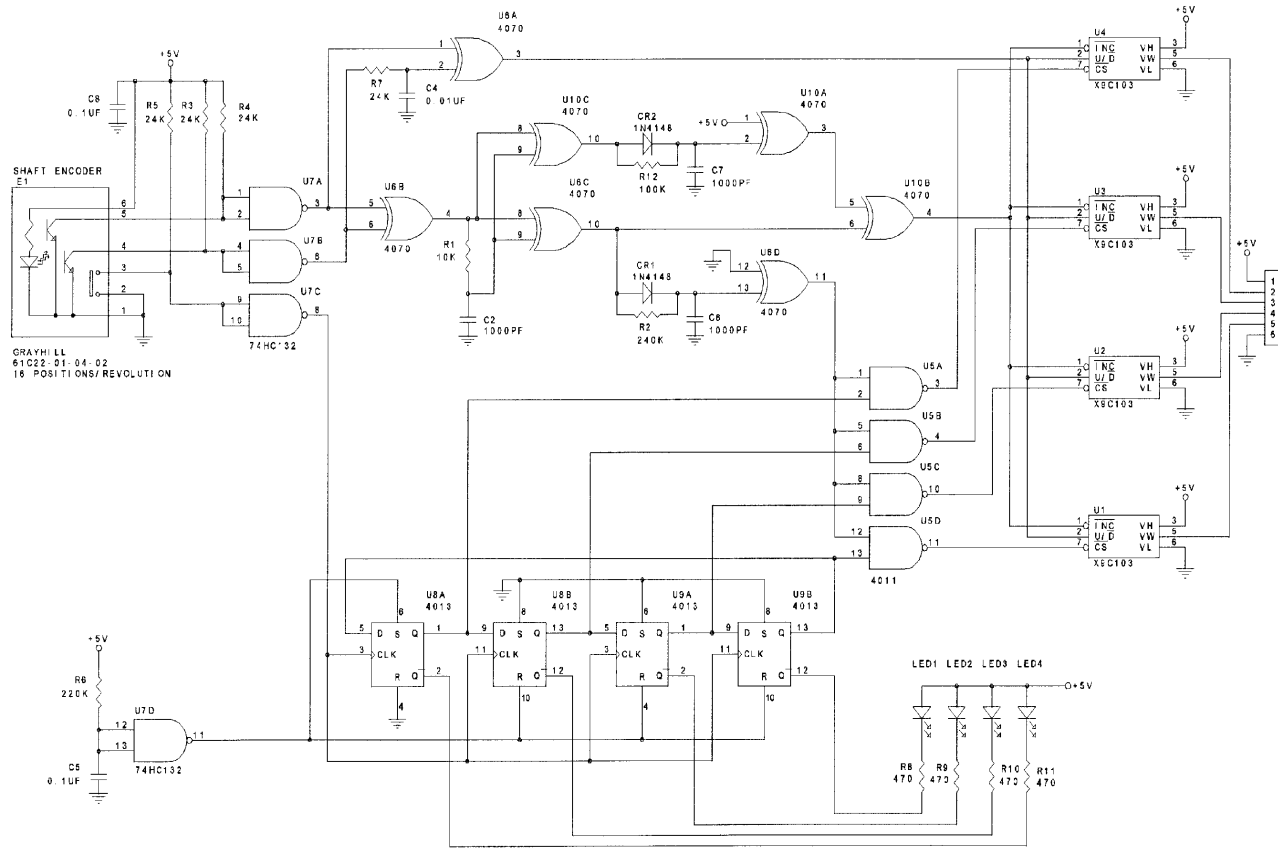


FIGURE 1. SHAFT ENCODER DRIVING MULTIPLE XDCPs

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
 2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
 3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
 4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
 5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
 6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
 7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
 8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
 9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
 10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
 11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
 12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.
- (Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
- (Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

Renesas Electronics America Inc.
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852-2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886-2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338