Topic 13:
Design, implementation and programming of the **Rotary Encoder Interface** for the Slow Control System MPD-NICA, on the NImyRIO and LabView platforms.[1]

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13 Rotary Encoder

A Rotary Encoder, also known as a quadrature encoder, combines a rotary knob and two switches that open and close in a staggered fashion as the knob turns. The knob angle and rotation direction can be sensed with suitable decoding of the switching waveforms. Figure 13.1 pictures the NImyRIO StarterKit Rotary Encoder.

Figure 13-1, NImyRIO StarterKit Rotary Encoder.

[1] Developed on the basis of educational materials: National Instruments, IBM, Reichle & De-Massari, Microsoft, Warsaw University of Technology, Joint Nuclear Institute Research

13.1 Learning Objectives:

After completing the activities in this chapter you will be able to:

Discuss essential concepts related to rotary encoders:

- [a] Quadrature waveforms A and B,
- [b] NImyRIO built-in encoder inputs and associated LabView VI Encoder to indicate counts (position) and direction,
- [c] Switch bounce that requires debouncing circuitry for reliable operation,

Connect the rotary encoder "common" terminal to work with digital inputs that include either internal pull-up or pull-down resistors.

13.2 Component Demonstration

Follow these steps to demonstrate correct operation of the rotary encoder.

13.2.1 Select these parts from the NImyRIO StarterKit:

- [a] Rotary encoder,

http://www.mantech.co.za/Datasheets/Products/F-11E.pdf

- [b] Resistor, 10 kΩ (2x)
- [c] 0.01 µF ceramic disk capacitor, marking "103" (2x),

http://www.avx.com/docs/Catalogs/class3-sc.pdf

- [d] Breadboard
- [e] Jumper wires, M-F (5x)

13.2.2 Build the interface circuit:

Refer to the schematic diagram and recommended breadboard layout shown in Figure 13.2.

TIP: Flatten the two tabs on either side of the rotary encoder so that it sits flush on the breadboard surface.

The rotary encoder interface circuit requires three connections to the NImyRIO MXP Connector B (see Figure A.1 Appendix):

- [a] Encoder A → B/ENC.A (pin 18)
- [b] Encoder A → B/DIO0 (pin 11)
- [c] Encoder B → B/ENC.B (pin 22)
- [d] Encoder B → B/DIO1 (pin 13)
- [e] Encoder COM → B/GND (pin 20)

13.2.3 Run the demonstration VI:

- [a] Download

http://www.ni.com/academic/myrio/project-guide-vis.zip

- [b] if you have not done so previously and unpack the contents to a convenient location,
- [c] Open the project Rotary Encoder demo.lvproj contained in the subfolder Rotary Encoder demo,
- [d] Expand the hierarchy button (a plus sign) for the myRIO item and then open Main.vi by double-clicking,
- [e] Confirm that NImyRIO is connected to your computer, and
- [f] Run the VI either by clicking the Run button on the toolbar or by pressing Ctrl+R.

Expect to see a "Deployment Process" window showing how the project compiles and deploys (downloads) to NImyRIO before the VI starts running.

NOTE: You may wish to select the "Close on successful completion" option to make the VI start automatically.

13.2.4 Expected results:

The demo VI displays the encoder A and B switch states as either "open" or "closed." Slowly turn the encoder shaft clockwise and you should observe the following sequence: 'A' switch state closed with 'B' switch state open, then both closed, then A open with B closed, and finally both open again. You should also observe that both switches are open when the encoder shaft is at rest in one of its twelve detente positions. Rotate the shaft in the counter-clockwise direction and you should see a similar sequence, but with switch B closing first.

The demo VI also maintains a counter of A/B switch transitions, and should increment by four counts for each click of the encoder in the clockwise direction and decrement by four counts for each click in the counter-clockwise direction. A front-panel indicator also displays the counter direction.

Click the Reset Counter control to clear the counter to zero; click again to continue counting. Click the Stop button or press the escape key to stop the VI and to reset NImyRIO.

13.2.5 Troubleshooting tips:

Not seeing the expected results? Confirm the following points:

[a] Glowing power indicator LED on NImyRIO,
[b] Black Run button on the toolbar signifying that the VI is in runmode, and
[c] Correct MXP connector terminals—ensure that you are using Connector B and that you have the correct pin connections.

13.3 Interface Theory

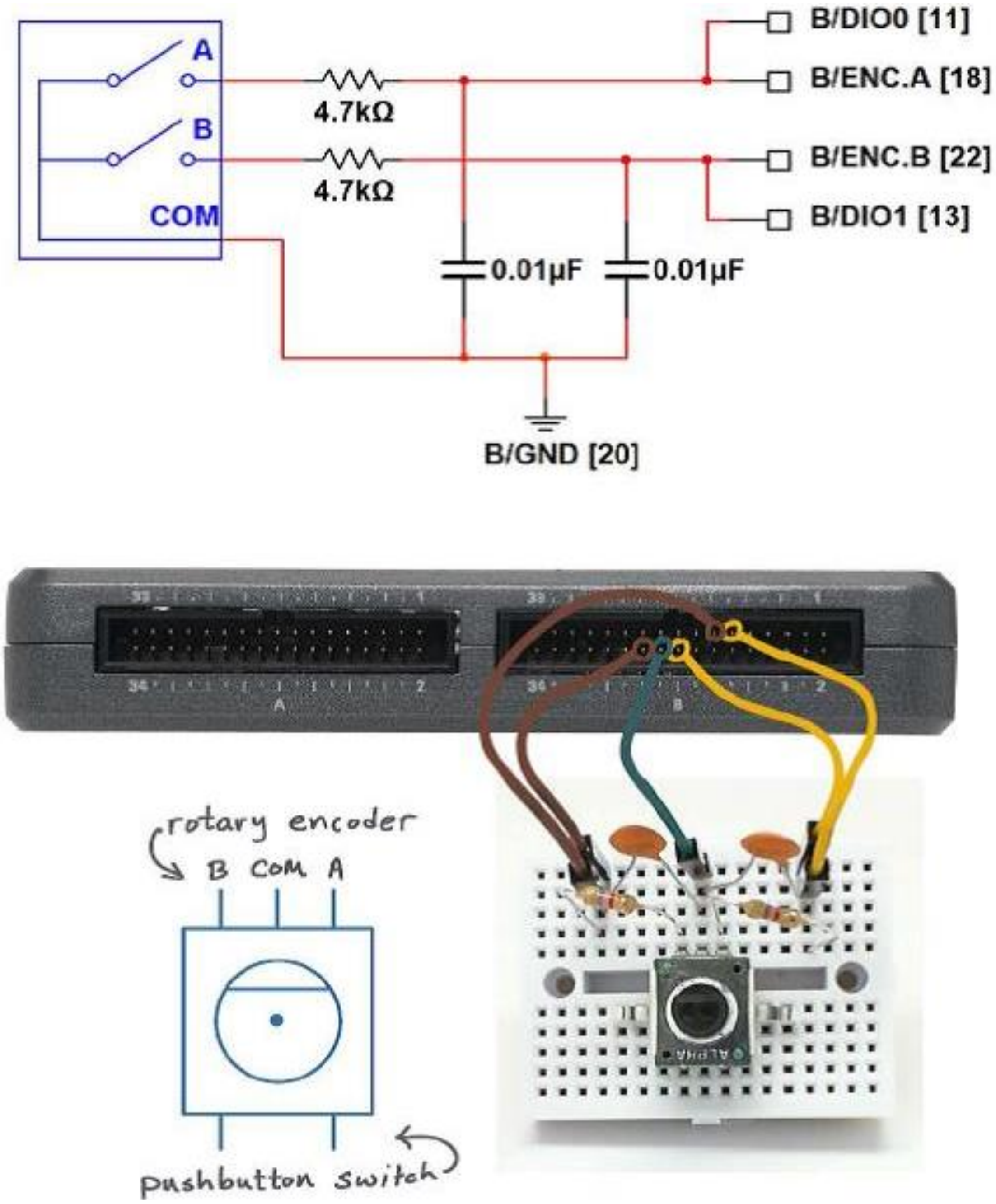

Figure 13-2; Figure 13.2: Demonstration circuit for rotary encoder: schematic diagram, recommended breadboard layout, and connection to NImyRIO MXP Connector B.

13.3.1 Interface circuit:

The rotary encoder translates shaft rotation into a pair of switch opening/closing patterns known as quadrature encoding. The pair of switches called A and B connect directly to one of four NImyRIO encoder inputs shared with the standard digital input/output (DIO) terminals. The Encoder Express VI decodes the switching patterns to produce a count value as well as the counter direction. These outputs indicate the relative position of the rotary encoder shaft since the last time the counter was initialized.

NOTE: The additional connections to B/DIO 0 and B/DIO 1 simply provide another way to observe the switching activity; they are not required for decoding.

Study the video **Rotary Encoder Interfacing Theory** (10:08)

https://www.youtube.com/watch?v=CpwGXZX-5Ug&feature=youtu.be

to learn about the rotary encoder principles of operation, the quadrature waveforms produced by Switches A and B, interfacing techniques for the NI myRIO MXP and MSP connectors, and dealing with switch bounce that when ignored causes erroneous decoding of the switching waveforms.

13.4 Basic Modifications

Study the video ***Rotary Encoder Demo Walk-Through*** (3:15)

https://www.youtube.com/watch?v=nmGIRqhQ6Rw&feature=youtu.be

to learn the design principles of Rotary Encoder demo, and then try making these modifications to the block diagram of Main.vi:

[a] Temporarily disconnect the two capacitors from the circuit, thereby removing the switch debouncing circuit. Experiment with various shaft rotation speeds and see if you can observe any relationship between rotation speed and counting error. Replace the capacitors and see if you can cause any count errors to occur – remember that each detente click corresponds to four counts.

[b] Create a front-panel indicator to display the number of full encoder shaft revolutions.

[c] Add the on board button (myRIO | Onboard | Button Express VI as another way to reset the counter value.

[d] Add two wires to use the pushbutton on the decoder.

13.5 Integrated Project Ideas

Now that you know how to use the rotary encoder consider integrating it with other devices to create a complete system, for example:

[a] Steer By Wire (Topic 43)

13.6 For More Information

[a] Quadrature Encoder Velocity and Acceleration Estimation with Compact RIO and LabVIEW FPGA by National Instruments s A good review of quadrature encoders:

http://www.ni.com/white-paper/3921/en

[b] Quadrature Encoding in a Rotary Encoder by Robot Room ~ Look at the insides of a rotary encoder to better understand how it works; see the adjacent pages in this article, too:

http://www.robotroom.com/Counter5.html

[c] Rotary Encoder: H/W, S/W or No Debounce? by HiFiDUINO ~ A nice discussion of the rotary encoder switch bounce problem, with hardware and software solutions:

http://hifiduino.wordpress.com/2010/10/20/rotaryencoder-hw-sw-no-debounce

Bibliography:

[a] www.jinr.ru
[b] www.ni.com
[c] www.nica.if.pw.edu.pl
[d] The Multi-Purpose Detector – MPD to Study Heavy Ion Collisions at NICA; (CDR Conceptual Design Report) Version 1.4; Project leaders: A. N. Sissakian, A. S. Sorin, V. D. Kekelidze.
[e] http://www.mantech.co.za/Datasheets/Products/F-11E.pdf
[f] http://www.avx.com/docs/Catalogs/class3-sc.pdf
[g] http://www.ni.com/academic/myrio/project-guide-vis.zip
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[k] http://www.robotroom.com/Counter5.html