Topic 15:
Design, implementation and programming of the **Hall-Effect Sensor Interface** for the Slow Control System MPD-NICA, on the NImyRIO and LabView platforms.[1]

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15 Hall-Effect Sensor

The Hall Effect provides an elegant way to sense magnetic fields as a change in voltage. Hall Effect Sensors provide either digital or analog outputs, with the former finding numerous applications in detecting proximity and sensing position and speed, while the latter can map the field strength pattern of a magnet. Figure 15.1 shows a photo of a typical Hall Effect Sensor.

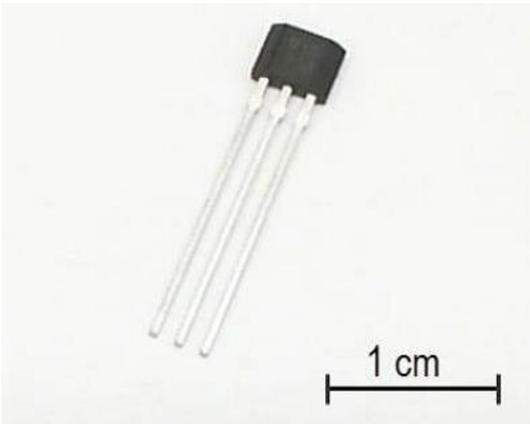

Figure 15-1, NImyRIO StarterKit Hall Effect Sensor.

15.1 Learning Objectives:

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

[a] Discuss the Hall effect principle,
[b] Discuss the two types of Hall-effect sensor behaviour (latching and switching),
[c] Connect an open-collector sensor output to digital inputs with either pull-up resistors (MXP connector) or pull-down resistors (MSP connector).

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

15.2 Component Demonstration

Follow these steps to demonstrate correct operation of the Hall Effect Sensor.

15.2.1 Select these parts from the NImyRIO StarterKit:

[a] US 1881 Hall Effect latch,

http://www.melexis.com/Hall-Effect-Sensor-ICs/Hall-Effect-Latches/US1881-140.aspx

[b] 0.1 µF ceramic disk capacitor, marking “104”,

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

[c] Breadboard
[d] Jumper wires, M-F (3x)

15.2.2 Build the interface circuit:

Refer to the schematic diagram and recommended breadboard layout shown in Figure 15.2. The Hall Effect sensor interface circuit requires three connections to NImyRIO MXP Connector B (see Figure A.1 Appendix):

[a] +5-volt supply → B/+5V (pin 1)
[b] Ground → B/GND (pin 6)
[c] Hall Effect Sensor output → B/DIO0 (pin 11)

15.2.3 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 Hall Effect Sensor demo.lvproj contained in the subfolder Hall Effect Sensor 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.
[g] 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.

15.2.4 Expected results:

The demo VI displays the state of the Hall-effect sensor output and the most-recent magnetic pole (north or south) applied to the marked side. The US1881 behaves as a latch, meaning that a magnetic field of the opposite pole must be applied to flip the latch to its opposite state.

Find as many magnets as you can — refrigerator magnets work nicely — and experiment with the sensitivity of the sensor (how close does the magnet need to be to flip the state) as well as the location of the north and south poles on the magnet. How many distinct pole locations can you detect on the magnet? The answer may surprise you!

Click the Stop button or press the escape key to stop the VI and to reset NImyRIO.

15.2.5 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,
[c] Correct MXP connector terminals—ensure that you are using Connector B and that you have the correct pin connections, and Correct orientation of the US1881—as you face the labelled side of the sensor you have V_{DD} on the left, ground in the middle, and the output on the right.

15.3 Interface Theory

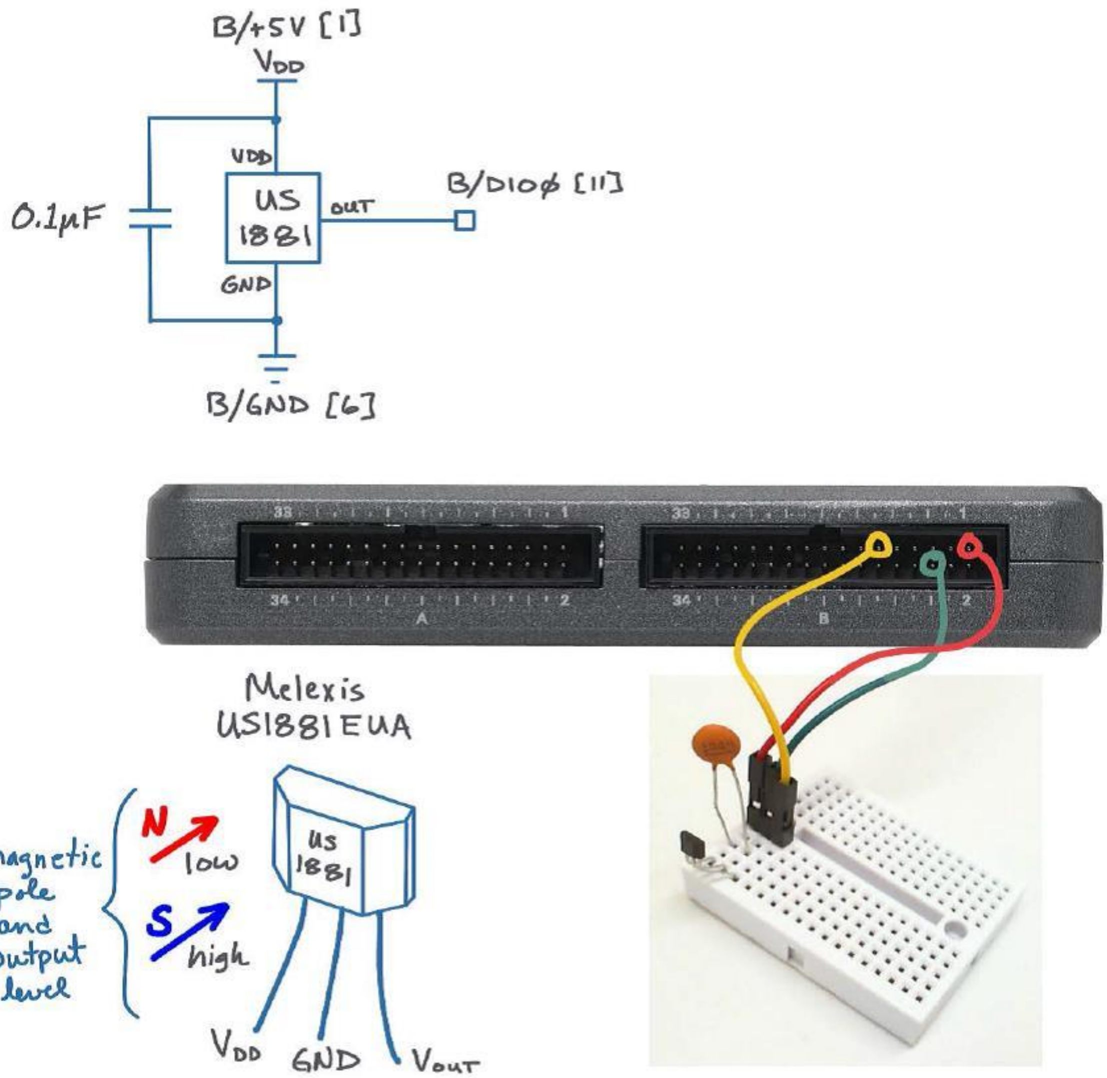

Figure 15-2; Demonstration circuit for Hall Effect Sensor: schematic diagram, recommended breadboard layout, and connection to NImyRIO MXP Connector B.

15.3.1 Interface circuit:

The Hall Effect relies on the fact that electrons moving across magnetic field lines experience a force. A current source establishes a current in a small semiconductor known as a Hall plate, and when subjected to a magnetic field the electrons tend to deflect to one side of the plate, leaving behind positive charges on the other side of the plate. The complete Hall-effect sensor on the US 1881 senses the charge displacement as a voltage, applies amplification and other signal conditioning operations, and indicates the sensed magnetic pole type as the state of an open-drain output suitable for digital inputs.

Study the video ***Hall-Effect Sensor Interfacing Theory*** (9:48)

https://www.youtube.com/watch?v=T9GP_cnz7rQ&feature=youtu.be

to learn more about the Hall effect, the various types of Hall effect sensor output behaviours (latch, switch, and linear), and interface circuit techniques for both the MXP and MSP connectors.

15.3.2 LabVIEW programming:

Study the video ***Digital Input Low-Level VIs*** (4:09)

https://www.youtube.com/watch?v=4nzr7THqU8U&feature=youtu.be

to learn how to use the low-level ***Digital Input VIs*** to sense the state of the Hall-effect sensor.

15.4 Basic Modifications

[a] Study the video Hall-Effect Sensor Demo Walk-Through (2:36)

https://www.youtube.com/watch?v=BCJLg-WbIK4&feature=youtu.be

[b] to learn the design principles of ***Hall-Effect Sensor demo***, and then try making these modifications to the block diagram of ***Main.vi:***

[c] Add the on board LED Express VI (myRIO | On board subpalette) to indicate the Hall-effect sensor output state.

15.5 Integrated Project Ideas

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

[a] Handheld Meter (Topic 39)
[b] Wireless Sensor (Topic 40)
[c] Data Logger (Topic 41)
[d] Steer By Wire (Topic 43)

15.6 For More Information

[a] What is the Hall Effect? by Melexis.com ~ Includes an excellent animation of the charge displacement phenomenon due to a magnetic field:

http://www.melexis.com/Assets/What-is-the-Hall-Effect-3720.aspx

[b] Hall Applications Guide by Melexis.com ~ Slide-by switch, proximity sensor, rotary interrupt switch, pushbutton, flowmeter, liquid-level sensing, brushless DC motor commutation, and many more; includes detailed discussion of magnet properties:

http://www.melexis.com/Assets/Hall-Applications-Guide--3715.aspx

[c] A Strange Attraction: Various Hall Effect Sensors by bildr.org ~ Video demonstration of latch, switch, and linear-mode behaviour:

http://bildr.org/2011/04/various-hall-effect-sensor

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.melexis.com/Hall-Effect-Sensor-ICs/Hall-Effect-Latches/US1881-140.aspx
[f] http://www.avx.com/docs/Catalogs/class3-sc.pdf
[g] http://www.ni.com/academic/myrio/project-guide-vis.zip
[h] https://www.youtube.com/watch?v=T9GP_cnz7rQ&feature=youtu.be
[i] https://www.youtube.com/watch?v=4nzr7THqU8U&feature=youtu.be
[j] https://www.youtube.com/watch?v=BCJLg-WbIK4&feature=youtu.be
[k] http://www.melexis.com/Assets/What-is-the-Hall-Effect-3720.aspx
[l] http://www.melexis.com/Assets/Hall-Applications-Guide--3715.aspx
[m] http://bildr.org/2011/04/various-hall-effect-sensor