

Topic 9: Design, implementation and programming of the **Photocell Interface** for the Slow Control System MPD-NICA, on the NImyRIO and LabView platforms.¹

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9 Photocell

A photocell is a two-terminal device fabricated from cadmium sulfide (CdS) and with resistance that varies with illumination in the visible spectrum of 400 to 700 nm. The photocell pictured in Figure 9.1 has a resistance that varies over many orders of magnitude: 10 k Ω at moderate illumination, less than 100 Ω at high illumination, and more than 10 M Ω in darkness.



Figure 9-1; NImyRIO StarterKit Photocell.

9.1.1 Learning Objectives:

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

- [a] Describe the photocell principles of operation,
- [b] Measure the photocell resistance with a voltage divider and analog input,
- [c] Size the voltage-divider resistor for the best measurement sensitivity and range.

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

9.2 Component Demonstration

Follow these steps to demonstrate correct operation of the photocell.

9.2.1 Select these parts from the NIMyRIO StarterKit:

- [a] Photocell, API PDV-P9203,

http://www.advancedphotonix.com/ap_products/pdfs/PDV-P9203.pdf

- [b] Resistor, 10 k Ω
- [c] Breadboard
- [d] Jumper wires, M-F (3x)

9.2.2 Build the interface circuit:

Refer to the schematic diagram and recommended breadboard layout shown in Figure 9.2 on the following page. The interface circuit requires three connections to NIMyRIO MXP Connector B (see Figure A.1 Appendix):

- [a] 5-volt power supply \rightarrow B/+5V (pin 1)
- [b] Ground \rightarrow B/GND (pin 6)
- [c] Photocell measurement \rightarrow B/AIO (pin 3)

Measure the resistance of the 10 k Ω resistor with an ohmmeter, as this value is required for the LabVIEW VI.

9.2.3 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 Photocell demo.lvproj contained in the subfolder Photocell demo,
- [d] Expand the hierarchy button (a plus sign) for the myRIO item and then open Main.vi by double-clicking,
- [e] Confirm that NI myRIO is connected to your computer,
- [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.

9.2.4 Expected results:

The demo VI displays the measured resistance of your photocell; expect to see a values in the range 1 k Ω to 10 k Ω at moderate illumination. Try blocking the light with a cover or cylindrical shroud such as a black straw. You should observe the resistance going up. How high can you make the resistance?

Use a flashlight or bright LED as illumination; you should observe the resistance going down. How low can you make the resistance?

Click the Stop button or press the escape key to stop the VI and to reset NIMyRIO; a myRIO reset causes all of the digital I/O pins to revert to input mode.

9.2.5 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.

9.3 Interface Theory

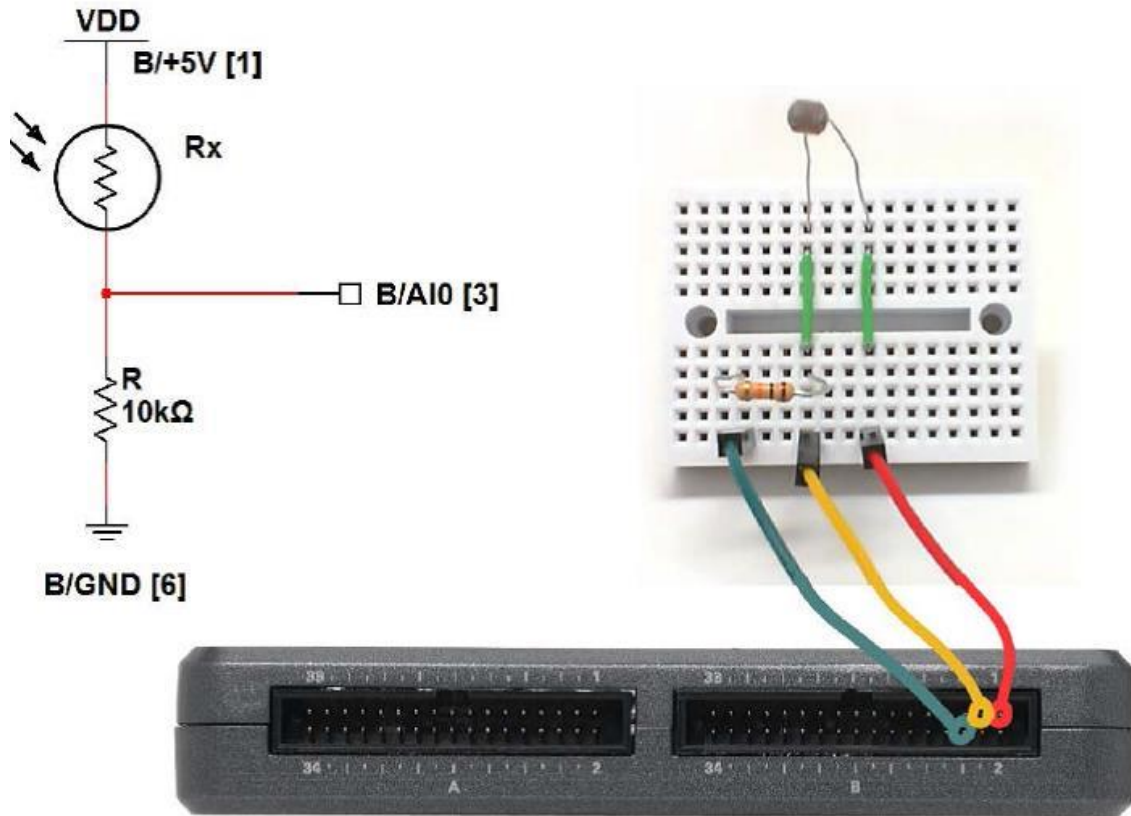


Figure 9-2, Demonstration circuit for photocell: schematic diagram, recommended breadboard layout, and connection to NImyRIO MXP Connector B.

9.3.1 Interface circuit:

Constructing a voltage divider from a photocell and a fixed-value resistor offers an effective and easy-to-build interface circuit. Placing the photocell in the top branch of the divider makes the measured voltage increase with more illumination.

Study the video *Photocell Characteristics* (4:45)

<https://www.youtube.com/watch?v=geNeoFUjMjQ&feature=youtu.be>

to learn about Photocell characteristics, and then study Measure Resistance with a Voltage Divider (9:44)

<https://www.youtube.com/watch?v=9KUVd7RkxNI>

to learn how to measure the photocell resistance with a voltage divider, and also how to properly choose the resistance R to maximize measurement sensitivity and range.

9.3.2 LabVIEW programming:

Study the video *Analog Input Express VI* (2:00)

<https://www.youtube.com/watch?v=N6Mi-VjBlmc>

to learn how to use *Analog Input Express VI* to measure the voltage divider's primary output.

9.4 Basic Modifications

Study the video **Photocell Demo Walk-Through** (3:07)

<https://www.youtube.com/watch?v=jZQqsc5GmoY>

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

- [a] Add a Boolean front-panel control to make the voltage divider configuration user-selectable, i.e., one state of the control corresponds to the Photocell in the lower branch while the other state selects the upper branch. Confirm that your modification works properly by swapping positions of the photocell and resistor.
- [b] Create a “room lights ON” detector with a suitable node from the Programming | Comparison subpalette and a Boolean front-panel indicator. Include a user-selectable threshold resistance as a front-panel numerical control.
- [c] Because analog inputs are not as plentiful as digital inputs, create the same “room lights ON” detector behavior, but do the comparison directly at a digital input;
- [d] Study the video Resistive-Sensor Threshold Detector (9:22)

<https://www.youtube.com/watch?v=TqLXJroefTA&feature=youtu.be>

to learn the design procedure.

9.5 Integrated Project Ideas

Now that you know how to use the photocell 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)
- [e] Scanning Sensor (Topic 50)
- [f] Music Maker (Topic 55)
- [g] Weather Station (Topic 57)

9.6 For More Information

- [a] Photocell Tutorial by Digital DIY s An excellent tutorial with many types of interface circuits for analog and digital inputs:

<http://digital-diy.com/general-electronics/269-photocell-tutorial.html>

- [b] Photocells by Adafruit - A good overview of CdS photocells with interesting applications such as light-based motor control, line-following robots, and laser pointer break beam sensor:

<http://learn.adafruit.com/photocells/overview>

- [c] Photocell Tutorial by Digital DIY – Several different light detector circuits, including a dual-photocell version that acts as a bi-stable latch:

<http://digital-diy.com/general-electronics/269-photocell-tutorial.html>

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.advancedphotonix.com/ap_products/pdfs/PDV-P9203.pdf
- [f] <http://www.ni.com/academic/myrio/project-guide-vis.zip>
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