Topic 2:
Design, implementation and programming of the **Discrete LED Interface** for the Slow Control System MPD-NICA, on the NImyRIO and LabView platforms.[1]

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2 Discrete LED

LEDs, or Light Emitting Diodes, provide simple yet essential visual indicators for system status and error conditions. Figure 2.1 shows some typical LEDs; the clear LEDs on the right are included in the NImyRIO StarterKit.

Figure 2-1; Typical LEDs including standard red and green, high-efficiency in various colours, and RGB.

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

2.1 Learning Objectives:

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

Describe the essential concepts related to LEDs:

[a] An LED is a diode that permits only one-way current,
[b] The LED forward-bias voltage drop varies with colour (wavelength),
[c] The interface circuit design depends on knowledge of the DIO output resistance and source voltage,
[d] LEDs may be direct-connected to the DIO under some circumstances.

Select a suitable current-limiting resistor (or no resistor) based on the LED type.

2.2 Component Demonstration

Follow these steps to demonstrate correct operation of the discrete LED component.

2.2.1 Select these parts from the NImyRIO StarterKit:

[a] Two 100 Ω resistors connected in series or two 470 Ω resistors connected in parallel
[b] Two-terminal LED
[c] Breadboard
[d] Jumper wires, M-F (2×)

2.2.2 Build the interface circuit:

Refer to the schematic diagram and recommended breadboard layout shown in Figure 2.2. The discrete LED interface circuit requires two connections to NImyRIO MXP Connector B (see Figure A.1 Appendix):

[a] Anode → B/+3,3V (pin 33)
[b] LED control → B/DIO0 (pin 11)

and connection to NImyRIO MXP Connector B.

2.2.3 Run the demonstration VI:

[a] Download:

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

if you have not done so previously and unpack the contents to a convenient location,

[b] Open the project ***Discrete LED demo.lvproj*** contained in the subfolder ***Discrete LED demo***
[c] Expand the hierarchy button (a plus sign) for the NImyRIO item and then open ***Main.vi*** by double-clicking,
[d] Confirm that NImyRIO is connected to your computer,
[e] 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.

2.2.4 Expected results:

The schematic diagram indicates a single 220 Ω current-limiting resistor; you may instead use two series-connected 100 Ω resistors or two parallel-connected 470 Ω resistors from the NImyRIO StarterKit. Also, all of the LEDs in the

StarterKit have clear plastic lenses with a wide variety of colors. You may wish to try multiple LEDs to investigate your color options.

Your discrete LED should be blinking on and off in synchronism with the front-panel indicator digital output state. Click the enable blinker front-panel button to disable blinking and to enable the digital level button; click this button to manually set the digital output state either high or low. Because this interface circuit is the *sinking current* form (explained in the next section), the LED is active when the digital output is in the *low* state, i.e., this is an active-low LED interface circuit.

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

2.2.5 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 run mode,
[c] Correct LED orientation — the diode conducts current in one direction only; remove the LED and reinsert it in the opposite direction, and
[d] Correct resistor value — use an ohmmeter to verify that the resistance is near 220 ohms.

2.3 Interface Theory

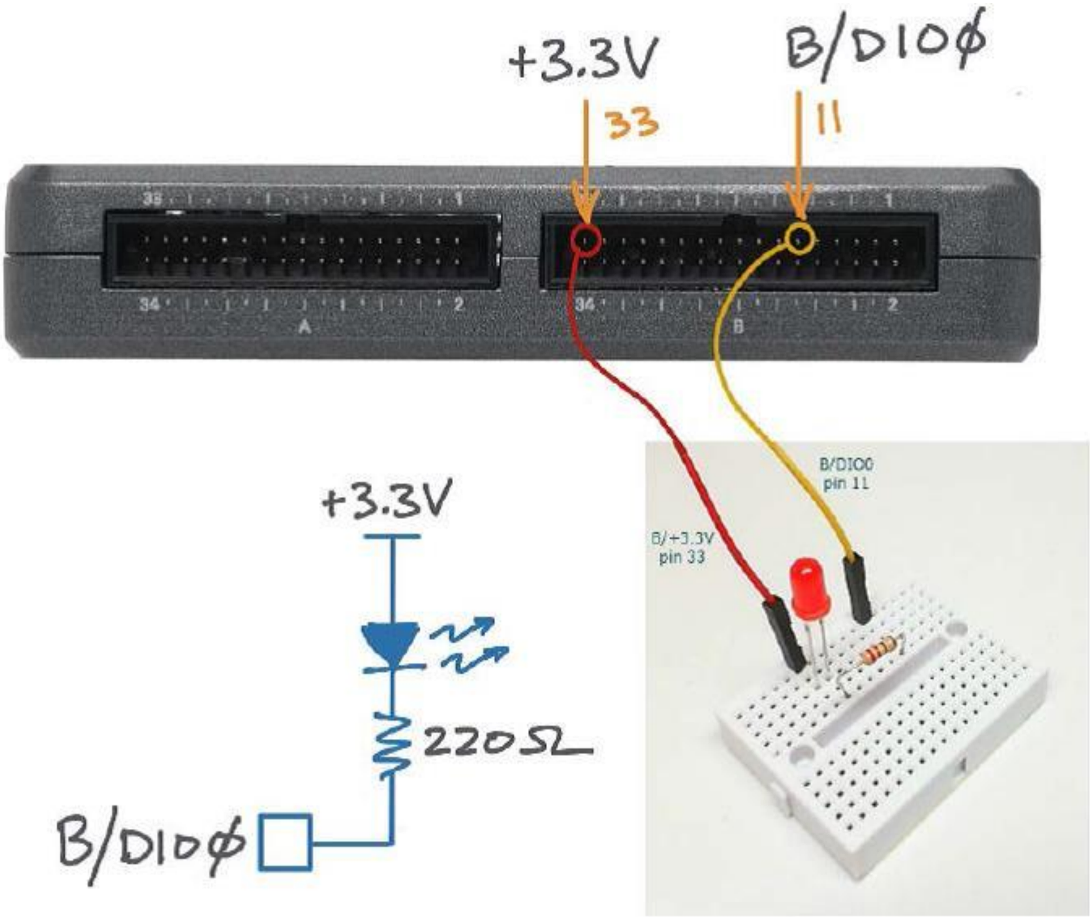

Figure 2-2; Demonstration circuit for discrete LED: schematic diagram, recommended breadboard layout, and connection to NImyRIO MXP Connector B.

2.3.1 Interface circuit,

Study the video ***Discrete LED Interfacing Theory*** (6:55)

https://www.youtube.com/watch?v=9-RlGPVgFW0&feature=youtu.be

to learn the basics of LEDs and the two types of interface circuits (current-sinking and currentsourcing).

Also study ***LED Current Management*** (15:06)

https://www.youtube.com/watch?v=JW-19uXrWNU&feature=youtu.be

to learn about the voltage-current characteristics of the various types of diodes included in the NImyRIO StarterKit (standard, super bright, and RGB), to learn principles of operation of the LED interface circuit including the current-sinking and current-sourcing forms, and to learn how to choose the size of the current-limiting resistor.

2.3.2 LabVIEW programming

Study the video ***Digital Output Express VI*** (2:21)

https://www.youtube.com/watch?v=Y8mKdsMAqrU&feature=youtu.be

to learn how to access all of the available digital outputs with the NImyRIO Digital Output Express VI, including single output, multiple outputs, and connector type.

2.4 Basic Modifications

Study the video ***LED Demo Walk-Through*** (2:03)

https://www.youtube.com/watch?v=SHJ-vu4jorU&feature=youtu.be

to learn the design principles of ***Discrete LED demo***, and then try making these modifications to the interface circuit and to ***Main.vi***:

[a] Add a front-panel control to adjust the blink frequency specified in Hertz; at what frequency does the blinking become imperceptible?
[b] Blink two adjacent LEDs to simulate a railroad crossing signal.
[c] Blink the green and blue LEDs of the RGB LED using the same LabVIEW code as the railroad crossing signal; refer to Figure 2.3 on the following page for the RGB LED pinout diagram. Use the current-sourcing interface circuit.
[d] Create an LED variable-intensity dimmer with the PWM Express VI to create a pulse-width modulated digital output. Set the Frequency to the default constant value of 1000 Hz and create a pointer slide control to adjust the duty cycle; select the logarithmic mapping option for the control, too. Add some code to account for the active-low current-sinking LED

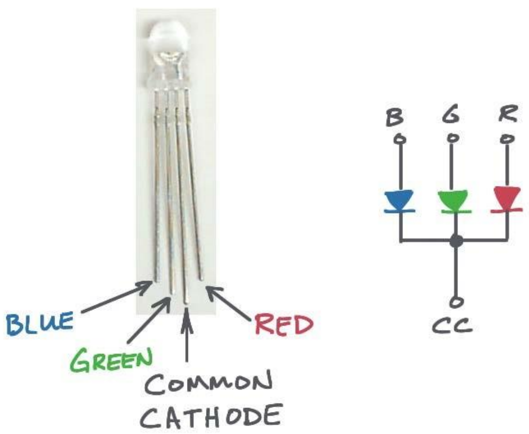

Figure 2-3, RGB LED pins and schematic diagram.

interface (bonus points with a Boolean control to select between current-sinking and current-sourcing interfaces).

2.4.1 Integrated Project Ideas

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

[a] 3-D Colour Controller (Topic 45)
[b] Digital Bubble Level (Topic 56)
[c] NTP Clock (Topic 42)

2.5 For More Information...

[a] LED Mixed Bag (5mm) by SparkFun ~ Need more LEDs? The LED Mixed Bag from SparkFun offers the same type as those in the NImyRIO StarterKit; also search SparkFun for many other sizes and types of LEDs:

http://www.sparkfun.com/products/9881

[b] Engineering Thursday: LED Light Boxes by SparkFun ~ Glowing multi-colour boxes as household art:

http://www.sparkfun.com/news/1210

[c] Use LEDs as photodiodes by EDN ~ LEDs can detect light, too, making them an interesting type of Photo Sensor:

http://www.edn.com/design/led/4363842/Use-LEDs-as-photodiodes

[d] LED Lighting Applications by OSRAM Opto Semiconductors ~ LEDs are everywhere these days, including outdoor street lighting, architectural illumination, downlights (i.e., ceiling lights), flashlights, and greenhouses:

http://ledlight.osram-os.com/applications/

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