18 Motor Adapter for NI myRIO and Geared Motor

The Motor Adapter for NI myRIO connects directly to an MXP port and integrates an H-bridge motor controller and power manager into a trouble-free solution to drive two DC motors using pulse-width modulation (PWM) speed control. Both the motor adapter and the compatible geared motor are included with the NI myRIO Mechatronics Kit (Figure 18.1). The Motor Adapter supports motor voltages in the 6 to 16 V range with up to 1.5 A current, accommodates quadrature encoder feedback for position and speed control, senses the motor current and voltage as waveforms for monitoring purposes, supports servo motors and stepper motors, and includes current overlimit protection.

Figure 18.1: NI myRIO Mechatronics Kit motor adapter and geared motor.

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

1. Describe the H-bridge principle of operation,
2. Explain how to control the motor speed and direction of rotation,
3. Sketch the quadrature encoded output waveforms of the shaft position sensor for clockwise and counterclockwise rotation,
4. Apply the LabVIEW PWM Express VI to control the motor speed, and
5. Apply the LabVIEW Encoder Express VI to measure the motor shaft position and speed.

18.1 Component Demonstration

Follow these steps to demonstrate correct operation of the motor adapter and geared motor.

Select these parts from the NI myRIO Mechatronics Kit:

- Motor Adapter for NI myRIO), `http://store.digilentinc.com/motor-adapter-for-ni-myrio`

- Geared motor, http://digilentinc.com/Products/Detail.cfm?NavPath=2,403,625&Prod=MT-MOTOR
- Small screwdriver

You will also need a DC power supply between 6 V to 12 V; a 9-volt battery will also work quite well.

Build the interface circuit: Refer to the diagram shown in Figure 18.2 on the next page. Simply connect the Motor Adapter to MXP Connector A, attach the geared motor, and attach the power supply as shown. Use a small Phillips or straight-bladed screwdriver to loosen and tighten the screws on the motor supply voltage connector.

Run the demonstration VI:

- 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,
- Open the project Motor Adapter & Geared Motor demo.lvproj contained in the subfolder Motor Adapter & Geared Motor demo,
- Expand the hierarchy button (a plus sign) for the myRIO item and then open Main.vi by double-clicking,
- Confirm that NI myRIO is connected to your computer, and
- 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 NI myRIO before the VI starts running.

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

Expected results: Increase the PWM duty (duty cycle) slider until the motor begins to turn. You should see the motor turn, the Counter Value indicator value increment in the positive direction, the Counter Direction indicator display "Counting Up," and activity on the motor current and voltage waveform displays. Continue increasing the PWM duty slider to speed up the motor.

Reduce the motor speed and then click the Direction button to reverse the motor direction. You should see the direction indicator change to "Counting Down" and the counter value decrementing.

Click the Reset Counter button and then experiment with the motor speed. Note that the counter now serves as a speed indicator reporting the number of "counts" measured in a 100 millisecond interval.

Try varying the PWM freq slide control to adjust the rate at which pulses are applied to the H-bridge controller's "Enable" input. Look for relationships between the PWM frequency and duty cycle especially in terms of these points:

1. What PWM frequency range makes it easiest to start the stopped motor when increasing the PWM duty cycle from zero?
2. What PWM frequency range causes audible tones?
3. What PWM frequency range is best for very slow rotation?

Bring the motor speed back to zero and then reset the counter, leaving the Reset Counter switch in its "off" state. Manually rotate the magnet on the back of the motor and observe the Counter Value display. How many counts do you see for one complete revolution of the magnet?

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

Troubleshooting tips: Not seeing the expected results? Confirm the following points:

- Glowing power indicator LED on NI myRIO,
- Black Run button on the toolbar signifying that the VI is in run mode,

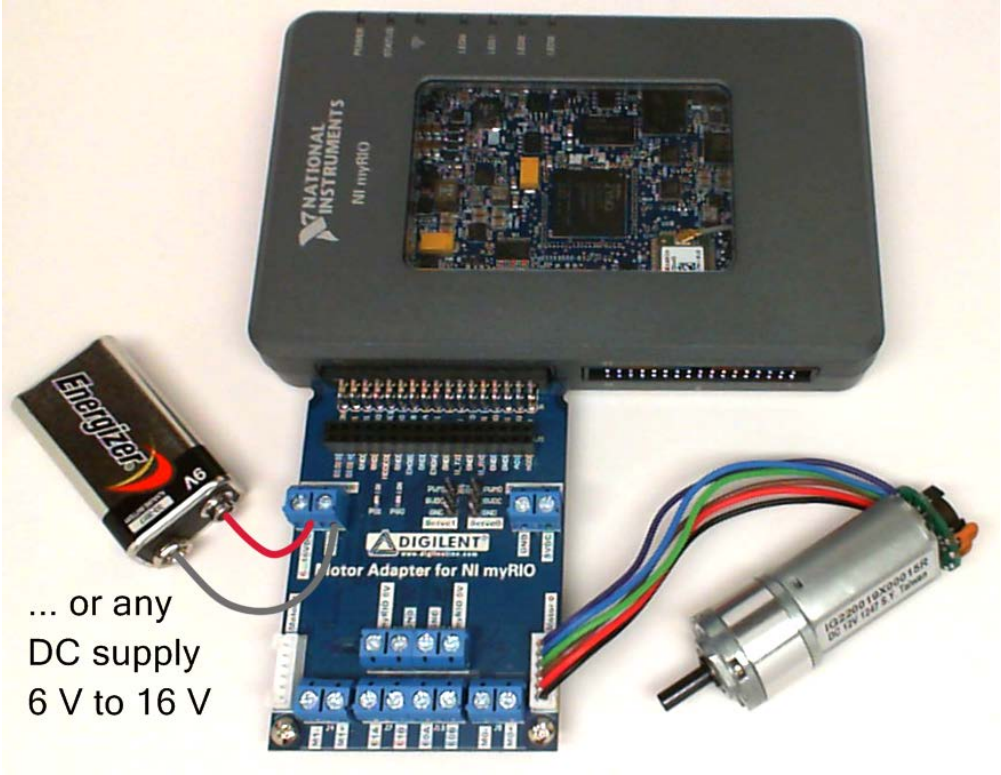

Figure 18.2: Demonstration circuit for motor adapter and geared motor: connected to NI myRIO MXP Connector A with motor and motor power supply connections.

- Correct MXP connector terminals — ensure that you are using Connector A for the motor adapter,
- Correct DC power supply terminals — double-check your connections, and ensure that you have not reversed the DC power supply terminals, and
- Glowing "power good" LED indicators (PG0 and PG1) on the motor adapter board.

18.2 Interface Theory

Interface circuit: The Motor Adapter for NI myRIO provides a flexible and trouble-free way to connect DC motors, servo motors, and stepper motors to your myRIO. Study the video *Motor Adapter for NI myRIO and Geared Motor Interfacing Theory* (`youtu.be/bkiopa5nxiE`, 8:54) to learn more about the features of this board as well as the geared motor, to understand the high-level functional behavior of the adapter, to learn how to connect motors and power supplies to the adapter, and to become aware of the various control and feedback/status signals offered at the MXP interface.

Study the video *H-Bridge and Geared Motor Interfacing Theory* (`youtu.be/W526ekpR8q4`, 11:26) to learn more about H-bridge principles of operation, speed control with pulse-width modulation (PWM), Hall-effect sensors and quadrature-encoded

sensor signals, and an overview of closed-loop control of the motor position and speed by using the sensor signals as feedback. This video discusses the PmodHB5 H-bridge specifically, but all of the theoretical concepts apply to the motor adapter, as well. See Chapter 35 on page 165 for more details.

LabVIEW programming: Study the video *PWM Express VI* (youtu.be/mVN9jfwXleI, 2:41) to learn how to use the PWM Express VI to create a pulse-width modulated square wave to provide variable-speed motor operation.

18.3 Basic Modifications

Study the video *Motor Adapter for NI myRIO Demo Walk-Through* (youtu.be/wg8FQ7kEmdE, 8:08) to learn the design principles of `Motor Adapter & Geared Motor demo`, and then try making these modifications to the block diagram of `Main.vi`:

1. Determine the number of shaft encoder counts for one revolution of the gearbox shaft output (hint: you need to know the gearbox ratio and the number of encoder counts for one revolution of the sensor magnet), and then add block diagram code to display the gearbox output shaft angle in degrees.
2. Add a display to show the gearbox output shaft RPS (revolutions per second).
3. Add front-panel meters for motor voltage and current; use the "DC" output of the `AC & DC Estimator.vi` located in the Signal Processing | Signal Operation subpalette. Note that this VI requires at least three waveform periods to properly estimate the DC value.
4. Add a front-panel meter for motor power by taking the product of voltage and current measured in the previous step. Investigate the motor current, voltage, and power as you vary the motor loading.
5. Try the servo motor connection; see Chapter 17 on page 69 for complete details. Remember that you can connect the servo motor power terminal block "5VDC" to the "myRIO 5V" to use myRIO to power your servo motor.
6. Add Boolean indicators for the fault ("FLT") and power-good ("PG") status signals.

18.4 For More Information

- *Motor Adapter for NI myRIO Reference Manual* by Digilent ~ Reference manual for the motor adapter:
  `https://reference.digilentinc.com/ni:mxp_motor_adapter:refmanual`
- *Motor Adapter for NI myRIO Schematic* by Digilent ~ Schematic diagram of the motor adapter:
  `https://reference.digilentinc.com/_media/ni:motoradapter_sch.pdf`
- *A4973 Full-Bridge PWM Motor Driver* by Allegro ~ Datasheet for the H-bridge motor driver at the heart of the motor adapter:
  `http://www.allegromicro.com/en/Products/Motor-Driver-And-Interface-ICs/Brush-DC-Motor-Drivers/A4973.aspx`
- *TPS24711 2.5V to 18V High Efficiency Power-Limiting Hot-Swap Controller* by Texas Instruments ~ Datasheet for the power manager used by the motor adapter:
  `http://www.ti.com/product/tps24711`
- *Motor/Gearbox* by Digilent ~ Need more geared motors for your project? The IG22 is supplied by Digilent:
  `http://digilentinc.com/Products/Detail.cfm?NavPath=2,403,625&Prod=MT-MOTOR`
- *IG22 Geared Motor Datasheet* by Sha Yang Ye ~ Datasheet for the motor and planetary gearbox:
  `http://www.geared-motor.com/english/pdf/IG-22GM-01&02.pdf`
- *Two-Channel Encoder Datasheet* by Sha Yang Ye ~ Datasheet for the two-channel quadrature

encoder:

http://www.geared-motor.com/english/pdf/Magnetic-Encoders.pdf