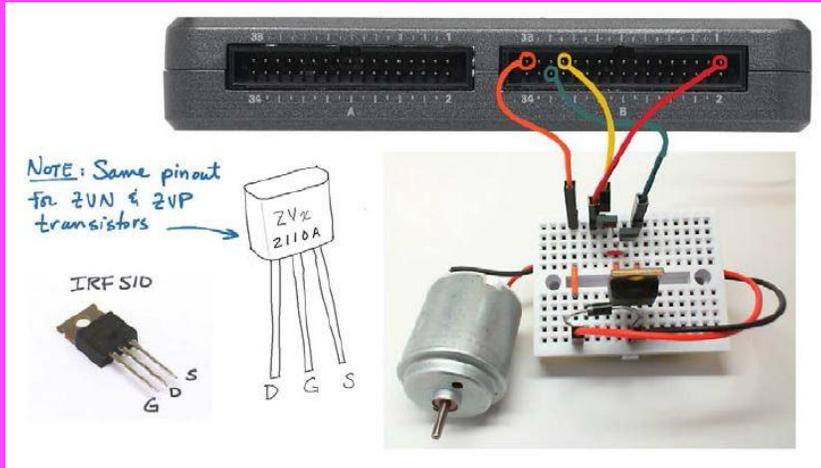
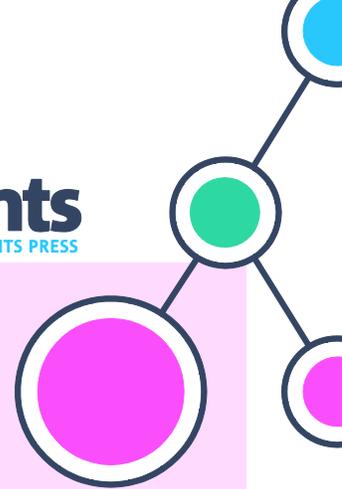


# DC Motor

## Core Concept Instructor Set



### Materials:

myRIO

DC Motor

## Learn It!

A DC motor takes an applied current and generates mechanical motion. This is accomplished by electromagnetic means, in which current generates a strong magnetic field turning the motor shaft. The DC motor included in this starter kit has a voltage range from 3.3 to 5 volts. Applying voltage will spin the motor shaft at a relatively high rotational speed. DC motors are used in a variety of devices, from

automotive starters to the vibration generator found in a common cell-phone.

In this exercise, you will learn how to connect and drive a very simple DC motor. The motor is driven by a simple digital signal, which turns the motor either entirely on or off.

“DC motors are used in a variety of devices, from automotive starters to the vibration generator found in a common cell-phone.”

## Build It!

DC Motors require a steady voltage with a relatively high current. For this reason you will use a transistor circuit to ground the motor, while supplying voltage via the myRIO's onboard power port.

### Creating an DC Motor Circuit

**Step 1:** Connect the DC Motor as indicated in the circuit diagrams. The DC Motor circuit requires a triple transistor circuit. This allows the motor to be switched entirely on or off with no lagging changes in voltage, as supplying under voltage to the motor can be damaging to it.

**Step 2:** Open the DC Motor demo folder and the DC Motor project (DC Motor demo.lvproj). Open the VI titled “Main.vi”. On the front panel should be a boolean for the motor's state, HI or LO (Figure 1). HI will turn the motor off while LO will activate it. This means that the circuit is an “active low” circuit, as our desired activity occurs when our digital state is written “low”.



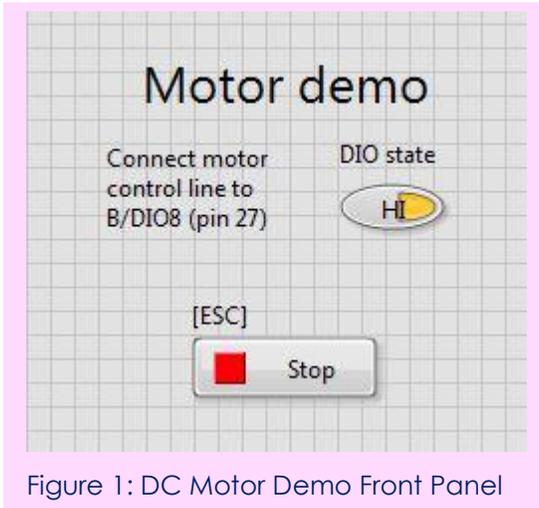


Figure 1: DC Motor Demo Front Panel

Step 3: Run the VI. Try switching the DIO state from HI to LO and see that the motor functions as it should. An indicated HI state should turn the motor off while an indicated LO state should turn the motor on

**Guiding Questions:**

- The front panel control allows the user to select a motor state, on or off. Can you think of another way of doing this more rapidly? What might happen to the motor's speed was switched extremely rapidly?

Step 4: Examine the Block Diagram of the Main VI (Figure 2). The main body of the code runs within a while loop, so that the state can be updated indefinitely as the code runs.

The heart of the code is a digital writing express VI, which simply writes either High or Low to a digital output. This triggers the transistor circuit to pass the proper voltage to the motor.

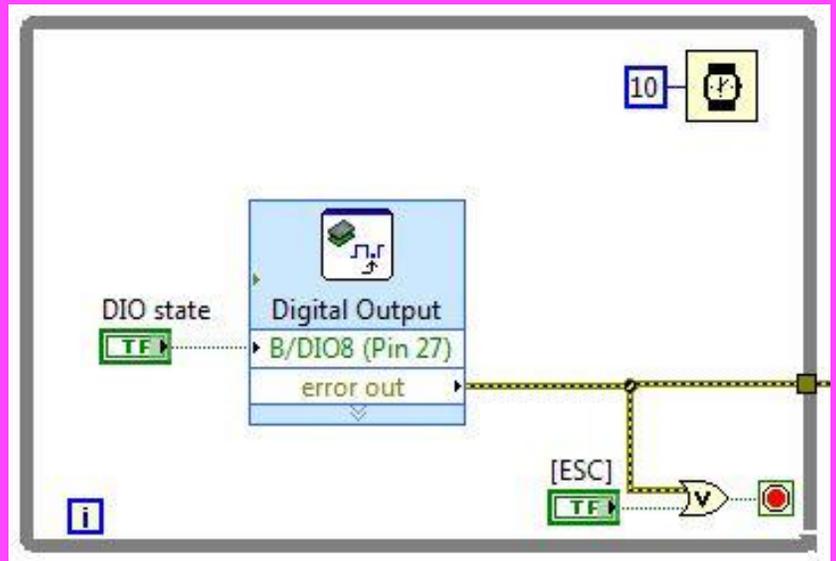
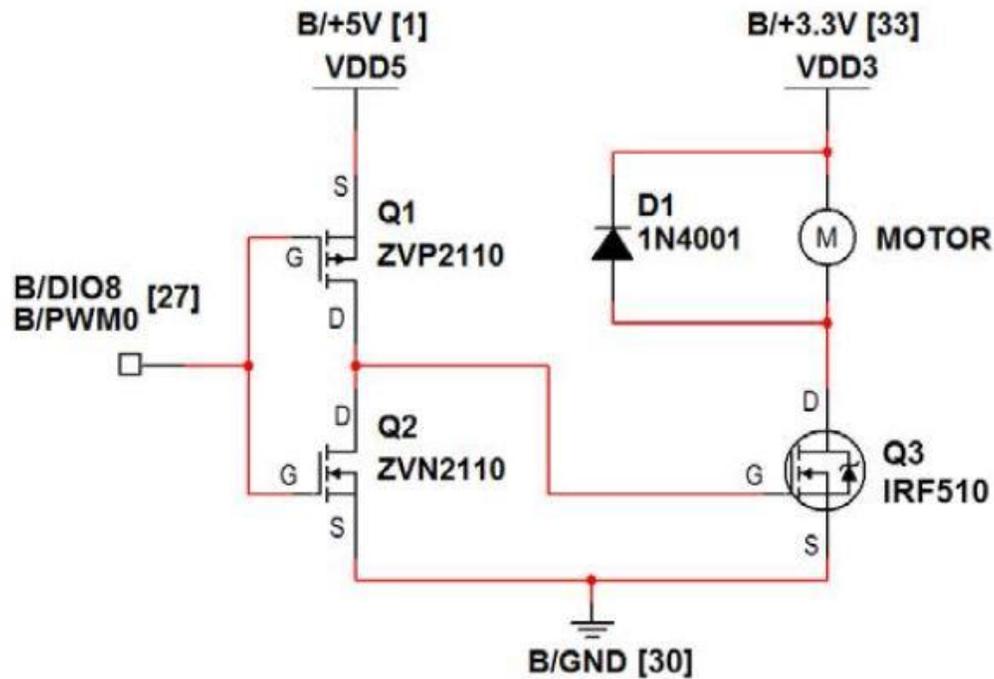


Figure 2: DC Motor Demo while loop with digital writing



DC Motor- Circuit Diagram

### Expand it!

- Insert additional code to deal with the fact that the motor control interface is active-low. That is, you want 0 % duty cycle to turn the motor off rather than causing maximum speed as it does now.
- Add a Boolean front-panel control as a motor enable. Try using a Select node under the Programming | Comparison subpalette to set the duty cycle either to 0 or to the value of the front-panel duty cycle control.
- Disconnect the motor control line and re-connect to C/PWM0 (pin 14) on MSP Connector C; adjust your VI to refer to this channel, too. You should observe that the motor is on due to the internal pull-down resistor. Now counter the effect of the internal pull-down with a 4.7 k external pull-up resistor connected between the motor control line and the +5-volt supply. The motor should now remain off when the NI myRIO first powers on or after executing a myRIO reset.
- Create variable-speed motor operation as follows:
  - Replace the existing Digital Output Express VI with the PWM Express VI. Choose the PWM channel as B/PWM0, the same connector pin as B/DIO8 (pin 27). Choose the remaining dialog box options so that both frequency and duty cycle are available as inputs,
  - Create pointer slide front-panel controls for each; right-click on each control and choose "Visible items" and the "Digital display," and
  - Right-click on the frequency control, select "Scale" and then "Mapping," and choose "Logarithmic." Also, double-click the upper limit of your frequency control and enter "40000" and then similarly set the lower limit to "40."

Experiment with both the duty cycle and frequency. What frequency minimizes audible PWM noise and maximizes your ability to create very slow motor speeds? What do you notice about restarting the motor after it stops? If you have a DMM ammeter handy, you may wish to observe the motor current under various conditions including mechanical loading, free running, and start-up.

## Research it!

Study the video Motor Demo Walk-Through ([youtu.be/UCqFck0CLpc](https://youtu.be/UCqFck0CLpc), 1:56) to learn the design principles of Motor demo.

Study the video PWM Express VI ([youtu.be/mVN9jfwXlel](https://youtu.be/mVN9jfwXlel), 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.

Study the video Motor Interfacing Theory ([youtu.be/C\\_22XZaL5TM](https://youtu.be/C_22XZaL5TM), 6:49) to learn more about the motor principles of operation and interface circuit design principles including: sizing the power transistor for motor current under various load conditions, importance of the rectifier to deal with back-emf voltage spiking, level-shifting circuit for 3.3-to-5 V, and required modification to connect the interface to the MSP connector with integral pull-down resistors.

DC motor:

[http://www.mabuchi-motor.co.jp/cgi-bin/catalog/e\\_catalog.cgi?CAT\\_ID=ff\\_180phsh](http://www.mabuchi-motor.co.jp/cgi-bin/catalog/e_catalog.cgi?CAT_ID=ff_180phsh)

1N4001 general-purpose rectifier:

<http://www.vishay.com/docs/88503/1n4001.pdf>

ZVN2110A n-channel enhancement-mode MOSFET:

<http://www.diodes.com/datasheets/ZVN2110A.pdf>

ZVP2110A p-channel enhancement-mode MOSFET:

<http://www.diodes.com/datasheets/ZVP2110A.pdf>

IRF510 n-channel enhancement-mode power MOSFET:

<http://www.vishay.com/docs/91015/sihf510.pdf>

Brushed DC Motor Fundamentals by Microchips Learn about DC motor principles of operation, drive circuits, direction control with an H-bridge, and speed control with Hall-effect sensors as feedback:

<http://ww1.microchip.com/downloads/en/AppNotes/00905B.pdf>