Module 12

Introduction: DC motors

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Educational Objectives:

UNDERSTAND Electromagnetic and mechanical model of a DC motor
INTERFACE The circuits needed to drive power to the DC motors
EXTEND The PWM software to provide software control of the motors
MEASURE Motor speed versus duty cycle

Prerequisites (Modules 2, 5, 9)
- Voltage, current and power (Module 2)
- Resistance, capacitance (Module 2)
- Battery and Voltage regulation (Module 5)
- SysTick Timer (Module 9)

Recommended reading materials for students:
- Volume 1 Sections 8.1, 8.6, and 8.7
  Embedded Systems: Introduction to the MSP432 Microcontroller, ISBN: 978-1512185676, Jonathan Valvano, copyright (c) 2017

or

- Volume 2 Sections 1.4 and 6.5
  Embedded Systems: Real-Time Interfacing to the MSP432 Microcontroller, ISBN: 978-1514676585, Jonathan Valvano, copyright (c) 2017

This module, together with the next (Module 13), will develop the robot so it moves, see Figure 1. Back in Module 9 you created software using *pulse width modulation* that dimmed an LED. You will now use that PWM software to adjust the power delivered to the DC motors on the robot.

The focus of this lab is the mechanical and electrical aspects of the motors, using **two H-bridges**. This is common circuit build to spin motors. You will also learn about a motor driver IC TI- DRV8838 which is used to interface the two DC motors to the microcontroller. Module 13 will focus on using the timers to create flexible and efficient software for generating two PWM outputs that will provide power to your DC motor.

In this lab, you will measure motor speed with your eyes and a stopwatch. However, in Module 16, you will interface a tachometer so the software can measure motor speed directly. Then, you will combine Modules 12, 13, 16, and 17 to create a **closed-loop control system** that allows you to set the desired speed of each motor.

The electrical **power** (P in watts) delivered to the motor is the product of voltage (V in volts), current (I in amps), and duty cycle (Duty as a dimensionless fraction 0 to 1, studied in Module 9). Motors can spin forward or backward because voltage and current have direction or polarity.

$$P = V * I * Duty$$

On this robot, voltage will be fixed at about 7V, and current will depend on the mechanical load (friction). Software, however, will set the duty cycle. The motor converts electrical power into mechanical power. This mechanical power delivers **torque** to the wheel (torque = force*distance), causing the wheel to spin and the robot to move.

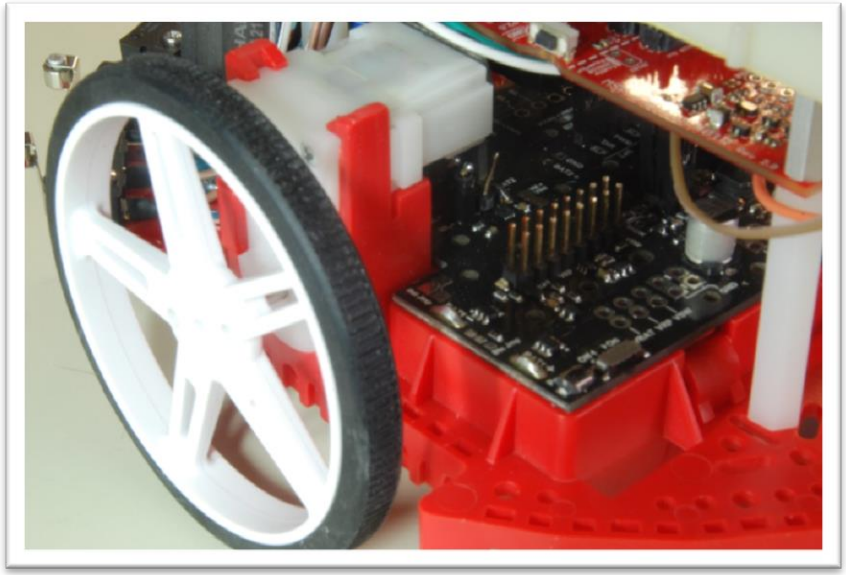

Figure 1. In this lab you add motors and wheels to the robot.

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