Tips For Selecting DC Motors For Your Mobile Robot

By AJ Neal

When building a mobile robot, selecting the drive motors is one of the most important decisions you will make. It is a perfect example of an ideal world meeting the real one. This article will cover some of the basic physics and the rules of thumb I use to select DC drive motors for mobile robots. Before you can select your motors, you'll need to know what characteristics the robot you want to build will have. How large will it be? How much will it weigh? How fast will it move? What terrain will it operate on?

Once you have an idea of what your robot will look like, start with some basic physics to get an idea of your motor requirements. After you have calculated your requirements, you can further define the motors that will best suit your robot. Finally, you can start looking for motors that will meet your needs armed with realistic specifications and an understanding of how they relate to your robot's performance and capabilities. In most cases, you will not find the perfect motors for your robot and you will need to make some tradeoffs in order to make your final motor selection.

Let's start at the beginning with some definitions. What exactly is a DC motor? A direct current (DC) motor consists of a set of magnets, rotor coil, and commutator. When you apply current to the rotor coil, it will turn into an electromagnet and repel the magnets. The commutator causes the current in the rotor coil to switch polarity as it rotates. This polarity switch causes the rotor coil to repel the magnets and generate continuous torque. Speed in a DC motor is proportional to the voltage applied to the rotor. The power produced by the motor is proportional to the voltage multiplied by the current. When working with DC motors, it is essential to remember the relationship between power, voltage, and current.

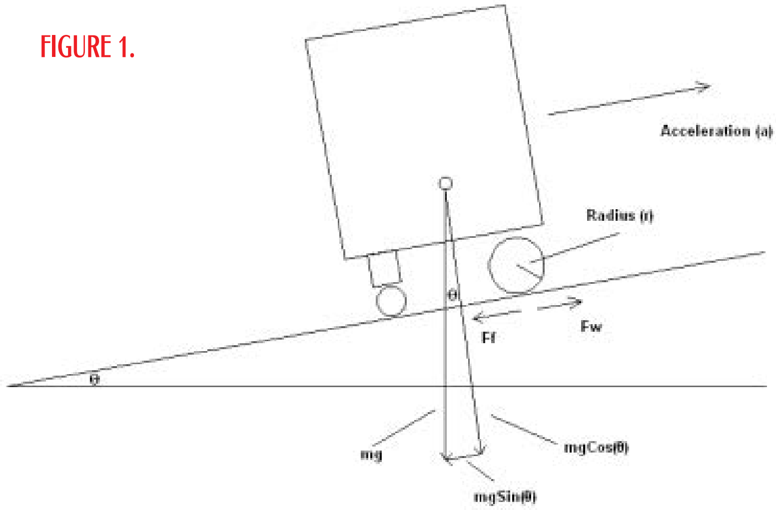
$$Power = Voltage \text{ x } Current$$
$$P_{watts} = V * I$$

Another key relationship is:

$$Power = Torque \text{ x } Angular\ Velocity$$
$$P = T * \omega$$

This means that in order to increase the power output of the motor, you can increase the voltage rating or

FIGURE 1.



increase the current. For example, a 12 volt DC motor can supply the same power as a six volt DC motor, but at 1/2 the current. This is important because most components are limited by the amount of current they can carry. If your robot will be extremely heavy, you may even want to look at 24 volt DC or even 90 volt DC motors. One of the trade offs for the higher voltage is safety. It is hard to shock yourself at 12 or 24 volts, but 90 volts can cause shock and possible injury. Another key property of DC motors is that the speed is controlled by changing the voltage. When sizing a DC motor, we will use the rated voltage of the motor. This is the maximum voltage the motor is designed to handle. There are several different types of DC motors to select from. In most cases, I use brushed DC gearhead motors. Gearhead motors have a gearbox installed as part of the motor. This gearhead is a gearbox attached to the output shaft of the motor. A few other types of DC motors include brushless and stepper motors.

Gearboxes are sometimes called reducers because the output shaft of the gearbox will be less than the output shaft of the motors. The reduction in speed results in an increase in torque. This is a good place to start because most DC motors have output shaft rpms (revolutions per minute) of several thousand and very little torque. Using a gearbox will reduce the shaft speed and increase the torque.

When selecting DC motors, you must understand some of the basic physics that will affect your robot. Some of these physics concepts you should understand are force, weight, mass, torque, acceleration, and velocity, and the relationships between them.

What is Weight?

Most of us have talked about weight all of our lives. We know that every object has a weight. But how is weight defined in the world of physics? Weight is actually defined as the force due to the acceleration of gravity on a body. On Earth, we normally use 9.8 m/(s^2) or 32 ft/(s^2). If you are planning on building a robot to roam around on the Moon or Mars, the acceleration value will be different. This means your robot's weight differs depending on what planet it is roaming around on. Let's take a robot that weights 25 lbs here on Earth. Remember, pounds are the English unit of weight, not mass. Each of the engineering equations we will use later has specific units. It is important to watch out for this. Nothing would be more embarrassing than sending a robot to Mars because weight was used when you should have used mass. **Figure 1** is a simple free body diagram of a simple robot with two front drive wheels and a rear caster. This demonstrates the various forces that will act on the robot. We will start by examining the effect of gravity on our robot. What is force?

$$Force = Mass \ x \ Acceleration$$

Most commonly written as:

$$Force = ma$$

On the free body diagram, the key forces are:

$$Weight = mass \ x \ acceleration = mass \ x \ gravity = mg$$

This is the force pulling the robot down toward the center of the Earth due to gravity.

On a free body diagram, the force of weight is broken down into its two components.

$$Force \ Pulling \ Robot \ Down \ Incline = f_g = mgsin\theta$$

The force is pulling your robot back down the incline and must be overcome by your drive motors. The greater the angle of incline, the greater this force will be. The incline a robot is trying to climb makes a significant difference in the torque required from your drive motors.

$$Force \ Pulling \ Robot \ to \ Incline = f_n = mgcos\theta$$

This force is holding your robot onto the incline. This force is required along with friction to allow your robot's drive wheels to push the robot forward up the incline. We will ignore friction, because the force of friction is what the drive wheels need to push to move the robot forward.

On our free body diagram, torque is the force at the edge of the drive wheels pushing our robot up the incline.

But What is Torque?

Torque is the measurement of the force applied to rotate a body around a particular axis. In a mobile robot, the body will be the wheel and the axis will be a motor