

Programming Documentation

Team 3250 Programming

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1 State Space Modeling and Control

1.1 Motor Modeling

When doing analysis DC motors, we represent them mathematically as a resistor and generator in series.

$$V = IR + \dot{\theta}_m k_v$$

For motors, it is assumed that the torque is proportional to the current.

$$\tau_m = I k_t$$

With this knowledge we can find the torque coming from a motor

$$\tau_m = -\frac{k_v k_t}{R} \dot{\theta}_m + \frac{k_t}{R} V$$

If we have a gearbox attached to our motor, we know that

$$\begin{aligned} \dot{\theta} &= G \dot{\theta}_m \\ \tau &= \frac{\tau_m}{G} \end{aligned}$$

where G is the gear ratio. Replacing this into the original formula gives us

$$\tau = -\frac{k_v k_t}{RG^2} \dot{\theta} + \frac{k_t}{RG} V$$

1.2 Mechanism Modeling

The model above allows you to model the many possible mechanisms on your robot as long as you have a basic understanding of high school physics. In order to make sure you have a useful model, check that you have a differential equation. Here we are going to go into detail on modeling specific models. These models will then be put into State Space Representation in order to conduct further analysis.

1.2.1 Motor with Mass Model

In this example, we are going to model a motor that has a mass attached to the output shaft. This motor will be attached to a gearbox that has the gear ratio G . In order to model this system, we will attempt to find the acceleration of the mass. We can do this by finding the net torque of the system as follows.

$$\sum \tau = L \ddot{\theta} = -\frac{k_v k_t}{RG^2} \dot{\theta} + \frac{k_t}{RG} V$$

Where L is your moment of inertia. Finally, your model will be

$$\ddot{\theta} = -\frac{k_v k_t}{LRG^2} \dot{\theta} + \frac{k_t}{LRG} V$$

1.2.2 Motor attached to Arm Model

1.3 State Space Representation