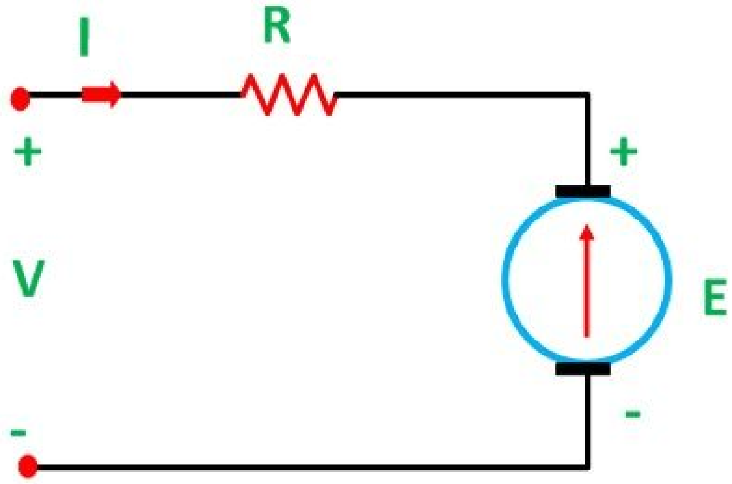
Mechanism Startup Calculator

AMB Calculator

This calculator is used to simulate the start-up response of a motorized mechanism.

A DC motor can be represented by the following electrical circuit:



The voltage in this circuit can be represented as:

$$V = IR - E \tag{1}$$

where V is the voltage applied to the motor, I is the current drawn by the motor, R is the armature resistance, and E is the back-emf generated by the motor. The back-emf is linearly related to the motor speed according to a constant k_B, so:

$$E = k_B \cdot \omega_{motor} \tag{2}$$

Plugging (2) into (1) and solving for the motor current gives:

$$I = \frac{V - k_B \cdot \omega_{motor}}{R} \tag{3}$$

This current can then be limited according to current limit set in the motor controller.

The torque generated by the motor T_{motor} is proportional to the armature current according to a constant k_T, so:

$$T_{motor} = k_T \cdot I \tag{4}$$

The speed of the motor ω_{motor} is G times faster than the mechanism speed ω, where G is the gear ratio between the two. The mechanism torque T is also G times greater than the motor torque T_{motor}.

$$T = k_T G \cdot I \qquad I = \frac{V - k_B G \cdot \omega}{R} \tag{5}$$

According to Newton's second law, the angular acceleration of the system α is proportional to the sum of the torques on the system ΣT and the mechanism's moment of inertial J:

$$\Sigma T = T - T_{load} = J \cdot \alpha \tag{6}$$

The load torque can be represented by the load force times the applied radius:

$$T_{load} = F_{load} \cdot r \tag{7}$$

And the moment of inertia can be approximated as that of a point mass m at radius r:

$$J \approx m \cdot r^2 \tag{8}$$

Combining these equations gives an expression for the angular acceleration of the system:

$$\alpha = \frac{T - T_{load}}{J} = \frac{T - F_{load} \cdot r}{mr^2} \tag{9}$$

The angular acceleration can then be used to find the change in angular velocity ω over one timestep dt, which can be used to find the change in position θ:

$$\omega_{t+dt} = \omega_t + \alpha \cdot dt \qquad \theta_{t+dt} = \theta_t + \omega_t \cdot dt + \tfrac{1}{2}\alpha_t \cdot dt^2 \tag{10}$$

Starting with $\theta_0 = 0$ and $\omega_0 = 0$, we can simulate the start up response of the system one timestep at a time, until either the target position/velocity or maximum time is reached.