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Tool: DC Motor Models

The DC motor eq'ns are

$$\frac{di}{dt} = \frac{1}{L}v - \frac{R}{L}i - \frac{K}{L}\omega \qquad (1)$$

$$\frac{d\omega}{dt} = \frac{K}{J}i - \frac{1}{J}\tau_{LF} \qquad (2)$$

We consider $\tau_{LF} = B\omega$ unless *otherwise noted.*

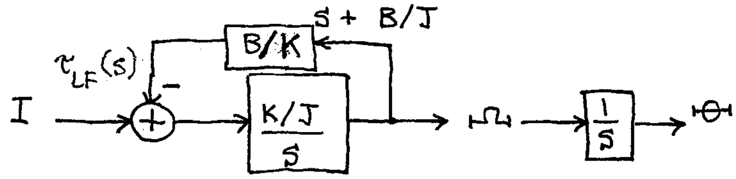
Current Control

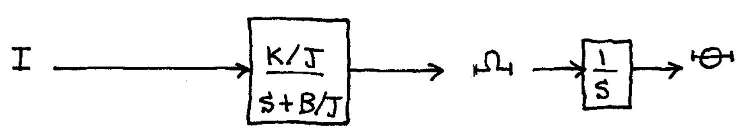
Current control means we use only eq'n (2).

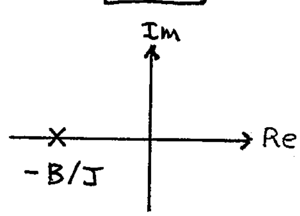
$$s\Omega(s) = \frac{K}{J}I(s) - \frac{1}{J}B\Omega(s)$$

$$\left(s + \frac{B}{J}\right)\Omega(s) = \frac{K}{J}I(s)$$

$$\Omega(s) = \frac{K/J}{s + B/J}I(s)$$







Voltage Control

For voltage control, we use both eq'ns (1) and (2).

Solving (1) for $I(s)$ in Laplace domain and substituting into (2) yields

$$\left(s^2 + \frac{R}{L}s + \frac{K^2}{JL}\right)\Omega(s) = \frac{K}{JL}V(s) - \left(\frac{sL+R}{JL}\right)B\,\Omega(s)$$

Note: substitute $\tau_{LF}(s)$ for $B\,\Omega(s)$ if desired.

Often we have a much faster time constant $\tau_e \equiv L/R$ for charging L than the time constant $\tau_m \equiv \frac{K^2}{RJ} + \frac{B}{J}$.

In that case, we have (for the denominator of $\frac{\Omega(s)}{V(s)}$):

$$s^2 + \left(\frac{R}{L} + \frac{B}{J}\right)s + \frac{K^2 + RB}{JL} \approx \left(s + \frac{R}{L}\right)\left(s + \frac{1}{J}\left[\frac{K^2}{R} + B\right]\right)$$

$$\therefore\ \Omega(s) \approx \frac{K/JL}{\left(s + \frac{R}{L}\right)\left(s + \frac{1}{J}\left[\frac{K^2}{R} + B\right]\right)}V(s)$$