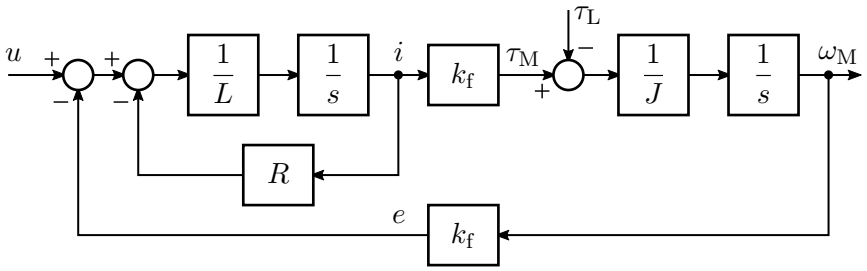
Problem 1: Transfer functions of a DC motor

The block diagram of a DC motor is shown in the figure.

(a) Derive the transfer functions

$$G_{\omega u}(s) = \frac{\omega_\mathrm{M}(s)}{u(s)} \quad \text{and} \quad G_{\omega\tau}(s) = \frac{\omega_\mathrm{M}(s)}{\tau_\mathrm{L}(s)}$$

(b) Replace the electric dynamics of the machine with the DC gain and formulate the transfer functions $G_{\omega u}(s)$ and $G_{\omega\tau}(s)$.



Problem 2: Current ripple

The parameters of a DC motor are: $R = 1\ \Omega$, $L = 10$ mH, and $k_\mathrm{f} = 4$ Vs. The average steady-state current taken by the motor is $I = 100$ A and the rotor speed is 560 r/min. The motor is supplied from a four-quadrant DC-DC converter, where the unipolar PWM is applied. The DC-bus voltage is $U_\mathrm{dc} = 450$ V and the switching (carrier) frequency is $f_\mathrm{sw} = 4$ kHz. Calculate the peak-to-peak current ripple.