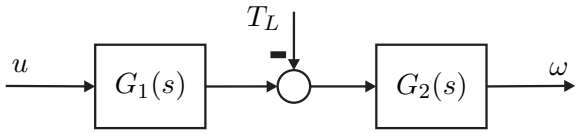
Exercise Sheet 11: Fundamental Limits

Problem 23:

We consider the same DC motor as before. We want to study design limitations of the DC motor. We first recall the block diagram of the DC motor as shown in the following figure. u is the input voltage of the DC motor, T_L is the load momentum and ω is the rotational velocity of the motor shaft.



It holds that $G_1(s) = \dfrac{0.005}{1 + 0.0002\,s}$ and $G_2(s) = 4000\dfrac{1 + 0.0002\,s}{2.4 \cdot 10^{-6}\,s^2 + 0.012\,s + 1}$.

a. We recall the PID-controller $C(s) = \dfrac{1.45s + 1781}{s}$ from the symmetric optimum design in Problem 9. Determine the maximum voltage value $u(t)$ of the controller output for a reference step of $r = 20\sigma(t)$ by simulation ($\sigma(t)$ is the unit step function). Determine by simulation what happens if the actuator voltage is limited to 10 V?

b. Write down the design equation for an extended pole placement controller for closed-loop poles at $s = -2000$ and zero steady-state error. The resulting controller and pre-filter are

$$C(s) = \frac{1.9201 \cdot 10^6 + 3.6901 \cdot 10^3\,s + 1.03\,s^2}{s\,(s + 3000)} \text{ and } F(s) = \frac{1}{1 + 0.0019\,s + 5.3646 \cdot 10^{-7}\,s^2}$$

Simulate the closed loop with this controller. Apply a reference step of 20 rad/sec and a disturbance step of 0.001 Nm. Verify that the controller output is not saturated.