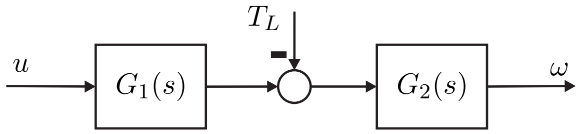
Exercise Sheet 4: Magnitude Optimum and Symmetric Optimum

Problem 9:

We consider the same DC motor as in Problem 6. We want to apply the magnitude optimum and symmetric optimum design to this DC motor.

The block diagram of the DC-motor is as shown in the next figure with $J_a = 3 \cdot 10^{-6}$ kg m^2, $R_a = 10\,\Omega$, $L_a = 2\,\mathrm{mH}$, $c\Phi_F = 0.05\,\frac{Nm}{A}$



$$G_1(s) = \frac{c\Phi_F/R_a}{1 + s\,L_a/R_a} \qquad G_2(s) = \frac{R_a}{c\Phi_F^2} \cdot \frac{1 + s\,L_a/R_a}{1 + s\,(J_a \cdot R_a)/c\Phi_F^2 + s^2\,(L_a \cdot J_a)/c\Phi_F^2}$$

- **a.** Design a PI-controller with the **Magnitude Optimum Method**
- **b.** Design a PI-controller with the **Symmetric Optimum Method**
- **c.** Sketch the overall feedback loop with the DC motor and the PID controller
- **d.** Realize the block diagram in **d.** in Simulink. Use plant model and parameters in the file `ECE441_Ex4_DCmotor.zip` from the course webpage.
- **e.** Perform a comparison of the closed loops according to **a.** and **b.** In particular, record and compare the reference and disturbance step responses in the closed loop. A reference step of 20 rad/sec and a disturbance step of 10^{-3} Nm should be applied.
- **f.** Record the control input for a disturbance step of 10^{-3} Nm and determine the maximum required input.
- **g.** Discuss the obtained results

Problem 10: [optional]

Consider the basic feedback control loop with the plant $G(s) = \dfrac{5}{s^2 + 2Ds + 1}$. Show that, if $D < 0.5$, then the magnitude optimum design leads to an instable closed loop.

Hint: First compute the closed-loop transfer function without evaluating the controller parameters. Then, study the dependency of the controller parameter r_0 on D to obtain the statement.