# EL2520 – Control Theory and Practice

# Classical Loop-Shaping

March 18, 2015


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**Abstract**

In this report, we consider the classical loop-shaping procedure for control design ...

## Basics

A system is modeled by the transfer function (given in [1])

$$G(s) = \frac{3(-s+1)}{(5s+1)(10s+1)}. \tag{1}$$

We will design a lead-lag compensator $F$ such that the closed loop system in fig. 1 fulfills the following specification:

- Crossover frequency $\omega_c = 0.4$ rad/s.
- Phase margin $\phi_m = 30°$.
- No stationary error for a step response.

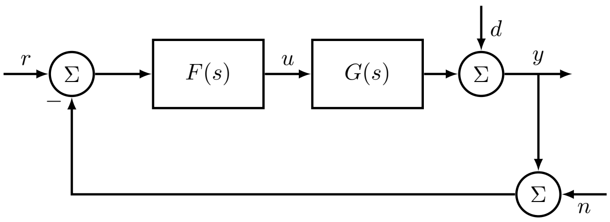


Figure 1: Closed loop block diagram, where $F$–controller, $G$–system, $r$–reference signal, $u$–control signal, $d$–disturbance signal, $y$–output signal, $n$–measurement noise.

We follow the procedure from [2] to determine the parameters $K, \beta, \tau_D, \tau_i, \gamma$ in the lead-lag compensator

$$F(s) = K \frac{\tau_D s + 1}{\beta \tau_D s + 1} \frac{\tau_I s + 1}{\tau_I s + \gamma}. \tag{2}$$

The system's phase, $\arg(G(i\omega_c)) = -170°$, is determined from the Bode diagram in fig. 2.

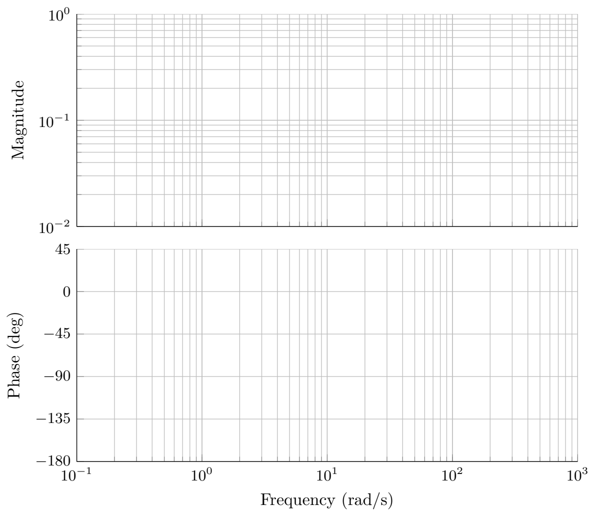


Figure 2: Bode diagram for system $G(s)$ in (1).

Thus, the necessary phase shift is

$$30° - (-170° - -180°) + 6° = 26°,$$

where an extra 6° has been added to account for the lag-part. The first parameter can now be selected from [2, fig. 5.13] as $\beta = 0.35$.

| $K$ | $\beta$ | $\tau_D$ | $\tau_i$ | $\gamma$ |
|---|---|---|---|---|
| | 0.35 | | | |

Table 1: Parameters for the lead-lag compensator.

. . .
The final controller is given by eq. (2) with the parameters in table 1.
. . .
The rise time and overshoot is determined form the step response in fig. 3, and given in table 2.

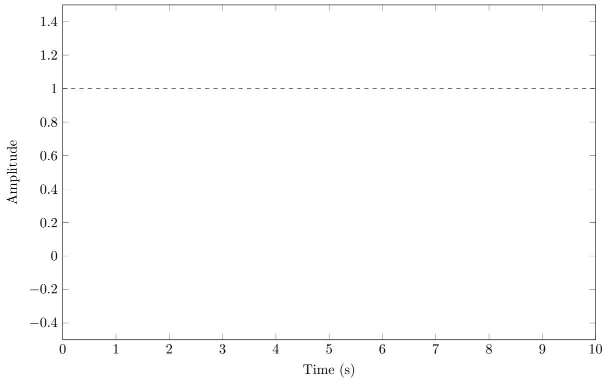


Figure 3: Step response for the closed loop system in fig. 1, with the lead-lag compensator.

| $\omega_B$ [rad/s] | $M_T$ [dB] | $T_r$ [s] | $M$ [%] |
|---|---|---|---|
| | | | |

Table 2: Closed loop system characteristics.

. . .

## Disturbance attenuation

. . .

## Conclusions

. . .

## References

[1] EL2520 Control Theory and Practice Advanced Course, *Computer Exercise: Classical Loop-Shaping*, 2014.

[2] T. Glad and L. Ljung, *Reglerteknik, Grundläggande teori*, Studentlitteratur, 2006.

## Some reminders

- Write clear and concise, but comprehensible. No novels!
- The report should be self-contained, don't assume the reader knows the lab instructions.
- However, don't repeat material from the course book, instead, use references.
- Make sure that all results and figures are reproducible.
- Start with a *short* summary of the results and the contents of the report.
- Motivate all the choices you have done.
- Show results in tables and figures that are easy to compare.
- Introduce figures in the text where it is needed, and remember to describe what the figure shows, what the axes corresponds to and what the results are.
- Be specific in your writing, and avoid vague expressions such as "some" and "not so good".
- Check grammar your and speling.