

EL2520 – Control Theory and Practice

Classical Loop-Shaping

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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])

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

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 $\phi_m = 30^\circ$.
- No stationary error for a step response.

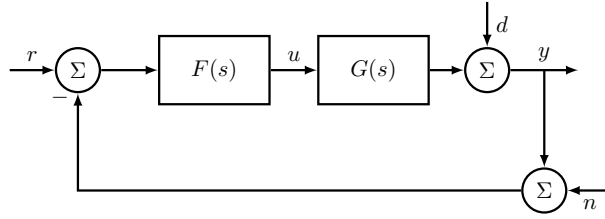


Figure 1: Closed loop block diagram, where F -controller, G -system, r -reference signal, u -control signal, d -disturbance signal, y -output signal, n -measurement noise.

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

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

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

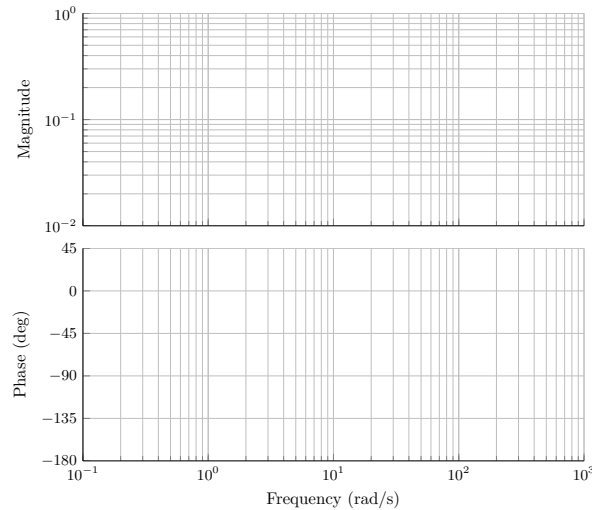


Figure 2: Bode diagram for system $G(s)$ in (1).

Thus, the necessary phase shift is

$$30^\circ - (-170^\circ - -180^\circ) + 6^\circ = 26^\circ,$$

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	β	τ_D	τ_i	γ
	0.35			

Table 1: Parameters for the lead-lag compensator.

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The final controller is given by eq. (2) with the parameters in table 1.

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The rise time and overshoot is determined from the step response in fig. 3, and given in table 2.

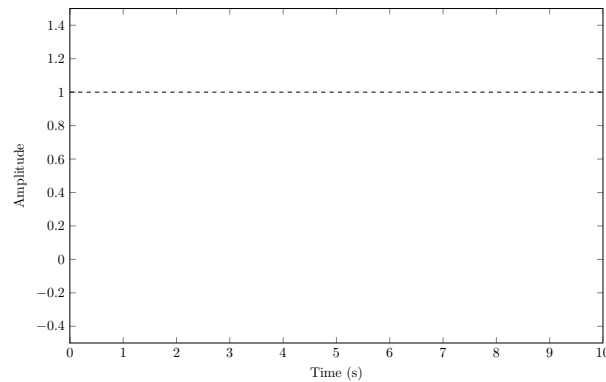


Figure 3: Step response for the closed loop system in fig. 1, with the lead-lag compensator.

ω_B	M_T	T_r	M

Table 2: Closed loop system characteristics.

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Disturbance attenuation

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Conclusions

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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!
- Start with a *short* summary of the results and the contents of the report.
- Don't repeat material from the course book, instead, use references.
- Motivate what 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 “not so good”.
- Check grammar your and speling.