**EL2520 – Control Theory and Practice**

**Classical Loop-Shaping**

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**Abstract**

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])

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

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

* Crossover frequency .
* Phase margin .
* No stationary error for a step response.



Figure 1: Closed loop block diagram, where F–controller, G–system, r–reference signal, u–control signal,

We follow the procedure from [2] to determine the parameters K, β, , , and γ in the lead-lag compensator

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

The system’s phase, , is determined from the Bode diagram in Figure 2.



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

Thus, the necessary phase shift is

,

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

Table 1: Parameters for the lead-lag compensator.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| K | β |  |  | γ |
| 2.0377 | 0.51 | 25 | 3.5007 | 0 |

. . .

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



Figure 3: Loop gain with the lead-lag compensator.

. . .

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



Figure 4: Step response for the closed loop system in fig. 1, with the lead-lag compensator.

Table 2: Closed loop system characteristics.

|  |  |  |  |
| --- | --- | --- | --- |
| [rad/s] | [dB] | [s] | [%] |
| 0.7811 | 5.8771 | 2.3921 | 37.1793 |

**New Parameter Setting**

Now the phase margin should be increased to with the same crossover frequency as before, which will introduce the parameters in table 3.

Table 3: Parameters for the lead-lag compensator.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| K | β |  |  | γ |
| 1.3684 | 0.23 | 25 | 5.2129 | 0 |

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Figure 5: Loop gain with the lead-lag compensator.

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Figure 6: Step response for the closed loop system in fig. 1, with the lead-lag compensator.

Table 4: Closed loop system characteristics.

|  |  |  |  |
| --- | --- | --- | --- |
| [rad/s] | [dB] | [s] | [%] |
| 0.9341 | 1.1032 | 2.4054 | 10.3174 |

**Disturbance attenuation**

. . .

**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!
* 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.