Classical Autonomous Systems – Autumn 2021

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Exercise Session 3

1. Consider the pitch dynamics of a Dakota Piper plane represented by the following transfer function

$$P(s) = \frac{\theta(s)}{\delta_e(s)} = \frac{160(s+2.5)(s+0.7)}{(s^2+5s+40)(s^2+0.03s+0.06)} \tag{1}$$

where θ is the pitch angle of the plane and δ_e is the elevator angle, both angles being expressed in degrees. Use the command `tf` to setup this system in Matlab. Verify whether this system is stable or not. Then, display the Bode plot (command `bode`).

2. Implement system (1) in Simulink using a Transfer Fcn block and apply a sine wave to its input. See what you obtain at the output. Then, apply a sine wave at the frequency where the system is most resonant.

3. Apply now a step input to system (1). Comment?

4. What is the zero-frequency gain of the system?

5. Implement and tune your own PID controller so that the pitch angle follows a desired reference.

6. Compute the transfer function of the system in closed-loop with your PID controller (the computation can either be done manually or by using the command `feedback`). Is this new system stable? Compare this with system (1) by itself.

7. Display the Bode plot of your system in closed-loop, and compare with the Bode plot you obtained in question 1 (resonance, zero-frequency gain).

8. (Extra) Using a Matlab function block (if you want), create a small program to construct an input signal made of a sum of 28 sine waves (from 0.01 to 0.09, from 1 to 10, from 10 to 100), with different and possibly randomly generated phases. Use two To Workspace blocks to save the input and the corresponding output. In the workspace, use the command `tfest` to identify the unknown transfer function of the Dakota Piper. Finally, display the corresponding Bode plot and compare it again with the original one obtained in question 1.