Modelling and control summaries

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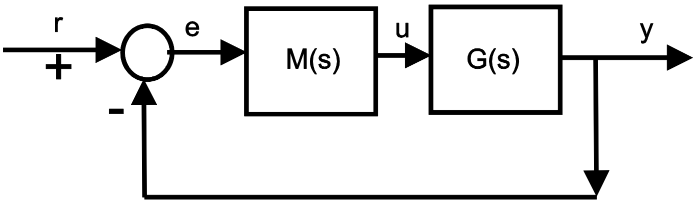
Intro. to feedback – tutorial

QUESTION 1: Demonstrate that the introduction of feedback changes behaviour. Is this a good thing or a bad thing and why? Illustrate your answer.

QUESTION 2: A system G(s) is connected with 3 alternative choices of feedback, M=K1 or K2 or K3.

- Compare and contrast the behaviour with these choices.
- Is the closed-loop behaviour better than open-loop?
- What happens for large K?



$$G=\frac{4}{s+6};\quad K1=0.1;\quad K2=1;\quad K3=10;$$

$$G=\frac{1}{s^3+s^2+3s+1};\quad K1=0.1;\quad K2=1;\quad K3=10;$$

$$G=\frac{4}{s^2+3s+1};\quad K1=0.1;\quad K2=1;\quad K3=10;$$

Use MATLAB for the 3rd order example.

QUESTION 3: A system G(s) is to be connected in feedback with a proportional compensator, M(s)=K as in question 2. Select a compensator to ensure that the closed-loop time constant is faster than 0.01 sec.

$$G=\frac{16}{s+48}$$

QUESTION 4: A system G(s) and compensator M(s)=K are connected with unity negative feedback.

1. Where is the closed-loop pole?
2. What is the required gain to make the closed-loop time constant = 4?

$$G=\frac{1.7}{11s+0.6}$$

QUESTION 5: A system G(s) is to be connected in feedback with a proportional compensator, M(s)=K. Given a desired settling time of 0.6 second and a desired steady-state gain of 0.9 and a maximum input of 3, justify a suitable choice of K.

$$G=\frac{0.2}{s+0.4}$$

QUESTION 6: A system G(s) is to be connected in feedback with a proportional compensator, M(s)=K. Select a compensator to give critical damping and a damping ratio of 0.7. What is the steady-state gain?

$$G=\frac{16}{s^2+4s+2}$$

QUESTION 7: A system G(s) and compensator K=M(s) are connected with unity negative feedback. 1. Where are the closed-loop poles? 2. What is the closed-loop gain? 3. Use MATLAB to show the closed-loop input/output responses.	$G=\frac{0.01}{s^2+0.1s+0.02}$ $K=3.2$

QUESTION 8: A system G(s) is to be connected in feedback with a proportional compensator, M(s)=K. Use MATLAB to show how the behaviour changes as K takes the values 0.1,0.5,2,5 and hence choose a K which gives a good balance between settling time, rise time, steady-state gain and overshoot.	$G=\frac{0.05}{s^2+0.4s+0.02}$

QUESTION 9: A system G(s) and compensator K=M(s) are connected with unity negative feedback. **Use MATLAB** to: 1. Determine the closed-loop poles? 2. Determine the closed-loop gain? 3. Plot the closed-loop step responses.	$G=\frac{0.001}{s^3+s^2+0.1s+0.02}$ $K=2$

QUESTION 10: A system G(s) is to be connected in feedback with a proportional compensator, M(s)=K. **Use MATLAB** to determine a suitable constant compensator which gives a balance between steady-state offset, speed of response, overshoot, oscillation and settling time. For what K is the system closed-loop unstable?.	$G=\frac{6(s+2)}{s(s+1)(s^2+4s+2)}$

SOLUTIONS

Concise worked solutions are provided in the associated videos on Youtube for links on intro to feedback 8-11.

Reminder of attributes that can be considered for the open-loop G(s) and closed-loop $G_c(s)$ transfer functions

1. Stability. (Is the output convergent, that is, are all poles in the LHP?)
2. Speed of response/settling time. (Taken to be about 3 times dominant time constant).
3. Closed-loop gain/offset. (Does the output reach the target and if not, how big is offset?)
4. Shape of response. (Are their oscillations and overshoots and if so, how big?)

ALSO

5. What time constant is desirable or realistic for this system?
6. What closed-loop gain is desirable? Do you need zero steady-state offset?
7. How much overshoot and oscillation is acceptable?
8. How much actuator energy/movement is available?
9. How would your design be effected by parameter uncertainty? [See videos on uncertainty]