EE5111/5061 Selected Topics in Industrial Control & Instrumentation

CA3b Assignment for Control Design

(Academic Year 2021/22, Semester I)

This assignment will contribute 20% to the total marks for the module EE5111 and 10% for EE5061.

Please make sure your CA3b report is clear and readable.

Please submit your CA3b report (soft copy: Word or .pdf) into the "CA3b - Submission" folder in LumiNUS.

Submission deadline: **Nov. 19, 2021**

Important: Each submitted CA3b report must be an individual report.

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1. Consider a second-order system shown in the following transfer function, please study this second-order system and design the PID controller for the system.

$$G(s) = \frac{1}{s^2 + 12s + 3}$$

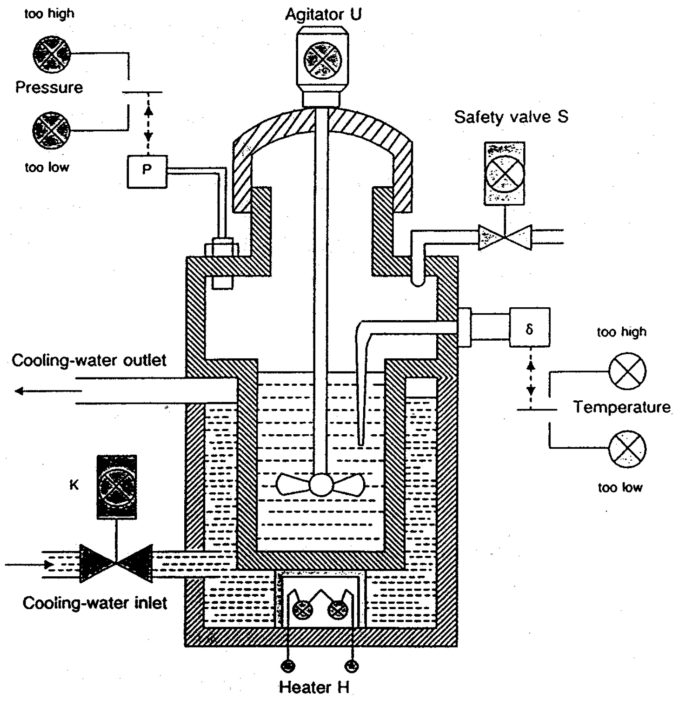
(1) Find a state-space model for the above system.

(2) Design a PID controller for the system using the LQR technique, simulate the designed control system and show the step responses of the designed control system.

(3) Discuss the effects of weightings Q and R on system performance and monitor the control signal.

(**Note:** Any programming language such as MATLAB, Simulink, Python, C++, etc. can be used for the simulations. In MATLAB, the function "lqr" can help to design the controller parameters via LQR.)

2. Consider a reactor vessel which process schematic is shown in the following figure, a chemical process is to take place in this reaction vessel at a specific temperature and at a specific pressure.



The reaction vessel has a thermal detector for measuring the temperature and a pressure gauge for the pressure.

The temperature and pressure are regulated via the following three actuators:

- Heater H
- Cooling-Water inlet K
- Safety valve S

The enabling conditions for the activation of the actuators are given as follows:

- Safety valve S is activated when
  - > pressure P is too high and
  - > temperature δ is too high or normal
- Cooling-Water inlet K is activated when
  - > temperature δ is too high and
  - > pressure P is too high or normal
- Heater H is activated when
  - > temperature δ is too low and
  - > pressure P is not too high

  or
  - > pressure P is too low and
  - > temperature δ is normal

As shown in the figure, we have

- a pressure sensor that turns on when pressure is too high,
- a pressure sensor that turns on when pressure is too low,
- a temperature sensor that turns on when temperature is too high, and
- a temperature sensor that turns on when temperature is too low.

The sequence control of the reaction vessel will be implemented using a PLC. Please provide a diagram showing the connection of the devices to the PLC and provide the ladder diagram (LD) implementing the logic.