Tanta University

Department: Electrical Power Engineering
Total Marks: 75 Marks

Faculty of Engineering

Course Title: Control of Electrical Power Systems	Course Code: EPM3216	Year: 3rd
Date: 9 /6 /2013 (Second term)	Allowed time: 3 hrs	No. of pages: (2)

Answer the following questions

Question (1) (20 Marks)

Consider a unity negative feedback system that is shown in **Fig**. (1)

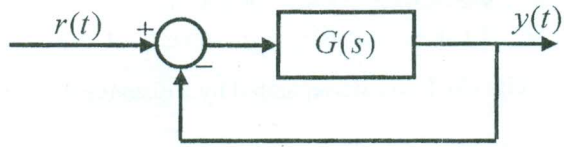


Fig. (1) Closed–loop system

The forward loop transfer function is given by:

$$G(s) = \frac{k}{s(s+3)(s+6)}$$

Design a ***suitable compensating circuit*** to meet the following specifications:

- The step response **settling time** is to be less than **5 sec.**
- The step response **overshoot** is to be less than **17 %.**
- The **steady-state error** to a unit ramp input must not exceed **10 %.**

Question (2) (15 Marks)

A servomechanism position control has the plant transfer function which is given by:

$$G(s) = \frac{k}{s^2(s+4)}$$

You are to **design** a **proper compensating circuit** that is inserted in series with plant transfer function as shown in the compensated closed-loop system that is depicted in **Fig**. (2)

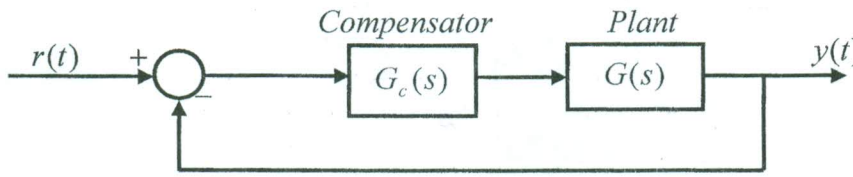


Fig. (2) Compensated system

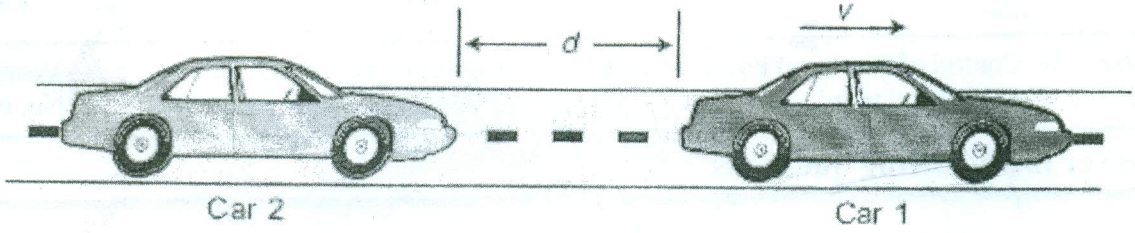
The compensator is required to achieve the following desired specifications:

- The response to a reference step input is to have no more than **25% overshoot.**
- The response to a reference step input is to have a **settling time** of no more than **5 sec.**

Question (3) (20 Marks)

Consider two cars, as shown in **Fig**. (3), separated by a distance ***d***, which can range between **0** and **120 feet**. Car (1) travels at a speed of ***v***, ranging from **0 to 80 mph**. Depending on the speed and distance, car (2) has several braking options (***B***) ranging from **light** to **hard** if car (1) slows down or stops. **Design a fuzzy logic controller** to generate the braking strength ***B*** of car (2). The fuzzy controller has two inputs (***d*** and ***v***) and one output.

a) Create three triangular-shaped fuzzy sets for each input and output.
b) Establish a set of heuristic fuzzy rules for the braking output as a function of the speed and distance. Explain how these rules are proposed?
c) Using the center of gravity method, calculate the value of the outcome ***B*** if car (1) is traveling at **65 mph** and the distance between car (1) and car (2) is **45 feet**.



d = distance between cars
v = velocity (speed) of car 1
B = braking strength (function of d and v)

Fig. (3) Two cars separated by a distance d

Question (4) (20 Marks)

Consider the tank with liquid shown in Fig. (4). It is required to design a fuzzy controller that will maintain that liquid level at a desired point (the set point-tracking problem). Suppose that the tank is **10 feet** tall and the tank is empty. We want to fill the tank to a level of **5 feet**, so we make the current set point, h_{ref}, equal to **5 feet**. The current level at any time t is designated as h. Liquid flows out of the tank through an open valve. This flow is designated by the letter q. Liquid flows into the tank by means of a pump. The pump flow, Q, can be regulated by the controller. The tank cross-sectional area is designated by the letter A. For the fuzzy controller, there are two inputs and one output control signal. The inputs are error e and rate of error $\dot{e}$ such that: $e = h_{ref} - h$ and $\dot{e} = -\dot{h}$.

a) **Design PID-type FLC** with configuration consists of **fuzzy PD + Fuzzy PI**. By using the standard step response of a 2nd order system, explain how the fuzzy rules are chosen? You can utilize **3 symmetrical triangular** membership functions for the inputs and the output.

b) **Draw** the overall schematic diagram of the closed-loop system illustrating a detailed blocks of the system.

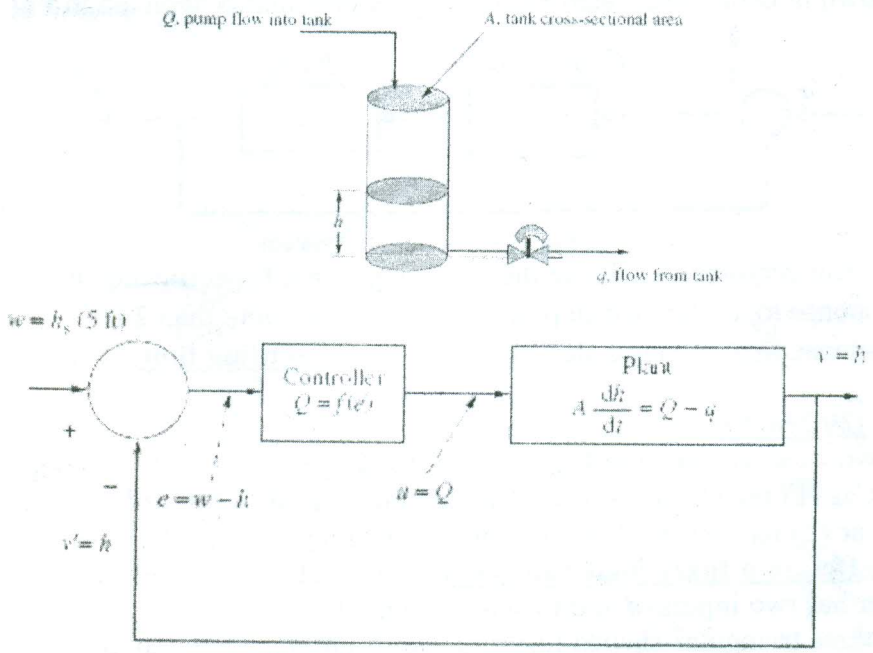


Fig. 4 Tank with a liquid level to be controlled

Good Luck

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