Tutorial 12
ELL-225: Control Engineering

Session: Semester-II (2022-23)

1. Self-guided vehicles, such as that shown in Figure 1, are used in factories to transport products from station to station. One method of construction angle is to embed a

Figure 1: Automated guided carts.

wire in the floor to provide guidance. Another method is to use an onboard computer and a laser scanning device. Bar-coded reflective devices at known locations allow the system to determine the vehicle's angular position. This system allows the vehicle to travel anywhere, including between buildings. Figure 2 shows a simplified block diagram of the vehicle's bearing control system. Design a lead compensator that will reduce the settling time by a factor of 2 from that of the uncompensated system while maintaining a 30% overshoot.

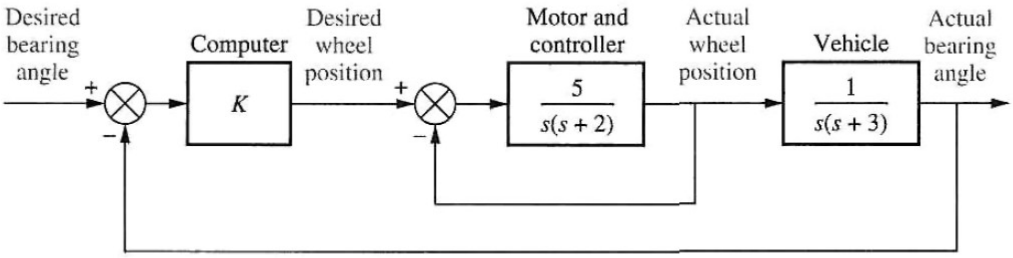


Figure 2: Simplified block diagram of a guided cart.

2. A stabilized precision rate table uses a precision tachometer and a DC direct-drive torque motor, as shown in fig. (3). To obtain a zero steady-state error for a step command design, select a proportional plus integral (PI) compensator. Select the appropriate gain constants so that the system has an overshoot of approximately 10% and settling time (with a 2% criterion) less than 1.5 seconds.

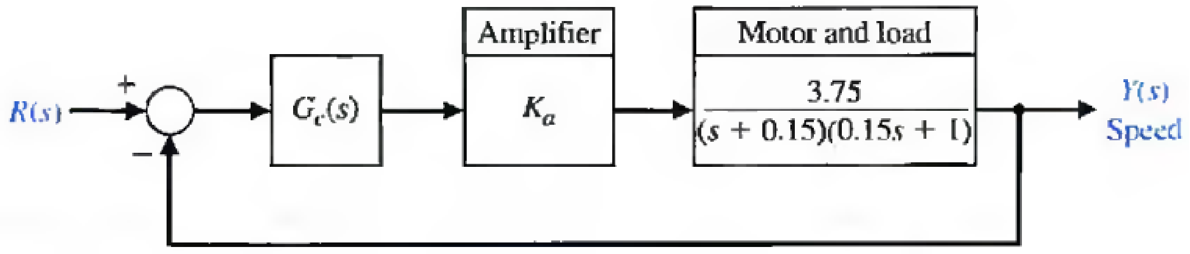
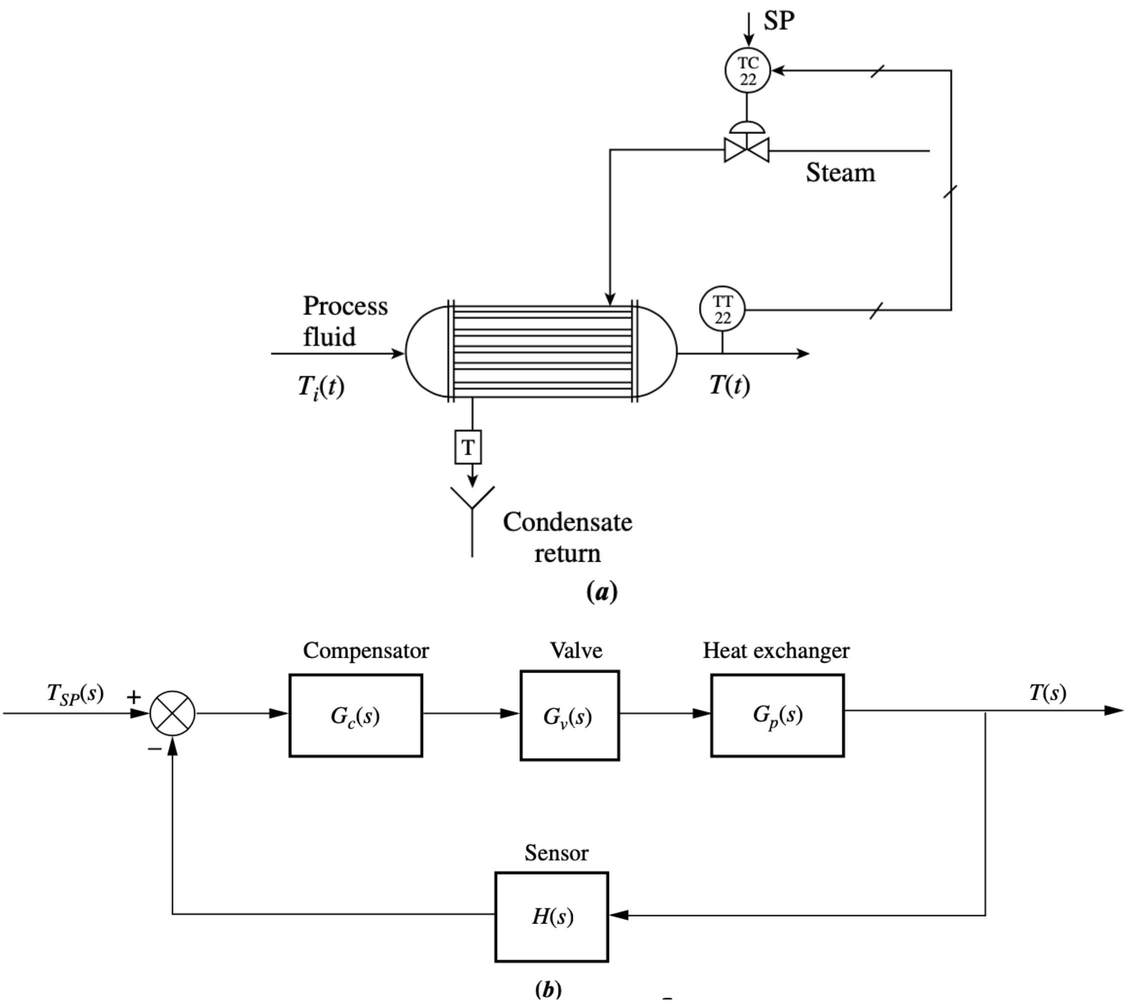


Figure 3: Stabilized rate table.

3. Figure 4(a) shows a heat-exchanger process whose purpose is to maintain the temperature of a liquid at a prescribed temperature. The temperature is measured using a sensor and a transmitter, $TT22$, that sends the measurement to a corresponding controller, TC 22, that compares the actual temperature with a desired temperature set point, SP. The controller automatically opens or closes a valve to allow or prevent the flow of steam from changing the temperature in the tank. The corresponding block diagram for this system is shown in Figure 4(b) (Smith 2002).



Assume the following transfer functions:

$$G_v(s) = \frac{0.02}{4s+1}, G_1(s) = \frac{70}{50s+1}, H_1(s) = \frac{1}{12s+1}$$

(a) Assuming $G_c(s) = K$, find the value of K that will result in a dominant pole with $\zeta = 0 : 7$. Obtain the corresponding T_s.

(b) Design PD controller to obtain th same damping factor as Part a but with a settling time 20% smaller

4. A linearized magnetic levitation system can be represented using an open loop transfer function as $G(s) = \frac{a}{(s^2-b^2)}$ and unity feedback. Assume $a = 1$ and $b = 3$.

   (a) Design a lead compensator $G_c(s)$ such that the dominant close-loop pole of the system is at $-1 \pm j1$. The zero of the compensator is placed at -4.

   (b) Find the closed-loop transfer function and the DC gain. Where is the third pole located?

   (c) What is the percentage overshoot of the compensated system? Comment on the performance of the compensated system (will the output follow the reference command). Suggest modifications in the compensator design such that the output follows the reference command.

   (d) Draw a rough sketch of the root locus of the compensated system to validate your design claim.