PART I

自動控制:

1. Please briefly explain the following questions. ***(20 %)***
   (a) What are the relative advantages and disadvantages of the three time-integral criteria, integral of the square error (ISE), integral of the absolute value of the error (IAE), and integral of the time-weighted absolute error (ITAE) ?
   (b) What are the relative advantages and disadvantages of the proportional, integral, and derivative (PID) control actions?

2. If the type of feedback controller (i.e., PID controller) has been selected, we still have the problem of deciding what values to use for its adjusted parameters. This is known as the controller tuning problem. Please describe the general approaches that we can use for tuning a controller from classical and modern (i.e., intelligent approach) control theory. ***(15 %)***

3. Consider the feedback control system of the following diagram as shown in Fig. 1. We have:

$$G_p = \frac{k_p}{(\tau_1 s+1)(\tau_2 s+1)} \qquad G_c = K_c$$

Please use Routh Locus method for the analysis of the system's dynamic response.

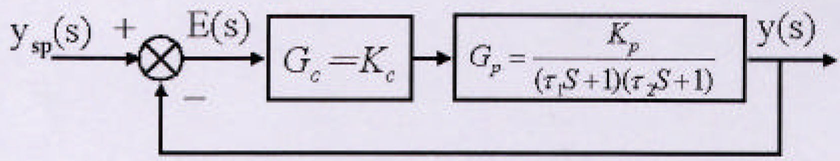

Fig. 1 Block diagram of the system

(Notation in figure: y(s), the output of the system; $y_{sp}(s)$, the set point of the system; E(s) = $y_{sp}(s) - y(s)$; G_c, the transfer function of the controller; G_p, the transfer function of the process; K_c, the proportional controller gain; k_p, the process gain; τ_1 and τ_2, the time constants of the system) ***(15 %)***

PART II (自控)

1. Design a digital controller for the open-loop system(40%):

$$\frac{d}{dt}\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{bmatrix} -10 & 0 \\ 8 & 0 \end{bmatrix}\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} + \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} u$$

$$y = \begin{bmatrix} 0 & 1 \end{bmatrix}\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}$$

satisfying the following specifications:

[1]. Design a state feedback control that the resultant closed-loop system is equivalent to a continuous time system with poles at $s_{1,2} = -20 \pm j15$

[2]. Only output y is measurable, therefore an observer has to be designed. The observer gives state estimation $\{x_1 \quad x_2\}^T$ to the state feedback. The poles of the observer can be placed at a bandwidth three times that of the closed loop system.

[3]. The controller (observer + state feedback) can be merged into a single-input/single-output system. Please derive the transfer function of the controller.

[4]. How to implement this controller in a computer. Describe the algorithm in flow chart format or a programming language you preferred.

2. Explain the "windup" phenomenon in a PID controller. How it happens? How can we modify the control structure to avoid it? (10%)