1. (18%) Given the following systems (a) $\frac{16}{s^2+4s+16}$, (b) $\frac{16}{s^2+6s+16}$, (c) $\frac{36}{s^2+6s+36}$, (d) $\frac{16(s+1)}{s^2+4s+16}$, (e) $\frac{16}{(s+1)(s^2+4s+16)}$, answer the following questions (may be multiple choices).

(i) Which systems (among a, b, c) have the largest percent overshoot with respect to step input?

(ii) Which system (among a, d, e) has the shortest rise time with respect to step input?

(iii) Which systems (among a, b, c) have the shortest settling time?

(iv) What is the percent overshoot of the system (b)?

(v) What is the damped frequency of oscillation of the system (c)?

(vi) What is the peak time of the system (a)?

2. (14%) The linear model of a phase-lock loop is depicted in Figure 1. The loop filter is given by $F(s)=\frac{10(s+4)}{(s+1)(s+40)}$. Let $K_v = K_a K$. Sketch the root locus of the system as a function of K_v. Specify important parameters pertaining to the root locus.

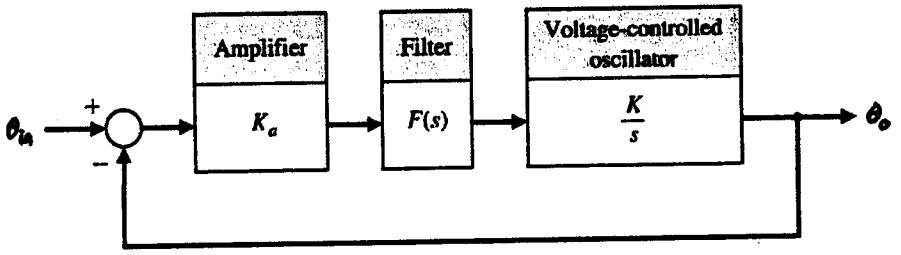

Figure 1.

3. (16%) A lead compensator has the form $G_c(s)=\frac{1+\alpha\tau s}{\alpha(1+\tau s)}$ for some τ and $\alpha>1$. Suppose that at least 30° phase angle is desired, what is the minimum value of α?

(背面仍有題目，請繼續作答)

4. (16%) A feedback control system has a characteristic equation $s^3 + (2+\alpha)s^2 + 10s + (5+20\alpha) = 0$. What is the maximum value of α can be assumed before the system becomes unstable? When α is equal to the maximum value, the system oscillates. Determine the angular frequency of oscillation.

5. (16%) A unity feedback control system has the open-loop transfer function $25/s(s+2)$. Please derive and determine the resonant frequency ω_p, peak resonant M_p, and bandwidth ω_{BW}.

6. (20%) Please prove the following theorem for $n = 4$.
The pair $(\mathbf{A} - \mathbf{bk},\ \mathbf{b})$, for any $1 \times n$ real constant vector **k**, is controllable if and only if $(\mathbf{A},\ \mathbf{b})$ is controllable.