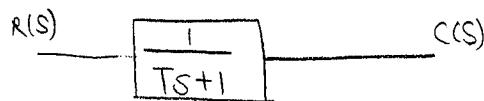


B-5-1



i) When $r(t)$ is a step function, $r(t) = 1(t)$

$$c(t) = (1 - e^{-t/T}) 1(t)$$

In order to get 98% of the response at $t=1$ min,

$$\text{we need } c(1) = 1 - e^{-1/T} = 0.98 \quad c(\infty) = 0.98$$

$$\therefore T = -\frac{1}{\ln(1-0.98)} = 0.256 \text{ (min)}$$

ii) Now $r(t)$ is a ramp function with $r(t) = 10t 1(t)$

$$\text{Hence } c(t) = 10(t - T + Te^{-t/T}) 1(t)$$

The error function is

$$e(t) = r(t) - c(t) = 10T(1 - e^{-t/T}) 1(t)$$

Let $t=\infty$, the steady state error is $10T = 2.56$ degree

B-5-7 The transfer function is

$$\frac{Y(s)}{X(s)} = \frac{2(s-1)}{(s+2)(s+1)}$$

∴ The Laplace Transform of the output $Y(s)$ for the unit step input

$$X(s) = \frac{1}{s} \text{ is}$$

$$Y(s) = \frac{Y(s)}{X(s)} \cdot X(s) = \frac{2(s-1)}{(s+2)(s+1)} \cdot \frac{1}{s} = \frac{-3}{s+2} + \frac{4}{s+1} - \frac{1}{s}$$

$$\therefore y(t) = \mathcal{L}^{-1}[Y(s)] = -3e^{-2t} + 4e^{-t} - 1$$

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B-3-29 Define

$$y = 0.2x^3 = f(x) \quad , \bar{x} = 2$$

Then

$$y = f(t) = f(\bar{x}) + \frac{df}{dx}(x - \bar{x}) + \dots$$

Since the higher order terms in this equation are small, neglecting those terms, we obtain

$$y - f(\bar{x}) = \frac{df}{dx}(x - \bar{x}) = 0.6\bar{x}^2(x - \bar{x}) \Big|_{\bar{x}=2}$$

$$\therefore y - 0.2 \times 2^3 = 0.6 \times 2^2(x - 2)$$

Thus, linear approximation of the given nonlinear equation near the operating point is

$$y = 2.4x - 3.2$$