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$$\text{Soln} - 1(a) \quad q_p(s) = \frac{10}{s+1}$$

$$q_d(s) = \frac{2}{(s+1)(5s+1)} = \frac{2}{5s^2 + 6s + 1}$$

$$\text{as } q_m = q_f = 1$$

transfer function of main forward controller

$$\Rightarrow q_c(s) = \frac{q_d(s)}{q_p(s)}$$

transfer function of set point element

$$q_{sp} = \frac{1}{q_d(s)}$$

then

$$\bullet \quad q_{sp} = \frac{1}{2} \times (5s^2 + 6s + 1)$$

$$q_c = \frac{2}{5s^2 + 6s + 1} \times \frac{5 \times 1}{10} = \frac{1}{5} \cdot \frac{1}{(5s+1)}$$

at steady state

$$k_p = q_p = 10, \quad q_d = 2 = k_d$$

\rightarrow design transfer function $q_c = \frac{k_d}{k_p}$

$$q_c = \frac{2}{10} = \frac{1}{5} = 0.2$$

$$q_{sp} = \frac{1}{k_d} = \frac{1}{2} = 0.5$$

$$\text{Solve } \textcircled{6} \quad q_p = \frac{s}{s^2 + 3s + 2}, \quad q_d = \frac{1}{s+1}$$

$$q_c = \frac{q_d}{q_p}$$

$$\frac{1}{\frac{s+1}{s}} = \frac{s^2 + 3s + 2}{s(s+1)}$$

\hookrightarrow Physically unrealisable because it has a higher order polynomial than denominator.

$$\textcircled{6} \quad q_p = 10e^{-0.1s} \quad q_d = \frac{2}{2s+1}$$

$$q_c = \frac{2}{\frac{2s+1}{10e^{-0.1s}}} = \frac{2(2s+1)}{(2s+1)(10e^{-0.1s})}$$

$$= \frac{2}{10e^{-0.1s}} = \frac{2}{10} e^{0.1s}$$

\hookrightarrow Physically unrealisable because the term $e^{0.1s}$ is a pure time delay

$$\textcircled{d} \quad q_P = \frac{e^{-0.5s}}{(s+1)(3s+1)} \quad q_d = \frac{e^{-s}}{s+1}$$

$$\Rightarrow q_c = \frac{\cancel{e^{-s}}}{\cancel{s+1}} \cdot \frac{e^{1-s}(s+1)(3s+1)}{\cancel{e^{-0.5s}} \cancel{(s+1)(3s+1)}} = \frac{e^{1-s}(s+1)(3s+1)}{(s+1)e^{-0.5s}}$$

$$= \frac{e^{-s+0.5s}(s+1)(3s+1)}{(s+1)}$$

$$= e^{-s+0.5s}(3s+1)$$

\hookrightarrow physical or realizable.