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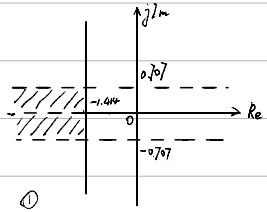
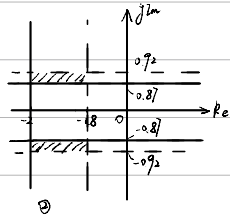
3.3 解: $\Phi(s)=\frac{\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$

① 当 $1>\zeta>0.707$ $\omega_n=2$ 系统处于欠阻尼 特征根为 $S_{1,2}=-\zeta\omega_n\pm j\omega_n\sqrt{1-\zeta^2}$

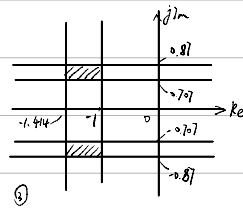
由题图中 ζ 和 ω_n 范围知 实部 ≤ -1.414 虚部绝对值大于0.707



①



②



③

② $0.5\geq\zeta>0.4$ $4\geq\omega_n\geq 2$ 系统处于欠阻尼 特征根 $S_{1,2}=-\zeta\omega_n\pm j\omega_n\sqrt{1-\zeta^2}$

$-2\leq Re<-0.8$ $0.87\leq|Im|<0.92$

③ $0.707\geq\zeta\geq 0.5$ $\omega_n\leq 2$ 系统处于欠阻尼 闭环有 $-1.414\leq Re\leq -1$ $0.707\leq|Im|\leq 0.87$

3.4 解: ①开环传递函数 $H(s)=\frac{Y(s)}{R(s)}=\frac{40}{s(0.1s+1)}$ ∴开环极点 $S_1=0$ $S_2=-10$

闭环传递函数 $H(s)=\frac{Y(s)}{R(s)}=\frac{\frac{k}{s(\frac{1}{5}s+1)}}{1+\frac{k}{s(\frac{1}{5}s+1)}}=\frac{k}{\frac{1}{5}s^2+s+k}=\frac{40}{0.1s^2+s+40}=\frac{400}{s^2+10s+400}$

∴闭环极点 $S_1=-5+5\sqrt{15}j$ $S_2=-5-5\sqrt{15}j$

② 传递函数 $H(s)=\frac{400}{s^2+10s+400}$ $2\zeta\omega_n=10$ $\omega_n^2=400$

故 $\zeta=0.25$ $\omega_n=20$

代入公式 $t_r=\frac{\pi-\beta}{\omega_n\sqrt{1-\zeta^2}}$ $\cos\beta=\zeta$ 解得 $t_r=0.0942s$

$t_s=\begin{cases}\frac{4}{\zeta\omega_n} & \Delta=2\\ \frac{3}{\zeta\omega_n} & \Delta=5\end{cases}=\begin{cases}0.8s & \Delta=2\\ 0.6s & \Delta=5\end{cases}$

$\sigma\%=e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}\times 100\%=44.43\%$

日期: /

3.8 解: 由系统框图得到传递函数

$$H(s)=\frac{Y(s)}{R(s)}=k_1\cdot\frac{\frac{k_2}{s(s+a)}}{1+\frac{k_2}{s(s+a)}}=\frac{k_1k_2}{s(s+a)+k_2}=\frac{k_1k_2}{s^2+as+k_2}$$

故 $2\zeta w_n=a \quad w_n^2=k_2$

由单位阶跃响应曲线知: $t_p=0.8 \quad \sigma\%=\frac{0.18}{2}\times100\%=9\%$

$$\therefore \begin{cases} t_p=\frac{\pi}{w_n\sqrt{1-\zeta^2}}=0.8 \\ \sigma\%=e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}}\times100\%=9\% \end{cases}$$

解得 $\begin{cases} \zeta=0.6083 \\ w_n=4.9478 \end{cases} \Rightarrow \begin{cases} k_2=24.4809 \\ a=6.0194 \end{cases}$

由于单位阶跃单独经过欠阻尼系统稳态值为1 故 $k_1=2$