Corso di Laurea in Ingegneria Informatica - Politecnico di Torino
Corso di Laurea in Ingegneria Informatica (GI-ZZ) - Politecnico di Torino
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# CONTROLLI AUTOMATICI (18AKSOA)

## Lab activity on frequency domain loop-shaping control system design (Part II): Problems P5-P8

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**Problem 5** — Given

$$G_p(s) = \frac{25}{s^3 + 3.3s^2 + 2s}$$

$G_s = 2$
$G_a = 0.38$
$G_r = 1$
$G_d(s) = 1$;
$d_a(t) = D_{a0}t$; $\mid D_{a0} \mid \leq 5.5 \cdot 10^{-3}$;
$d_p(t) = a_p \sin(\omega_p t)$, $\quad \mid a_p \mid \leq 2 \cdot 10^{-2}$, $\ \omega_p \leq 0.02$ rad s$^{-1}$.
$d_s(t) = a_s \sin(\omega_s t)$, $\quad \mid a_s \mid \leq 10^{-1}$, $\ \omega_s \geq 40$ rad s$^{-1}$.

Specifications
(S1) Steady-state gain of the feedback control system: $K_d = 4$
(S2) Steady-state output error when the reference is a ramp ($R_0 = 1$) : $\mid e_r^\infty \mid < 1.5 \cdot 10^{-1}$
(S3) Steady-state output error in the presence of $d_a$: $\mid e_{d_a}^\infty \mid < 5.8$
(S4) Steady-state output error in the presence of $d_p$: $\mid e_{d_p}^\infty \mid < 3.6 \cdot 10^{-4}$.
(S5) Steady-state output error in the presence of $d_s$: $\mid e_{d_s}^\infty \mid < 1.25 \cdot 10^{-4}$.
(S6) Rise time: $t_r < 2.5$ s
(S7) Settling time: $t_{s,\,5\%} < 5$ s
(S8) Step response overshoot: $\hat{s} < 12\%$

**Problem 6** — Given

$$G_p(s) = \frac{40}{s^3 + 3s^2 + 4.5s}$$

$G_s = 3$
$G_a = -0.27$
$G_r = 1$
$G_d(s) = 1$;
$d_a(t) = D_{a0}$; $\mid D_{a0} \mid \leq 8.5 \cdot 10^{-3}$;
$d_p(t) = D_{p0}t^2$; $\mid D_{p0} \mid \leq 3 \cdot 10^{-3}$;
$d_s(t) = a_s \sin(\omega_s t)$, $\quad \mid a_s \mid \leq 10^{-2}$, $\ \omega_s \geq 50$ rad s$^{-1}$.

Specifications
(S1) Steady-state gain of the feedback control system: $K_d = 3$
(S2) Steady-state output error when the reference is a ramp ($R_0 = 1$) : $\mid e_r^\infty \mid < 3.5 \cdot 10^{-1}$
(S3) Steady-state output error in the presence of $d_a$: $\mid e_{d_a}^\infty \mid < 1.75 \cdot 10^{-2}$
(S4) Steady-state output error in the presence of $d_p$: $\mid e_{d_p}^\infty \mid < 0.375$

(S5) Steady-state output error in the presence of $d_s$: $\mid e_{d_s}^{\infty} \mid < 3.3 \cdot 10^{-5}$.
(S6) Rise time: $t_r < 2.35$ s
(S7) Settling time: $t_{s,\,5\%} < 8$ s
(S8) Step response overshoot: $\hat{s} \leq 9\%$

**Problem 7** — Given

$$G_p(s) = \frac{100}{s^3 + 5.5s^2 + 4.5s}$$

$G_s = 0.5$
$G_a = 0.112$
$G_r = 1$
$G_d(s) = 1$;
$d_a(t) = D_{a0}t$; $\mid D_{a0} \mid \leq 1.5 \cdot 10^{-3}$;
$d_p(t) = a_p \sin(\omega_p t)$, $\mid a_p \mid \leq 16 \cdot 10^{-2}$, $\omega_p \leq 0.03$ rad s$^{-1}$.
$d_s(t) = a_s \sin(\omega_s t)$, $\mid a_s \mid \leq 2 \cdot 10^{-1}$, $\omega_s \geq 60$ rad s$^{-1}$.

Specifications
(S1) Steady-state gain of the feedback control system: $K_d = 8$
(S2) Steady-state output error when the reference is a ramp $(R_0 = 1)$ : $\mid e_r^{\infty} \mid < 1.5 \cdot 10^{-1}$
(S3) Steady-state output error in the presence of $d_a$: $\mid e_{d_a}^{\infty} \mid < 2.14$
(S4) Steady-state output error in the presence of $d_p$: $\mid e_{d_p}^{\infty} \mid < 5.1 \cdot 10^{-3}$.
(S5) Steady-state output error in the presence of $d_s$: $\mid e_{d_s}^{\infty} \mid < 1.6 \cdot 10^{-3}$.
(S6) Rise time: $t_r < 1.8$ s
(S7) Settling time: $t_{s,\,5\%} < 6$ s
(S8) Step response overshoot: $\hat{s} < 13\%$

**Problem 8** — Given

$$G_p(s) = \frac{-30}{s^3 + 3s^2 + 2s}$$

$G_s = 10$
$G_a = 0.06$
$G_r = 1$
$G_d(s) = 1$;
$d_a(t) = D_{a0}$; $\mid D_{a0} \mid \leq 2.5 \cdot 10^{-3}$;
$d_p(t) = D_{p0}t^2$; $\mid D_{p0} \mid \leq 8.5 \cdot 10^{-3}$;
$d_s(t) = a_s \sin(\omega_s t)$, $\mid a_s \mid \leq 5 \cdot 10^{-2}$, $\omega_s \geq 40$ rad s$^{-1}$.

Specifications
(S1) Steady-state gain of the feedback control system: $K_d = 10$
(S2) Steady-state output error when the reference is a ramp $(R_0 = 1)$ : $\mid e_r^{\infty} \mid < 2.5 \cdot 10^{-1}$
(S3) Steady-state output error in the presence of $d_a$: $\mid e_{d_a}^{\infty} \mid < 1 \cdot 10^{-2}$
(S4) Steady-state output error in the presence of $d_p$: $\mid e_{d_p}^{\infty} \mid < 0.94$
(S5) Steady-state output error in the presence of $d_s$: $\mid e_{d_s}^{\infty} \mid < 1.6 \cdot 10^{-5}$.
(S6) Rise time: $t_r < 2.5$ s
(S7) Settling time: $t_{s,\,5\%} < 13$ s
(S8) Step response overshoot: $\hat{s} < 14\%$