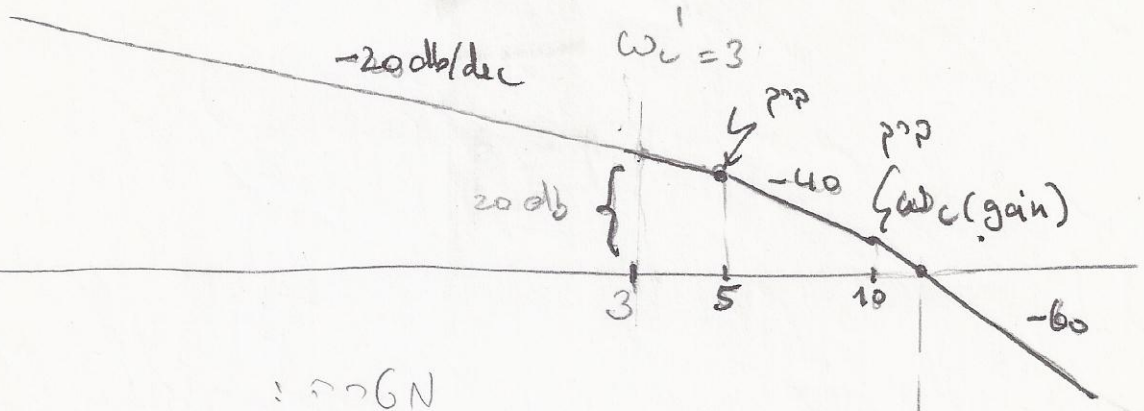
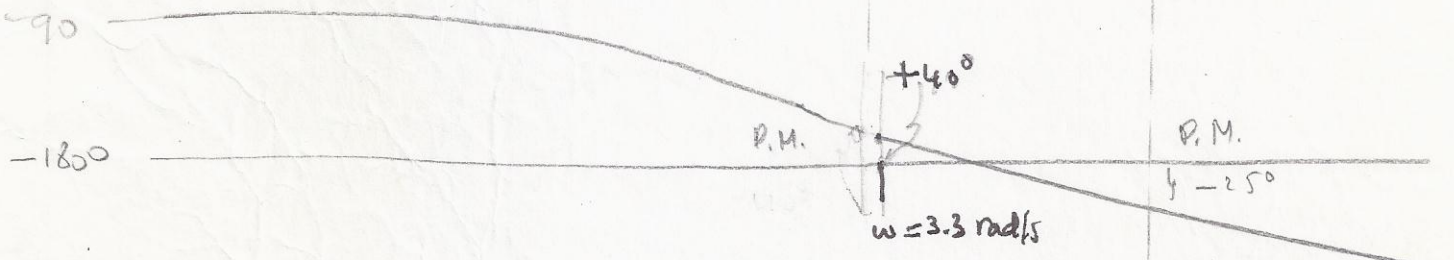
$$G_{OL}(j\omega)=\frac{30}{j\omega(1+0.1j\omega)(1+0.2j\omega)}$$

at $\omega=3 \rightarrow G_{OL}$ ≈ $\frac{30}{j\omega} = \frac{30}{j3} = -10 \Rightarrow 20\log 10 = 20$ db





$\omega = 3.3 \leftarrow$ P.M. 40°

$\omega^{*1} = 3$ rad/s

$$|G_{OL}|'_{db} = |G_{OL}|_{db} + |G_c|_{db}$$

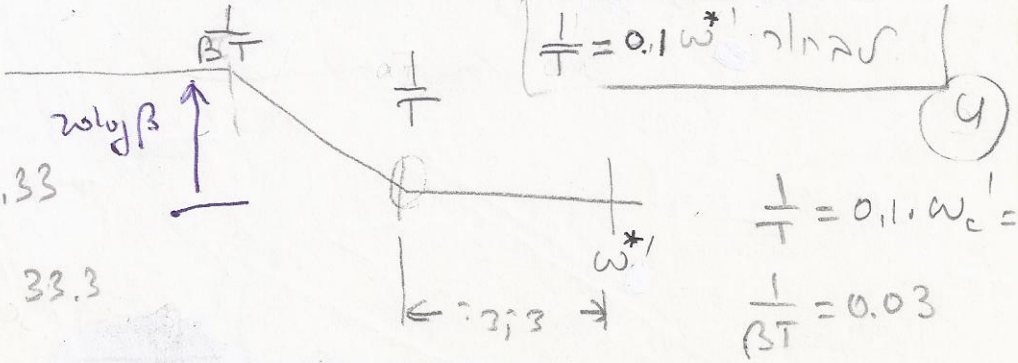
$$= |G_{OL}|_{db} + 20\log\beta = 0$$

$$20\log\beta = -20 \rightarrow$$

$$\log\beta = 1 \rightarrow \beta = 10$$

$\frac{1}{T}$ קרוב ל-

$\frac{1}{T} = 0.1\,\omega^{*1}$ ערך מרוחק

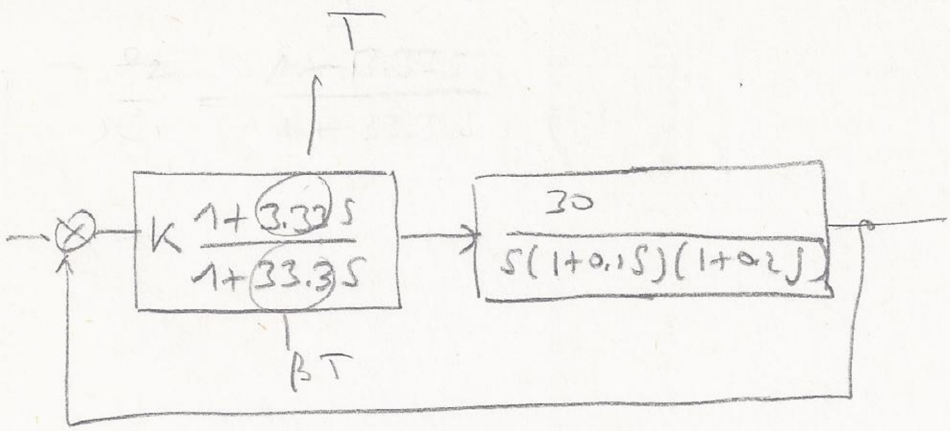


$T = \frac{1}{0.3} = 3.33$

$\beta T = \frac{1}{0.03} = 33.3$

$\frac{1}{T} = 0.1 \cdot \omega_c' = 0.3$

$\frac{1}{\beta T} = 0.03$



סיכום תכונות:

1. ω_c^* קטנה ! רחב הסרט קטנה
2. overshoot קטן אולם זמן העליה גדל

12.1.81

(קידום פז.)

הזזת קטבים (בעזרת רשת תיקון)

K R.L

1) דוגמה .

$$GH(s) = \frac{K}{s(s+2)(s+4)}$$

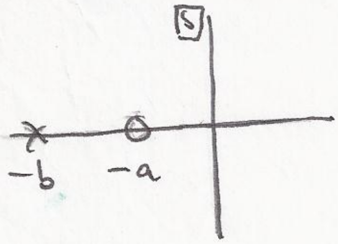
דרישה: הקטבים בחוג סגור ב: $s_{1,2} = -1 \pm \sqrt{3}j$

נתון: להשתמש ברשת קידום פזה:

$$H_c(s) = \frac{s+a}{s+b} \qquad a < b$$

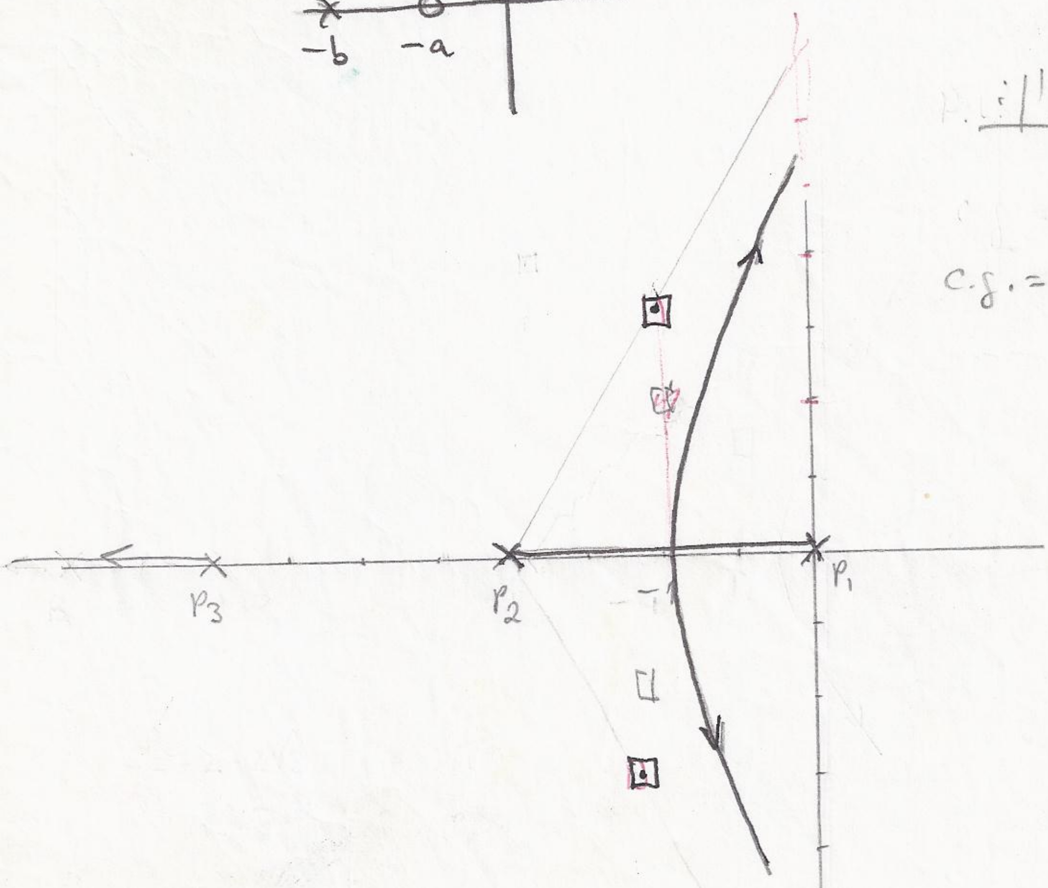
case 1:

- b נתון
- מצא את a, K



R.L ללא תיקון:

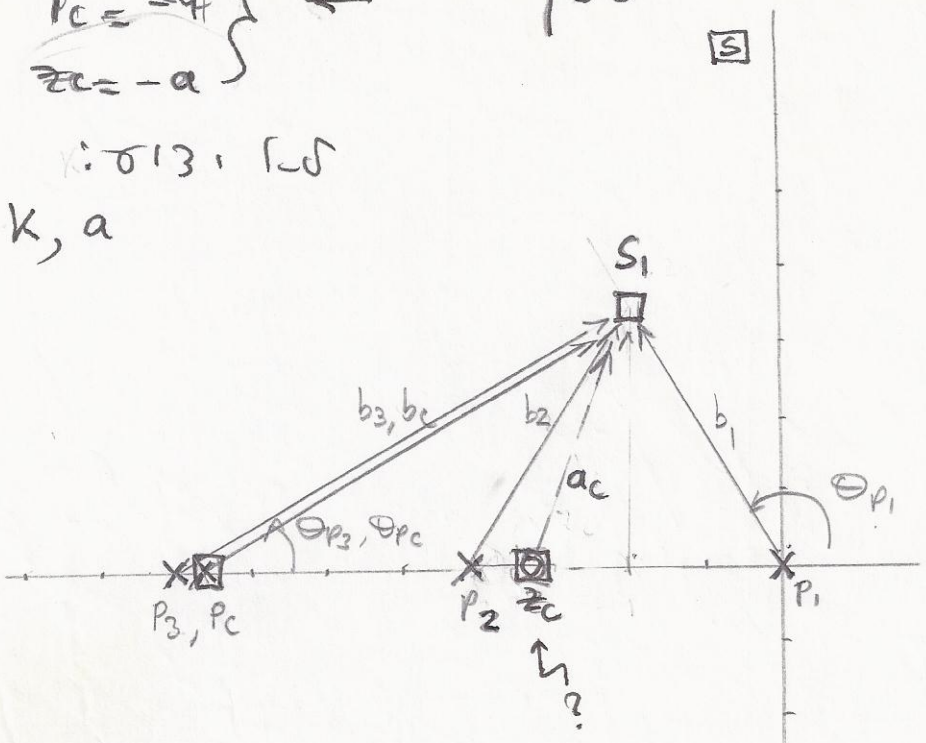
$$c.g. = \frac{\Sigma(0) - 2 - 4}{3} = -2$$



$$G_c = \frac{s+a}{(s+4)}$$

$p_c = -4$
$z_c = -a$ ←

K, a



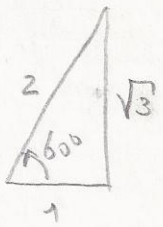
$$\theta_{z_c} - [\theta_{p_c} + \theta_{p_1} + \theta_{p_2} + \theta_{p_3}] = 180^\circ \Rightarrow$$

$$\theta_{z_c} = 180^\circ + [120^\circ + 60^\circ + 2\cdot(30^\circ)]$$

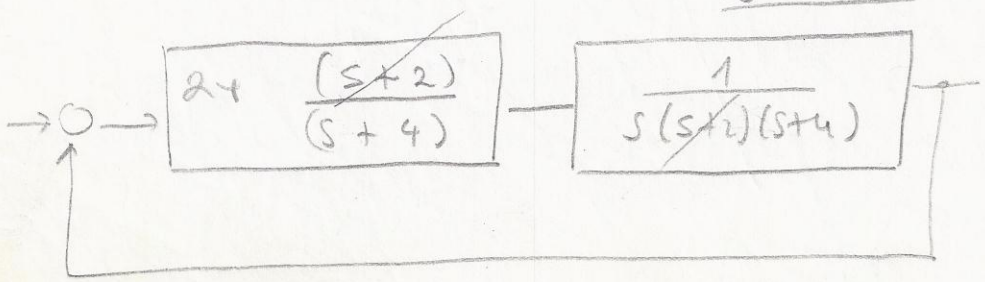
$$= 180^\circ + 240^\circ = 420 = 60^\circ$$

$$\phi_{z_c} = 60^\circ$$

$$\boxed{z_c = -2}$$



$$K = \frac{b_1 b_2 b_3 b_c}{a_c} = 2 \cdot 2\sqrt{3} \cdot 2\sqrt{3} = 8 \cdot 3 = \underline{\underline{24}}$$



נבדוק:

$$GH(s)' = \frac{24}{s(s+4)^2}$$

$$\Delta(s) = 1 + GH' = 1 + \frac{24}{s(s+4)^2} \Rightarrow s^3 + 8s^2 + 16s + 24 = 0$$

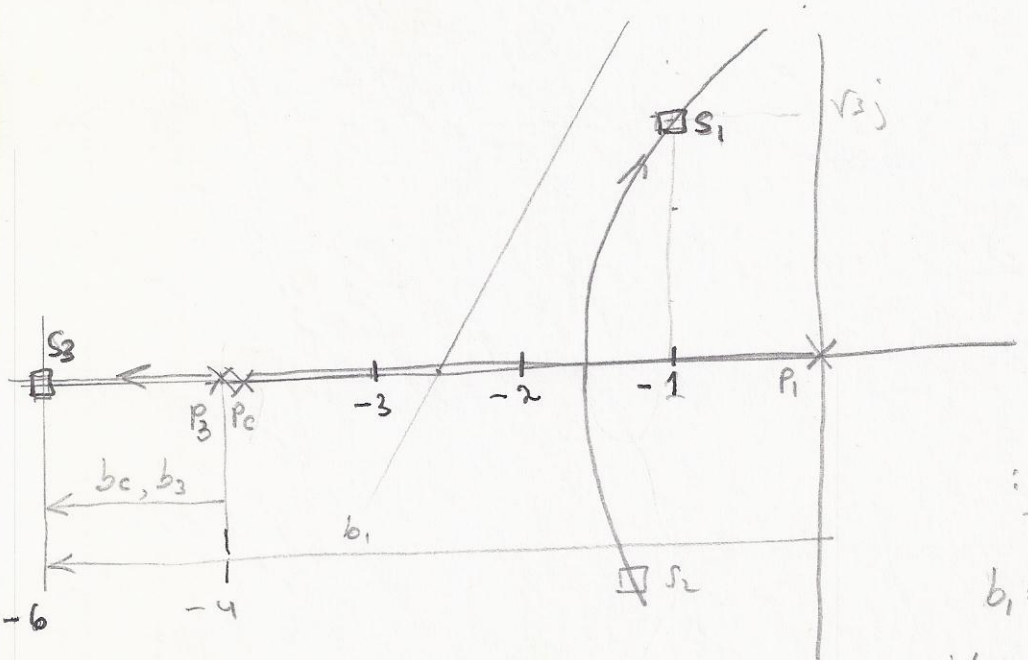
$$s_{1,2} = -1 \pm \sqrt{3}j \rightarrow \left.\begin{matrix} \zeta = 0.5 \\ \omega_0 = 2 \end{matrix}\right\} \rightarrow$$

$$s^2 + 2\zeta\omega_0 s + \omega_0^2 = 0 \rightarrow (s^2 + 2s + 4) = 0$$

$$s^2 + 2s + 4 \,/\, s^3 + 8s^2 + 16s + 24 \,|\, (s + 6)$$

$$\begin{array}{l} s^3 + 2s^2 + 4s \\ \hline \quad 6s^2 + 12s + 24 \\ \quad 6s^2 + 12s + 24 \\ \hline \qquad\qquad 0 \end{array}$$

$$(s^2 + 2s + 4)(s + 6) = 0$$



$$C.G. = \frac{\Sigma(0) - 2\cdot(4)}{3} = -\frac{8}{3}$$

בדיקה של s_3:

$$b_1 b_2 b_3 = 24$$

$$6 \cdot 2 \cdot 2 = \underline{\underline{24}}$$

הצבת קטבים

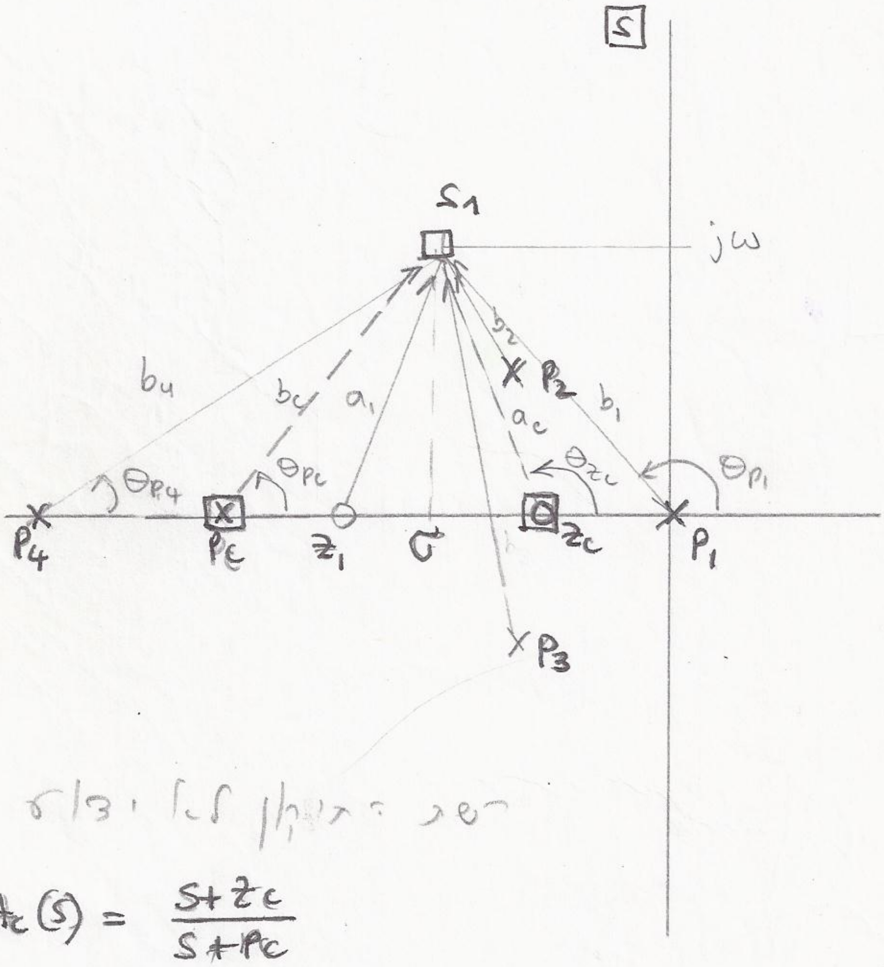
נתון:

$$GH(s) = K\frac{(s+z_1)}{s(s+p_2)(s+p_3)(s+p_4)}$$

דרוש:

1) K_v נתון

2. הקטבים בחוג סגור $s_{1,2} = -\sigma \pm j\omega$

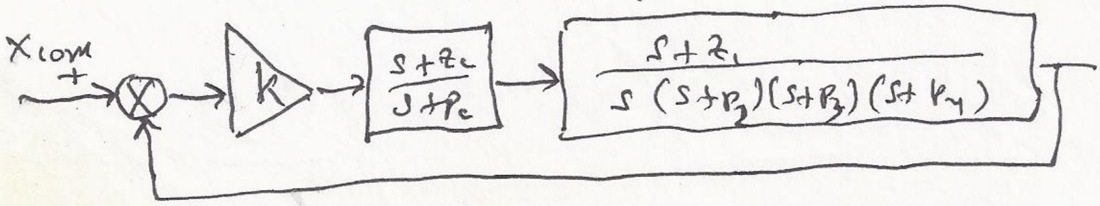


רשת התיקון לא ידועה

$$H_c(s) = \frac{s+z_c}{s+p_c}$$

p_c ו- z_c לא ידועים

ו- K לא ידוע.



k

z_c, p_c ?

$$GH'(s) = GH(s)\,G_c(s)$$: (1) פתרון

$$k_v = \lim_{s\to 0} s\,GH'(s) = \lim_{s\to 0}\left\{K\frac{(s+z_c)}{(s+p_c)}\frac{(s+z_1)}{s(s+p_2)(s+p_3)(s+p_4)}\right\}$$

$$k_v = K\frac{z_c}{p_c}\frac{z_1}{p_2 p_3 p_4} \rightarrow$$

$$K = \left(k_v\frac{p_c}{z_c}\right)\frac{p_2 p_3 p_4}{z_1}$$

(2) פתרון

ב) אילוץ זווית פאזה:

$$\frac{a_c\cdot a_1}{b_c b_1 b_2 b_3 b_4} = \frac{1}{K}$$

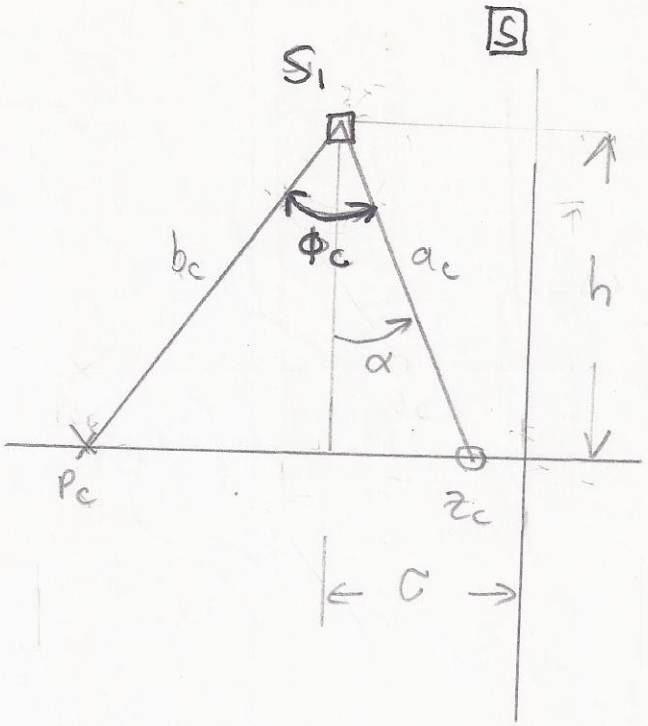
$$\frac{a_c}{b_c} = \frac{b_1 b_2 b_3 b_4}{a_1}\cdot\frac{1}{K} = \underbrace{\frac{1}{k_v}\frac{b_1 b_2 b_3 b_4}{a_1}\frac{z_1}{p_2 p_3 p_4}}_{Q}\frac{z_c}{p_c}$$

$$Q = \frac{1}{k_v}\frac{b_1 b_2 b_3 b_4}{a_1}\frac{z_1}{p_2 p_3 p_4} \qquad \frac{a_c}{b_c} = Q\frac{z_c}{p_c}$$

אילוץ זווית פאזה:

$$\theta_{z_c} + \theta_{z_1} - \theta_{p_c} - \{\theta_{p_1} + \theta_{p_2} + \theta_{p_3} + \theta_{p_4}\} = 180^\circ$$

$$[\theta_{z_c} - \theta_{p_c}] = 180^\circ - \theta_{z_1} + \{\theta_{p_1} + \theta_{p_2} + \theta_{p_3} + \theta_{p_4}\} = \Phi_c$$



(例題 Q) $\frac{a_c}{b_c} = Q\frac{z_c}{P_c}$ (1) : 例題

Φ_c (2)

C, h (3)

$$\alpha = \tan^{-1}\left(\frac{C}{h}\right) - \tan^{-1}\left\{\frac{\sin\Phi_c}{Q - \cos\Phi_c}\right\}$$

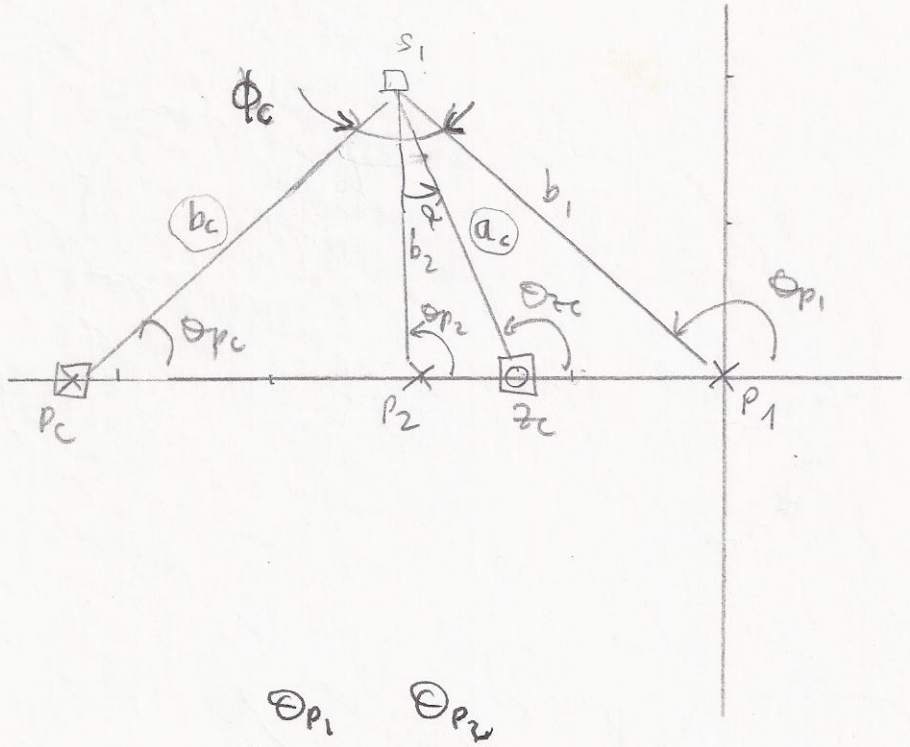
שאלה 3:

$$G_H(s) = K \frac{1}{s(s+2)}$$

$s_{1,2} = -2 \pm 2j$.(1

$k_v = 2$.(2

.(1



θ_{p_1} θ_{p_2}

$\theta_{z_c} - \theta_{p_c} = 180^\circ + [135^\circ + 90^\circ] = 405^\circ$: פתרון חלופי

$\phi_c = \theta_{z_c} - \theta_{p_c} = 45^\circ$

$\sin\phi_c = \frac{1}{2}\sqrt{2}$

$\cos\phi_c = \frac{1}{2}\sqrt{2}$

$$G_{H'} = \frac{(S+z_c)}{(S+p_c)} \cdot \frac{K}{S(S+2)} \quad \text{(2} \qquad K_v = 2 \rightarrow$$

$$K_v = \lim_{S\to 0} S G_{H'}(S) = \frac{K}{2}\,\frac{z_c}{p_c} \rightarrow$$

$$K = K_v\,\frac{2p_c}{z_c}$$

נמצא את הפרמטרים:

$$K\,\frac{a_c}{b_c \cdot b_1 b_2} = 1 \rightarrow \frac{a_c}{b_c b_1 b_2} = \frac{1}{K} \rightarrow$$

$$\boxed{\frac{a_c}{b_c} = Q \cdot \frac{z_c}{p_c}}$$

K נמצא

$$\frac{a_c}{b_c} = \frac{b_1 b_2}{K} = \left(\frac{b_1 b_2}{2K_v}\right) \cdot \frac{z_c}{p_c}$$

$K_v = 2$ נמצא

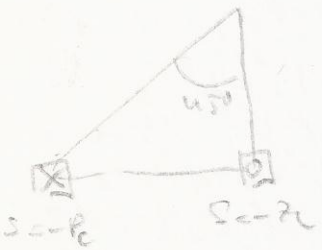
$$Q = \frac{b_1 b_2}{2K_v} = \frac{2\sqrt{2}\cdot 2}{2\cdot 2} = \sqrt{2}$$

$$\alpha = \tan^{-1}\left(\frac{\sigma}{h}\right) - \tan^{-1}\left\{\frac{\sin\phi_c}{Q - \cos\phi_c}\right\}$$

$$\tan^{-1}\frac{\sigma}{h} = 45^\circ \qquad \text{(3}$$

$$\alpha = 45^\circ - \tan^{-1}\left\{\frac{\frac{1}{2}\sqrt{2}}{\sqrt{2} - \frac{1}{2}\sqrt{2}}\right\} = 45^\circ - 45^\circ = 0^\circ$$

($\sin\phi_c$ במונה, Q במכנה, $\cos\phi_c$ במכנה)

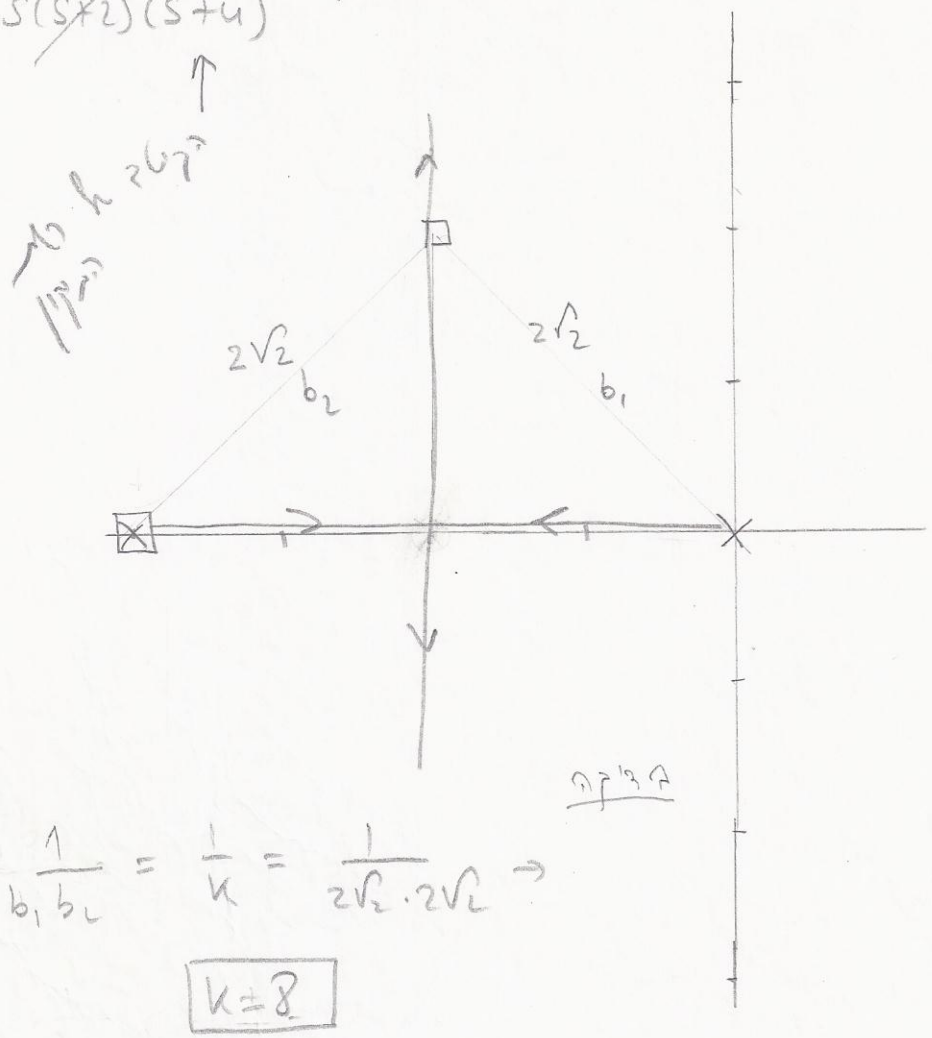


$$\left.\begin{aligned} z_c &= 2 \\ p_c &= 4 \end{aligned}\right\}$$

$$K = K_v\,\frac{2p_c}{z_c} \rightarrow K = 2\cdot 2\cdot \frac{4}{2} = 8$$

$$\boxed{K = 8}$$

$$G(s) = 8\,\frac{(s+2)}{s(s+2)(s+4)}$$



$$\frac{1}{b_1 b_2} = \frac{1}{k} = \frac{1}{2\sqrt{2}\cdot 2\sqrt{2}} \rightarrow$$

$$\boxed{k = 8}$$

$$\boxed{k_v = 3}$$

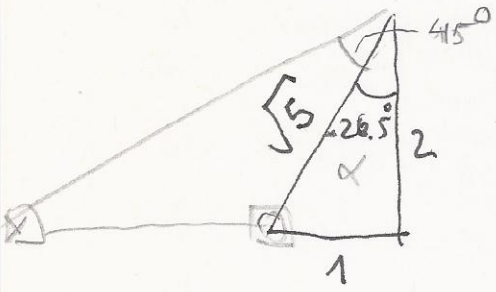
$$Q = \frac{b_1 b_2}{2 k_v} = \frac{2\sqrt{2}\cdot 2}{2\cdot 3} = \frac{2}{3}\sqrt{2}$$

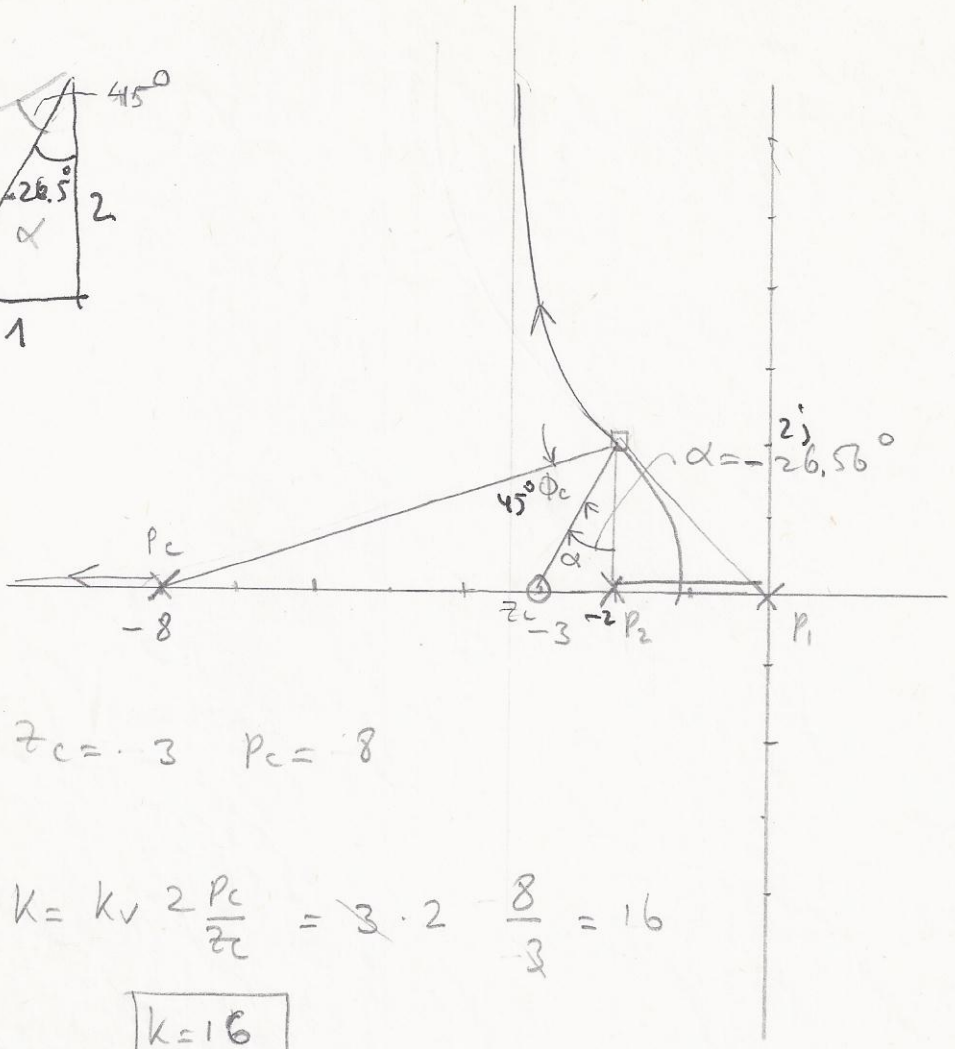
$$\tan^{-1}\frac{\sigma}{h} = 45^\circ \qquad \phi_c = 45^\circ$$

$$\alpha = \tan^{-1}\left(\frac{\sigma}{h}\right) - \tan^{-1}\left\{\frac{\sin\phi_c}{Q - \cos\phi_c}\right\}$$

$$\alpha = 45^\circ - \tan^{-1}\left\{\frac{\frac{1}{2}\sqrt{2}}{\frac{2}{3}\sqrt{2} - \frac{1}{2}\sqrt{2}}\right\}$$

$$\alpha = 45^\circ - \tan^{-1}\{3\} = 45^\circ - 71.56^\circ = -26.56$$



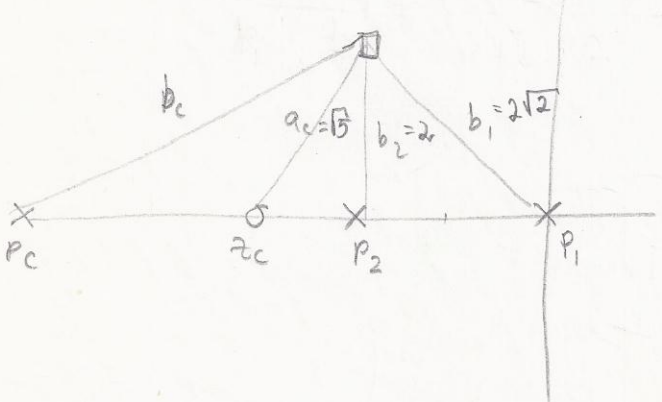


$z_c = -3 \quad p_c = -8$

$$K = K_V \, 2 \frac{p_c}{z_c} = 3 \cdot 2 \, \frac{8}{3} = 16$$

$\boxed{K = 16}$

$$GH = 16 \, \frac{(s+3)}{(s+8)} \, \frac{1}{s(s+2)}$$

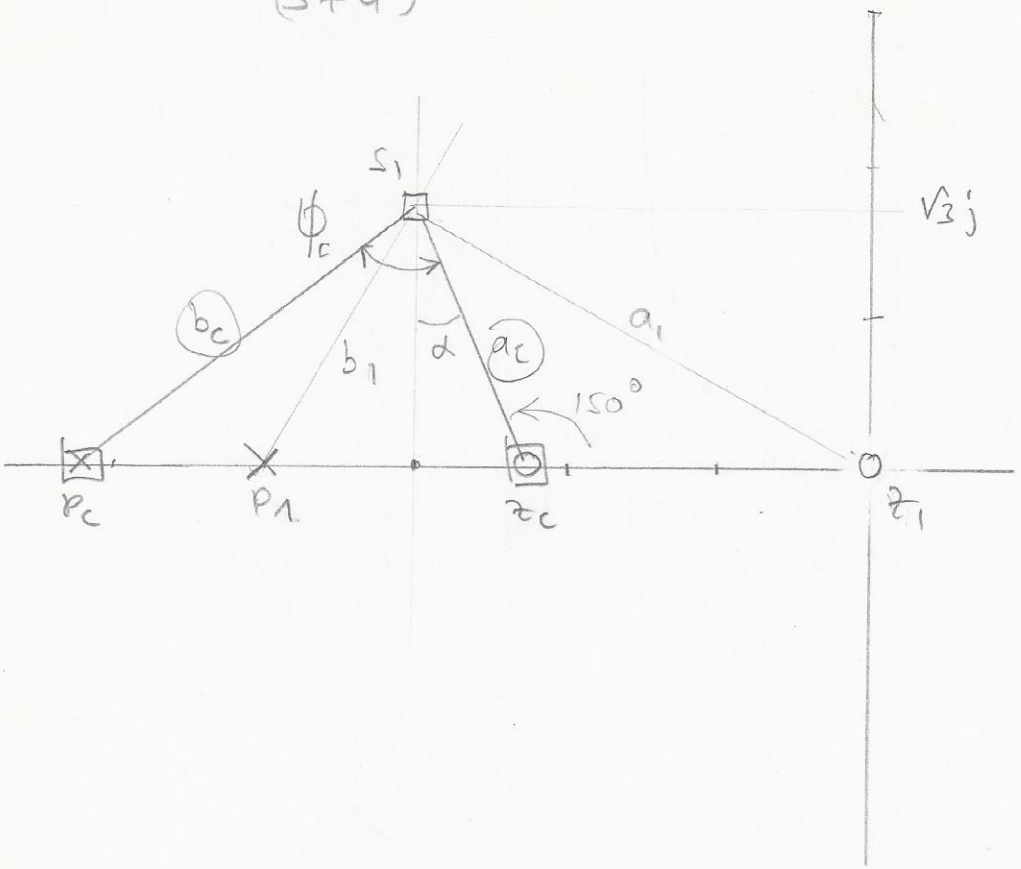


$$\frac{a_c}{b_1 b_2 b_c} = \frac{\sqrt{5}}{2\sqrt{2} \cdot 2 \cdot \sqrt{40}} = \frac{\sqrt{5}}{4\sqrt{80}} = \frac{1}{16} = \frac{1}{K}$$

$\boxed{K = 16}$

: שאלה 3

$$GH(s) = K\frac{s}{(s+4)}$$



$k_v = \frac{1}{12}$ .1 :סעיף 3

$s_{1,2} = -3 \pm \sqrt{3}j$ .2

$$k_v = \frac{K}{4}\frac{z_c}{p_c} \rightarrow K = 4k_v\frac{p_c}{z_c}$$

(1)

:מכפלת אורכים

$$\frac{a_1 a_c}{b_1 b_c} = \frac{1}{K} \rightarrow \frac{a_c}{b_c} = \underbrace{\frac{b_1}{a_1}\frac{1}{4k_v}}_{Q}\frac{z_c}{p_c}$$

$$Q = \frac{2}{2\sqrt{3}}\frac{12}{4} = \frac{3}{\sqrt{3}} = \sqrt{3}$$

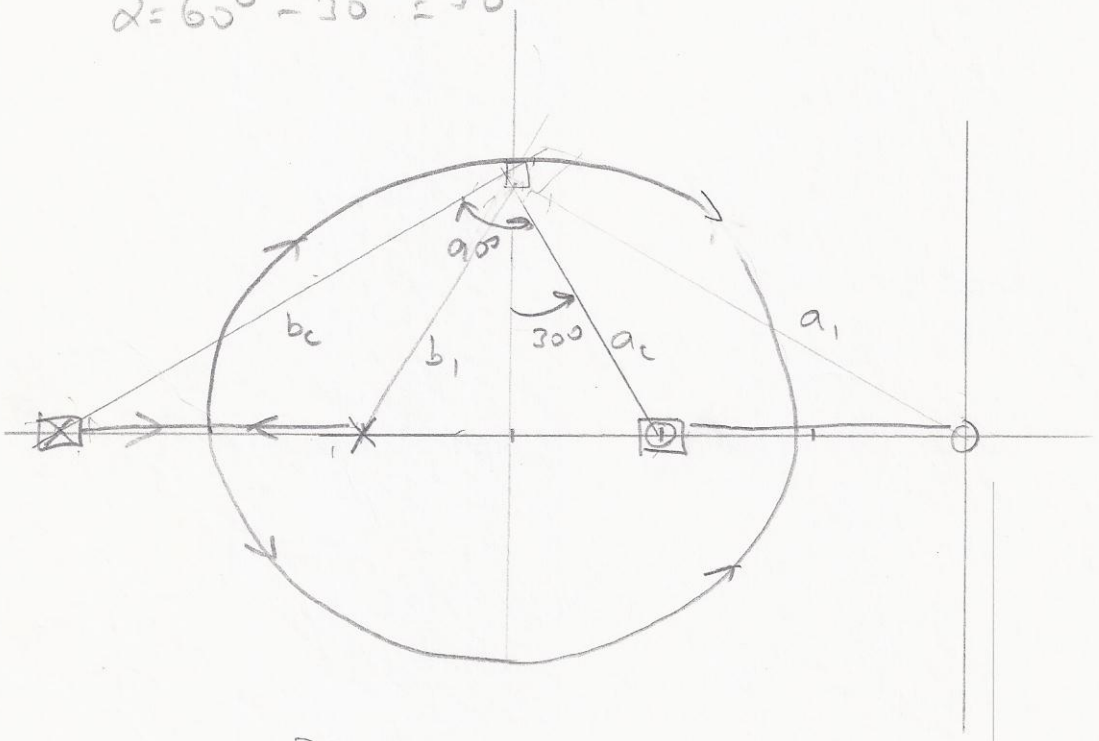
$\Phi_c = 180° - 150° + 60° = 90°$ (2)

$\tan^{-1}\left(\frac{\sqrt{3}}{h}\right) = 60°$ (3)

$\alpha = 60° - \tan^{-1}\left\{\frac{1}{\sqrt{3} - 0}\right\}$

$\alpha = 60° - \tan^{-1}\left\{\frac{1}{3}\sqrt{3}\right\}$

$\alpha = 60° - 30° = 30°$



$z_c = -2$
$p_c = -6$

$K = 4k_v \frac{p_c}{z_c} = \frac{4}{12}\frac{-6}{-2} = \frac{24}{24} = 1$

$\frac{a_1 a_c}{b_1 b_c} = \frac{2\sqrt{3} \cdot 2}{2 \cdot 2\sqrt{3}} = \frac{1}{K} = 1$