

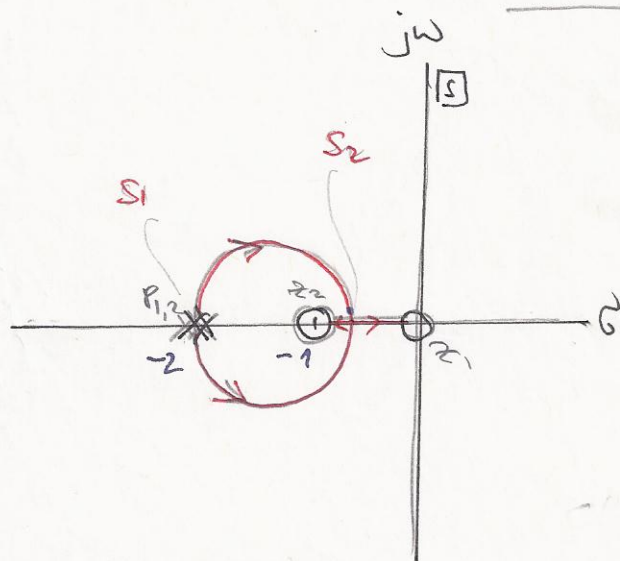
הצגת פונקציית המערכת

\*)

5. הוצגה פונקציית המערכת  $G(s)H(s)$  של מערכת סגורה. מצא את פונקציית המערכת  $G(s)$ .

$$\frac{d}{ds} [G(s)H(s)] = 0$$

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



$$\frac{d}{ds} \left[ \frac{(s+2)^2}{s^2+s} \right] =$$

$$2(s+2)(s^2+s) - (s+2)^2(2s+1) = 0$$

$$(s+2) \{ 2s^2 + 2s - 2s^2 - 5s - 2 \} = 0$$

$$(s+2)(-3s-2) = 0$$

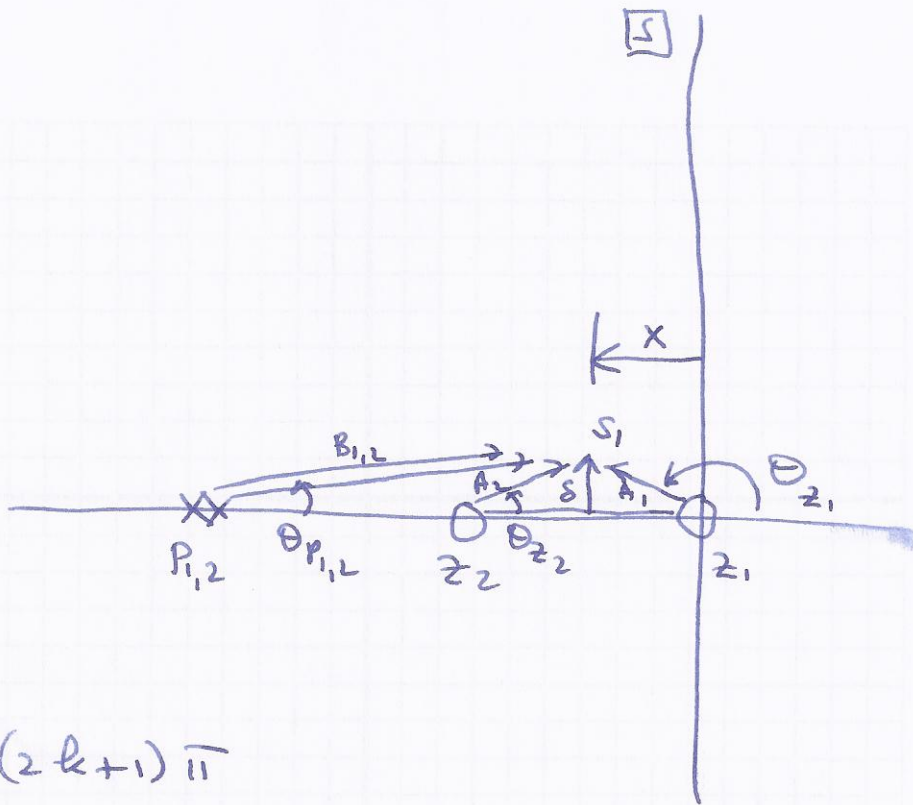
$$s_1 = -2$$

$$s_2 = -\frac{2}{3}$$

אם  $N$  = מספר אפסים והמכנה  $D$  = מספר קטבים

- 1 -

$$\therefore \rightarrow \text{N3) } \tau = \tau_{\text{Ge}} = 105$$



$$\Sigma \theta = (2k+1)\pi$$

$$\theta_{z_1} + \theta_{z_2} - \theta_{P_1} - \theta_{P_2} = (2k+1)\pi$$

~~$$\left(\pi - \frac{s}{A_1}\right) + \frac{s}{A_2} - \frac{s}{B_1} - \frac{s}{B_2} = \pi$$~~

$$-\frac{1}{A_1} + \frac{1}{A_2} - \frac{1}{B_1} - \frac{1}{B_2} = 0$$

$$-\frac{1}{x} + \frac{1}{(1-x)} - \frac{2}{(2-x)} = 0$$

$$-(1-x)(2-x) + x(2-x) - 2x(1-x) = 0$$

$$-(2 - 3x + x^2) + 2x - x^2 - 2x + 2x^2 = 0$$

$$-2 + 3x - x^2 + 2x - x^2 - 2x + 2x^2 = 0$$

$$-2 + 3x = 0 \quad \boxed{x = \frac{2}{3}} \quad s_1 = -\frac{2}{3}$$

R.L.

and the stability derivatives are assumed to be invariant with the engine torque.

B. Basic Geometry of the Perspective Tunnel Display. The basic principle, underlying the tunnel display, is shown in Fig. 1a. The trajectory which is to be followed, is projected by a perspective

image with a constant and rectangular cross-section. The width and height of the rectangle indicate the allowed deviations from the reference trajec-

tory, in lateral and vertical directions respectively, from a square cross-

section is chosen. The perspective tunnel image is associated with the vehicle position, and provides displacement, as well as directional cues. A

basic reference line in this image is the horizontal line which remains parallel

to the "through the windshield" true horizontal. The vehicle is banked to the left and the bank angle follows from the inclination of line AA with respect

to the reference frame. Point C indicates the center of the monitor image, but which represents the vehicle axis. Point B is not explicitly displayed, but

its location can be estimated by the pilot using the monitor frame as a reference. Point W indicates the instantaneous trajectory direction and its

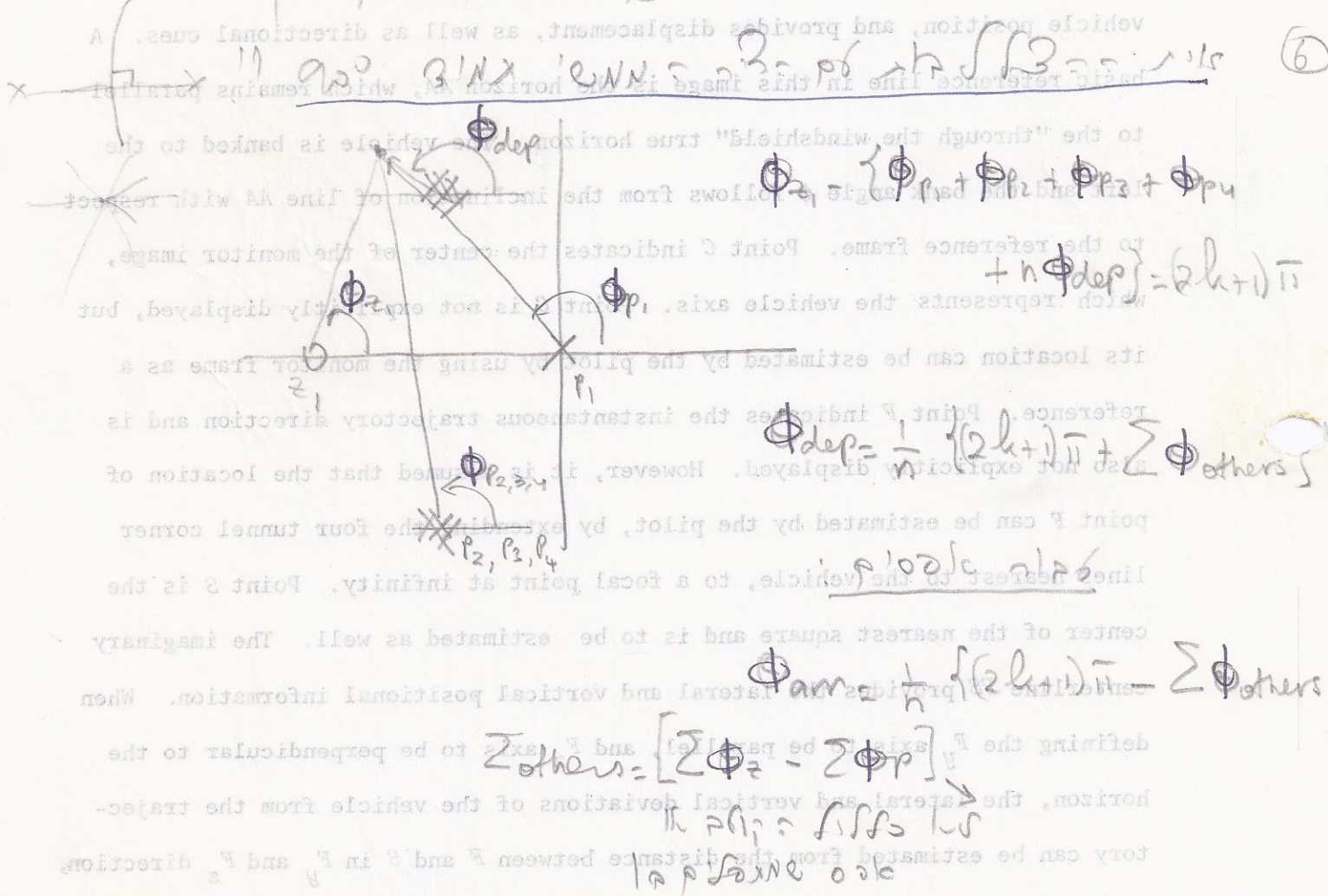
location of also not explicitly displayed. However, it is assumed that the location of point F can be estimated by the pilot, by extending the four tunnel corner

lines to the vehicle, to a focal point at infinity. Point S is the center of the nearest square and is to be estimated as well. The imaginary

center of the nearest square and is to be estimated as well. When defining the V axis to be parallel and V axis to be perpendicular to the

horizon, the lateral and vertical deviations of the vehicle from the trajectory can be estimated from the distance between S and V in V and V directions

respectively.



$$\phi_a = \phi_p + \phi_r + \phi_s + \phi_u$$

$$+ n \phi_{dep} = (2h + 1) \pi$$

$$\phi_{dep} = \frac{1}{n} \{ (2h + 1) \pi - \sum \phi_{others} \}$$

$$\phi_{am} = \frac{1}{h} \{ (2h + 1) \pi - \sum \phi_{others} \}$$

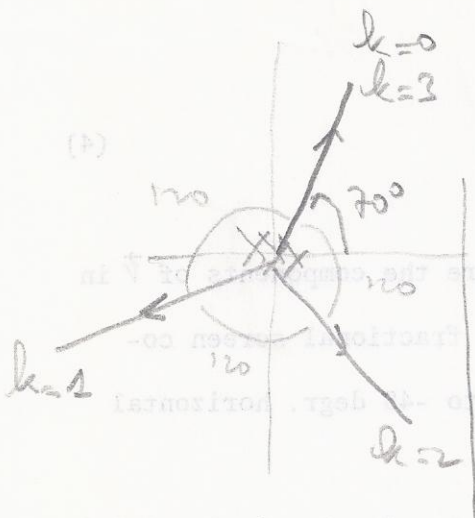
$$\sum \phi_{others} = [ \sum \phi_s - \sum \phi_p ]$$

$$h = \frac{P_1 P_2}{P_1 P_3}$$

$$P_1 P_2 \sin \theta = P_1 P_3 \sin \phi$$

⑥





$$: \quad ? \quad N \leq 1 \quad \sqrt{\quad}$$

$$n = 3$$

$$\sum \Theta_{\text{others}} = 30^\circ$$

$$\Theta_{\text{dep}} = \frac{1}{3} \{ (2k+1)\pi + 30^\circ \}$$

$$\Theta_{\text{dep}} = k \frac{2\pi}{3} + \left( \frac{\pi}{3} + \frac{30^\circ}{2} \right)$$

$$\Theta_{\text{dep}} = k \cdot 120^\circ + 70^\circ$$

$$k=0 \rightarrow \Theta_{\text{dep}1} = 70^\circ$$

$$k=1 \rightarrow \Theta_{\text{dep}2} = 190^\circ$$

$$k=2 \rightarrow \Theta_{\text{dep}3} = 310^\circ$$

(2)

$$a_y = V^2/R_y(t) = V^2/r(t)$$

Then, for small deviations,  $\delta_y$  and  $\delta_r$  are given by:

(6)

$$\delta_y(t) = \frac{1}{V} \int [a_r(t) - a_y(t)] dt$$

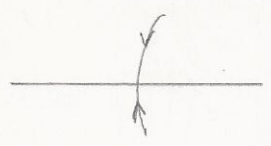
(7)

$$\delta_r(t) = V \int \delta_y(t) dt$$

-3- (5b)

: 1000 030 p0 1000 0300 115

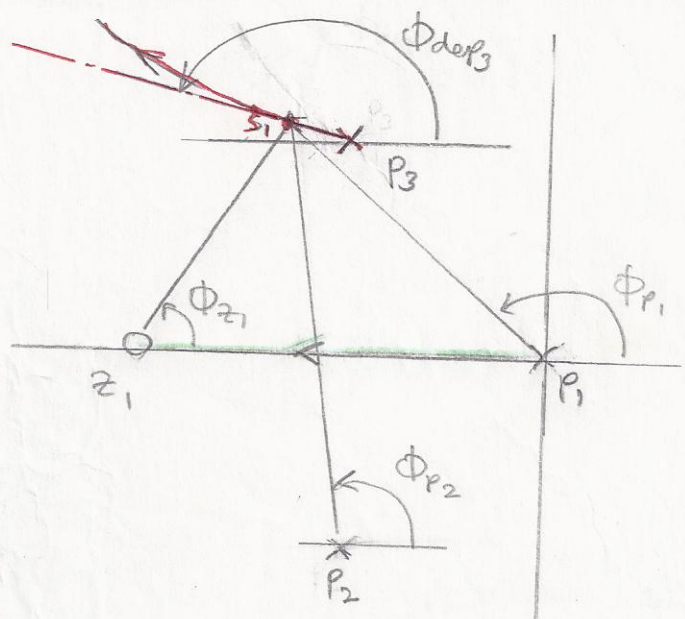
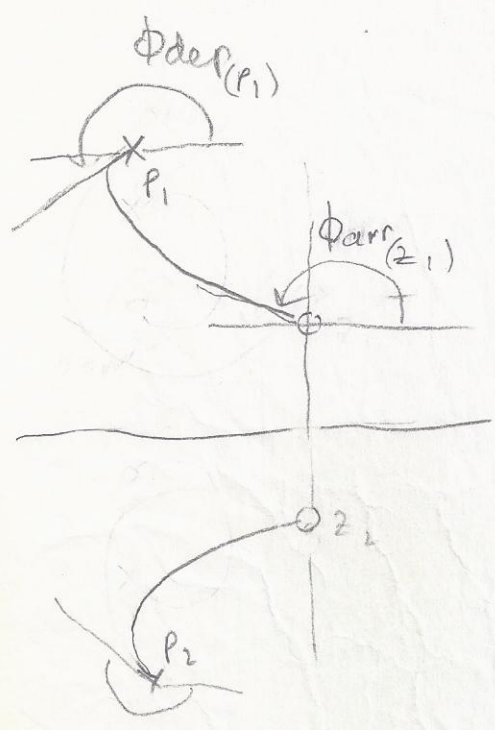
(6)



900 0115

: 000 110 000 010 R.L. 0 115

(7)



$$\phi_{z_1} - \{\phi_{p_1} + \phi_{p_2} + \phi_{dep_3}\} = (2k+1)\pi \quad k=0, \pm 1, \pm 2,$$

$$\phi_{dep_3} = -(2k+1)\pi + \sum \{\phi_{z_1} - \phi_{p_1} - \phi_{p_2}\}$$

$\phi_{dep} = \pi + \sum \phi_{others} \quad (p' \neq 0)$ $\phi_{arr} = \pi - \sum \phi_{others} \quad (p' = 0)$
--

0000 0300  
p3/p

: 000 0300 p'000 010 p'000 115

$\phi_{dep} = \frac{1}{n} \{(2k+1)\pi + \sum \phi_{others}\}$ $\phi_{arr} = \frac{1}{n} \{(2k+1)\pi - \sum \phi_{others}\}$
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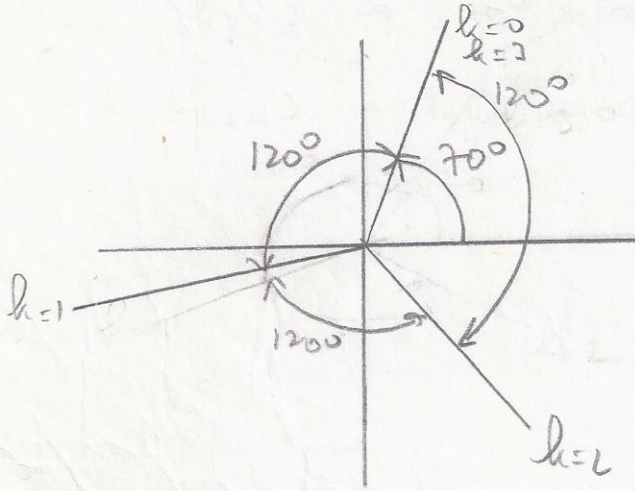
$n = 3$

$\phi_{\text{others}} = 30^\circ$

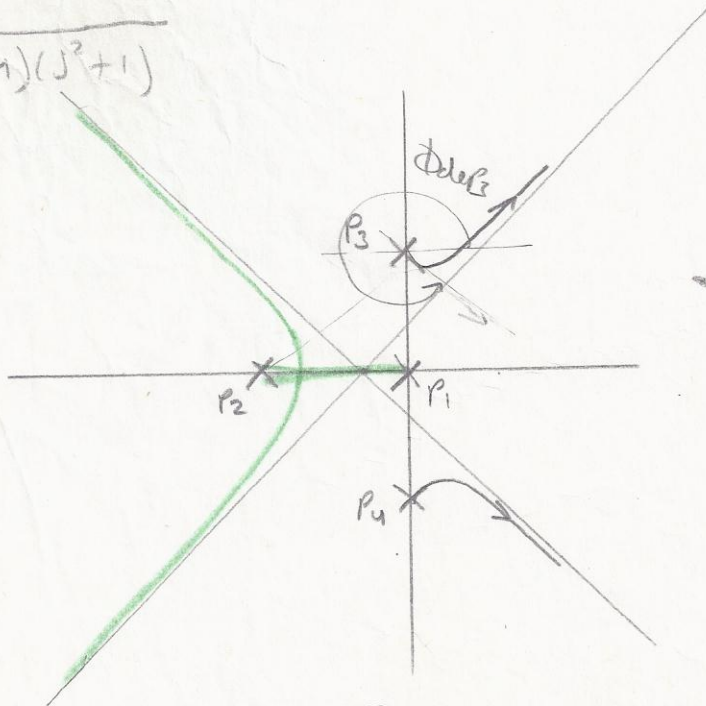
$$\phi_{\text{dep}} = \frac{1}{3} \{ (2k+1)\pi + 30^\circ \} = k \frac{2\pi}{3} + \left\{ \frac{\pi}{3} + \frac{30^\circ}{3} \right\}$$

$\phi_{\text{dep}} = k 120^\circ + 70^\circ \rightarrow$

- $190^\circ \quad k=0$
- $310^\circ \quad k=1$
- $\quad \quad \quad k=2$



$G.H = \frac{1}{s(s+1)(s^2+1)}$



$c.g. = \frac{\sum -1 - \sum 0}{4} = -0.25$

$\alpha_k = \frac{(2k+1)\pi}{4}$

- 45, 135, 225, 315

$\phi_{\text{dep}_3} = \left( \frac{\pi}{4} \right) + \sum \phi_{\text{others}}$

$\sum \phi_{\text{others}} = \sum -\phi_{p_1} - \phi_{p_2} - \phi_{p_4} = -\frac{\pi}{2} - \frac{\pi}{4} - \frac{\pi}{2} = -\frac{5\pi}{4}$

$\phi_{\text{dep}_3} = \frac{\pi}{4} - \frac{5\pi}{4} = -\frac{\pi}{4}$

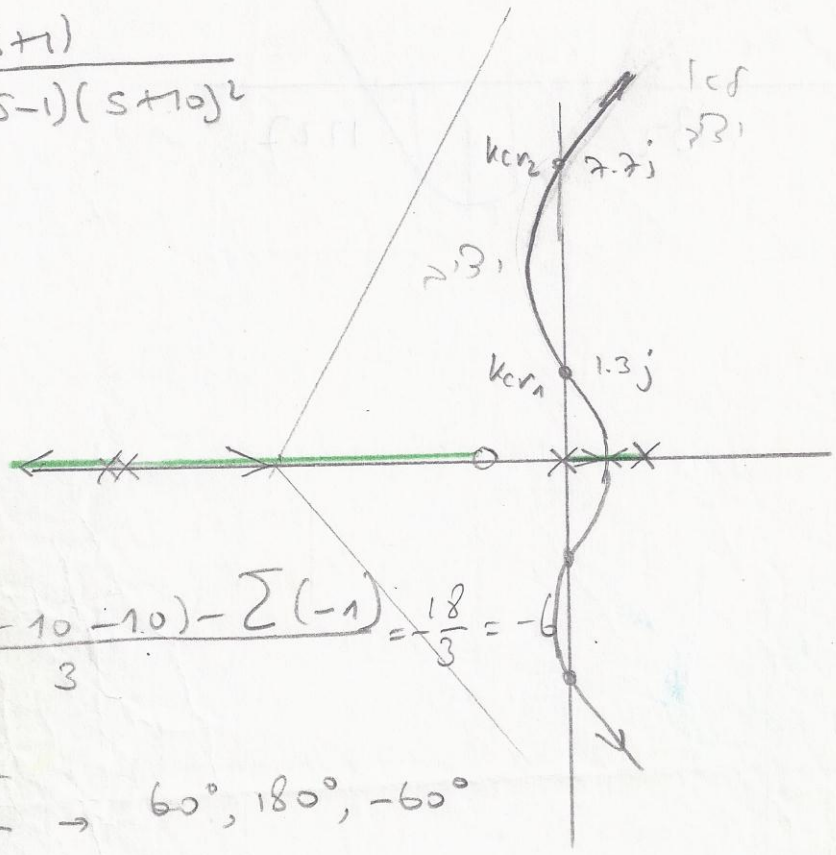


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Cannon P. 674.

$$G(s) = k \frac{(s+1)}{s(s-1)(s+10)^2}$$



$$e.g. = \frac{\sum(1+0-10-10) - \sum(-1)}{3} = \frac{-18}{3} = -6$$

$$\alpha_h = \frac{(2h+1)\pi}{3} \rightarrow 60^\circ, 180^\circ, -60^\circ$$

$$G(s) + 1 = 0 \rightarrow$$

$$\frac{k(s+1)}{s(s-1)(s+10)^2} + 1 = 0$$

$$k(s+1) + s(s-1)(s+10)^2 = 0$$

$$\begin{aligned} & s(s^2+20s+100)(s-1) = \\ & (s^3+20s^2+100s)(s-1) \\ & s^4+20s^3+100s^2 \\ & - s^3-20s^2-100s \\ \hline & s^4+19s^3+80s^2+k s+k \end{aligned}$$

	$s^4 + 19s^3 + 80s^2 + (k-100)s + k = 0$		
$s^4$	1	80	k
$s^3$	19	$(k-100)$	0
$\rightarrow s^2$	$\frac{1520 - (k-100)}{19}$	k	
$s^1$	$\frac{(1620 - k)(k-100) - k(19^2)}{(1620 - k)}$		0
$s^0$	k		

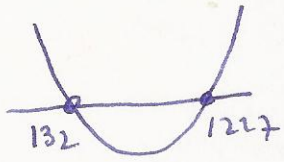
-6-

$$k < 1620$$

$$s^2 \rightarrow 1620 - k > 0$$

$$s^1 \rightarrow -k^2 + 1720k - 162000 - 261k \geq 0$$

$$k^2 - 1359k - 162000 < 0$$



$$k_{1,2} \leq 679.5 \pm 547.5$$

$$132 < k < 1227$$

$k_{cr1}$

$k_{cr2}$

$$s^0 \rightarrow k > 0$$

$$s^2 \quad f_0 = 0/10$$

$$\frac{1520 - (k-100)}{19} s^1 + k s^2 = 0 \rightarrow$$

$$\leftarrow k = 132 \quad (P.B.)$$

$$78.3 s^1 + 132 s^2 = 0 \rightarrow \left. \begin{array}{l} s_1 = 0 \\ s_2 = 1.3j \\ s_3 = -1.3j \end{array} \right\}$$

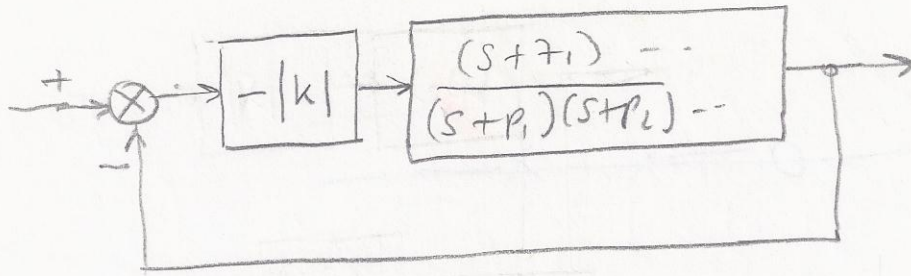
$$\leftarrow k = 1227 \quad (P.B.)$$

$$\frac{1520 - (1227 - 100)}{19} s^1 + 1227 s^2 = 0$$

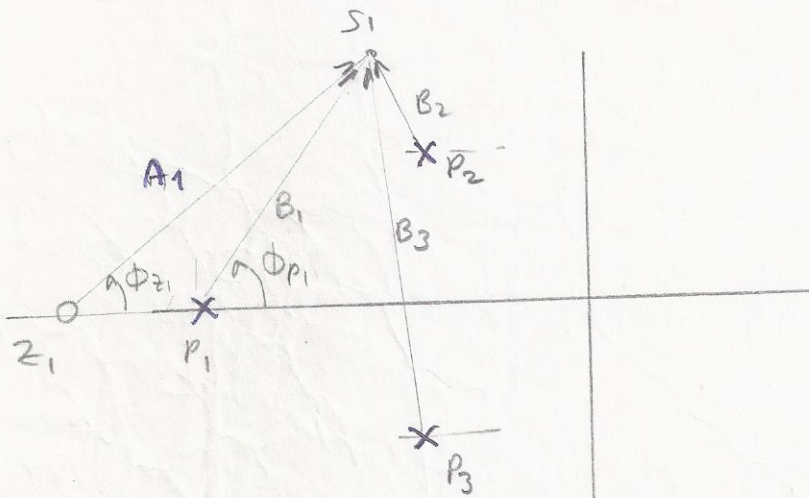
$$20.68 s^1 + 1227 s^2 = 0 \rightarrow \left. \begin{array}{l} s_1 = 0 \\ s_2 = +7.7j \\ s_3 = -7.7j \end{array} \right\}$$



$-\infty < k < 0$  (ZERO Angle R.L.) isfe k n/2π R.L



$$G(s) H(s) = -|k| \frac{(s+z_1)}{(s+p_1)(s+p_2)} = -|k| \frac{A_1}{B_1 B_2} e^{j\{\phi_{z_1} - \phi_{p_1} - \phi_{p_2}\}}$$



isfe R.L. for  $\omega > 0$ ,  $\omega > s_1$

$$G(s) H(s) + 1 = 0 \rightarrow$$

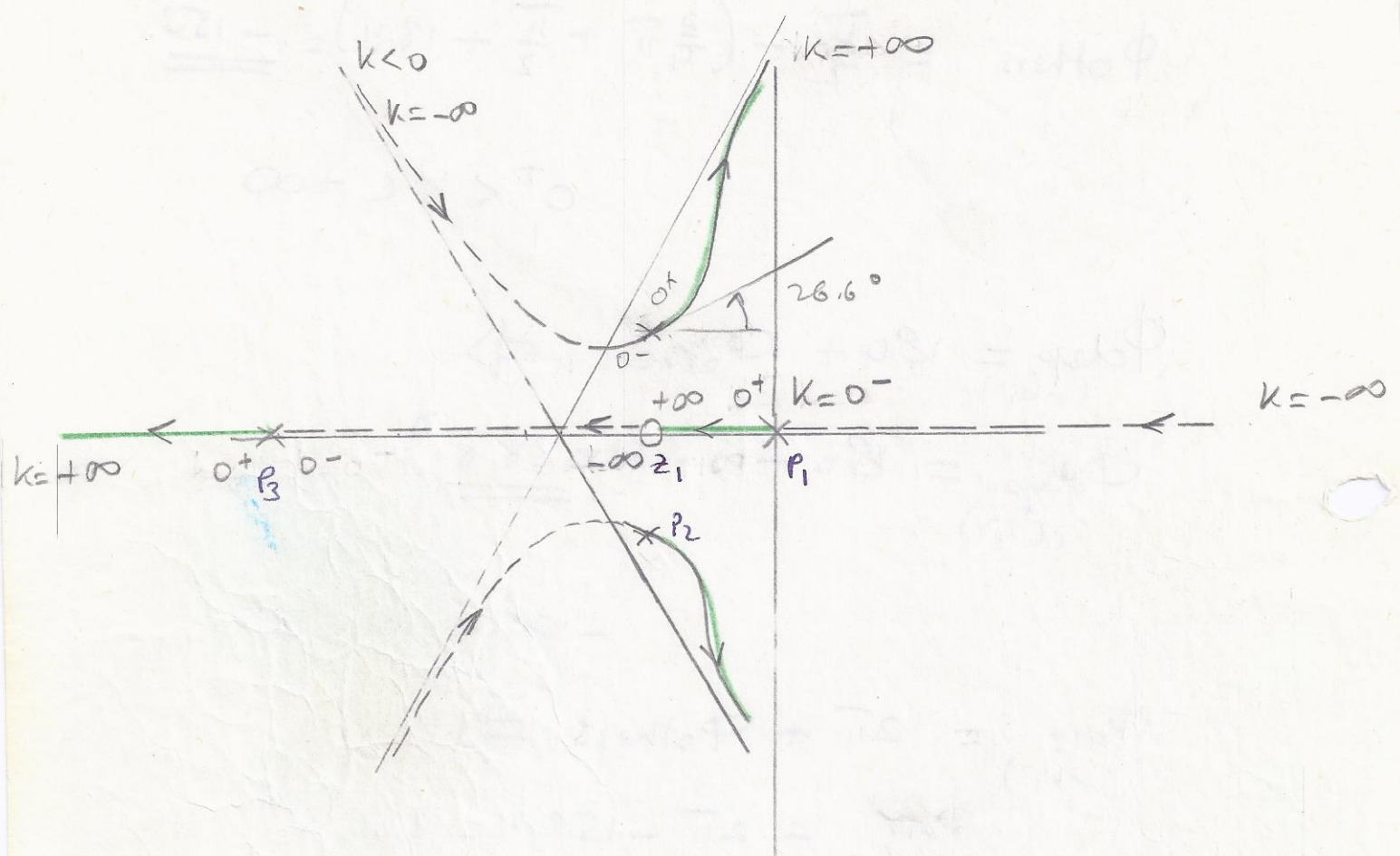
$$G(s) H(s) = -1 \rightarrow -|k| \frac{A_1}{B_1 B_2 B_3} e^{j\sum\phi} = -1 = -e^{k \cdot 2\pi j}$$

$$(1) |k| \frac{A_1}{B_1 B_2 B_3} = 1 \quad |p_3| \omega >$$

$$(2) \sum\phi = k \cdot 2\pi \quad k = 0, \pm 1, \pm 2$$



$$G(s)H(s) = \frac{k(s+1)}{s(s+4)(s^2+2s+2)}$$



$$0^+ < k < \infty \rightarrow \alpha_h = \frac{(2h+1)\pi}{3} = 60^\circ, 180^\circ, -60^\circ$$

$$-\infty < k < 0^- \rightarrow \alpha_h = \frac{2h\pi}{3} = 0^\circ, 120^\circ, 240^\circ$$

$$e.g. = \frac{\sum(0-1-1-4) - \sum(-1)}{3} = -\frac{5}{3} = -1.66$$

!  $-\infty < k < 0^-$  > root locus in the right half plane