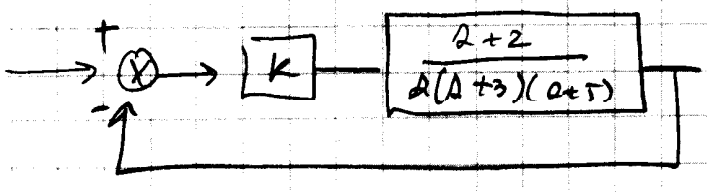
QUIZ 9 - KEY



(a) i) Fz @ -2 2 Infinite Zeros

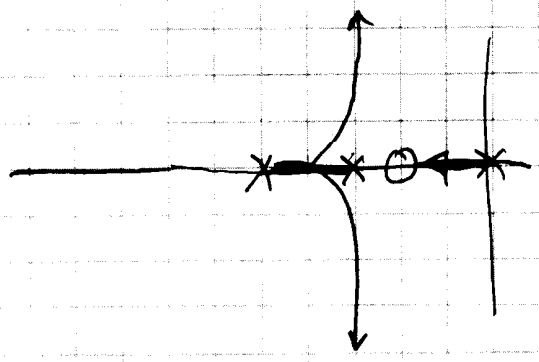
ii) Fp @ 0, -3, -5 0 Infinite Pols

iii)

$$\sigma_0 = \frac{(0-3-5)-(-2)}{3-1} = -3$$

$$\Theta = \frac{(2k+1)\pi}{3-1} = 90°, 270°$$

Sketch:



(b) i) $\frac{1}{s+2} = \frac{1}{s} + \frac{1}{s+3} + \frac{1}{s+5}$ or $\frac{1}{s+2} = \frac{(s+3)(s+5)+s(s+5)+s(s+3)}{s(s+3)(s+5)}$

$$\Rightarrow (s+2)[s^2+8s+15+s^2+5s+s^2+3s] = s[s^2+8s+15]$$

$$(s+2)[3s^2+16s+15] = s^3+8s^2+15s$$

$$3s^3+22s^2+47s+30 = s^3+8s^2+15s$$

$$2s^3+14s^2+32s+30 = 0$$

$$s = -3.86, -1.56 \pm j1.19$$

Breakaway must be $\underline{-3.86}$

b-ii Routh table:

$$\frac{G}{1+GH} = \frac{K(s+2)}{s(s+3)(s+5)+(s+2)K} = \frac{s+2}{s^3+8s^2+(15+K)s+2K}$$

s^3	1	$15+K$
s^2	8	$2K$
s^1	$\frac{3}{4}(20+K)$	
s^0	$2K$	

So $K = -20$ (Not possible) or $\underline{K = 0}$

when $K=0$, we have $s^3+8s^2+15s = 0$

or $\underline{s=0}$

this is the open loop pole we already knew about

b-iii angle of departure/arrival

pole @ $s=0$ 180°

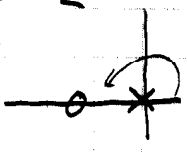
$s=-3$ 180°

$s=-5$ 0°

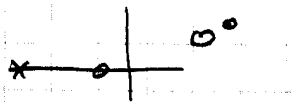
$s=-2$ 0°

example – Zero at $s=-2$

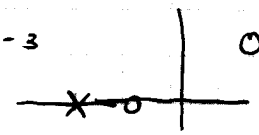
angle from $s=0$



angle from $s=-5$



angle from $s=-3$



$180 + \sum \angle$'s fp $= \underline{360^\circ = 0^\circ}$