1 a)

$$G\,H(s) = \frac{K}{s(s+1)(s+2)} = FTMA$$

$$FTMF = \frac{FTMA}{1 + FTMA} =$$

$FTMA = \frac{N(s)}{D(s)}$

$N(s) = K$

$D(s) = s(s+1)(s+2)$

$$= \frac{\frac{N(s)}{D(s)}}{1 + \frac{N(s)}{D(s)}}$$

$$= \frac{\frac{N(s)}{\cancel{D(s)}}}{\frac{D_s + N(s)}{\cancel{D(s)}}} = \frac{N(s)}{D(s)+N(s)}$$

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

$$D(s) = s(s+1)(s+2)+K$$
$$= (s^2+s)(s+2)+K = s^3+2s^2+s^2+2s+K$$

$D(s) = 0$ ; $K = ?$

$$K = -s^3-3s^2-2s$$

$$\frac{d}{ds}K = \frac{d}{ds}\left[-s^3-3s^2-2s\right] = -\frac{d}{ds}\left[s^3+3s^2+2s\right]$$
$$= -\left[3s^2+6s+2\right]$$

$$\frac{d}{ds}K = \phi \Big|_{s=?}$$

$$-(3s^2+6s+2) = \phi \iff 3s^2+6s+2 = \phi$$
$$s^2+2s+\frac{2}{3} = \phi$$

$x = \frac{1}{3}$

$P_1 = -0{,}4226$

~~$P_2 = -1{,}5773$~~

; Zeros ⇒ non

Polos ⇒ $\phi$ ; $-1$ ; $-2$

$\boxed{\text{calculadora}}$

3 RAMOS

3 Asymptotas

Angulos

⇒ 180°

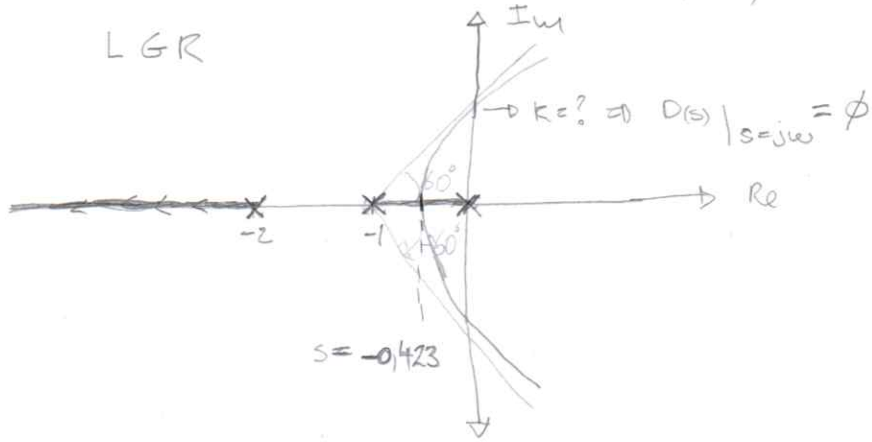
⇒ −60°

⇒ +60°

Intercepção Asymptotas

−1

LGR



1a) $s^3+2s^2+s^2+2s+K=\phi \quad \Big|_{s=j\omega}$ $\qquad \omega=?$

$j\omega^3-3\omega^2+2j\omega+K=\phi$ $\qquad K=?$

$$\begin{cases} -j\omega^3+2j\omega=\phi & \left(\times\frac{1}{j}\right) \\ -3\omega^2+K=\phi \end{cases} \quad \begin{cases} \omega^3+2\omega=\phi\ \left(\times\frac{1}{\omega}\right)=\omega^2+2=\phi \\ K=3\omega^2 \end{cases}$$

$\omega=\pm\sqrt{-2}=\pm j\sqrt{2}$

$K=+3\cdot(\sqrt{2})^2$

$=6$

$$\begin{cases} \omega(\omega^2+2)=\phi \\ K=3\omega^2 \end{cases} \quad \begin{cases} \omega=0 \vee \omega=\pm\sqrt{2} \\ K=6 \end{cases}$$

1. a) $G\,H(s) = \dfrac{K}{s(s+1)(s+2)}$

1º $\dfrac{K}{s(s+1)(s+2)} = -1$

$K = -s(s+1)(s+2)$

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

$= -s^3-3s^2-2s$

2º

zeros : non

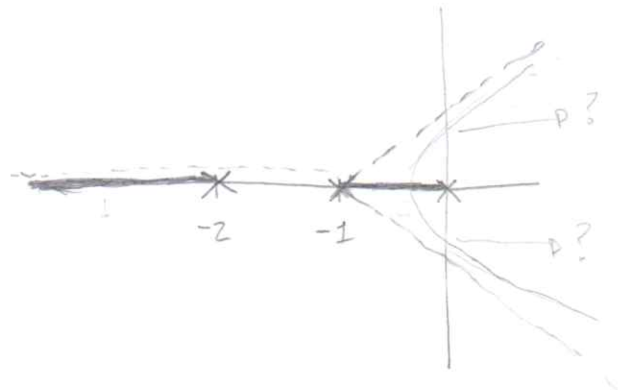
poles : 0 ; -1 ; -2

number of branches : 3

number of asymptotes : 3

Asymptotes angles : 180° ; ± 60°

Asymptotes interception : -1



# LGR

Exemplo

$$K\,W(s)\,H(s) = K \frac{1}{s(s+1)(s+2)}$$

Z: não existe $\qquad n = 0$

P: $0 + j0$; $-1 + j0$; $-2 + j0$ $\qquad d = 3$

acaba em

$-\infty + j0$,
$+\infty + j\infty$
$+\infty - j\infty$

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

FTMA

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

$$K = -s(s+1)(s+2)$$
$$= -s(s+1)(s+2)$$

$$\frac{d}{ds}K = \frac{d}{ds}\left(-s^3 - 3s^2 - 2s\right) = 0$$

$$\begin{cases} s = -1{,}577 \\ s = -0{,}423 \Rightarrow -s(s+1)(s+2)\big|_{s=-0{,}423} \end{cases}$$

$K = 0{,}384$

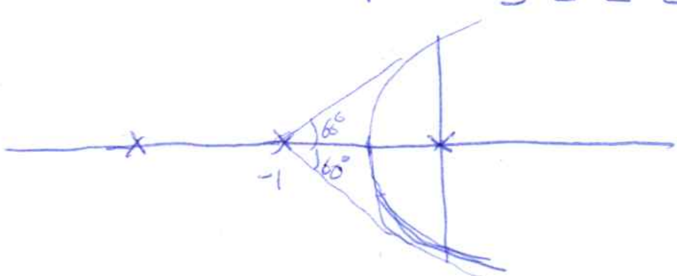
$\sigma$ - centroide - calculador prog!

Angulo Assimpt - calculador prog!

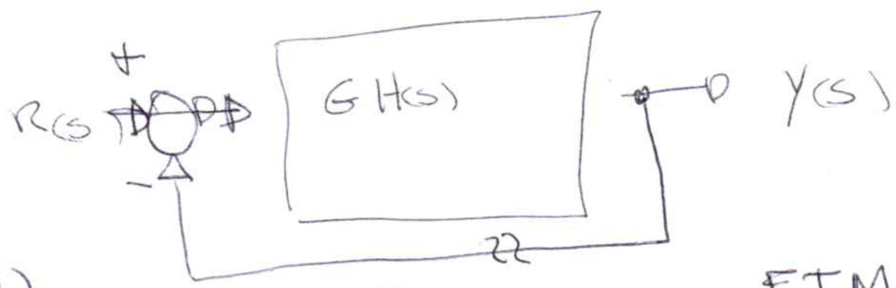
Routh - Hurwitz

$s^3 + 3s^2 + 2s + K$

$\Rightarrow \quad s = \pm j\sqrt{2}$



1 a) LGR




a) FTMA

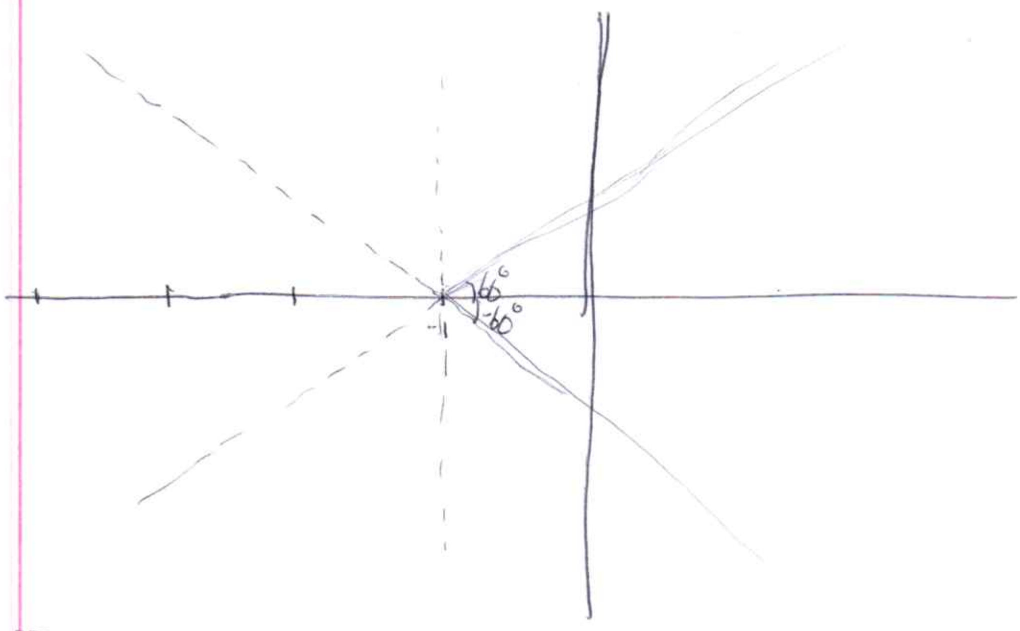
$$GH(s) = \frac{K}{s(s+1)(s+2)}$$

zeros: não existe : n=0

polos: $0+j0$; $-1+j0$; $-2+j0$ : d=3

Assimptotas: $\pm 60°$

centroid: $-1$




>> O numero de ramos do LGR é igual ao numero de polos da FTMA. Ramos = d = 3

>> O LGR começa nos polos em malha aberta e termina nos zeros em malha aberta ou no infinito.

1a)

# LGR

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

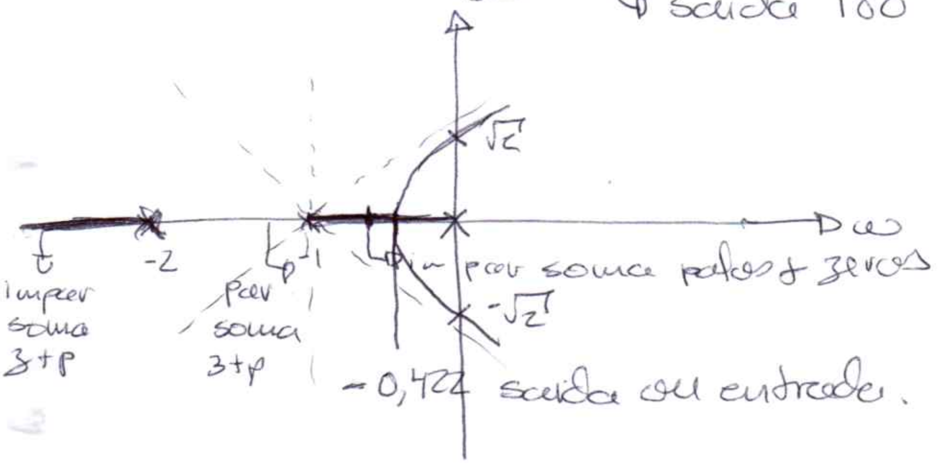
$$K = -s(s+1)(s+2)$$
$$= -(s^2+s)(s+2)$$
$$= -(s^3+2s^2+s^2+2s)$$
$$= -s^3 + 3s^2 - 2s$$

$$\frac{dK}{ds} = 0$$

$$= -3s^2 - 6s - 2 = 0$$
$$(s+1{,}577)(s+0{,}422) = 0$$

$$\therefore \begin{cases} s = -1{,}577 \; \times \\ s = -0{,}422 \end{cases}$$

↳ saída 180°




Pontos de intercepção eixo imaginário.

$$\Rightarrow \boxed{1 + GH(s)\Big|_{s=j\omega} = 0}$$

$$1 + \frac{K}{s(s+1)(s+2)}\Bigg|_{s=j\omega} = 0$$

$$\frac{s(s+1)(s+2)+K}{s(s+1)(s+2)}\Bigg|_{s=j\omega} = 0$$

1.

a) $GH(s) = \dfrac{K}{s(s+1)(s+2)}$ nº polos = Nº ramos.

$D = 3$
$N = 0$
$\begin{cases} -60^\circ & -180^\circ \\ +60^\circ & +180^\circ \end{cases}$ formula $\dfrac{(2L+1)}{D-N} \cdot 180 \Big|_{L=1,2,3\ldots}$

Polos: $0$; $-1$; $-2$

zeros: não tem

$\delta = \dfrac{\Sigma \text{ polos} - \Sigma \text{ zeros}}{D-N}$

$\dfrac{K}{s(s+1)(s+2)} = -1$

$K = -s\overbrace{(s+1)(s+2)}^{s^2+2s+s+2}$

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

$\boxed{\delta = -1}$

$\dfrac{dK'}{ds} = -3s^2 - 6s - 2 = 0$ valores para $x = 0$

$\Rightarrow \dfrac{dK}{ds} = 0 \begin{cases} s = -0,422 \\ s = \cancel{-1,577} \text{ sem significado} \end{cases}$

$\dfrac{K}{s(s+1)(s+2)} + 1 \Big|_{s=j\omega} = 0$ valores para $y = 0$

$K + s(s+1)(s+2) \Big|_{s=j\omega} = 0$

$K + s^3 + 3s^2 + 2s \Big|_{s=j\omega} = 0$

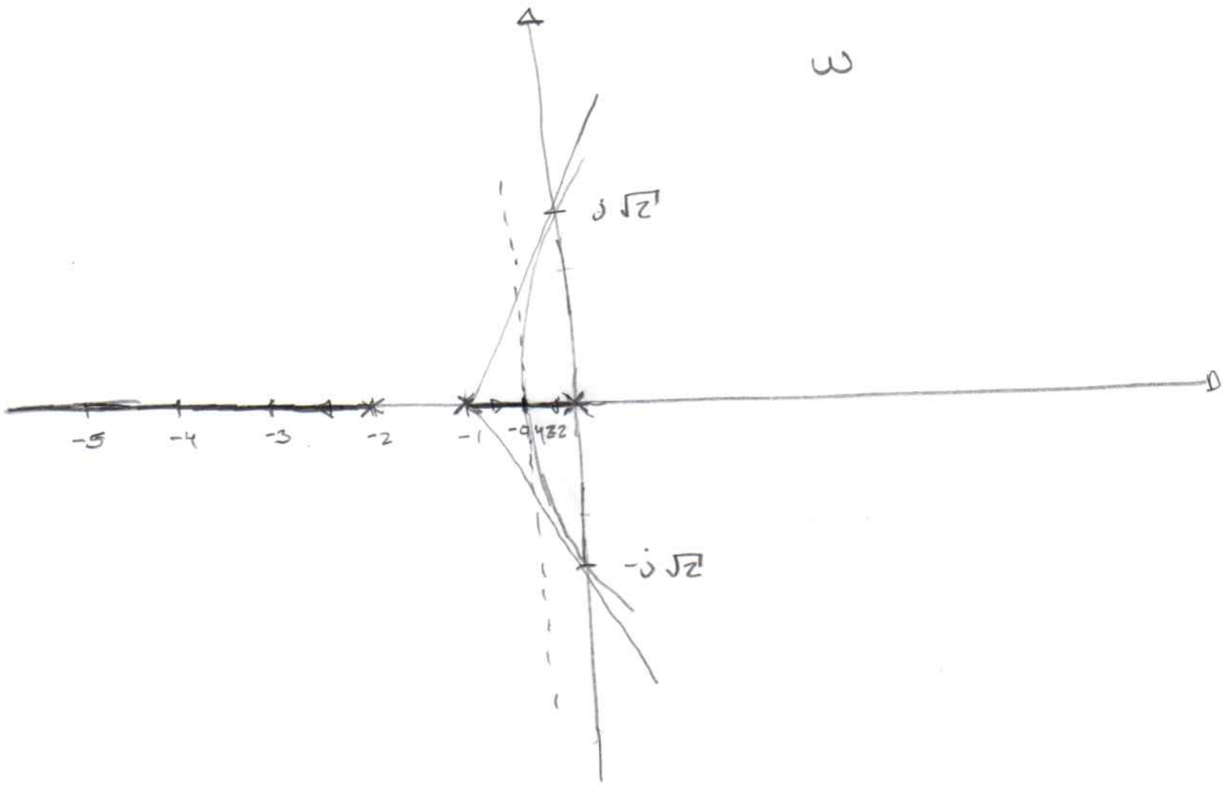
$(j\omega)^3 + 3(j\omega)^2 + 2(j\omega) + K = 0$

$j\omega^3 - 3\omega^2 + 2j\omega + K = 0$

$\begin{cases} j\omega^3 + 2j\omega = 0 \\ -3\omega^2 + K = 0 \end{cases}$ $\begin{cases} \omega^3 + 2\omega = 0 \\ K = 3\omega^2 \end{cases}$

$\begin{cases} \omega(\omega^2+2) = 0 \Rightarrow \omega = \pm\sqrt{2} \vee \omega = 0 \\ \therefore K = 3(\pm\sqrt{2})^2 \\ = \pm 6 \quad \vee \quad K = 3 \cdot 0 = 0 \end{cases}$

1.




se $s = -0{,}422 \Rightarrow K = 1{,}453$

$K = 6$ ; $\omega = \pm\sqrt{2}$

1 a)

$LGR \to FTMA \to FTMF \to P(s) \to \frac{dK}{ds}$

FTMA $\downarrow$ Polos, Zeros, centroide, Angulo Assimpt., Regiao LGR

$P(s) \downarrow$ $P(s) = \emptyset$ intercepcao eixo imag

$\frac{dK}{ds}$ Pontos Quebra

$$s(s+1)(s+2)+K=\emptyset$$

$$K = -s(s+1)(s+2)$$

$$= -(s^2+s)(s+2) = -(s^2+s).s+(s^2+s).2$$

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

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

$$\frac{dK}{ds} = -(3s^2+6s+2)$$

$$-(3s^2+6s+2)=0$$

$$3s^2+6s+2=0$$

$$x = \frac{-3+\sqrt{3}}{3} \wedge x = \frac{-3-\sqrt{3}}{3}$$

como LGR $0 < x < -1$

$$\frac{-3+\sqrt{3}}{3} \in LGR$$

— // —

$$K+(s^3+3s^2+2s)=\emptyset$$

$$(jw)^3+3(jw)^2+2jw+K=\emptyset$$

$$\underline{-jw^3}-3w^2+\underline{2jw}+K=\emptyset$$

$$\begin{matrix} j \\ R \end{matrix}\begin{cases} -w^3+2w=0 \\ -3w^2+K=0 \end{cases} \begin{cases} w=\sqrt{2};\ w=0;\ w=-\sqrt{2} \\ K=3w^2=3.\sqrt{2}^2=6 \wedge K=-6 \end{cases}$$

$\therefore$ intercepcao eixo imaginario

$K=6 \wedge K=-6$ para $w=j\sqrt{2} \wedge$
$w=-j\sqrt{2}$

using calculator equation solver.