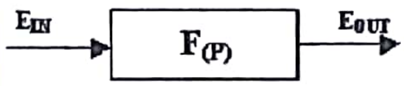
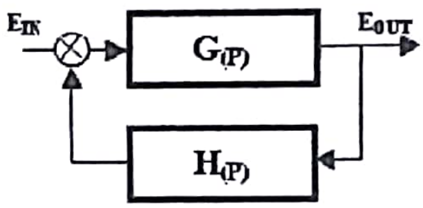
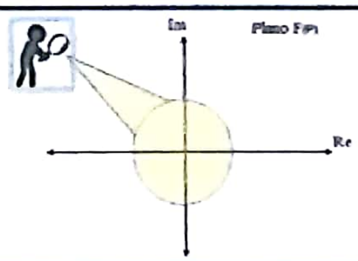
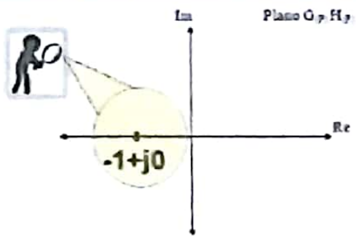
RESUMEN DE CONSIGNAS CRITERIO DE NYQUIST

TIPO DE FUNCIÓN	FUNCIÓN DE TRANSFERENCIA TOTAL	FUNCIÓN DE TRANSFERENCIA DE LAZO ABIERTO
FUNCIÓN DE TRANSFERENCIA	$F_{(P)}$	$G_{(P)} \cdot H_{(P)}$
DIAGRAMA EN BLOQUES DEL SISTEMA		
TRAZAR EL DIAGRAMA POLAR	EMPLEE "RECETA DE COCINA" DESDE EL PASO 1 HASTA EL PASO 11	EMPLEE "RECETA DE COCINA" DESDE EL PASO 1 HASTA EL PASO 10
LUGAR DE OBSERVACIÓN DE LOS RODEOS		
CONCLUSIONES SI: $N = Z - P$ $N = 0$	NO SE SABE POR CRITERIO DE NYQUIST. APLICAR OTRO MÉTODO	NO SE SABE POR CRITERIO DE NYQUIST. APLICAR OTRO MÉTODO
CONCLUSIONES SI: $N = Z - P$ N = Numero positivo	NO SE SABE POR CRITERIO DE NYQUIST. APLICAR OTRO MÉTODO	INESTABLE
CONCLUSIONES SI: $N = Z - P$ N = Numero negativo	INESTABLE	NO SE SABE POR CRITERIO DE NYQUIST. APLICAR OTRO MÉTODO

NYQUIST

Final Micaela 2020.

Función de Lazo Abierto $G(p) \cdot H(p)$ trace el Diagrama Polar y aplique criterio de Nyquist.

$$\boxed{GH(p) = \frac{15(P-2)}{P^3+6P^2+10P}}$$

zpk([2],[0 -3+i -3-i],15)

$$GH(P) = \frac{15P-30}{P^3+6P^2+10P}$$

Paso 1: Origen del diagrama polar. $F(P)/_{P\to 0}$

$$F(p)/_{P\to 0} = \frac{K_{TE}}{p^K}\Big/_{P\to 0} = \frac{-30}{p^{1}} = \infty$$

$$F(P)/_{P\to 0} = \frac{K_{TE}}{(\rho e^{j\theta})^K}\Big/_{P\to 0} = \infty \angle -90°\cdot K - 180° = \infty \angle -90 \cdot 1 - 180°$$

$$\boxed{= \infty \angle -270°}$$

Paso 2: Punto final del diagrama polar. $P\to\infty$

$$\lim_{P\to\infty} \frac{15\cancel{P}}{P^{\cancel{3}\,2}} = 0\angle -90°\cdot K = 0 \angle -90°\cdot 2 = \boxed{0\angle -180°}$$

Paso 3: Cambio $P \to j\omega$

$$\left.\begin{aligned} P^3 &= -j\omega^3 \\ P^2 &= -\omega^2 \\ P &= j\omega \end{aligned}\right\} = \frac{15j\omega - 30}{-j\omega^3 - 6\omega^2 + 10j\omega} = \frac{-30 + 15j\omega}{-6\omega^2 - j(\omega^3 - 10\omega)}$$

$$= \frac{-30 + 15j\omega}{-6\omega^2 - j(\omega^3 - 10\omega)} \cdot \frac{-6\omega^2 + j(\omega^3 - 10\omega)}{-6\omega^2 + j(\omega^3 - 10\omega)}$$

$$= \frac{180\omega^2 - j30\omega^3 + j300\omega \cancel{+} - j90\omega^3 - 15\omega^4 + 150\omega^2}{36\omega^4 - j6\omega^5 + j60\omega^3 + j6\omega^5 + \omega^6 + j10\omega^4 + j60\omega^3 - j10\omega^4 + 100\omega^2}$$

$$= \frac{180\omega^2 + 150\omega^2 - 15\omega^4 + j(-120\omega^3 + 300\omega)}{\cancel{26\omega^4 + \omega^6 + 100\omega^2 + j(-16\omega^4} \quad 36\omega^4 + (\omega^3 - 10\omega)^2}$$

$$= \frac{-15\omega^4 + 330\omega^2 + j(-120\omega^3 + 300\omega)}{\cancel{36\omega^4} \ \omega^6 - 16\omega^4 + 100\omega^2}$$

$$= \frac{-15\omega^4 + 330\omega^2}{\omega^6 + 16\omega^4 + 100\omega^2} + j\left[\frac{-120\omega^3 + 300\omega}{\omega^6 + 16\omega^4 + 100\omega^2}\right]$$

Paso 4

$Re + j\, Im$

Paso 5: Saco la raíz de la parte real.

$$-15\omega^4 + 330\omega^2 = 0$$

$$\omega^2(-15\omega^2 + 330) = 0$$

$\omega_1 = \sqrt{22}$ Evaluo en la parte Img para corte sobre eje Img. (tomo siempre raíz positiva).

$\omega_1 = 4{,}690$

6) Corte al eje imaginario:

$$j\frac{-120\,\omega^3+300\omega}{\omega^6+16\omega^4+100\omega^2}\Bigg|_{\sqrt{22}} = -0{,}53300$$

7) Obtengo Raíces de la parte imaginaria.

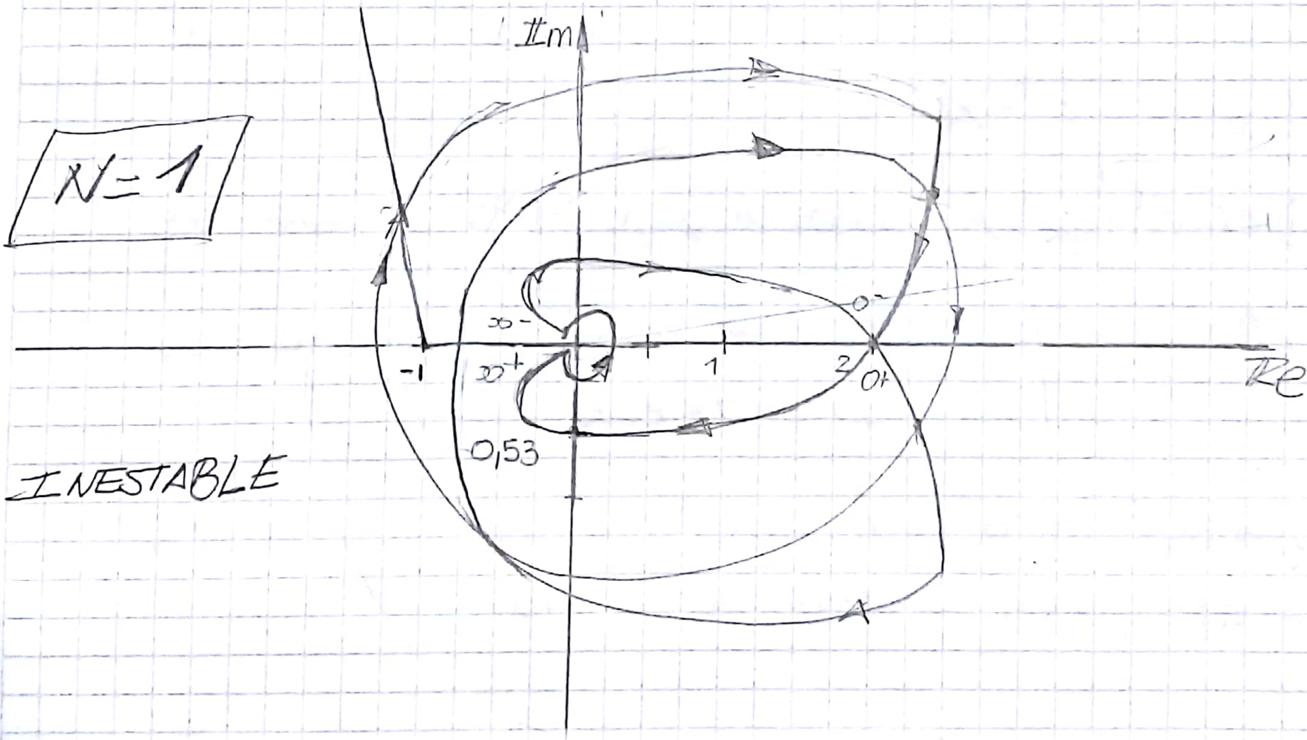
$$-120\,\omega^3+300\,\omega=0$$

$$\omega(-120\,\omega^2+300)=0 \Rightarrow \frac{\sqrt{10}}{2} = 1{,}5811$$

8) Corte en el eje Real

$$\frac{-15\omega^4+330\omega^2}{\omega^6+16\omega^4+100\omega^2}\Bigg|_{\frac{\sqrt{10}}{2}=\boxed{1{,}5811}} \Rightarrow \cancel{\omega_1=\frac{26}{5}=5{,}2} \quad \omega_1=2.$$

$\boxed{N=1}$



INESTABLE

Paso 10 Cierre de 0^+ a 0^- $\rightarrow$ $3\times-180° = -540°$

2020

Final de Rojas: Nyquist.

Idem al 05/12/2017 y 21/02/2018

$$\boxed{GH(P) = \frac{10P - 10}{P^3 + 4P^2 + 8P}}$$

zpK([1], [0 -2+2i -2-2i], 10)

Paso 1: Inicio del Diagrama para $P \to 0$

$P \to 0$ $\quad GH(0) = \frac{-10}{P^n} = \infty \angle -90° \times n - 180°$

$$G(P)H(P)\Big|_{P\to 0} = \frac{-10}{P}\Big|_{P\to 0} = |\infty| \angle -270°$$

Paso 2: Final del Diagrama para $P \to \infty$

$$G(P)H(P)\Big|_{P\to\infty} = \frac{10\cancel{P}}{P^{\cancel{3}2}} = \frac{10}{P^2} = |0| \angle -90 \times n = |0| \angle -180°$$

Paso 3: Cambio P por $j\omega$

$P^3 = -j\omega^3$

$P^2 = -\omega^2$

$P = j\omega$

$$\Rightarrow G(j\omega)H(j\omega) = \frac{10j\omega - 10}{-j\omega^3 + 4(-\omega^2) + 8j\omega} = \frac{10j\omega - 10}{-4\omega^2 + j(8\omega - \omega^3)}$$

$$= \frac{-10 + 10j\omega}{-4\omega^2 - j(\omega^3 - 8\omega)} \cdot \frac{-4\omega^2 + j(\omega^3 - 8\omega)}{-4\omega^2 + j(\omega^3 - 8\omega)}$$

$$= \frac{40\omega^2 - 10j\omega^3 + 80j\omega - 40j\omega^3 - 10\omega^4 + 80\omega^2}{16\omega^4 + \omega^6 - 8\omega^4 - 8\omega^4 + 64\omega^2}$$

$$= \frac{120\omega^2 - 10\omega^4 - j(50\omega^3 - 80\omega)}{\omega^6 + 64\omega^2} = \underbrace{\frac{120\omega^2 - 10\omega^4}{\omega^6 + 64\omega^2}}_{Re} + \underbrace{\frac{j(80\omega - 50\omega^3)}{\omega^6 + 64\omega^2}}_{Img.}$$

Paso 4:

$$G(jw)H(jw) = \frac{120w^2 - 10w^4}{w^6 + 64w^2} + j\frac{(-50w^3 + 80w)}{w^6 + 64w^2}$$

Paso 5: $\mathbb{R}e/_{w} = 0$

$$\frac{120w^2 - 10w^4}{w^6 + 64w^2} = 0 \Rightarrow 120w^2 - 10w^4 = 0$$

$$\text{Raíces} = \pm\sqrt{12} = 2\sqrt{3} = 3{,}464$$

Paso 6: Corte al eje ~~Real~~ Imaginario

Evalúo la parte Img en $w = 2\sqrt{3} = 3{,}464$

$$\left.\frac{-50w^3 + 80w}{w^6 + 64w^2}\right|_{w=2\sqrt{3}} = \boxed{-0{,}7216}$$

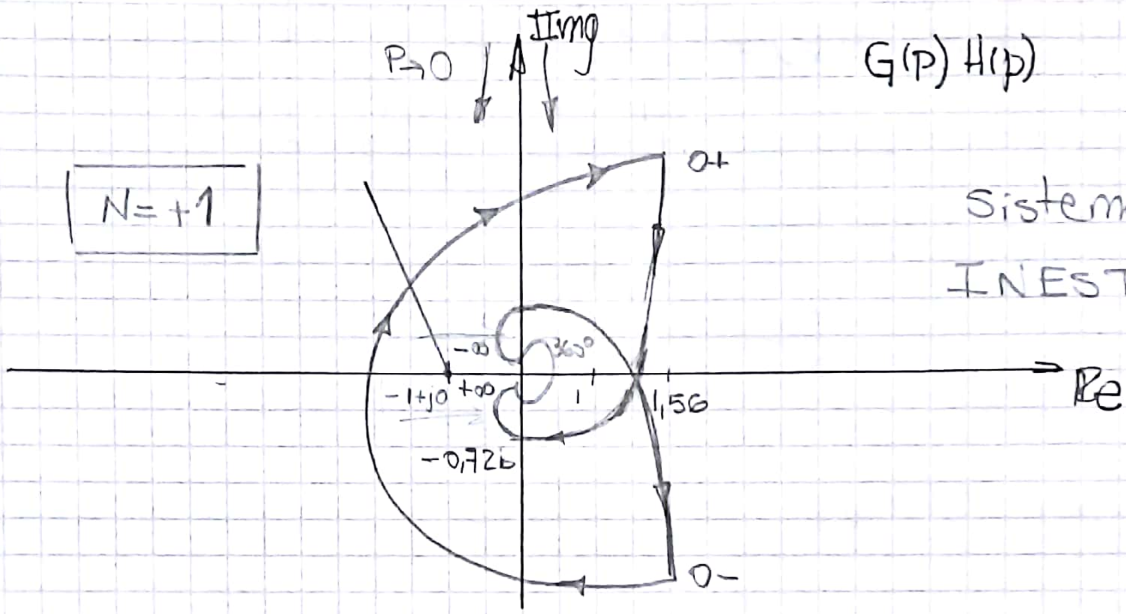
Paso 7: $\mathbb{I}m/w = 0$

$$-50w^3 + 80w = 0 \Rightarrow \text{Raíces}: \pm\frac{2\sqrt{10}}{5} \qquad w = \frac{2\sqrt{10}}{5} = 1{,}2649$$

Paso 8: Corte al eje Real:

$$\left.\frac{120w^2 - 10w^4}{w^6 + 64w^2}\right|_{w=\frac{2\sqrt{10}}{5}} = 1{,}5625$$

Paso 9: Cantidad de rodeos al punto $-1+j0$



$\boxed{N=+1}$

Sistema INESTABLE

Paso 10:

Para cerrar el diagrama

$P \to \infty \quad \frac{Kte}{p^2} \Rightarrow 2 \times -180 = -360$

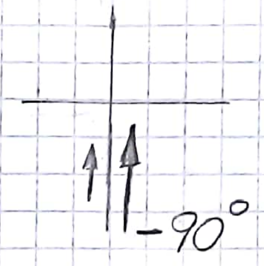
$P \to 0 \quad \frac{Kte}{P} \Rightarrow 1 \times -180 = -180$

Final 08/05/2019

$$\boxed{G(p)\,H(p) = \frac{10P+50}{p\,(p^2-p+4)}} = \frac{10P+50}{p^3-p^2+4p}$$

1) Inicio del Diagrama para $P \to 0$

$$G(P)H(P)\Big/_{P\to 0} = \frac{50}{P} = \infty \angle -90$$



2) Fin del Diagrama para $P \to \infty$

$$G(P)H(P)\Big/_{P\to\infty} = \frac{10P}{P^3} = \frac{10}{P^2} = 0 \angle -180^0$$

3) Cambio $P \to jw$

$P \to jw$, $P^2 \to -w^2$

$$G(jw)H(jw) = \frac{10\,jw+50}{jw\,(-w^2-jw+4)}$$

$$= \frac{50+j10w}{-jw^3+w^2+j4w} = \frac{50+j10w}{w^2+j(4w-w^3)} \cdot \frac{w^2-j(4w-w^3)}{w^2-j(4w-w^3)}$$

$$= \frac{50w^2-j200w+50w^3+j10w^3+40w^2-10w^4}{w^4+(4w-w^3)^2}$$

$$= \frac{90w^2+50w^3-10w^4+j(10w^3-200w)}{w^4+w^6-8w^4+16w^2} \quad X$$

$$= \underbrace{\frac{90w^2 \qquad -10w^4}{w^6-7w^4+16w^2}}_{Re} + j\underbrace{\frac{(60w^3-200w)}{w^6-7w^4+16w^2}}_{Img}$$

✓ Correcto

4) $Re/\omega = 0$ $\quad 90\omega^2 - 10\omega^4 = 0$

$10\omega^2 = 90 \Rightarrow \omega = \sqrt{9} = \boxed{3}$

5) Corte al eje Imaginario

$$\left.\frac{-60\omega^3 - 200\omega}{\omega^6 - 7\omega^4 + 16\omega^2}\right|_{\omega=3} = 3,33$$

6) $Im/\omega = 0$

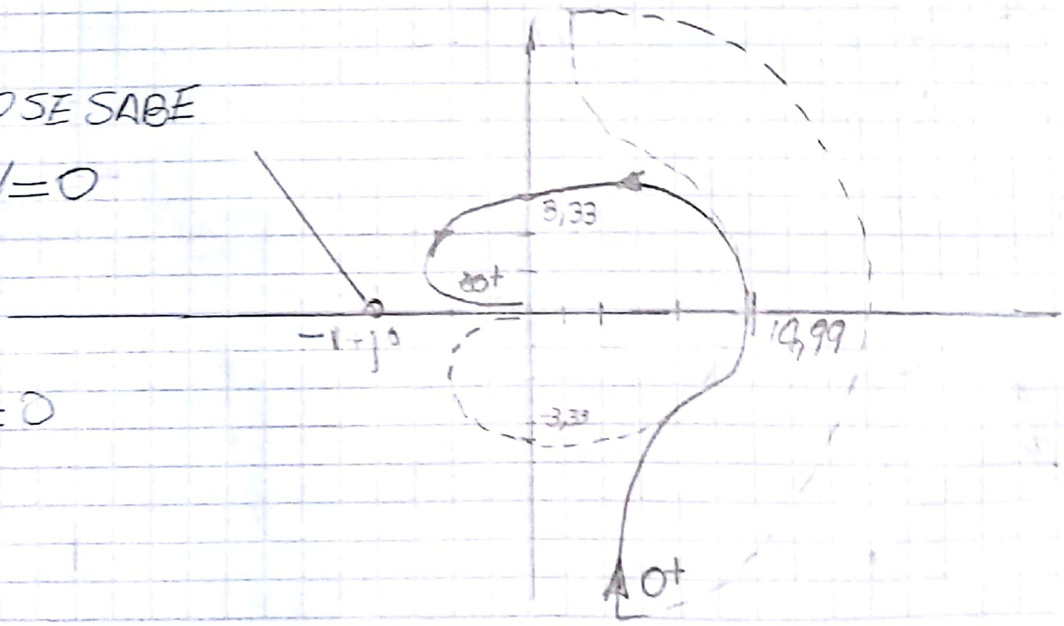
$60\omega^3 - 200\omega = 0 \quad$ Raíces $= \frac{\sqrt{30}}{3} \Rightarrow \omega = 1,825741$

7) Corte al eje Real

$$\left.\frac{90\omega^2 - 10\omega^4}{\omega^6 - 7\omega^4 + 16\omega^2}\right|_{\omega=1,825} = 14,99$$

NO SE SABE

N=0



N=0

Final 21/02/2018 (idem al sept. 2020 de Rojas)

$$G(P)H(P) = \frac{10(P-1)}{P^3+4P^2+8P} = \frac{10P-10}{P^3+4P^2+8P}$$

1) Inicio para $P \to 0$

$$G(P)\,H(P)\Big|_{P\to 0} = \frac{-10}{P} = \infty \angle -90.1 -180 = \infty \angle -270^0$$

2) Final para $P \to \infty$

$$G(P)\,H(P)\Big|_{P\to\infty} = \frac{10\cancel{P}}{P^3} = \frac{10}{P^2} = 0 \angle -180^0$$

3) $P \to jW$ $\quad P = jW \,,\ P^2 = -W^2 \,;\ P^3 = -jW^3$

Reemplazo;

$$\frac{10jW-10}{-jW^3+4(-W^2)+8jW} = \frac{-10+j10W}{-4W^2+j(8W-W^3)} \cdot \frac{-4W^2-j(8W-W^3)}{-4W^2-j(8W-W^3)}$$

$$= \frac{40W^2+j80W-10jW^3-j40W^3+80W^2-10W^4}{16W^4+(8W-W^3)^2}$$

$$= \frac{120W^2-10W^4+j(-50W^3+80W^2+80W)}{W^6+64W^2}$$

$$= \underbrace{\frac{120W^2-10W^4}{W^6+64W^2}}_{Re} + j\underbrace{\frac{(-50W^3+80W^2+80W)}{W^6+64W^2}}_{Img}$$

4

Final ~~05/12/~~2017

$$\boxed{G(P)\,H(P) = \frac{10(P+10)}{P^3 + \cancel{12}\,4P^2 + 8P}} = \frac{10P + 100}{P^3 + 4P^2 + 8P}$$

1) Inicio para $P \to 0$

$$G(P)H(P)\Big|_{P\to 0} = \frac{+100}{P} = \cancel{\infty \angle -270^\circ}\ \infty \angle -90^\circ$$

2) Fin para $P \to \infty$

$$G\,H(P)\Big|_{P\to\infty} = \frac{10\cancel{P}}{P^{\cancel{3}}} = \frac{10}{P^2} = 0 \angle -180^\circ$$

3) $P \to j\omega$ $\quad P = j\omega\ ;\ P^2 = -\omega^2\ ,\ P^3 = -j\omega^3$

$$\frac{10j\omega + 100}{-j\omega^3 + 4.(-\omega^2) + 8j\omega} = \frac{100 + j10\omega}{-4\omega^2 + j(8\omega - \omega^3)} \cdot \frac{-4\omega^2 - j(8\omega - \omega^3)}{-4\omega^2 - j(8\omega - \omega^3)}$$

$$= \frac{-400\omega^2 - j800\omega + j100\omega^3 - j40\omega^3 + 80\omega^2 - 10\omega^4}{\cancel{16\omega^2}\ \ \omega^6 + 64\omega^2}$$

$$= \frac{-320\omega^2 - 10\omega^4}{\omega^6 + 64\omega^2} + j\,\frac{(60\omega^3 - 800\omega)}{\omega^6 + 64\omega^2}$$

4) $\mathrm{Re}\big|_{\omega=0}$ $\quad -320\omega^2 - 10\omega^4 = 0 \Rightarrow \omega = j4\sqrt{2}$

5) La frecuencia ω es un número real, por lo que

No hay corte al eje Imaginario.

6) $Im|_{\omega}=0$

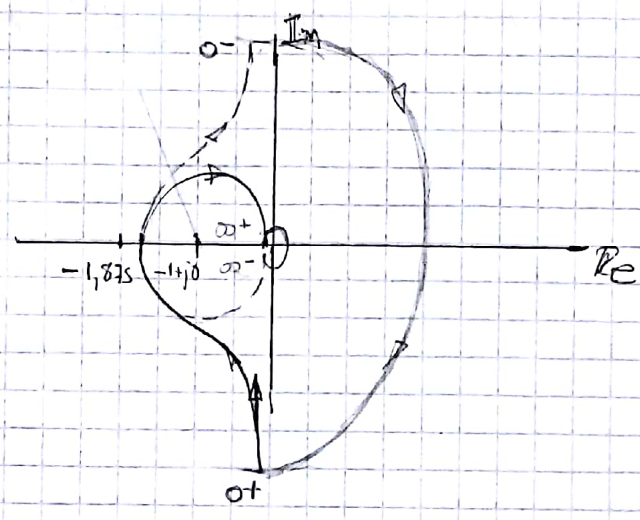
$60\omega^3 - 800\omega = 0 \qquad \omega = \frac{2\sqrt{30}}{3} = 3,6514$

7) Corte al eje Real

$$\left.\frac{-320\omega^2 - 10\omega^4}{\omega^6 + 64\omega^2}\right|_{\omega=\frac{2\sqrt{30}}{3}} = -\frac{15}{8} = -1,875$$

$N = +2$

INESTABLE

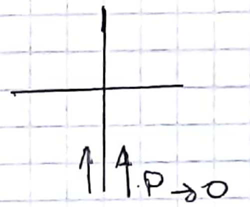


Final
30/05/2010

Nyquist.

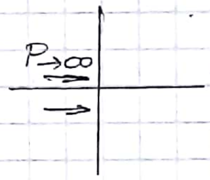
$$\boxed{G(P)\cdot H(P) = \frac{20(P+4)}{P^3+2P^2+4P}} = \frac{20P+80}{P^3+2P^2+4P}$$

1) Inicio para $P\to 0$



$$G(P)\,H(P)\Big|_{P\to 0} = \frac{80}{4P} = \infty\angle{-90^\circ}$$

2) Final para $P\to\infty$



$$G(P)\,H(P)\Big|_{P\to\infty} = \frac{20P}{P^{\cancel{3}2}} = \frac{20}{P^2} = 0\angle{-180^\circ}$$

3) $P\to jw$ $\quad P=jw\,;\ P^2=-w^2\,;\ P^3=-jw^3$

$$G(jw)\,H(jw) = \frac{20jw+80}{-jw^3+2(-w^2)+4jw} = \frac{80+j20w}{-2w^2+j(4w-w^3)}\cdot\frac{-2w^2-j(4w-w^3)}{-2w^2-j(4w-w^3)}$$

$$= \frac{-20w^4-80w^2}{w^6-4w^4+16w^2} + j\,\frac{40w^3-320w}{w^6-4w^4+16w^2}$$

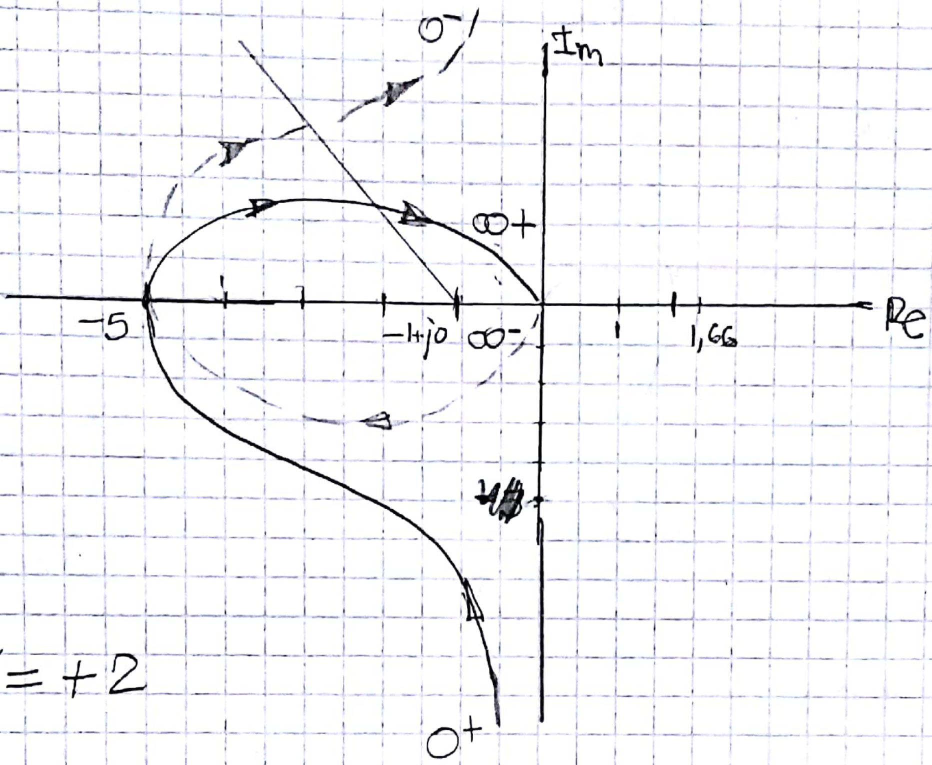
4) $Re|_w = 0$

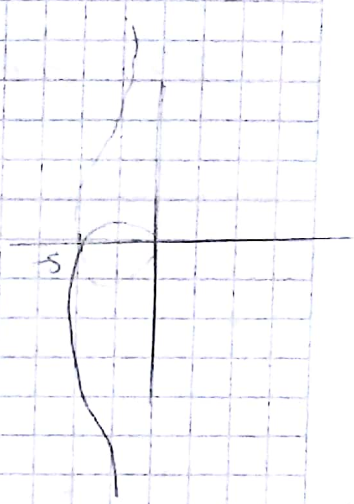
$-20w^4-80w^2=0 \Rightarrow \cancel{w=2}$ $\quad W$ es un imaginario $\therefore$ No hay

5) Corte al eje Imaginario

6) $Im|_w = 0$ $\quad 40w^3-320w=0 \Rightarrow w=2\sqrt{2}$

7) $\left.Re\right|_{\omega=2\sqrt{2}} = \boxed{-5}$ $\cancel{\frac{5}{3}} = \cancel{1{,}666}$ Corte al eje Real





$N = +2$

INESTABLE

Ejemplo de Abad — Nyquist — 2020

$$G(P)H(P) = \frac{10P+20}{P^2-3P} = 10\frac{(P+20)}{P(P-3)}$$

1) Inico para $P \to 0$: $\frac{20}{-3P} = -\infty\angle -90 = \infty \angle -270^0$

2) Final para $P \to \infty$ $\frac{10\cancel{P}}{P^{\cancel{2}}} = \frac{10}{P} = 0 \angle -90^0$

3) $P \to jw$

$$G(jw)H(jw) = \frac{-50w^2}{w^4+9w^2} + j\frac{60w-10w^3}{w^4+9w^2}$$

4) $Re/_w = 0$ $\frac{-50w^2}{w^4+9w^2} = 0$ $-50w^2 = 0$

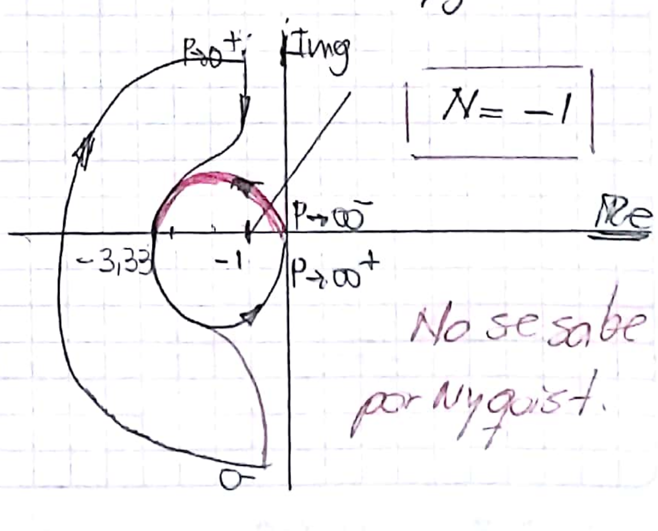
Como w debe ~~ser~~ ser un número Real

5) Por lo tanto no hay corte al eje real, salvo para $w \to 0$ y $w \to \infty$

6) $Img/_w = 0$ $60w - 10w^3 = 0$ $\therefore$ $w = \pm\sqrt{\frac{60}{10}} = +2,4494$

7) Corte al eje Real

$$\left.\frac{-50w^2}{w^4+9w^2}\right|_{w=2,4494} = -3,33$$



$\boxed{N = -1}$

No se sabe por Nyquist.

Ejemplos

$$G(P)\,H(P) = \frac{100}{P^3+5P^2+6P} \Rightarrow \text{Inestable}$$

$$G(P)\,H(P) = \frac{10P+30}{P^2-4} \Rightarrow \text{Estable}$$

$$G(P)\,H(P) = \frac{50P+150}{P^3-P^2+11P-51} \Rightarrow \text{Inestable}$$

$$G(P)\,H(P) = \frac{10P+20}{P^3+3P^2} \Rightarrow \text{Estable.}$$

$$G(P)\,H(P) = \frac{20}{P^3+5P^2+6P} = \frac{20}{P(P+3)(P+2)} \Rightarrow \underline{\text{Estable}}$$

$$G(P)\,H(P) = \frac{10P+40}{P^3-6P^2-16P} \Rightarrow \underline{\text{Inestable}} \quad N=1$$

(Aunque reduzca la Ganancia seguira siendo inestable

$$G(P)\,H(P) = \frac{Kte}{P^3+2P^2+4P}$$

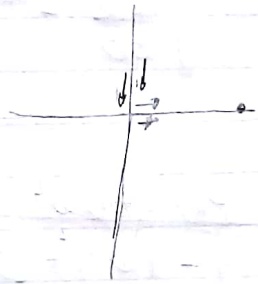
con $Kte = 10$ u 8 Sistema Inestable

con Kte $6 \Rightarrow$ Estable

Si Reduzco Ganancia si es Estable)

Ejemplo:

$$G(p)\cdot H(p) = \frac{20}{p^3+4p^2+5p+4} = \frac{20}{}$$



(1) Origen del diagrama

$$\lim_{p\to 0} G(p)\cdot H(p) = \frac{20}{4} = 5\angle 0^\circ$$

(2) Determinar el final del diagrama

$$\lim_{p\to\infty} G(p)\cdot H(p) = \frac{20}{p^3} = \frac{Kte}{p^3\cdot(e^{j90})^3} = 0\angle -90\cdot 3 = -270$$

$$0\angle -0\cdot 3 =$$

(3) $P \to j\omega =$

$$\frac{20}{-j\omega^3 - 4\omega^2 + j5\omega + 4} = \frac{20}{-4\omega^2+4+j(\omega\cdot 5-\omega^3)}$$

$$= \frac{20}{4-4\omega^2+j(\omega\cdot 5-\omega^3)} \cdot \frac{(4-4\omega^2)-j(\omega 5-\omega^3)}{(4-4\omega^2)-j(\omega 5\cdot\omega^3)}$$

$$= \frac{80-80\omega^2-j(100\omega-20\omega^3)}{(4-4\omega^2)^2+(\omega\cdot 5-\omega^3)^2} = \frac{80-80\omega^2}{(4-4\omega^2)^2+(5\omega-\omega^3)^2} - \frac{j(100\omega-20\omega^3)}{}$$

(4)

Real $= 0$

$$80-80\omega^2 = 0 \wedge 80 = 80\omega^2$$

$$\sqrt{1} = \pm 1$$

$\mathrm{Im}_{\omega=1} =$

$$\frac{-j((100-20))}{(4-4)+(5-1)^2} = \frac{80}{16} = \boxed{-j5}$$

Scanned by CamScanner

$100w - 20w^3 = 0 \rightarrow w(100 - 20w^2) =$

$100 = 20w^2$

$\sqrt{\frac{100}{20}} = w = 2,23$

$$\frac{80-80w^2}{(4-4w^2)^2+(5w-w^3)^2} = \frac{80-80.(2,23)^2}{(4-4.(2,23)^2)^2+(5.2,23-(2,23)^3)^2}$$

$= -1,25$

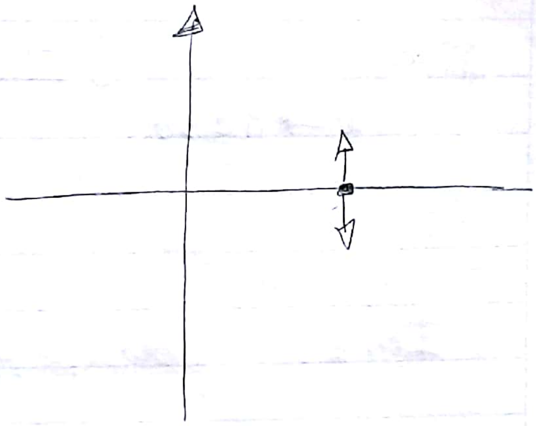
Analisis del Argumento:

$$tg^{-1}\frac{Im}{Real} = \frac{(\overbrace{100w}^{0}+\overbrace{20w^3}^{\infty})}{\underbrace{80}_{0}-\underbrace{80w^2}_{\infty}} = - \qquad w=0 \quad tg^{-1} = -\#$$

$\lim_{\infty}$ $\qquad w=$

$$F(p) = \frac{10}{p^3 + 2p^2 + 2p + 40}$$

① Origem del Diagrama.



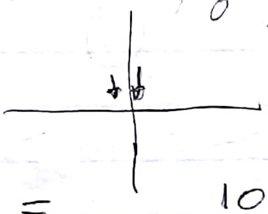
$$\lim_{p \to 0} \frac{10}{40} = 0{,}25 = 0{,}25 \angle 0^\circ$$

② Final del Diagrama.

$$\lim_{p \to \infty} \frac{10}{p^3 + 2p^2 + 2p + 40} = \frac{10}{p^3\left(1 + \frac{2\cancel{p^2}}{p^{\cancel{3}}} + \frac{2\cancel{p}}{p^{\cancel{3}\,2}} + \frac{40}{p^3}\right)} = \frac{10}{(P \cdot e^{j90})^3}$$

$$= e^{j90 \cdot 3} \qquad \boxed{= 0 \angle -270^\circ}$$

③ $p \to j\omega$



$$F(j\omega) = \frac{10}{(j\omega)^3 + 2(j\omega)^2 + 2j\omega + 40} = \frac{10}{-j\omega^3 - 2\omega^2 + j2\omega + 40} = \frac{10}{(40 - 2\omega^2) + j(2\omega - \omega^3)}$$

$$= \frac{10}{(40 - 2\omega^2) + j(2\omega - \omega^3)}$$

④ $\boxed{F(j\omega) = Re + Im}$

$$F(j\omega) = \frac{10}{(40 - 2\omega^2) + j(2\omega - \omega^3)} \cdot \frac{(40 - 2\omega^2) - j(2\omega - \omega^3)}{(40 - 2\omega^2) - j(2\omega - \omega^3)} =$$

$$= \frac{10(40 - 2\omega^2) - j10(2\omega - \omega^3)}{(40 - 2\omega^2)^2 + (2\omega - \omega^3)^2} = \frac{10(40 - 2\omega^2)}{(40 - 2\omega^2)^2 + (2\omega - \omega^3)^2} - \frac{j10(2\omega - \omega^3)}{(40 - 2\omega^2)^2 + (2\omega - \omega^3)^2}$$

⑤ $Re = 0$

$$\frac{10(40 - 2\omega^2)}{(40 - 2\omega^2)^2 + (2\omega - \omega^3)^2} = 0 \to = 10(40 - 2\omega^2) = \boxed{2\sqrt{5}}$$

$$= 400 - 20\omega^2 \quad \to 2\sqrt{5}, \; -2\sqrt{5}$$

$$=$$

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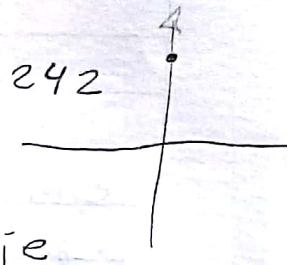
(6)

$$Im\Big|_{\omega \to Re=0} \quad j\,\frac{-10.(2.(2\sqrt{5})-(2\sqrt{5})^3)}{\underbrace{(40-2(2\sqrt{5})^2)^2}_{0}+(2(2\sqrt{5})-(2\sqrt{5})^3)^2}$$

$$Im\Big|_{\omega \to Re=0} \quad j\,\frac{-10}{(2(2\sqrt{5})-(2\sqrt{5})^3)} = j\,0,1242$$



↳ Corte al eje Im para $\omega = 2\sqrt{5}$ [rps]

(7) Im = 0 y despejar ω:

$$\frac{-10(2\omega-\omega^3)}{(40-2\omega^2)^2+(2\omega-\omega^3)^2}=0 \Rightarrow -10(2\omega-\omega^3)=0$$

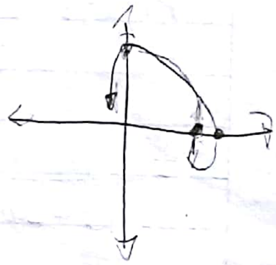
$$10\omega^3-20\omega=0 \rightarrow \sqrt{2}=1,4142 \quad -\sqrt{2} \quad 0$$

(8)

$$Re\Big|_{\omega \to Im=0} \quad \frac{10(40-2(\sqrt{2})^2)}{(40-2(\sqrt{2})^2)^2+\underbrace{(2.\sqrt{2}-(\sqrt{2})^3)^2}_{0}} = \frac{10}{36} =$$

$= 0,2778$

↳ Corte al eje Re para $\omega=\sqrt{2}$ [rps]



(9) Analisis de Argumento:

$$\varphi = tg^{-1}\frac{Im}{Re} = tg^{-1}\frac{-\cancel{10}(2\omega-\omega^3)}{\cancel{10}(40-2(\omega)^2)}$$

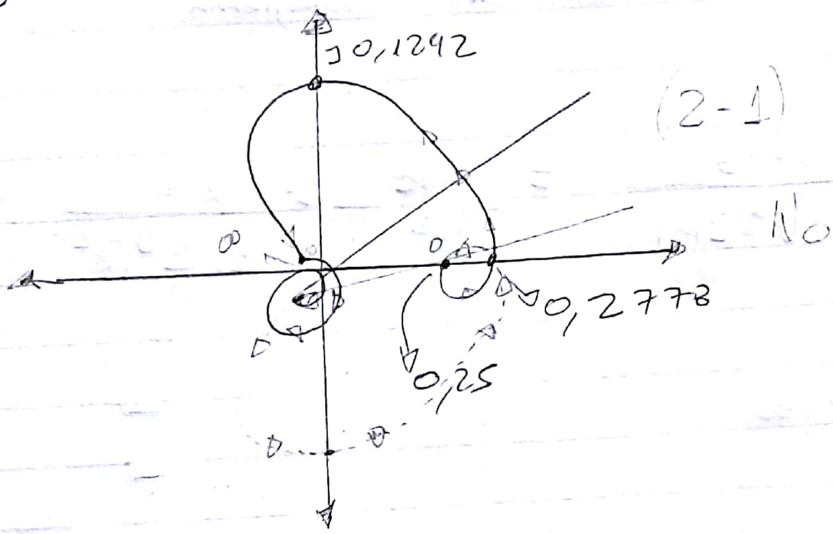
4(−)

$p/\omega \to 0 : tg^{-1} = \frac{-}{+}$ (4° Cuadrante) (2° Cuadrante)

$$p/\omega \to \infty : tg^{-1} = \frac{-(2\omega-\omega^3)}{(40-2.(\omega)^2)} = \frac{+\omega^3}{-2(\omega)^2} = \frac{+}{-}$$

4to Cuad
2do

9) Diagrama polar



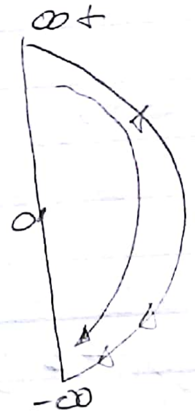
10) Cierre para $\rho \to 0$
Mismo punto que el 1: $0,25\angle 0°$

0 - ∞+ - (-∞ - (0

11) Cierre para $\rho \to \infty$
Mismo que la 2

$$\lim_{\rho \to \infty} \frac{10}{\rho^3} = \frac{10}{(\rho \cdot e^{j90})^3} = (0 \angle -90) \cdot 3$$

$\rho \to \infty$



$\sigma = -180$

$\phi = 3 \times -180° = -540°$

$-10\omega^3+8\omega)$

$$F(p)=\frac{10p+20}{p^4-2p^3+5p^2}=\frac{10p+20}{p^2\cdot(p^2-2p+5)}=$$

Paso 1: Para el comienzo del Diagrama

$$\lim_{\to 0} F(p)\ \frac{10p+20}{p^2(p^2-2p+5)}=\frac{Kte}{p^2}=\frac{Kte}{(\varepsilon.e^{J90})^2}=\frac{Kte}{\varepsilon^2.e^{J180}}$$

$$\boxed{=\infty\angle-180}$$

Paso 2: Final de la grafica

$F_{(p)}$ $_{\to\infty}$

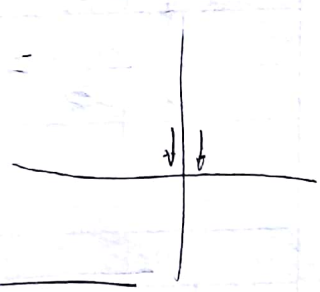
$$\lim_{\to\infty} F(p)\ \frac{10p+20}{p^4-2p^3+5p^2}=\frac{Kte}{p^3}=\frac{Kte}{(p^3.e^{J90})^3}=|0|\angle-270$$

Paso 3: $P\to J\omega$

$J^1=J$ $\quad J^4=1$

$J^2=-1$ $\quad J^5=J$

$J^3=-J$



$$F_{(J\omega)}=\frac{10(J\omega)+20}{(J\omega)^4-2.(J\omega)^3+5.(J\omega)^2}=\frac{10(J\omega)+20}{\omega^4-5\omega^2+J2.\omega^3}$$

Paso 4: Separo $Re+Im.$

$$=\frac{10(J\omega)+20}{(\omega^4-5\omega^2)+J2\omega^3}\cdot\frac{\omega^4-5\omega^2-J2\omega^3}{(\omega^4-5\omega^2)-J2\omega^3}=$$

$$=\frac{40\omega^4-100\omega^2}{(\omega^4-5\omega^2)^2+(2\omega^3)^2}+J\frac{10\omega^5-90\omega^3}{(\omega^4-5\omega^2)^2+(2\omega^3)^2}$$

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Paso 5:

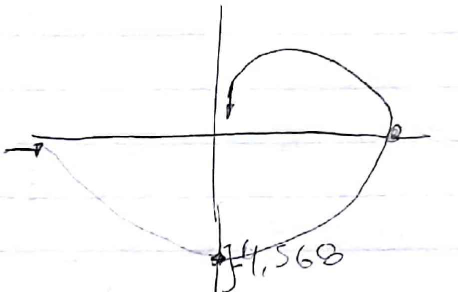
Real = 0

$N°$ = Grado 4 -
De = Grado 8
4 denominador

$$\frac{40\omega^4 - 100\omega^2}{(\omega^4 - 5\omega^2)^2 + (2\omega^3)^2} = 0 \Rightarrow 40\omega^4 - 100\omega^2 = 0$$

$$40\omega^4 - 100\omega^2 = 0 \rightarrow \omega^2(40\omega^2 - 100) = 0$$

$$\omega = \sqrt{\frac{100}{40}} = \pm 1{,}5811$$



Paso 6: Lo inserto en Im ω:

$$= J\,\frac{10\cdot(1{,}5811)^5 - 90\cdot(1{,}5811)^3}{(1{,}5811)^4 - 5\cdot(1{,}5811^2) + (2\cdot(1{,}5811)^3)^2} = \frac{-256{,}92}{56{,}2407}$$

$4\omega^{6(3\cdot2)}$

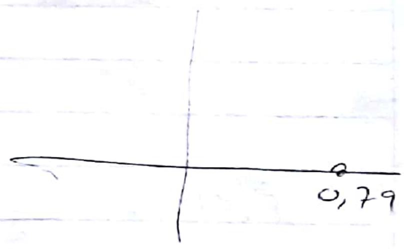
$$= J\frac{(10\omega^5 - 90\omega^3)}{(\omega^4 - 5\omega^2) + 4\omega^6} = \boxed{-J4{,}568}$$

Corte en el eje Imaginario

Paso 7: Im = 0

$$(10(\omega)^5 - 90(\omega)^3 = 0$$

$$\omega^3(10\omega^2 - 90) = 0 \qquad \omega = \sqrt{\frac{90}{10}} = \pm 3$$



Paso 8: Real $\omega = 3$

$$\frac{40(3)^4 - 100(3)^2}{((3)^4 - 5\cdot(3)^2)^2 + (2\cdot 3^3)^2} = 0{,}79$$ Corte en el eje Real

Paso 9: Analisis del Argumento:

$$p\,\omega \to 0 = tg^{-1} = \frac{Im}{Real} = \frac{10\omega^2 - 90}{40\omega^2 - 100} = +$$

1° Cuadrante
3° Cuadrante

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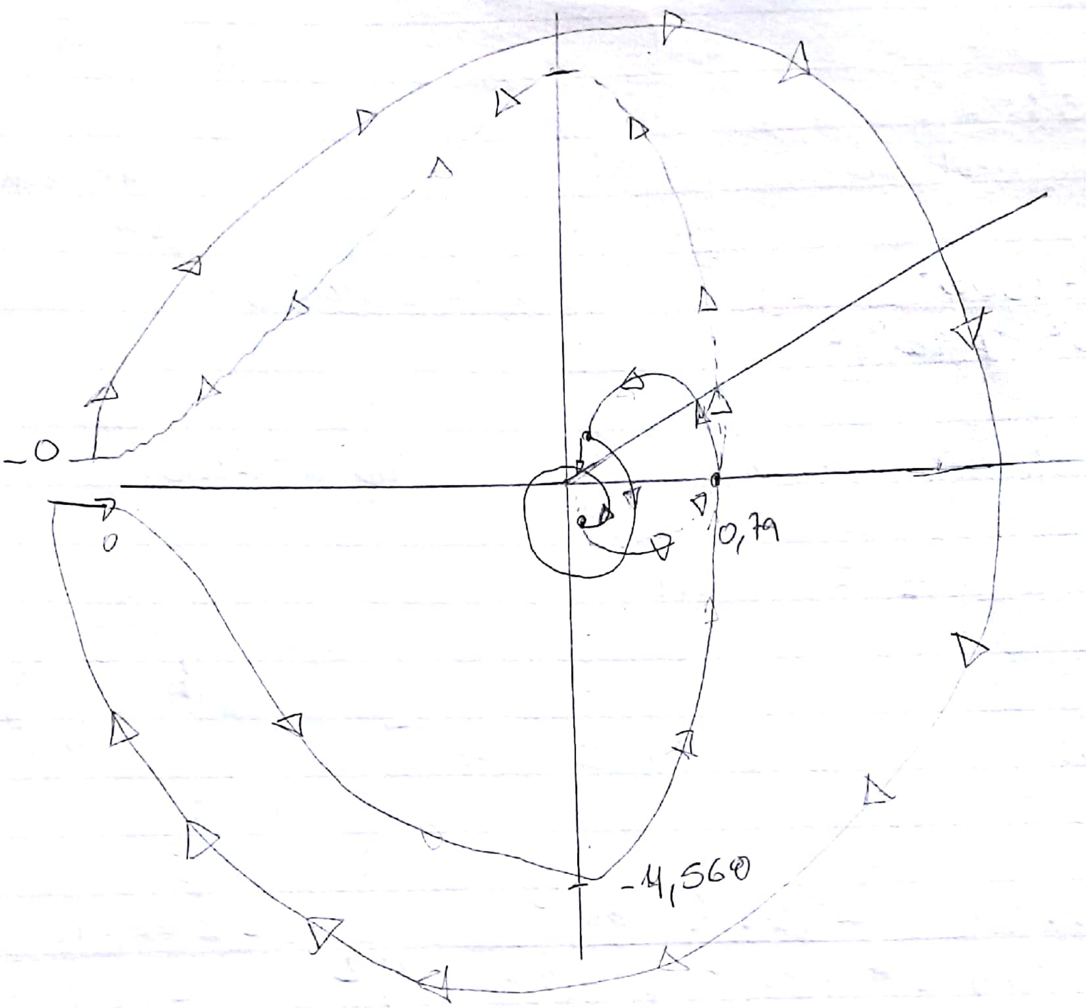
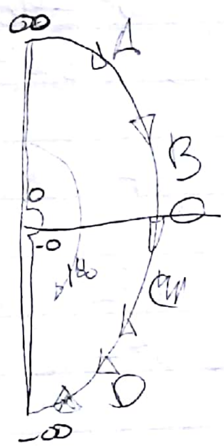


(10) Cierre para $\rho \to 0$ $\qquad 0^+ \to 0^-$

$$F(P)\Big|_{\rho \to 0} = \frac{K\,de}{\rho^2} = 100 / \angle 2 \cdot \theta$$

$\theta = -180 \qquad 2 \cdot 180 = 360$



$$F(P)_{P \to \infty} = \frac{10}{\rho^3} = \frac{10}{\rho \cdot (e^{j\theta})^3} = 0 \angle 3 \cdot \theta - 180^\circ$$

$$= 0 \angle -540$$

$$(0^+) \to (\infty^+) \to (\infty^-) \to (-0)$$

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Ejercicios de Nyquist.

Trazar el diagrama polar y aplique criterio de Nyquist.

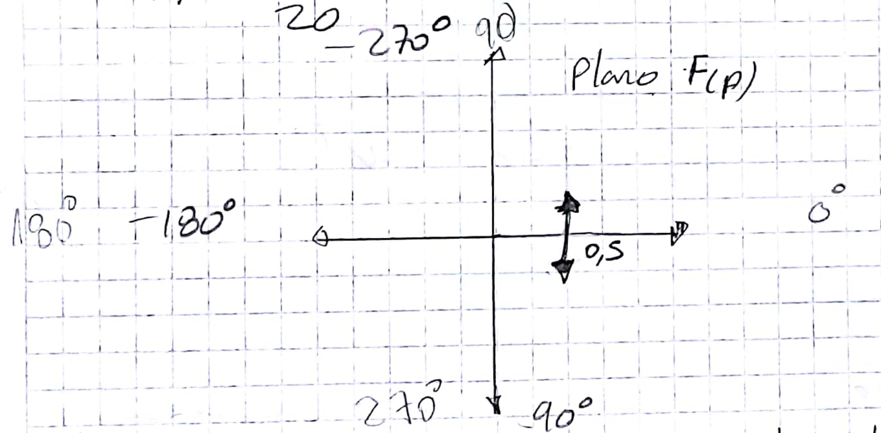
$$\boxed{F(p)=\frac{10}{(p^4+6.p^3+8.p^2+10.p+20)}}$$

1er Paso: Determinar el Origen del diagrama polar:

Evaluar $F(p)|_{p\to 0}$ ó $G(p).H(p)|_{p\to 0}$

$F(p)=\frac{10}{20}=0,5\,\angle 0$ Modulo 0,5 ; angulo cero.

Porque no hay "P".

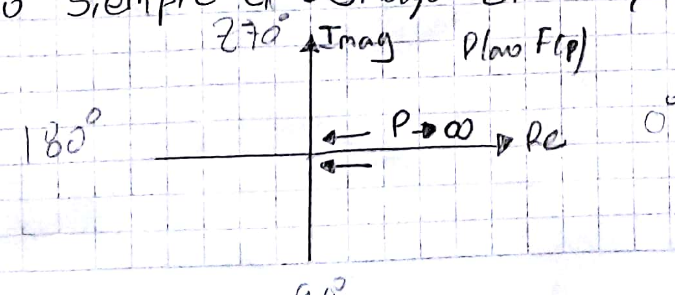


2do Paso: Determinar el final del diagrama Polar.

Evaluar $F(p)|_{p\to\infty}$ ó $G(p) * H(p)|_{p\to\infty}$

$$F(p)_{p\to\infty}=\frac{10}{p^4}=\frac{10}{\infty}=0\,\angle{-4\cdot 90°}=|0|\cdot\angle{-360°}$$

"Tomo siempre el de mayor orden y la constante.



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$J^2 = -1$; $J^0 = 1$; $J^1 = J$

Paso N°3: Cambiar en la función de transferencia $p \to J\omega$.

Es decir que $F(p) \to F(J\omega)$ o $G(p) * H(p) \to G(J\omega) . H(J\omega)$

$$p^4 = J^4 \omega^4 = J^2 . J^2 . \omega^4 = (-1).(-1).\omega^2 = 1\omega^4$$

$$p^3 = J^2 . J\omega^3 = -1 J\omega^3 = -J\omega^3$$

$$p^2 = J^2 \omega^2 = -\omega^2$$

$$p = J\omega = J\omega.$$

$$F(p) = \frac{10}{\omega^2 + 6.(-J\omega^3) + 8.(-\omega^2) + 10(J\omega) + 20}$$

$$F(p) = \frac{10}{\omega^4 + 6J\omega^3 - 8\omega^2 + 10J\omega + 20} = \frac{10}{(\omega^4 - 8\omega^2 + 20) + J(10J\omega - \dots}$$

Paso 4: $F(J\omega) = Re + J\, im$. Separa parte real y parte imaginaria.

$$F(p) = \frac{10}{(\omega^4 - 8\omega^2 + 20) + J(10\omega - 6\omega^3)} \cdot \frac{\omega^4 - 8\omega^2 + 20 - J(10\omega - 6\omega^3)}{(\omega^4 - 8\omega^2 + 20) - J(10\omega - 6\omega^3)}$$

Resultado

$$F(p) = \frac{10.(\omega^4 - 8\omega^2 + 20)}{(\omega^4 - 8\omega^2 + 20)^2 + (10\omega - 6\omega^3)^2} + J \frac{10.(6\omega^3 - 10\omega)}{(\omega^4 - 8\omega^2 + 20)^2 + J(10\omega - 6\omega^3)^2}$$

43210

Paso N°5:

Hacer la parte real de $F(j\omega)$ o de $G(j\omega) * H(j\omega)$ igual a cero.

$Re|F(j\omega) = 0$

$$Re = 0 = \frac{10\ (\omega^4 - 8\omega^2 + 20)}{(\omega^4 - 8\omega^2 + 20)^2 + (10.\omega - 6\omega^3)^2} = 0$$

Calculo las raíces. No hay ningun valor real de ω.

Recordatorio: Si hay un valor de ω que me hace la parte real cero. Este valor de ω lo evaluo en la parte imaginaria y eso va a ser el corte al eje imaginario.

Paso N°6: Corte imaginario:

$$Img|_{F(j\omega)}|_{\omega \to Re = 0}.$$

No Tenemos

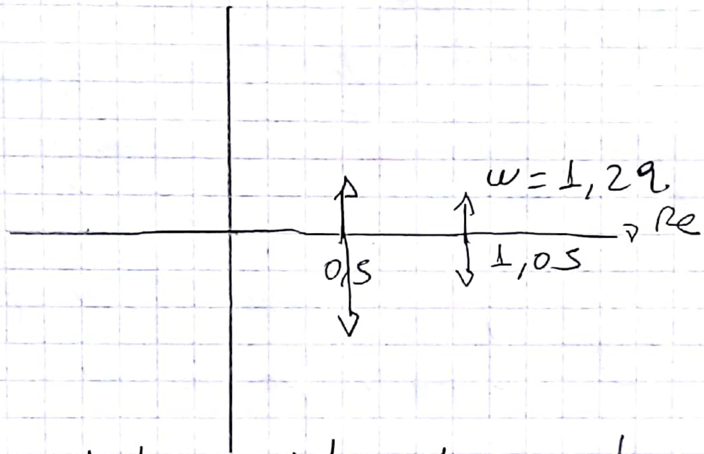
Paso N° 7: Hacer la parte imaginaria de $F(j\omega)$ o de $G(j\omega) * H(j\omega)$ igual a cero.

$$Im_{F(j\omega)} = 0 = j\frac{10.(6\omega^3 - 10\omega)}{(\omega^4 - 8\omega^2 + 20)^2 + j(10\omega - 6\omega^3)^2} =$$

$$\omega = \sqrt{\frac{10}{6}} = \pm 1{,}290$$

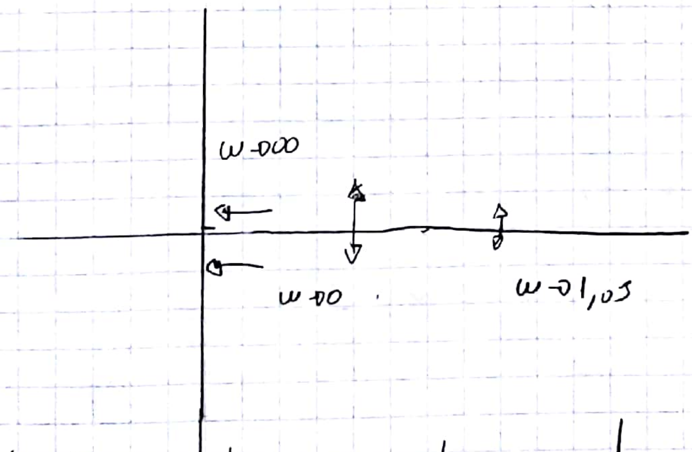
Paso 8: Determinar el corte al eje real, con "ω" obtenida en Paso 7.

$$Re\Big|_{\omega=+1,290} = \frac{10(\omega^4-8\omega^2+20)}{(\omega^4-8\omega^2+20)^2+(10} = 1,0588.$$

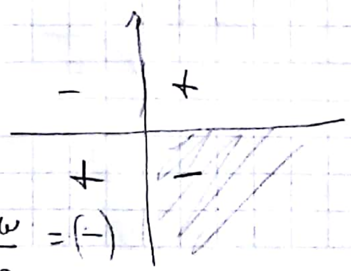


Paso 9: Con los datos obtenidos en los pasos 1, 2, 6, 7 y 8, Trazar el diagrama polar de las frecuencias positivas.

Luego Trazar las frecuencias negativas, Haciendo el espejo de la curva anterior sobre el eje real



Si tengo dudas de como trazar la curva me Fijo en el argumento.



a) $\text{Fase} = tg^{-1} = \dfrac{6\omega^3-10\omega}{\omega^4-8\omega^2+20} = \ldots -\pi$ $\quad \omega\to 0 \quad -\dfrac{10\omega}{20} = (-)$

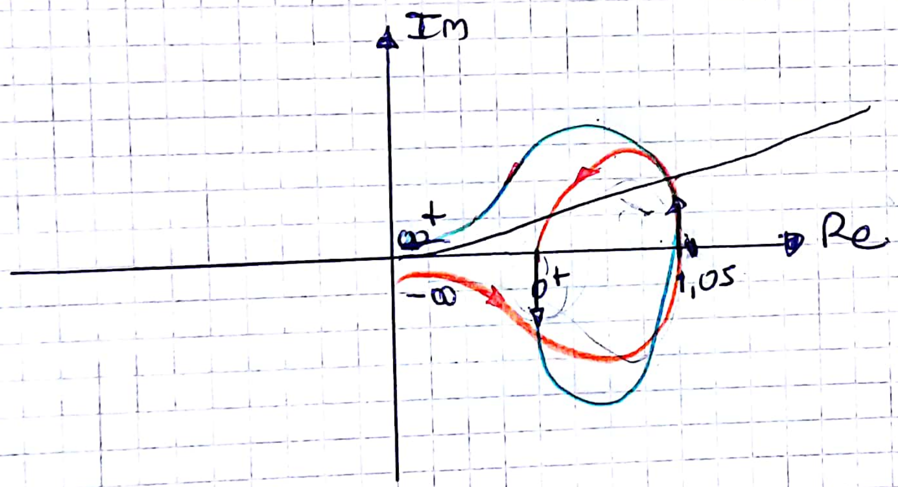
b) Fase $= tg^{-1} \dfrac{6\omega^3 - 10\omega}{\omega^4 - 8\omega^2 + 20} = \dfrac{6-10}{1-8+20} = \dfrac{-4}{13}$

$\omega = 1$

Positivo no se porque?

Fase $= tg^{-1} \dfrac{6\omega^3 - 10\omega}{\omega^4 - 8\omega^2 + 20} = \dfrac{6\omega^3}{\omega^4} = \dfrac{+}{+} = +$

$\omega \to \infty$



N = -2

INESTABLE

Paso N°10 = Cerrar diagrama para P→0

Dado que la función no tiene polos en el origem, este paso no se aplica.

$-10\omega^4 + 80\omega^2 + 40\omega + J(-40\omega^2 - 10\omega^3 + 8\omega)$

Ejemplo 2: NyQuist.

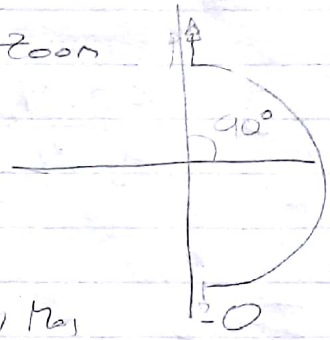
$$F(p) = \frac{5p+30}{p^5 - 3p^4 + 2p^3} = \frac{5(p+6)}{p^3(p^2-3p+2)}$$

① Determino el Comienzo del diagrama

$$\lim_{p \to 0} = \frac{5}{p^3} = \frac{K.Je}{\varepsilon^3.(e^{390})^3} = \infty \angle -270$$

$$= \infty \angle -3.\theta$$

zoom



valor muy alto

② Fin del diagrama

Pregunta

$$\lim_{p \to \infty} = \frac{5p+30}{p^5 - 3p^4 + 2p^3} = \frac{Kte}{p^4} = 0 \angle -4.\theta$$

$$= \frac{Kte}{P.(e^{390})}$$

③ $P \to (J\omega)$

$$F(p) = \frac{5.(J\omega) + 30}{J\omega^5 - 3.\omega^4 + J2.\omega^3}$$

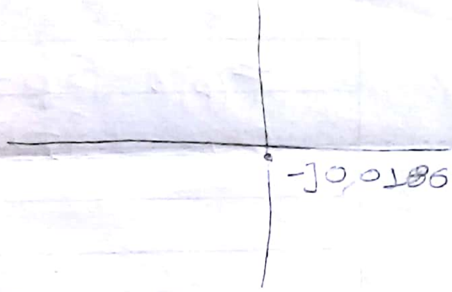
④ Separa Real + Ima

$$F(p) = \frac{5J\omega + 30}{3\omega^4 + J(\omega^5 - 2\omega^3)} \cdot \frac{-3\omega^4 - J(\omega^5 - 2\omega^3)}{-3\omega^4 - J(\omega^5 - 2\omega^3)}$$

$$F(p) = \frac{5\omega^6 - 100\omega^4}{9\omega^8 + (\omega^5 - 2\omega^3)^2} + J\frac{(60\omega^3 - 45\omega^5)}{9\omega^8 + (\omega^5 - 2\omega^3)^2}$$

(5) $F(j\omega) = \overset{Re=0}{\overline{5\omega^6 - 100\omega^4}} = 0 \rightarrow \omega^4(5\omega^2 - 100)$

$\omega = \sqrt{\frac{100}{5}} = \pm 4{,}47$



(6) $Im\big|_{\omega = Real_0} =$

$j\,\dfrac{60.(4{,}47)^3 - 45.(4{,}47)^5}{9.(4{,}47)^8 + ((-4{,}97)^5 - 2.(4{,}97)^3)^2} = -j\,0{,}0186$

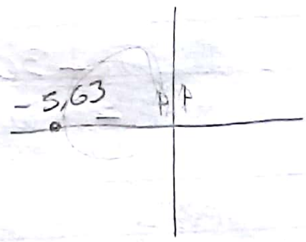
(8) $Im = 0$

$60\omega^3 - 45\omega^5 = 0 \rightarrow \omega^3 \cdot (60 - 45\omega^2)$

$60 = 45\omega^2$

$\sqrt{\frac{60}{45}} = \omega = 1{,}154$

$Rea = \Big|_{\omega \, Im=0} \dfrac{5\omega^6 - 100\omega^4}{9\omega^8 + (\omega^5 - 2\omega^3)^2} = -5{,}63$



(9) Analisis de Argumento

$p \rightarrow \omega = 0 \quad tg^{-1}\dfrac{Im}{Real} = \dfrac{60 - 45\omega^2}{5\omega^2 - 100} = -$ 2do o Cuadr

$p \rightarrow \omega = \infty \quad tg^{-1}\dfrac{Im}{Real} = \dfrac{60 - 45\omega^2}{5\omega^2 - 100} = \dfrac{-45\omega^2}{5\omega^2} = -$ Cuarto Cuadrant

Cierre para $p \rightarrow 0$

$-3.180 = -510$

Cierre para $p \rightarrow \infty$

$-4.180 = -720$