PRÁCTICA

"CRITERIO DE NYQUIST"

FUNCIÓN DE TRANSFERENCIA TOTAL

por

Ing. Juan José Garcia Abad

EJEMPLO 1

Dada la siguiente función de Transferencia Total, trace el diagrama polar y aplique criterio de Nyquist

$$F_{(P)} = \frac{10\,P + 20}{P^4 - 2P^3 + 5P^2}$$

EJEMPLO 1

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PASO 1 : Origen del Diagrama $F(P)\big|_{P \to 0}$

EJEMPLO 1

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PASO 1 : Origen del Diagrama $F(P)\big|_{P \to 0}$

$$F_{(P)}\Big|_{P\to 0} = \frac{Kcte}{P^2}\Big|_{P\to 0} = |\infty| \angle -180^{\circ}$$

EJEMPLO 1

$$F_{(P)} = \frac{10P + 20}{P^4 - 2P^3 + 5P^2}$$

PASO 2 : Final del Diagrama $F(P)|_{P \to \infty}$

EJEMPLO 1

$$F_{(P)} = \frac{10P + 20}{P^4 - 2P^3 + 5P^2}$$

PASO 2 : Final del Diagrama $F(P)|_{P \to \infty}$

$$F_{(P)}\Big|_{P\to\infty} = \frac{Kcte}{P^3}\Big|_{P\to\infty} = |0| \xrightarrow{-270^\circ}$$

EJEMPLO 1

$$F_{(P)} = \frac{10\,P + 20}{P^4 - 2P^3 + 5P^2}$$

PASO 3 : P →jω es decir F(P) →F(j ω)

$$F_{(j\omega)} = \frac{10\,j\omega + 20}{\omega^4 + 2j\omega^3 - 5\omega^2}$$

EJEMPLO 1

$$F_{(j\omega)} = \frac{10\,j\omega + 20}{\omega^4 + 2j\omega^3 - 5\omega^2}$$

PASO 4 : F(jω) = Re +j Im

$$F_{(j\omega)} = \frac{40\,\omega^4 - 100\omega^2}{(\omega^4 - 5\omega^2)^2 + 4\omega^6} + j\,\frac{10\,\omega^5 - 90\omega^3}{(\omega^4 - 5\omega^2)^2 + 4\omega^6}$$

Re + j Im

EJEMPLO 1

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PASO 5 : $\mathrm{Re}\,|_{F(j\omega)} = 0$

EJEMPLO 1

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PASO 5 : $\mathrm{Re}\,|_{F(j\omega)} = 0$

$$\omega = \sqrt{\frac{100}{40}} = \pm 1{,}58113883$$

EJEMPLO 1

PASO 6 : Corte eje Imaginario. $\mathrm{Im}\,|_{F(j\omega)|\omega\to Re=0}$

$$\mathrm{Im}\,F_{(j\omega)}\Big|_{\omega=+1,5811} = j\,\frac{10\,\omega^5-90\,\omega^3}{(\omega^4-5\omega^2)^2+4\omega^6}\Bigg|_{\omega=+1,5811}$$

EJEMPLO 1

PASO 6 : Corte eje Imaginario. $\mathrm{Im}\,|_{F(j\omega)|\omega\to Re=0}$

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$$\mathrm{Im}\,F_{(j\omega)}\Big|_{\omega=+1,5811} = -j\;2,529822128$$

EJEMPLO 1

$$F_{(j\omega)} = \frac{40\,\omega^4 - 100\omega^2}{(\omega^4 - 5\omega^2)^2 + 4\omega^6} + j\,\frac{10\,\omega^5 - 90\omega^3}{(\omega^4 - 5\omega^2)^2 + 4\omega^6}$$

PASO 7 : = $\mathrm{Im}\,|_{F(j\omega)} = 0$

EJEMPLO 1

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PASO 7 : = $\mathrm{Im}\,|_{F(j\omega)} = 0$

$$\omega = \sqrt{\frac{90}{10}} = \pm 3$$

EJEMPLO 1

PASO 8 : Corte eje Real. $\mathrm{Re}\left|_{F(j\omega)\,\omega\to Im=0}\right.$

$$\mathrm{Re}_{F(j\omega)}\Big|_{\omega=+3} = \frac{40\,\omega^4-100\omega^2}{(\omega^4-5\omega^2)^2+4\omega^6}\Bigg|_{\omega=+3}$$

EJEMPLO 1

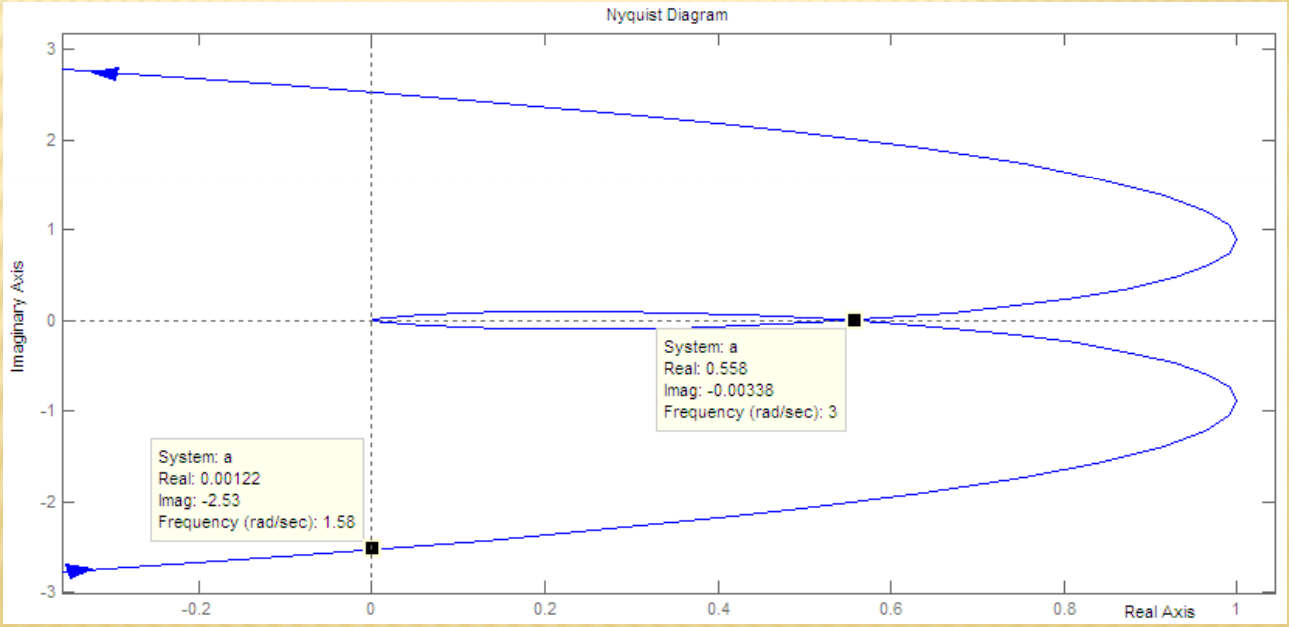
PASO 8 : Corte eje Real. $\mathrm{Re}\left|_{F(j\omega)\,\omega\to Im=0}\right.$

$$\mathrm{Re}_{F(j\omega)}\Big|_{\omega=+3} = \frac{40\,\omega^4-100\omega^2}{(\omega^4-5\omega^2)^2+4\omega^6}\Bigg|_{\omega=+3}$$

$$\mathrm{Re}_{F(j\omega)}\Big|_{\omega=+3} = 0{,}55555$$

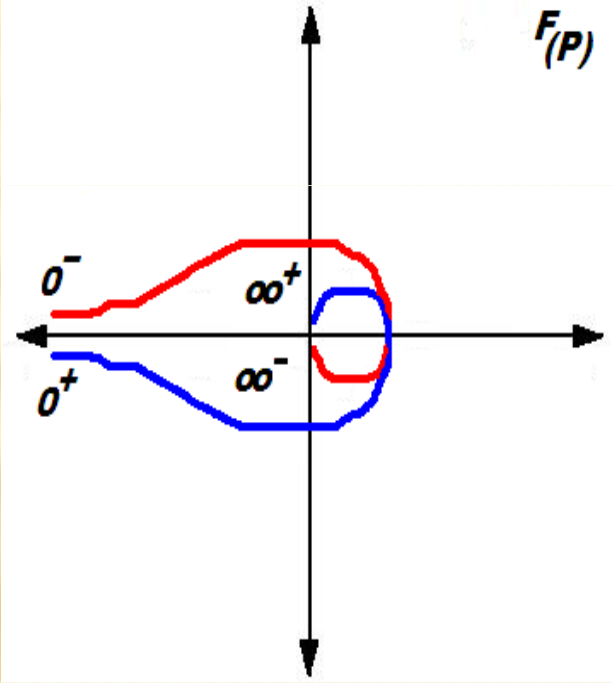
EJEMPLO 1

PASO 9 : Trazar el diagrama Polar



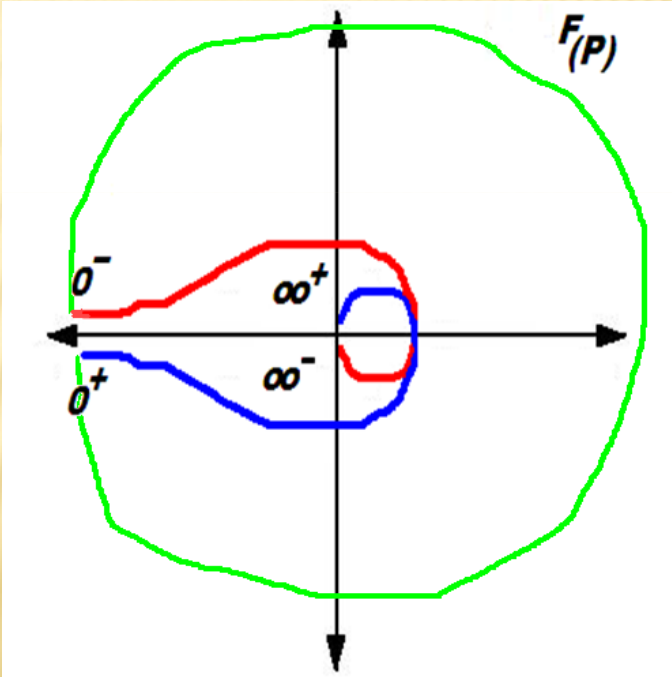
EJEMPLO 1

PASO 10 : Cerrar diagrama para P→0



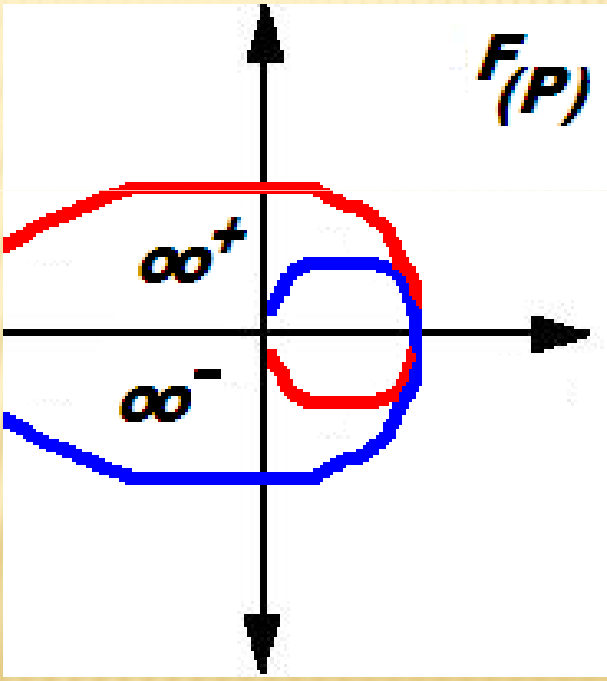
EJEMPLO 1

PASO 10 : Cerrar diagrama para P→0



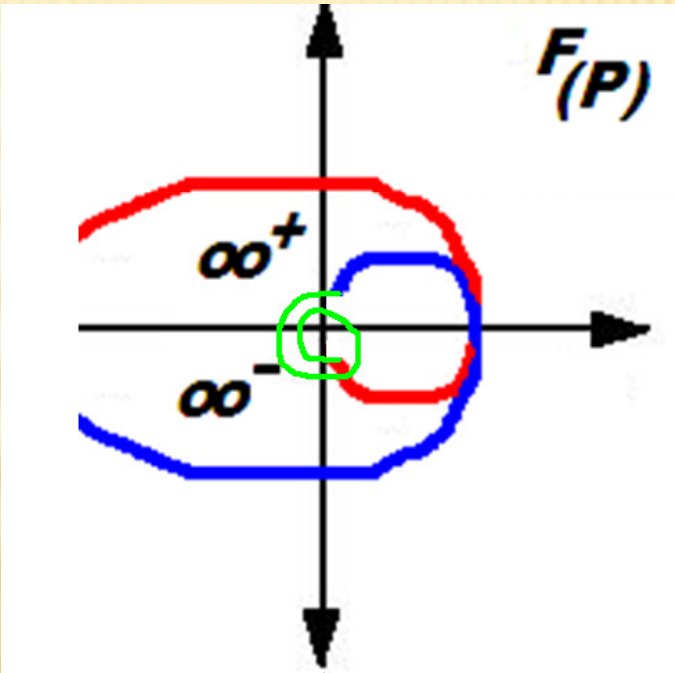
EJEMPLO 1

PASO 11 : Cerrar diagrama para P→∞



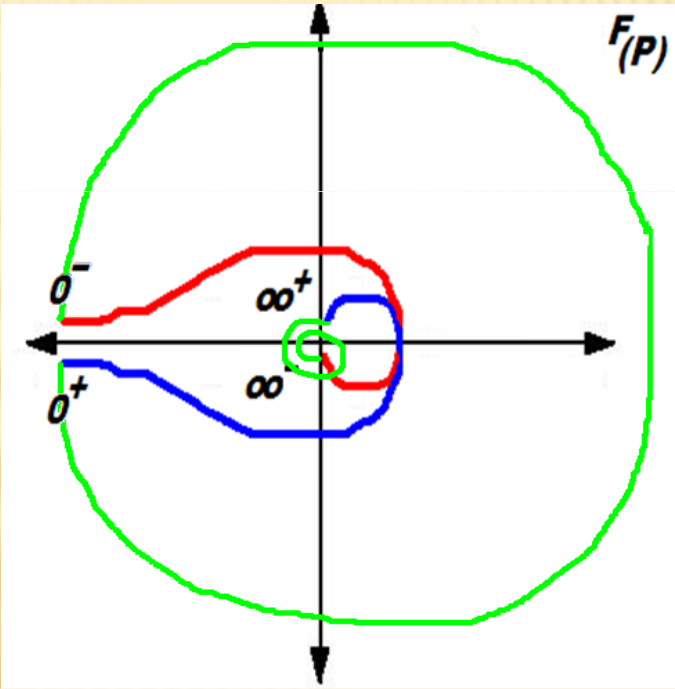
EJEMPLO 1

PASO 11 : Cerrar diagrama para P→∞



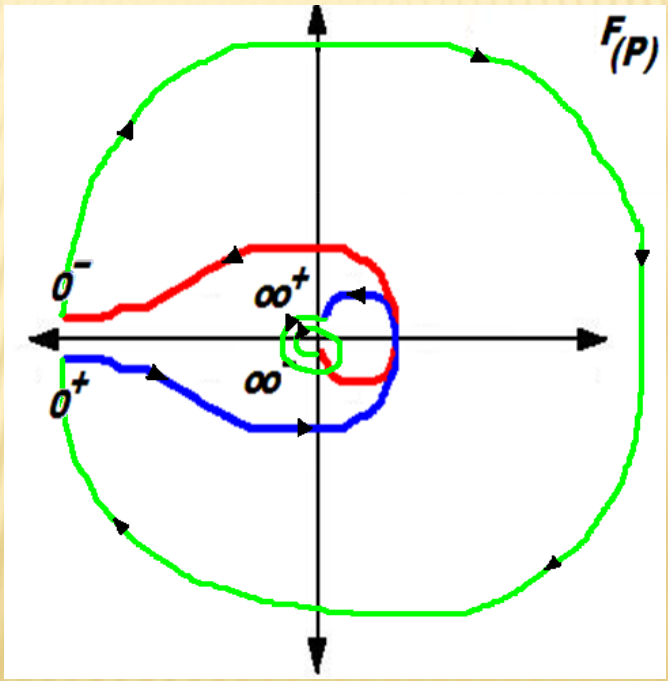
EJEMPLO 1

PASO 12 : Aplicar criterio de Nyquist



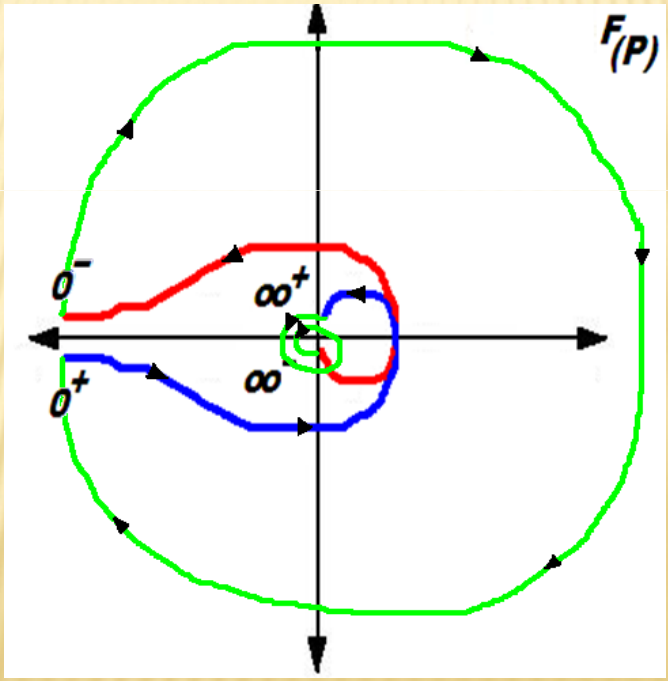
EJEMPLO 1

PASO 12 : Aplicar criterio de Nyquist



EJEMPLO 1

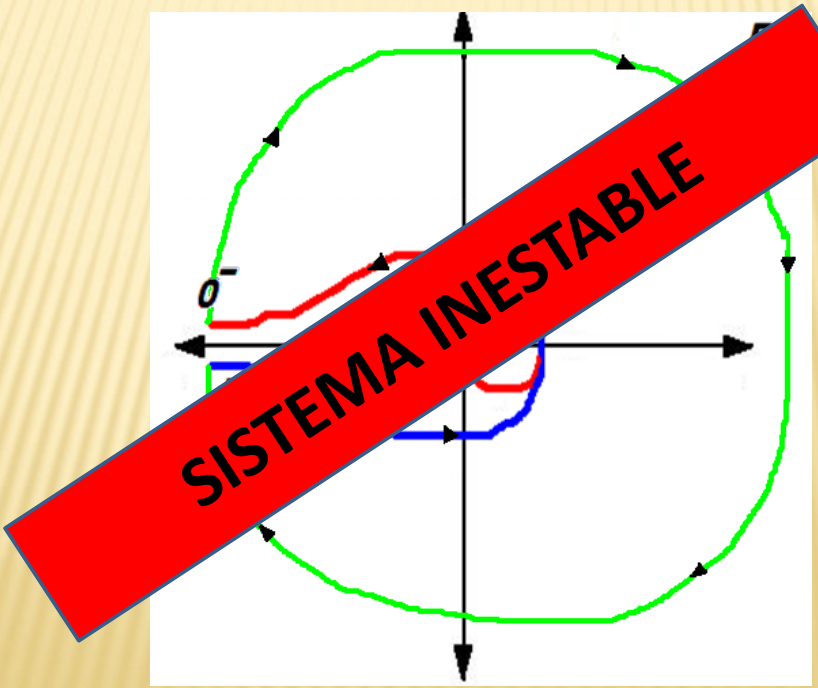
PASO 12 : Aplicar criterio de Nyquist



N= -2

EJEMPLO 1

PASO 12 : Aplicar criterio de Nyquist



N= -2

EJEMPLO 2

Dada la siguiente función, trace diagrama polar y aplique criterio de Nyquist

$$F_{(P)} = \frac{5\,P + 30}{P^5 - 3\,P^4 + 2\,P^3}$$

EJEMPLO 2

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PASO 1 : Origen del Diagrama $F(P)\big|_{P \to 0}$

EJEMPLO 2

$$F_{(P)} = \frac{5\,P + 30}{P^5 - 3\,P^4 + 2\,P^3}$$

PASO 1 : Origen del Diagrama $F(P)\big|_{P \to 0}$

$$F_{(P)}\Big|_{P\to 0} = \frac{Kcte}{P^3}\Big|_{P\to 0} = |\infty|\angle -270^{\circ}$$

EJEMPLO 2

$$F_{(P)} = \frac{5\ P + 30}{P^5 - 3\ P^4 + 2\ P^3}$$

PASO 2 : Final del Diagrama $F(P)|_{P \to \infty}$

EJEMPLO 2

$$F_{(P)} = \frac{5\ P + 30}{P^5 - 3\ P^4 + 2\ P^3}$$

PASO 2 : Final del Diagrama $F(P)|_{P \to \infty}$

$$F_{(P)}\Big|_{P\to\infty} = \frac{Kcte}{P^4}\Big|_{P\to\infty} = |0| \angle -360^\circ \rightarrow$$

EJEMPLO 2

$$F_{(P)} = \frac{5\ P + 30}{P^5 - 3\ P^4 + 2\ P^3}$$

PASO 3 : P →jω es decir F(P) →F(j ω)

$$F_{(j\omega)} = \frac{5\ j\omega + 30}{-3\ \omega^4 + j(\omega^5 - 2\omega^3)}$$

EJEMPLO 2

$$F_{(j\omega)} = \frac{5\ j\omega + 30}{-3\ \omega^4 + j(\omega^5 - 2\omega^3)}$$

PASO 4 : F(jω) = Re +j Im

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

Re + j Im

EJEMPLO 2

$$F_{(j\omega)} = \frac{5\omega^6 - 100\omega^4}{9\,\omega^8 + (\omega^5 - 2\omega^3)^2} + j\,\frac{60\omega^3 - 45\omega^5}{9\,\omega^8 + (\omega^5 - 2\omega^3)^2}$$

PASO 5 : $\mathrm{Re}\,|_{F(j\omega)} = 0$

EJEMPLO 2

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PASO 5 : $\mathrm{Re}\,|_{F(j\omega)} = 0$

$$\omega = \sqrt{\frac{100}{5}} = \pm 4{,}472135955$$

EJEMPLO 2

PASO 6 : Corte eje Imaginario. $\mathrm{Im}\left|_{F(j\omega)\,\omega\to Re=0}\right.$

$$\mathrm{Im}_{F(j\omega)}\Big|_{\omega\to \mathrm{Re}=0} = +j\left.\frac{60\omega^3-45\omega^5}{9\,\omega^8+(\omega^5-2\omega^3)^2}\right|_{\omega=4,472}$$

EJEMPLO 2

PASO 6 : Corte eje Imaginario. $\mathrm{Im}\left|_{F(j\omega)\,\omega\to Re=0}\right.$

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$$\mathrm{Im}_{F(j\omega)}\Big|_{\omega\to \mathrm{Re}=0} = -j\,0{,}018633$$

EJEMPLO 2

$$F_{(j\omega)} = \frac{5\omega^6 - 100\omega^4}{9\,\omega^8 + (\omega^5 - 2\omega^3)^2} + j\,\frac{60\omega^3 - 45\omega^5}{9\,\omega^8 + (\omega^5 - 2\omega^3)^2}$$

PASO 7 : = Im | $_{F(j\omega)} = 0$

EJEMPLO 2

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PASO 7 : = Im | $_{F(j\omega)} = 0$

$$\omega = \sqrt{\frac{60}{45}} = \pm 1{,}154700538$$

EJEMPLO 2

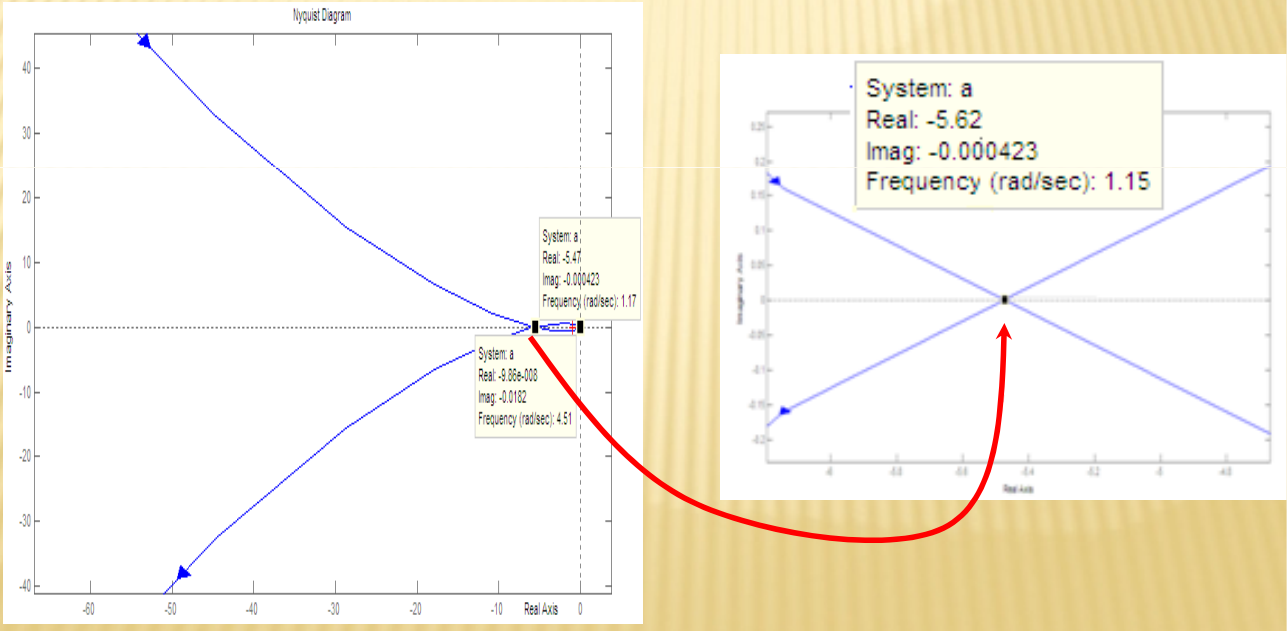
PASO 8 : Corte eje Real. $\mathrm{Re}\left|_{F(j\omega)}\right|_{\omega\to \mathrm{Im}=0}$

$$\mathrm{Re}_{F(j\omega)}\Big|_{\omega\to \mathrm{Im}=0} = +j\,\frac{5\omega^6 - 100\omega^4}{9\,\omega^8 + (\omega^5 - 2\omega^3)^2}\Bigg|_{\omega=1{,}154}$$

$$\mathrm{Re}_{F(j\omega)}\Big|_{\omega\to \mathrm{Im}=0} = -5{,}625$$

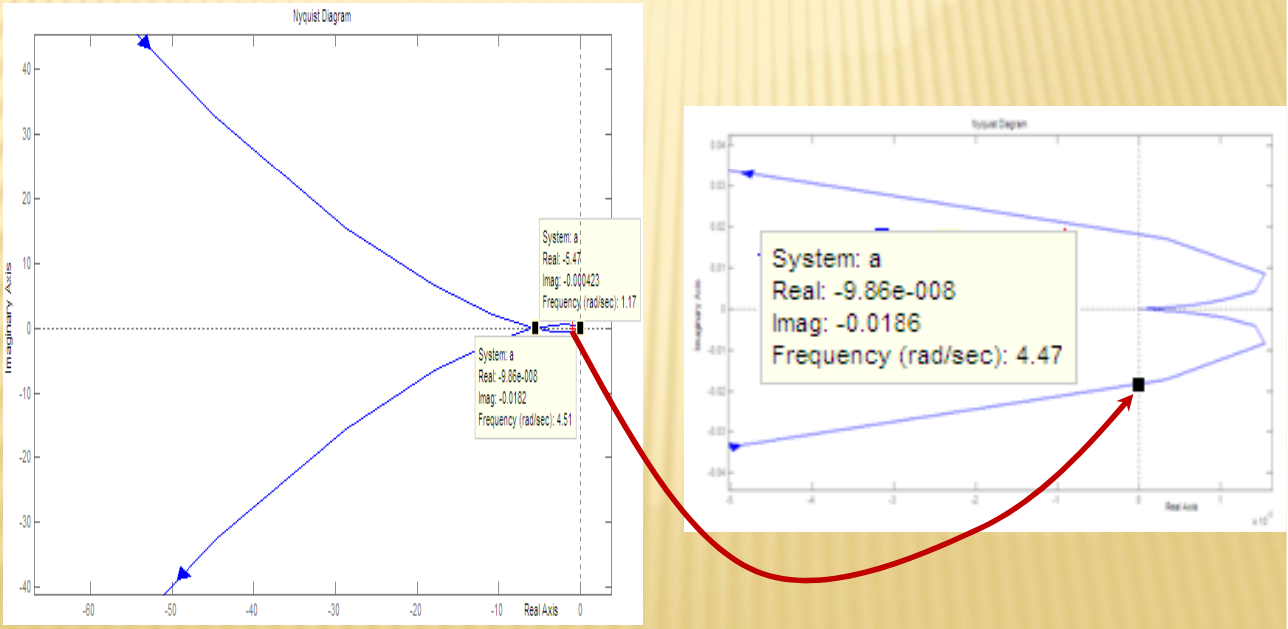
EJEMPLO 2

PASO 9 : Trazar el diagrama Polar



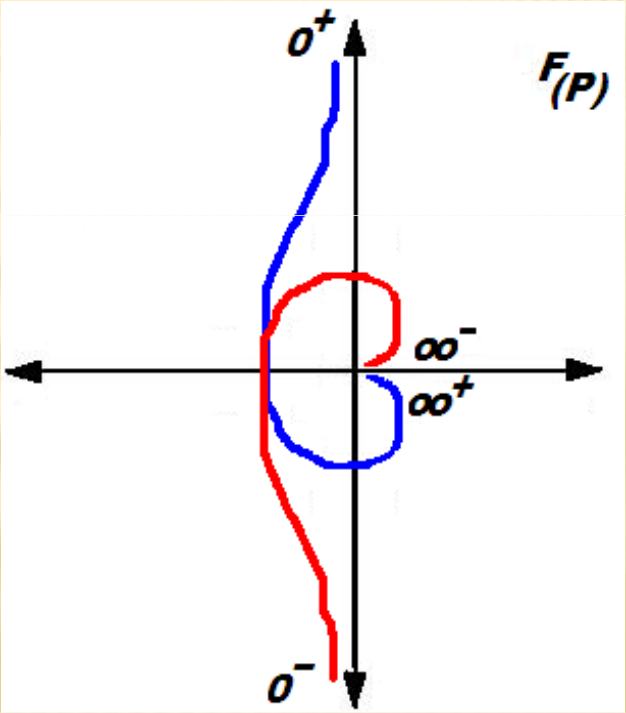
EJEMPLO 2

PASO 9 : Trazar el diagrama Polar



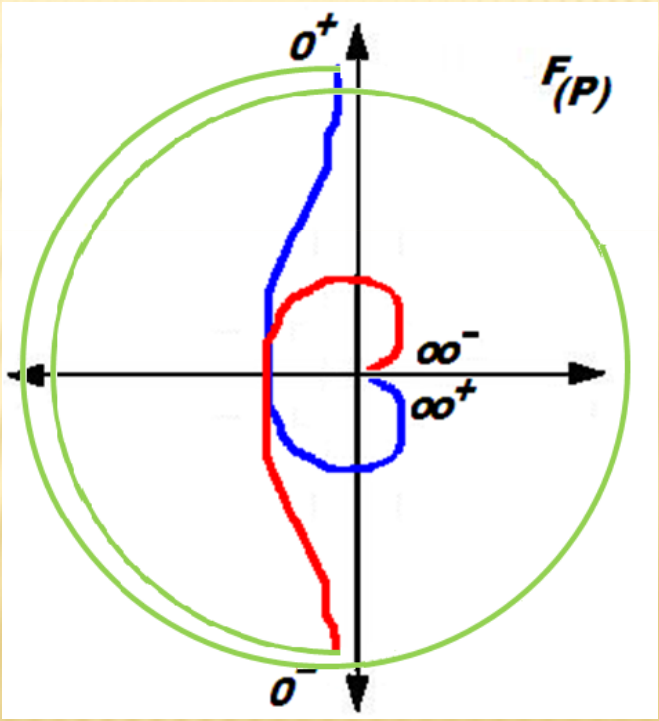
EJEMPLO 2

PASO 10 : Cerrar diagrama para P→0



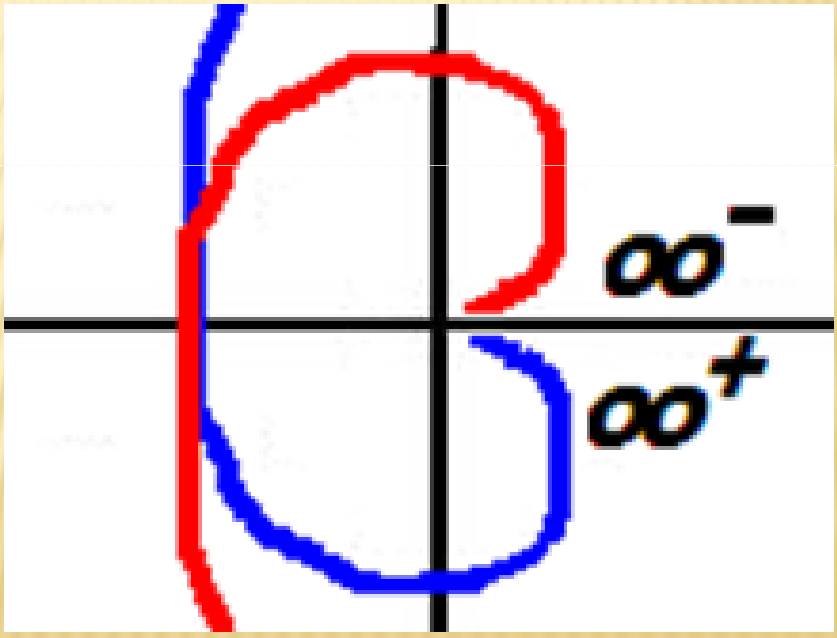
EJEMPLO 2

PASO 10 : Cerrar diagrama para P→0



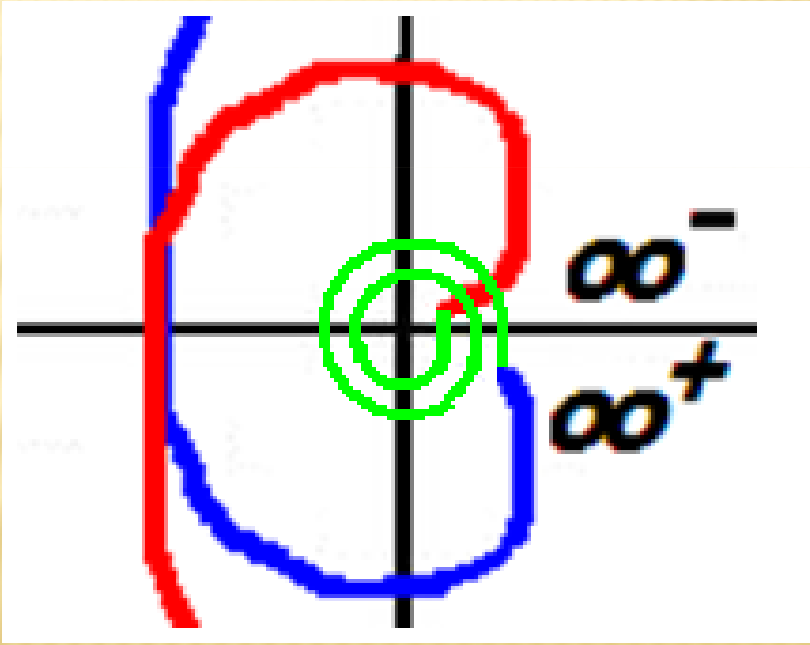
EJEMPLO 2

PASO 11 : Cerrar diagrama para P→∞



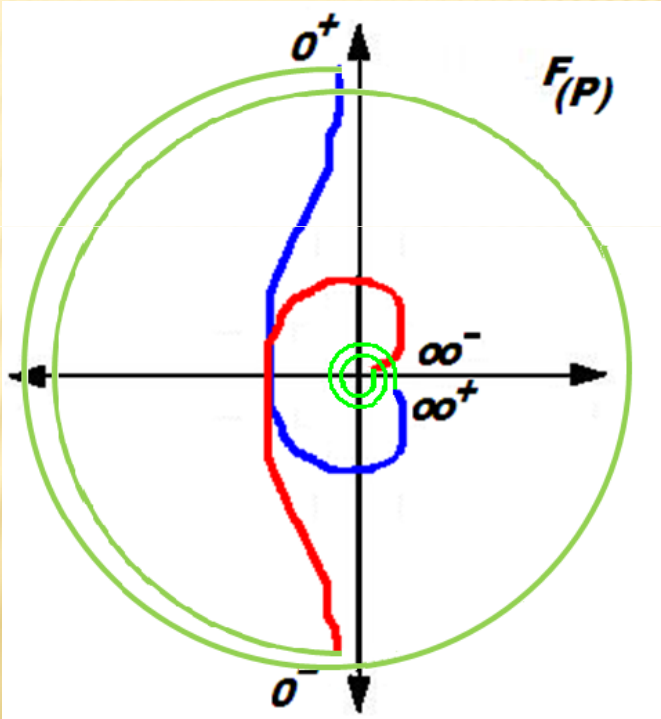
EJEMPLO 2

PASO 11 : Cerrar diagrama para P→∞



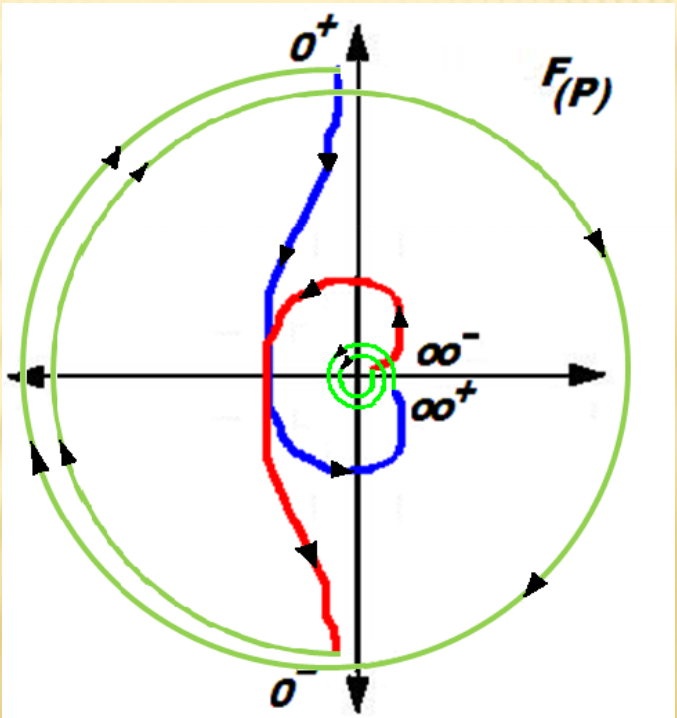
EJEMPLO 2

PASO 12 : Aplicar criterio de Nyquist



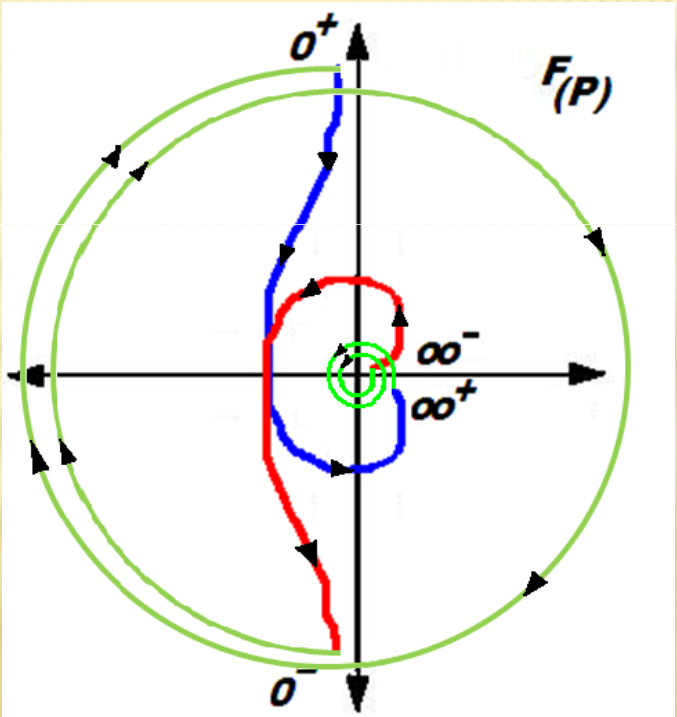
EJEMPLO 2

PASO 12 : Aplicar criterio de Nyquist



EJEMPLO 2

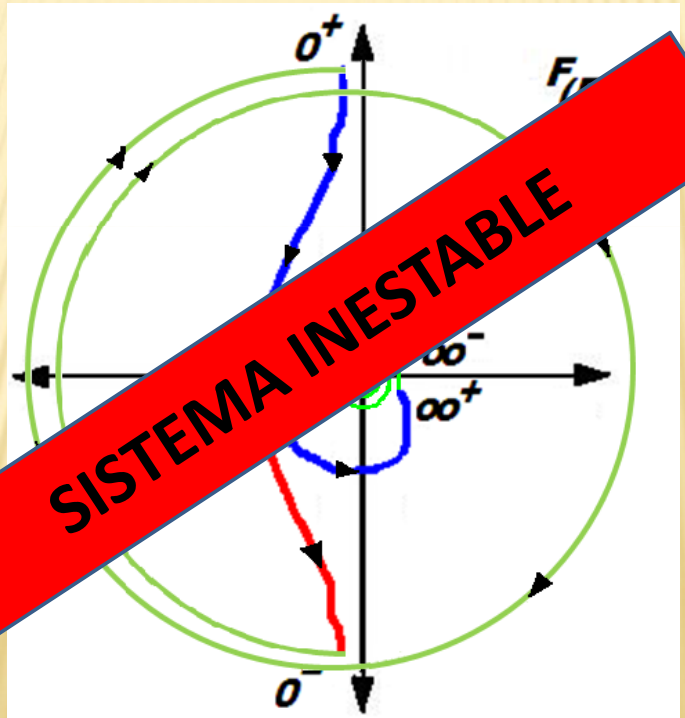
PASO 12 : Aplicar criterio de Nyquist



N= -2

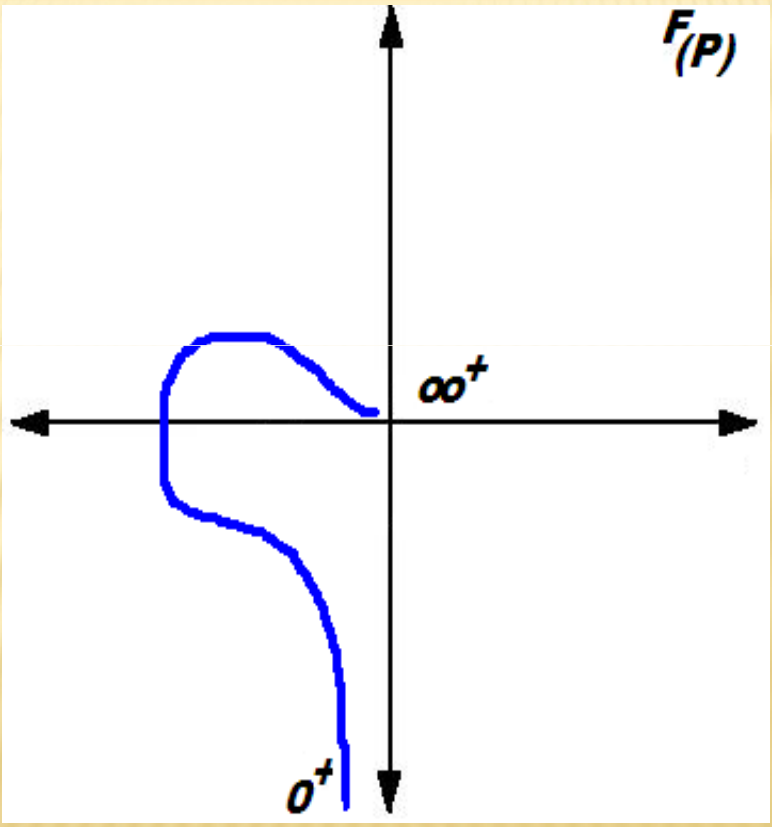
EJEMPLO 2

PASO 12 : Aplicar criterio de Nyquist



N= -2

EJEMPLO 3



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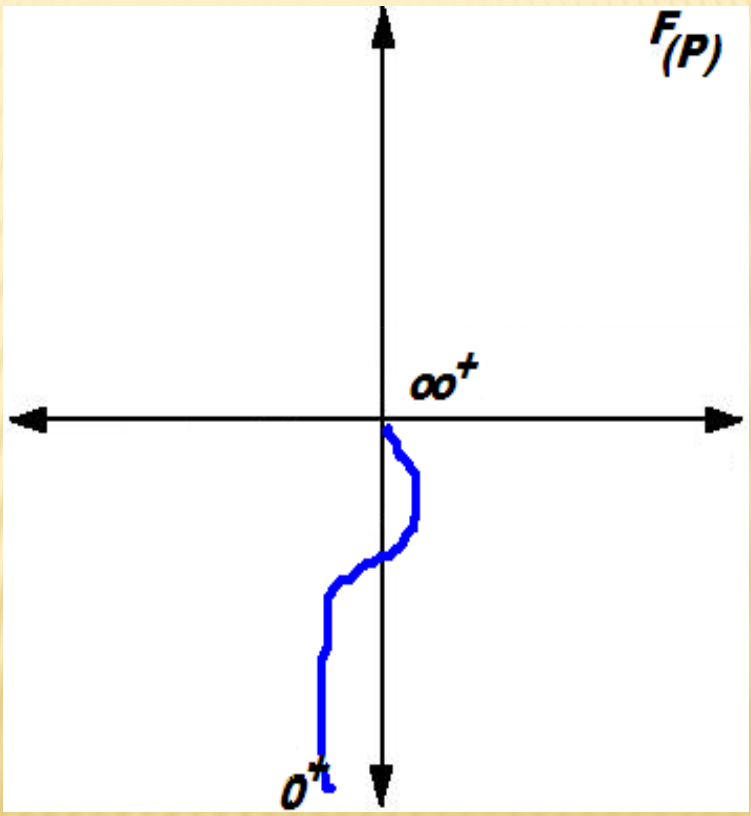

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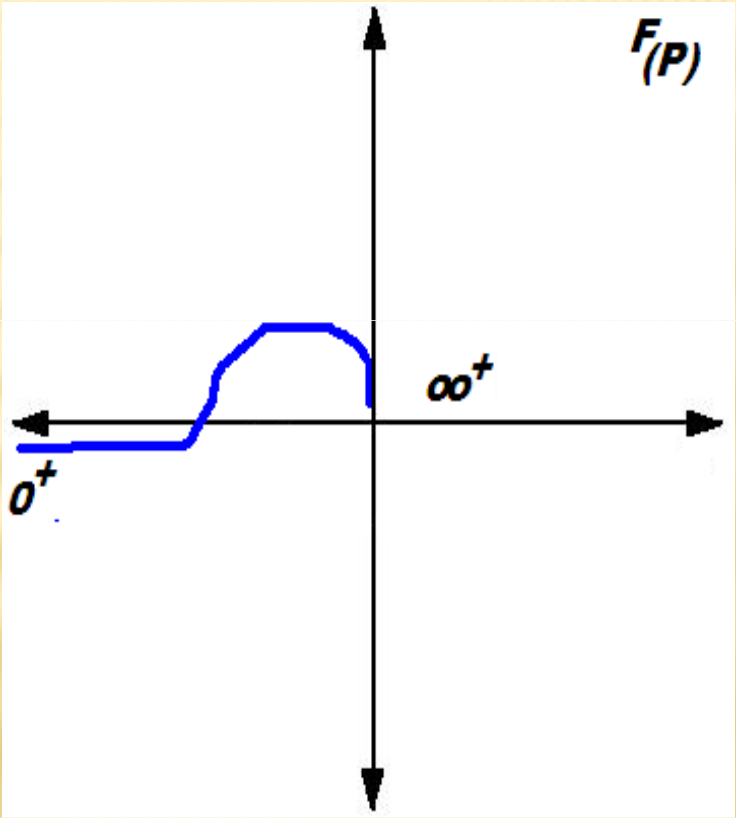

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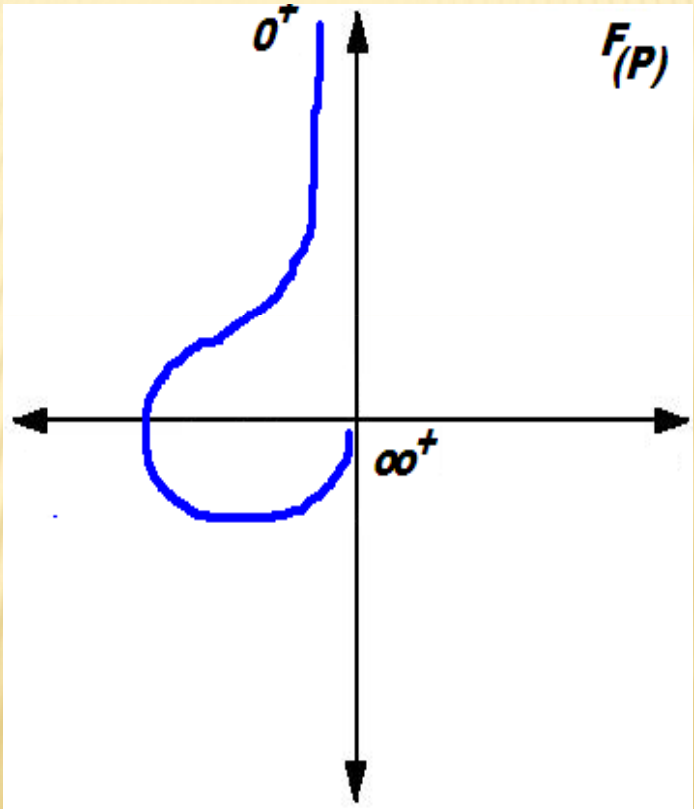

FIN DE LA PRESENTACIÓN

REPORTE ERRORES A : ⇒ jgarcia_abad@electronica.frc.utn.edu.ar

ó A : ⇒ jgarciaabad@iua.edu.ar