17 February:

$$s^4 + s^2 + 1$$

s^4 : $1 \quad 1 \quad 1$

s^3 : $\cancel{4}\,2 \quad \cancel{2}\,1$

s^2 : $\frac{1}{2} \quad 1$

s : -3

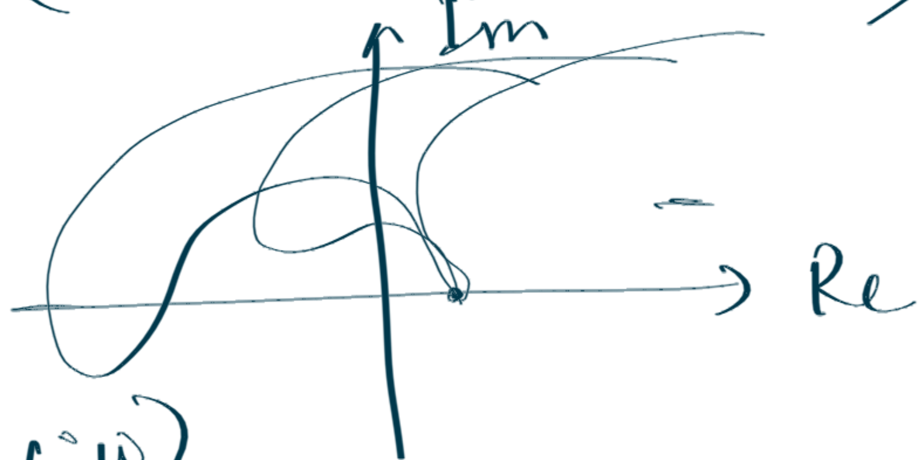
1 : 1

$p(s)$ even polynomial

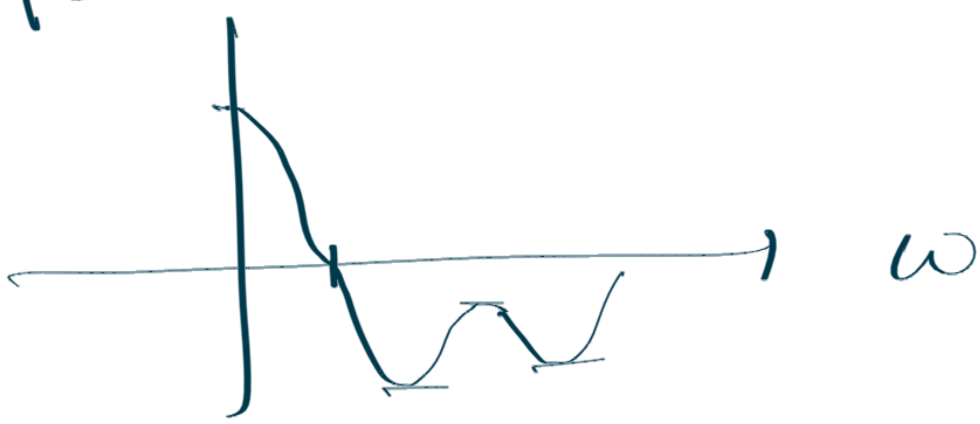
$\deg p = 2m$

r roots on the $\mathbb{C}^+$

$$(s^4 + s^2 + 1 + 4s^3 + 2s)$$



$p(j\omega)$



$$\underline{(2m - 2r)}$$

$$(2m - r)\frac{\pi}{2} - r\frac{\pi}{2}$$

$$= m\pi - r\pi$$

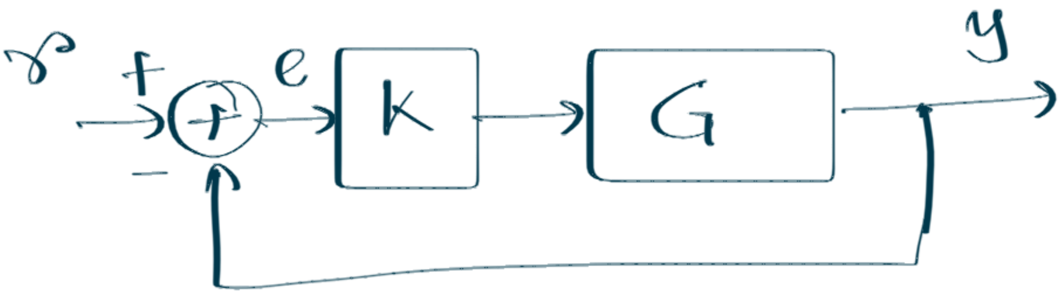
$$= 2(m-r)\frac{\pi}{2}$$

s^n : ______ → P_{even}

s^{n-1} : ______ → P_{odd}

s^{n-2} : ( )

Negative feedback :



$$\text{CLTF} = \left(\frac{KG}{1+KG}\right) \approx 1 \text{ as } K >> 0$$

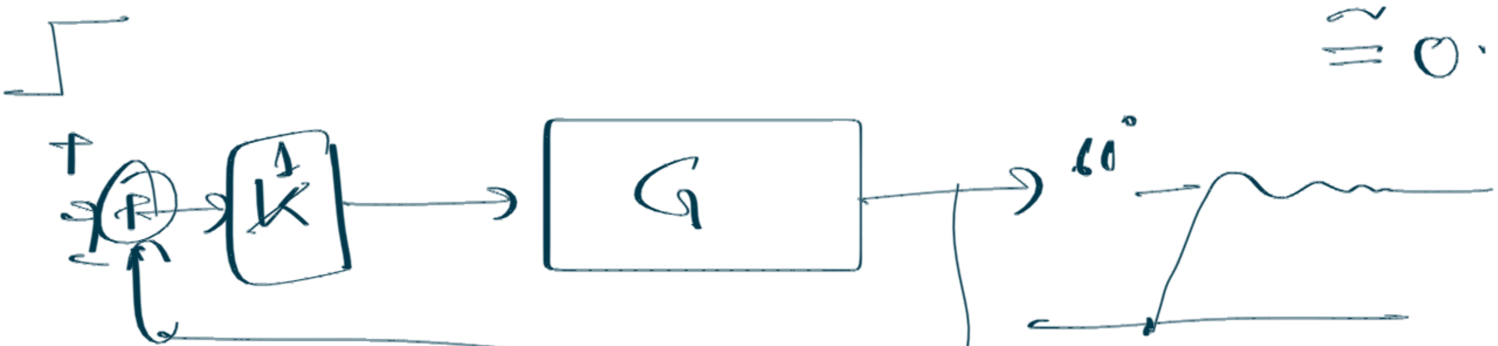
$$\left[\frac{G+\Delta G}{G}\right] = 1 + \left(\frac{\Delta G}{G}\right) \text{ OLTF.}$$

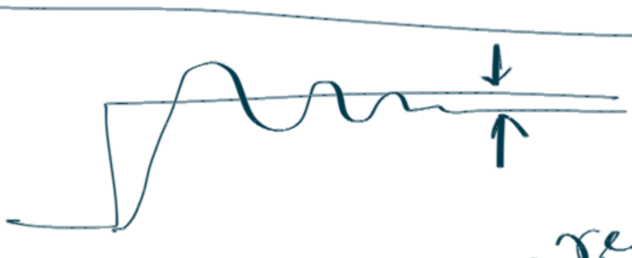
$$G = 1, \quad \Delta G = 0.1$$

OLTF 1.1.

$$\text{CLTF} = \frac{K}{1+K} \checkmark = \frac{1000}{1001} \cong 0.999$$

$$\text{CLTF} = \frac{K \times 1.1}{1+K1.1} = \frac{1100}{1+1100} = \frac{1100}{1101} \cong 0.999$$





Steady-state error,

ref. input

output

error, $e := r - y$

$$\boxed{e_{ss} := \lim_{t\to\infty} e(t)} = \underline{\underline{e(\infty)}}$$

Error transfer f^n:

$$E(s) = R(s) - Y(s)$$
$$= R(s) - G(s)E(s)$$
$$\Rightarrow (1+G(s))E(s) = R(s)$$
$$\Rightarrow E(s) = \boxed{\frac{1}{1+G(s)}} \cdot R(s)$$

error transfer f^n.

$$f(t) \xrightarrow{\mathcal{L}} F(s)$$

$$\boxed{\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s)}$$

Final value theorem

$$F(s) = \frac{1}{s(s-1)}$$

$$f(t) = A\,1(t) + \underline{B}\, e^{t}\,1(t)$$

$$\lim_{s\to 0} sF(s) = 1$$

$$R(s) = \frac{1}{s}$$

$$e(\infty) = \lim_{s\to 0} \cancel{s}\left(\frac{1}{\cancel{s}} \cdot \frac{1}{1+G(s)}\right)$$

$$= \frac{1}{1 + G(0)}$$ (assuming closed-loop stability)