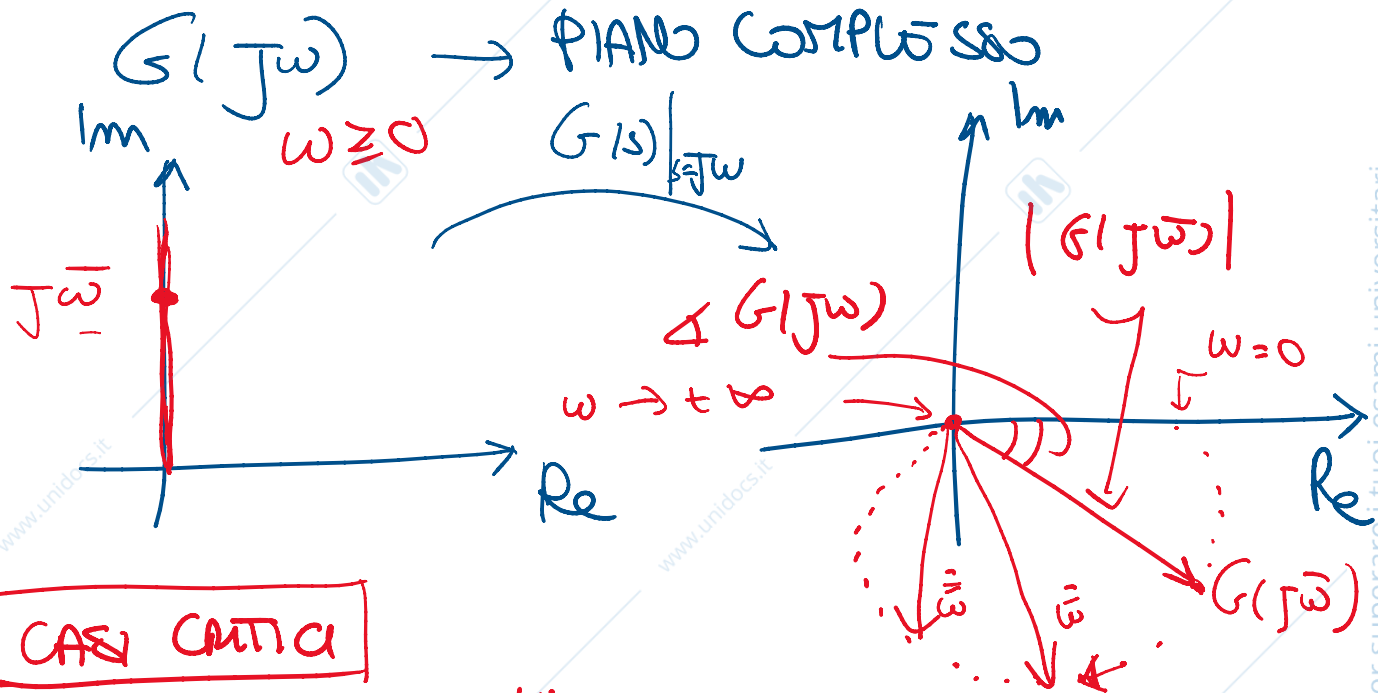
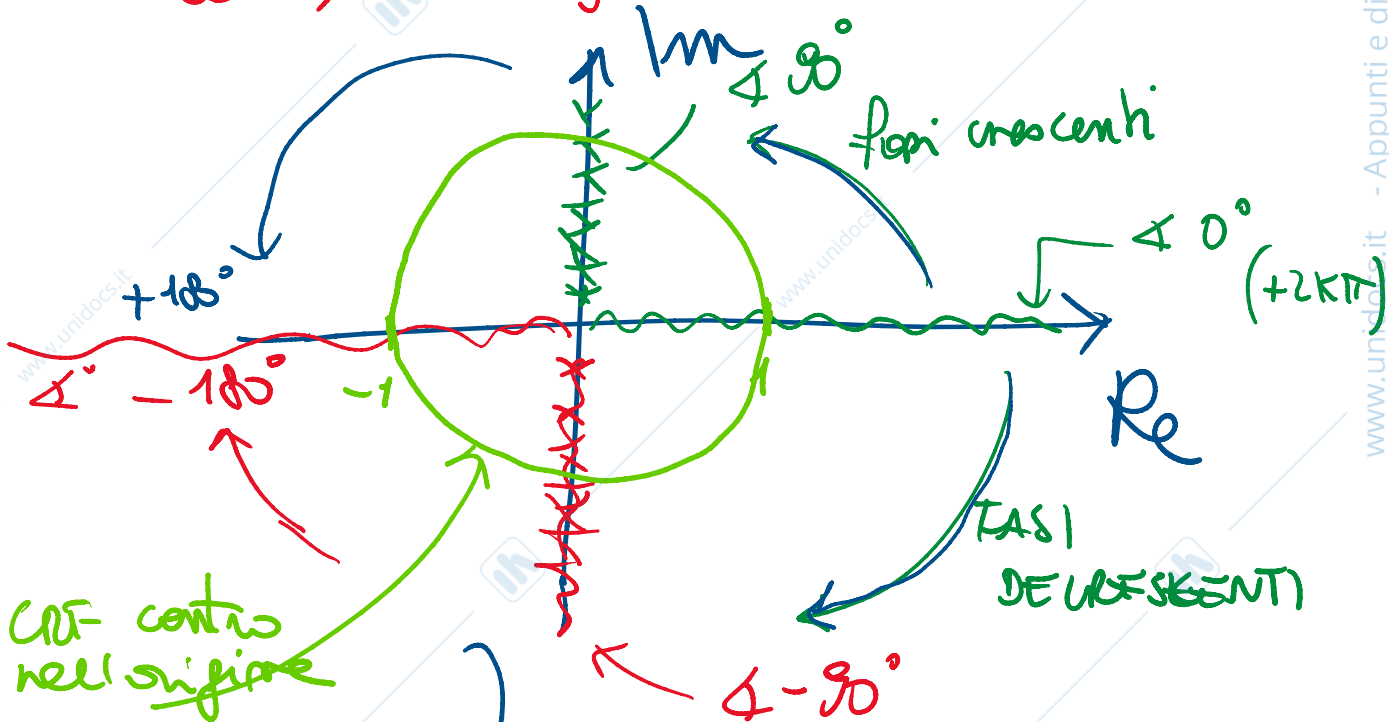


DIAGRAMMA POLARE



CASI CRITICI

$G(s)$ ha poli sull'asse IMMAG.
 $w=0, w = \pm j\bar{w}$



CFE- centro nell'origine
 e raggio UNITARIO
 ≡
 area a 0 dB

→ LOGO DEI PUNTI A MODULO UNITARIO → CIRCONF. UNITARIA

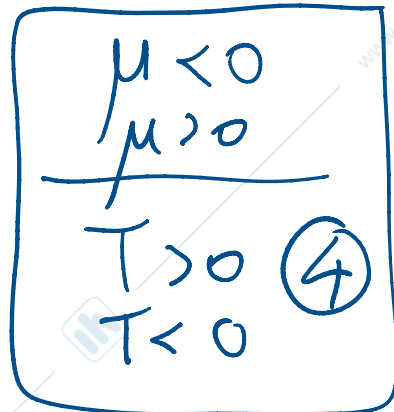
ESEMPLI

u

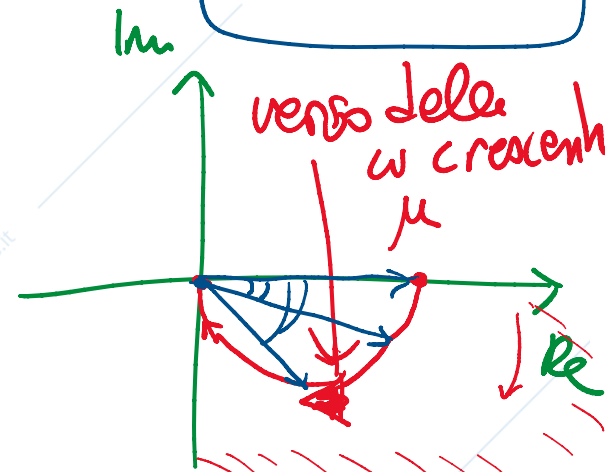
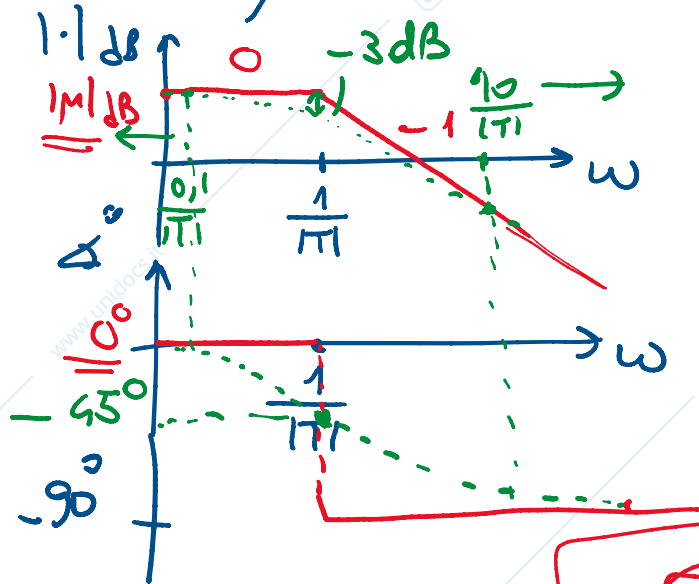
ESEMPLI

$$G(s) = \frac{\mu}{1+sT}$$

UNITARIETA

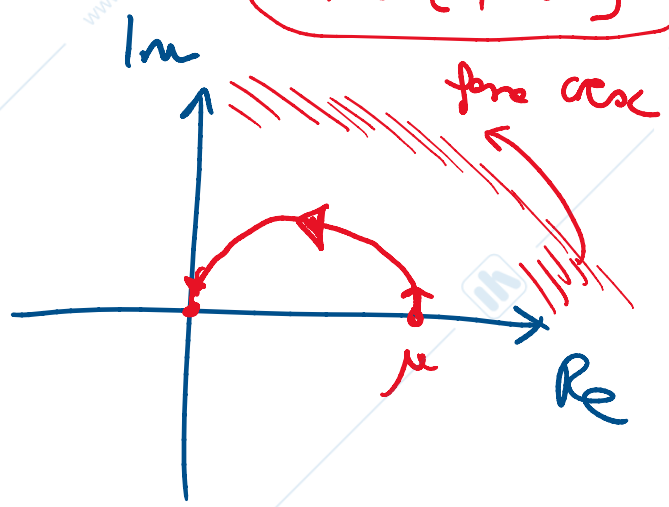
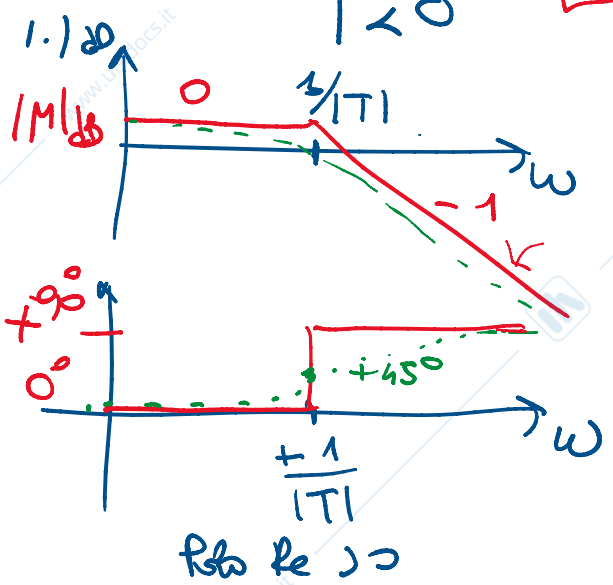


CASO 1 $\mu, T > 0$



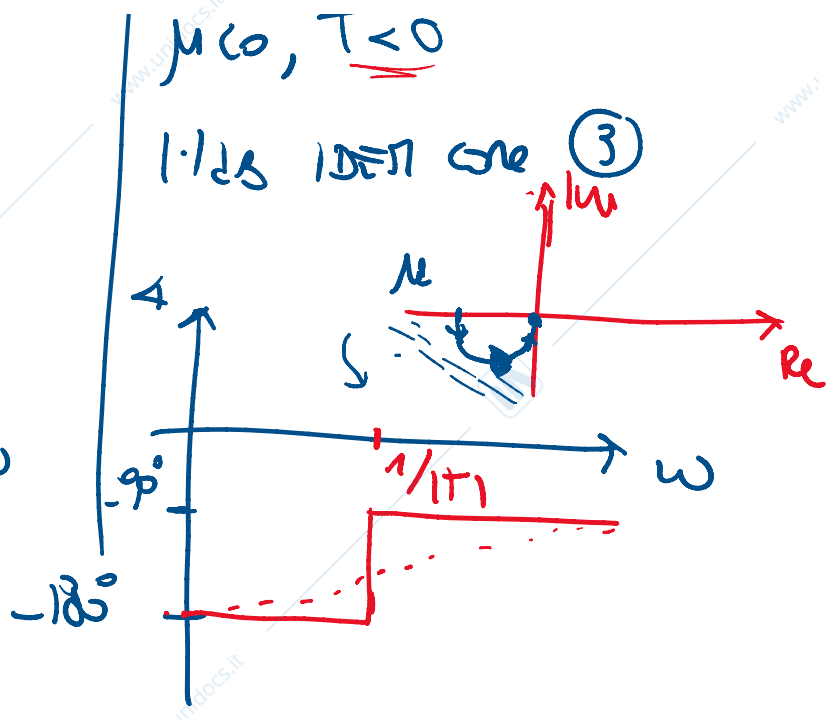
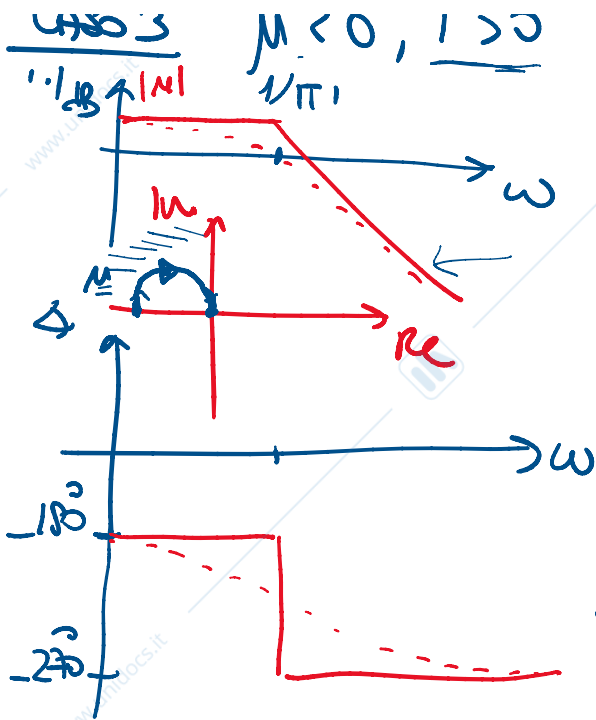
$\omega = 0$	$\omega \rightarrow +\infty$
$ G = \mu $	$ G _{dB} \rightarrow -\infty$
$\Delta = \Delta \mu = 0^\circ$	$ G \rightarrow 0$
	$\Delta \rightarrow -90^\circ$
	$\Delta \in [0, -90^\circ]$

CASO 2 $\mu > 0, T < 0$



CASO 3 $\mu < 0, T > 0$

$\mu < 0, T < 0$



ESEMPIO

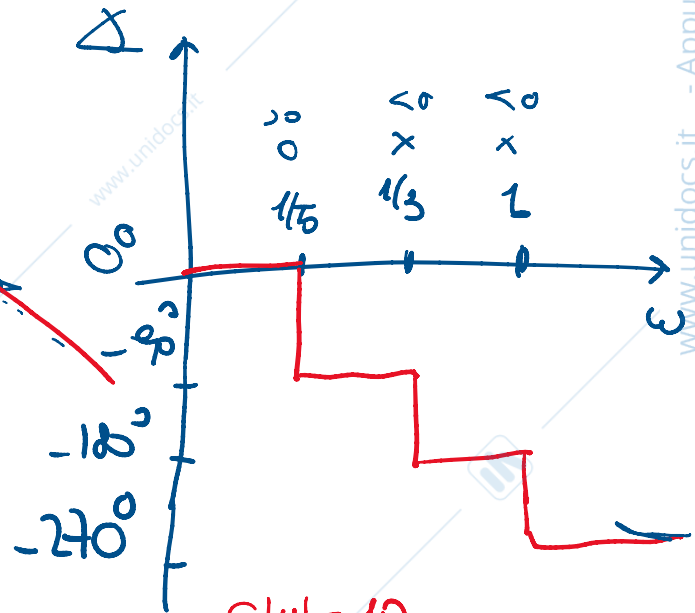
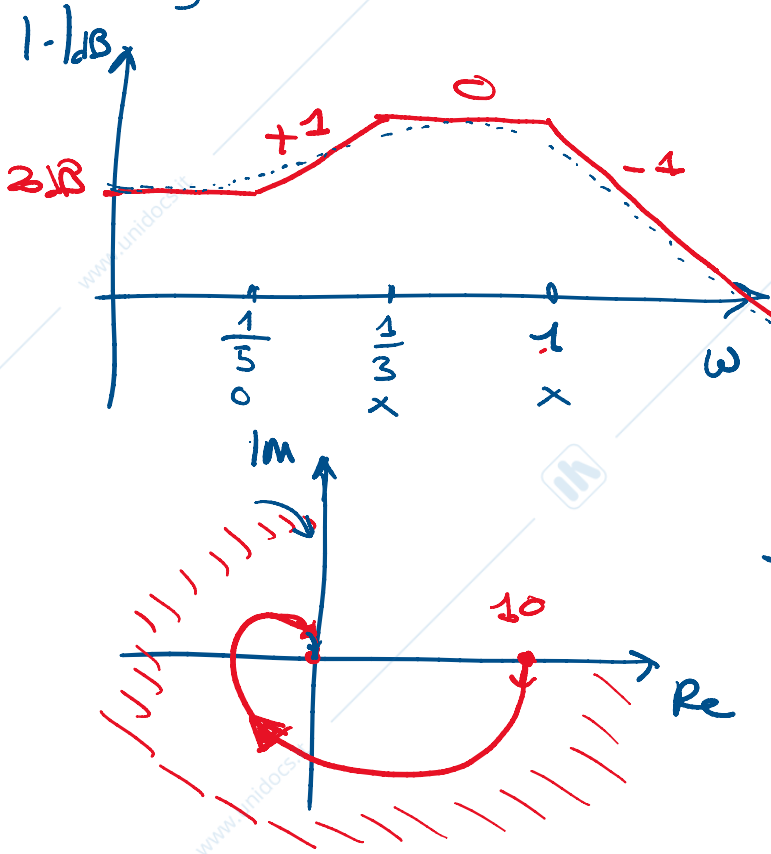
$G(s) = 10 \frac{-5s + 2}{(s+1)(3s+1)}$

$\frac{-5s + 2}{(s+1)(3s+1)}$

DIAGR. POLARE di $G(j\omega)$

$T_{HP} \quad g=0$
 $\mu = 10$
 $z = \frac{2}{5} > 0$

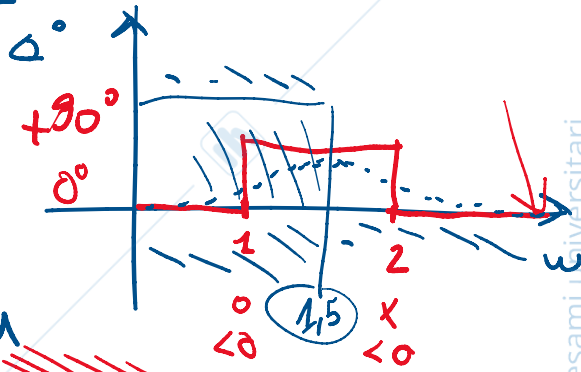
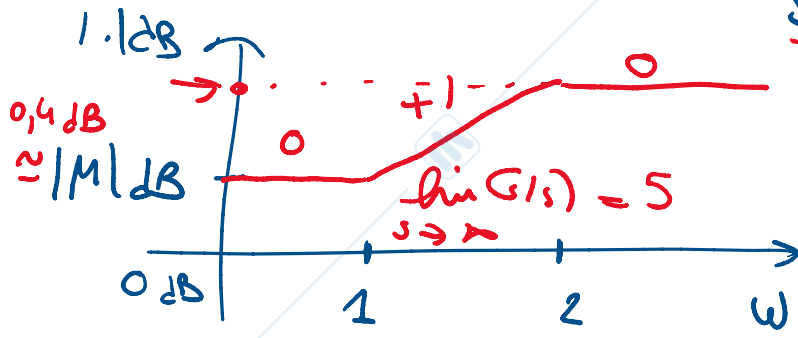
$p_1 = -1 < 0$
 $p_2 = -\frac{1}{3} < 0$



$\omega=0 \quad \begin{cases} |M| = 10 \\ \angle = 0^\circ \end{cases}$
 $\omega \rightarrow \infty \quad \begin{cases} |M| \rightarrow 0 \\ \angle \rightarrow [-90, -270]^\circ \end{cases}$

ESEMPIO

$$G(s) = 5 \frac{s+1}{s+2} \quad \pi = 0$$



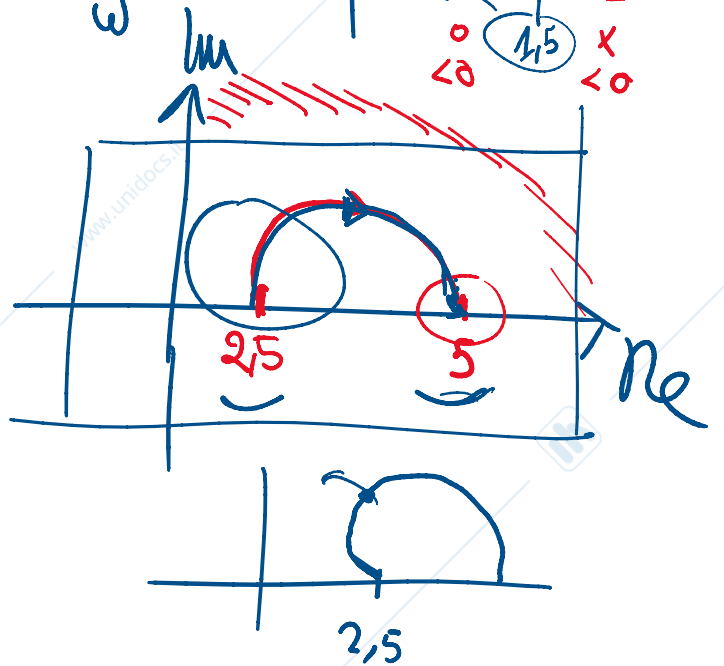
$$\mu = \frac{5}{2} = 2.5$$

$$p = -2 < 0$$

$$z = -1 < 0$$

$$\omega = 0 \begin{cases} \mu = 2.5 \\ \phi = 0 \end{cases}$$

$$\omega \rightarrow \infty \begin{cases} |M| \rightarrow 5 \\ \phi \rightarrow 0^\circ \end{cases}$$

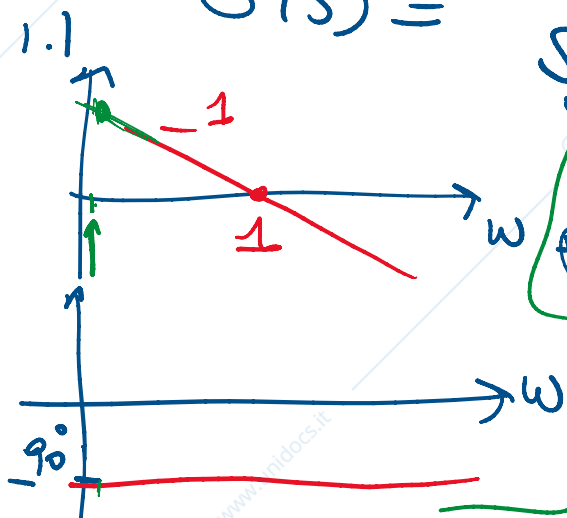


CASO CRITICO POLO IN S=0

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

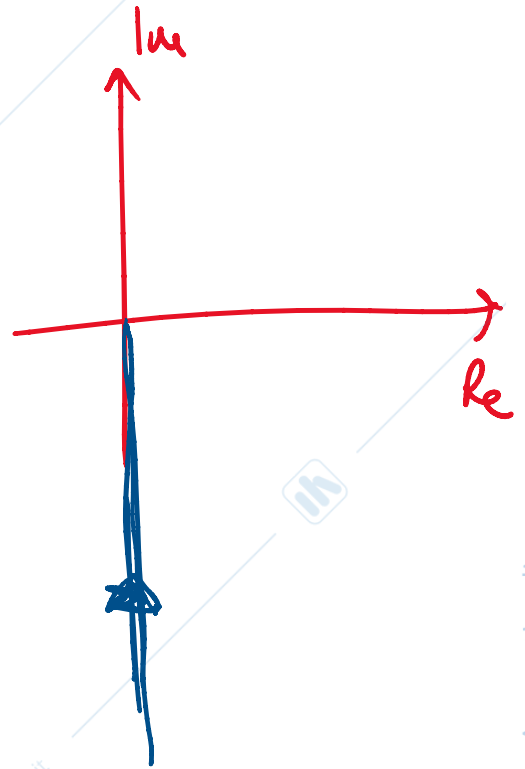
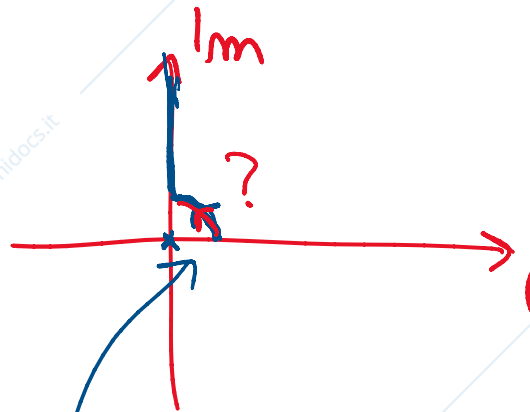
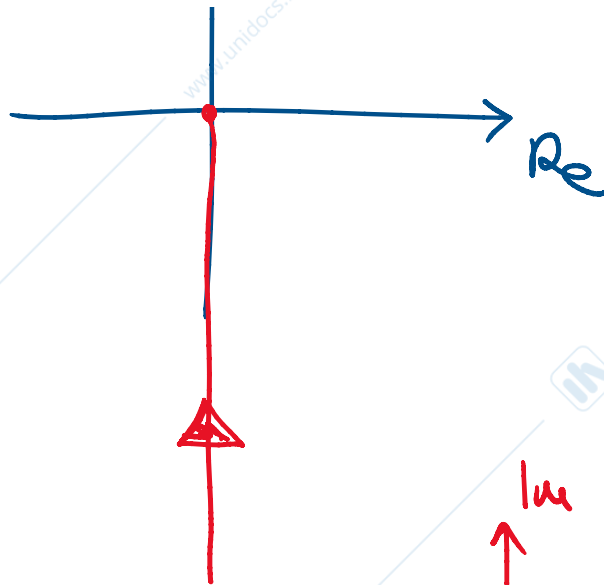
$$G(j\omega) = \frac{1}{j\omega}$$

$\omega \geq 0$ PUNTO CRITICO
 $\omega = 0 !!$

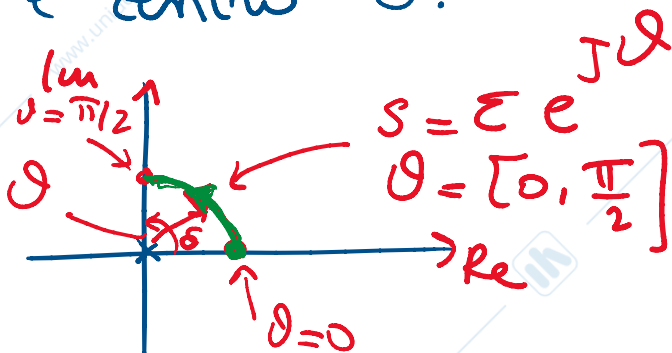


$$\omega = 0^+ \quad |M| = \infty$$

$$\begin{aligned} \underline{\omega=0^+} & \begin{cases} |G| = \infty \\ \angle = -90^\circ \end{cases} \\ \underline{\omega \rightarrow +\infty} & \begin{cases} |G| = 0 \\ \angle = -90^\circ \end{cases} \end{aligned}$$



Il punto "critico" $\omega=0$ viene eliminato dal semipiano $\text{Im} > 0$ con un quarto di CRF di RAGGIO ϵ (INFINITESIMO) e centro 0.

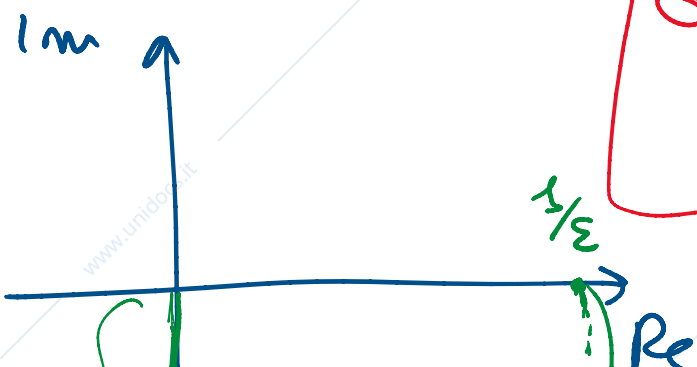


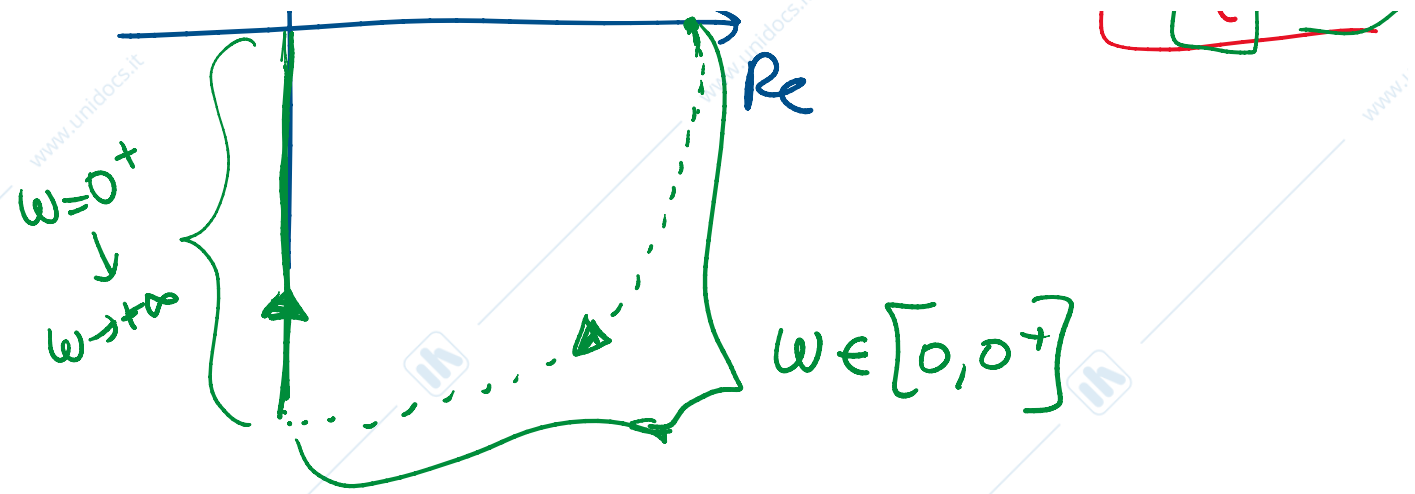
$$G(s) = \frac{1}{s}$$

$$\omega \in [0, 0^+]$$

$$G(s) = \frac{1}{\epsilon e^{j\theta}}$$

- $\theta = 0$
- $1/\epsilon$
- $\theta = \pi/2$
- $\frac{1}{\epsilon} e^{-j\pi/2}$

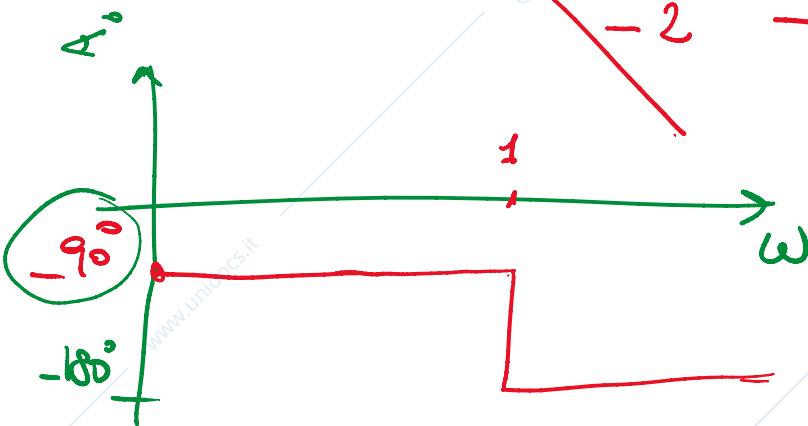
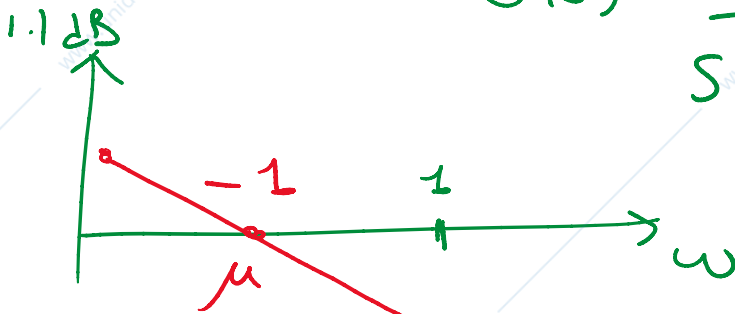




ESEMPIO

$$G(s) = \frac{\mu}{s(s+1)}$$

$\mu > 0, |\mu| < 1$
DIAGR. BODE



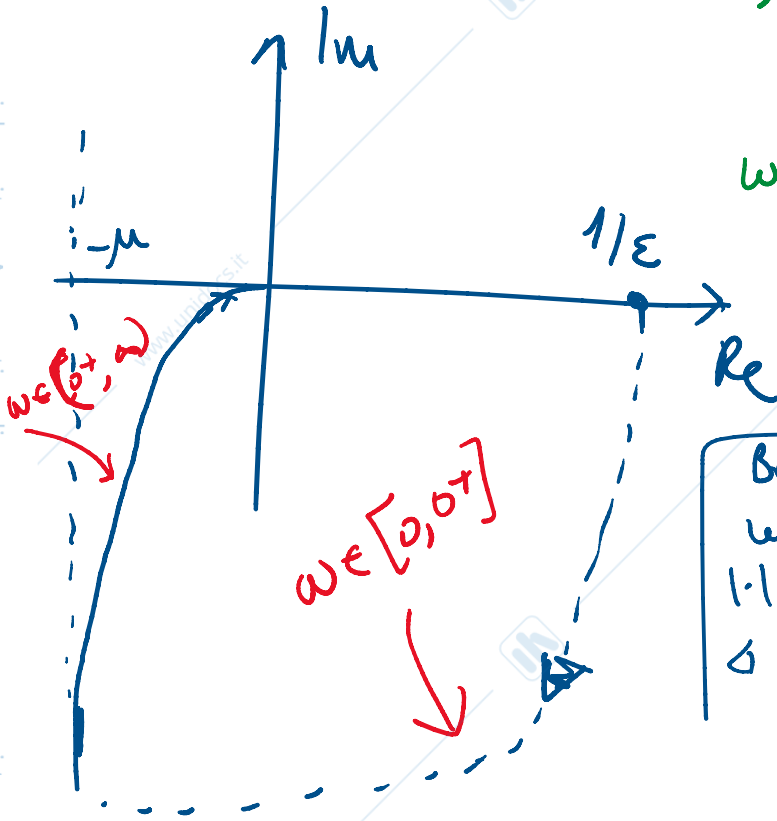
$$G(s) = \frac{\mu}{s(s+1)}$$

In questo caso occorre analizzare meglio $G(j\omega)$

$$G(j\omega) = \frac{\mu}{j\omega(j\omega+1)} = \frac{\mu}{- \omega^2 + j\omega} \cdot \frac{-\omega^2 - j\omega}{-\omega^2 - j\omega} = \frac{\mu}{-\omega^2 - j\omega}$$

$$|G(j\omega)| = \mu \frac{\omega^2}{\omega^4 + \omega^2}$$

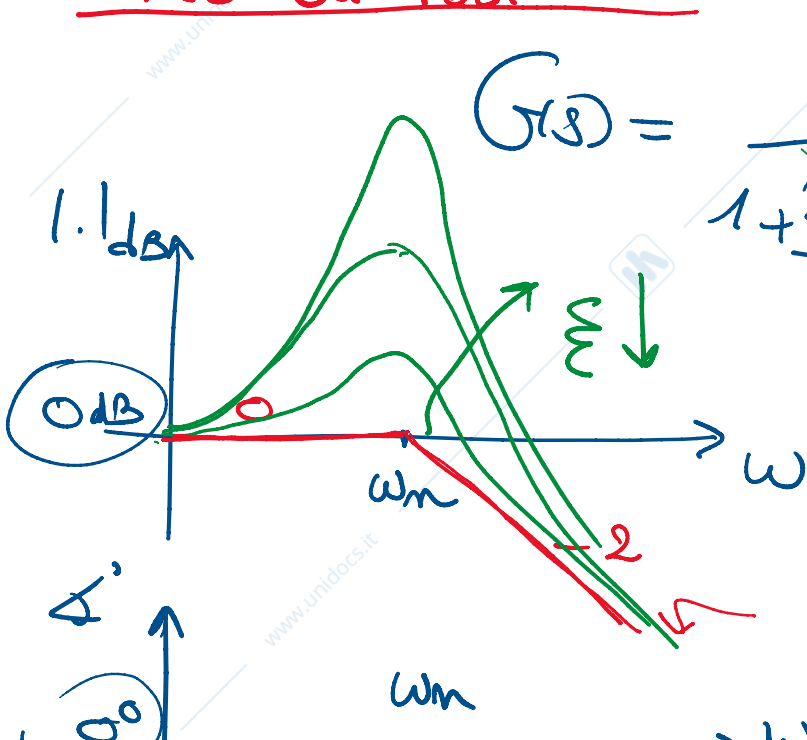
$$\text{Re}(G(j\omega)) + j\text{Im}(G(j\omega)) = -\frac{\mu\omega^2}{\omega^4 + \omega^2} - j\frac{\mu\omega}{\omega^4 + \omega^2}$$



$\omega \rightarrow 0^+ \downarrow -\mu$
 $\omega \rightarrow +\infty \downarrow -\infty$

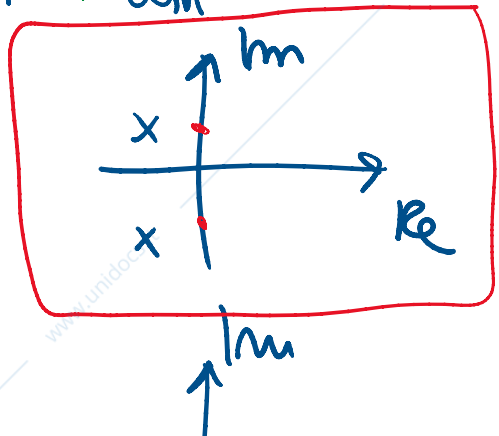
BODE	
$\omega = 0^+$	$\omega \rightarrow +\infty$
$ G = +\infty$	$ G = 0$
$\Delta = -90^\circ$	$\Delta = -180^\circ$

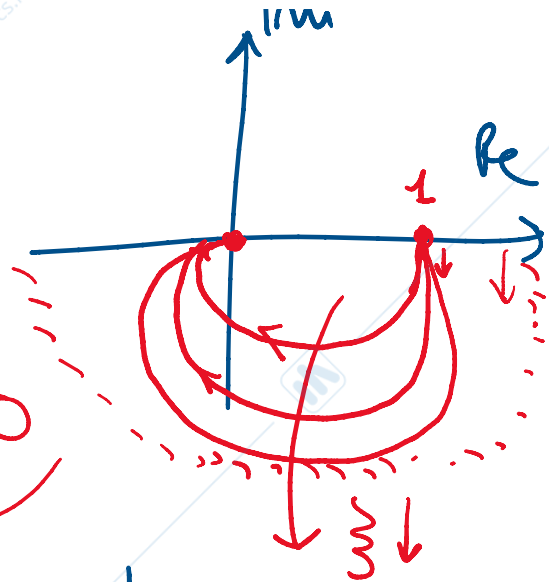
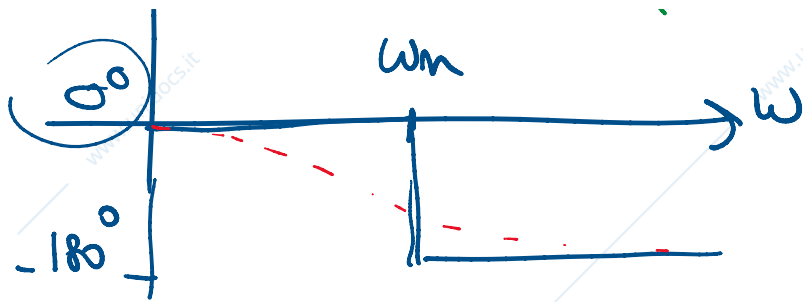
CASO di poli c.c.



$$G(s) = \frac{\mu}{1 + 2\zeta s + \frac{s^2}{\omega_n^2}}$$

$\mu = 1$
 Poli $\text{Re} < 0$

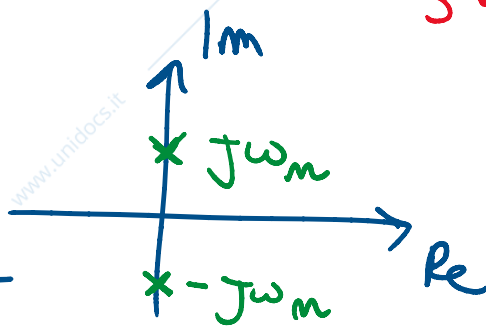




CASO CRITICO per $\zeta = 0$

POLI IMM. PURI

Se $\zeta = 0$ la $G(s)$ scritta sopra diventa



$$G(s) = \frac{1}{1 + \frac{s^2}{\omega_m^2}} = \frac{\omega_m^2}{s^2 + \omega_m^2}$$

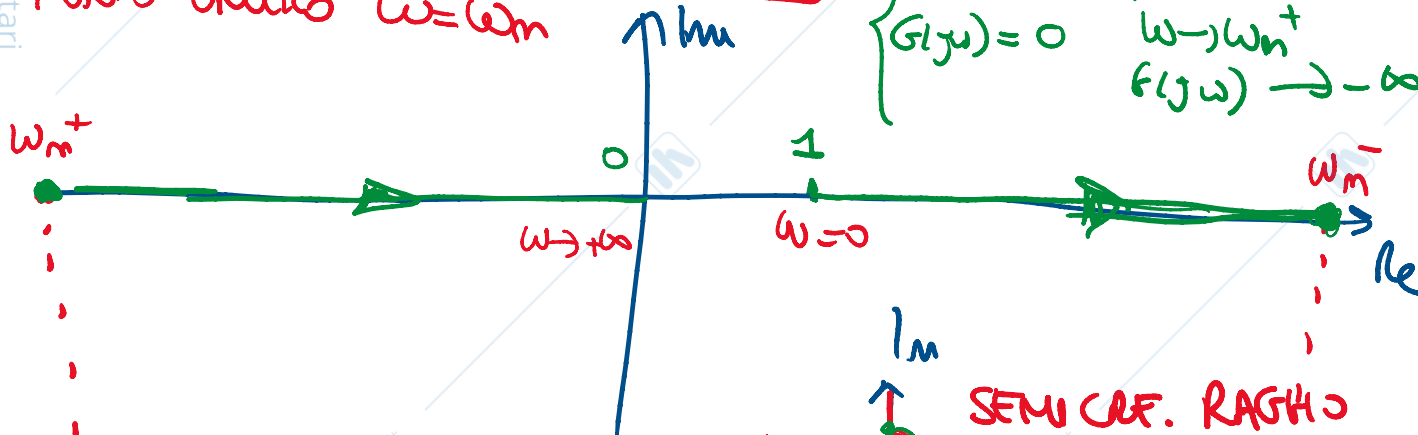
$$G(j\omega) = \frac{\omega_m^2}{\omega_m^2 - \omega^2}$$

$\in \mathbb{R}$

- $\omega = 0 \rightarrow G(j\omega) = 1$
- $\omega \rightarrow \omega_m^- \rightarrow G(j\omega) \rightarrow +\infty$
- $\omega \rightarrow \omega_m^+ \rightarrow G(j\omega) \rightarrow -\infty$

$G(j\omega) = 0$

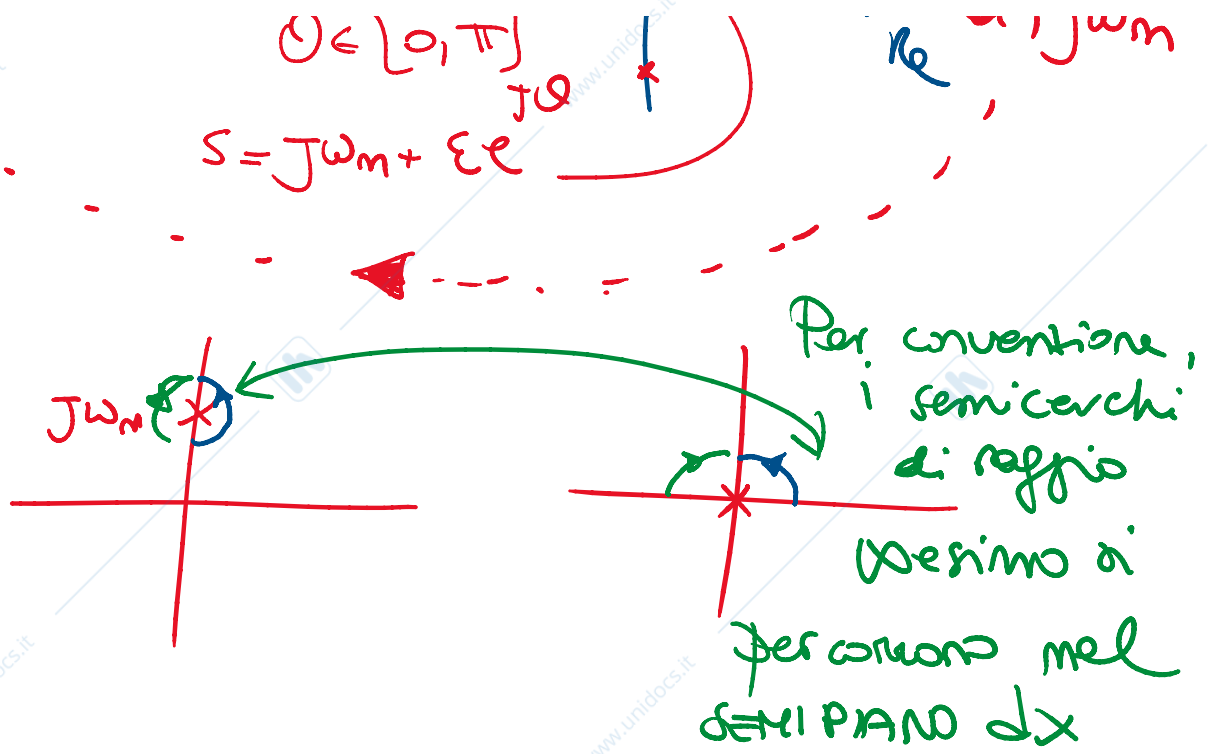
PUNTO UNICO $\omega = \omega_m$



SEMICER. RAGGIO ϵ attorno a $j\omega_m$

$0 < [\theta, \pi]$

A small diagram showing a semi-circular contour in the complex plane around the pole at $j\omega_m$. The contour is in the right half-plane, starting and ending on the real axis. The angle θ is indicated as being between 0 and π .



RITARDO DI TEMPO

$$G(s) = e^{-sT}$$

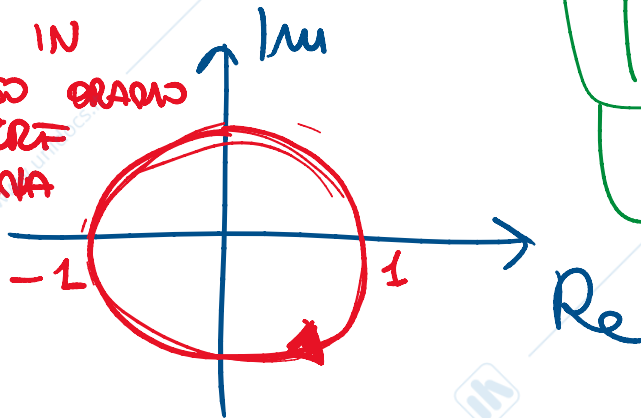
NON RAZIONALE

$$\rightarrow G(j\omega) = e^{-j\omega T}$$

$$|G(j\omega)| = 1$$

$$\Delta = -\omega T \frac{180^\circ}{\pi}$$

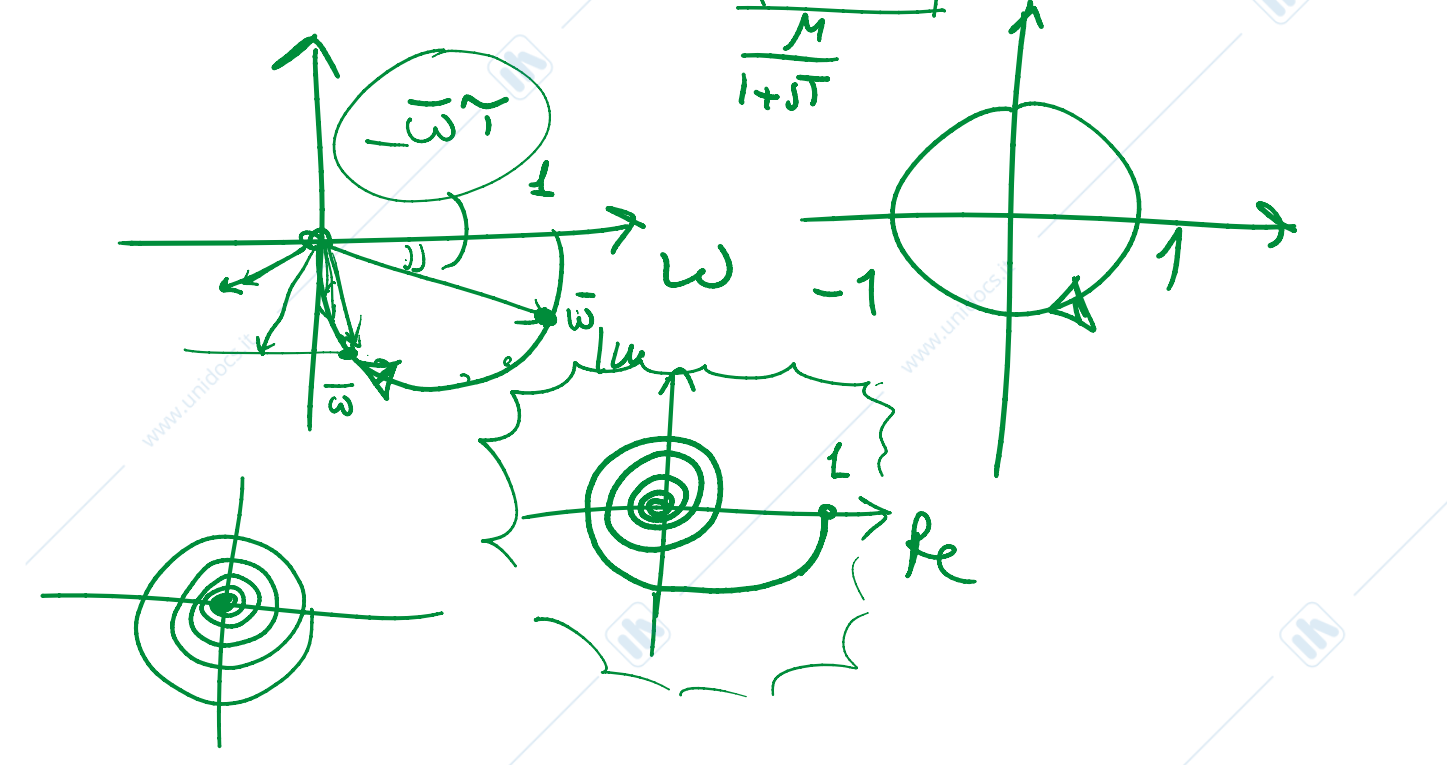
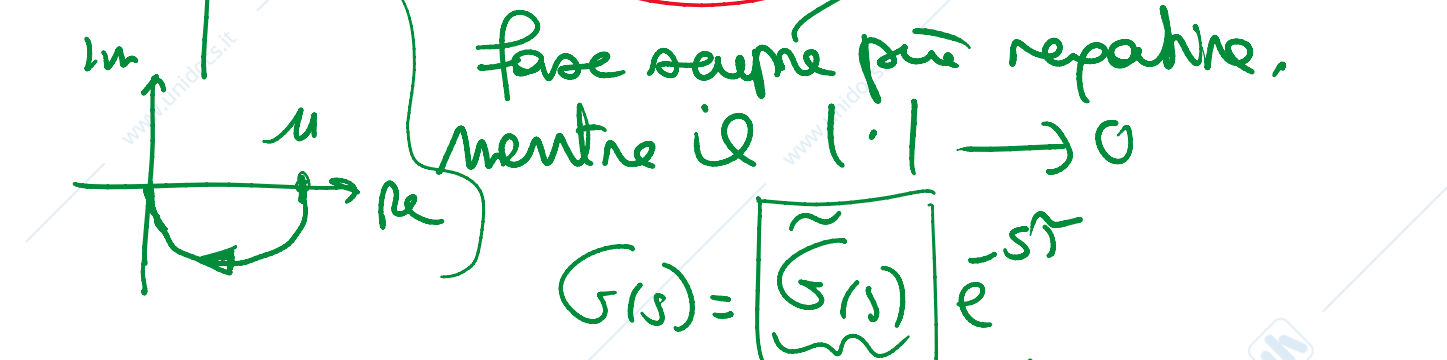
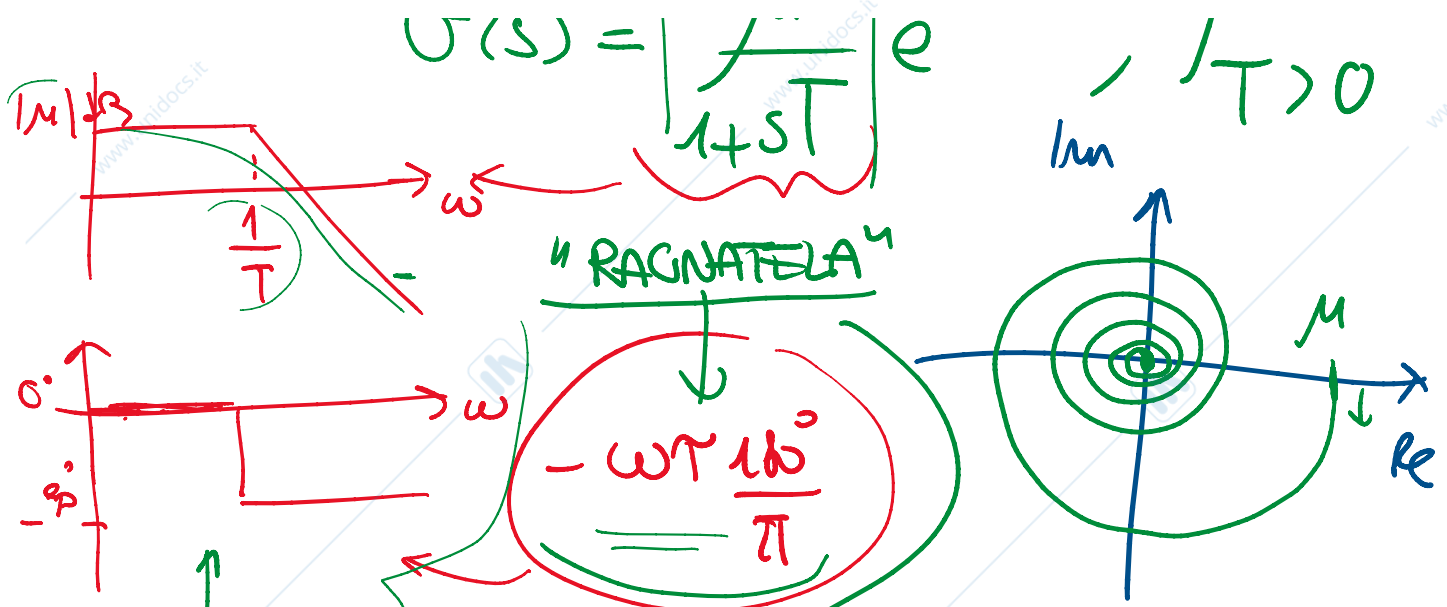
GIRI IN SENSO ORARIO SU CTF UNITARIA



Se ho un RITARDO che si "AGGIUNGE" AD UNA DINAMICA LTI

$$G(s) = \left[\frac{\mu}{T} \right] e^{-sT}, \quad \begin{matrix} \mu > 0 \\ T > 0 \end{matrix}$$

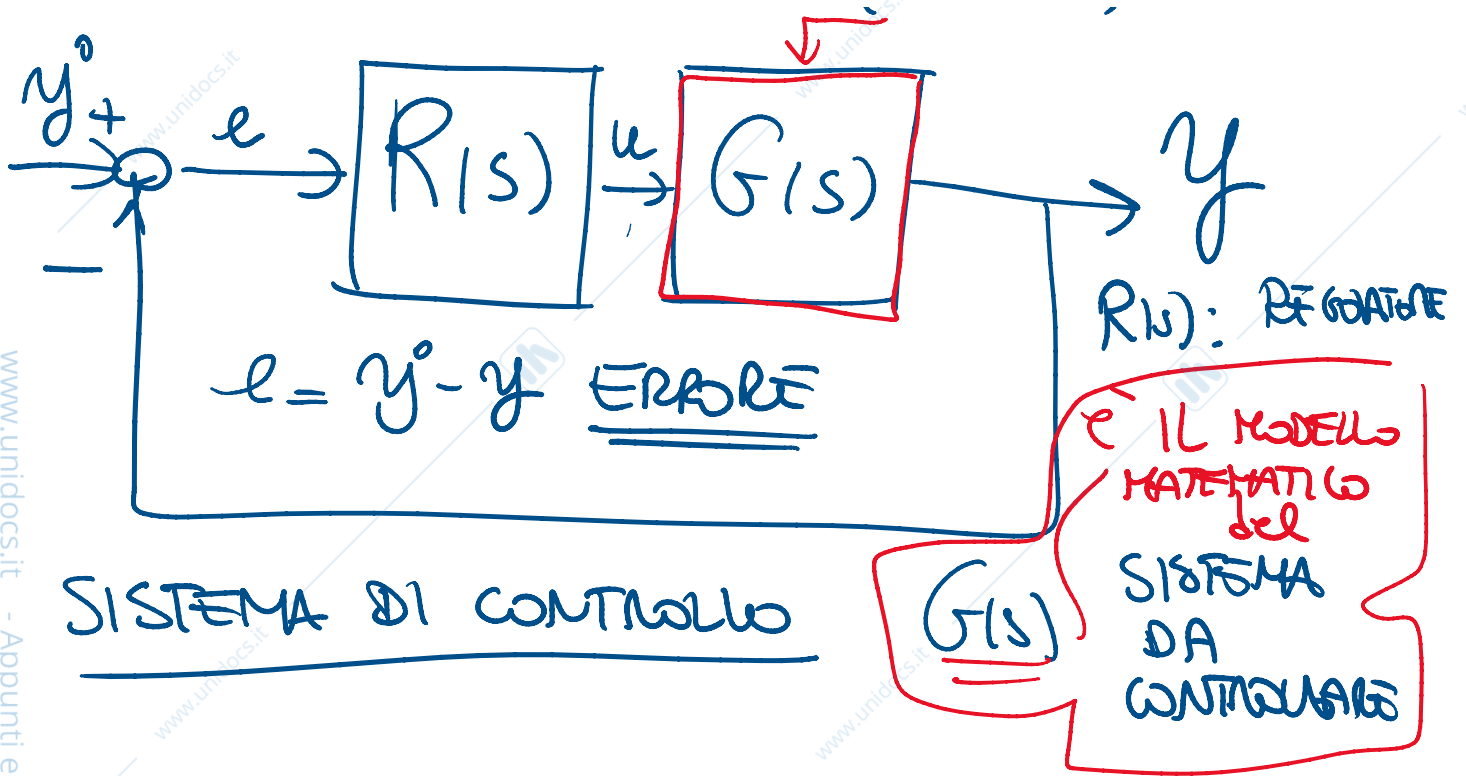
1.1.1.1



STUDIO SISTEMI RETROAZIONATI

SEGNALE DI RIFERIMENTO (SET-POINT)



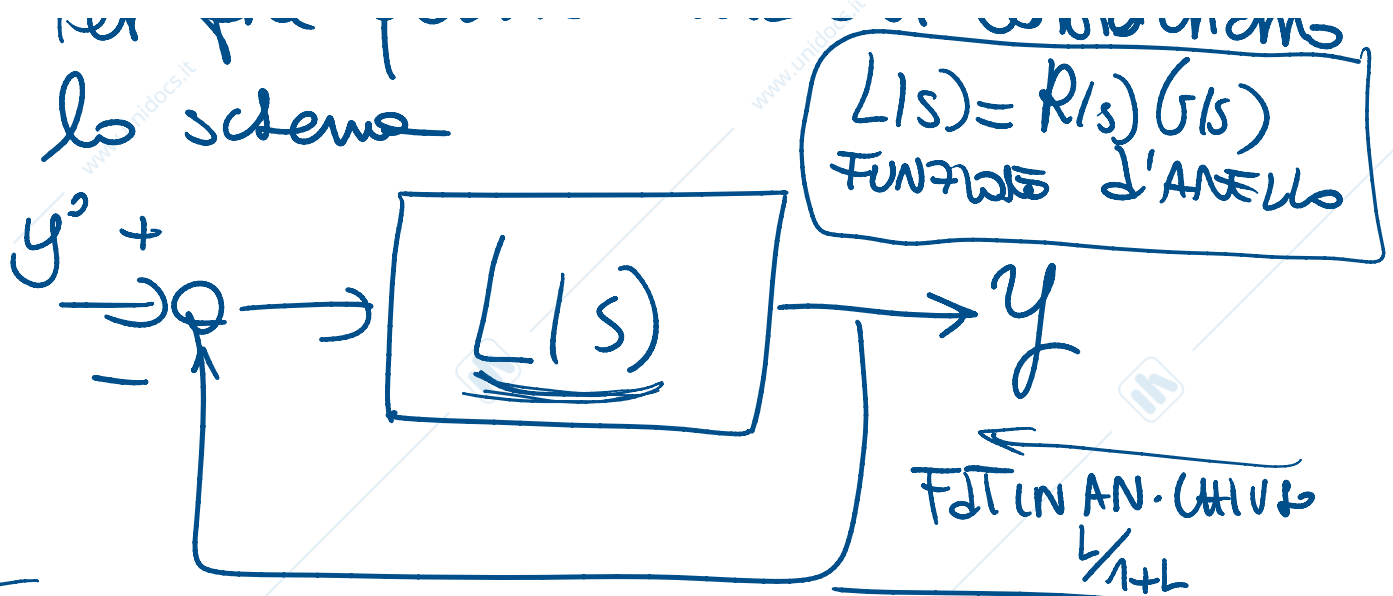


LA PRIMA PROPRIETÀ da STUDIARE è

LA STABILITÀ del sistema RETROAZIONATO

<p>STABILITÀ IN CONDIZIONI NOMINALI (1)</p>	<p>STABILITÀ IN CONDIZIONI (2) PERTURBATE</p>
<p>Ipotizzo che $G(s)$ sia un modello ESATTO del sistema da CONTROLLARE</p>	<p>$G(s) \neq$ SISTEMA DA CONTROLLARE</p> <p>\Downarrow</p> <p>"errori di modello"</p>

Per fare queste analisi consideriamo $(1/s) - R(s)G(s)$



Vogliamo studiare la STAB. del sistema in AN. CHUS analizzando la r.i.f. $L(j\omega)$ associate alle F. d'anello