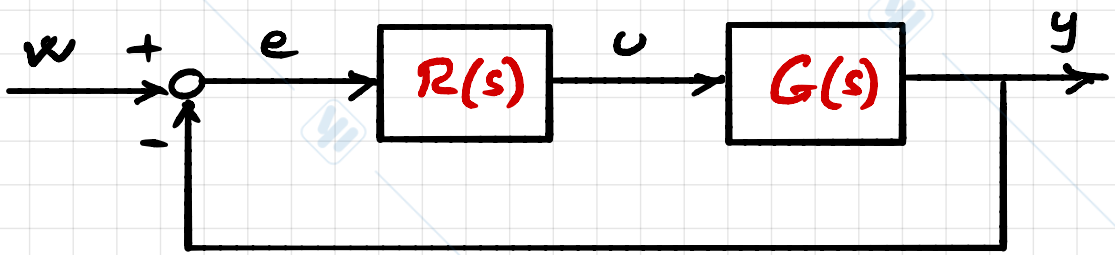
Progetto del Controllore Per Sistemi Instabili

- CONTROLLO DI SISTEMI INSTABILI

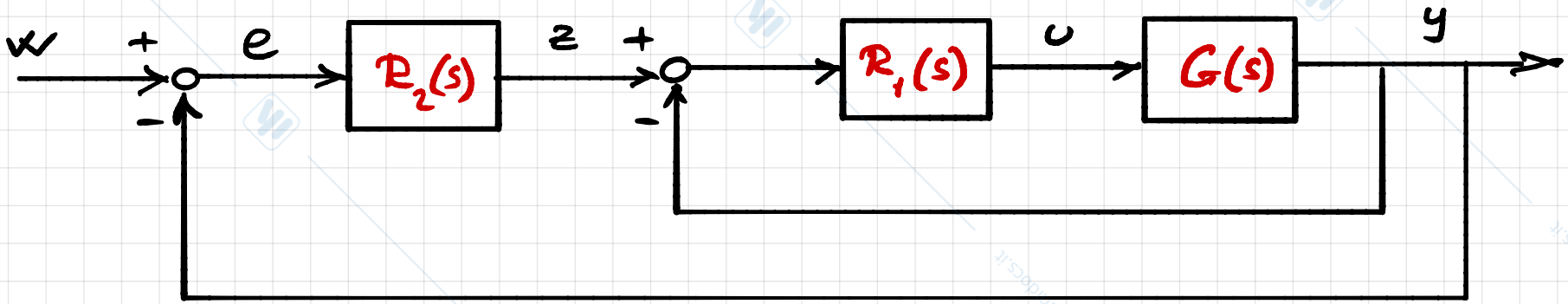


- SE $G(s)$ HA POLI CON $Re > 0$ (INSTABILE)

$\Longrightarrow$

- NON SONO CANCELLABILI CON ZERI DI $R(s)$
- CRITERIO DI BODE NON APPLICABILE
- METODI DI PROGETTO ?

- POSSIBILE SOLUZIONE (SCHEMA IN CASCATA)



1. $R_1(s)$ PROGETTATO PER STABILIZZARE
2. $R_2(s)$ PROGETTATO SU $F_1(s)$ PER RISPETTARE LE SPECIFICHE

$$F_1(s) = \frac{R_1(s)G(s)}{1 + R_1(s)G(s)}$$

- ESEMPIO

$$G(s) = \frac{100}{(1-0.1s)(1+0.2s)}$$

POLO IN +10 (INSTABILE)

- SPECIFICHE

(a) $e(\infty) = 0$ CON $w(t) = sca(t)$

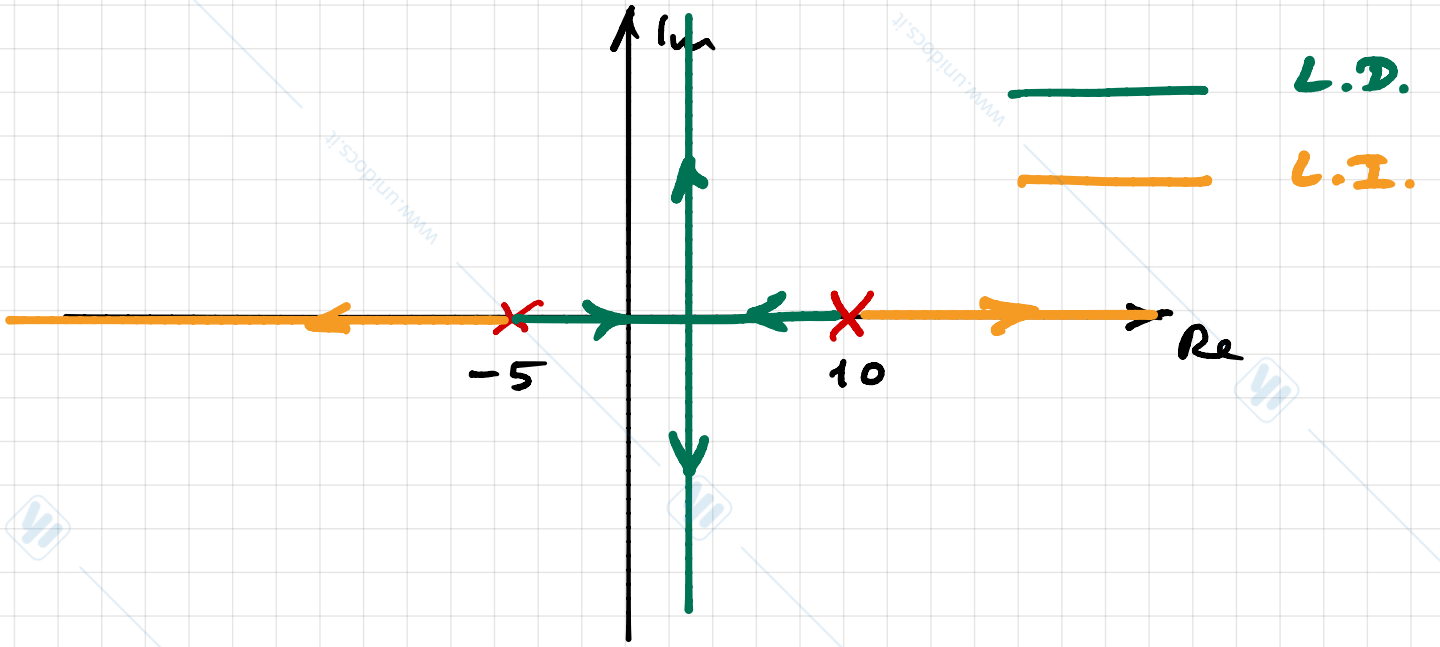
(b) $\omega_c \geq 10$

(c) $\varphi_m \geq 45°$

- PROGETTO DI $R_1(s)$ (CON LDR)

- TENTATIVO 1: $R_1(s) = k$ (CONTROLLORE P)

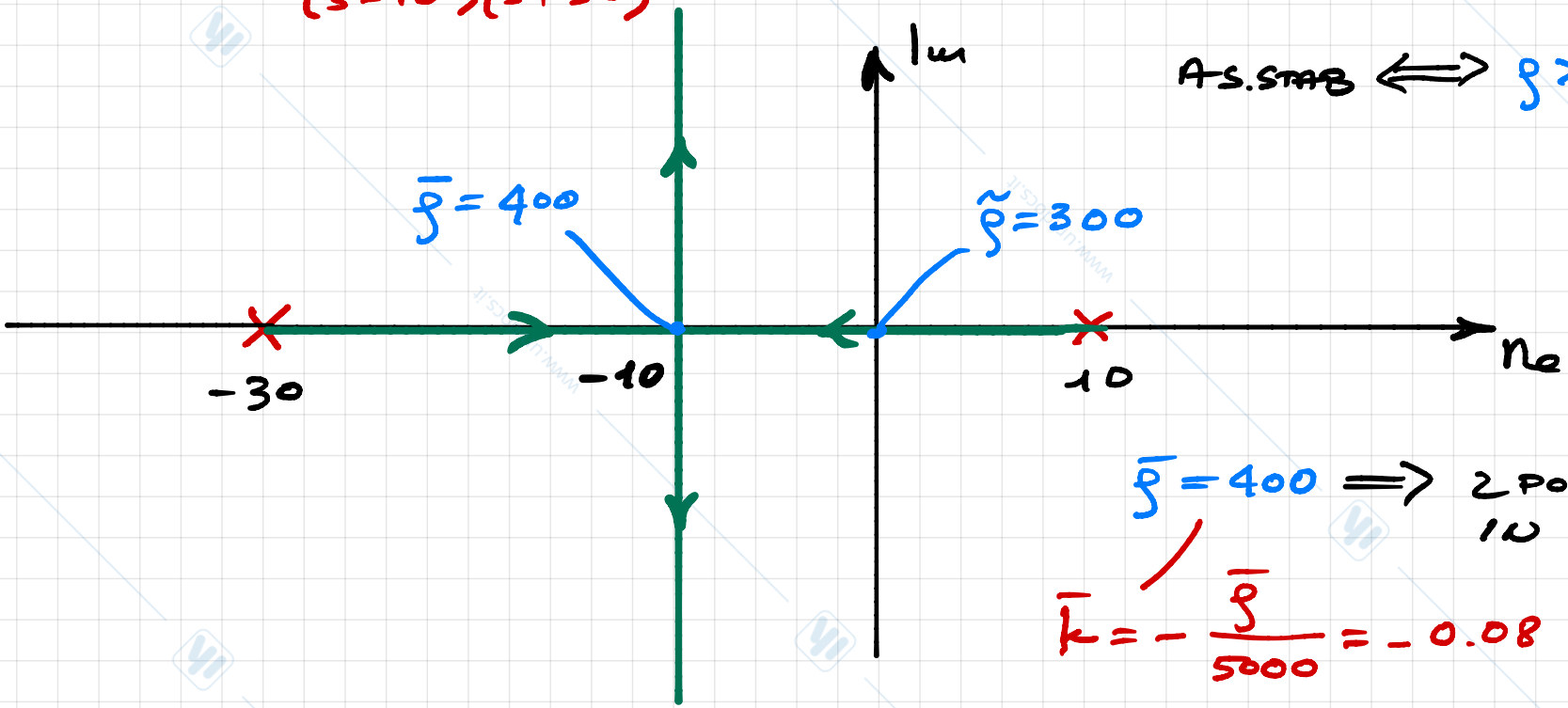
$$L_1(s) = \frac{100k}{(1-0.1s)(1+0.2s)} = \frac{-5000k}{(s-10)(s+5)} \qquad \rho = -5000k$$



$\Longrightarrow$ NON ESISTE ρ CHE STABILIZZA!

_TENTATIVO 2: $R_1(s) = k\,\frac{s+5}{s+30}$

$$L_1(s) = \frac{-5000k}{(s-10)(s+30)} \qquad \rho = -5000k$$



AS.STAB $\Longleftrightarrow \rho > 300$

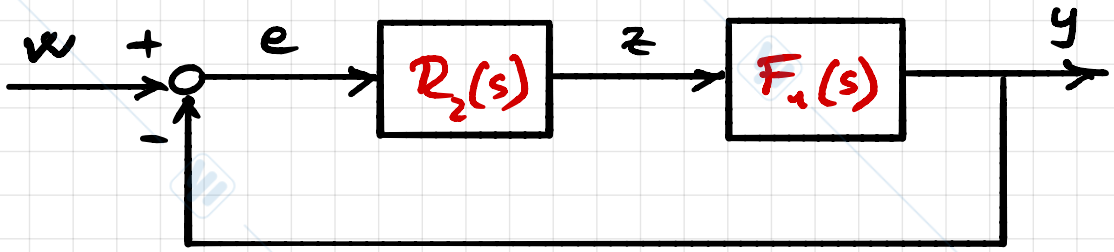
$\bar{\rho}=400 \Longrightarrow$ 2 POLI COINC. in -10

$$\bar{k} = -\frac{\bar{\rho}}{5000} = -0.08$$

$$R_1(s) = -0.08\,\frac{s+5}{s+30} \Longrightarrow L_1(s) = \frac{400}{(s-10)(s+30)}$$

$$F_1(s) = \frac{L_1(s)}{1+L_1(s)} = \frac{400}{s^2+20s+100} = \frac{400}{(s+10)^2} = \frac{4}{(1+0.1s)^2}$$

- Progetto di $R_2(s)$



$$F_1(s) = \frac{4}{(1+0.1s)^2}$$

$$R_2(s) = \mu_R \frac{(1+0.1s)^2}{s} \qquad \text{(PID "IDEALE")}$$

$$L_2(s) = R_2(s)F_1(s) = \frac{4\mu_R}{s}$$

$$\omega_c = 4\mu_R$$
$$\varphi_m = 90°$$

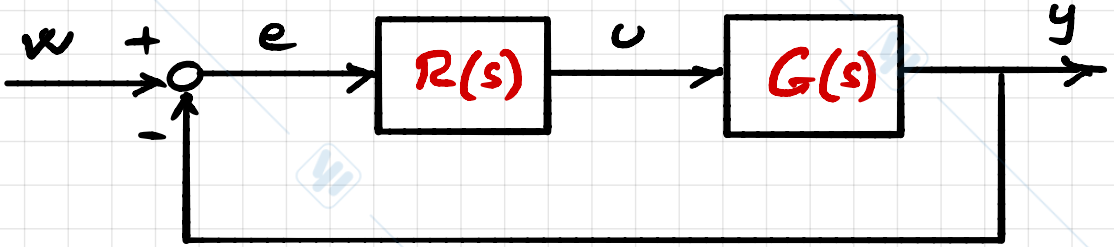
$$\begin{cases} \omega_c = 4\mu_R \geq 10 \implies \mu_R \geq 2.5 \\ \varphi_m = 90° > 45° \quad \text{OK} \end{cases} \implies R_2(s) = 2.5\frac{(1+0.1s)^2}{s}$$

- Polo aggiuntivo

PID "REALE"

$$R_2(s) = 2.5\frac{(1+0.1s)^2}{s(1+0.01s)} \implies \begin{cases} \omega_c \simeq 10 \\ \varphi_m \simeq 85° \end{cases} \quad \text{OK}$$

- PROGETTO DIRETTO DI $R(s)$ MEDIANTE L.D.R.



$$G(s) = \frac{100}{(1-0.1s)(1+0.2s)}$$

- SPECIFICHE

(a) $e(\infty) = 0$ CON $w(t) = sca(t)$ $\Longrightarrow$ AZIONE INTEGRALE

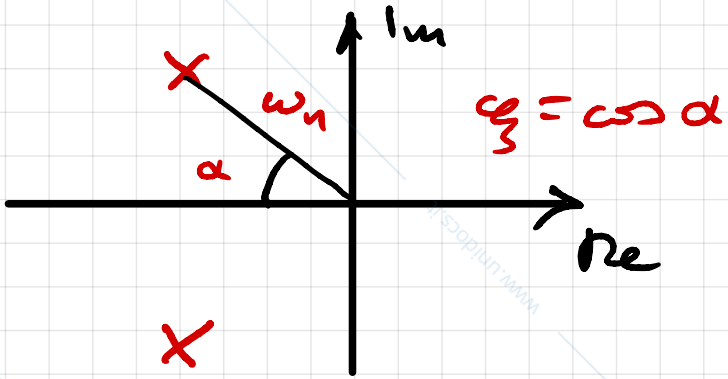
(b) $\omega_c \geq 10$

(c) $\varphi_m \geq 45°$

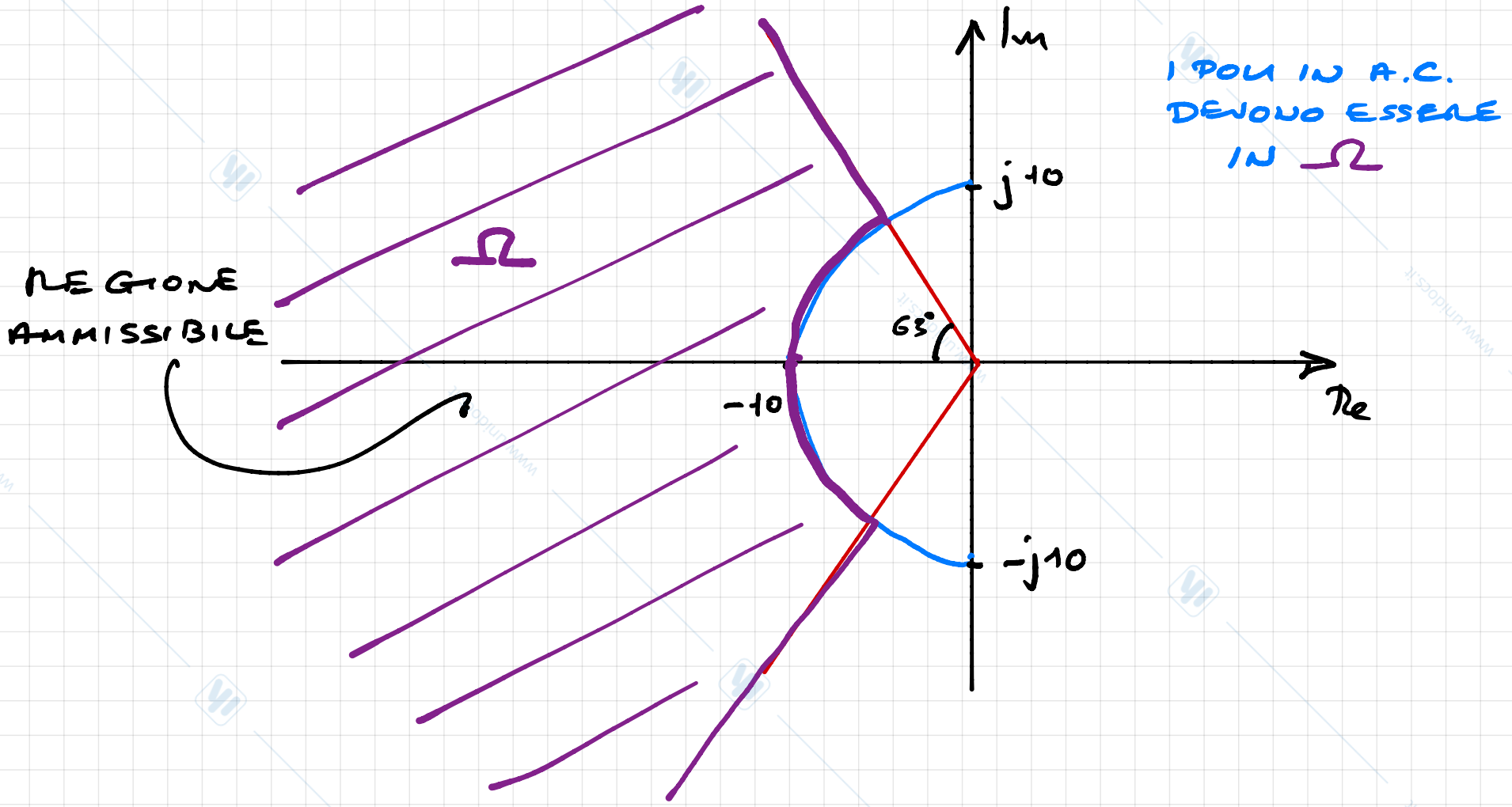
$\Longrightarrow$ POLI DOMINANTI IN A.C. CON

$$\begin{cases} \omega_n \geq 10 \\ \xi \geq 0.45 \end{cases}$$

$\alpha \leq \arccos(0.45) \simeq 63°$



- INTERPRETAZIONE NEL PIANO COMPLESSO



I POLI IN A.C. DEVONO ESSERE IN Ω

- TENTATIVO 1: $R(s) = \frac{\mu_R}{s}$

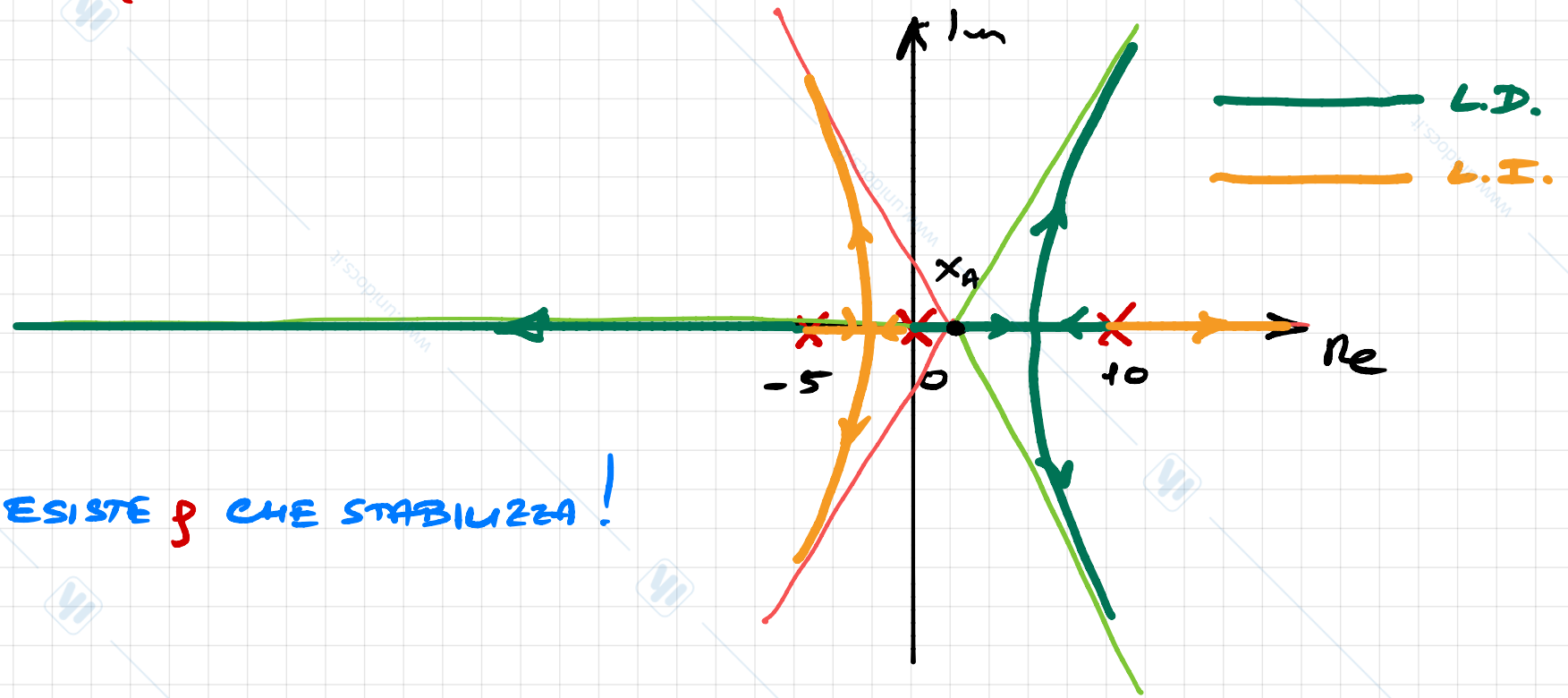
$$L(s) = \frac{-5000\mu_R}{s(s-10)(s+5)}$$

$\beta = -5000\mu_R$

$n = 3$
$m = 0$
$\nu = 3$

$x_A = \frac{1}{3}(-5+10) = \frac{5}{3}$

$x_B = x_A$



NON ESISTE β CHE STABILIZZA !

_TENTATIVO 2

_ IDEE:
- AGGIUNGERE POLO "VELOCE" PER SPOSTARE X_A, X_B A SINISTRA
- AGGIUNGERE ZERI IN Ω PER ATTIRARE I RAMI

$$R(s) = \mu_R \frac{(1+sT)^2}{s(1+s\tau)}$$

$$L(s) = \frac{-5000\mu_R(1+sT)^2}{s(1+s\tau)(s-10)(s+5)} = \frac{\beta\left(s+\frac{1}{T}\right)^2}{s\left(s+\frac{1}{\tau}\right)(s-10)(s+5)}$$

$$\beta = -5000\mu_R\frac{T^2}{\tau}$$

$n = 4$
$m = 2$
$\nu = 2$

$$x_A = \frac{1}{2}\left(5 - \frac{1}{\tau} + \frac{2}{T}\right)$$

$$x_B = \frac{1}{4}\left(5 - \frac{1}{\tau}\right)$$

p.e.

$$\begin{cases} \tau = 0.005 \\ T = 0.05 \end{cases}$$

$x_A = -77.5$
$x_B = -48.7$

_ LUOGO DELLE RADICI

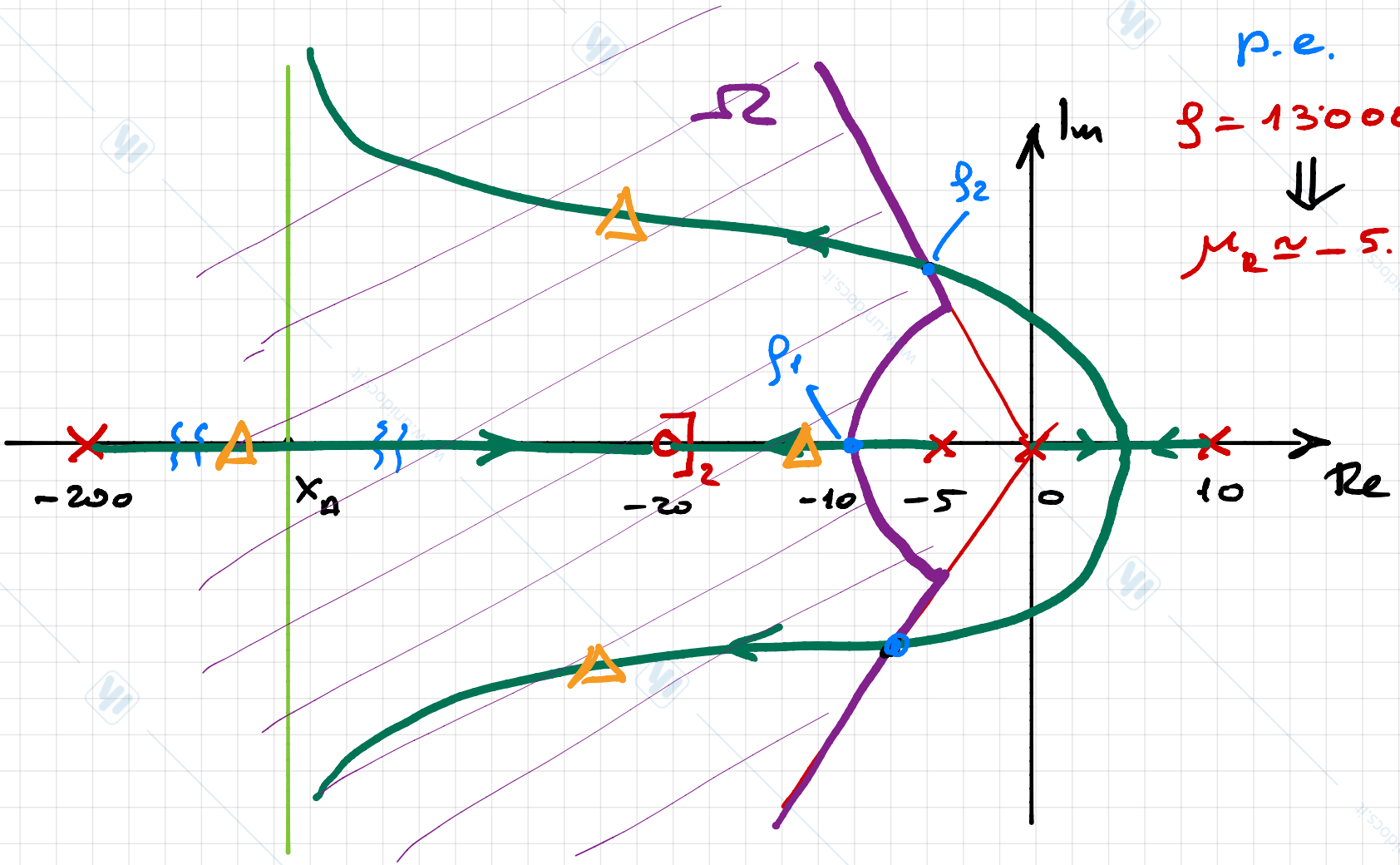
$\rho > \max(\rho_1, \rho_2)$

p.e.

$\rho = 13000$

$\Downarrow$

$\mu_R \simeq -5.2$



$$R(s) = -5.2 \frac{(1+0.05s)^2}{s(1+0.005s)} \Longrightarrow$$

_POLI IN A.C.

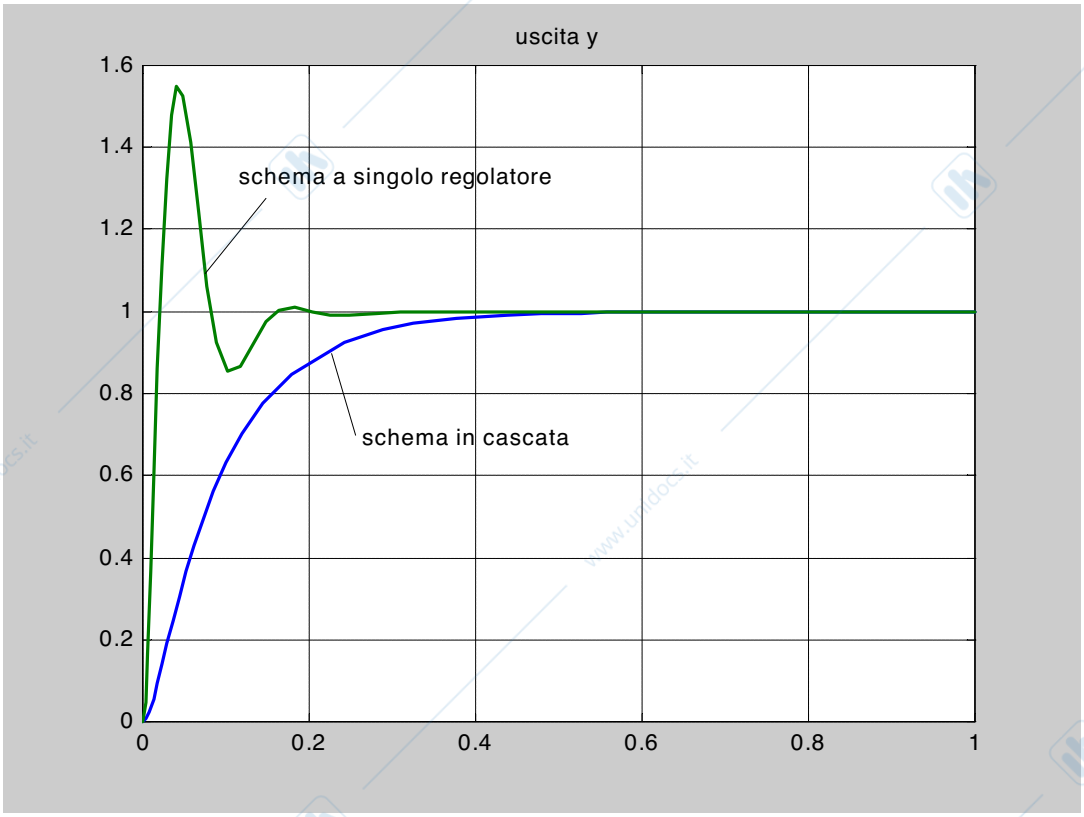
$s_1 = -131$

$s_2 = -13.7$

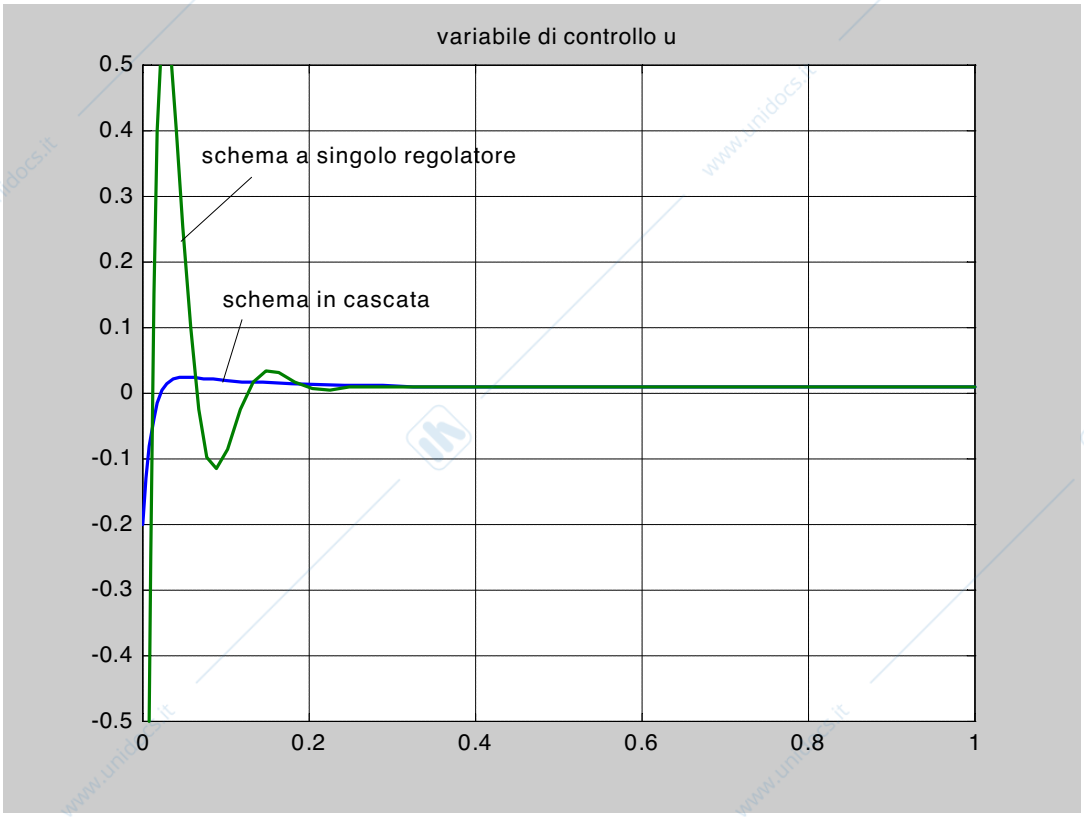
$s_{3,4} = -25 \pm j48$

$\xi \simeq 0.46$

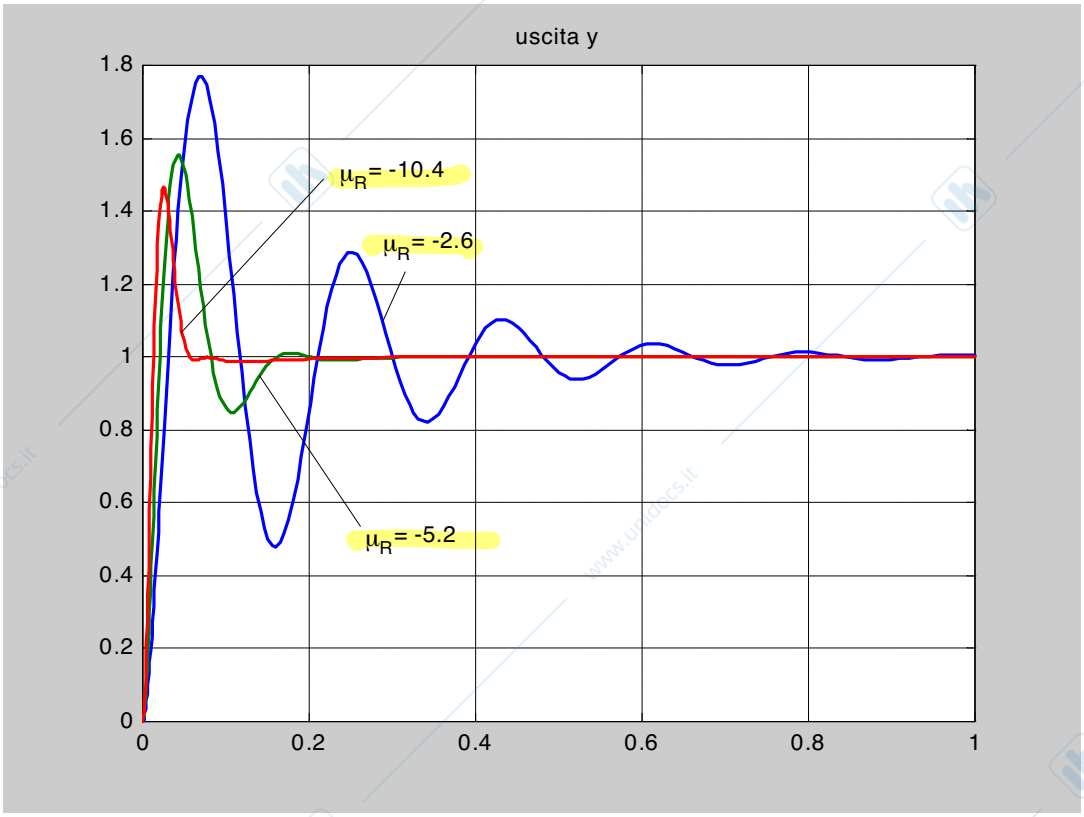
1. CONTROLLO DI SISTEMA INSTABILE – RISPOSTA DELL'USCITA AD UN RIFERIMENTO A SCALINO



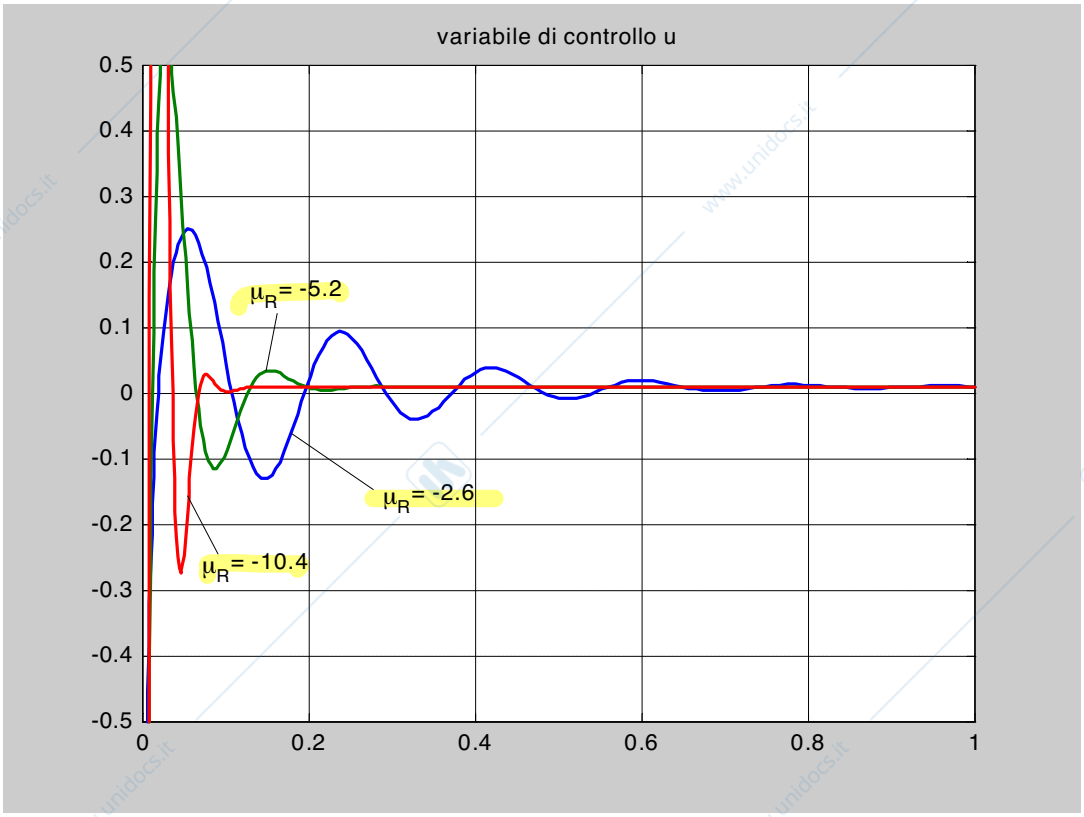
2. CONTROLLO DI SISTEMA INSTABILE – RISPOSTA DELLA VARIABILE DI CONTROLLO AD UN RIFERIMENTO A SCALINO



3. CONTROLLO DI SISTEMA INSTABILE – SCHEMA A SINGOLO REGOLATORE CON DIVERSI VALORI DEL GUADAGNO



4. CONTROLLO DI SISTEMA INSTABILE – SCHEMA A SINGOLO REGOLATORE CON DIVERSI VALORI DEL GUADAGNO



- OSSERVAZIONI

  - LO SCHEMA A SINGOLO REGOLATORE PRODUCE:

    - ELEVATA SOVRAELONGAZIONE

      DOVUTA A: - SMORZAMENTO ζ NON ABBASTANZA ELEVATO

      - ZERI A BASSA FREQUENZA DI $R(s)$

    - SCARSA MODERAZIONE

- CONCLUSIONE

  MEGLIO USARE LO SCHEMA IN CASCATA