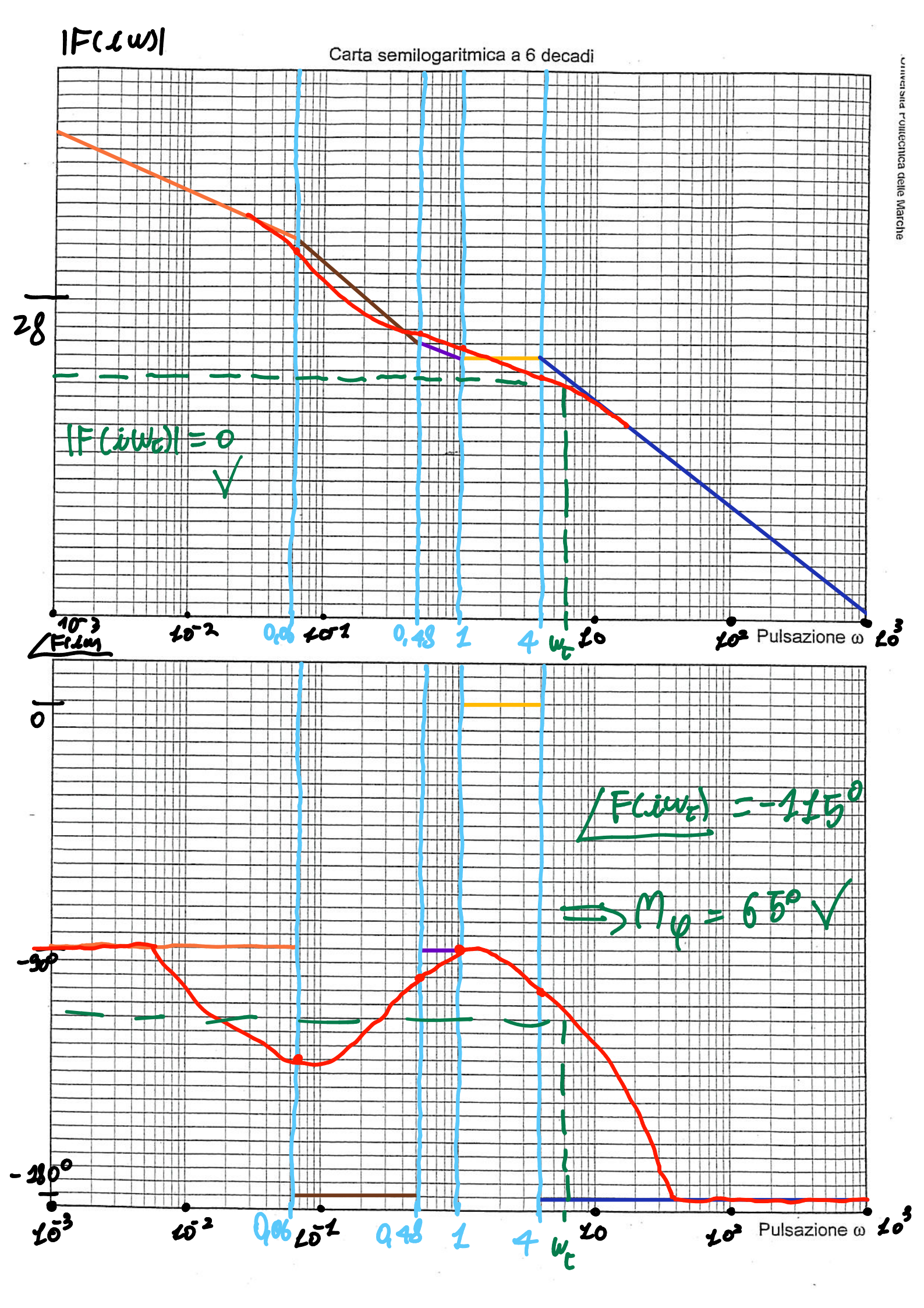
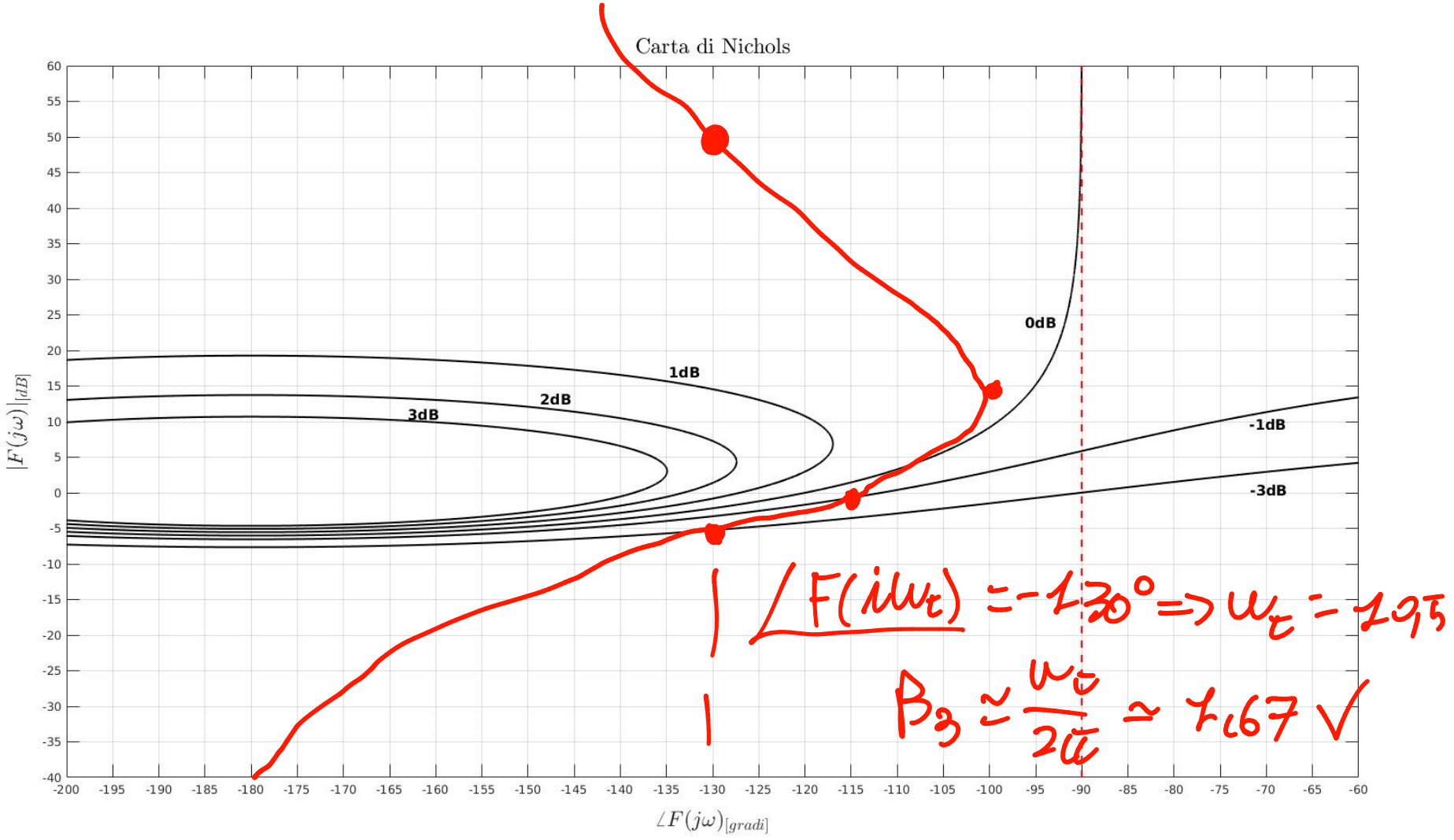

|F(iω)|
Carta semilogaritmica a 6 decadi
Università Politecnica delle Marche
28
|F(iω_t)| = 0
√
10^-3
10^-2
0,06
10^-1
0,48
1
4
ω_t
10
10^2
Pulsazione ω
10^3
Fidm
0
-90°
-180°
∠F(iω_t) = -115°
⇒ M_φ = 65° √
10^-3
10^-2
0,06
10^-1
0,48
1
4
ω_t
10
10^2
Pulsazione ω
10^3


Carta di Nichols
0dB
1dB
2dB
3dB
-1dB
-3dB
$|F(j\omega)|_{[dB]}$
$\angle F(j\omega)_{[gradi]}$
$\angle F(j\omega_c) = -120° \Rightarrow \omega_c = 1.95$
$B_3 \simeq \frac{\omega_c}{2\pi} \simeq 4.67$ √

$$U(t) = (3t+5)\delta_{-1}(t) = 3(t)\delta_{-1}(t) + (5)\delta_{-1}(t)$$

$$= 3U_1(t) + 5U_2(t)$$

- $U_1(t)$

$$\tilde{e}_{U_1}(t) = K_g U_1(t) - \tilde{y}_{U_1}(t)$$

$$\tilde{e}_{U_1}(t) = \frac{1}{K_g \cdot K_p} = \frac{1}{K_F} = \frac{1}{25}$$

$$\tilde{y}_{U_1}(t) = K_g U_1(t) - \tilde{e}_{U_1}(t) = \left(t - \frac{1}{25}\right)\delta_{-1}(t)$$

- $U_2(t)$

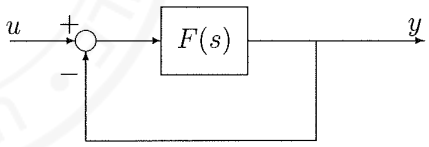
GRADO DI $U_2(t)$ < TIPO DI $F(s)$ $\Rightarrow \tilde{y}_{U_2}(t) = \delta_{-1}(t)$

$$\Rightarrow \tilde{y}(t) = 3\left(t - \frac{1}{25}\right)\delta_{-1}(t) + 5\,\delta_{-1}(t)$$

Domanda Scritta di Controlli Automatici (9CFU) - 16/7/2012

Esercizio 1

È dato il sistema in controreazione:

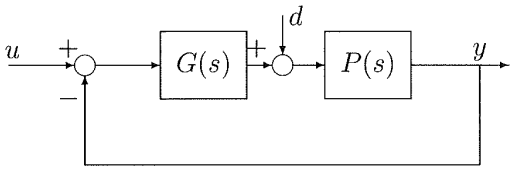


in cui $F(s) = \dfrac{K(s+1)(s+4)(s+5)}{(s-2)(s+10)(s^2+4s+8)}$, $K \in \mathbb{R}$.

- Tracciare il luogo positivo delle radici;
- tracciare il luogo negativo delle radici;
- determinare per quali valori di K il sistema a ciclo chiuso è asintoticamente stabile;
- se $K = 10$, esiste la risposta a regime permanente a ciclo chiuso per un ingresso a gradino? Motivare la risposta.

Esercizio 2

È dato il sistema di controllo:



in cui:

$$P(s) = \frac{10(s+0.1)}{s(s+2)^2}; \quad d(t) = \delta_{-1}(t).$$

Progettare $G(s)$ con la sintesi per tentativi in ω in modo che:

- $|\tilde{y}_d(t)| \leq 0.05$, essendo $\tilde{y}_d(t)$ la risposta a regime permanente al disturbo $d(t)$;
- $M_r \leq 3\ dB$;
- $B_3 \simeq 1\ Hz$.

Calcolare infine la risposta a regime permanente all'ingresso: $u(t) = (-2t+4)\cdot\delta_{-1}(t)$.

①

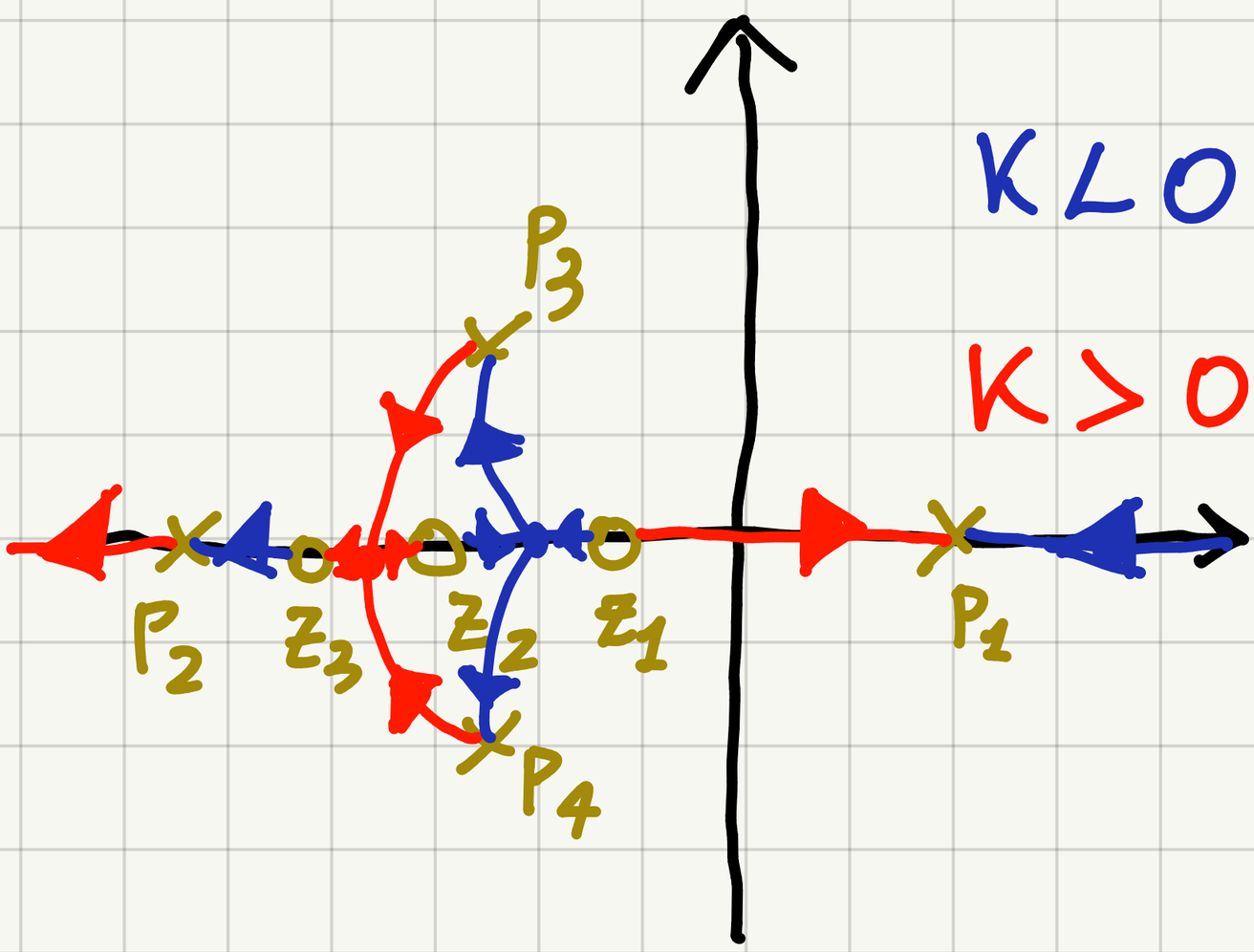
$$F(s) = K \cdot \frac{(s+1)(s+4)(s+5)}{(s-2)(s+10)(s^2+4s+8)} \qquad K \in \mathbb{R}$$

$n = 4, \; m = 3 \quad \Rightarrow \quad n - m = 1$

$\frac{-8 \pm 4i}{2}$

$p_1 = 2 \qquad p_2 = -10 \qquad p_3 = -2+2i \qquad p_4 = -2-2i$

$z_1 = -1 \qquad z_2 = -4 \qquad z_3 = -5$



$$p(s,K) = (s-2)(s+10)(s^2+4s+8) + K(s+1)(s+4)(s+5) \Big|_{s=0} = 0$$

$-160 + 20K = 0 \qquad K = 8$

SISTEMA STABILE $\forall K > 8$

$\Rightarrow \exists$ RISPOSTA A REGIME PERMANENTE PER $K = 10$

$$|\tilde{Y}_d(\omega)| = \left|\frac{1}{K_T \cdot K_0}\right| \leq 0{,}05 \quad (2) \Rightarrow K_0 \geq 20$$

$$M_r \leq 3\,dB \Rightarrow M_\varphi \geq 42^\circ$$

$B_3 \simeq 1\,Hz \Rightarrow \omega_c = 3 \div 5\, B_3 = 4 B_3 = 4 \frac{rad}{s}$

DALLE SPECIFICHE UNIVOCHE E DALLA STRUTTURA DI

$P(s),\ G(s) = K_0 \cdot P(s) = 20 \cdot P(s) \qquad F(s) = G(s) \cdot P(s)$

1° TENTATIVO: $P(s) = 1$

$$\Rightarrow F(s) = \frac{200(s+0{,}1)}{s(s+2)^2} \qquad F(i\omega) \simeq 5 \cdot \frac{\left(1 + \frac{i\omega}{0{,}1}\right)}{i\omega\left(1 + \frac{i\omega}{2}\right)^2}$$

$5 \rightarrow 20\log_{10}(5) = 14\,dB$

PUNTI DI ROTTURA:

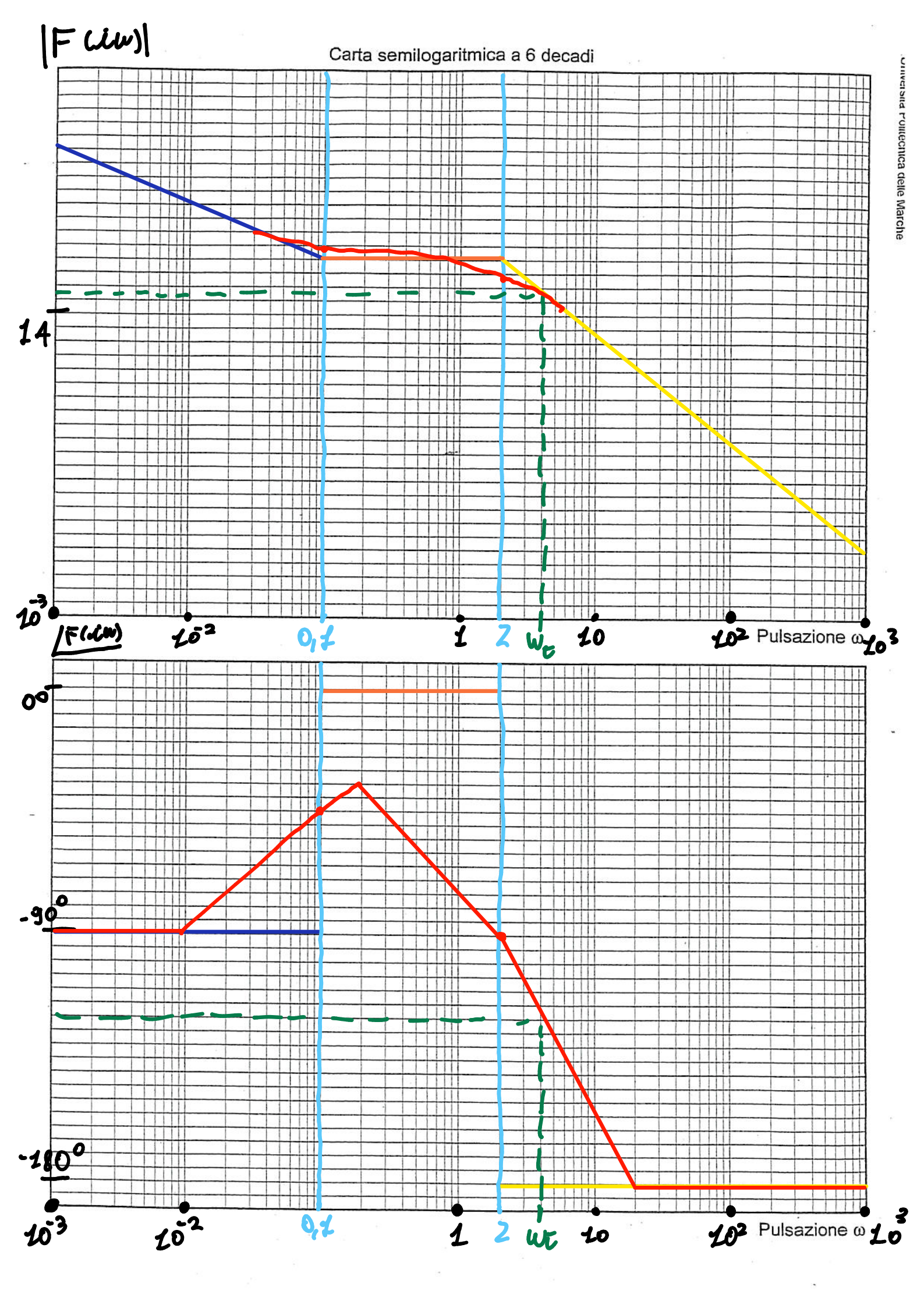
• $\omega = 0$	•	$-20\,dB/dec$	-90°	$-20\,dB/dec$ -90°
• $\omega = 0{,}1$	•	$+20\,dB/dec$	$+90^\circ$	0 0
• $\omega = 2$	•	$-40\,dB/dec$	-180°	$-40\,dB/dec$ -180°

CORREZIONE MODULO

ω	$1 + \frac{i\omega}{0{,}1}$	$1 + \frac{i\omega}{2}$	TOT
0,1	+3dB	0	+3dB
2	0	−6dB	−6dB

CORREZIONE FASE

ω	$i\omega$	$1 + \frac{i\omega}{0{,}1}$	$1 + \frac{i\omega}{2}$	TOT
0,1	-90°	$+45^\circ$	0	-45°
2	-90°	$+90^\circ$	-90°	-90°


|F(jω)|
Carta semilogaritmica a 6 decadi
Università Politecnica delle Marche
14
10^-3
10^-2
0,1
1
2
ωc
10
10^2
10^3
Pulsazione ω
|F(jω)|
00
-90°
-180°
10^-3
10^-2
0,1
1
2
ωc
10
10^2
10^3
Pulsazione ω

$|F(i\omega_t)| = 20\,dB$

$\underline{\angle F(i\omega_t)} = -120^\circ \Rightarrow M_\varphi = 60^\circ$

OBIETTIVO:

- $|F(i\omega_t)| = 0$ ✗

$\Rightarrow$ DIMINUIRE MODULO

- $M_\varphi \geq 42^\circ$ ✓

$\Rightarrow$ FUNZIONE ATTENUATRICE $R_i(s) = \dfrac{1 + \frac{s}{m_i \omega_i}}{1 + \frac{s}{\omega_i}}$

$m_i = 10,\ \omega_t \gamma_i = 100 \Rightarrow \omega_i = \dfrac{\omega_t}{100} = 0{,}04$

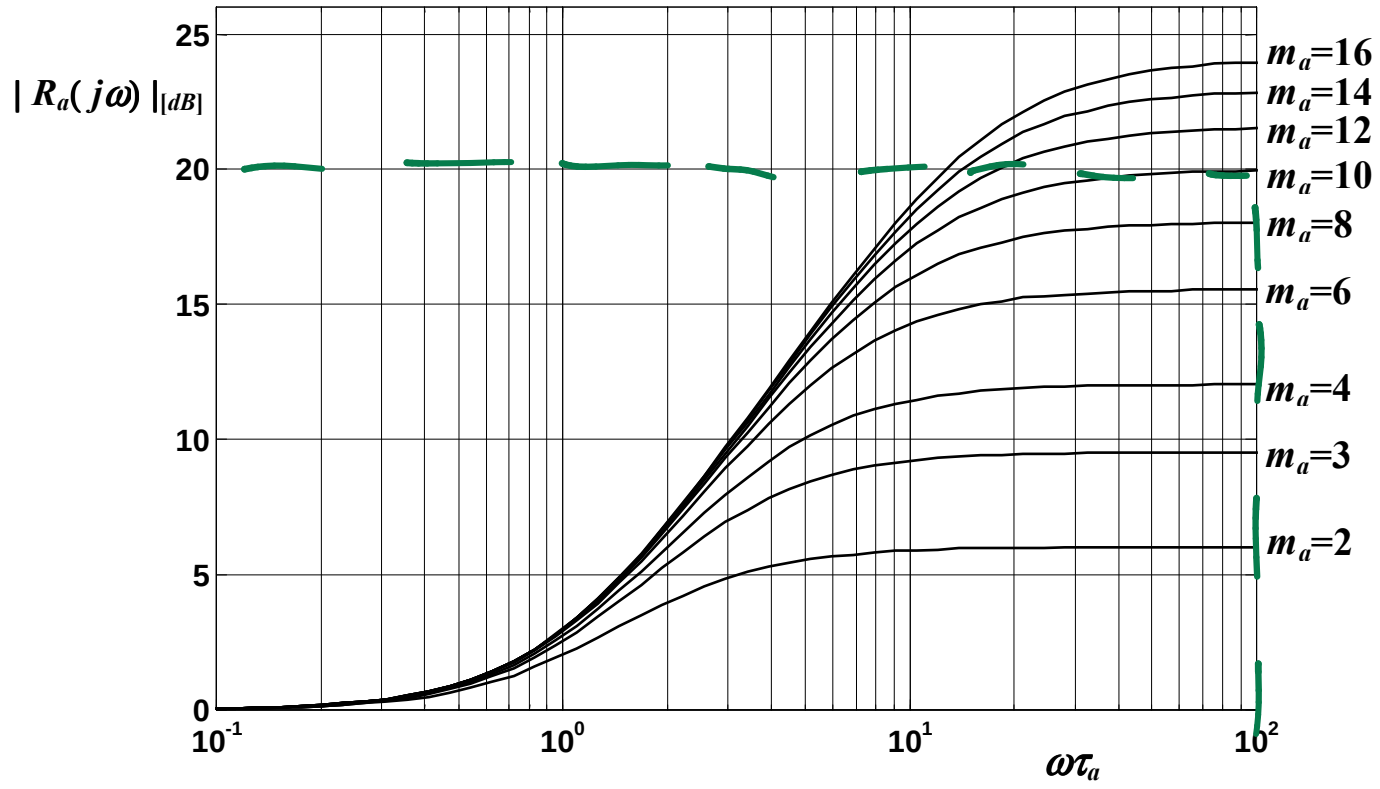
$\Rightarrow R(s) = R_i(s) = \dfrac{1 + \frac{s}{0{,}4}}{1 + \frac{s}{0{,}04}}$

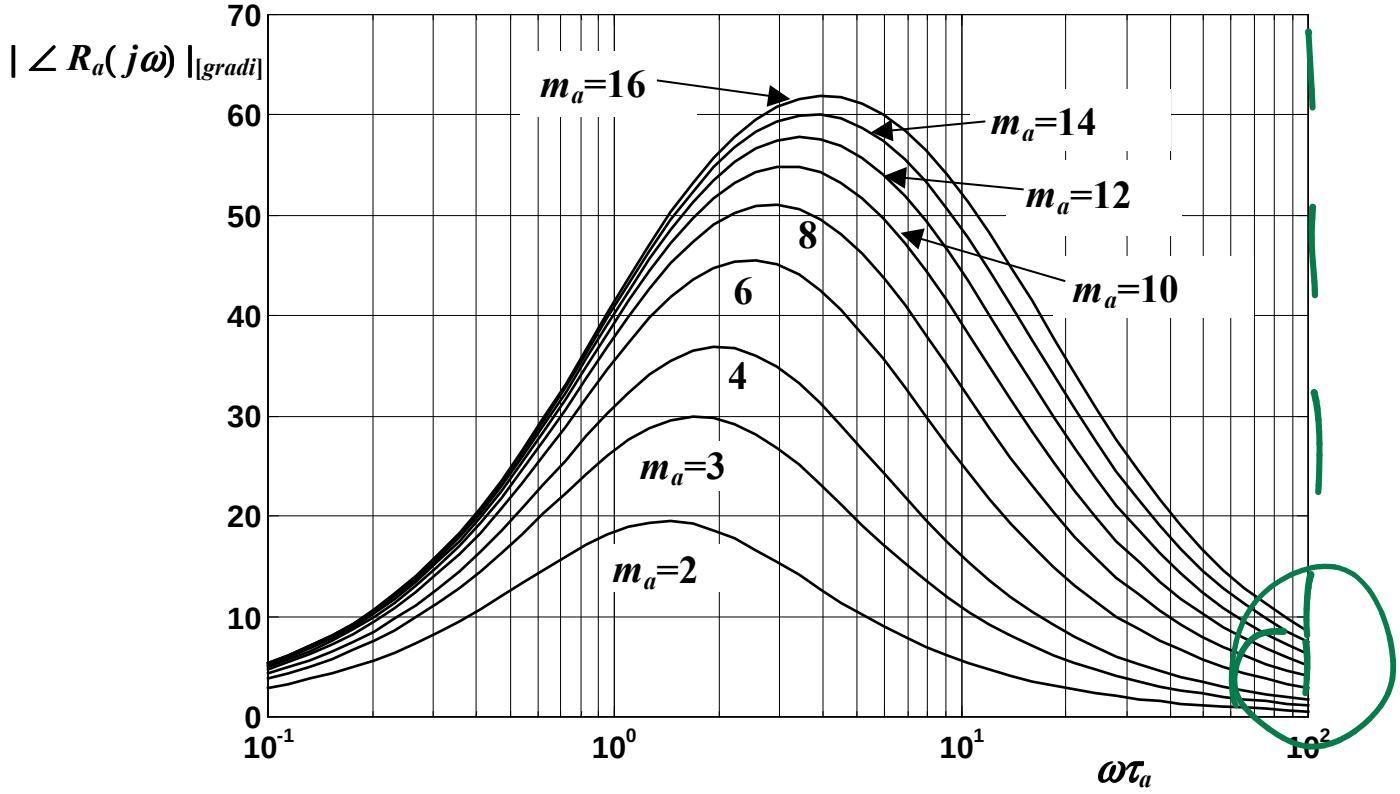
$\Rightarrow G(s) = 20 \cdot \dfrac{1 + \frac{s}{0{,}4}}{1 + \frac{s}{0{,}04}}$

$\Rightarrow F(i\omega) = 5 \cdot \dfrac{\left(1 + \frac{i\omega}{0{,}1}\right)}{i\omega\left(1 + \frac{i\omega}{2}\right)^2} \cdot \dfrac{1 + \frac{i\omega}{0{,}4}}{1 + \frac{i\omega}{0{,}04}}$

PUNTI DI ROTTURA:

• $\omega = 0$	● −20dB/dec	−90°	−20dB/dec	−90°
• $\omega = 0{,}04$	● −20dB/dec	−90°	−40dB/dec	−180°
• $\omega = 0{,}1$	● +20dB/dec	+90°	−20dB/dec	−90°
• $\omega = 0{,}4$	● +20dB/dec	+90°	0	0
• $\omega = 2$	● −40dB/dec	−180°	−40dB/dec	−180°


| $R_a(j\omega)$ |$_{[dB]}$
25
20
15
10
5
0
10^{-1}
10^{0}
10^{1}
10^{2}
$\omega\tau_a$
m_a=16
m_a=14
m_a=12
m_a=10
m_a=8
m_a=6
m_a=4
m_a=3
m_a=2

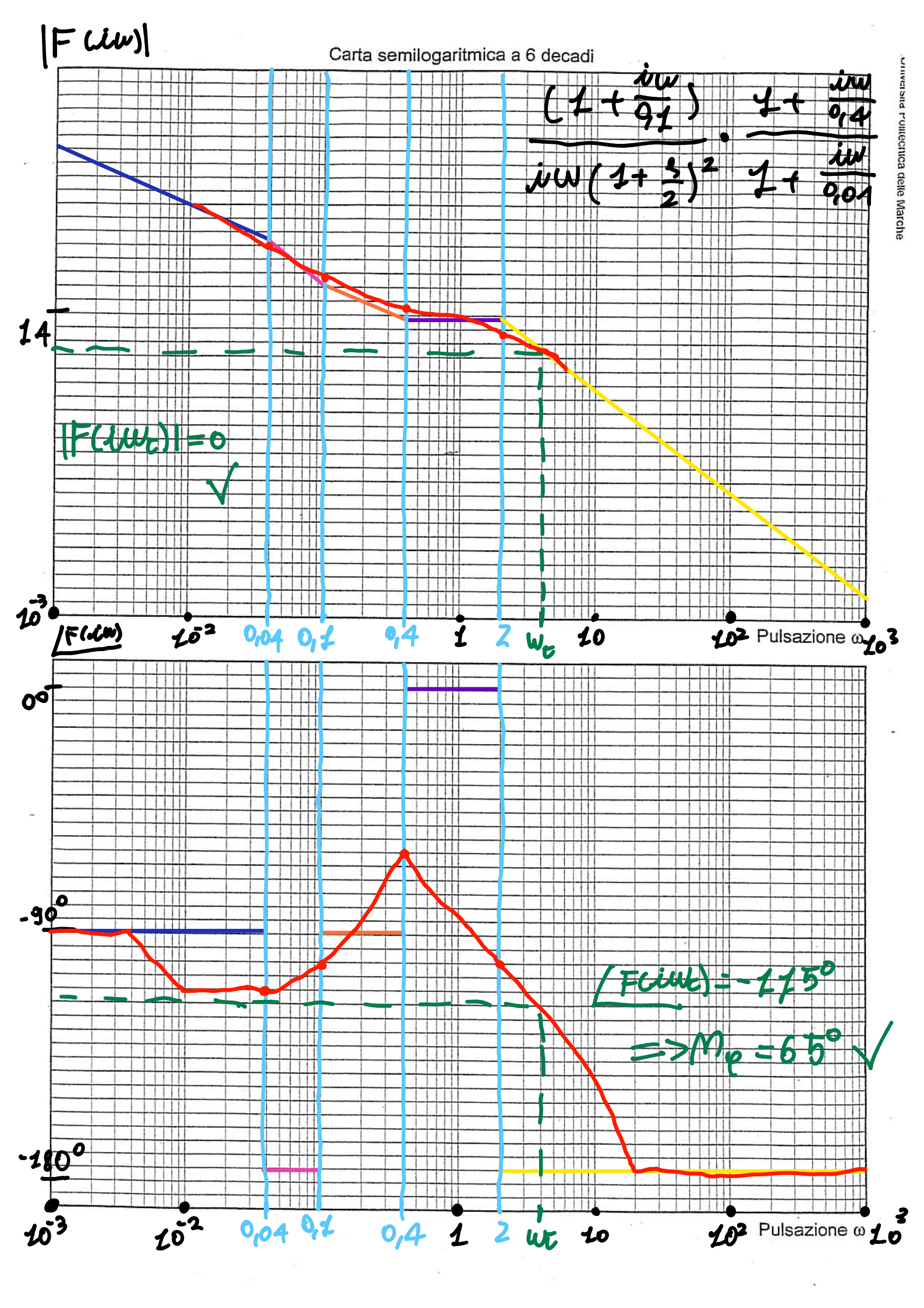

| $\angle R_a(j\omega)$ |$_{[gradi]}$
70
60
50
40
30
20
10
0
10^{-1}
10^{0}
10^{1}
10^{2}
$\omega\tau_a$
m_a=16
m_a=14
m_a=12
m_a=10
8
6
4
m_a=3
m_a=2

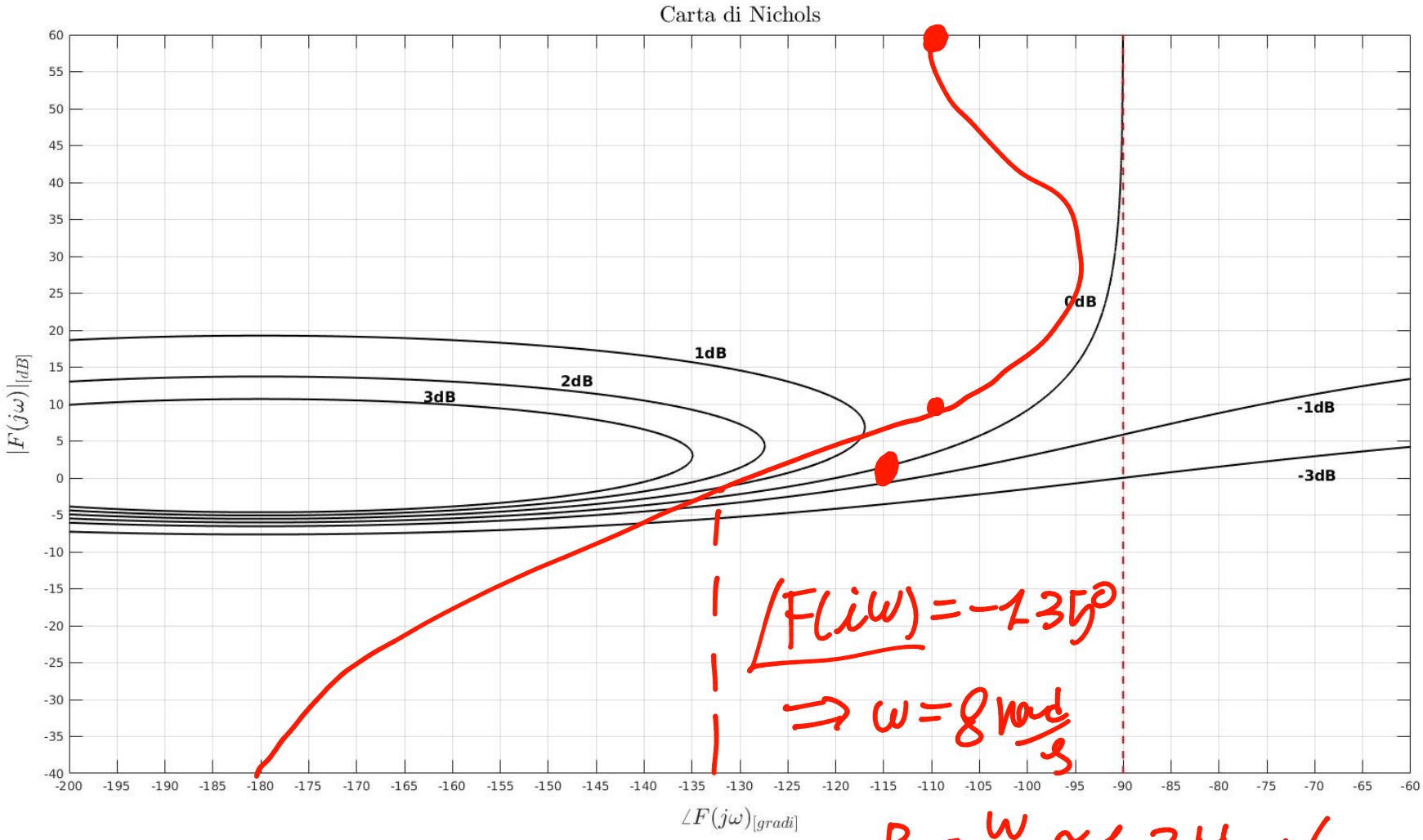
CORREZIONE MODULO

ω	$1+\frac{i\omega}{0,04}$	$1+\frac{i\omega}{0,1}$	$1+\frac{i\omega}{0,4}$	$1+\frac{i\omega}{2}$	TOT
0,04	-3dB	+1dB	0	0	-2dB
0,1	-1dB	+3dB	0	0	+2dB
0,4	0	0	+3dB	0	+3dB
2	0	0	0	-6dB	-6dB

CORREZIONE FASE

ω	$i\omega$	$1+\frac{i\omega}{0,04}$	$1+\frac{i\omega}{0,1}$	$1+\frac{i\omega}{0,4}$	$1+\frac{i\omega}{2}$	TOT
0,04	-90°	-45°	+25°	0	0	-110°
0,1	-90°	-70°	+45°	+15°	0	-100°
0,4	-90°	-90°	+75°	+45°	0	-60°
2	-90°	-90°	+90°	+80°	-90°	-100°


|F(jω)|
Carta semilogaritmica a 6 decadi
$\frac{(1+\frac{j\omega}{0,1})}{j\omega(1+\frac{s}{2})^2}\cdot\frac{1+\frac{j\omega}{0,4}}{1+\frac{j\omega}{0,01}}$
14
$|F(j\omega_c)|=0$ √
10^{-3} 10^{-2} 0,04 0,1 0,4 1 2 ω_c 10 10^2 Pulsazione ω 10^3
|F(jω)|
0°
-90°
-180°
$\angle F(j\omega_c) = -175°$
$\Rightarrow M_\varphi = 65°$ √
10^{-3} 10^{-2} 0,04 0,1 0,4 1 2 ω_c 10 10^2 Pulsazione ω 10^3


Carta di Nichols
$|F(j\omega)|_{[dB]}$
$\angle F(j\omega)_{[gradi]}$
0dB
1dB
2dB
3dB
-1dB
-3dB
$\angle F(j\omega) = -135°$
$\Rightarrow \omega = 8 \frac{rad}{s}$
$B_3 = \frac{\omega}{2\pi} \simeq 1.3\,Hz$ ✓