Reti correttrici

(vedi Vitelli, vol.2, Par. 2.1, 2.1.1,2.2, 2.2.1, 2.2.2,2.2.3)

Dopo aver soddisfatto le specifiche a regime, si passa al transitorio:

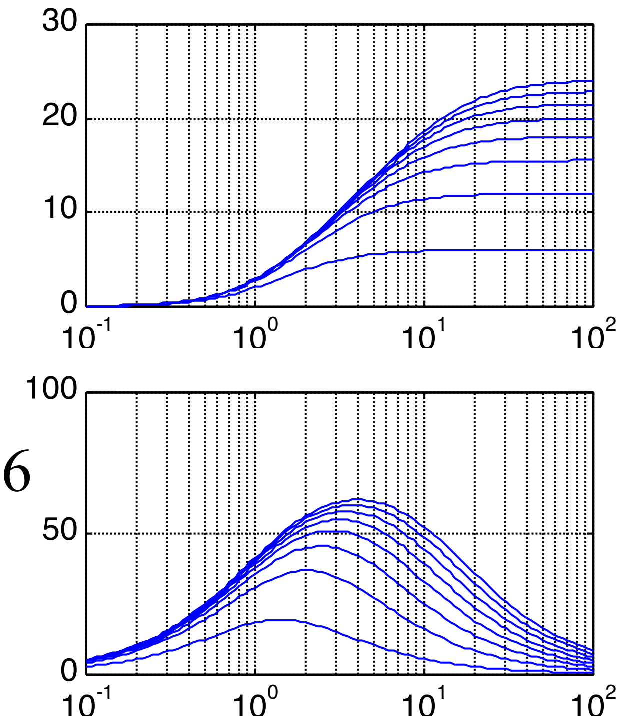
1. Tracciare il diagramma di Bode di $(K_c/s^h)\, F(s)$
2. Osservare ω_T e $m\varphi$
3. Confrontarli con quelli desiderati
4. Aggiungere in cascata una o più reti di correzione

- **Modificano selettivamente (a certe frequenze) modulo e/o fase di**
- **Sono semplici FILTRI**
- **Se ne possono usare più d'una in cascata**
- **Due tipi elementari:**

ANTICIPATRICE

$$\frac{1+\tau s}{1+\dfrac{\tau}{m}s}$$

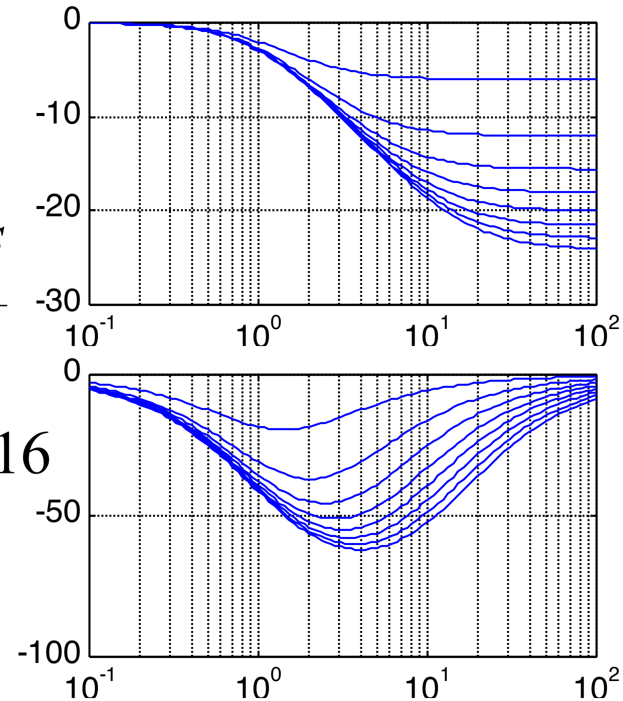
$$m = 2, 4, \cdots, 16$$

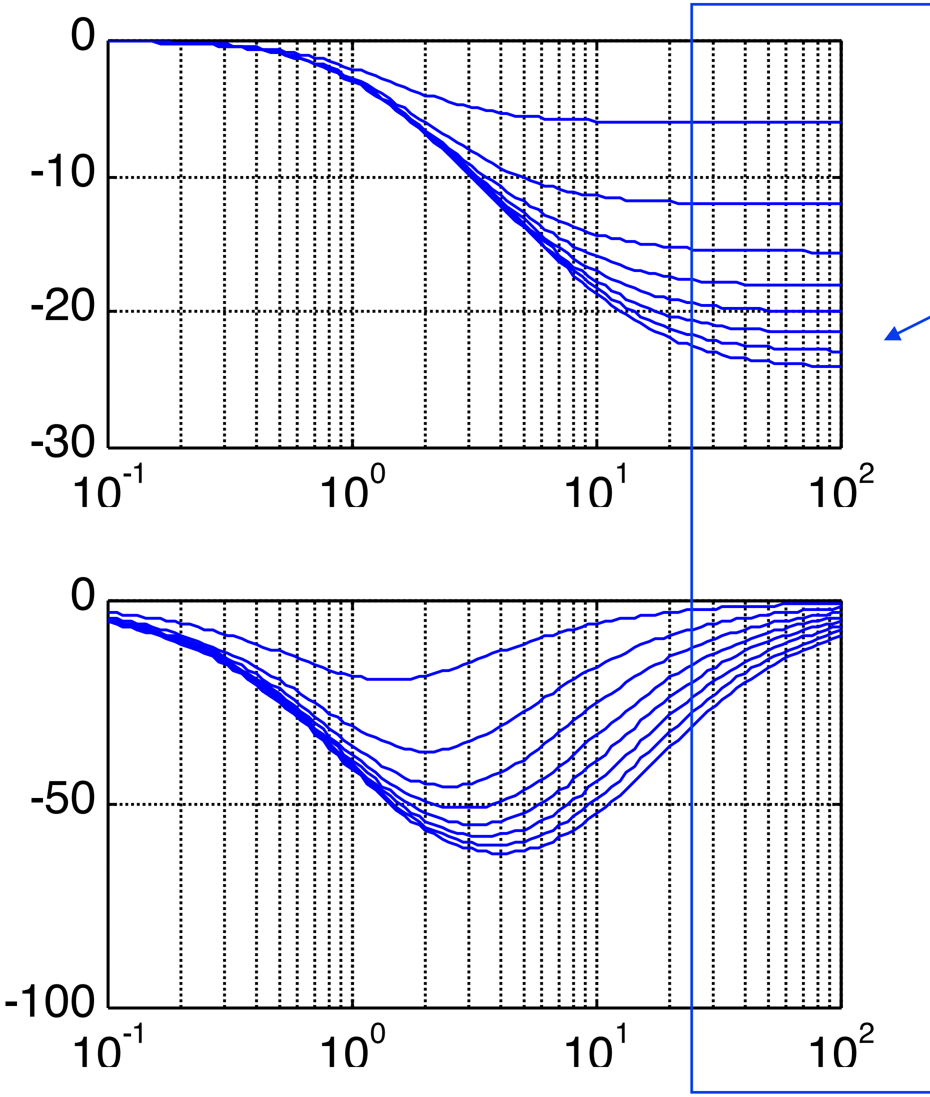


ATTENUATRICE

$$\frac{1+\dfrac{\tau}{m}s}{1+\tau s}$$

$$m = 2, 4, \cdots, 16$$

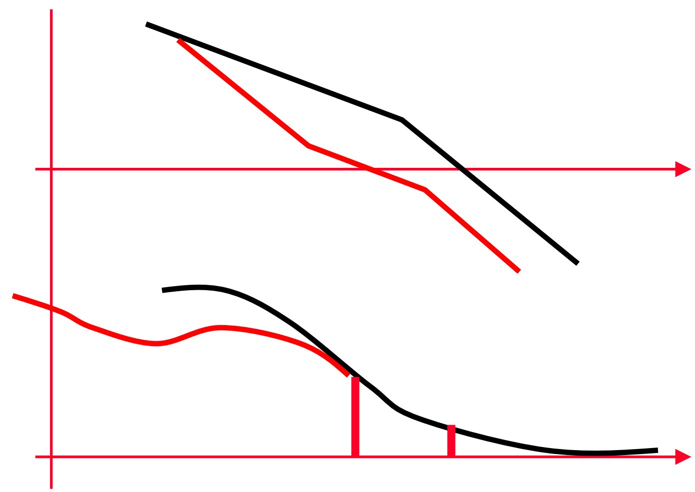


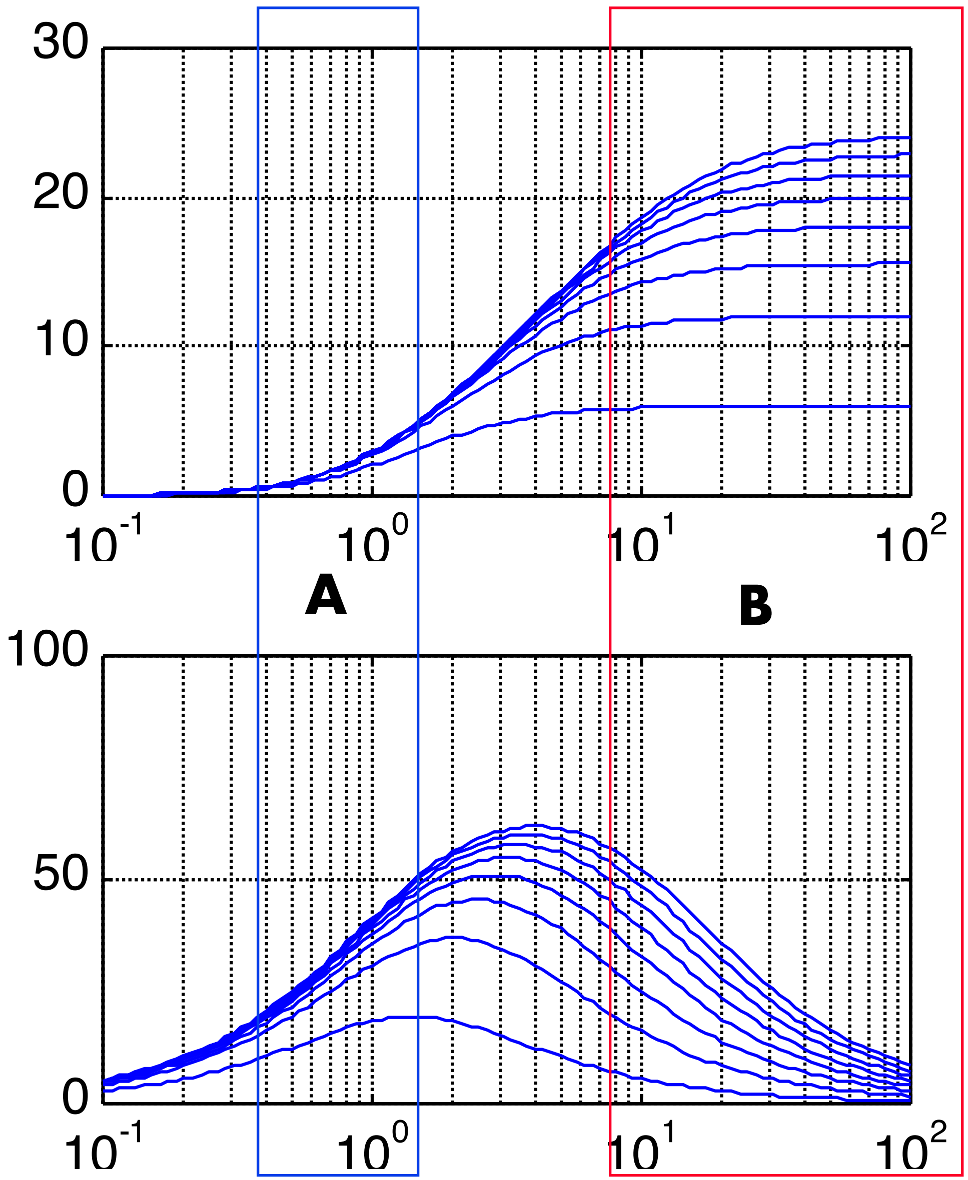


prima il polo poi lo zero

Zona utile

Riduce il modulo selettivamente
ma
aumenta lo sfasamento





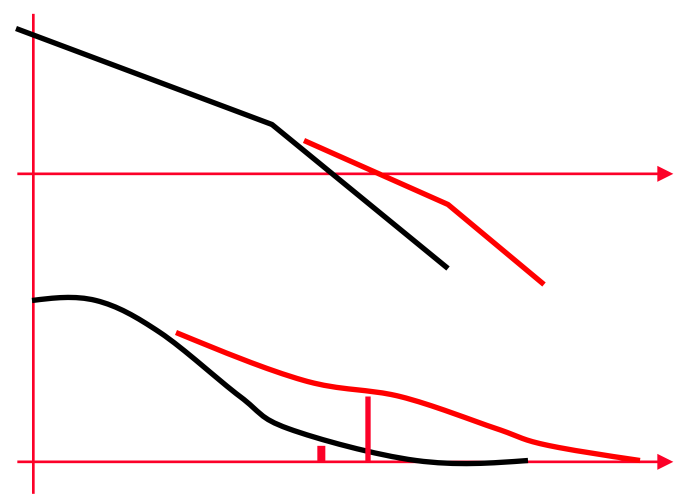
prima lo zero poi il polo

A:

aumenta le fasi e poco il modulo

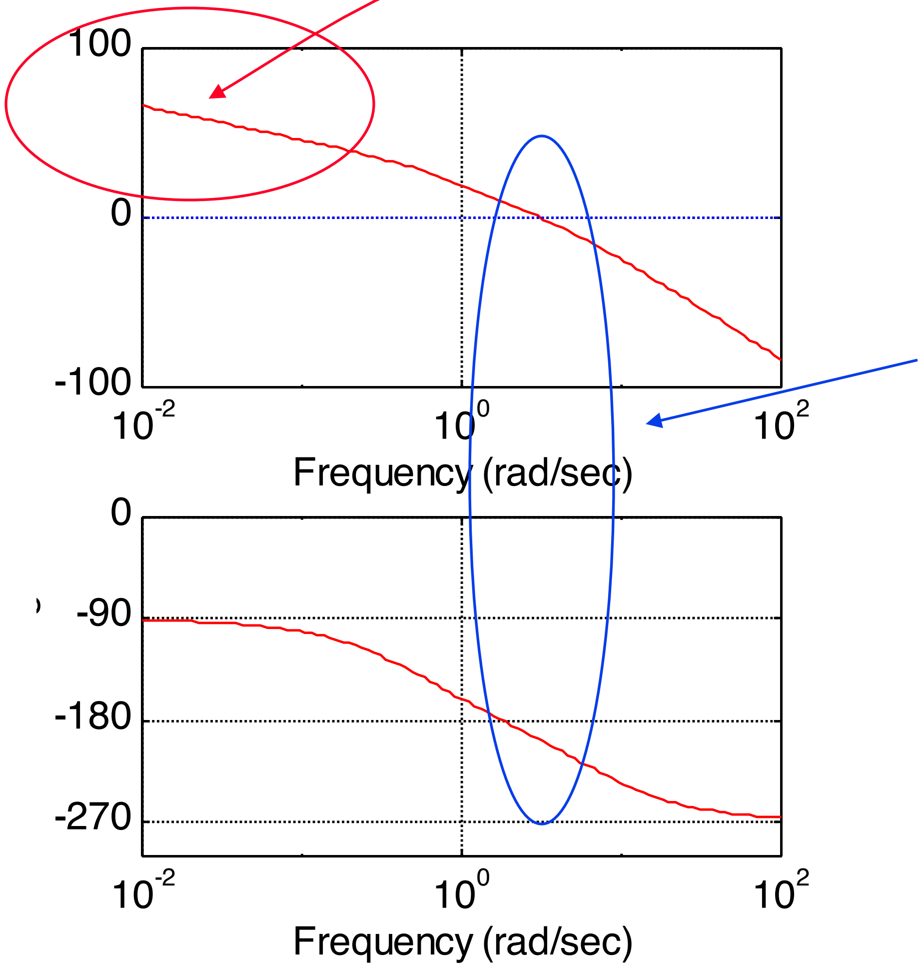
B:

aumenta modulo e fasi



Diagrammi di Bode dopo aver imposto il comportamento a regime

$$\frac{K_c}{s^h}P(s)H(s)$$

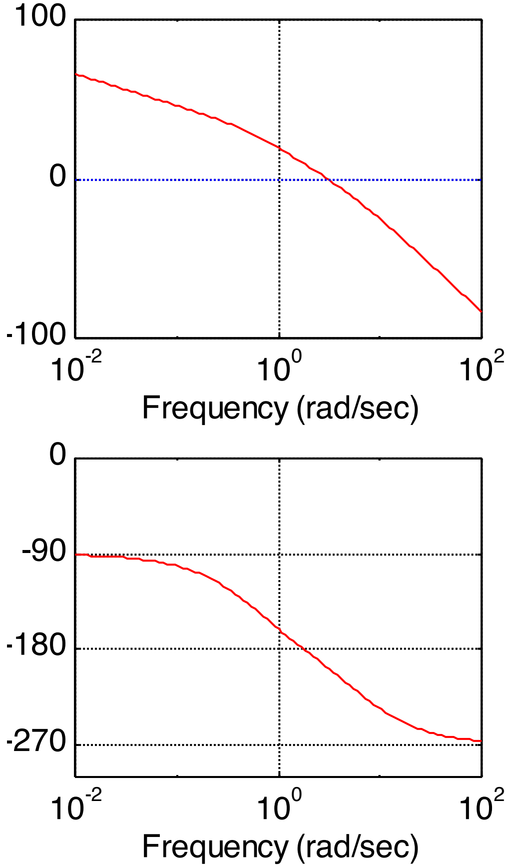


Bloccato perché imposto dalle specs a regime (si può aumentare K_F)

Da modificare per imporre

ω_T e m_ϕ

i.e. il transitorio



Aumentare ω_T: facile aumento di K_F anticipatrice (B)

Aumentare m_ϕ : diversi casi

1) $m_\phi = m_\phi^*$ per $\omega = \omega_T^*$

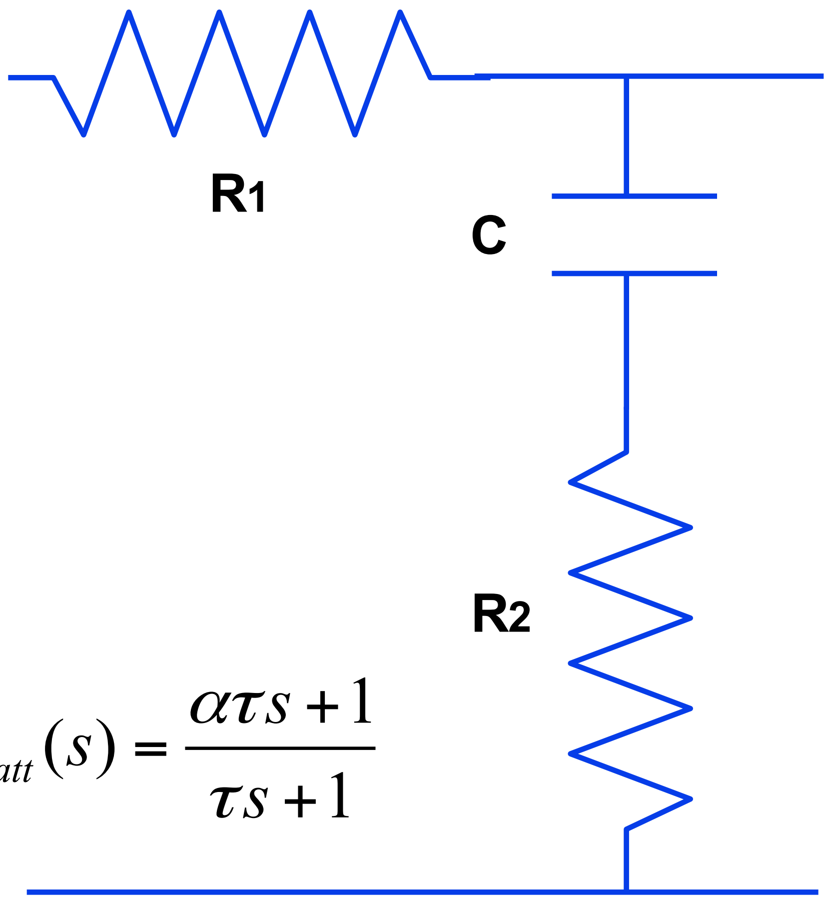
2) $m_\phi < m_\phi^*$ per $\omega = \omega_T^*$

*** = desiderato**

1)
- **$\omega_T < \omega_T^*$ aumentare ω_T**
- **$\omega_T \geq \omega_T^*$ attenuatrice**

2)
- **$\omega_T << \omega_T^*$ anticipatrice (B)**
- **$\omega_T \geq \omega_T^*$ anticipatrice (A)**

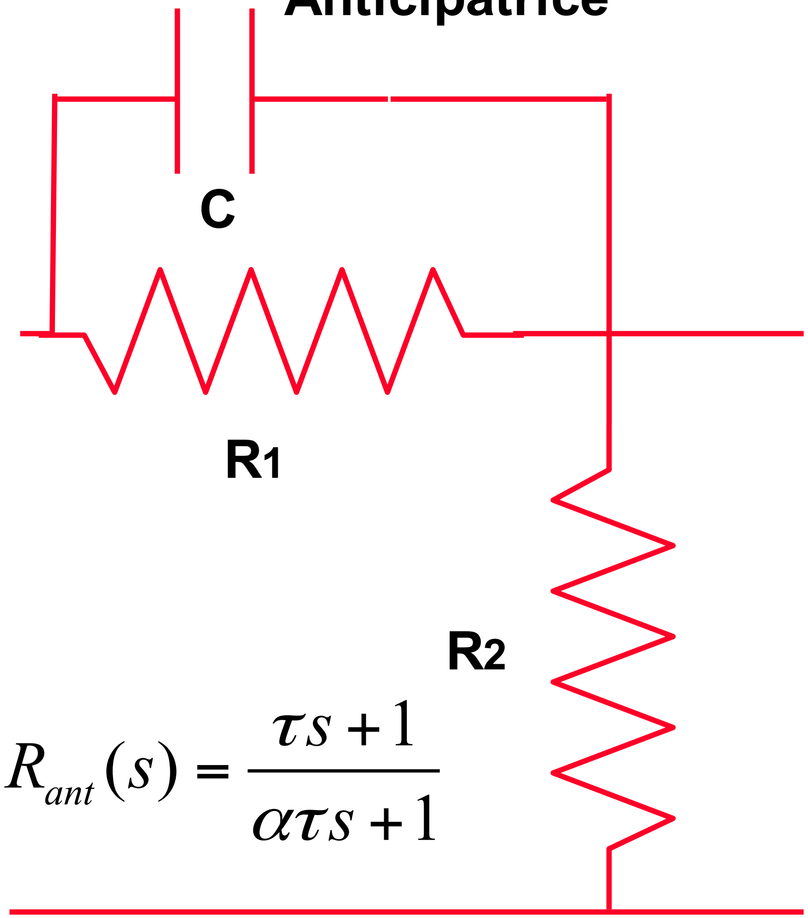
Attenuatrice



$$R_{att}(s) = \frac{\alpha\tau s + 1}{\tau s + 1}$$

$$\tau = (R_1 + R_2)C; \quad \alpha = \frac{R_2}{R_1 + R_2}$$

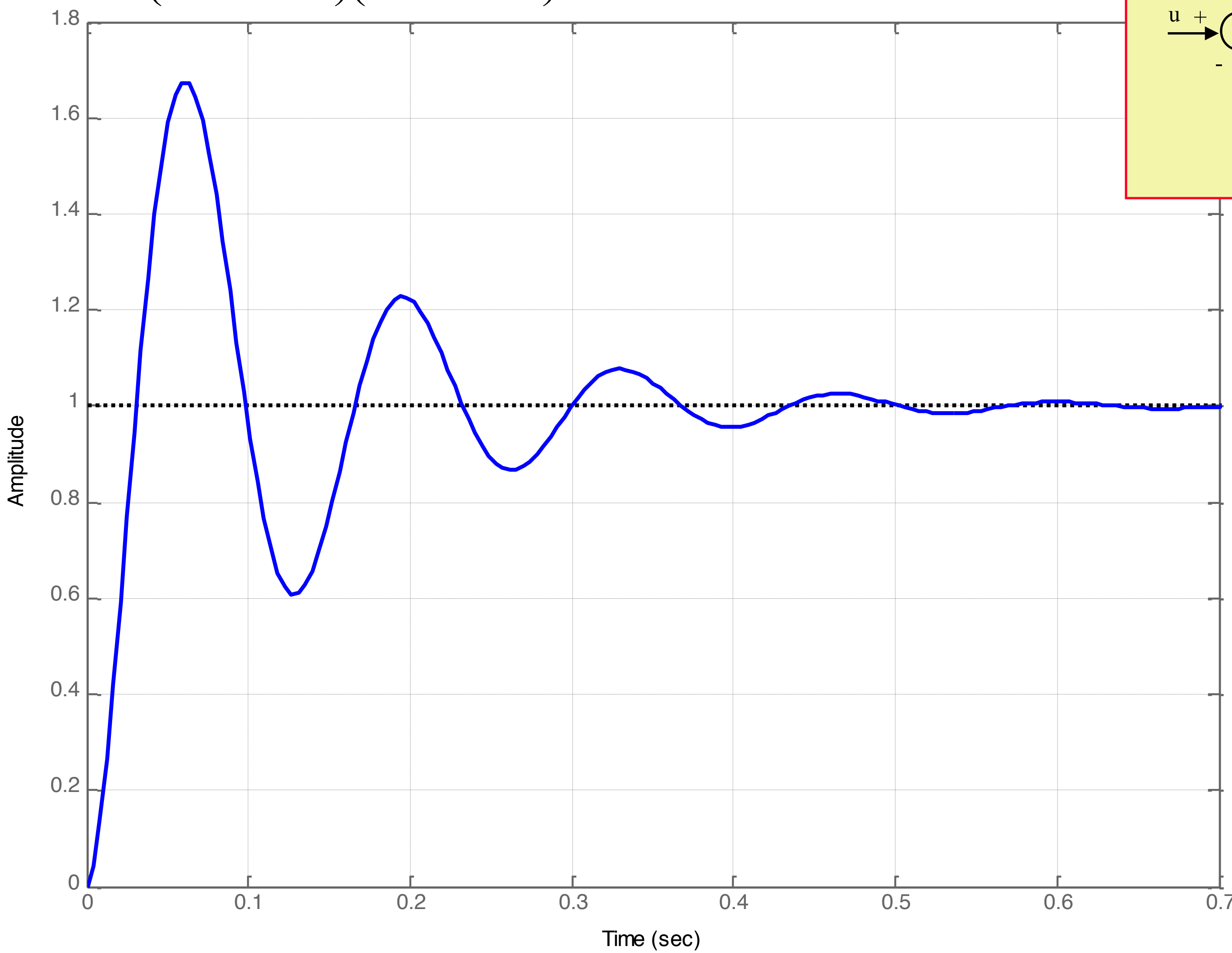
Anticipatrice

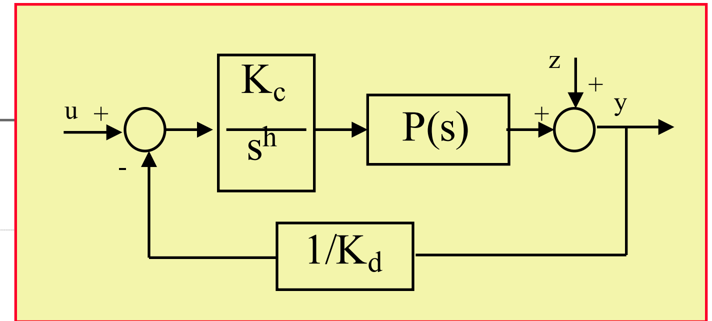


$$R_{ant}(s) = \frac{\tau s + 1}{\alpha\tau s + 1}$$

$$\tau = R_1 C; \quad \alpha = \frac{R_2}{R_1 + R_2}$$

$$P(S) = \frac{500(s/60+1)(s/300+1)}{(s/100+1)(s/600+1)};\ K_c = 4;\ h = 2;\ K_d = 1$$

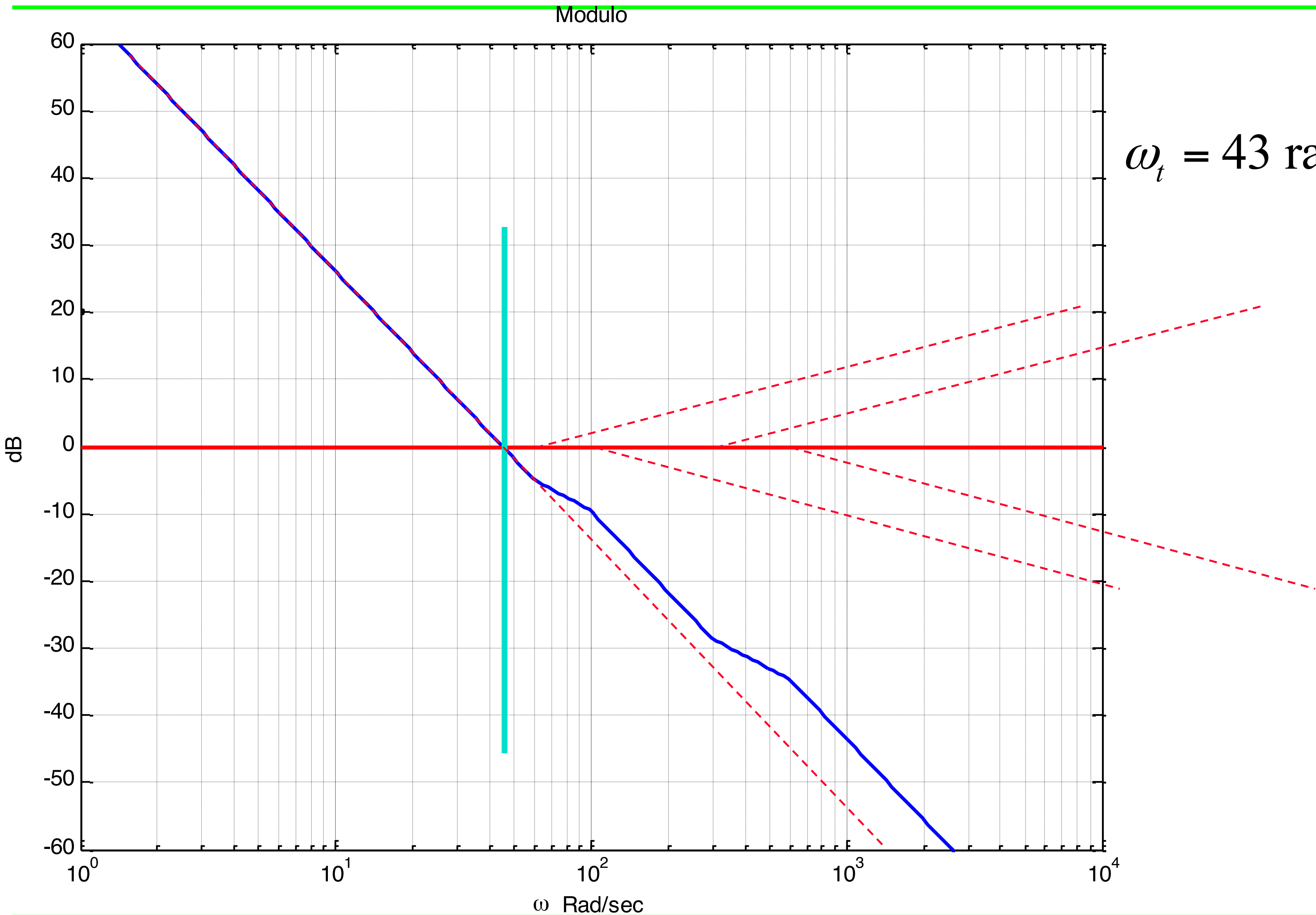




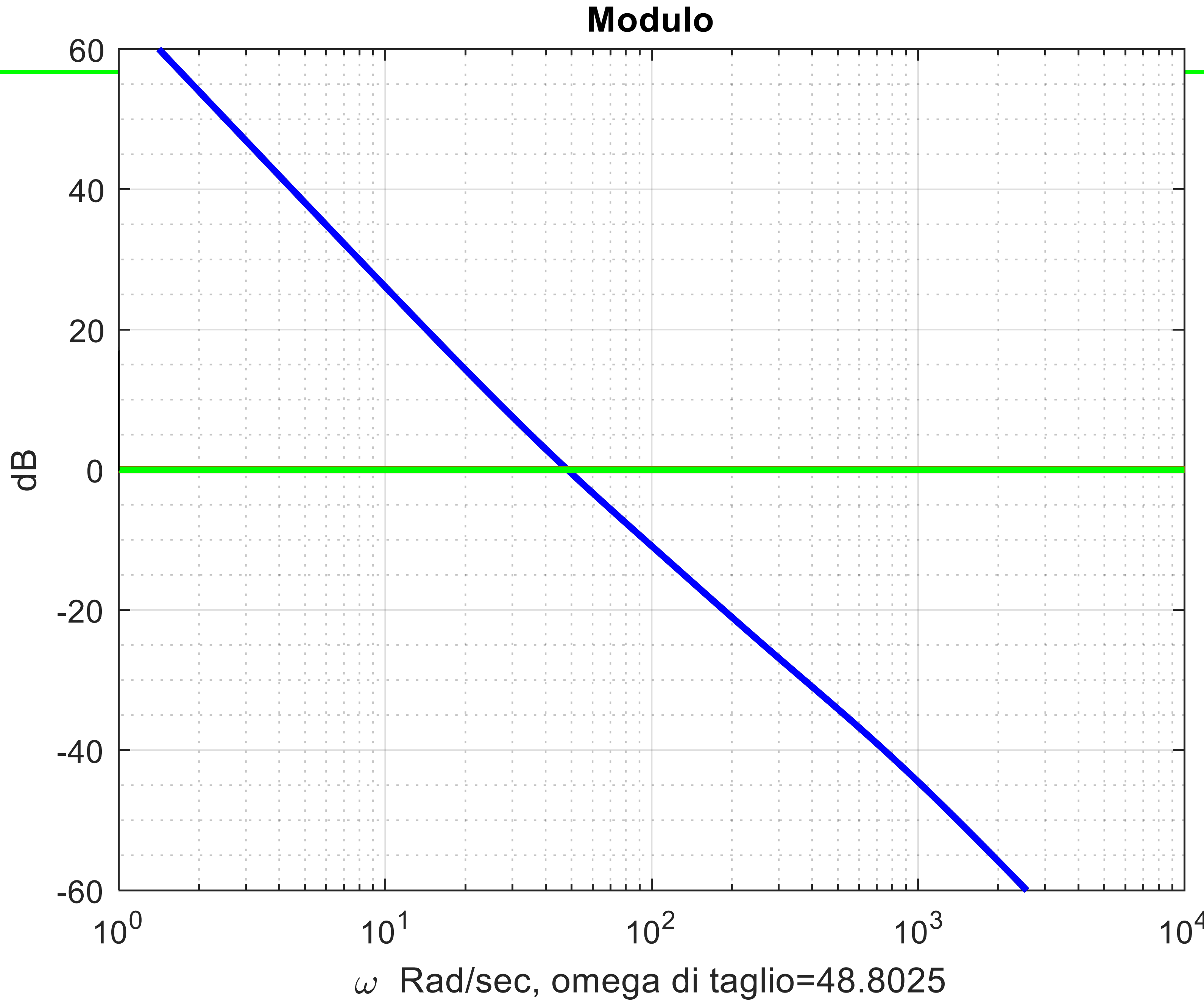
Risposta indiciale della $W(s)$

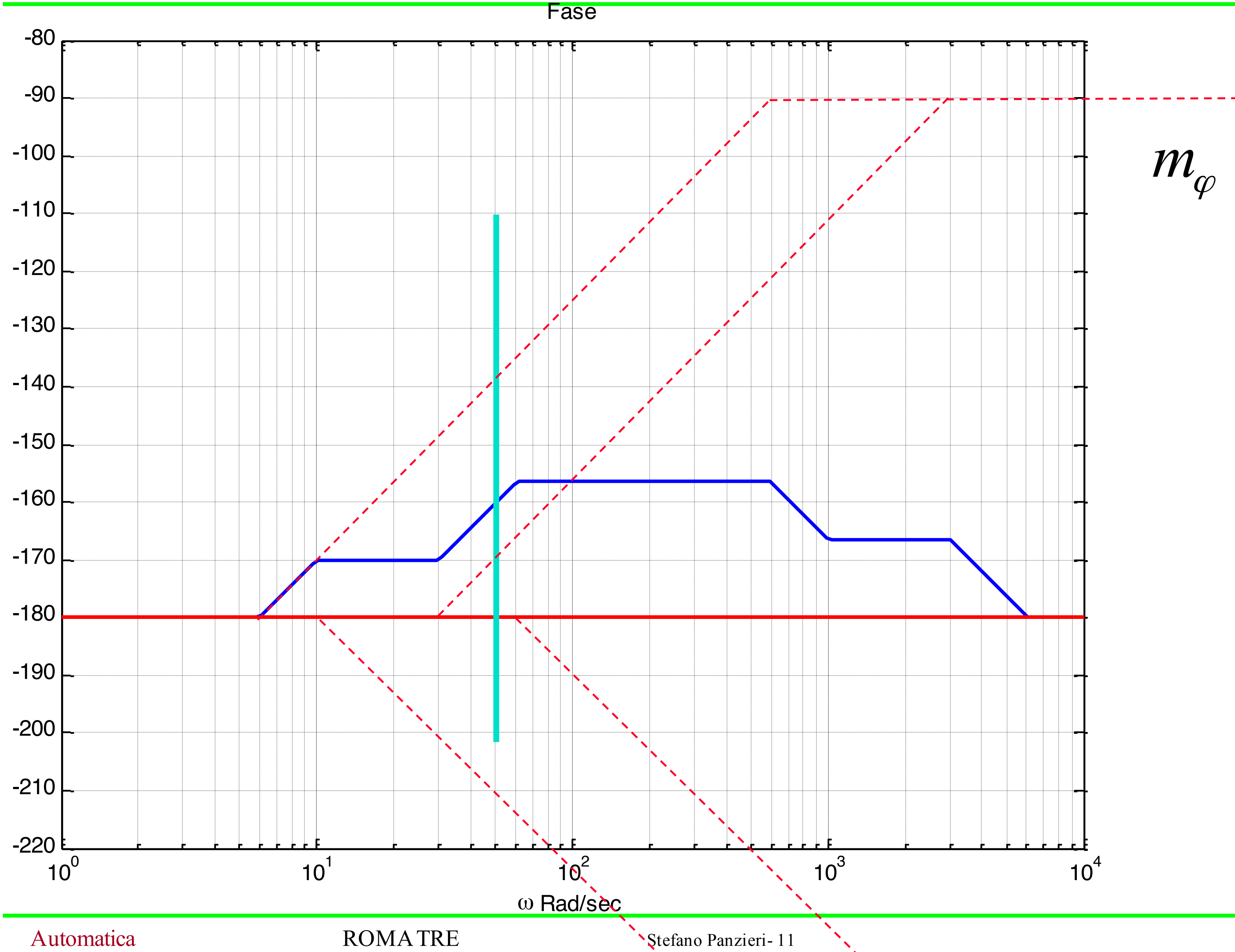
$t_r = 0.0214$ sec

$s = 0.7$

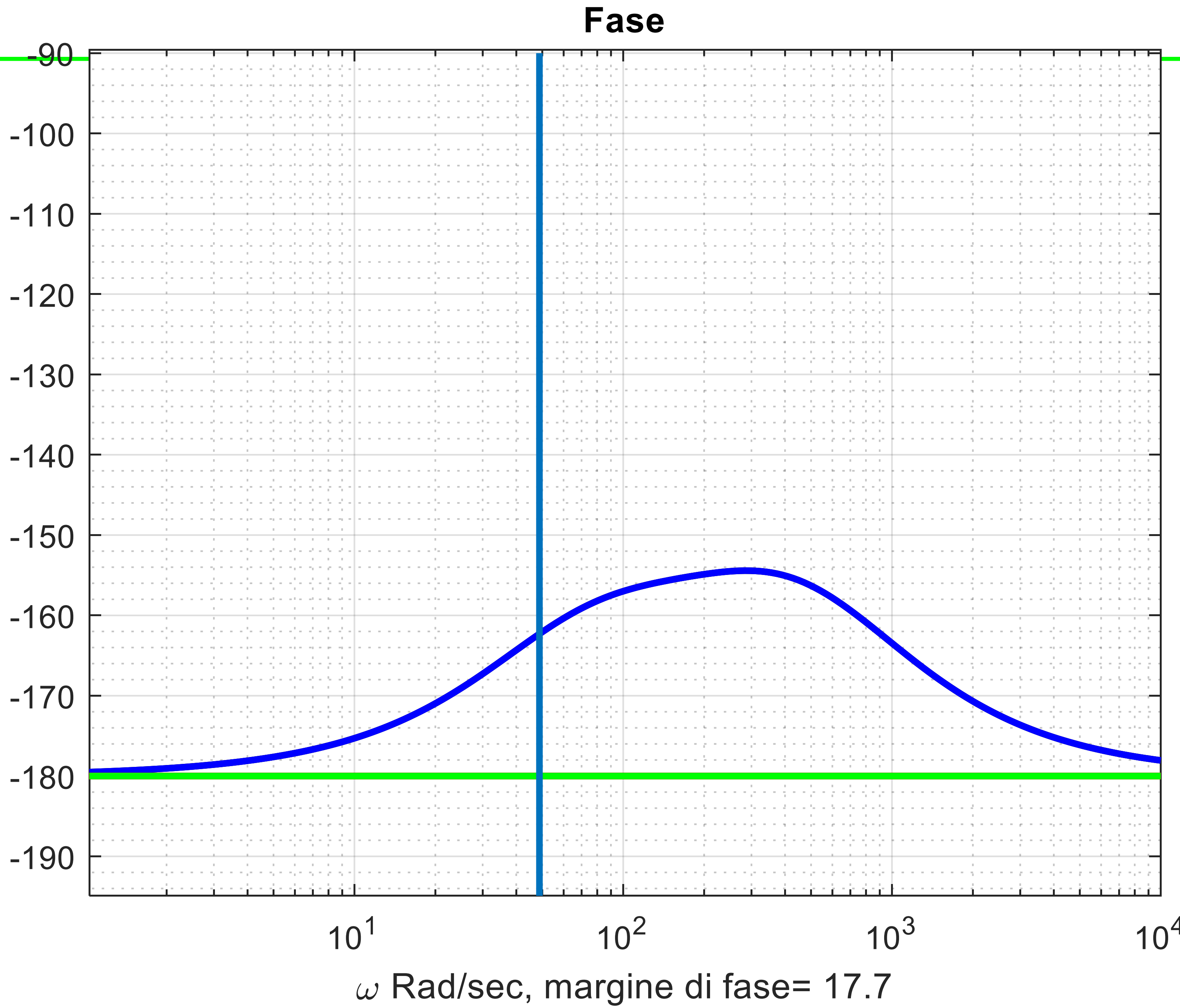


$$\omega_t = 43 \text{ rad/sec}$$

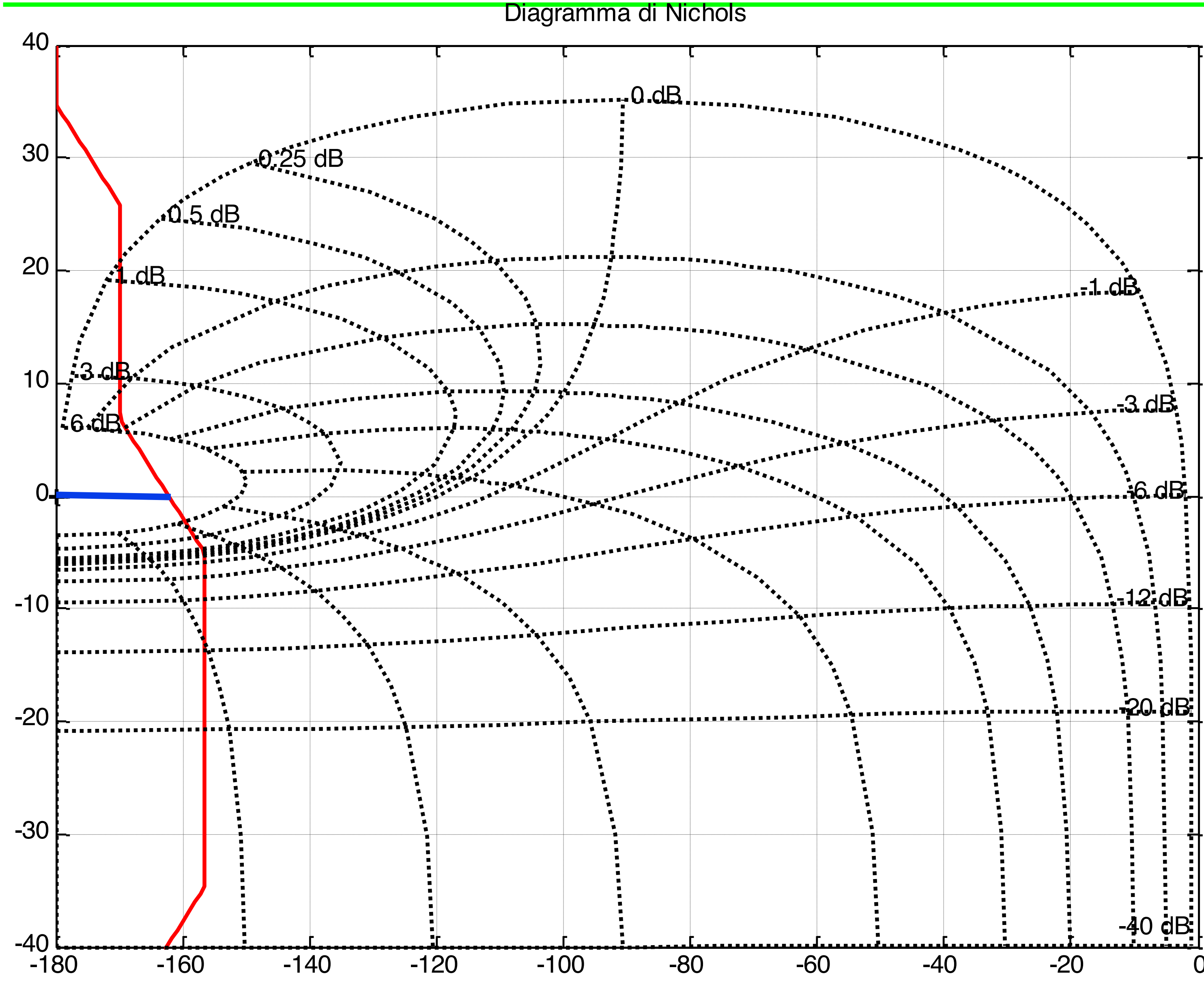

Modulo
60
40
20
0
-20
-40
-60
dB
10^0
10^1
10^2
10^3
10^4
ω Rad/sec, omega di taglio=48.8025



$$m_\varphi = 20^\circ$$


Fase
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
10^1
10^2
10^3
10^4
ω Rad/sec, margine di fase= 17.7

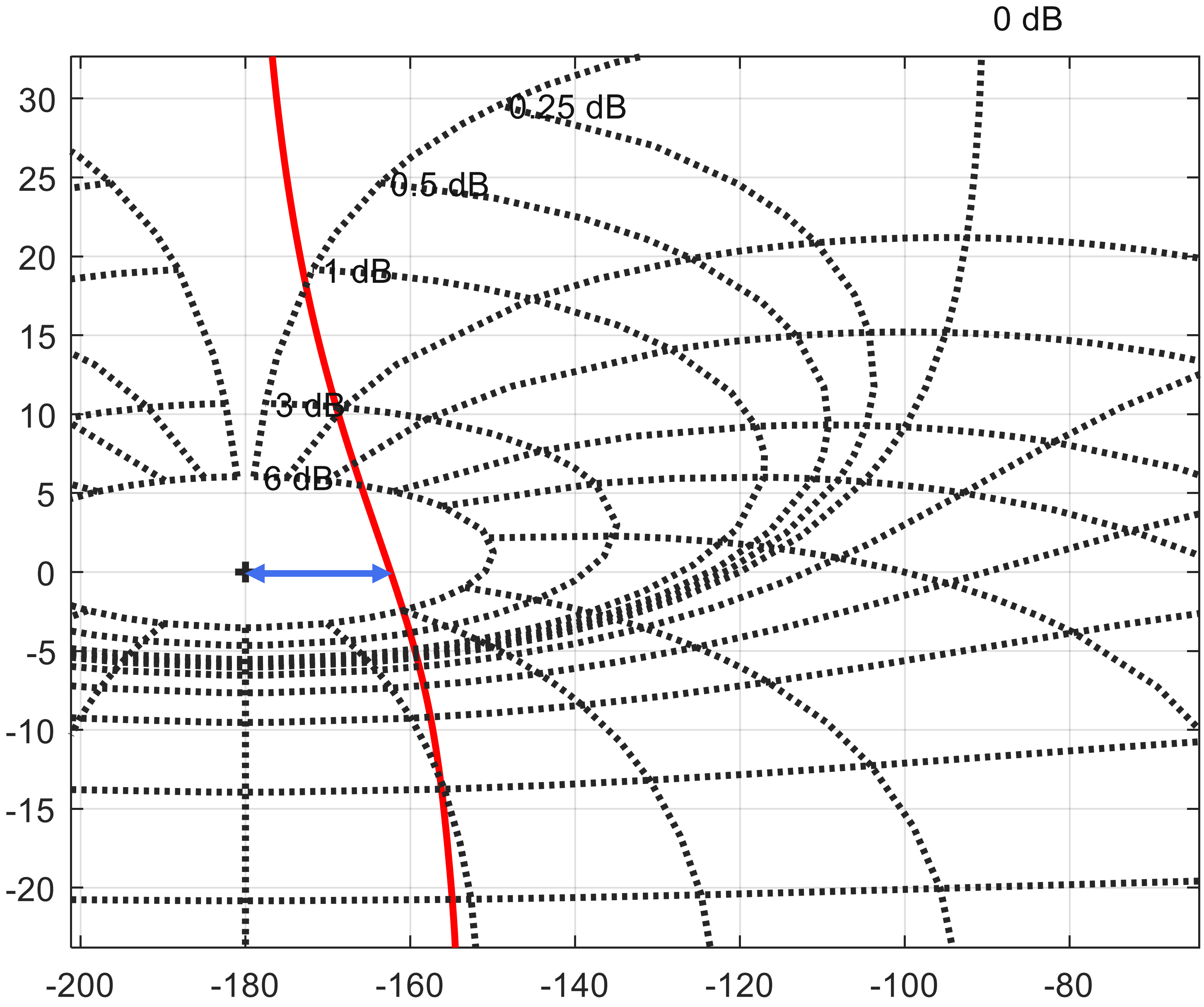
Nichols prima della correzione



$$\omega_{-3} = 77 \text{ rad/sec}$$

$$M_r = 10.6\text{dB}$$

NICHOLS PRIMA DELLA CORREZIONE



$$\omega_{-3} = 77 \text{ rad/sec}$$

$$M_r = 10.6\text{dB}$$

Tempo di salita dimezzato

→ Banda passante doppia ($\omega_{-3} t_r$=0.00698)

→ ω_t di taglio doppia (maggiore di 100 rad/sec)

Sovraelongazione massima del 10%

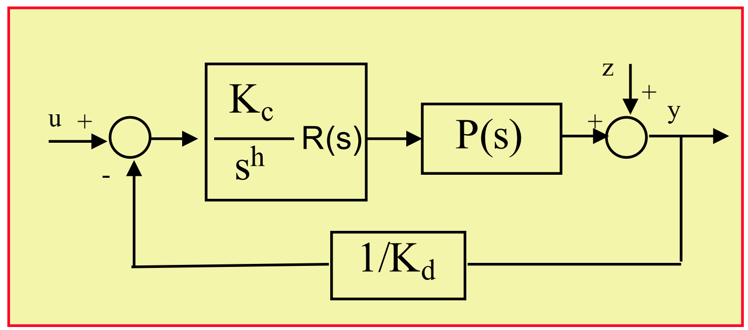
→ M_r=1.29 $(1 + s \simeq 0.85 M_r)$

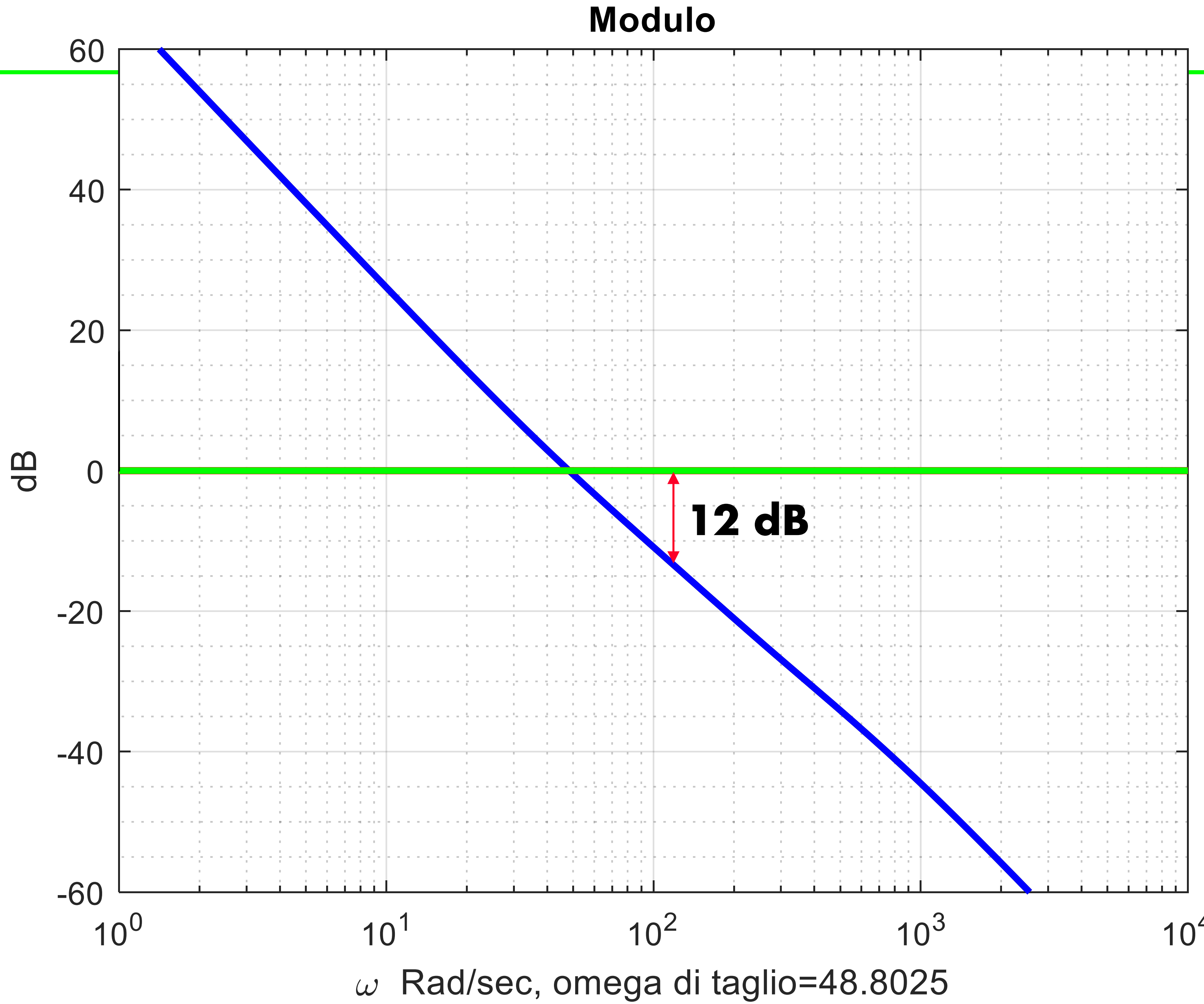
→ m_φ> 52.2 $(m_\varphi > 60° \times (1 - M_r\,|\,dB * 0.1)$

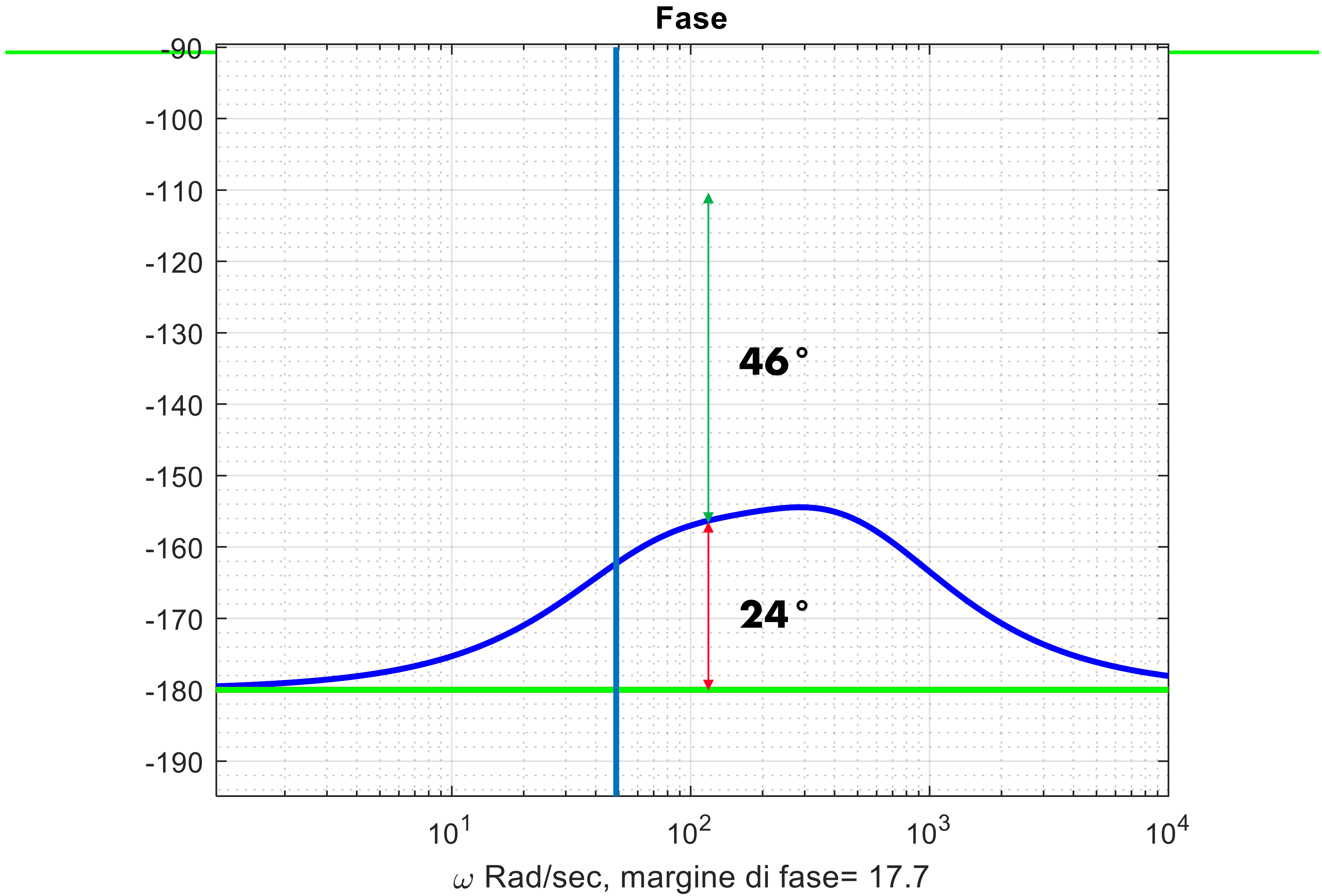
Scegliamo:

$\omega_t = 110$ rad/sec

$m_\varphi = 70°$

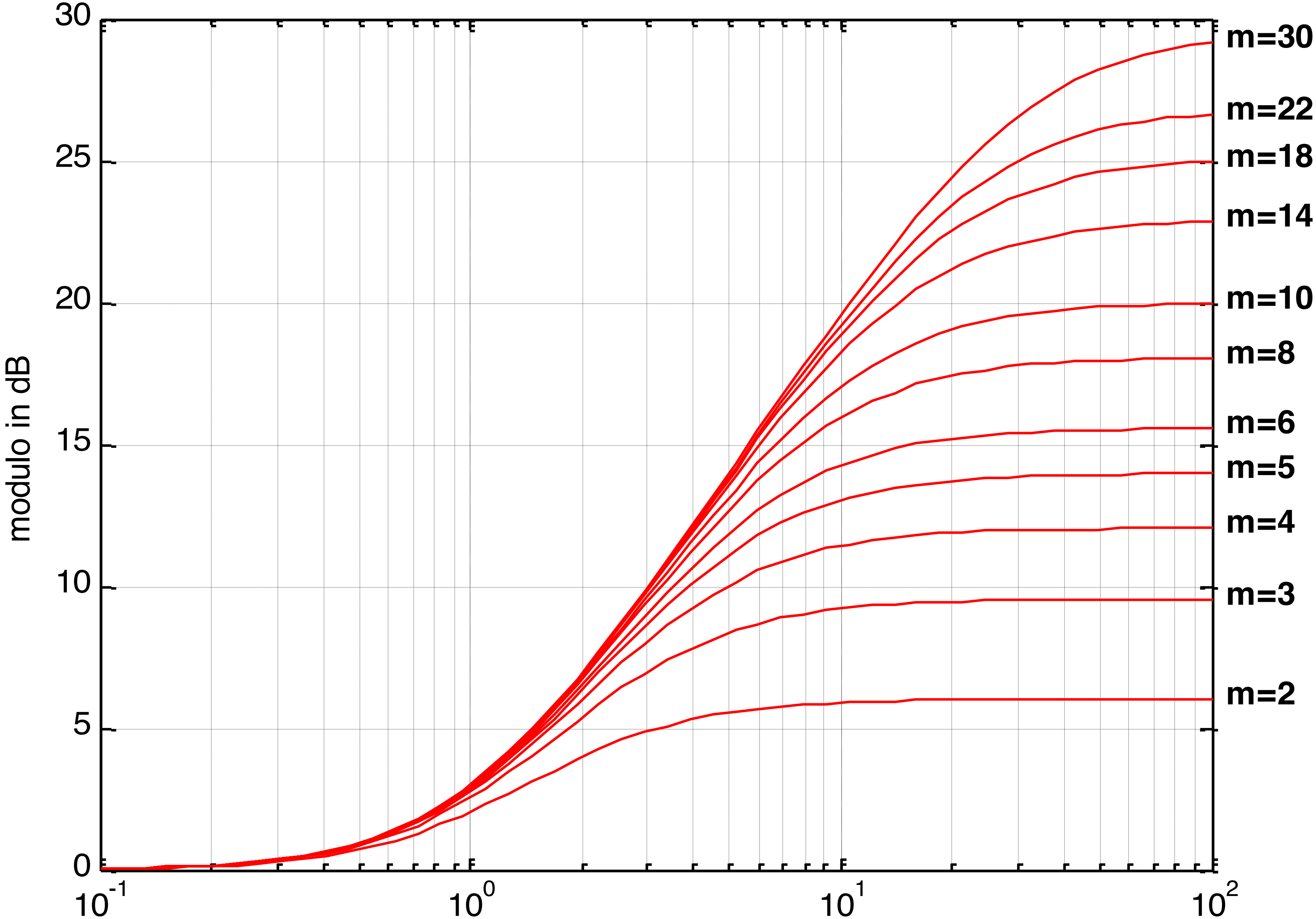



Modulo
60
40
20
0
-20
-40
-60
dB
12 dB
10^0
10^1
10^2
10^3
10^4
ω Rad/sec, omega di taglio=48.8025

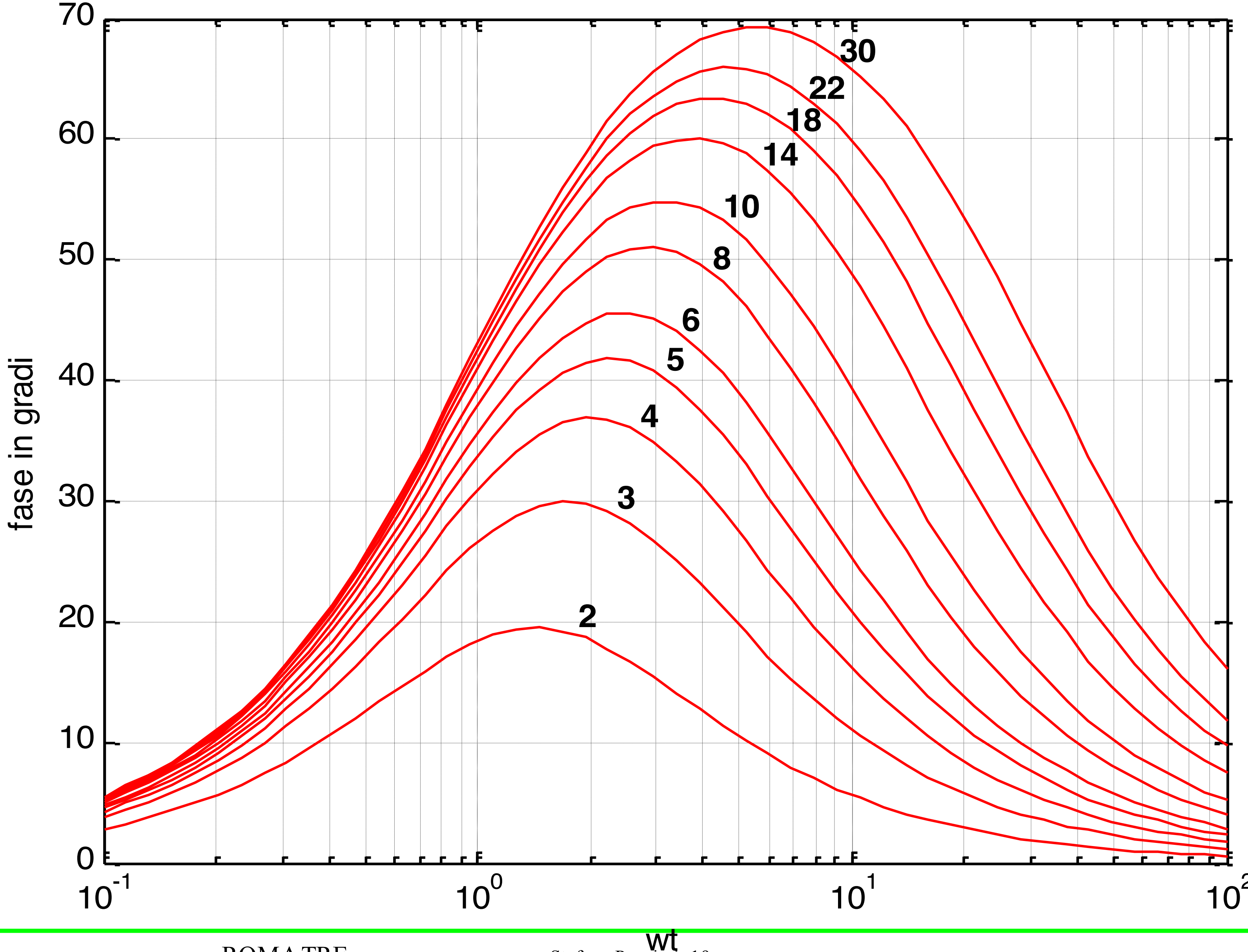


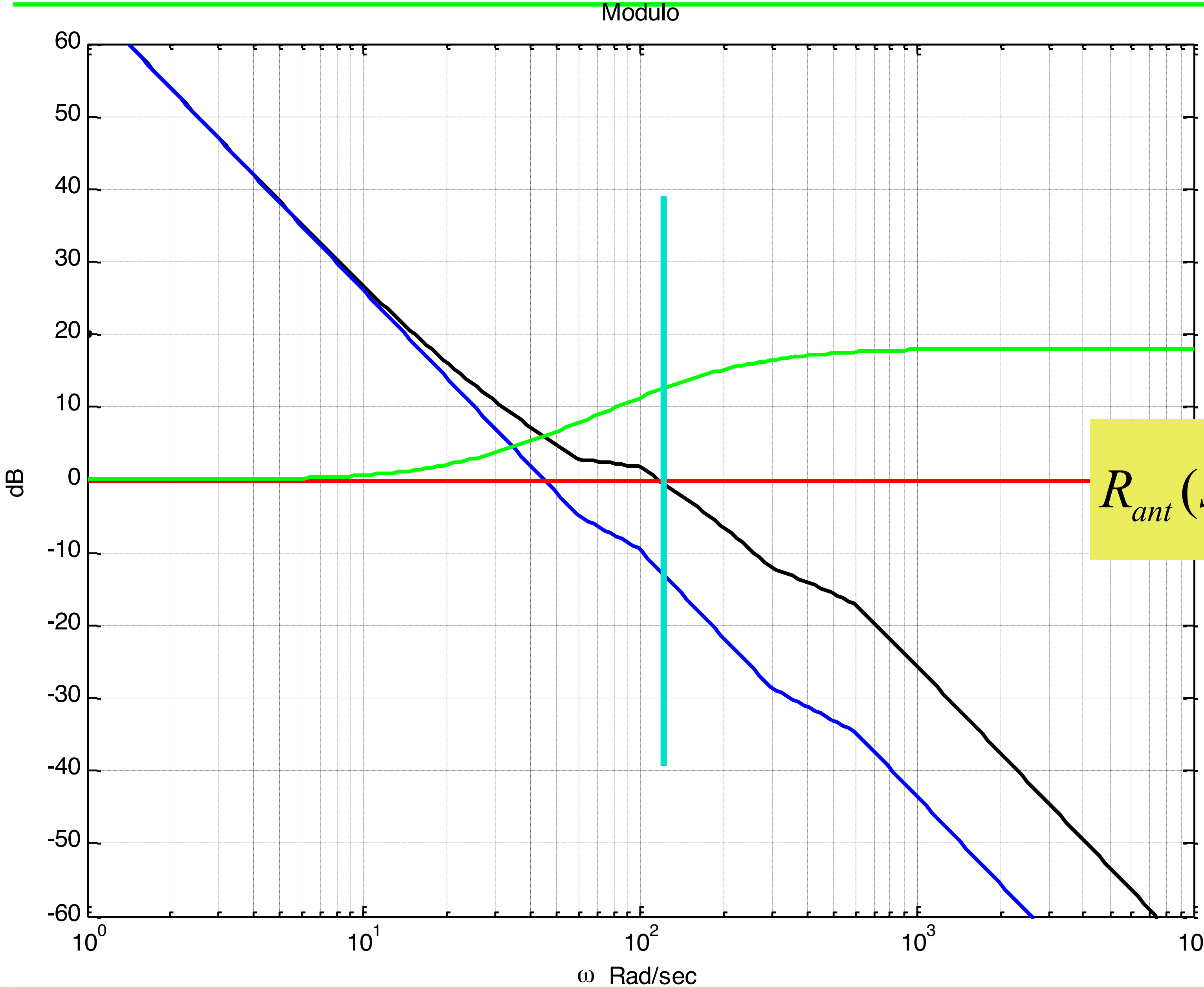
Fase
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
46°
24°
10^1
10^2
10^3
10^4
ω Rad/sec, margine di fase= 17.7

Rete Compensatrice - Modulo



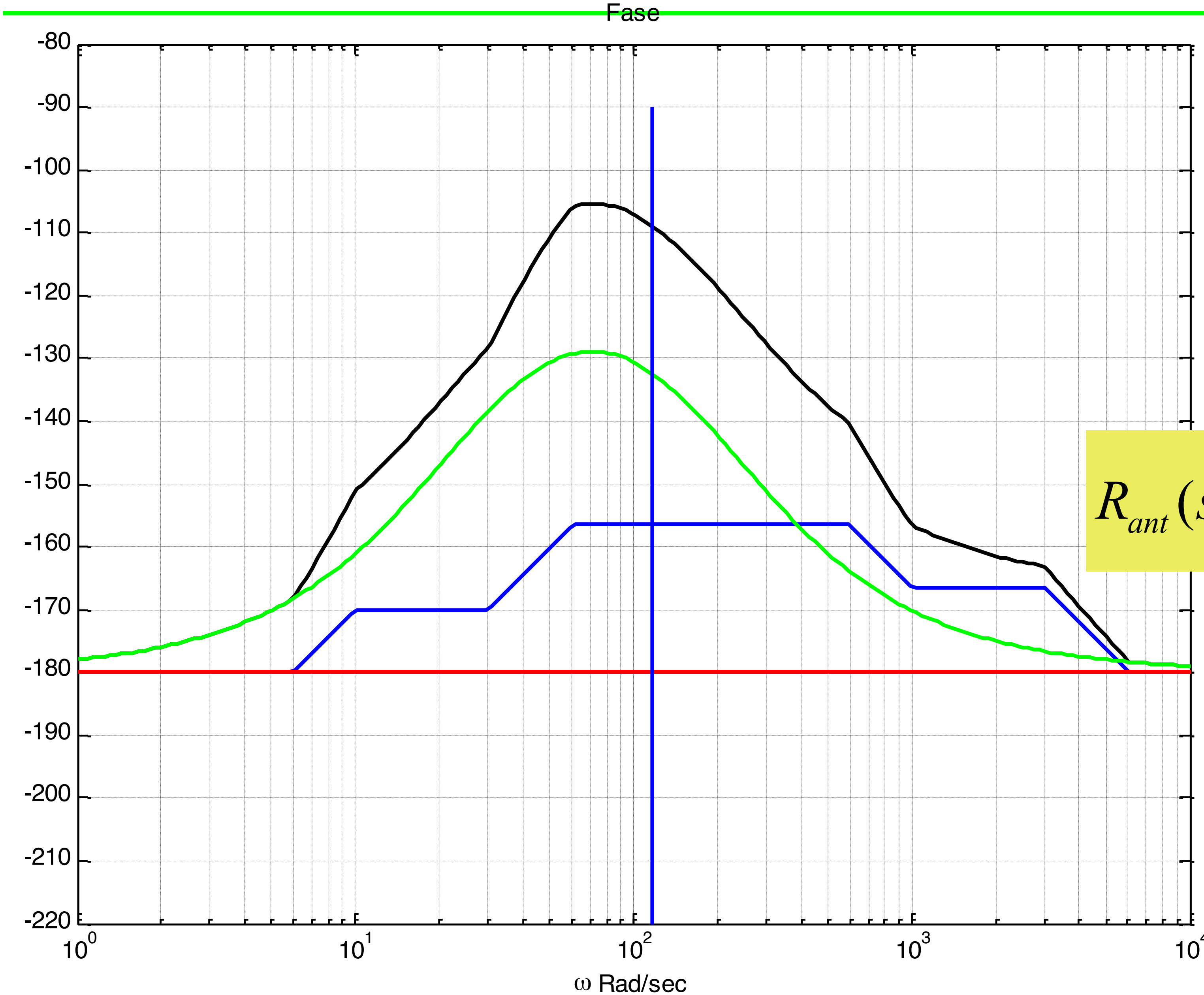
Rete Compensatrice - Fase





$$\omega_t = 110 \text{ rad/sec}$$

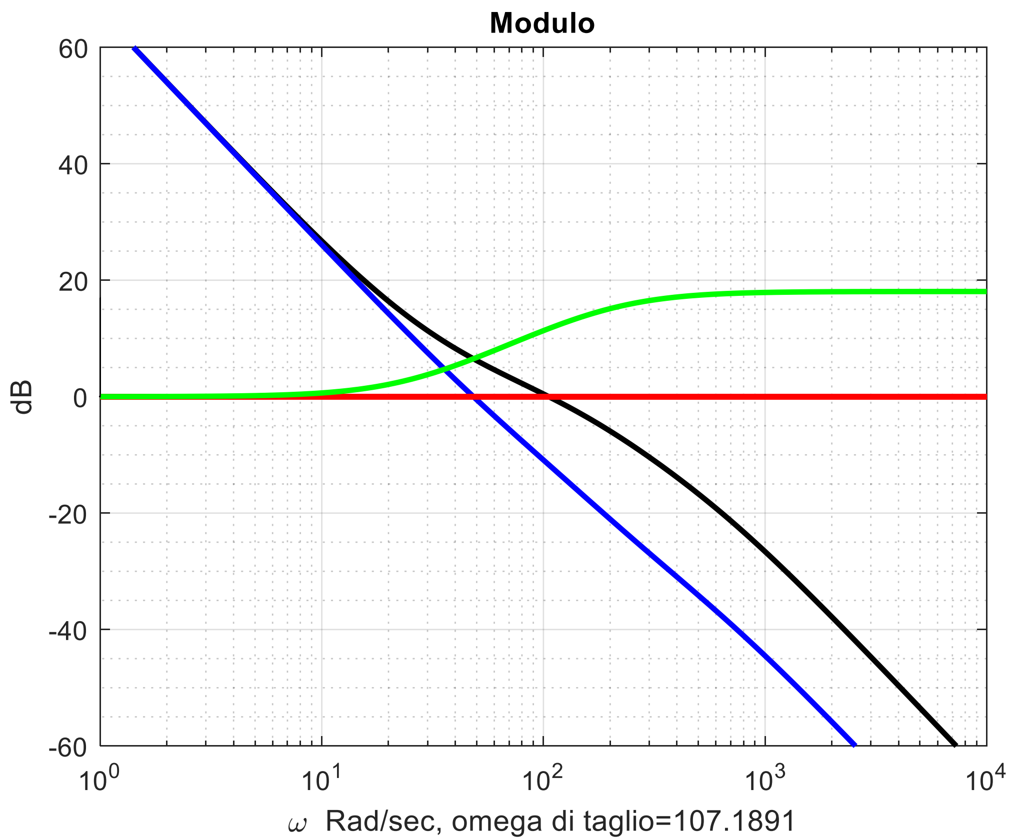
$$R_{ant}(s) = \frac{0.04s + 1}{0.04/8s + 1}$$

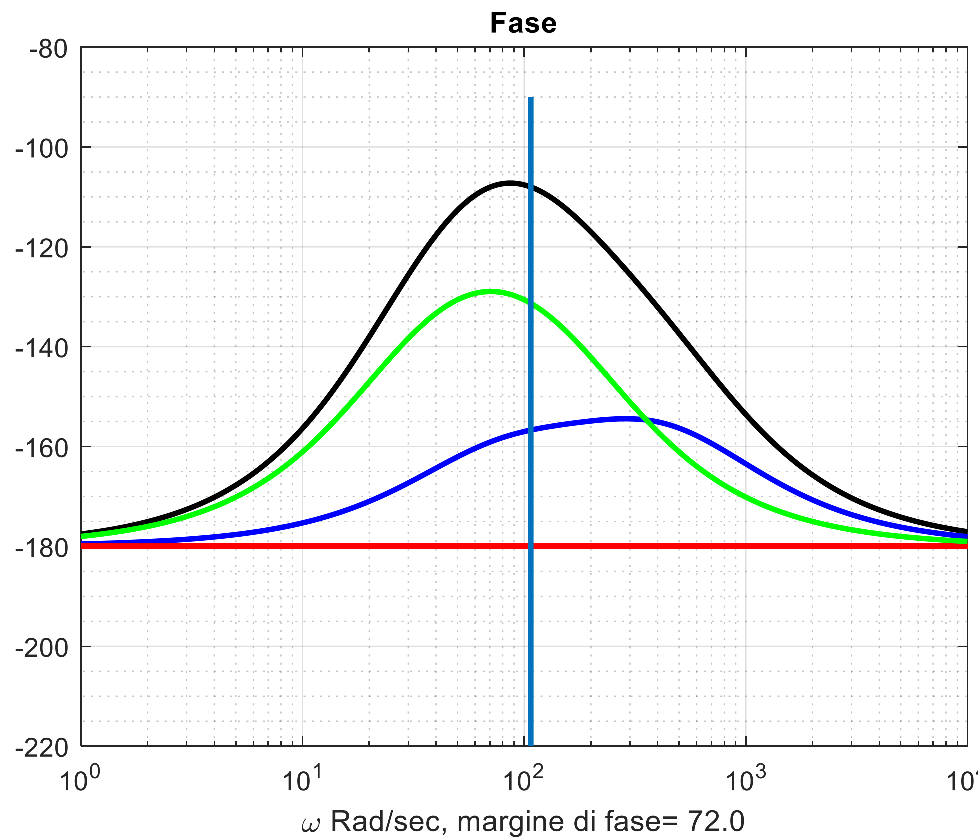


$$m_\varphi = 70^\circ$$

$$R_{ant}(s) = \frac{0.04s + 1}{0.04/8s + 1}$$

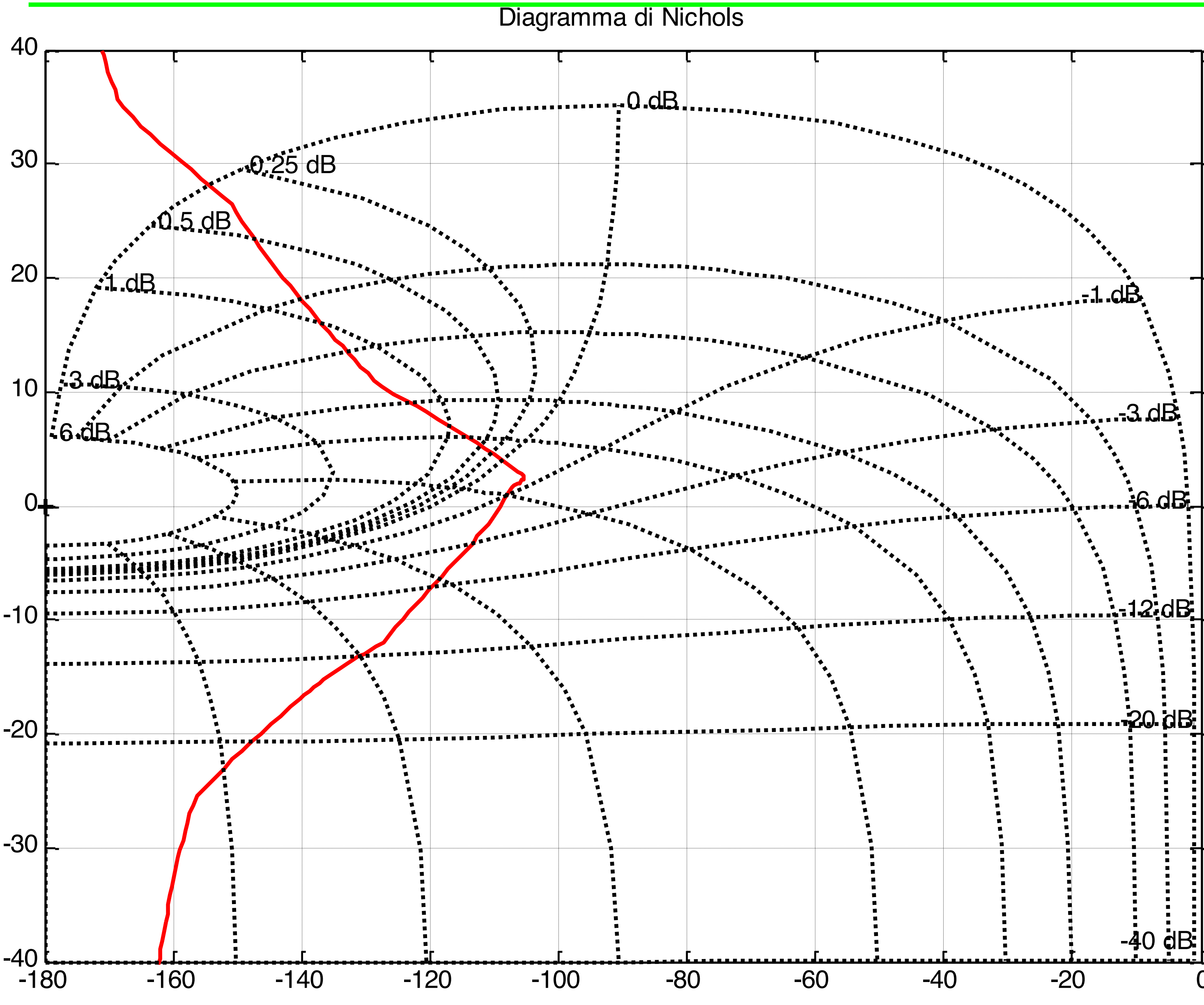
Rete correttrice e funzione corretta





$$R_{ant}(s) = \frac{0.04s + 1}{0.04/8s + 1}$$

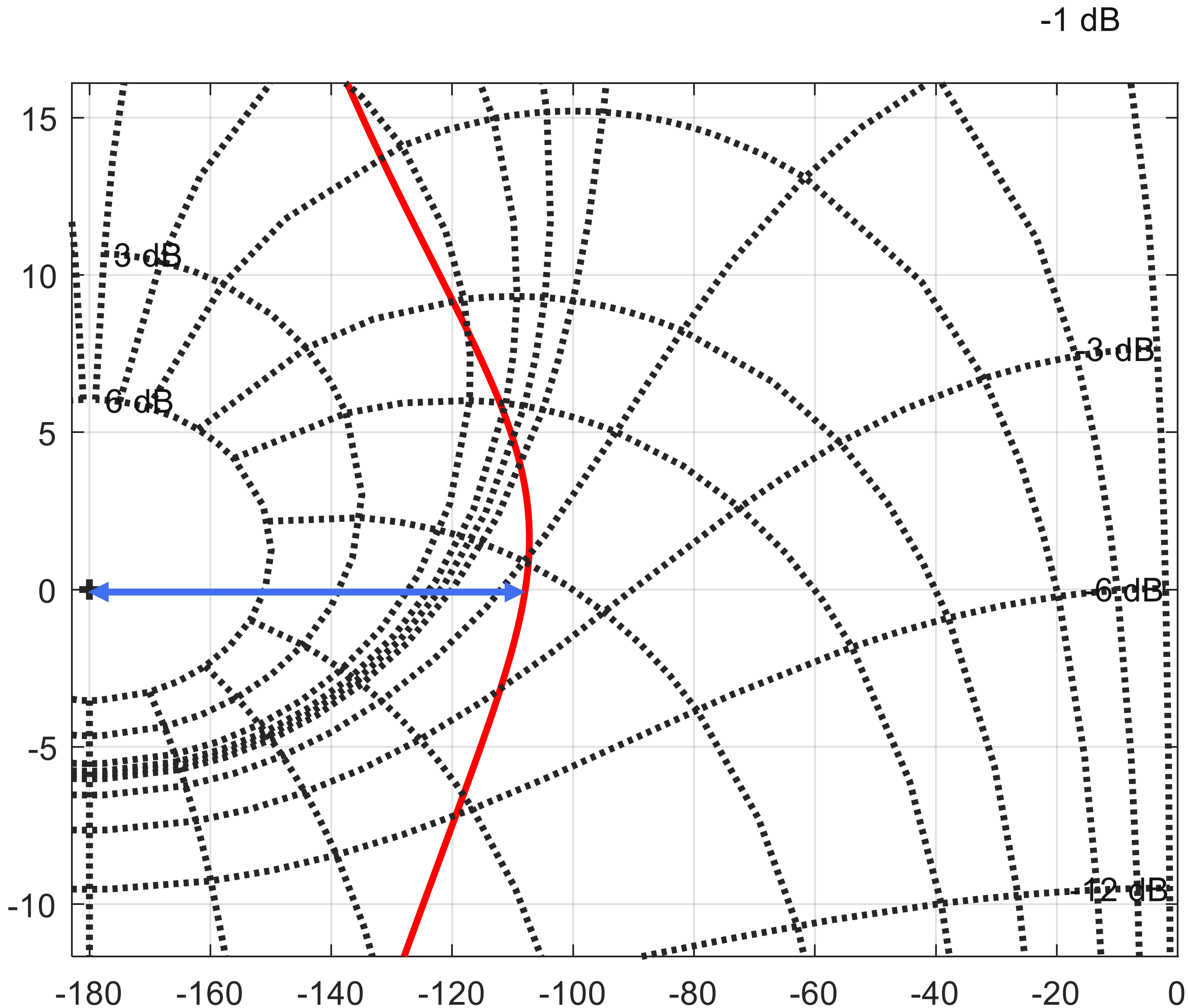
NICHOLS DOPO LA CORREZIONE



$$\omega_{-3} = 162 \text{ rad/sec}$$

$$M_r = 1.4\text{dB}$$

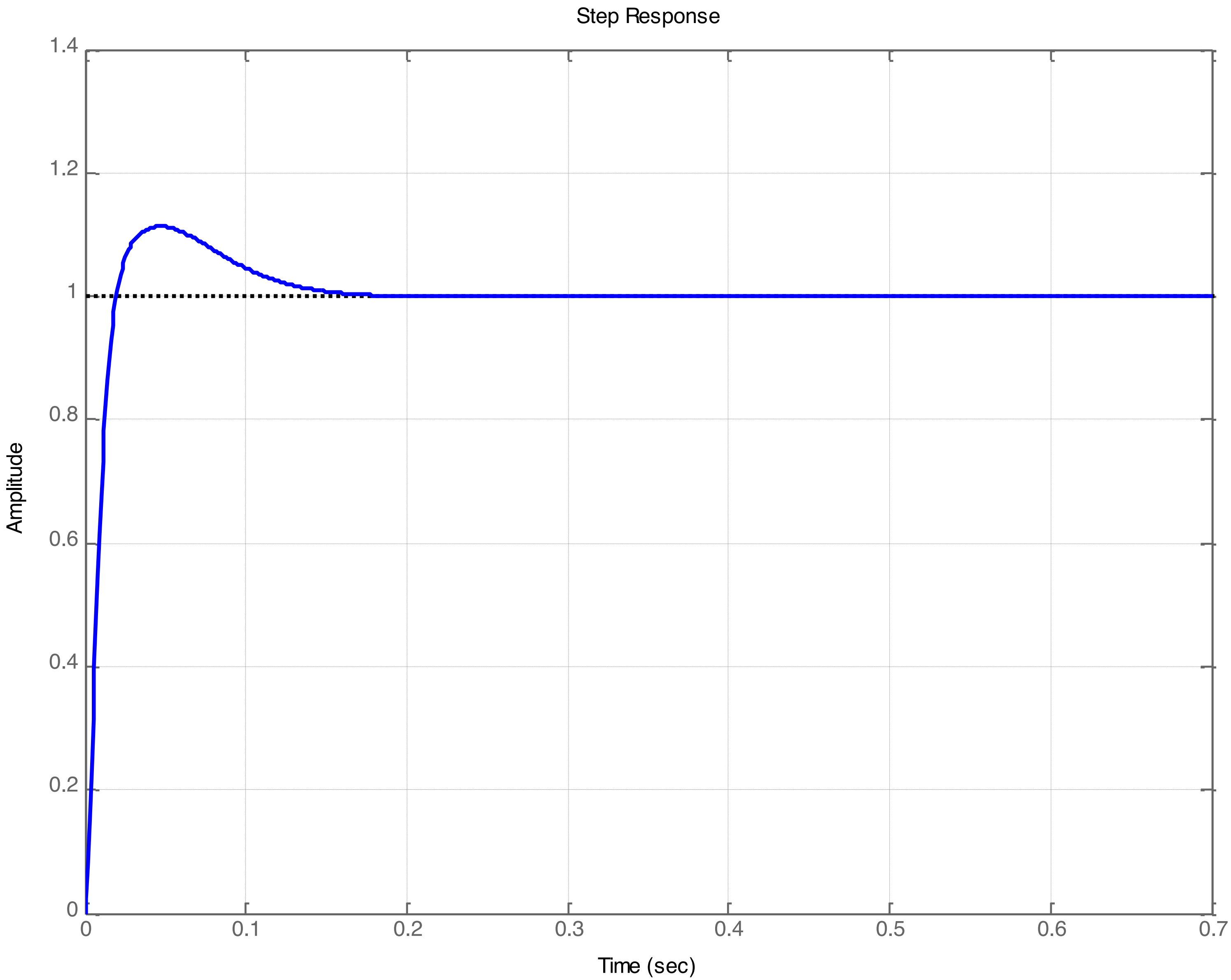
NICHOLS DOPO LA CORREZIONE



$$\omega_{-3} = 155 \text{ rad/sec}$$

$$M_r = 1.2\text{dB}$$

Risposta indiciale dopo la correzione

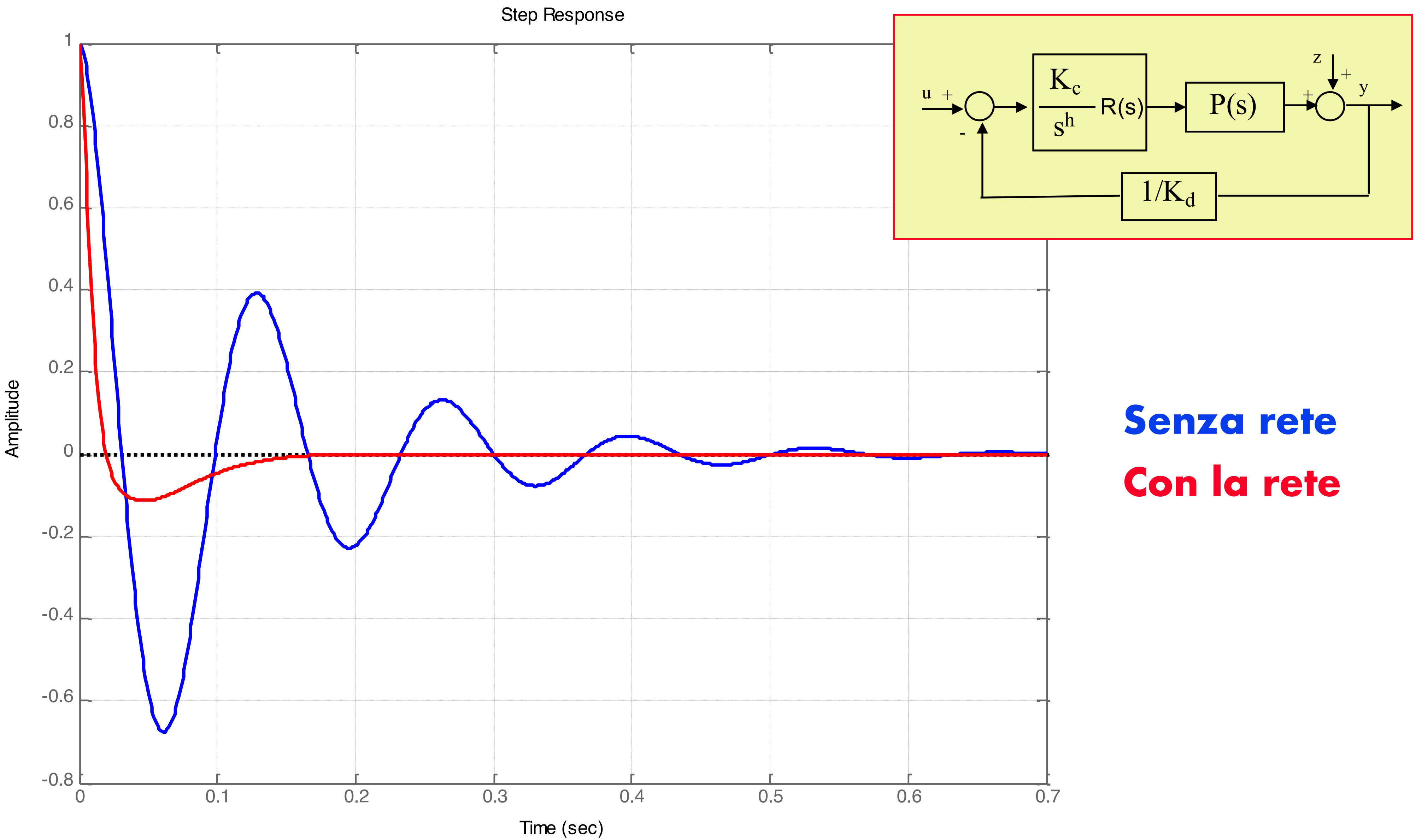


Nuova Risposta indiciale della $W(s)$

$t_r = 0.0127$ sec

$s = 0.11$

Risposta al disturbo a gradino

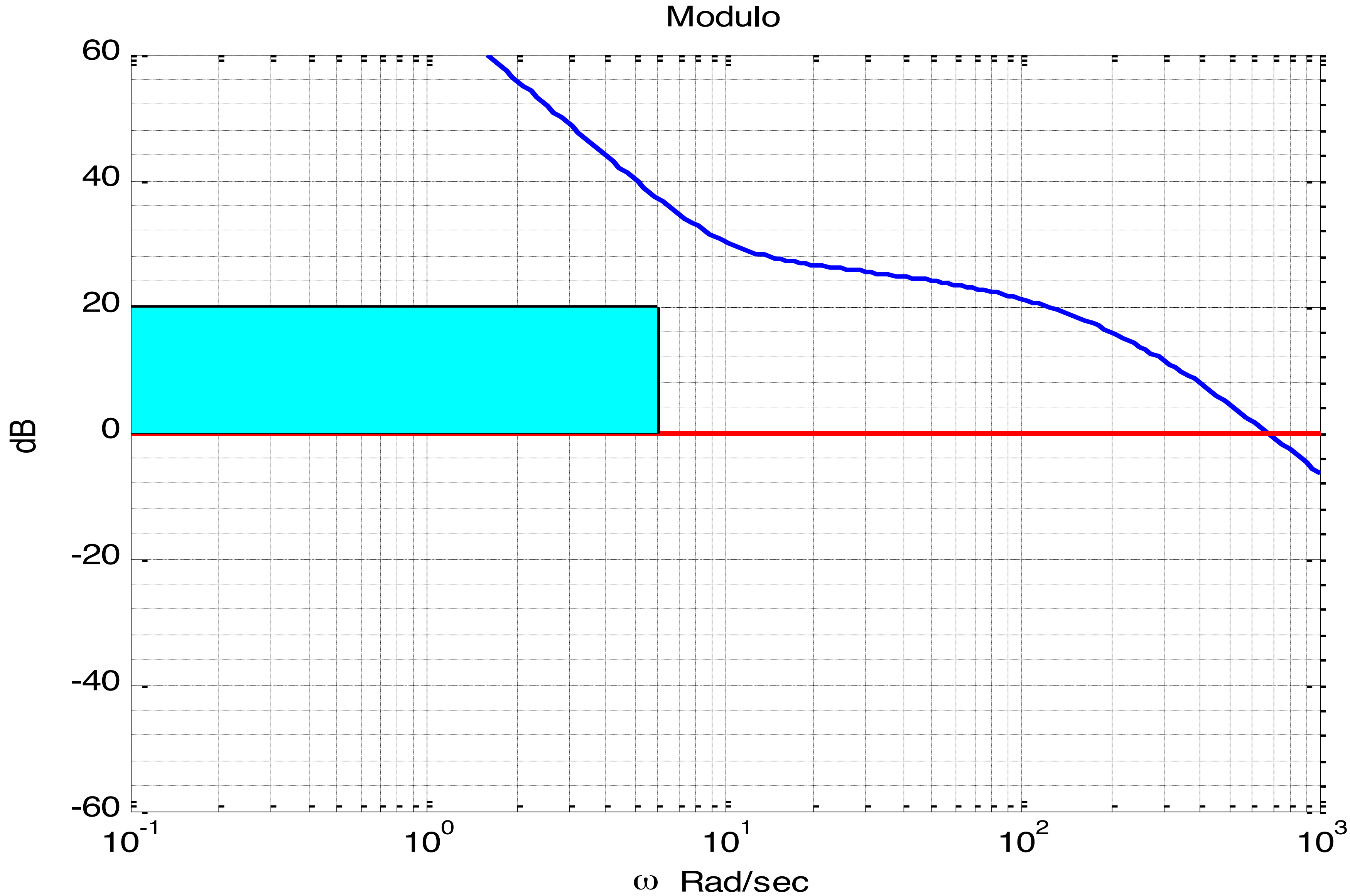


Senza rete

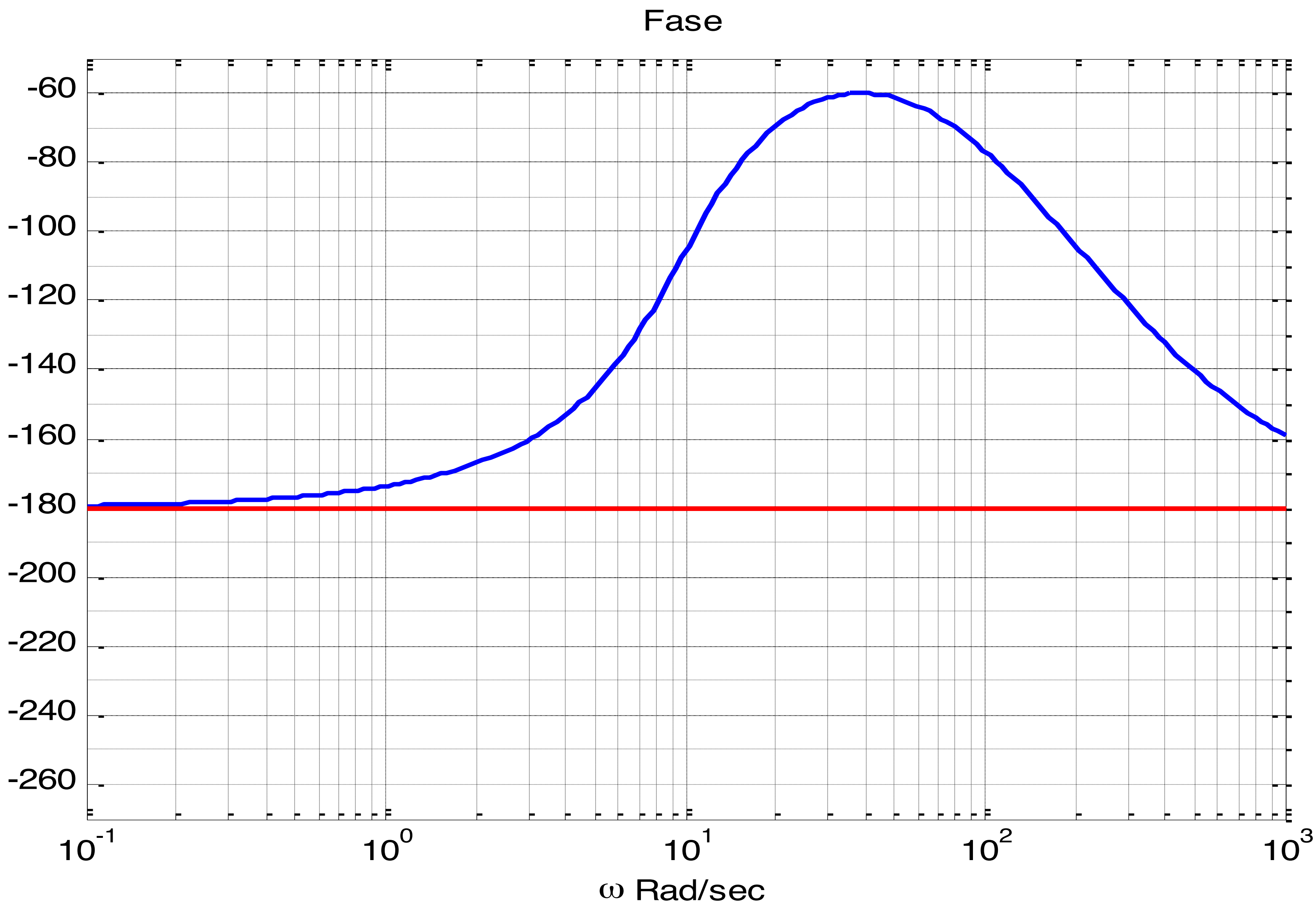
Con la rete

Esercizio 31 Gennaio 2014

Funzione non compensata - modulo

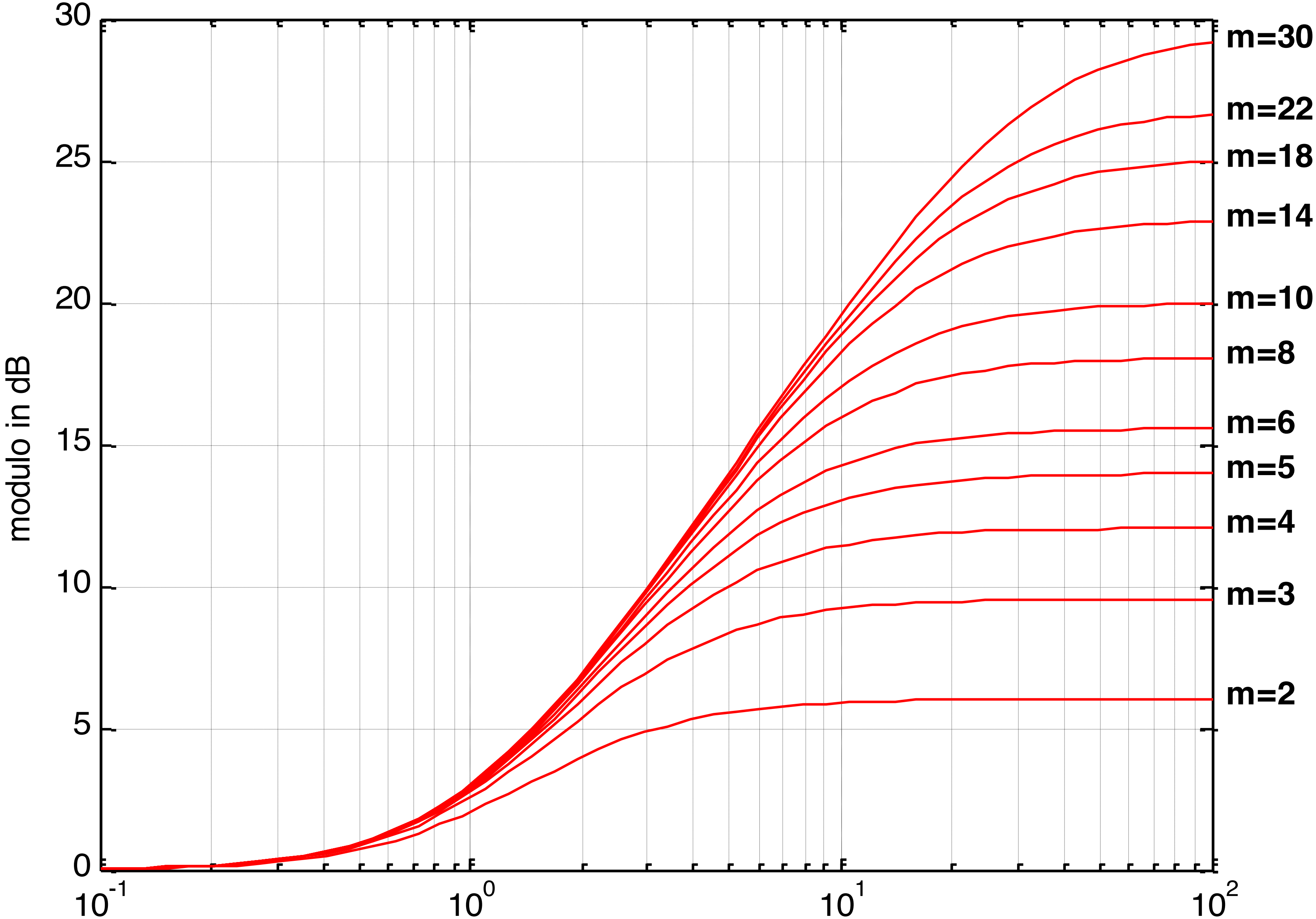


Funzione non compensata - Fase

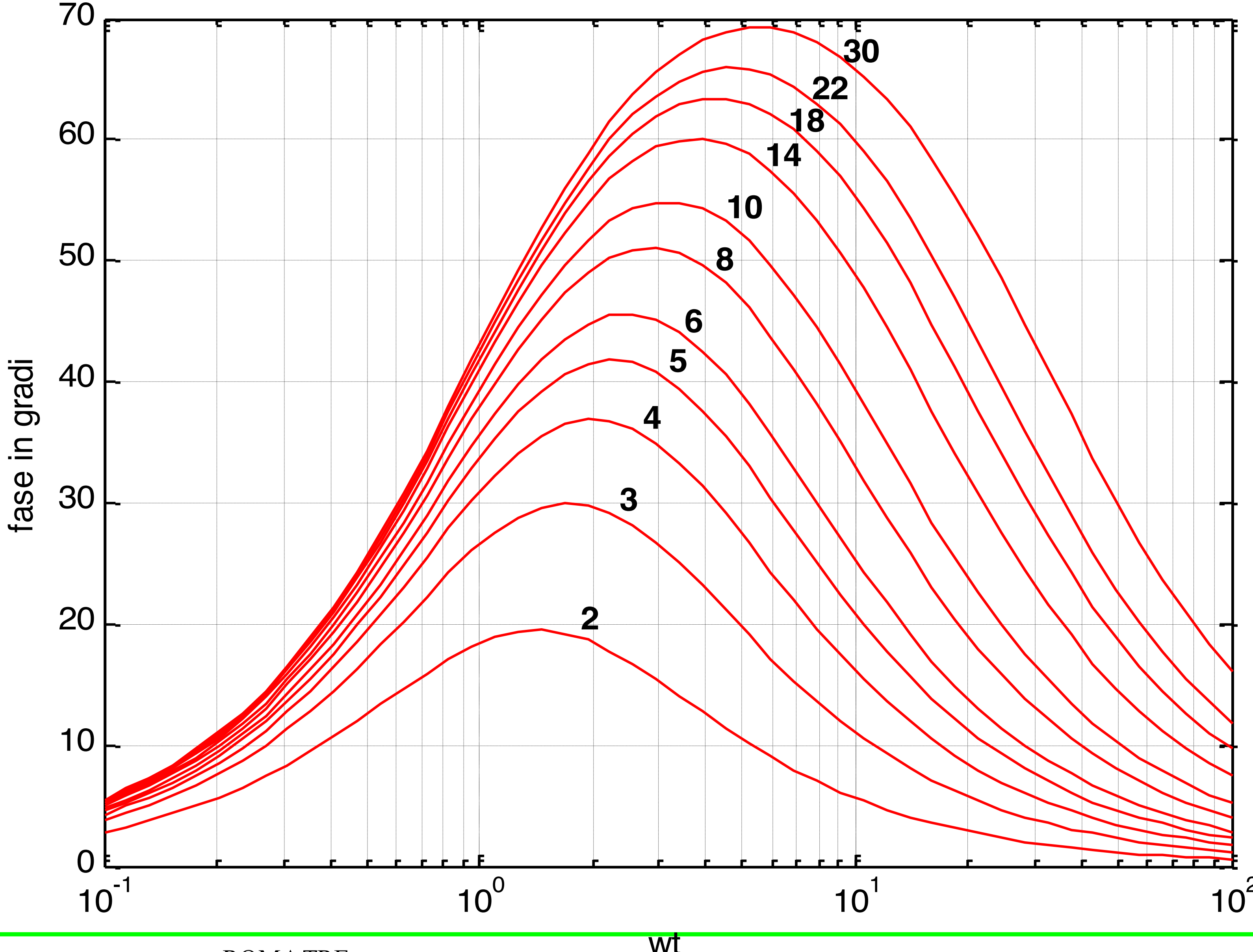


1. **(<u>tutti</u>) Dato il diagramma di BODE della funzione di trasferimento a ciclo aperto F(s) sotto riportata (non ci sono poli a parte reale positiva) determinare la rete compensatrice R(s) tale da assicurare ω_t<=100 rad/sec, m_ϕ>=70° e il rispetto della finestra proibita indicata in figura. Tracciare quindi il diagramma di NICHOLS della funzione compensata F'(s)=F(s)R(s) e determinare su di esso il modulo alla risonanza Mr e la banda passante a –3 Decibel ω_{-3} .**

Rete Compensatrice - Modulo

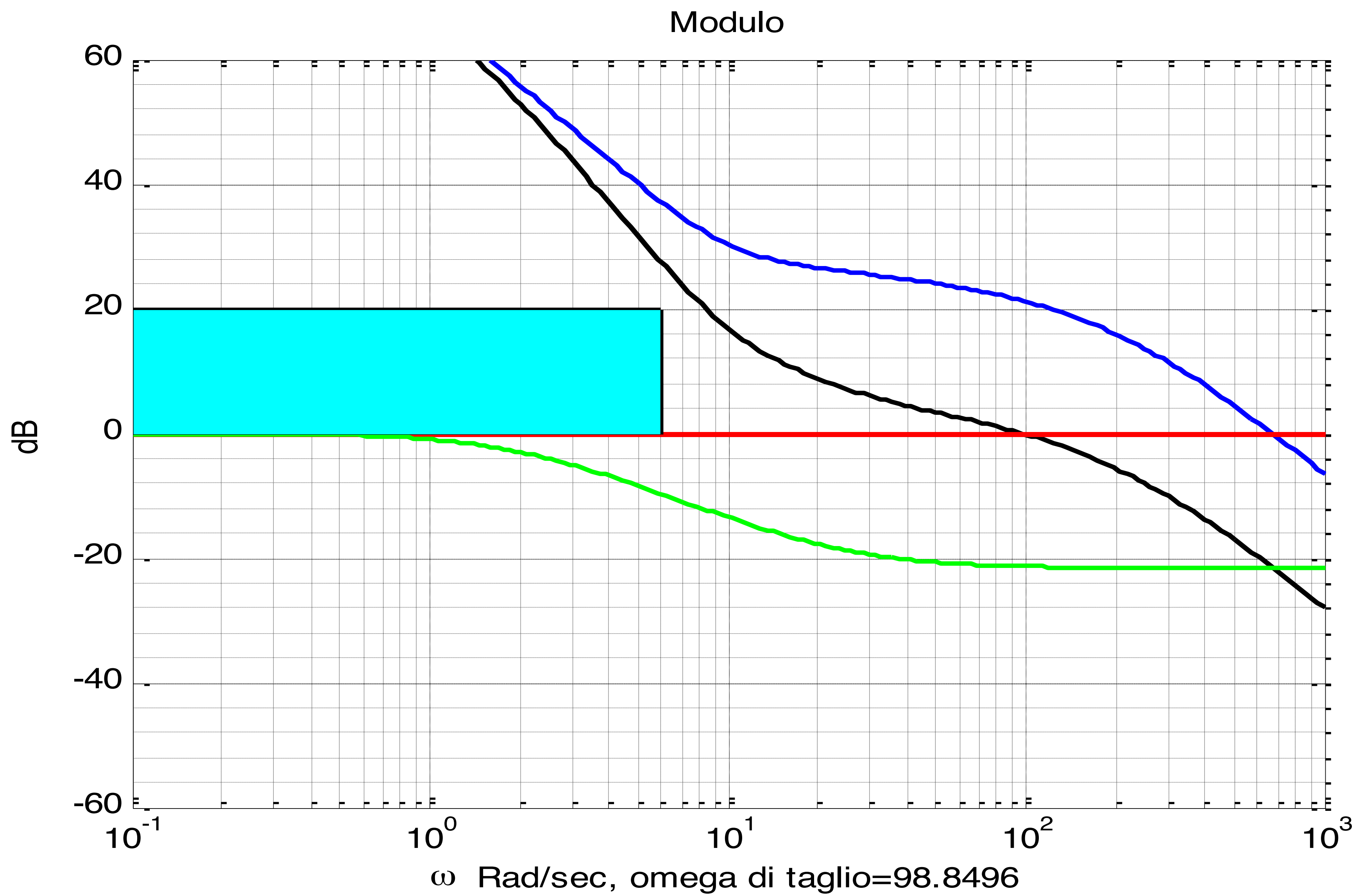


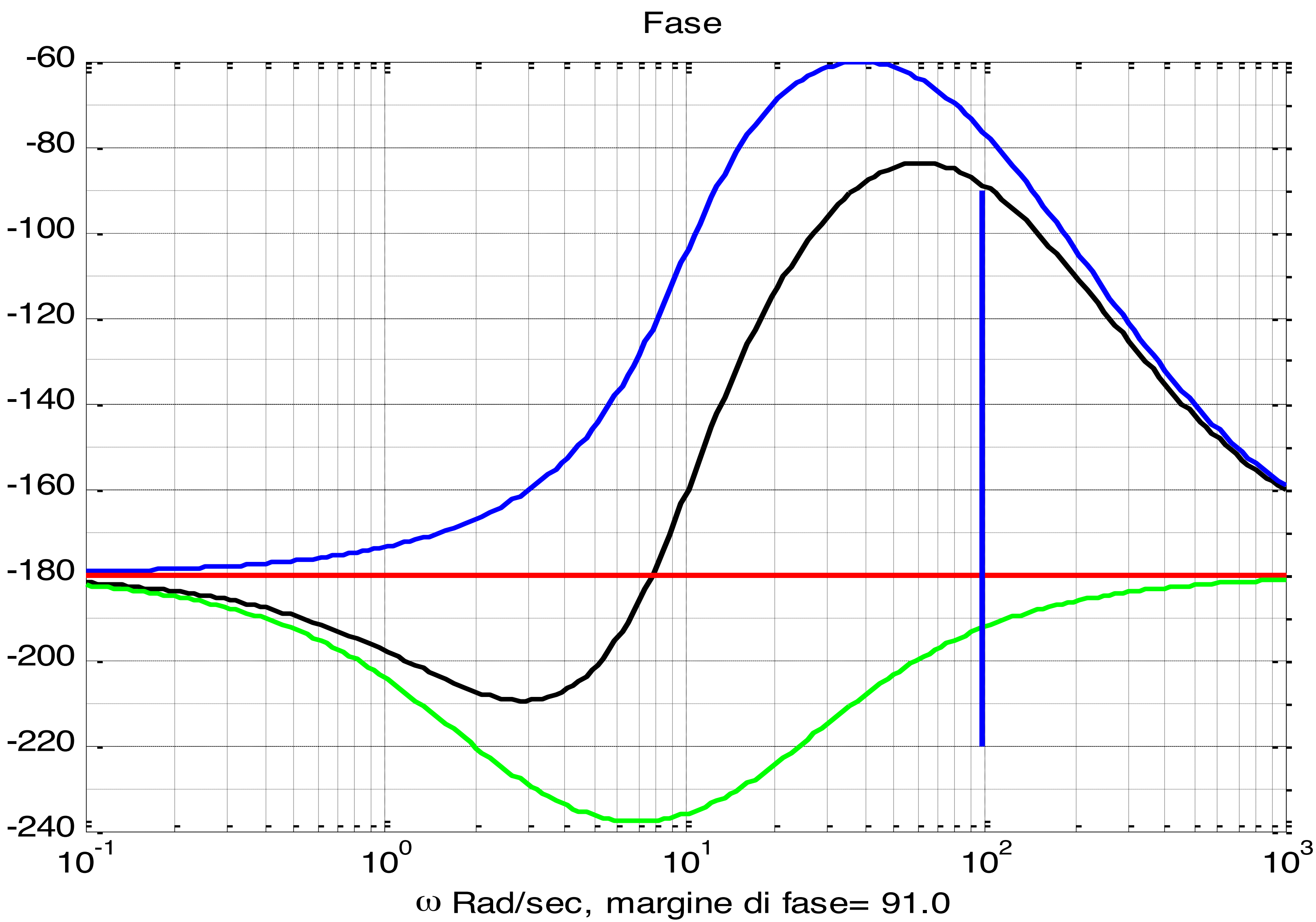
Rete Compensatrice - Fase



```
%Attenuatrice
m=12;tau=0.5;
```

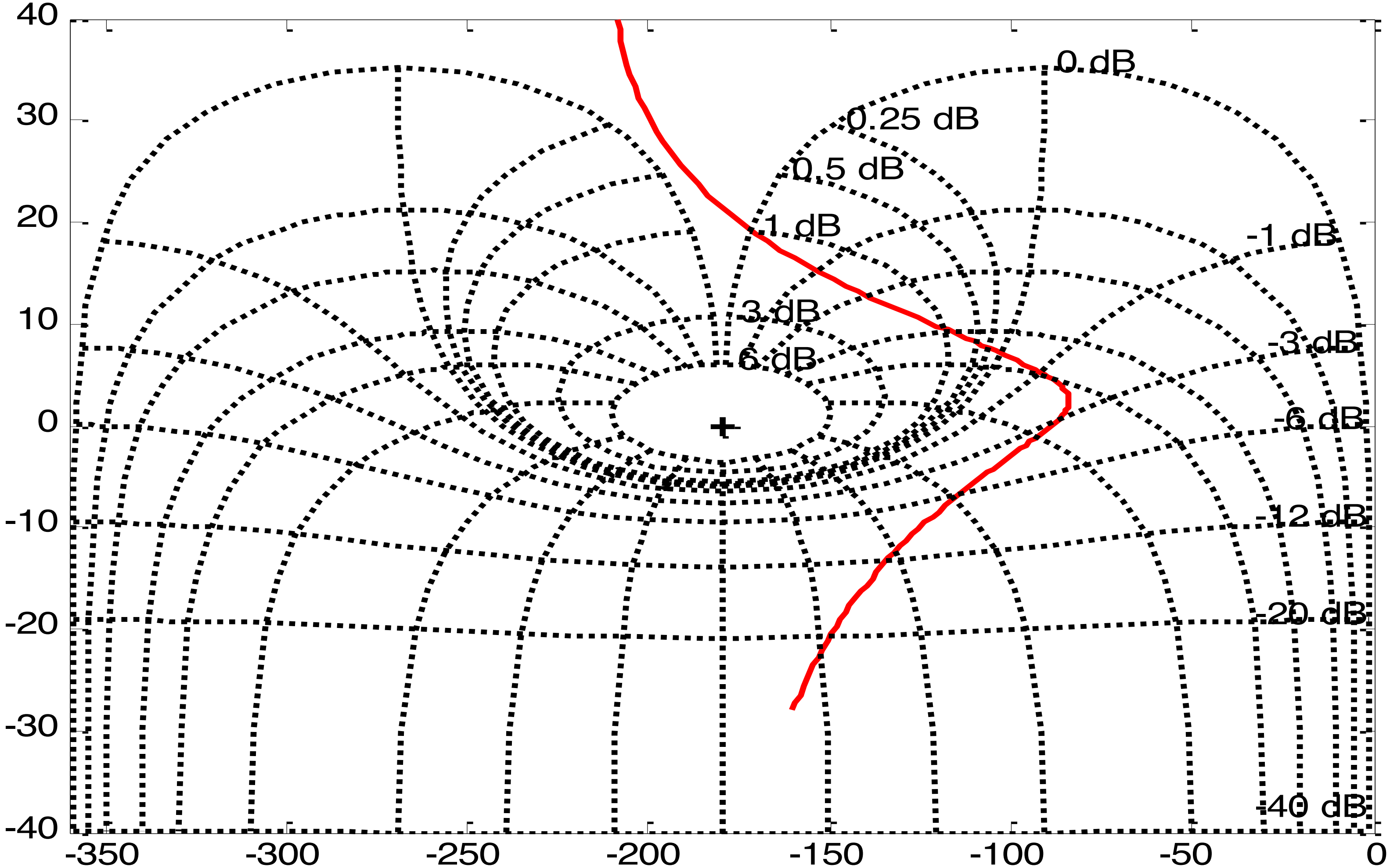
Funzione Corretta - Modulo



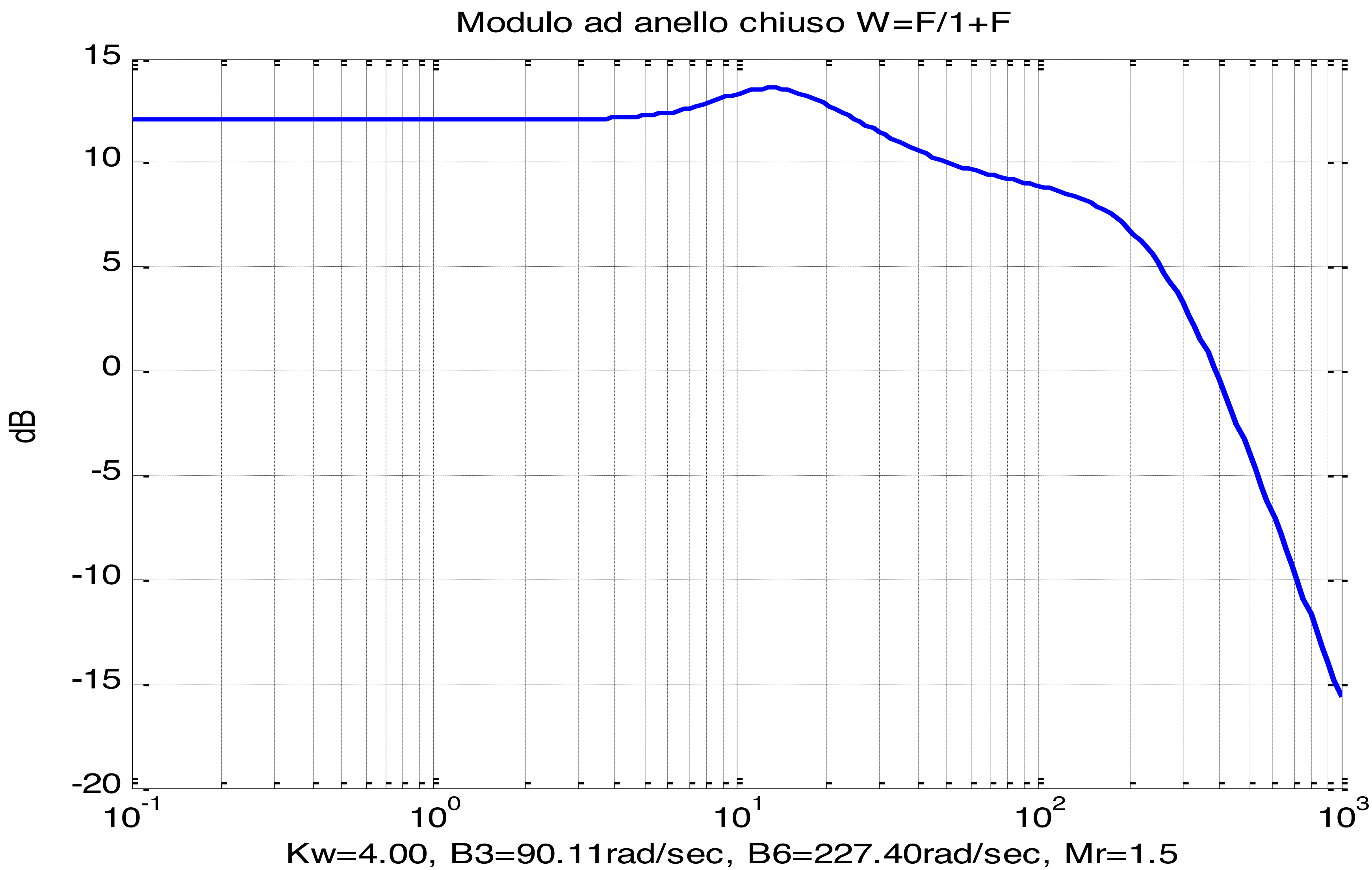


Fase
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
ω Rad/sec, margine di fase= 91.0

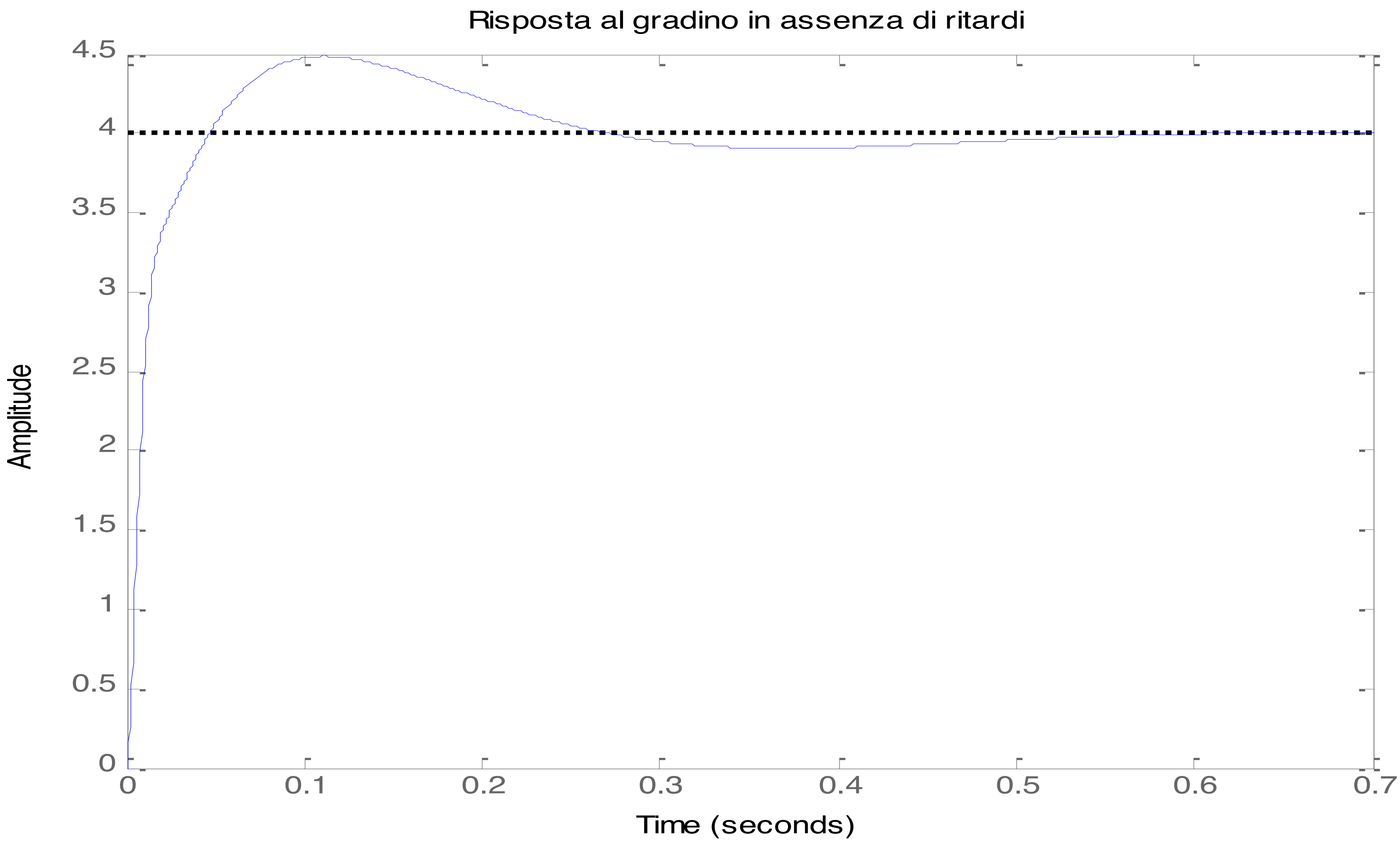
Funzione Corretta - Nichols



Funzione Corretta - Ciclo chiuso

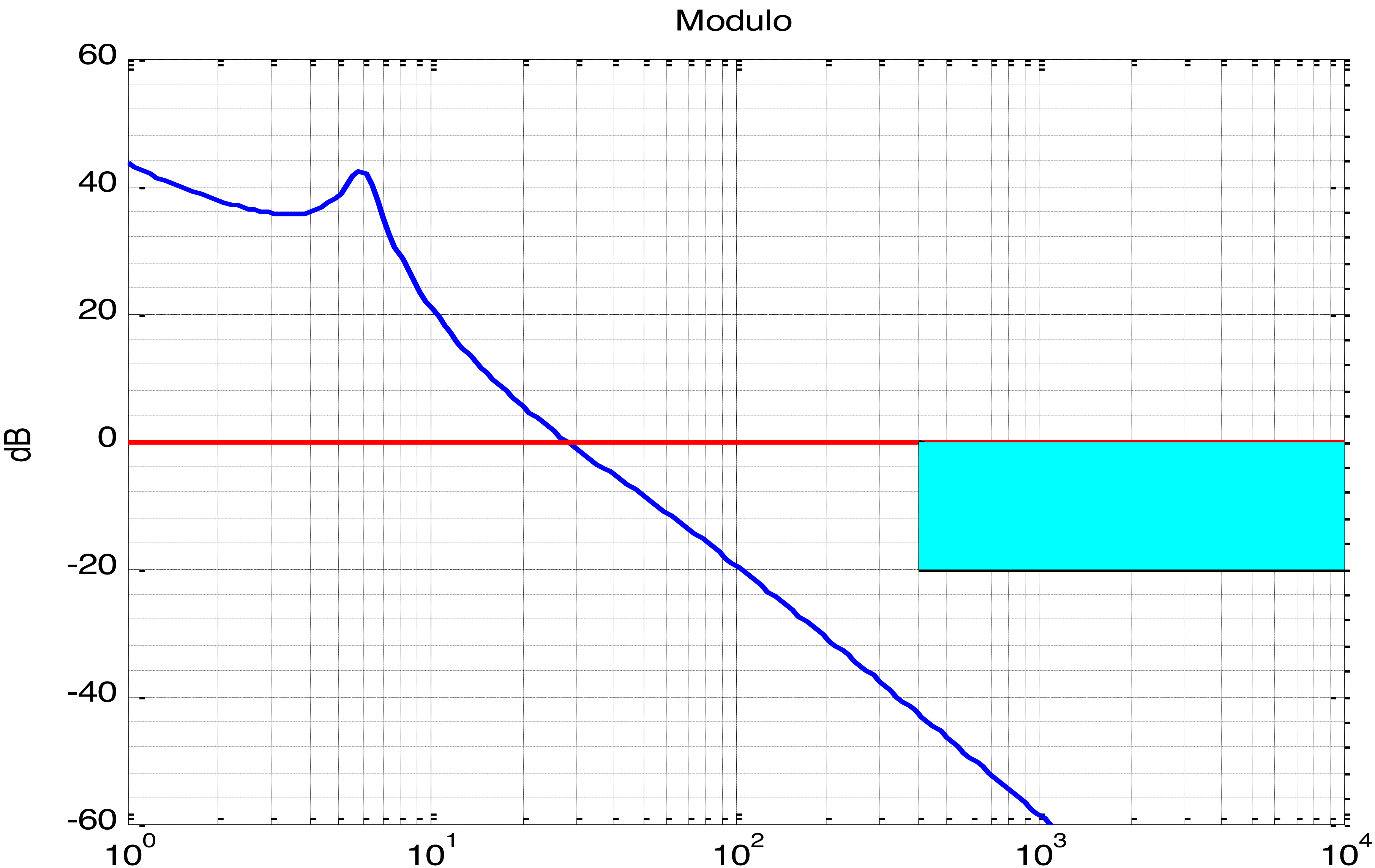


Funzione Corretta – Risposta al gradino

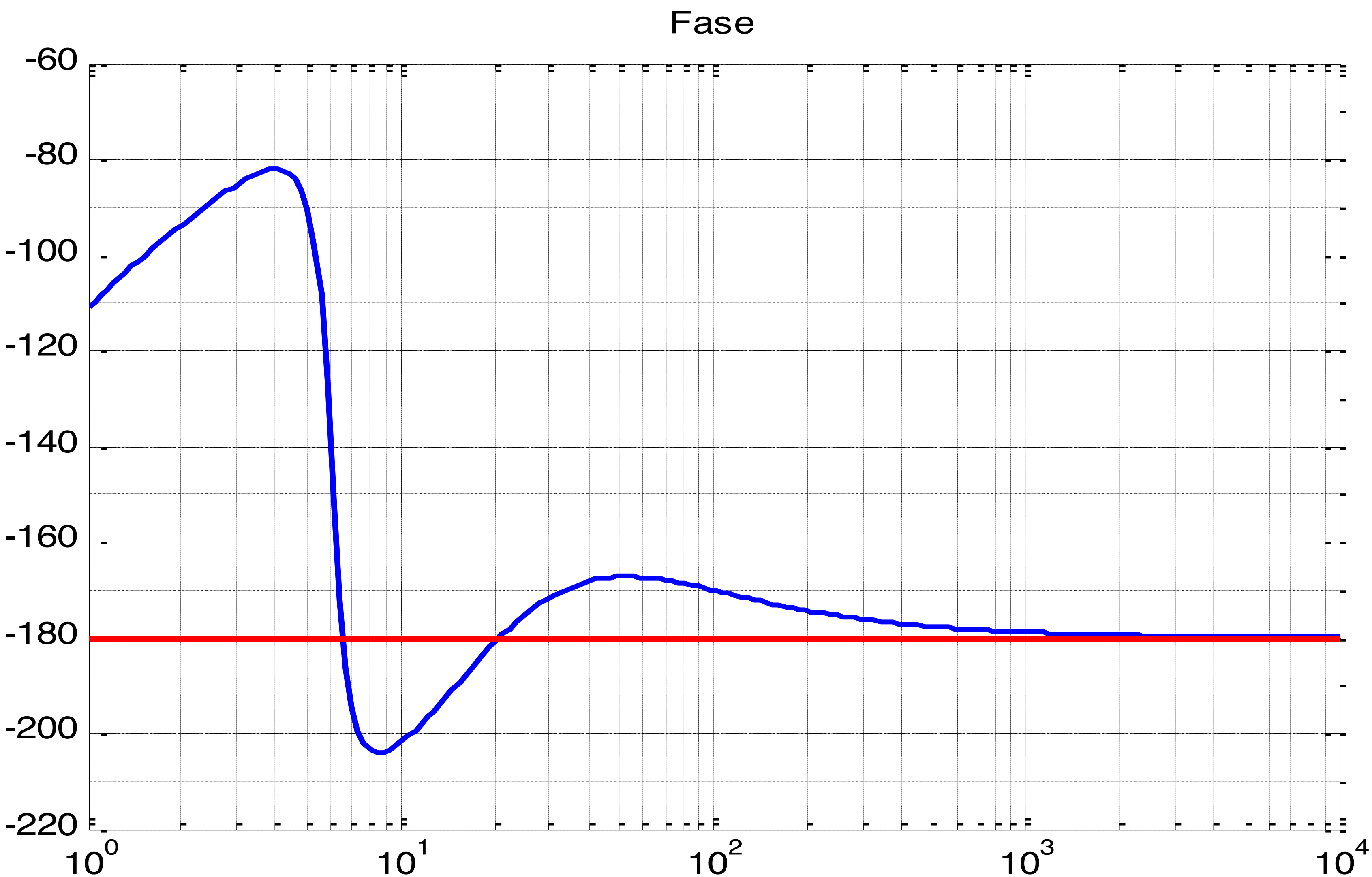


Esercizio 15 Giugno 2012

Funzione non compensata - modulo

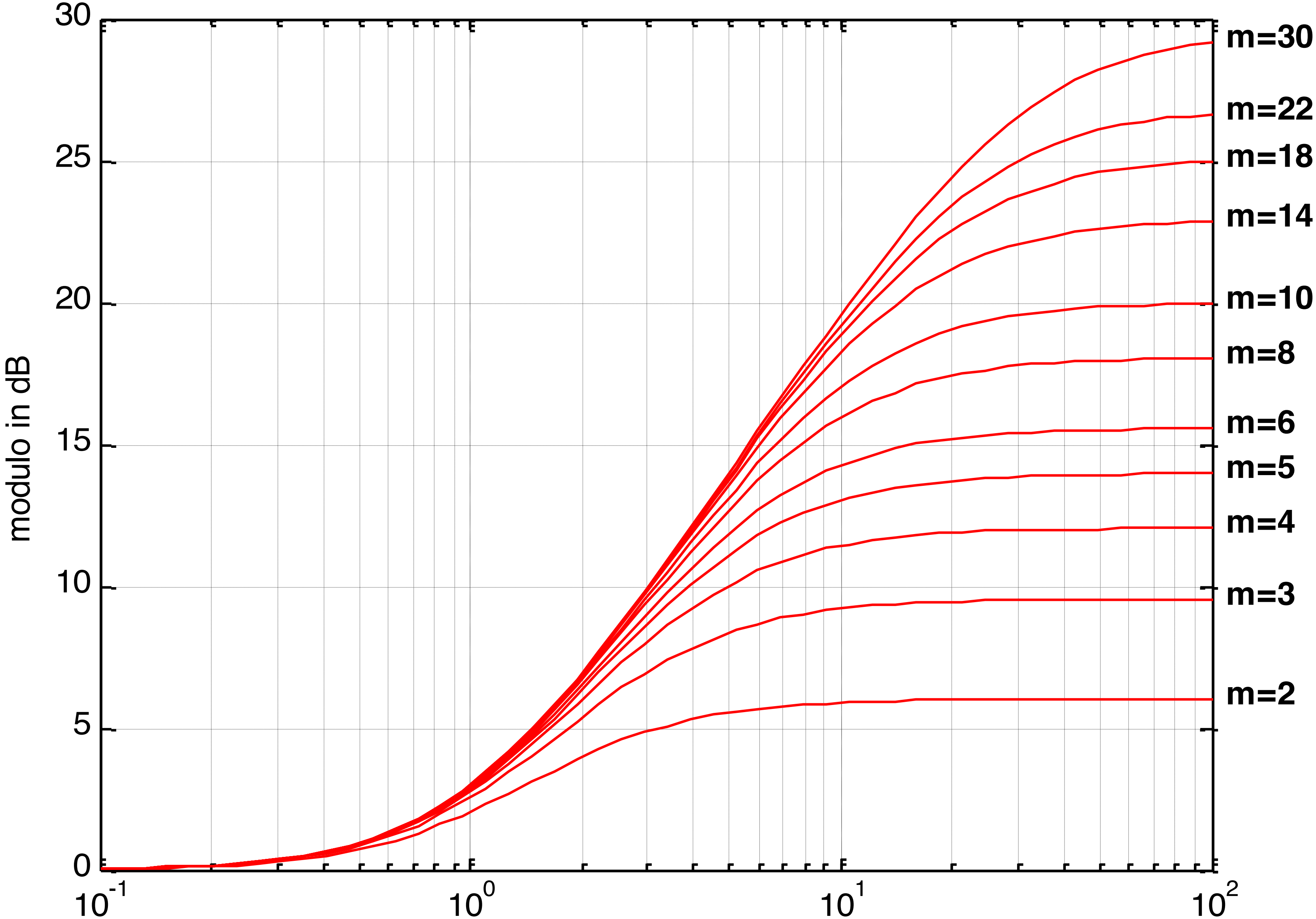


FUNZIONE NON COMPENSATA - FASE

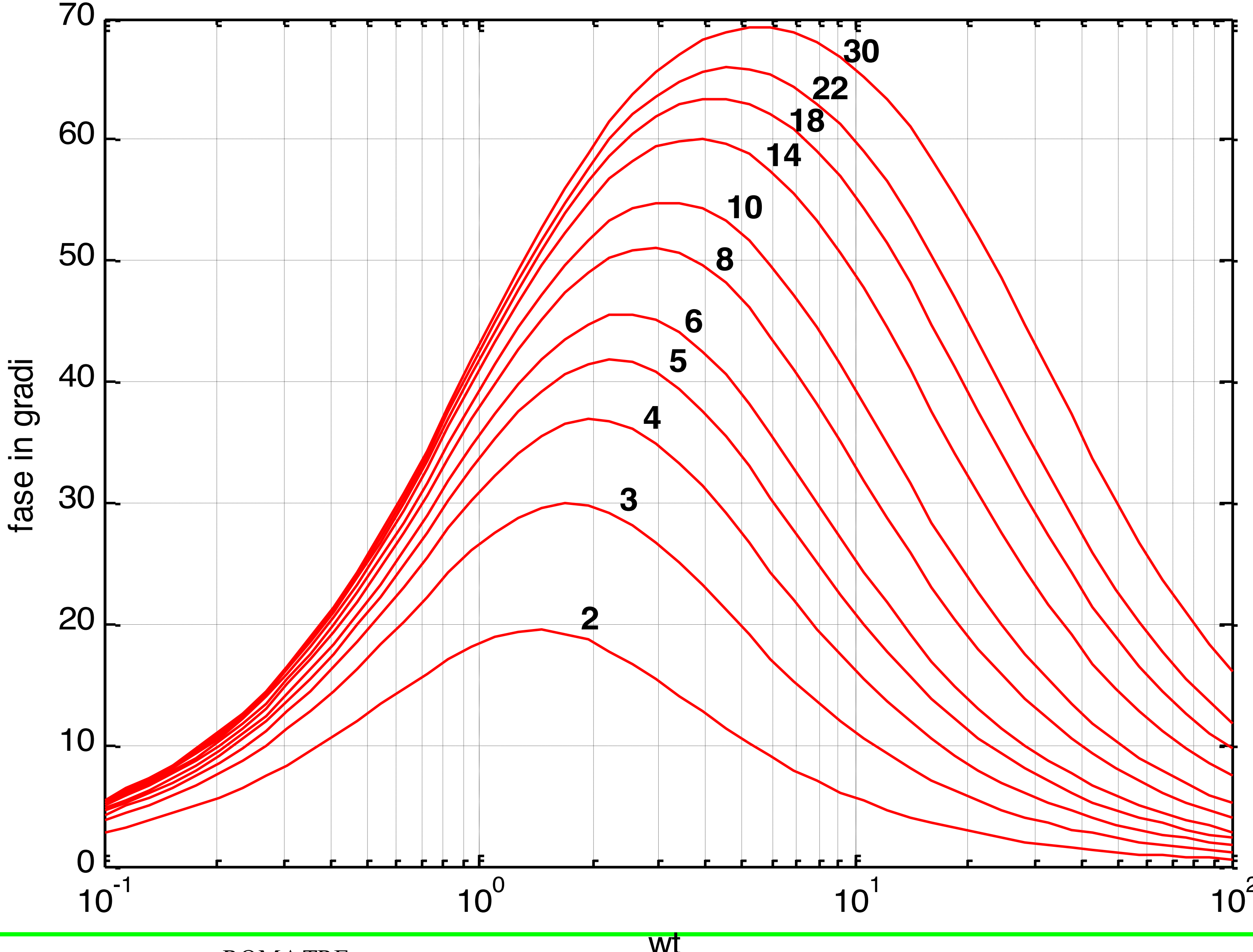


Dato il diagramma di BODE della funzione di trasferimento a ciclo aperto F(s) sotto riportata (non ci sono poli a parte reale positiva) determinare la rete compensatrice R(s) tale da assicurare ω_t>=40 rad/sec, m_ϕ>=55° e il rispetto della finestra proibita indicata in figura. Tracciare quindi il diagramma di NICHOLS della funzione compensata F'(s)=F(s)R(s) e determinare su di esso il modulo alla risonanza Mr e la banda passante a –3 Decibel ω_{-3} .

Rete Compensatrice - Modulo

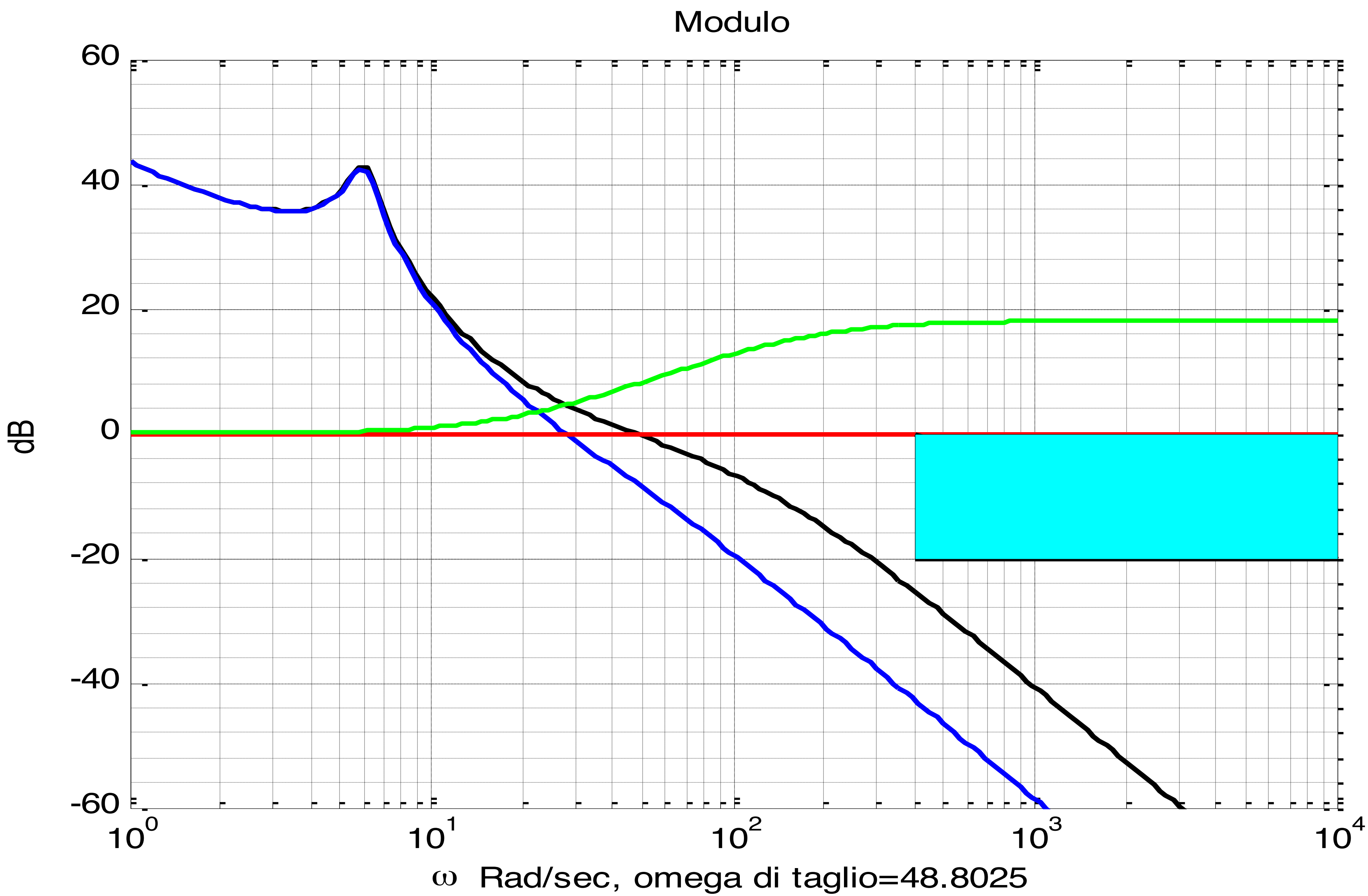


Rete Compensatrice - Fase

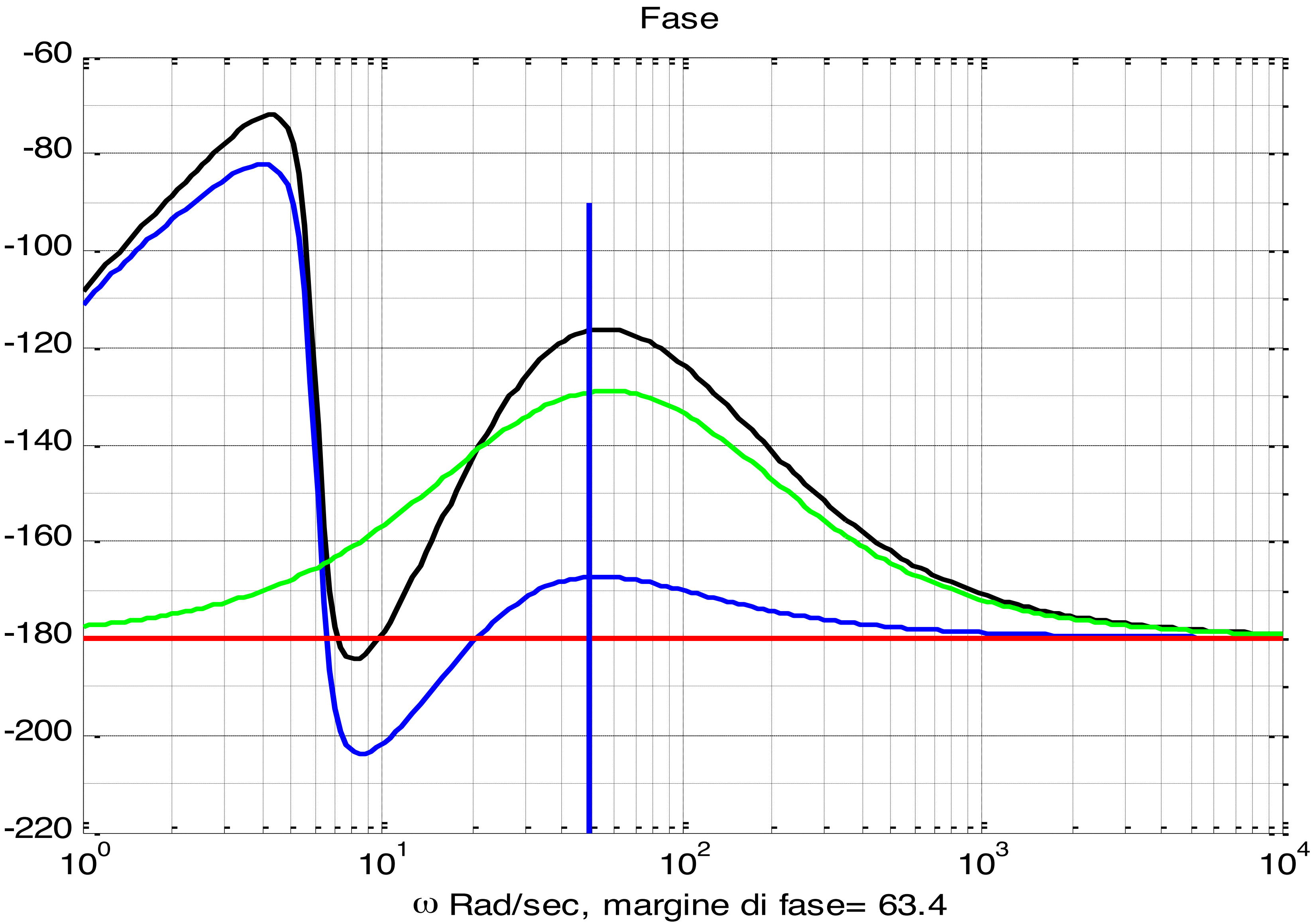


```
%Anticipatrice
m=8;tau=0.05;
```

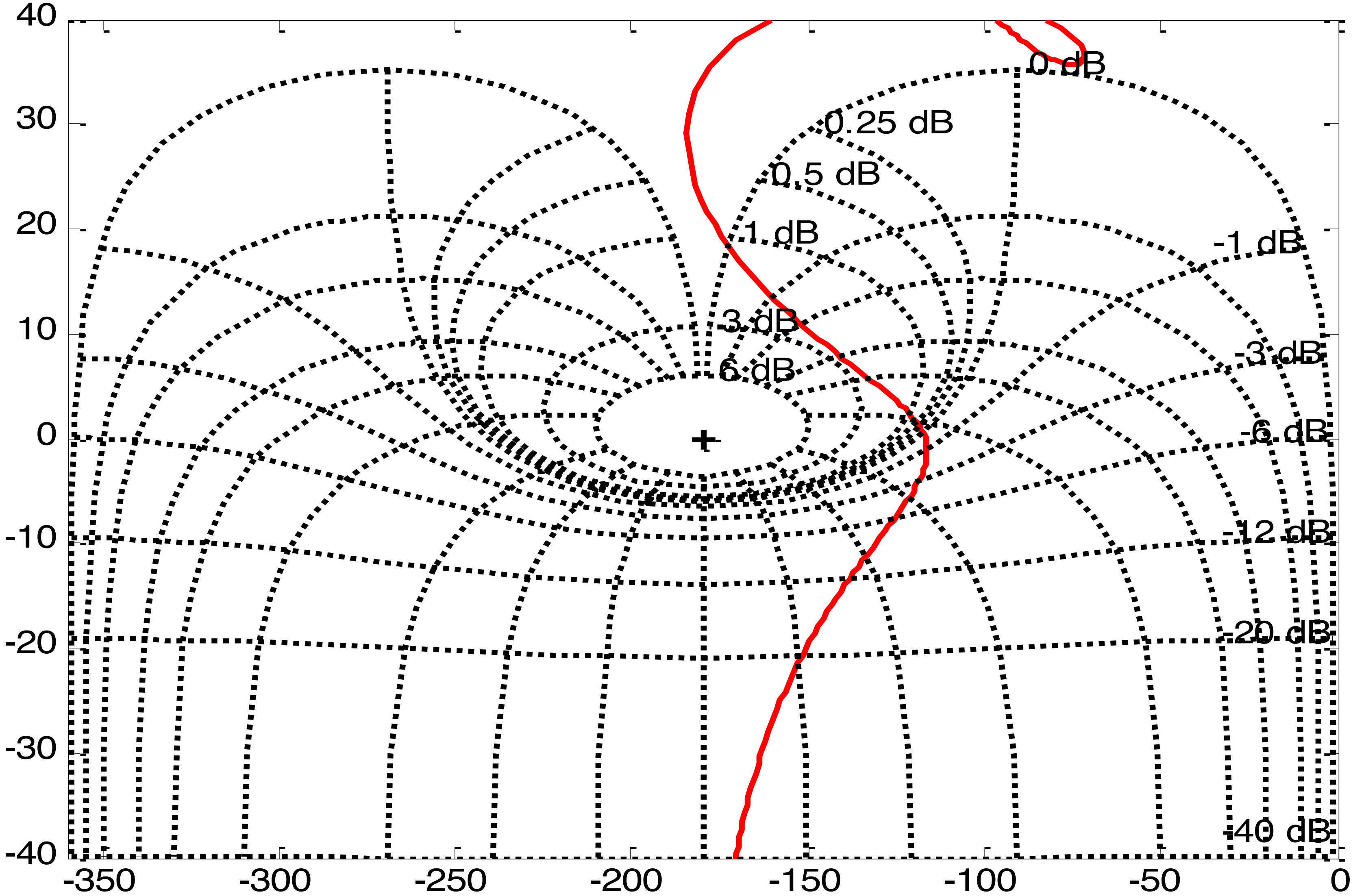
Funzione Corretta - Modulo



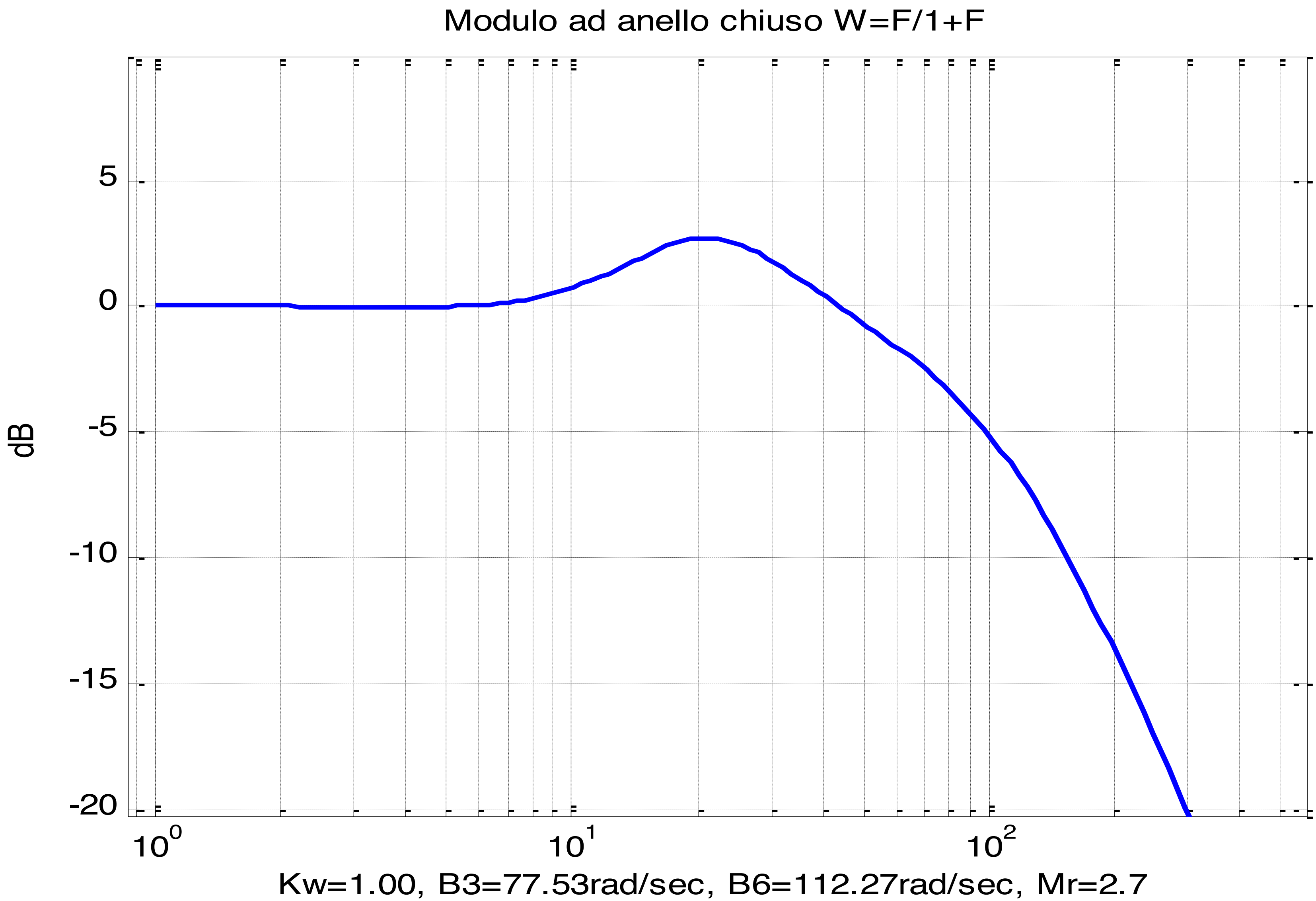
Funzione Corretta - fase



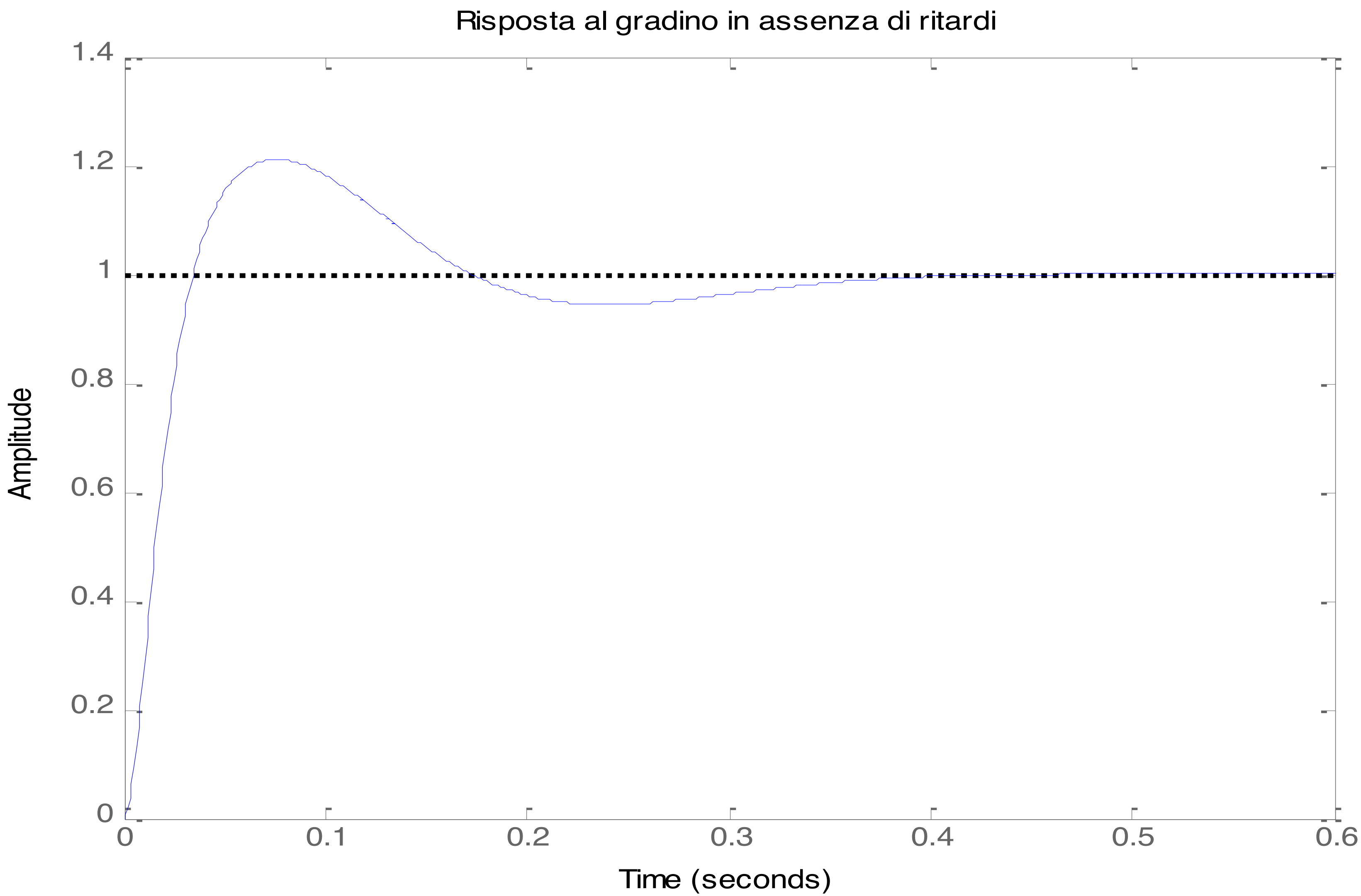
Funzione Corretta - Nichols



Funzione Corretta - Ciclo chiuso

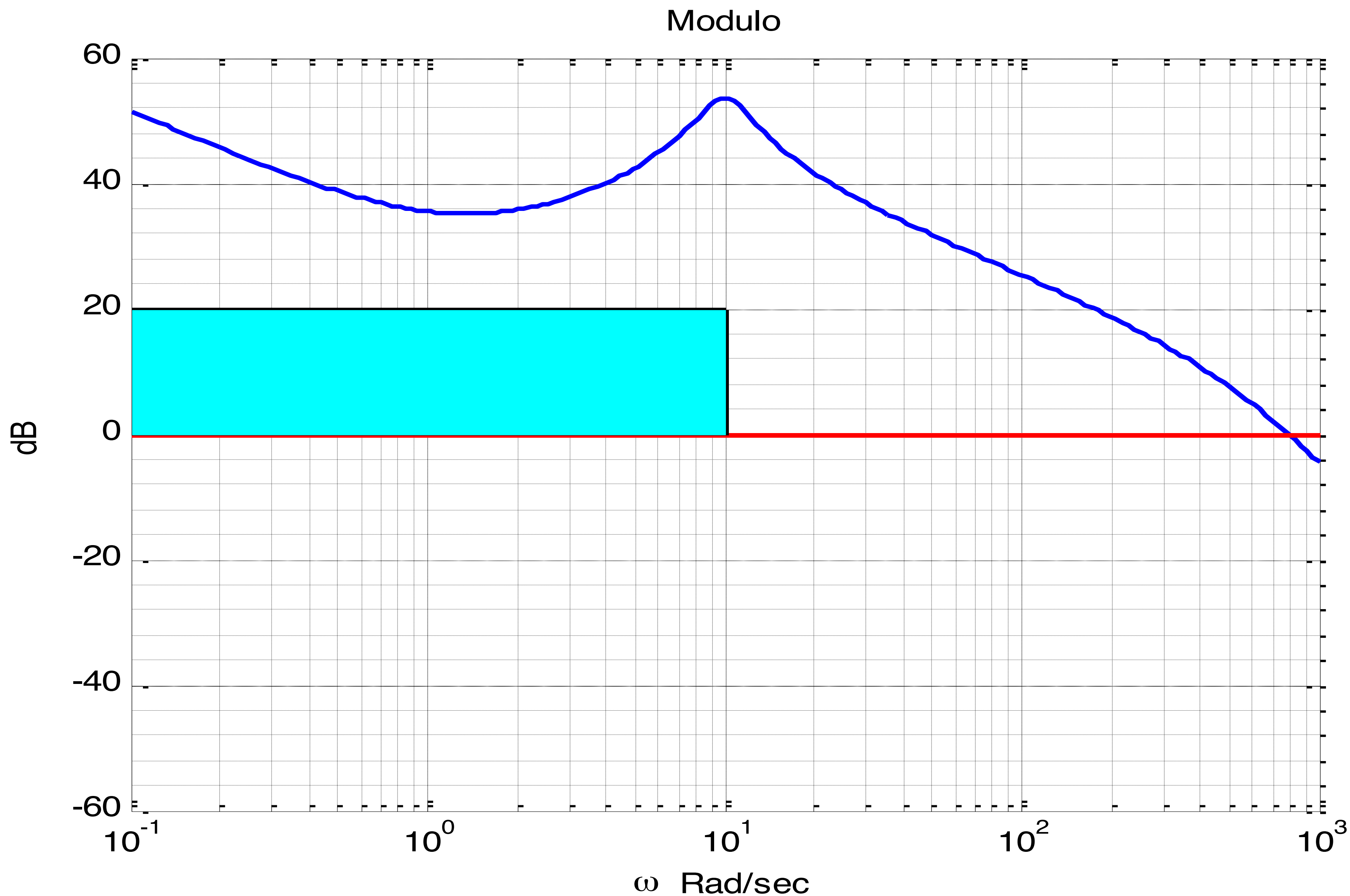


Funzione Corretta – Risposta al gradino

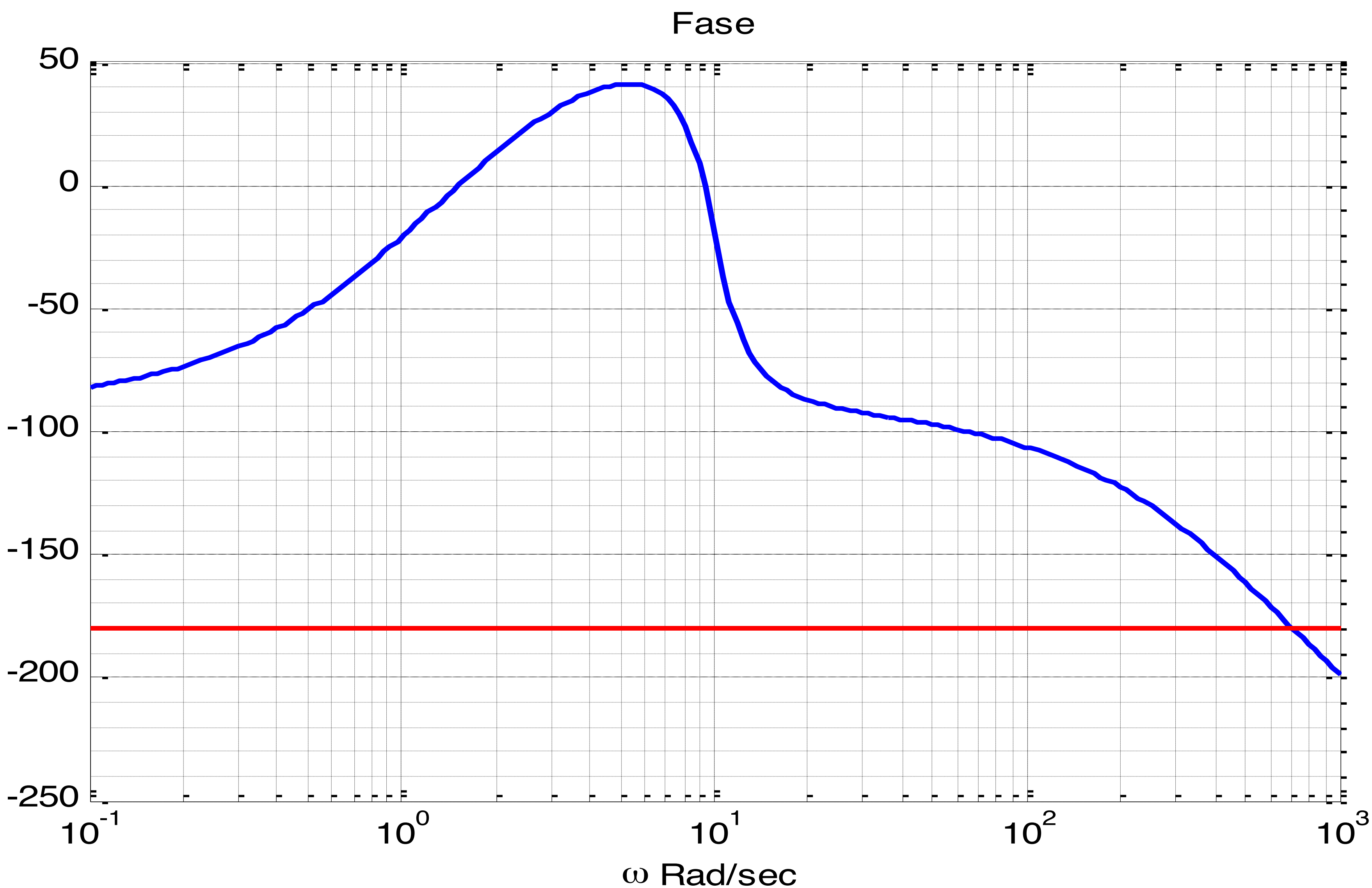


Esercizio
13 Settembre 2013

Funzione non compensata - modulo

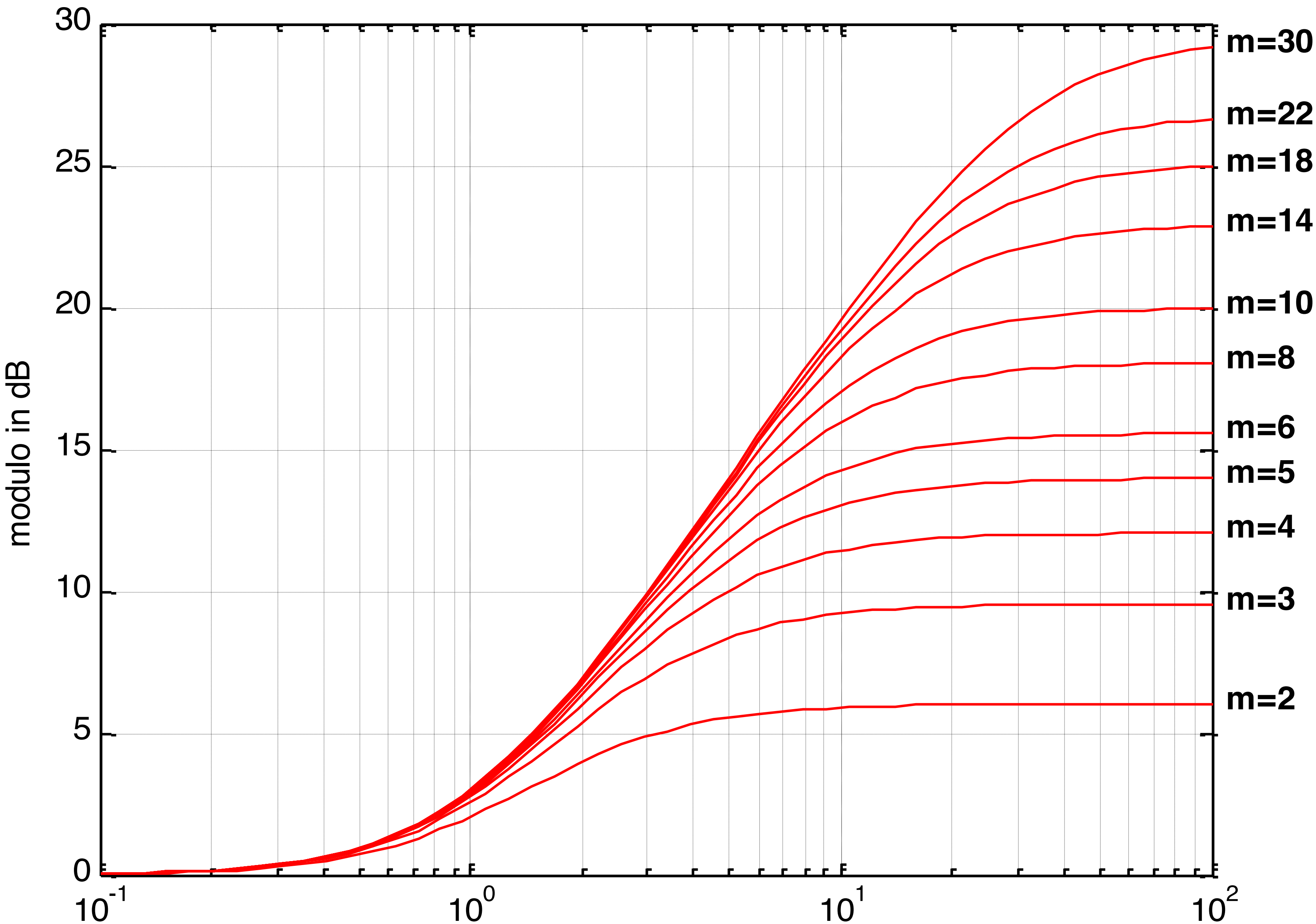


Funzione non compensata - Fase

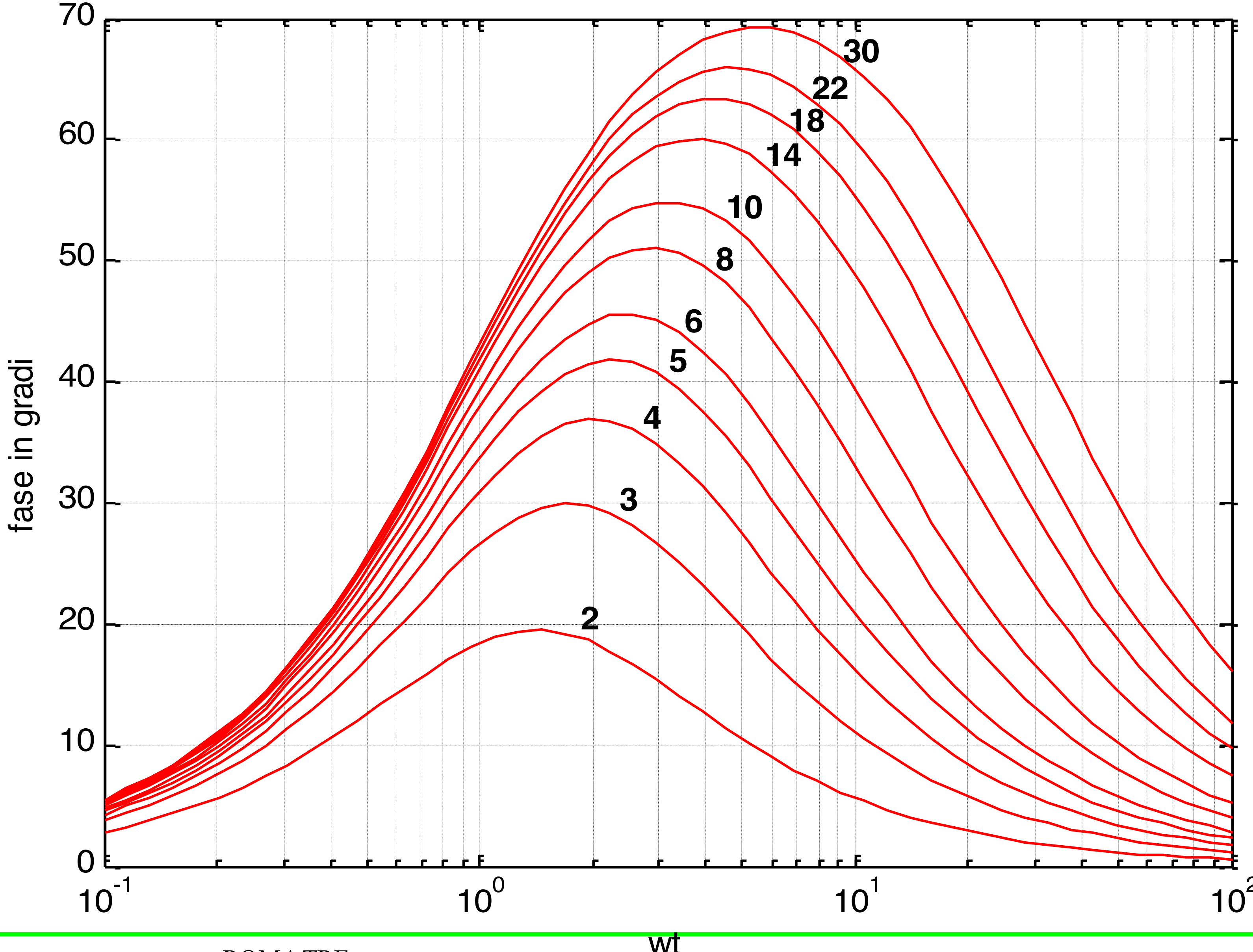


Dato il diagramma di BODE della funzione di trasferimento a ciclo aperto F(s) sotto riportata (non ci sono poli a parte reale positiva) determinare la rete compensatrice R(s) tale da assicurare ω_t<=200 rad/sec, m_ϕ>=50° e il rispetto della finestra proibita indicata in figura. Tracciare quindi il diagramma di NICHOLS della funzione compensata F'(s)=F(s)R(s) e determinare su di esso il modulo alla risonanza Mr e la banda passante a –3 Decibel ω_{-3} .

Rete Compensatrice - Modulo

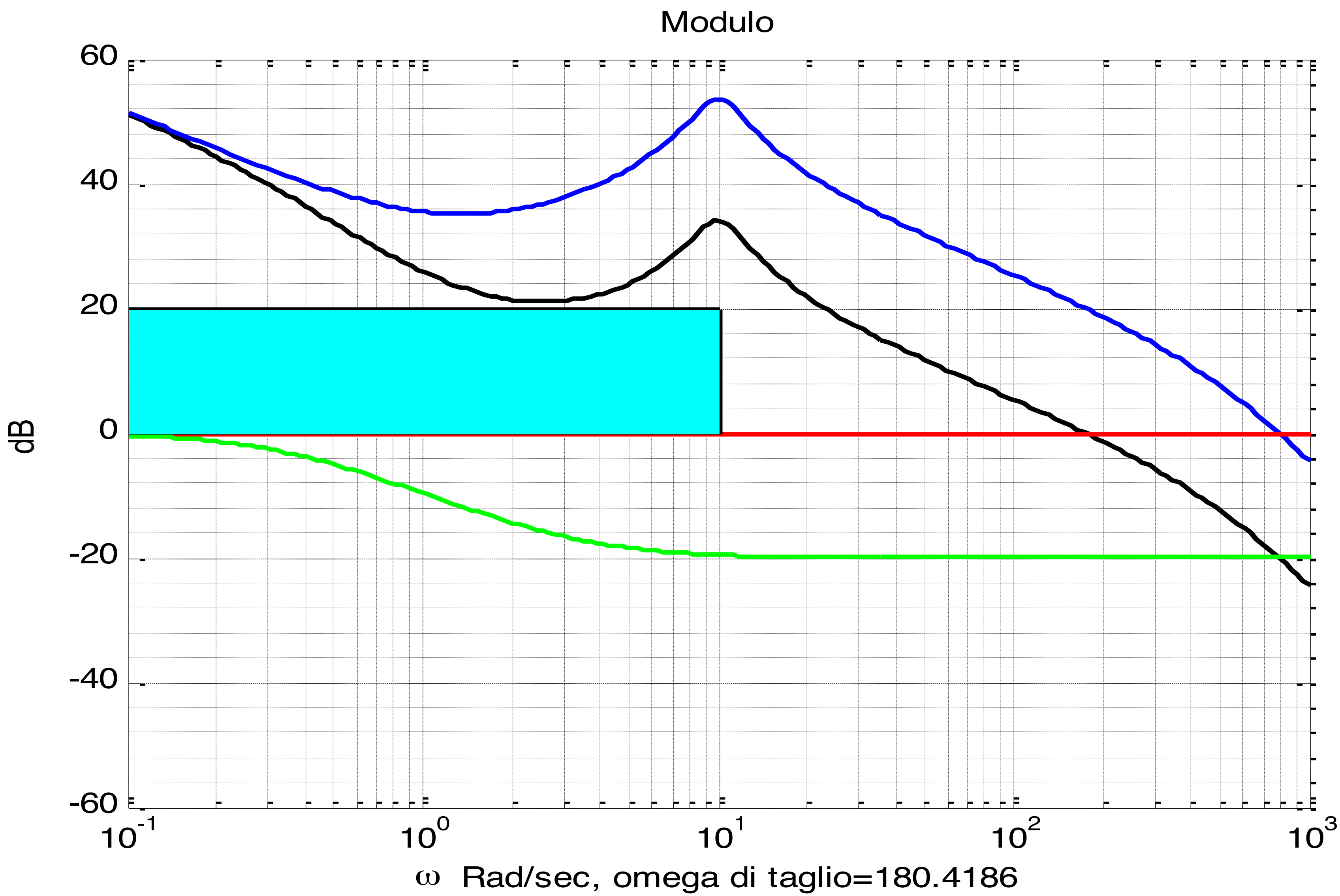


Rete Compensatrice - Fase

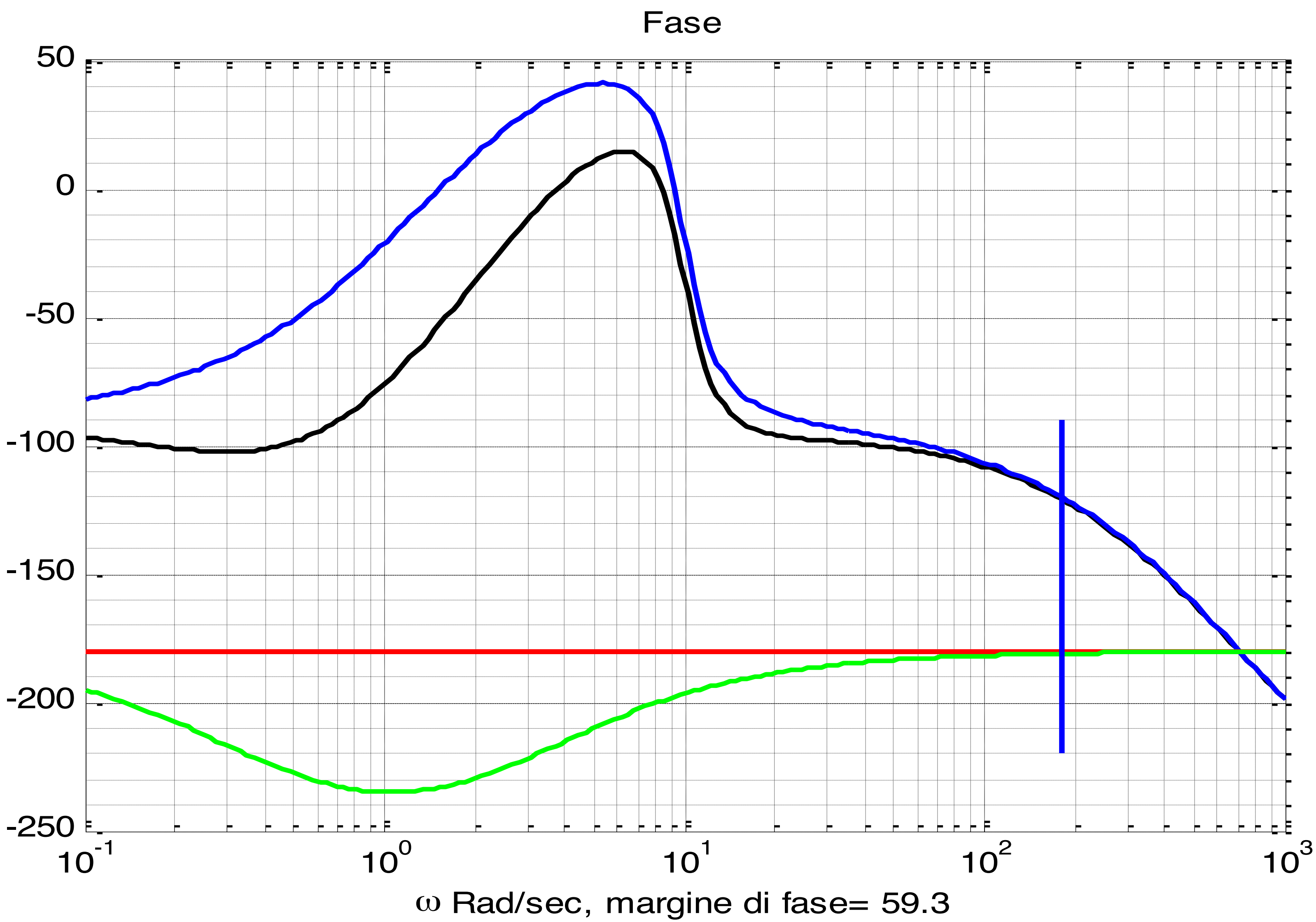


```
%Attenuatrice
m=10;tau=3;
```

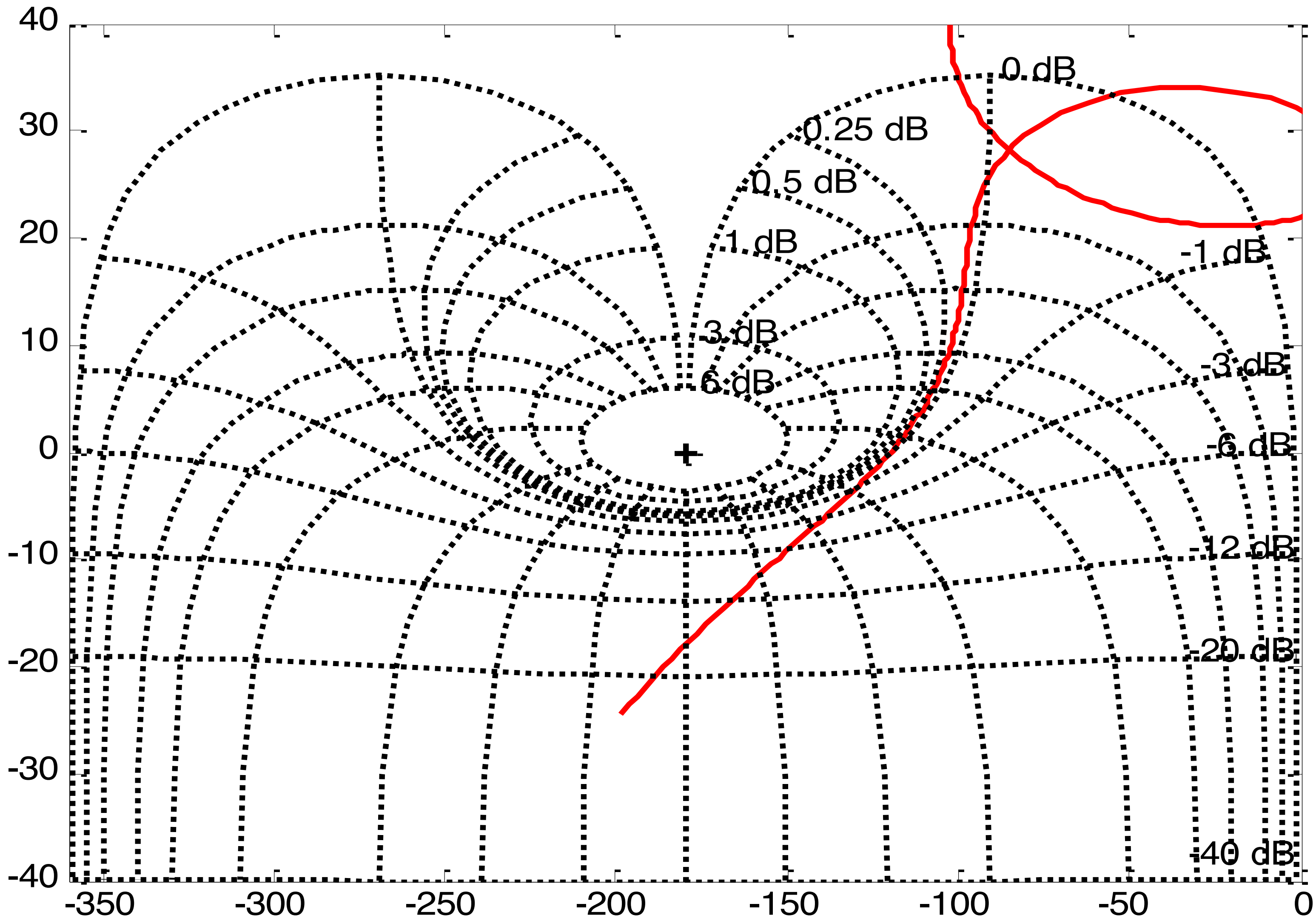
Funzione Corretta - Modulo



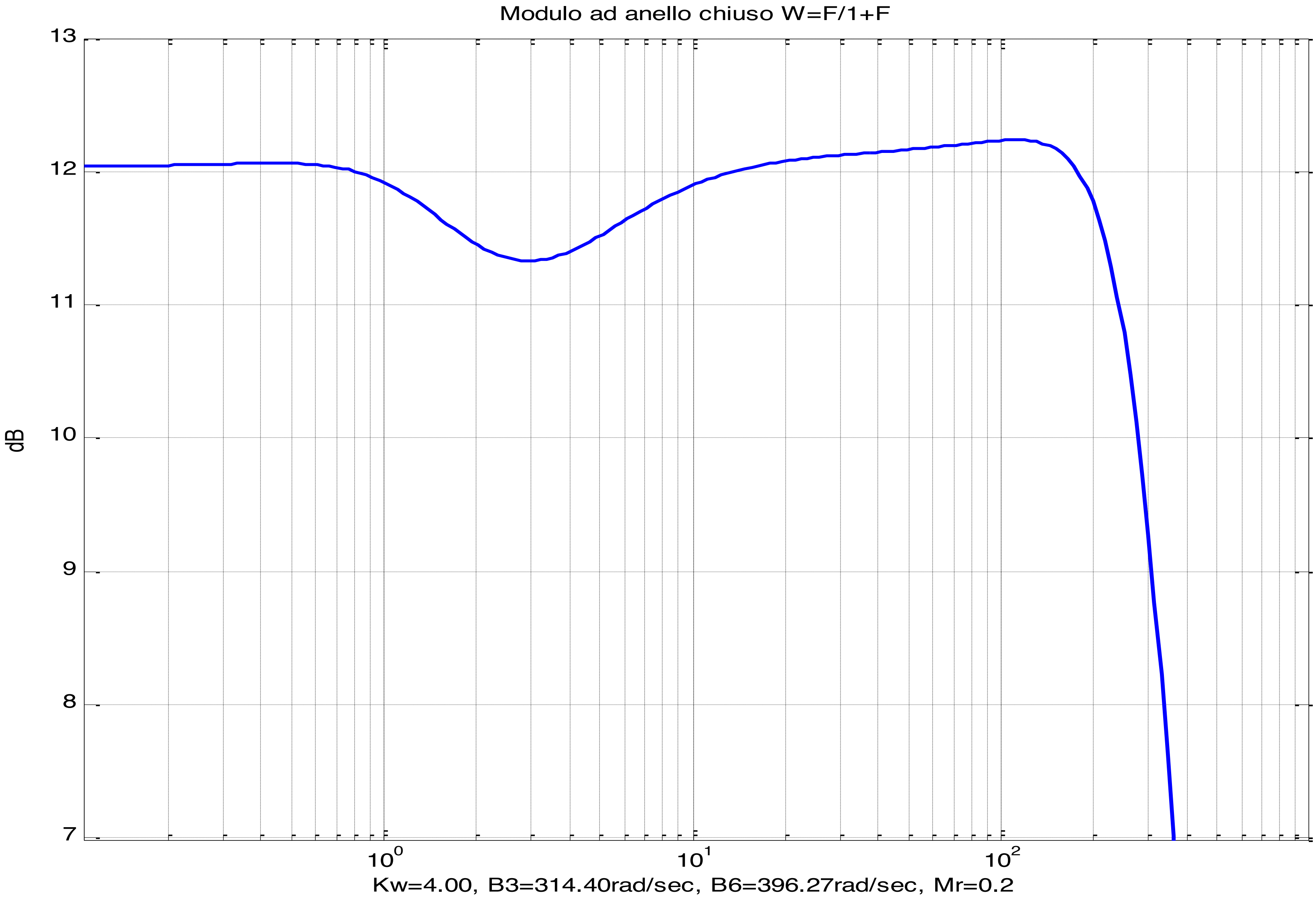
Funzione Corretta - fase



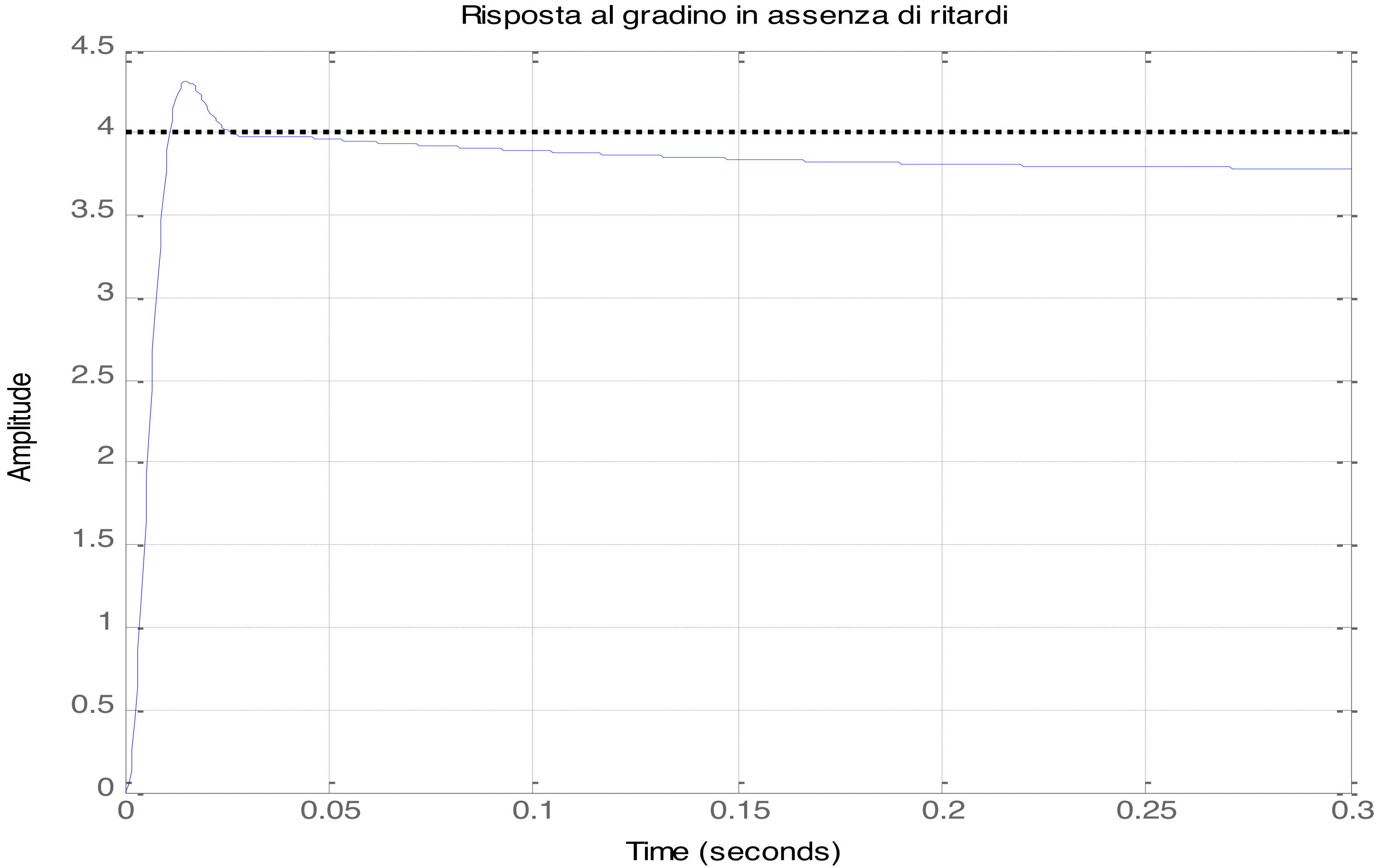
Funzione Corretta - Nichols



FUNZIONE CORRETTA - CICLO CHIUSO



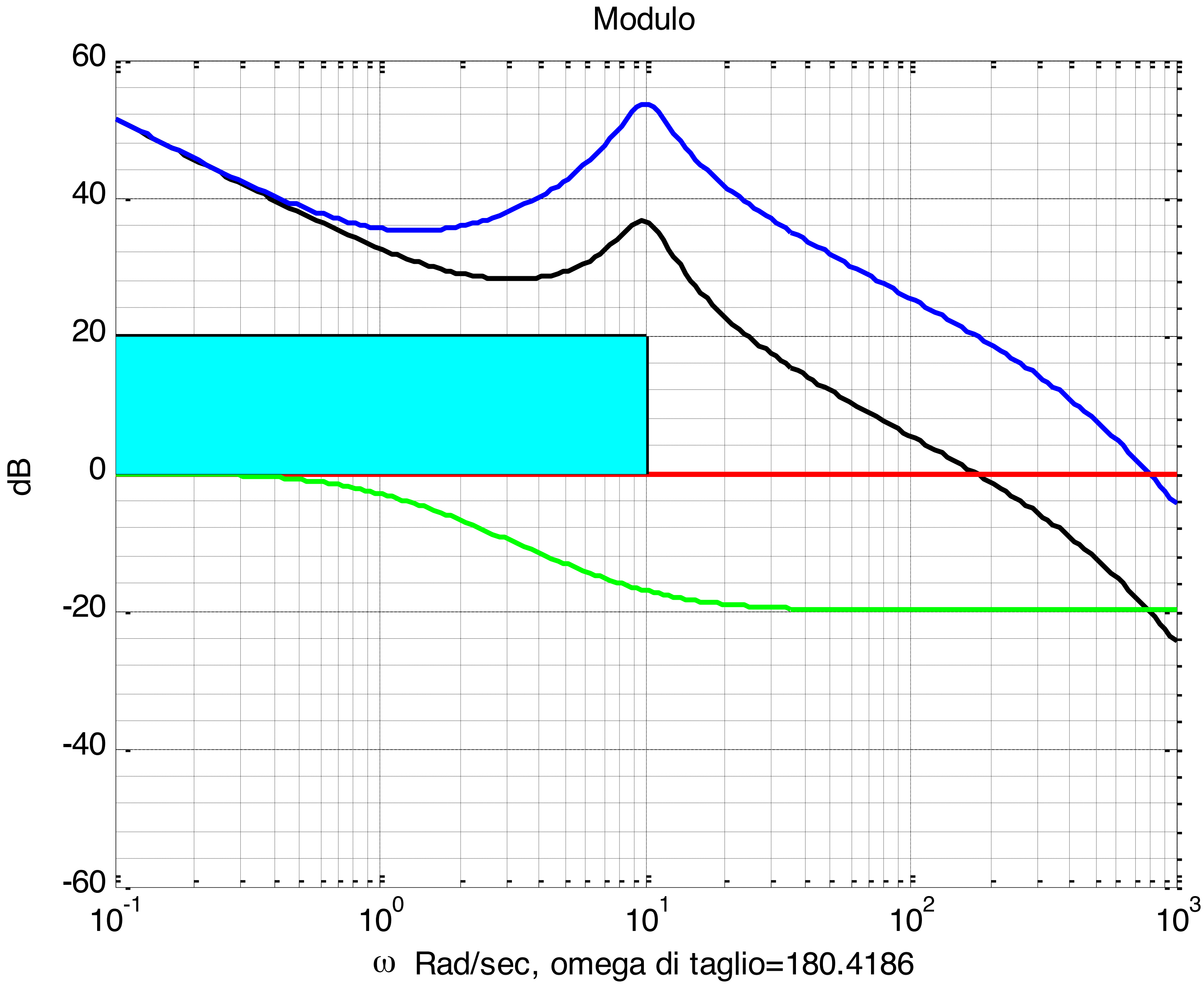
Funzione Corretta – Risposta al gradino



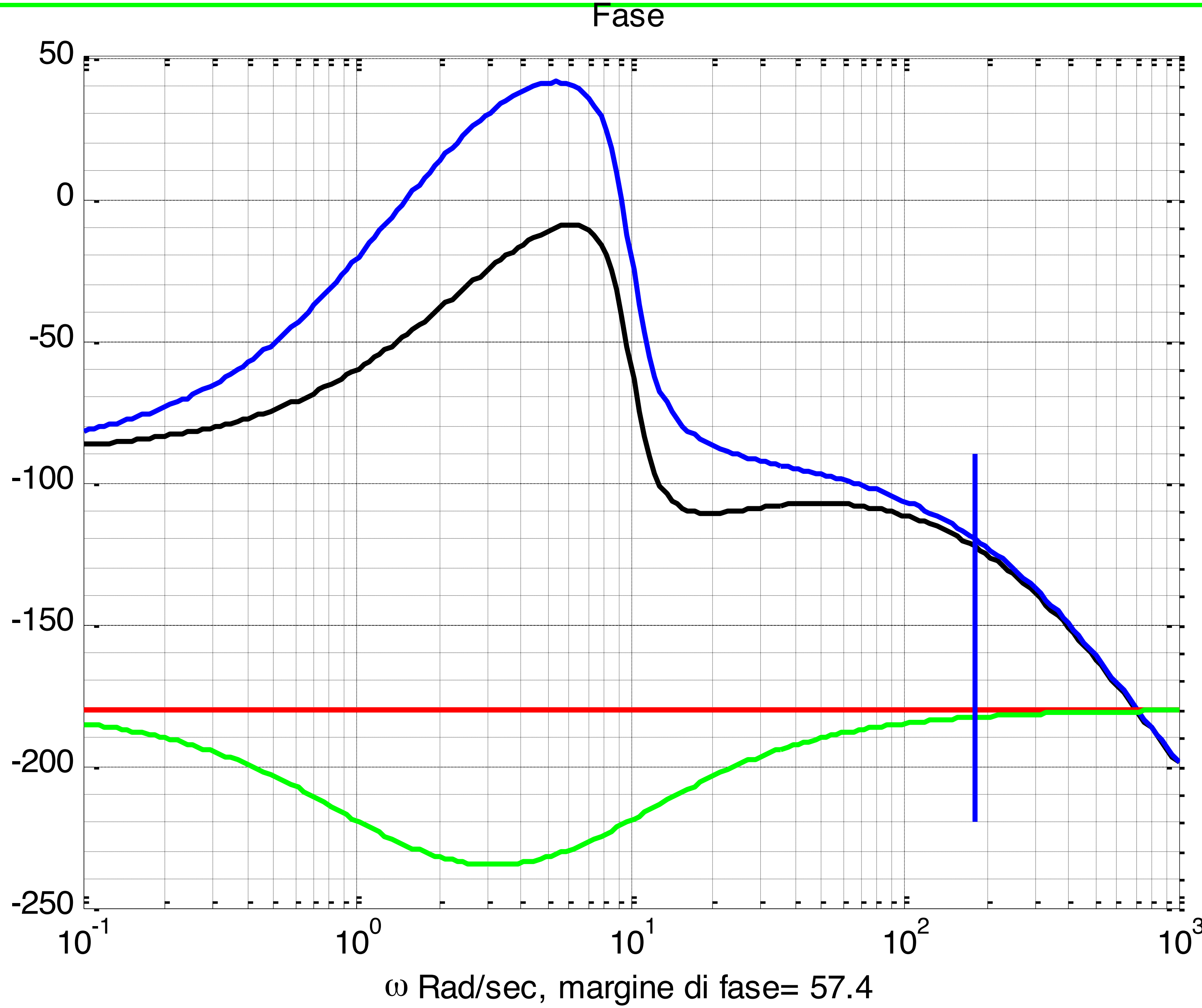
«Buona» Soluzione

```
%Attenuatrice
m=10;tau=1;
```

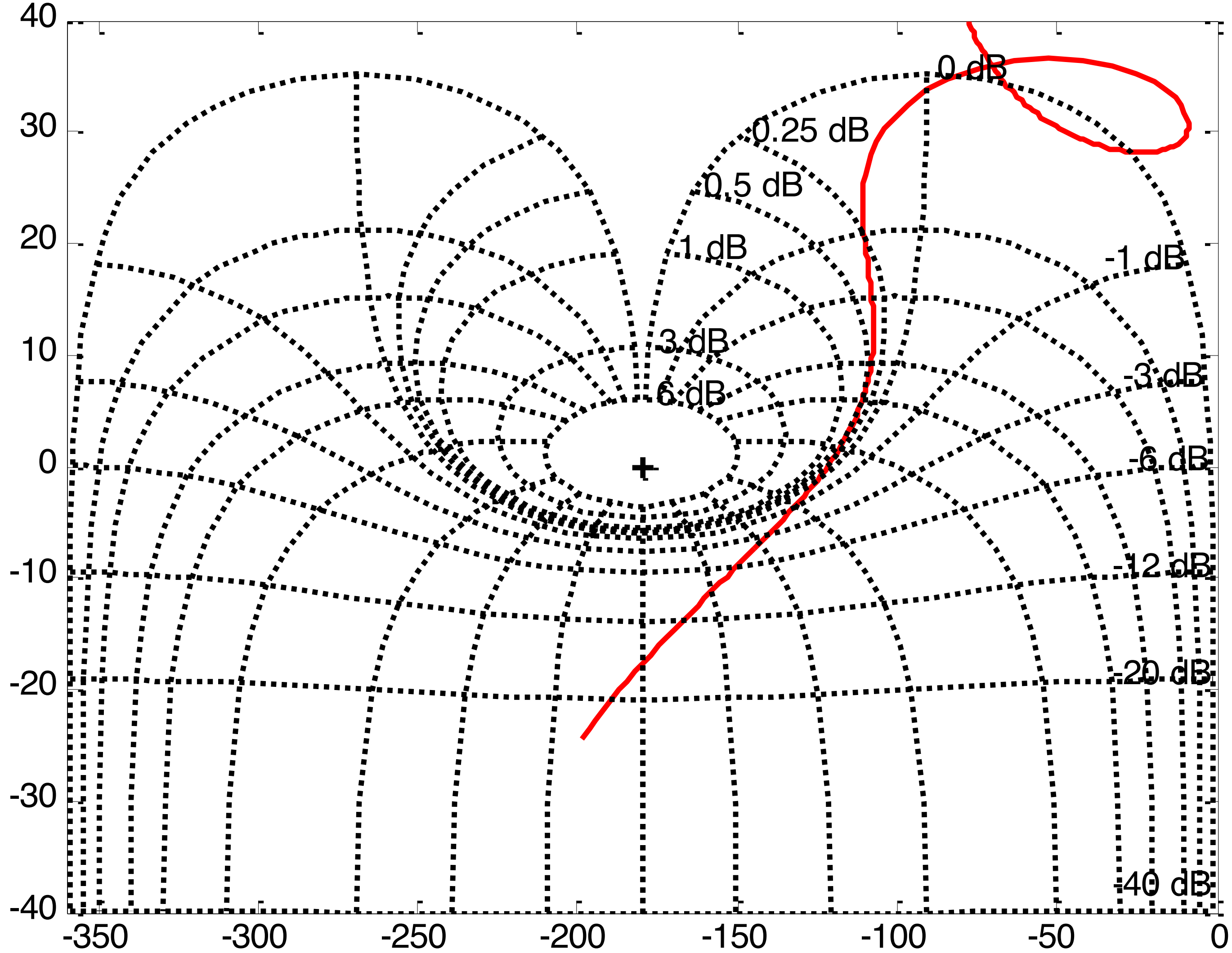
Funzione Corretta - Modulo



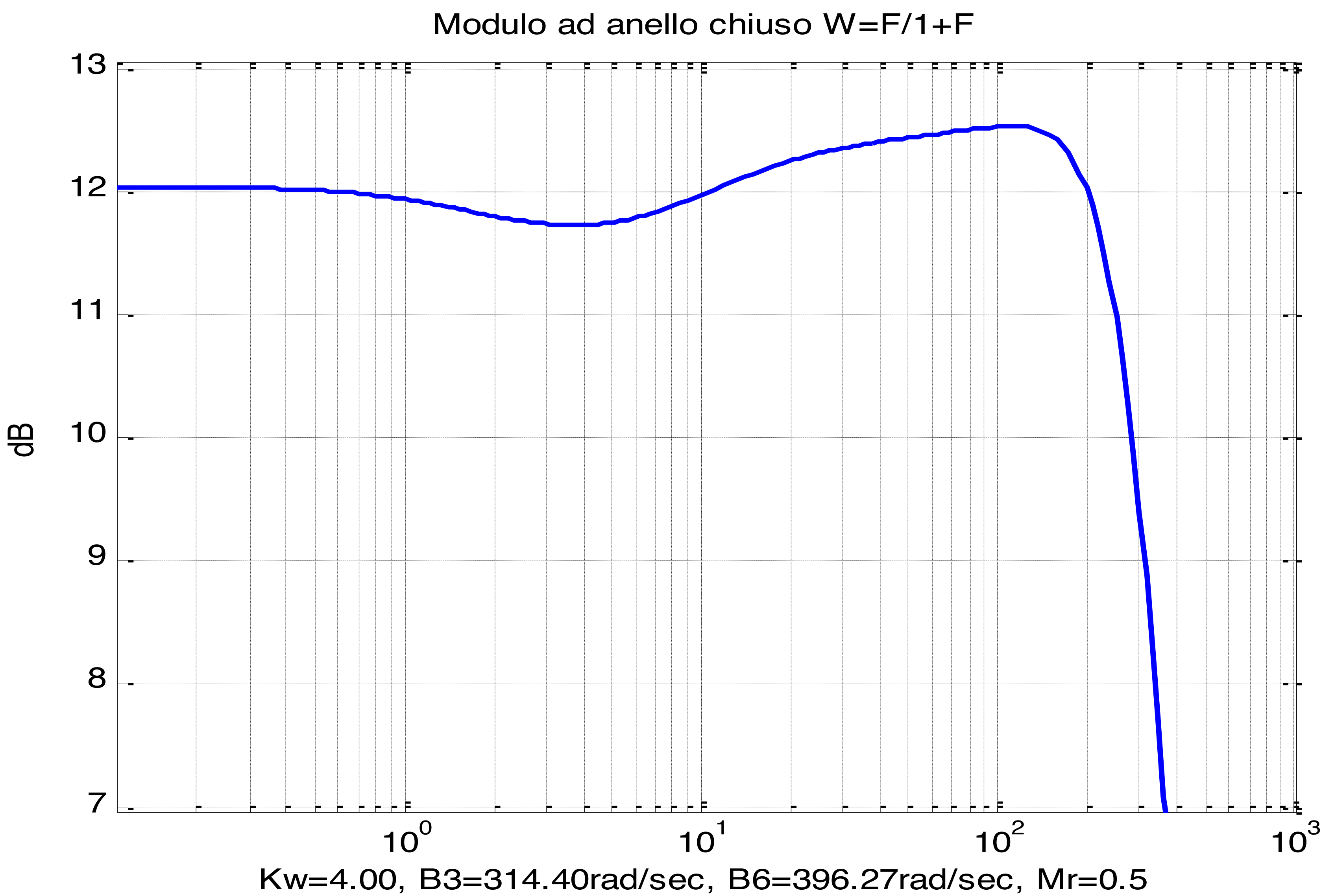
Funzione Corretta - fase



Funzione Corretta - Nichols



Funzione Corretta - Ciclo chiuso



Funzione Corretta – Risposta al gradino