SCHEMAS AND NOTES ON MOTION CONTROL

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Motor Dynamics

electric balance (armature)

$$V_a = (R_a + sL_a)I_a + V_g$$
$$V_g = k_v \Omega,$$

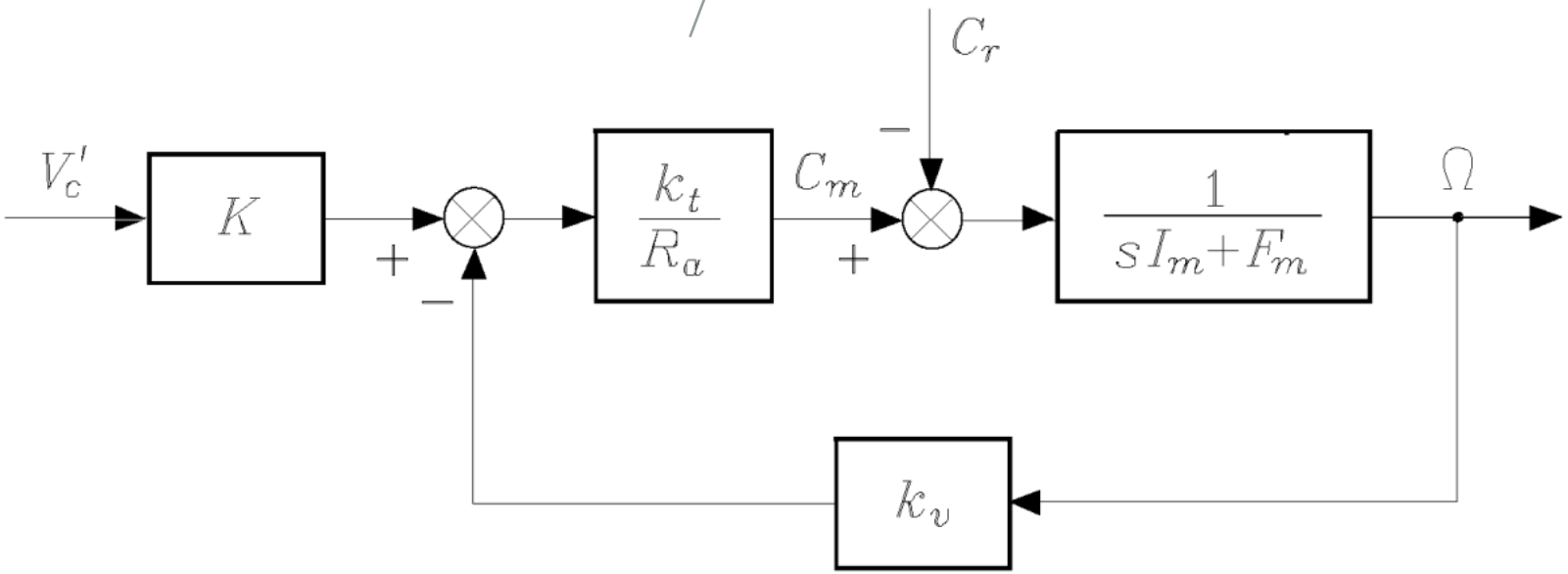
mechanics

$$C_m = (sI_m + F_m)\Omega + C_r$$
$$C_m = k_t I_a,$$

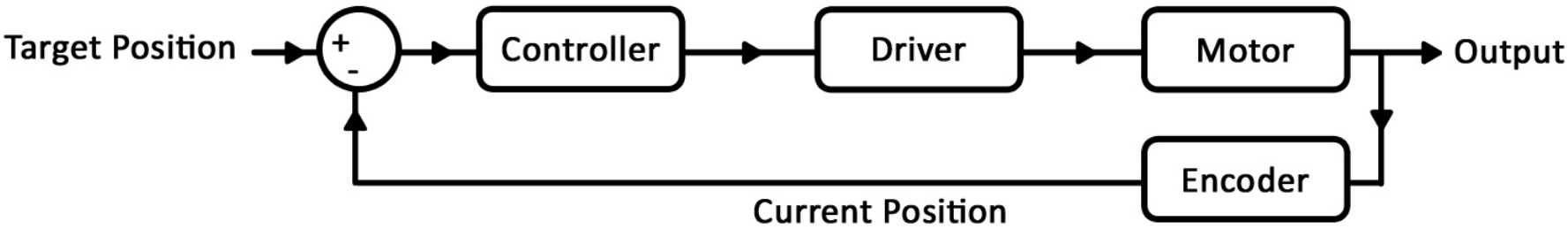
Motor Dynamics

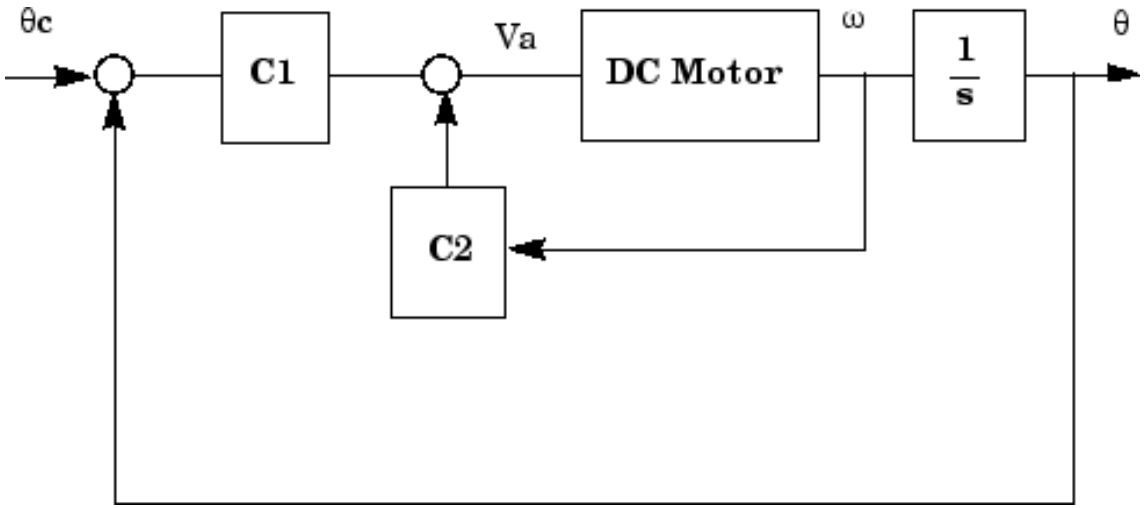
Voltage control

Oversimplification:
the electric dynamics is missing!



Position Control





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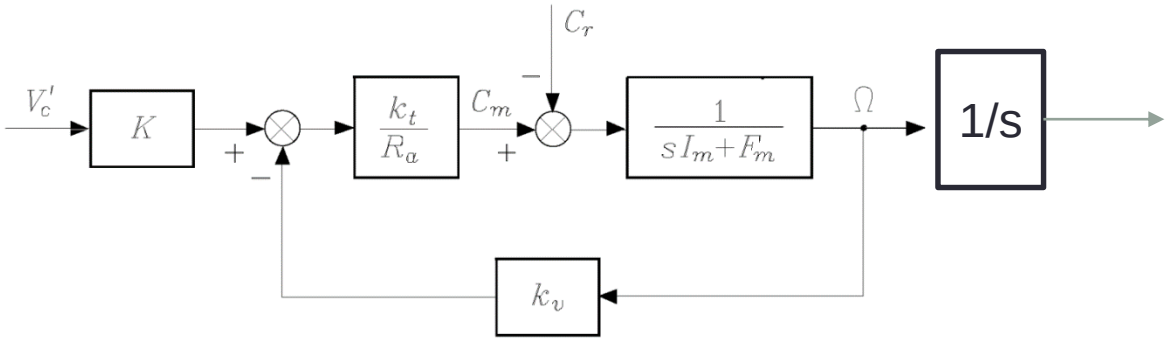

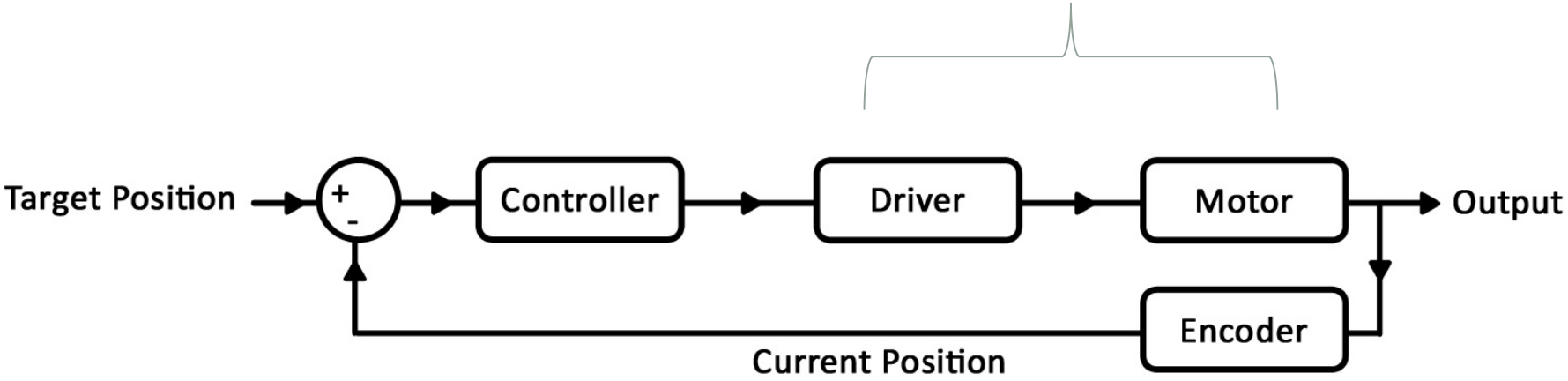

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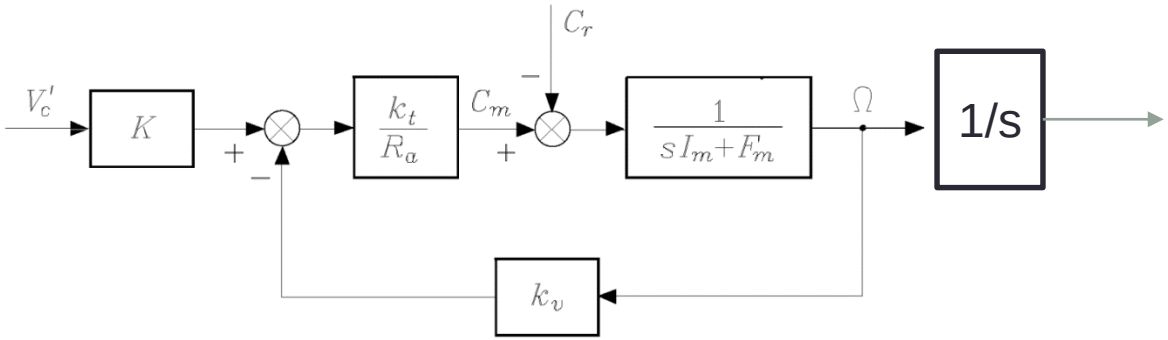
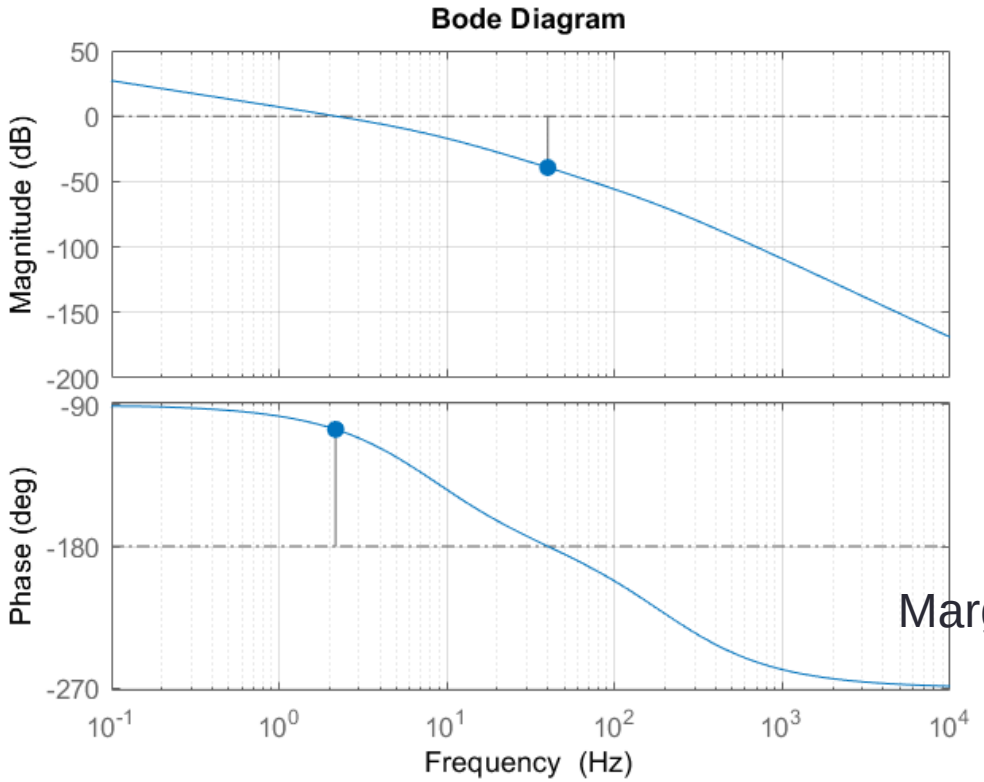




EC 90 flat Ø90 mm, senza spazzole, 90 Watt, con sensori Hall
Codice articolo 323772

Margine di fase con C(s) = 1!

Example

EC 90 flat Ø90 mm, senza spazzole, 90 Watt, con sensori Hall
Codice articolo 323772

Tensione nominale	24 V
Velocità a vuoto	3190 rpm
Corrente a vuoto	538 mA
Velocità nominale	2590 rpm
Coppia nominale (coppia max. continuativa)	444 mNm
Corrente nominale (corrente max. continuativa)	6.06 A
Coppia di stallo	4940 mNm
Corrente di avvio	70 A
Efficienza max.	83 %

Example

EC 90 flat Ø90 mm, senza spazzole, 90 Watt, con sensori Hall
Codice articolo 323772

Resistenza ai terminali	0.343 Ω
Induttanza ai terminali	0.264 mH
Costante di coppia	70.5 mNm/A
Costante di velocità	135 rpm/V
Gradiente velocità/coppia	0.659 rpm/mNm
Costante di tempo meccanica	21.1 ms
Inerzia del rotore	3060 gcm²

Do we miss something?
The transmission ratio! Let us consider 1:50

Example

I parametri vanno espressi in unità SI. Esempio:

- Momento inerzia motore
  $I_m = 3060\ gcm^2 = 0.0003\ kgm^2$
- Attrito viscoso: $F_m = 0.00001 \frac{Nms^2}{rad}$

- Momento inerzia riflessa motore $k_r = 50$
  $I_m = 0.0003\ kgm^2 * k_r^2 = 0.75\ kgm^2$
- Attrito viscoso riflesso: $F_m = 0.00001 \frac{Nms^2}{rad} * k_r^2 = 0.025 \frac{Nms^2}{rad}$

Position Control

```
Kt = 0.0705;
Im = 0.0003;
Itot = Im
Fm = 0.00001;

Kv = 1/(2*pi*135/60);
Ra = 0.343;
La = 0.000264;

s = tf([1 0],1);

fw_path = Kt / ((s*La + Ra) * (s*Im + Fm));

zpk(fw_path)
fb_path = Kv;
sys = feedback(fw_path,fb_path) * (1/s);

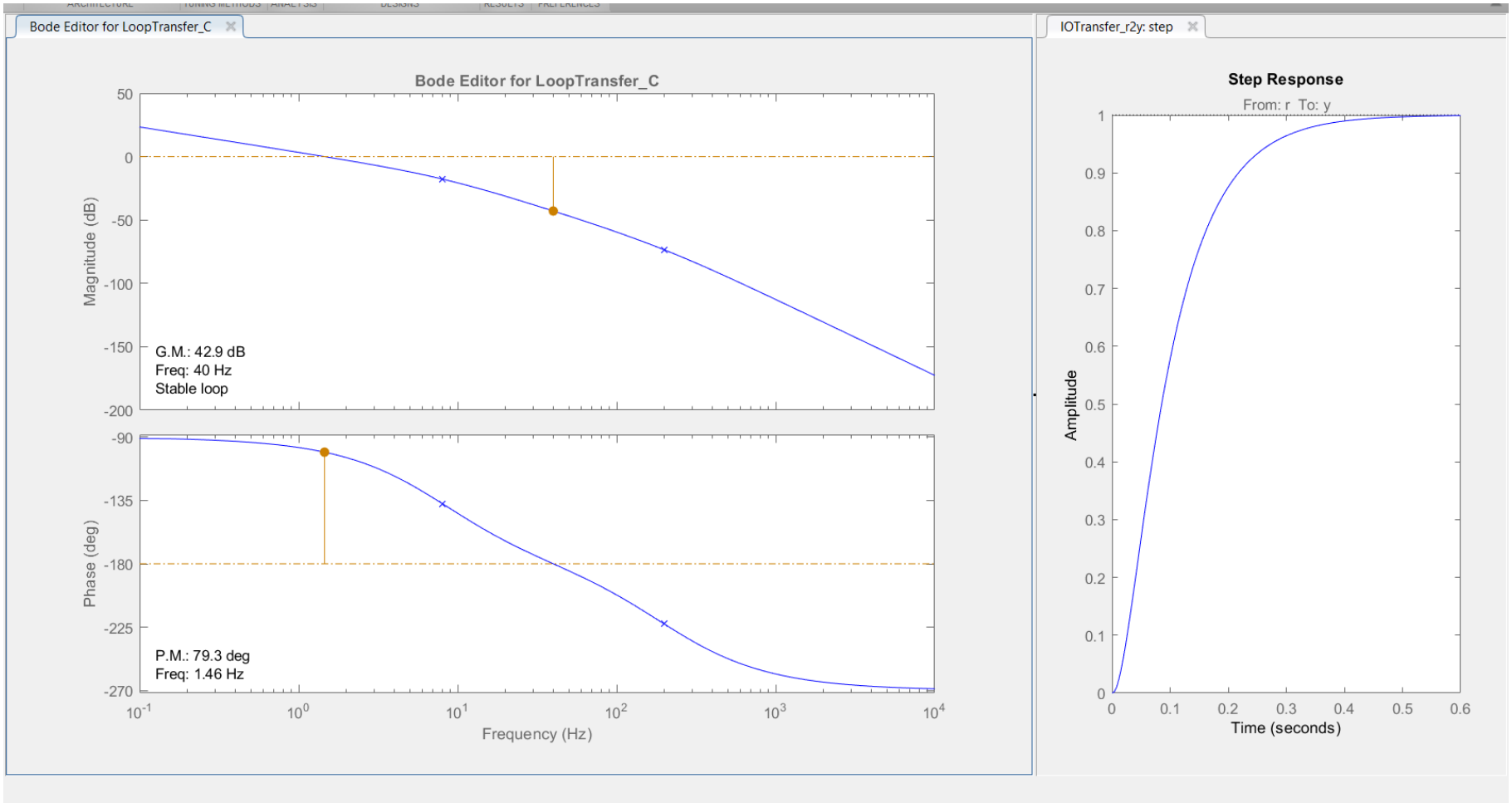
set(cstprefs.tbxprefs,'FrequencyUnits','Hz')

bode(sys)
grid on
```

Matlab code to draw the above Bode plot

Position Control with SISOTool

```
>> sisotool(sys)
Proportional Control:
```



Position Control with SISOTool

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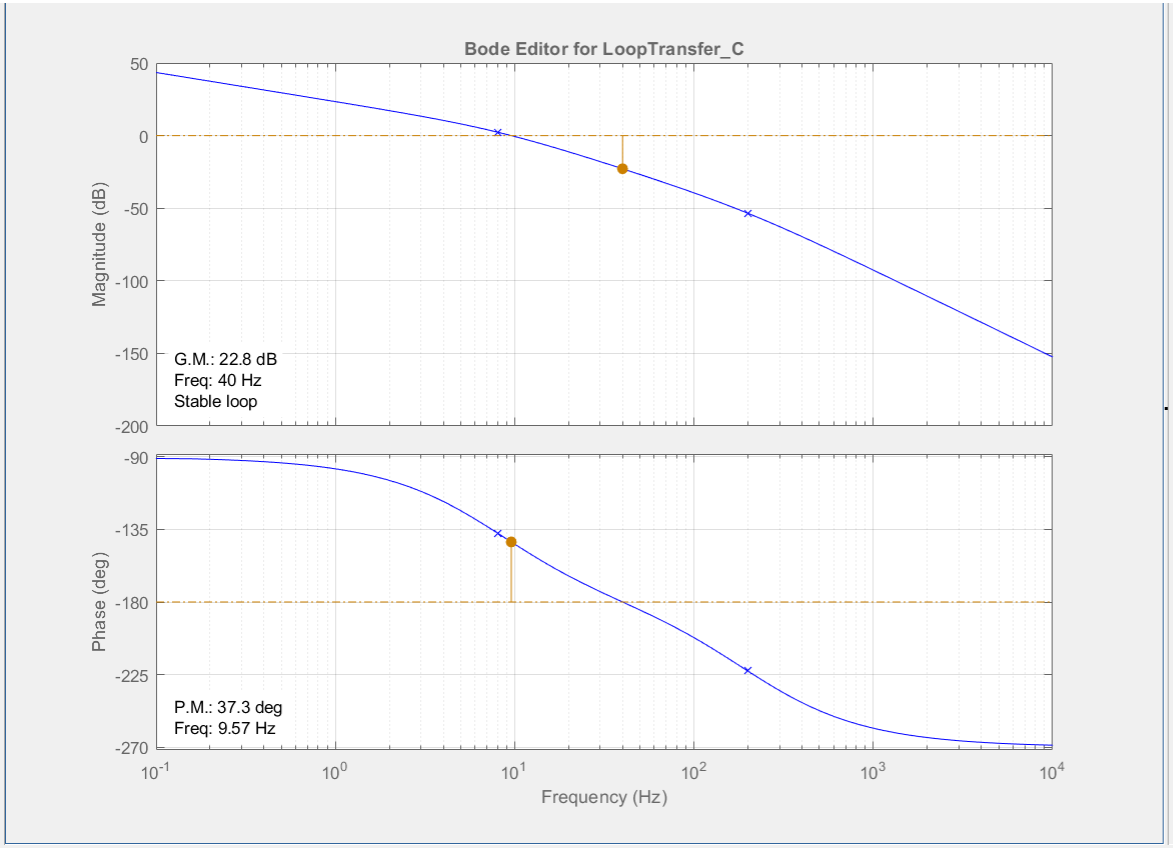

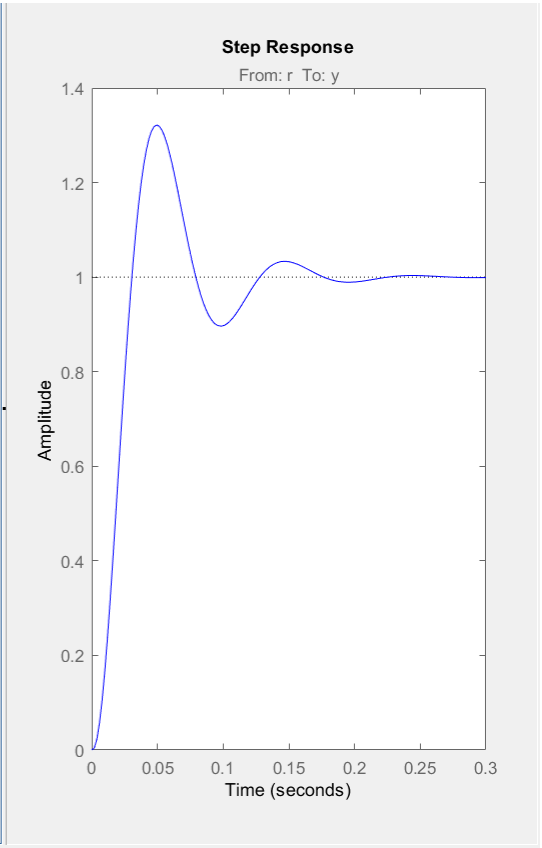

Position Control with SISOTool

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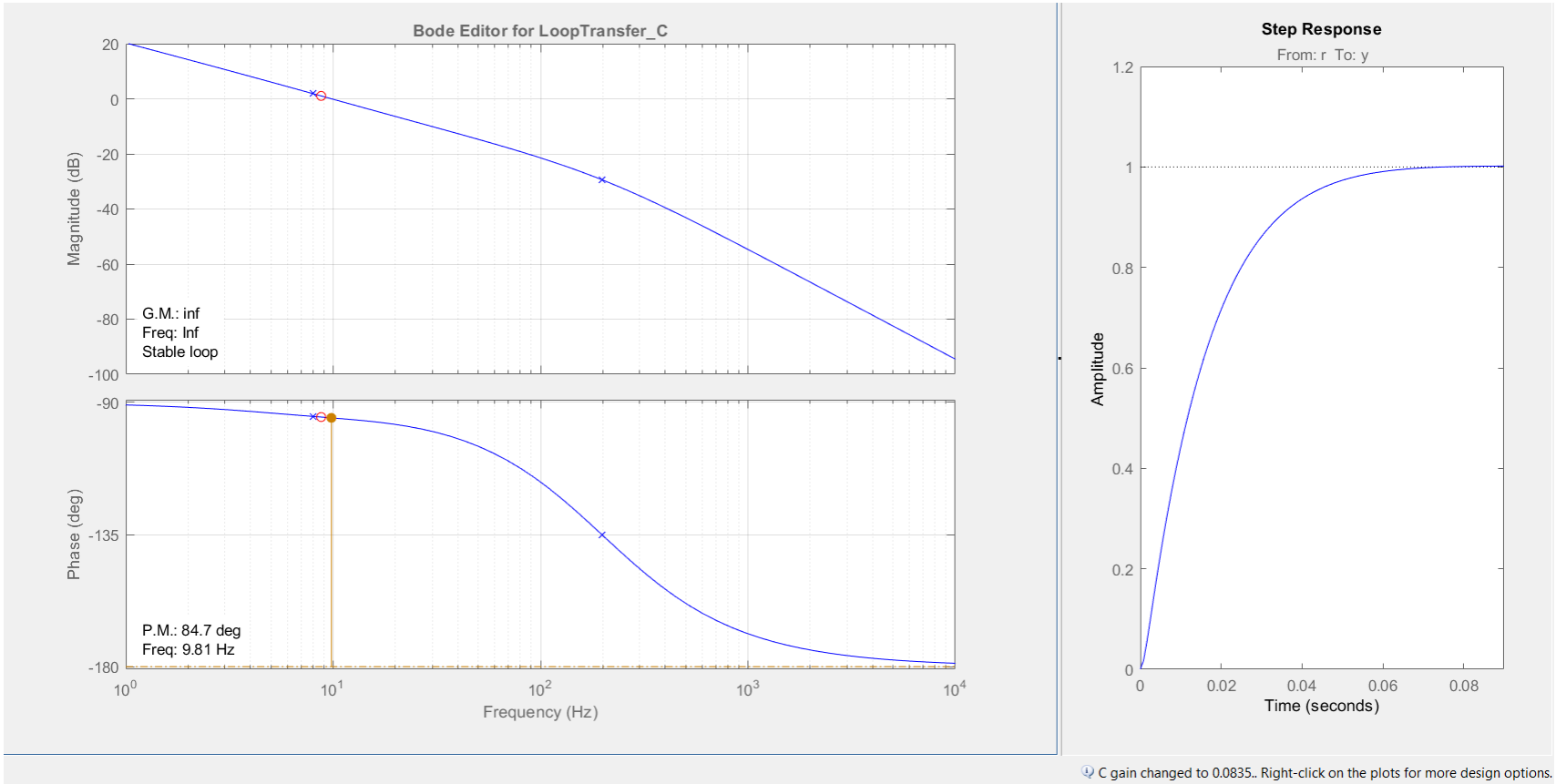
>> sisotool(sys)
Proportional-Derivative Control:
```



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Proportional-Derivative Control:
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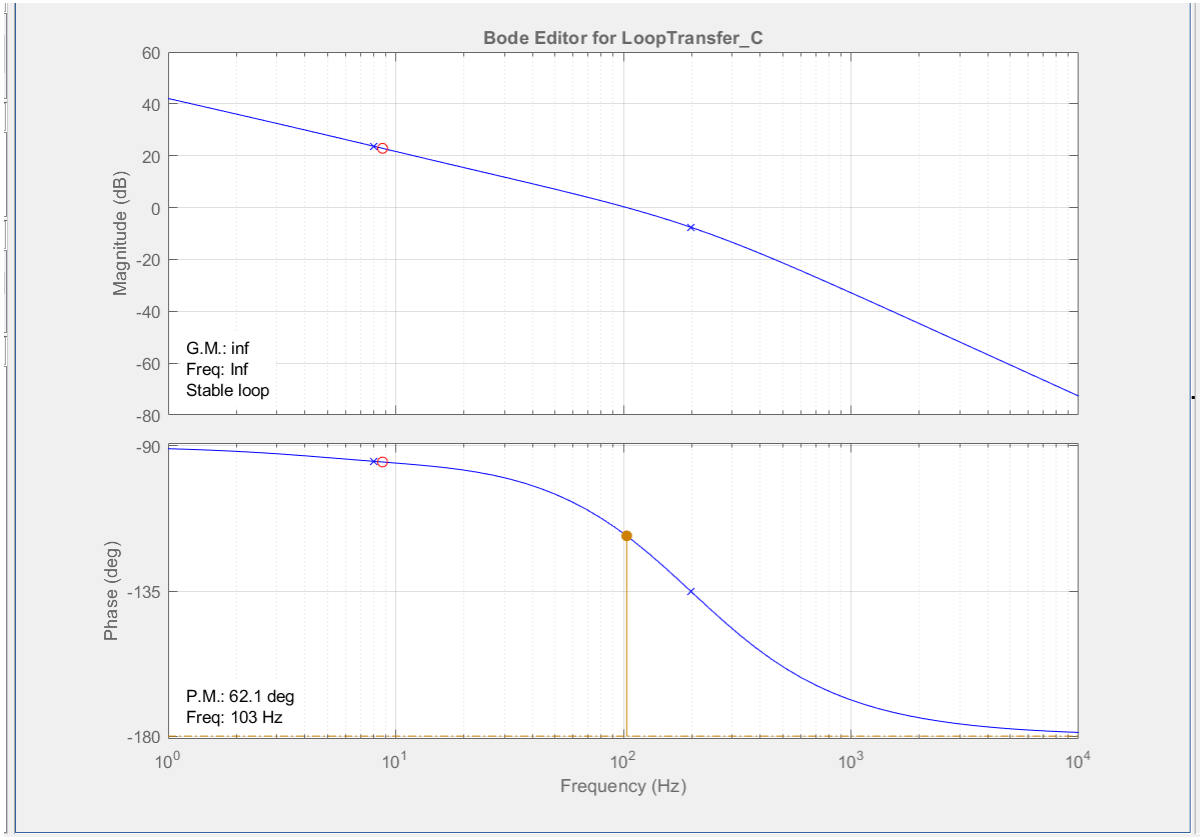
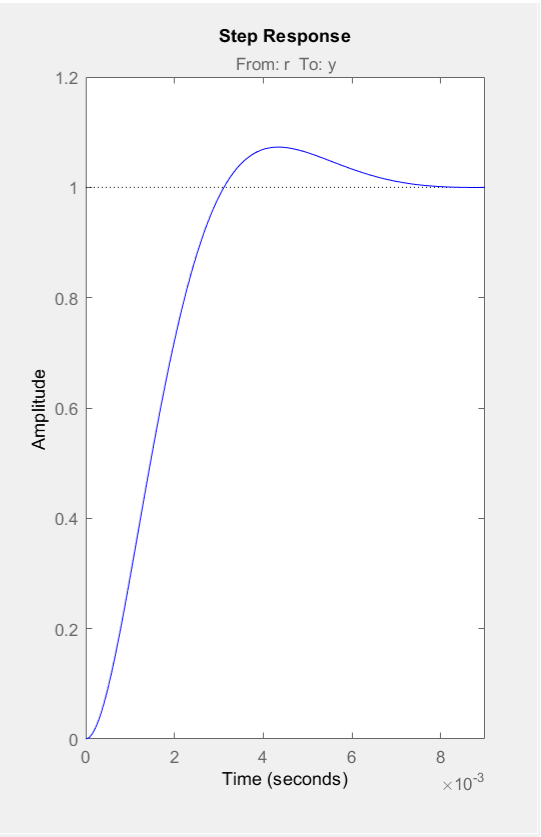
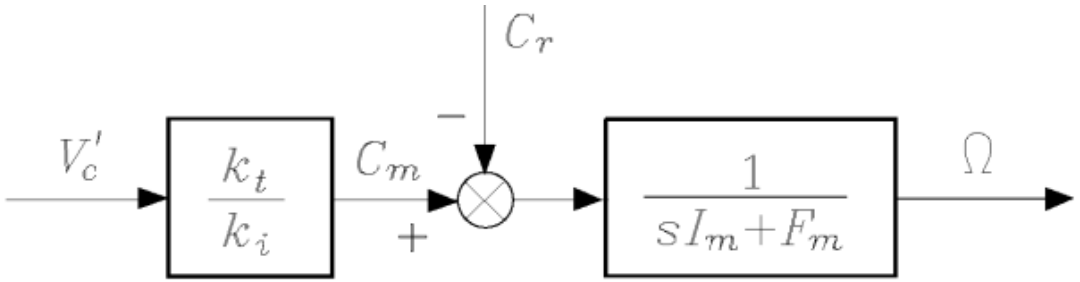
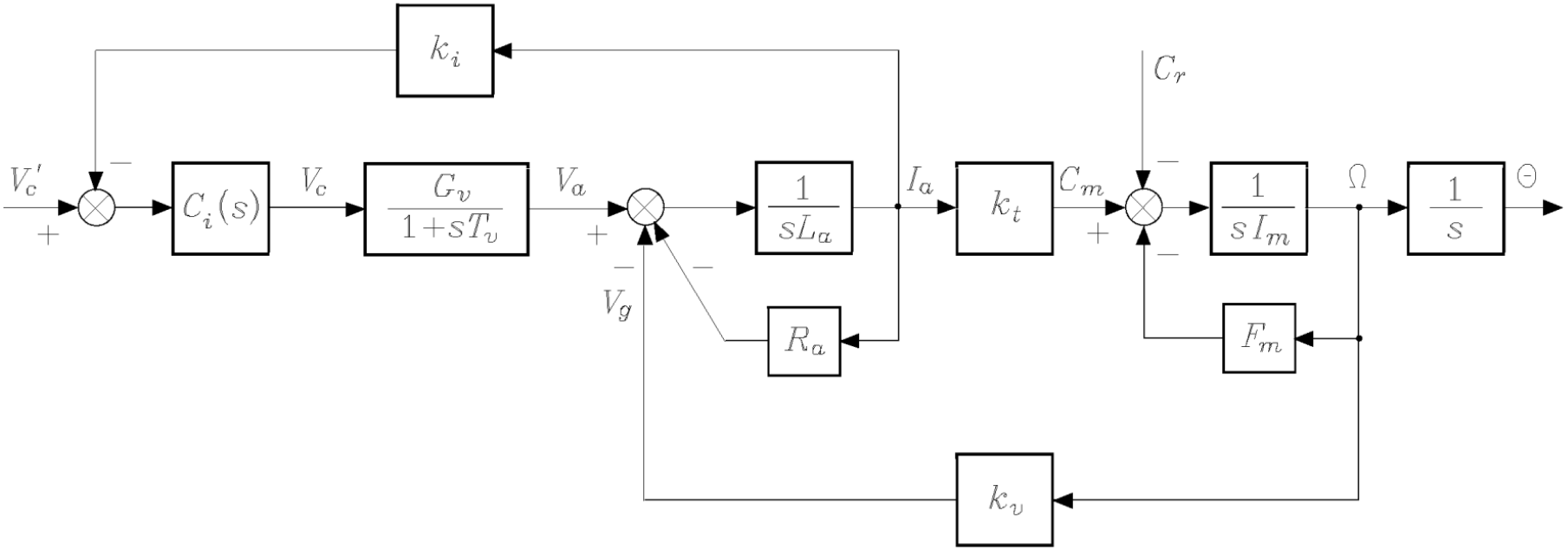




Motor Dynamics

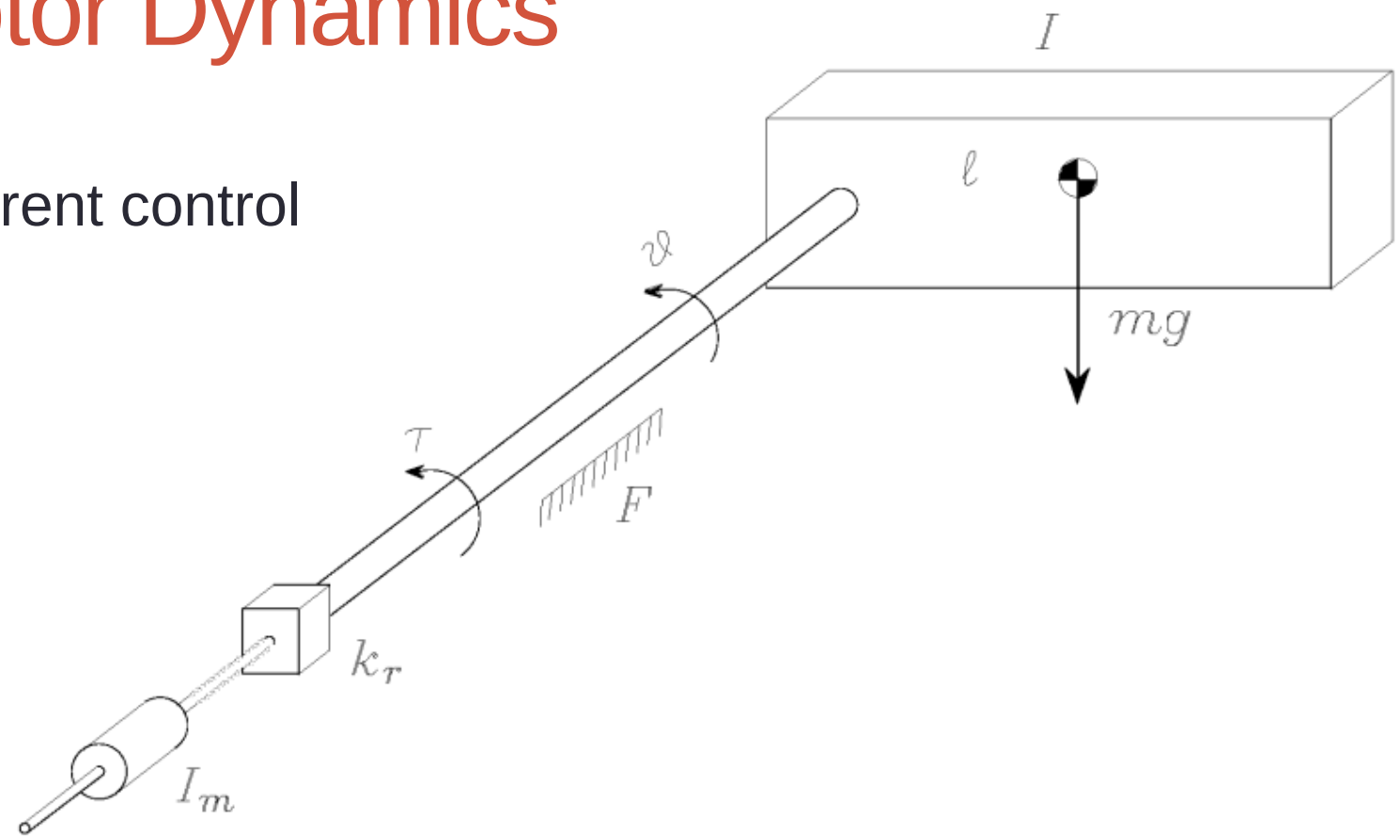
Current control





Motor Dynamics

Current control



$$(I + I_m k_r^2)\ddot{\vartheta} + F\dot{\vartheta} + mg\ell \sin\vartheta = \tau$$