

Practice 2

Mathematical model of electromechanical device

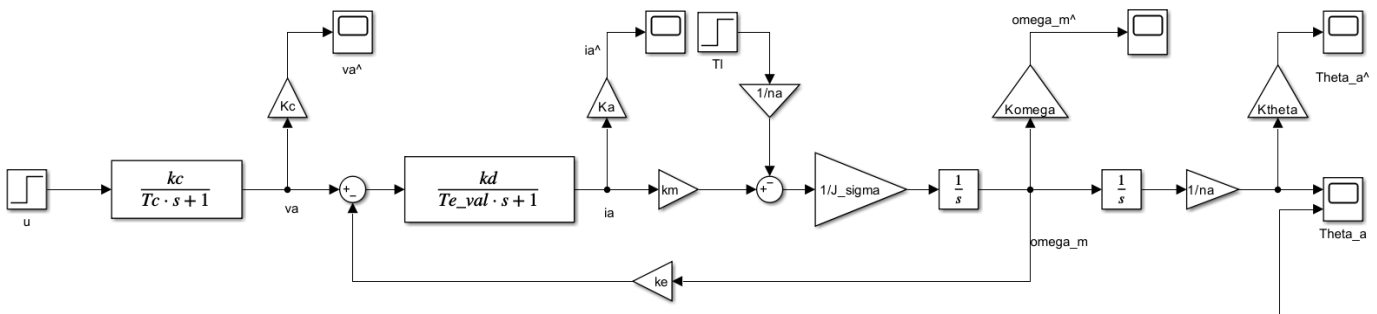
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Variant : 2

k	$U_{nom},$ [V]	$n_0,$ [rpm]	$I_{nom},$ [A]	$\tau_{nom},$ [N · m]	$R_a,$ [Ohm]	$T_e,$ [ms]	$J_m,$ [kg · m ²]	$T_c,$ [ms]	n_a	$J_a,$ [kg · m ²]
2	36	4000	6.5	0.57	0.85	3	$2.2 \cdot 10^{-4}$	6	40	0.15



1. calculate all parameters of full EMD model and its simplified version.

【基本参数】

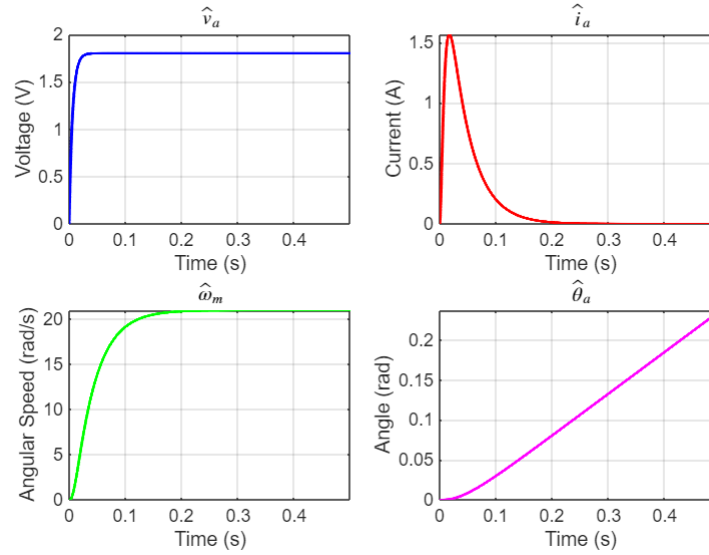
额定电压 U_{nom}	=	36.0 V
空载转速 n_0	=	4000 rpm
额定电流 I_{nom}	=	6.50 A
额定扭矩 τ_{nom}	=	0.57 N·m
电枢电阻 R_a	=	0.85 Ohm
电时间常数 T_e	=	0.003 s
电机惯量 J_m	=	0.0002 kg·m ²
功率转换器时间常数 T_c	=	0.006 s
变速箱传动比 n_a	=	40
执行器惯量 J_a	=	0.15 kg·m ²

【衍生参数】

空载角速度 ω_0	=	418.88 rad/s
反电动势系数 k_e	=	0.0859 V·s/rad
扭矩常数 k_m	=	0.0877 N·m/A
变速箱惯量 J_{gb}	=	0.0000 kg·m ²
总转动惯量 J_Σ	=	0.000358 kg·m ²

2. plot the transient processes with $\tau_L = 0$ [N· m] and $u = 5$ [V].

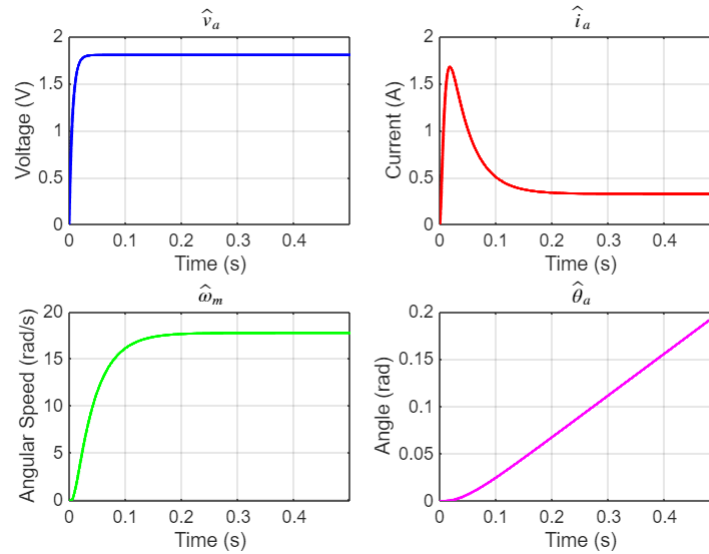
Transient Processes of EMD Model ($u = 5\text{V}$, $\tau_L = 0$)



3. Plot the graphs for different values of TI – from 0 to $n_a \cdot \tau_{\text{nom}}$.

TI = 11.399:

Transient Processes of EMD Model ($u = 5\text{V}$, $\tau_L = 11.399\text{ Nm}$)



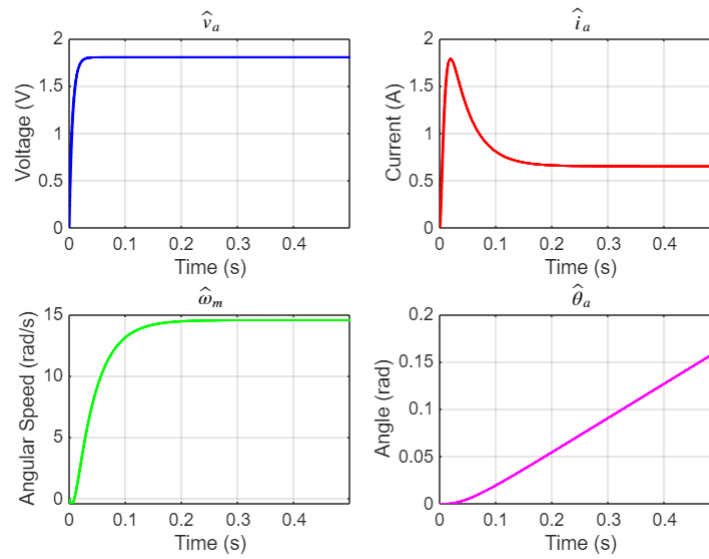
settling time : 0.25s

steady-state values of angular speed : 17.71 rad/s

and armature current: 0.3281 A

TI = 22.799:

Transient Processes of EMD Model ($u = 5V$, $\tau_L = 22.799 \text{ Nm}$)



settling time : 0.253s

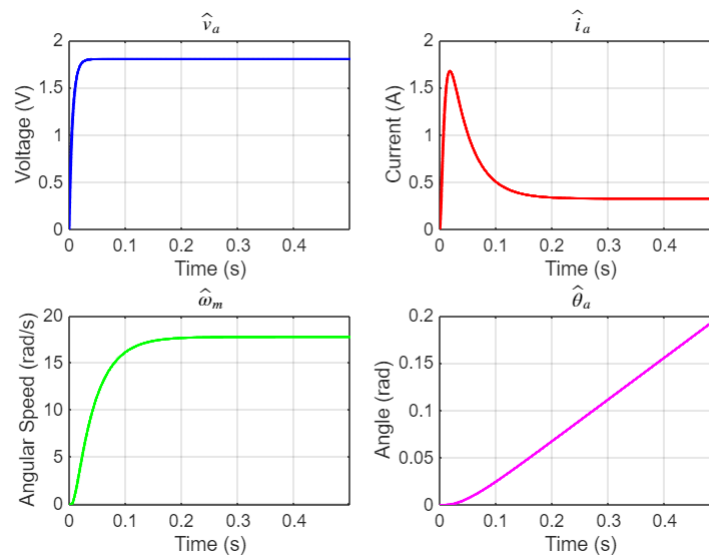
steady-state values of angular speed :14.53 rad/s

and armature current: 0.6526 A

4. Repeat task 3 for different values of J_a

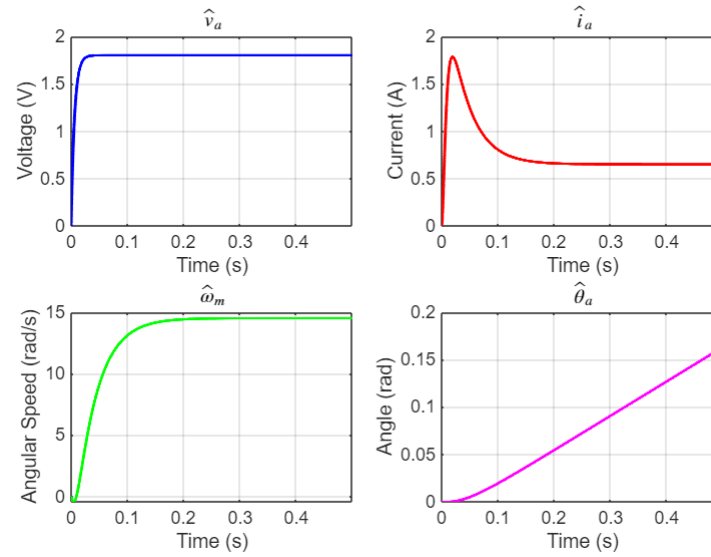
$J_a = 0.5 * J_a$, $T_L = 11.399$:

Transient Processes of EMD Model ($0.5 * J_a$, $\tau_L = 11.399 \text{ Nm}$)



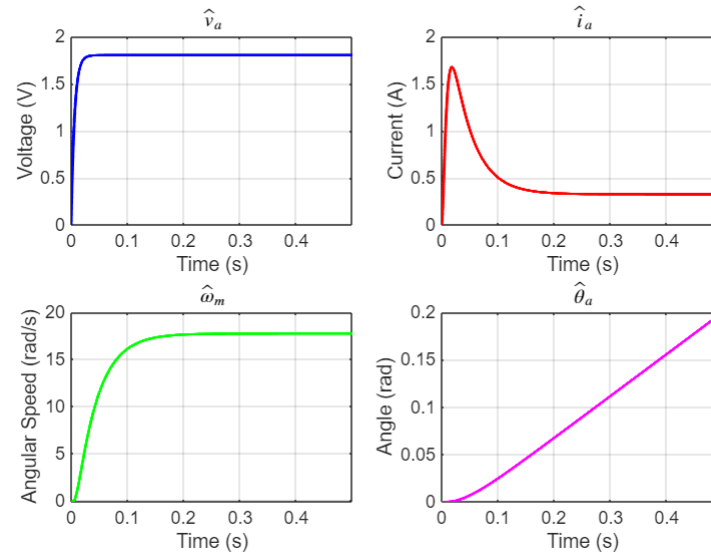
$J_a = 0.5 * J_a$, $T_L = 22.799$:

Transient Processes of EMD Model ($0.5 \cdot J_a$, $\tau_L = 22.799$ Nm)



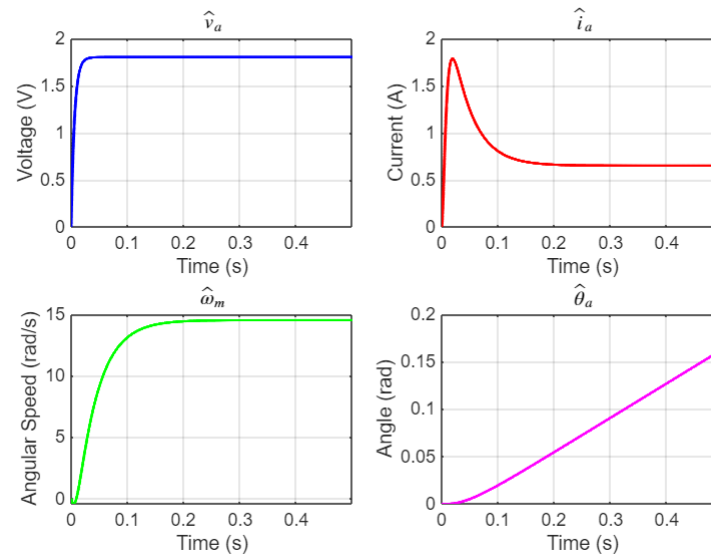
$J_a = 1.5 \cdot J_a$, $T_L = 11.399$:

Transient Processes of EMD Model ($1.5 \cdot J_a$, $\tau_L = 11.399$ Nm)



$J_a = 1.5 \cdot J_a$, $T_L = 22.799$:

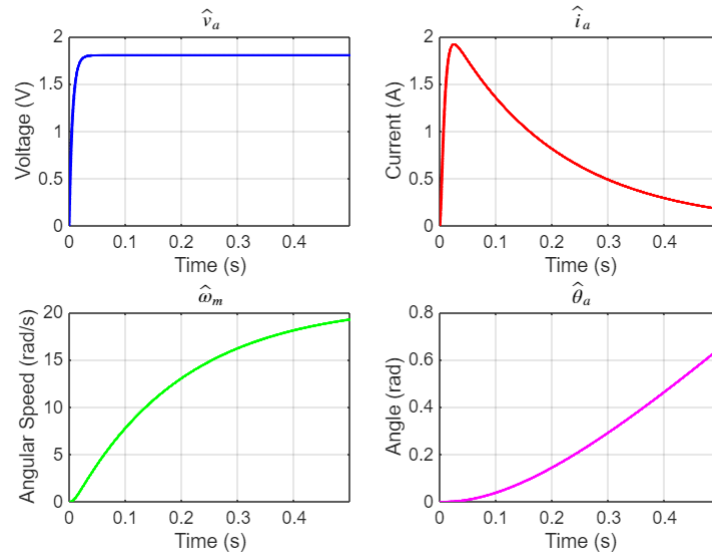
Transient Processes of EMD Model ($1.5 \cdot J_a$, $\tau_L = 22.799 \text{ Nm}$)



5. Repeat task 3 for different values of n_a

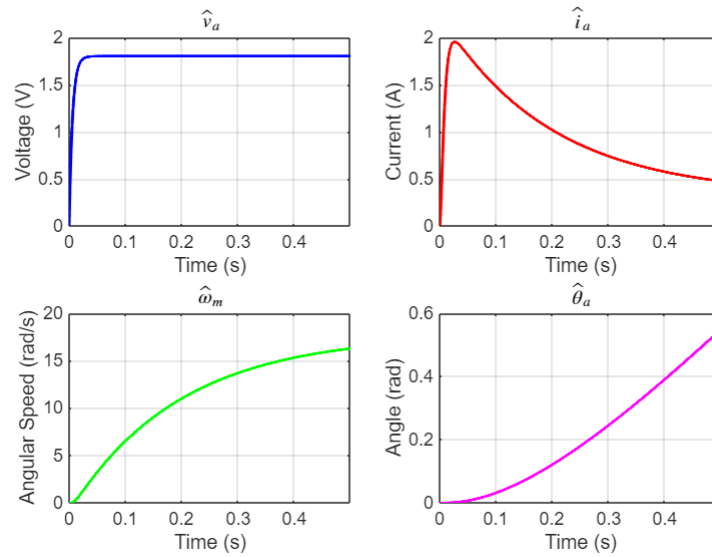
$n_a = 0.25 \cdot n_a$, $T_L = 0$:

Transient Processes of EMD Model ($0.25 \cdot n_a$, $\tau_L = 0$ Nm)



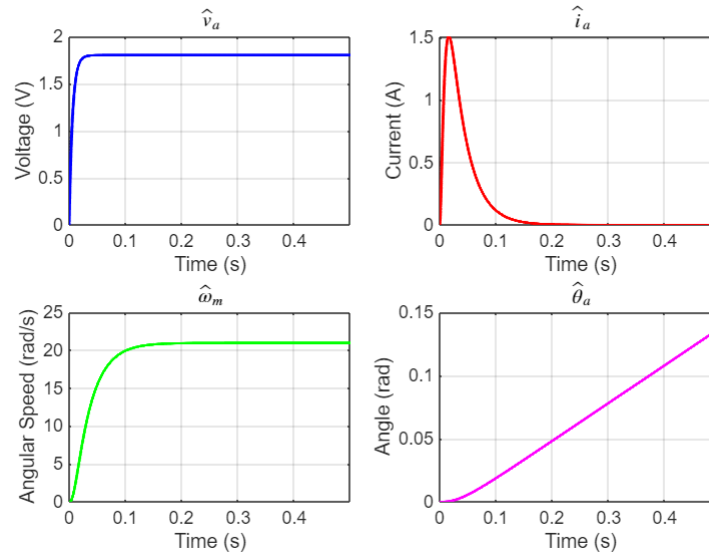
$n_a = 0.25 \cdot n_a$, $T_L = n_a \cdot \tau_{nom}/2$:

Transient Processes of EMD Model ($n_a = 0.25 \cdot n_a$, $\tau_L = n_a \cdot \tau_{nom}/2$)



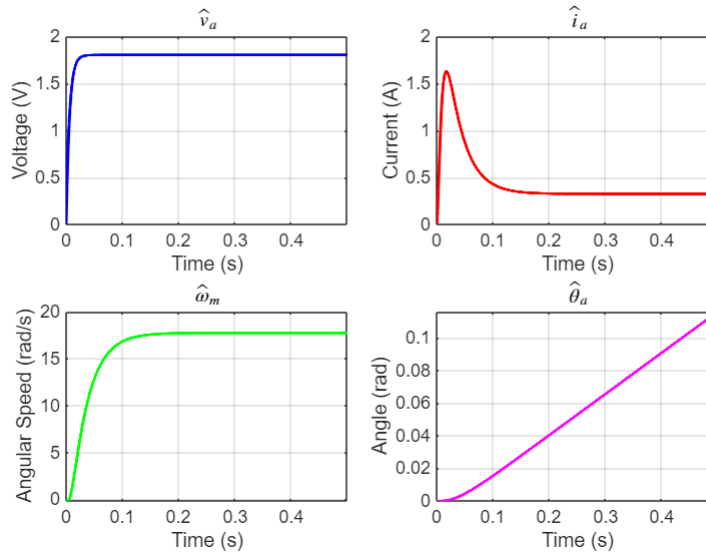
$n_a = 1.75 \cdot n_a$, $T_L = 0$:

Transient Processes of EMD Model ($1.75 \cdot n_a$, $\tau_L = 0$ Nm)



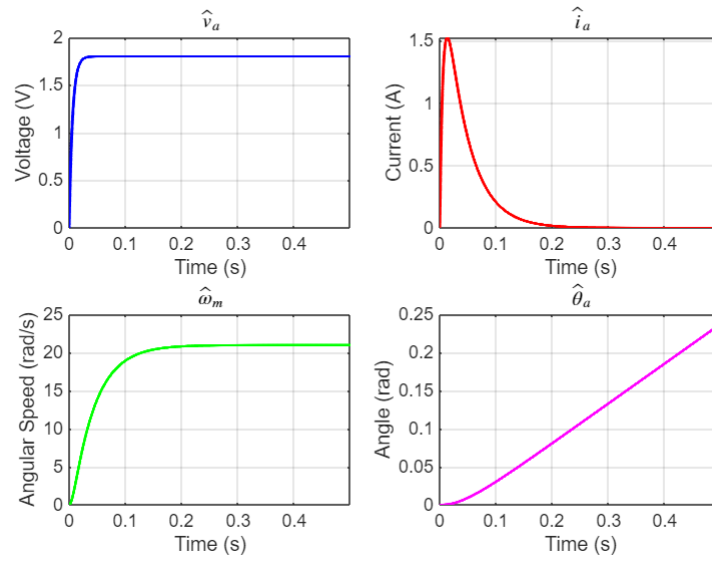
$n_a = 1.75 \cdot n_a$, $T_L = n_a \cdot \tau_{nom}/2$:

Transient Processes of EMD Model ($1.75 \cdot n_a$, $\tau_L = n_a \cdot \tau_{nom}/2$)

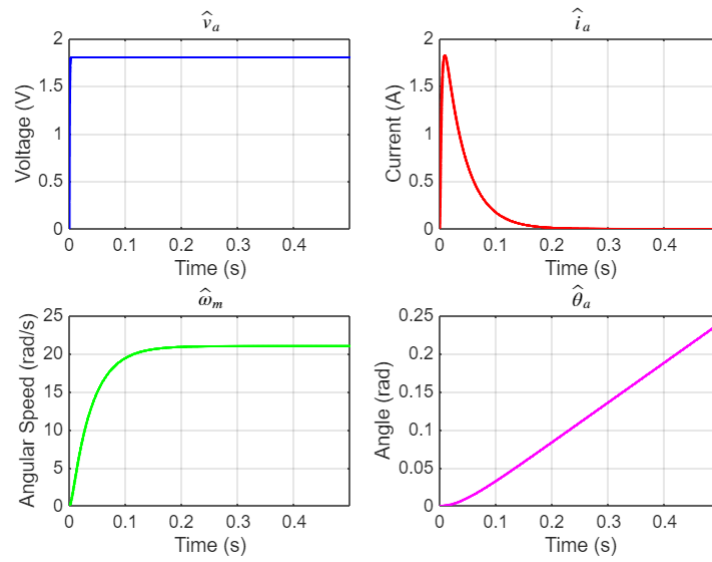


6. Obtain transient processes for values of T_c , T_e one order lower:

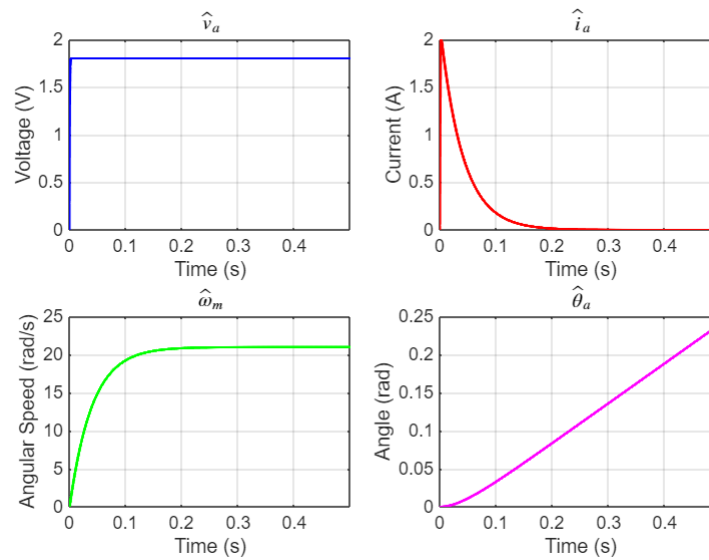
Transient Processes of EMD Model ($0.1 \cdot T_e$)



Transient Processes of EMD Model ($0.1 \cdot T_c$)



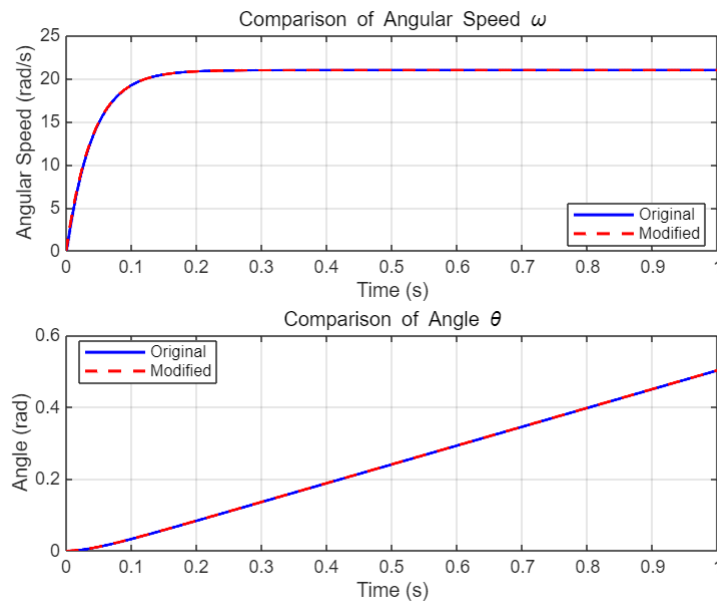
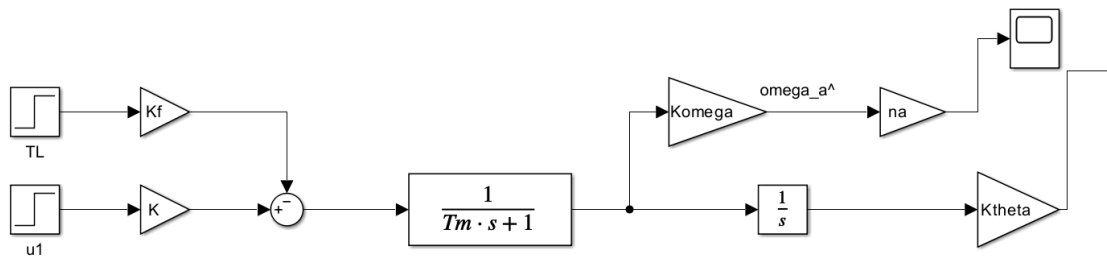
Transient Processes of EMD Model ($0.1 \cdot T_c$ & $0.1 \cdot T_e$)



Comment:

I can see that the time variation of the transient is not very large, but the magnitude does change

7. Simplified EMD model



Comment:

I can see that The angular velocity and angular images of the two models coincide almost perfectly.

状态空间表示

完整模型状态空间表示：

A 矩阵：

-333.3333	-33.7034	0	392.1569
245.1218	0	0	0
0	0.0250	0	0
0	0	0	-166.6667

B 矩阵：

0
0
0
600

C 矩阵：

0.1000	0	0	0
0	0.1000	0	0
0	0	0.1000	0
0	0	0	0.1000

D 矩阵：

0
0
0
0

简化模型状态空间表示：

A 矩阵：

-24.7843

B 矩阵：

25.9541	-1.7470
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C 矩阵：

0.1000
2.4784

D 矩阵：

0	0
0	0

Conclusion:

In this experiment, the full and simplified models of the Electromechanical Drive (EMD) system were analyzed under various conditions. The key findings are summarized as follows:

1. Parameter Calculation: Both full and simplified EMD models were analyzed, with derived parameters like k_e and k_m computed.
2. Transient Processes:
 - No load ($T_L=0$) at 5 V input yielded smooth dynamics.
 - Varying T_L (0 to $n \cdot \tau_{nom}$) kept settling time (~ 0.25 s) stable, while steady-state speed and current scaled with load.
3. Inertia (J_a): Halving J_a sped up response; increasing it by 50% slowed it—steady-state values stayed consistent.
4. Gear Ratio (n): Lower n improved response speed; higher n increased load effects and slowed dynamics.
5. Time Constants (T_c , T_e): Reducing them by an order changed response magnitude but not duration, highlighting their damping role.
6. Simplified Model: Matched the full model in angular velocity and current, proving useful for reduced-order analysis.

Both models effectively describe EMD behavior, with the simplified version offering a practical trade-off between accuracy and complexity.