

Simulations in Mechatronic Design				
Title of exercise	Ex. 3 – Modelling a mechanical system with flexible elements			
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Group	1	No. of points		
Academic year	2023/2024		Σ	/7

Catalogue number of the motor: 17N78
Value of the electromechanical time constant of the motor: $8 * 10^{-3}s$
Clutch activation time : $24.7 * 10^{-3}s$

1. Angular position of the motor rotor and load - a set of mathematical dependencies transformed into a form $\varphi_1=...$ and $\varphi_2=...$
<div></div>

$$J_s \ddot{\varphi}_1 = M_e - M_F - c(\varphi_1 - \varphi_2) - b(\dot{\varphi}_1 - \dot{\varphi}_2)$$

$$J_{red} \ddot{\varphi}_2 = -M_{red} + c(\varphi_1 - \varphi_2) + b(\dot{\varphi}_1 - \dot{\varphi}_2)$$

$$\varphi_1 = \iint \left(\frac{M_e - M_F - c(\varphi_1 - \varphi_2) - b(\dot{\varphi}_1 - \dot{\varphi}_2)}{J_s} \right) dx dy$$

$$\varphi_2 = \iint \left(\frac{-M_{red} + c(\varphi_1 - \varphi_2) + b(\dot{\varphi}_1 - \dot{\varphi}_2)}{J_{red}} \right) dx dy$$

$$J_{red} = 2 \cdot J_s, M_{red} = \frac{\text{Stall torque}}{2}$$

$$M_e = K_T \cdot \left(\frac{V - L \frac{d\dot{\varphi}_1}{dt} - K_e \cdot \dot{\varphi}_1}{R_T} \right)$$

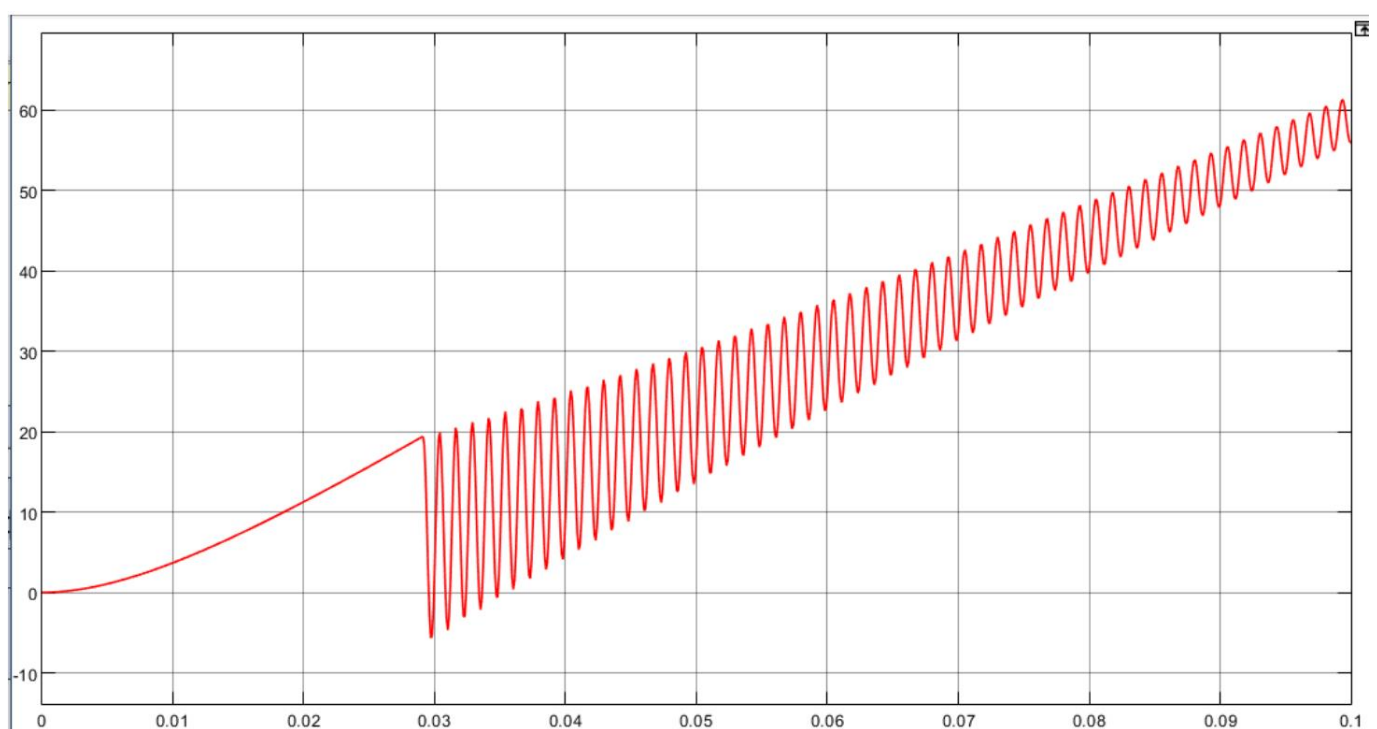
$$M_F = K_D \dot{\varphi}_1 + \text{sgn}(\dot{\varphi}_1) (K_T I_0 - K_D \omega_0)$$

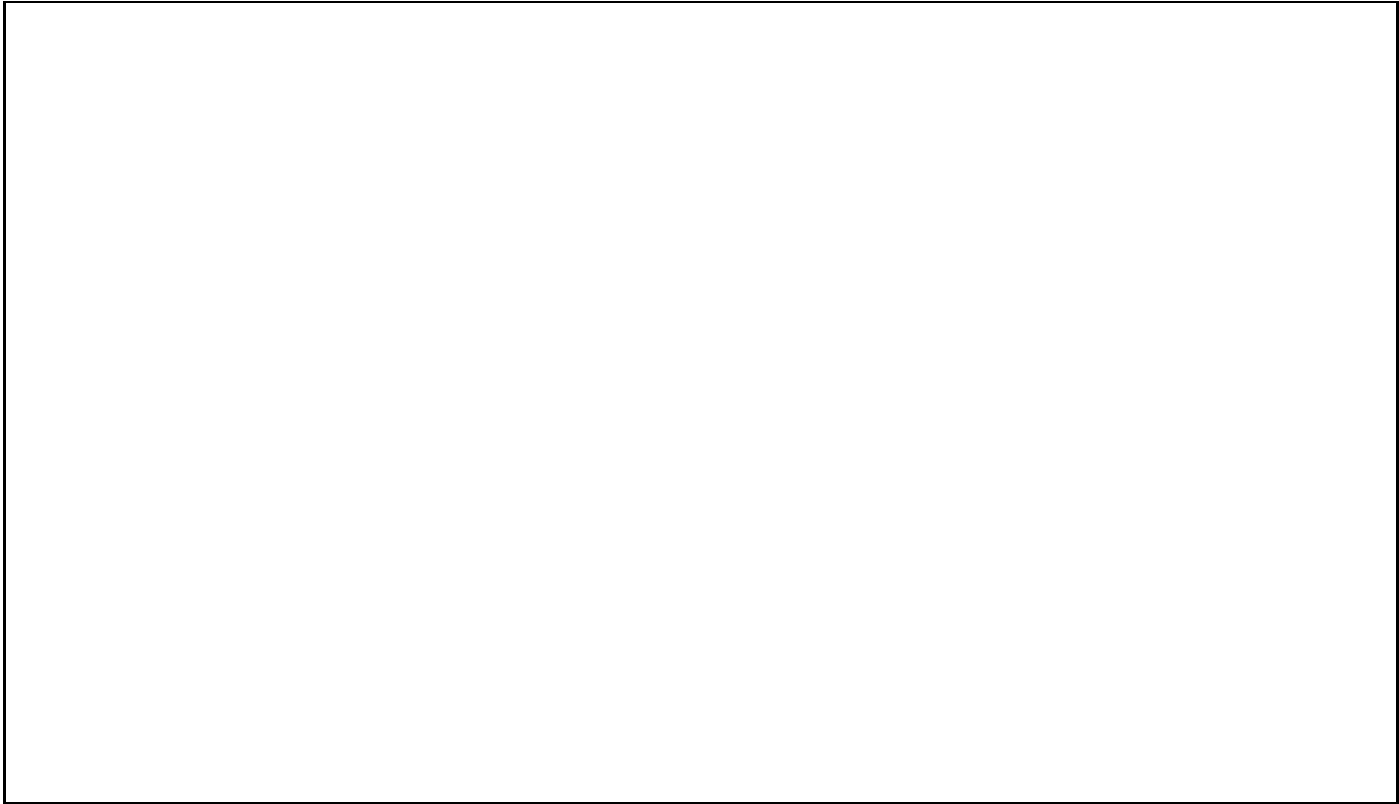
Explanation of symbols

Symbol (and value)	Name of the quantity / parameter	Unit
φ_1	The angular position of the motor rotor	rad
φ_2	The angular position of the load	rad
$M_{red} = 12(0.25) = 3$	reduced active load torque	Nmm
$J_{red} = J_s * 2 = 2.4(10^{-4})$	reduced mass moment of inertia of the driven elements	gm ²

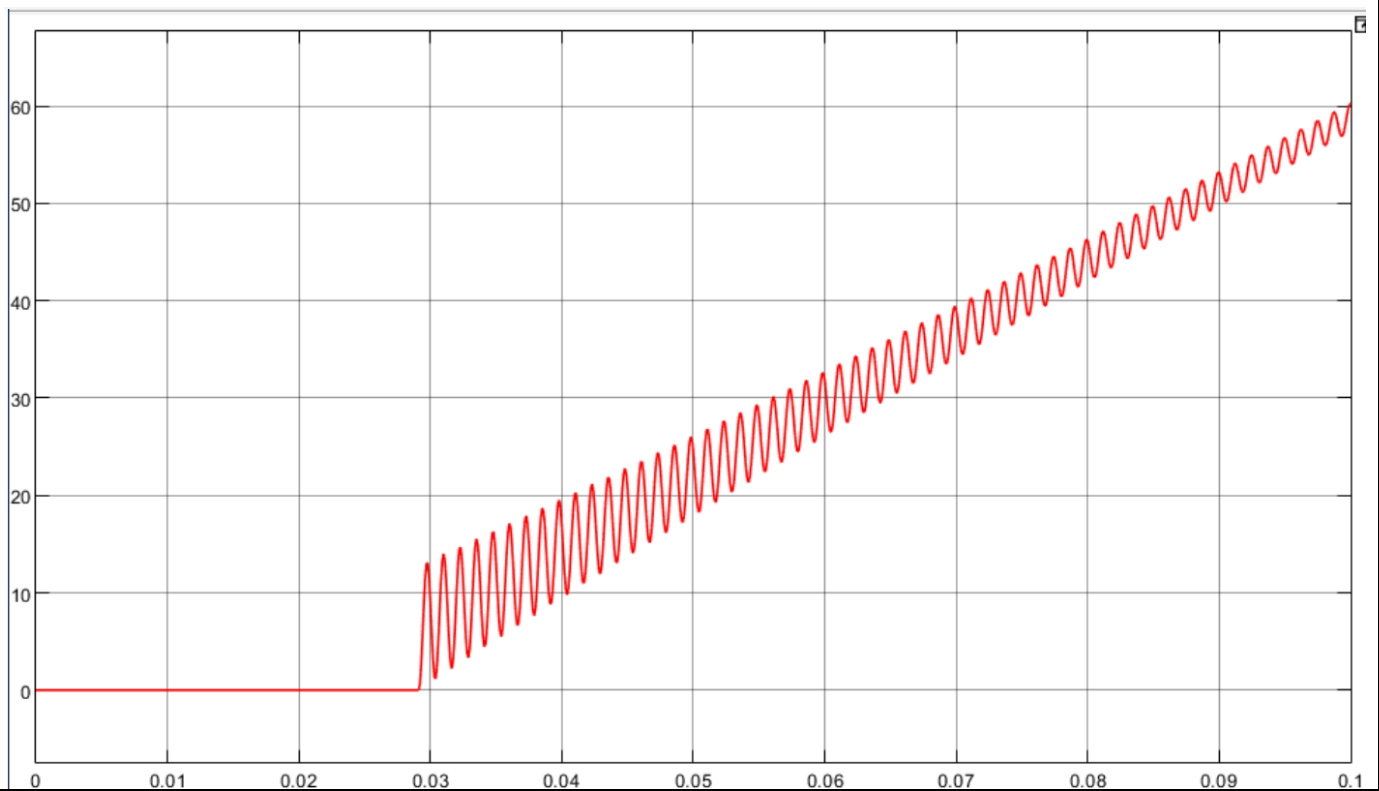
C=2	coefficient of angular stiffness	Nmm/rad
Explanation of symbols cont.		
Symbol (and value)	Name of the quantity / parameter	Unit
b	coefficient of angular dumping	Nmm*s
M_e	electromagnetic torque of the motor	Nmm
M_r	friction torque in the motor	Nmm
$J_s = 1.2 * 10^{-4}$	Rotor inertia	gm^2
φ'_1	angular velocity of the motor rotor	Rad/s
φ'_2	angular velocity of the load	Rad/s
$K_T = 0.0184$	Torque constant	Nmm/mA
$K_e = 18.43$	Back emf constant	mV/rad/s
V = 18000	Supply voltage	mV
$R_t = 27.5$	Terminal resistance	Ohms
i	armature current	mA
L = 0.0047	Rotor inductance	H
$i_0 = 5$	average no-load current	mA

2. Graph of the angular position of the motor rotor

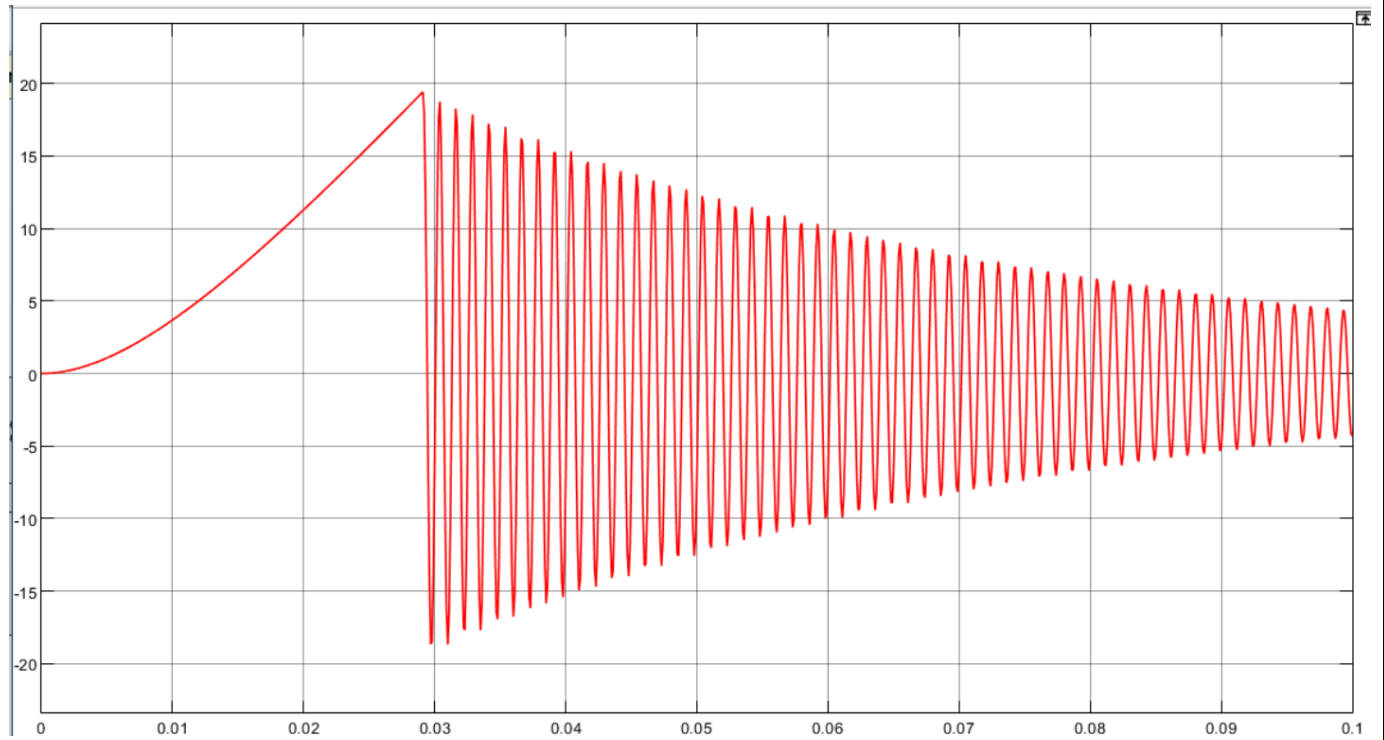




3. Graph of the angular position of the load



4. Graph of difference in angular positions of the rotor and the load ($\varphi_1 - \varphi_2$)



5. Simulation model

