MODELLING AND SIMULATION USING MATLAB/SIMULINK AND ITS APPLICATIONS IN ELECTRIC POWER STEERING SYTEM.

Student and instructor

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Group project title

Study of Matlab/Simulink and application on simulation and analysis of mechanical components of the (complete) EPS system.

BK - OISP

1 INTRODUCTION

a) Goal of the project

To study :

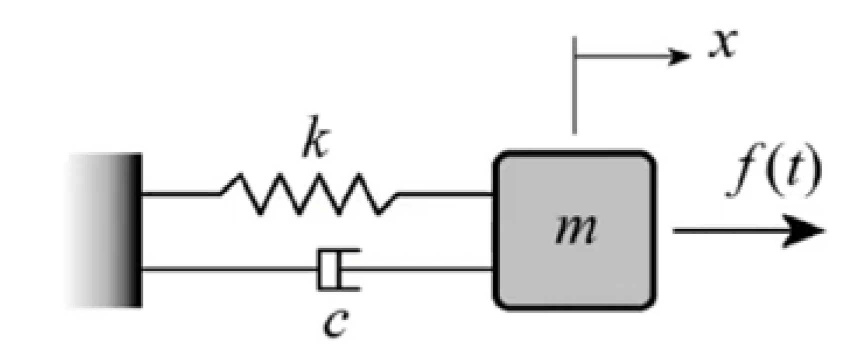
- How to model mechanical system
- How to use Matlab/Simulink with mass - damper system
- How to determine EPS equation and simulate in Simulink by using above knowledge

b) Why Electric Power Steering system (EPS)

- Electrically assisted power steering is replacing the traditional hydraulic system where the pressure is provided via a pump driven by the vehicles engine. The hydraulic system is constantly running and by using the EPS the fuel consumption can be reduced. In electric and hybrid vehicles, the engine does not run continuously so electric power steering is the only possible solution

2 THEORETICAL BASIS

a) Mass-Damper model



$$m\ddot{x} + c\dot{x} + kx = f(t)$$

$$\Rightarrow \quad \ddot{x} = \frac{1}{m}(f(t) - c\dot{x} - kx)$$

Figure: Mass - damper model and dynamic equation

b) EPS model

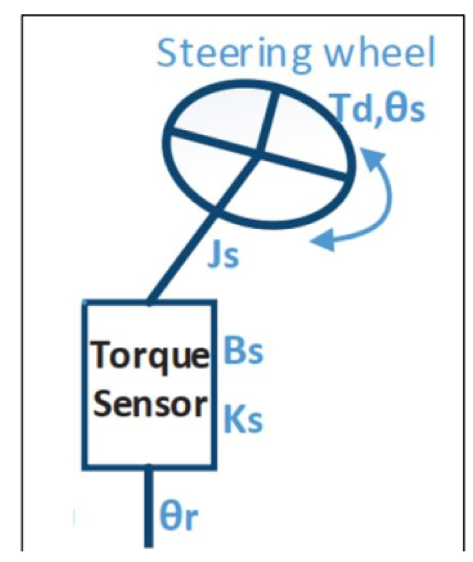


Figure: Overall structure of the steering input (Equation EPS.1)

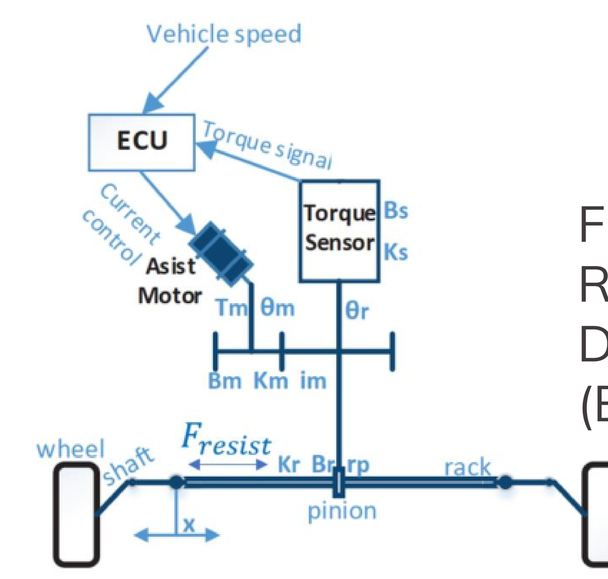


Figure: Overall Rack and Pinion Dynamics (Equation EPS.2)

$$J_s \times \frac{d^2_{\theta_s}}{dt^2} = T_d - K_s(\theta_s - \theta_r) - B_s \times \frac{d_{\theta_s}}{dt^2} \qquad \text{(Equation EPS.1)}$$

$$m \times \frac{d^2x}{dt^2} = \frac{1}{r_p}[K_m(\theta_m - i_m\theta_r)i_m + K_s(\theta_s - \theta_r)] - B_r \times \frac{d_x}{dt} - K_r \times x - F_{resist} \qquad \text{(Equation EPS.2)}$$

3 SIMULATION DATA, PROCESS AND RESULT

a) Mass-Damper model

Parameter	Value
Mass of solid (m)	1.0 kg
Spring constant (k)	100 N/m
Damping coeff. (C)	0.15 N/(m/s)
Force applied (F)	100 N

Table: Mass-Damper parameters

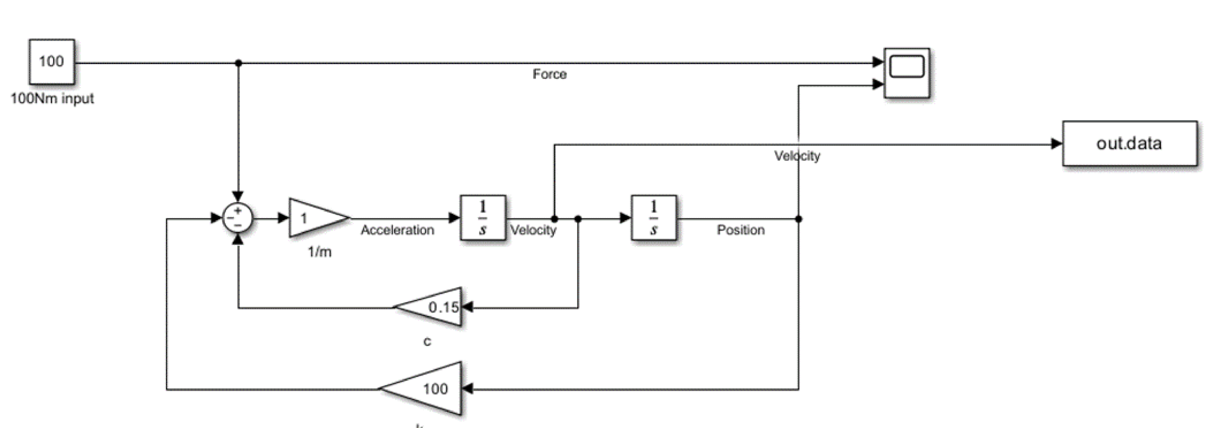


Figure: Mass-Damper block in Simulink

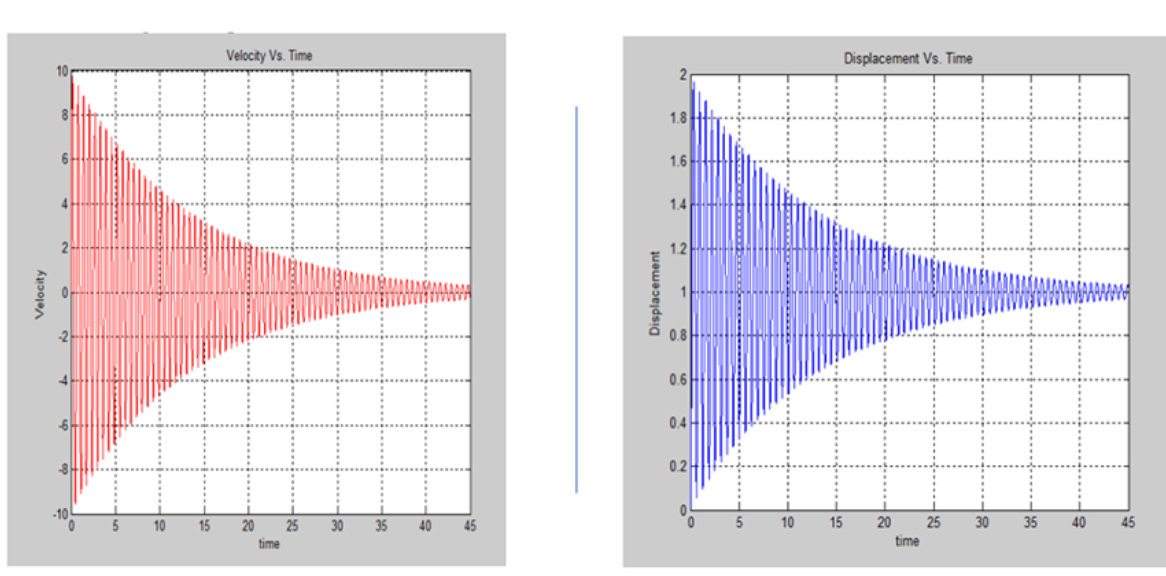


Figure: Result of Mass-Damper model simulation

Result: For the given parameters of the system, the position vs. time response in MATLAB gives the maximum value equal to 1.961 m. Similarly, the maximum velocity is found to be 9.761 m/s. After that, both will fluctuate in a downtrend to a specific number

b) EPS model

Symbols	Value	Name
J_s	0.0012 [kgm^2]	Inertia of steering wheel and steering column
B_s	0.26 [$Nmrad^{-1}$]	Viscous damping coefficient of steering column
K_s	115 [$Nmrad^{-1}$]	Rigidity of torsional bar
θ_s	[Rad]	Turn angle of steering wheel
θ_r	[Rad]	Turn angle of output steering axle
T_d	[Nm]	Input torque of steering wheel
K_r	91064 [Nm^{-1}]	Linear rigidity
B_r	653.203 [$Nmrad^{-1}$]	Viscous damping coefficient of rack and pinion
r_p	0.007783 [m]	Pinion radius
x	m	Rack displacement
m_r	32 [kG]	Mass of the rack and pinion system

Table: EPS parameters

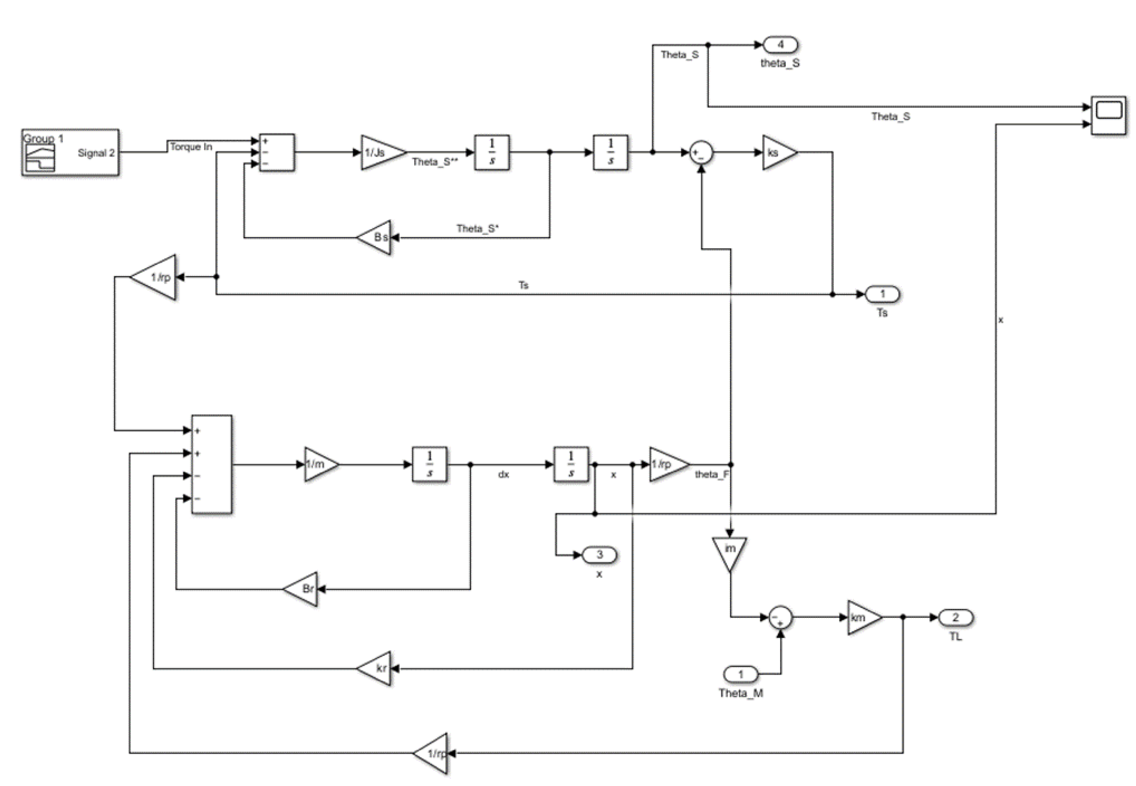


Figure: EPS block in Simulink

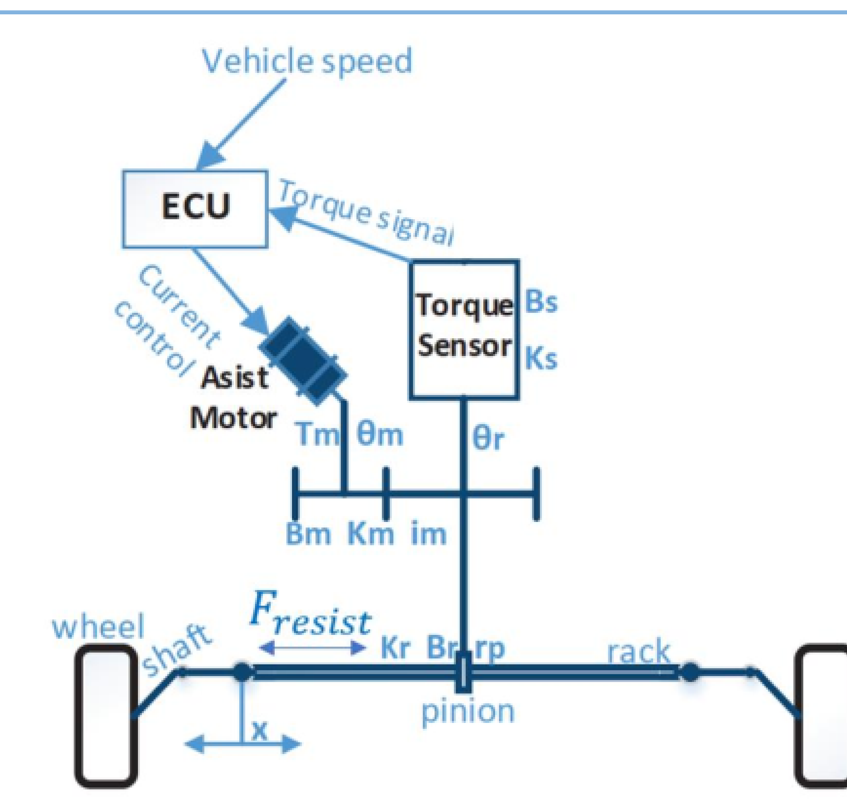


Figure: Full EPS Model

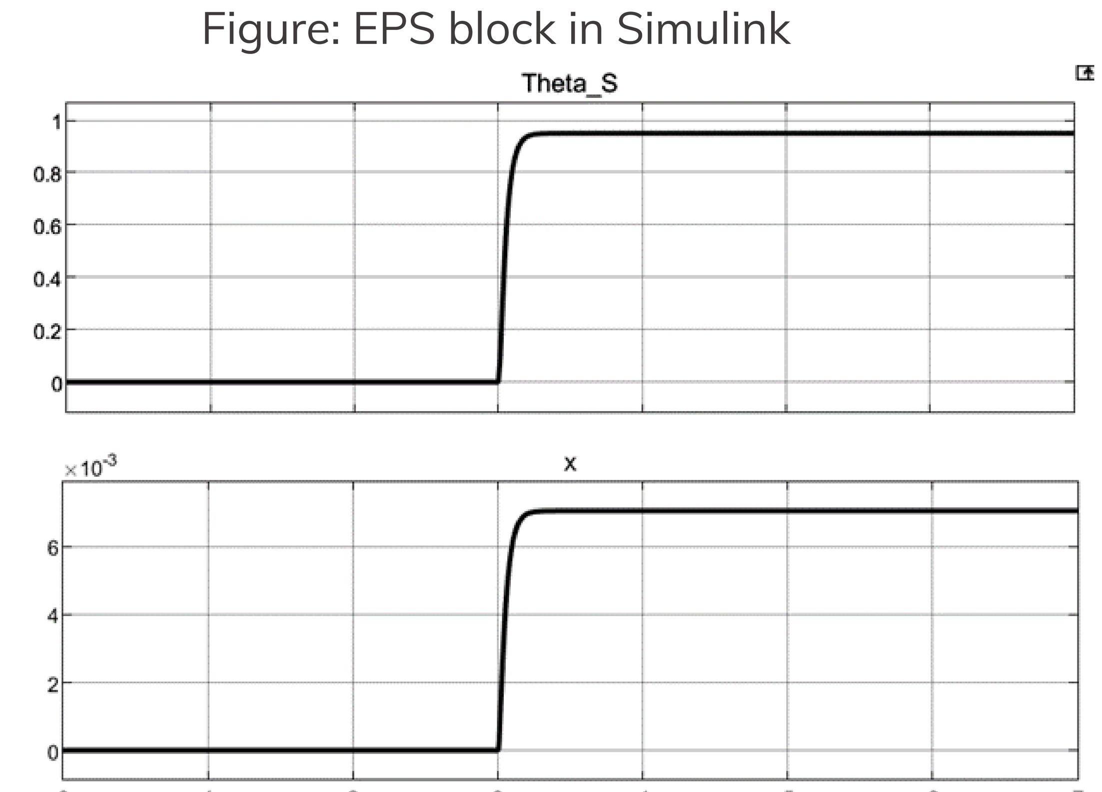


Figure: First Result

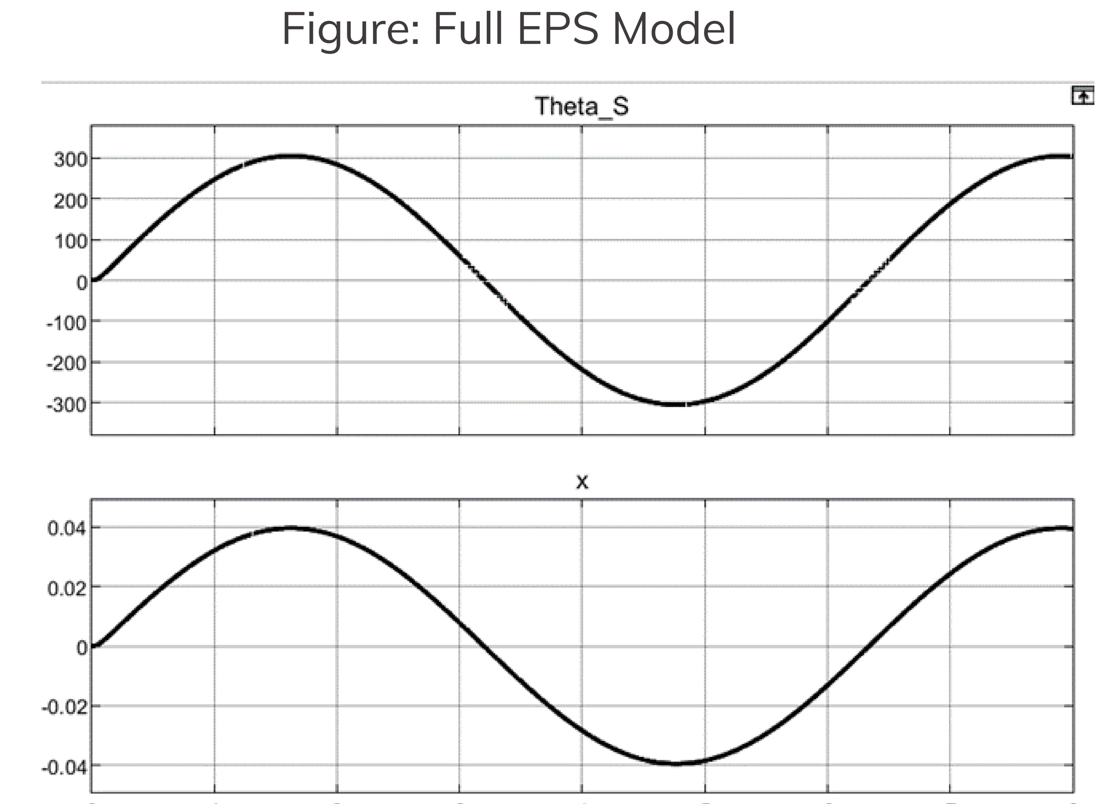


Figure: Second Result

First Result : The inputs to this system are the torque generated by the driver. Since we present a model of the power steering system, details of the tire dynamics are neglected. The outputs of the mechanical subsystem are the displacement of the rack, X, and the rotational displacement of the steering column θS.As we can see from Fig :First Result , with θS changed from 0 to nearly 1 rad, x jumped to approximately 7x10^-3 m. Input touque at 3s is 5Nm.

SecondResult : In second result, the input in steering wheel angle is generated in a sine shape which goes from -300 degrees to 300 degrees. As we can see, the rack displacement also changed in sine shape also, going from -0.04m from center to 0.04m (positive direction goes from left to right)

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