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

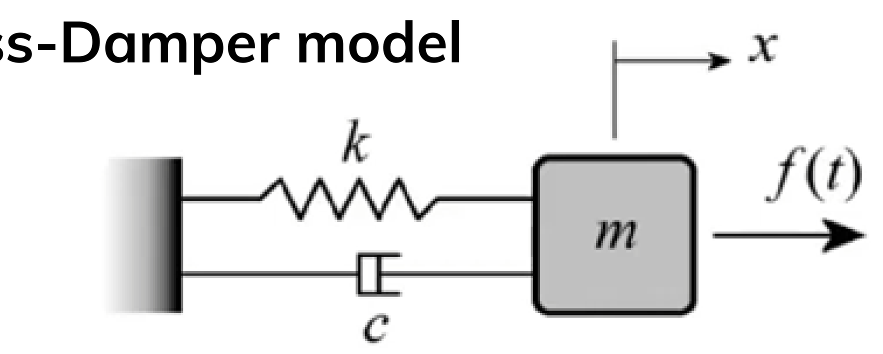
a) Goal of the project

- Learning how to use MATLAB/Simulink with the Mass-Spring-Damper model.
- Contribution to an analysis of the dynamic behavior of the mechanical components of EPS system
- Analysis of the complete system dynamics of EPS, and implementation of the EPS simulation model on Matlab/Simulink, with simulation results analysis.

b) Limitation : This project skips on the effect of motor and effect of forces acting from road to EPS system through wheels.

2 THEORETICAL BASIS AND METHOD

a) Mass-Damper model



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

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

Figure: Mass - damper model and dynamic equation

b) EPS model

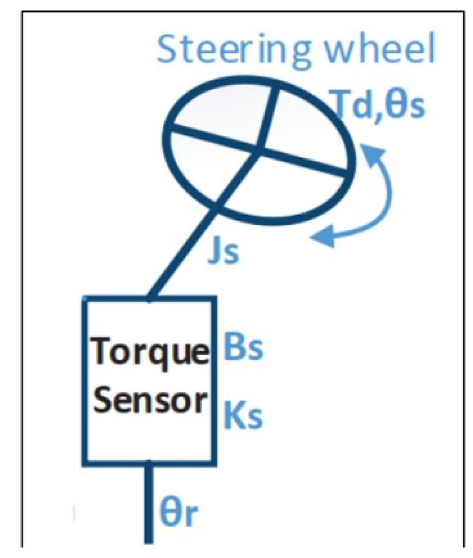


Figure: Overall structure of the steering input (Equation EPS.1)

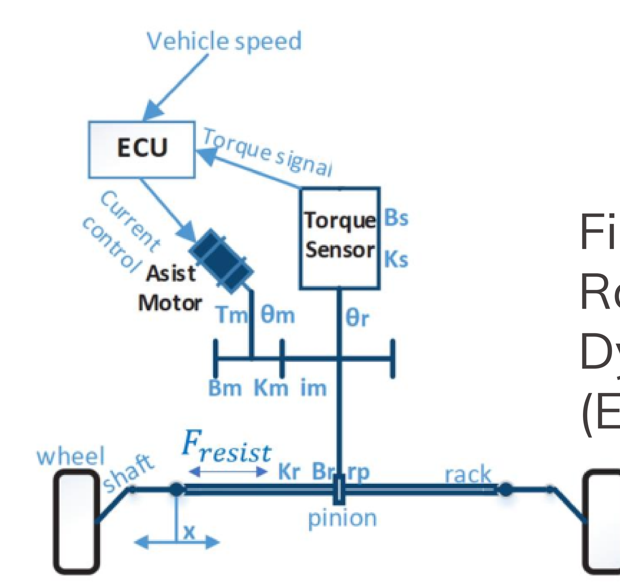
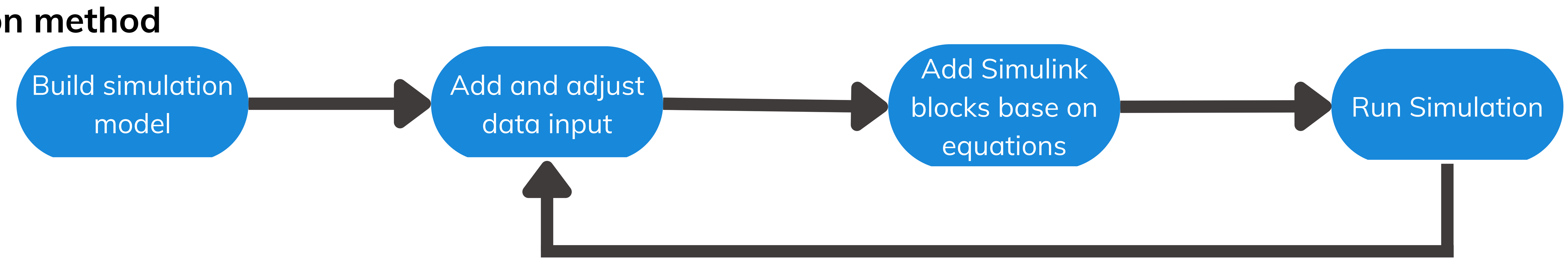


Figure: Overall Rack and Pinion Dynamics (Equation EPS.2)

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

c) Simulation method



4 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

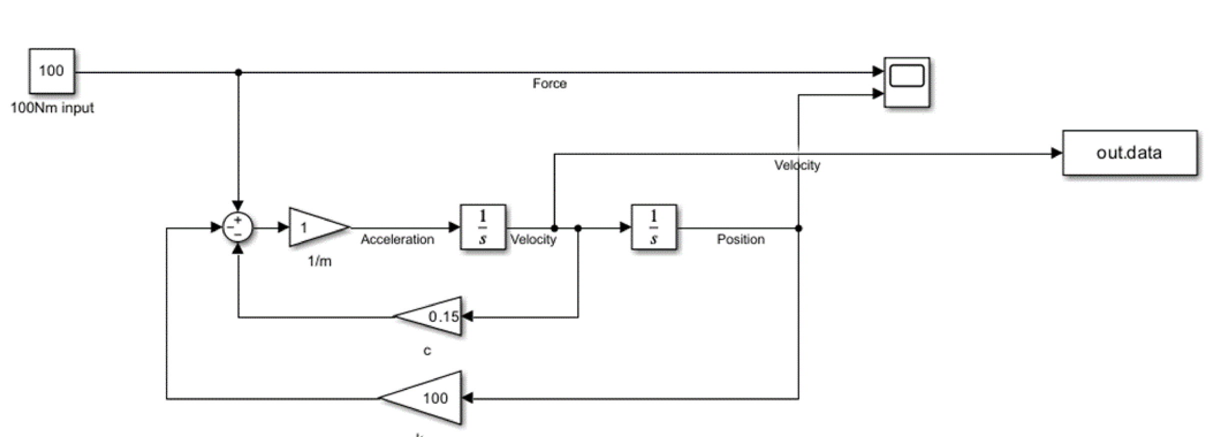


Figure: Mass-Damper block in Simulink

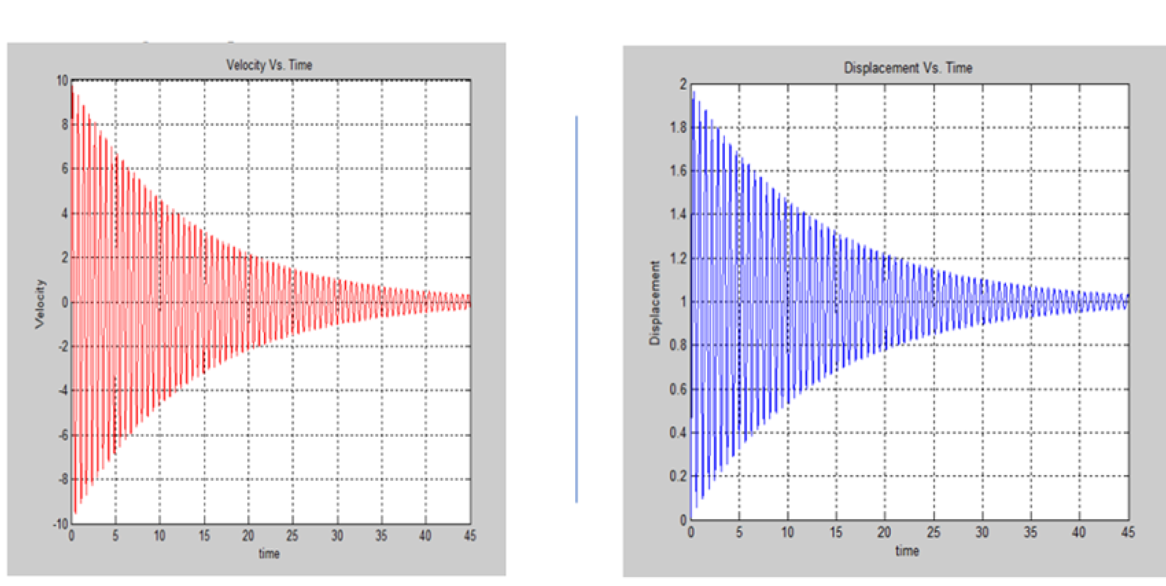


Figure: Result of Mass-Damper model simulation

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

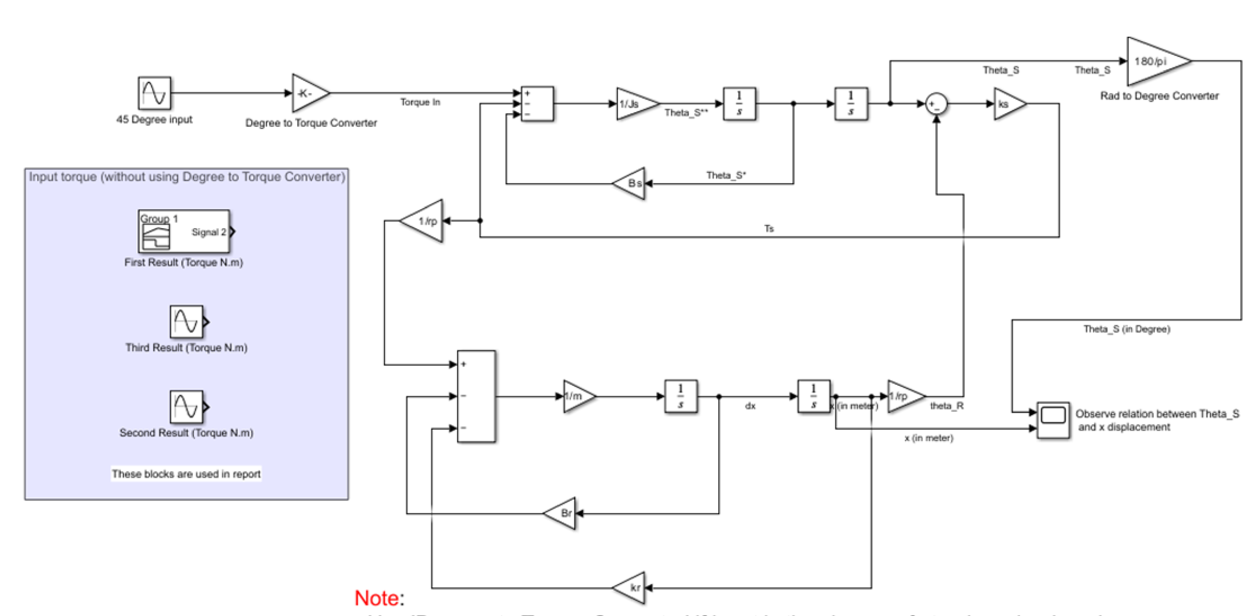


Figure: EPS block in Simulink

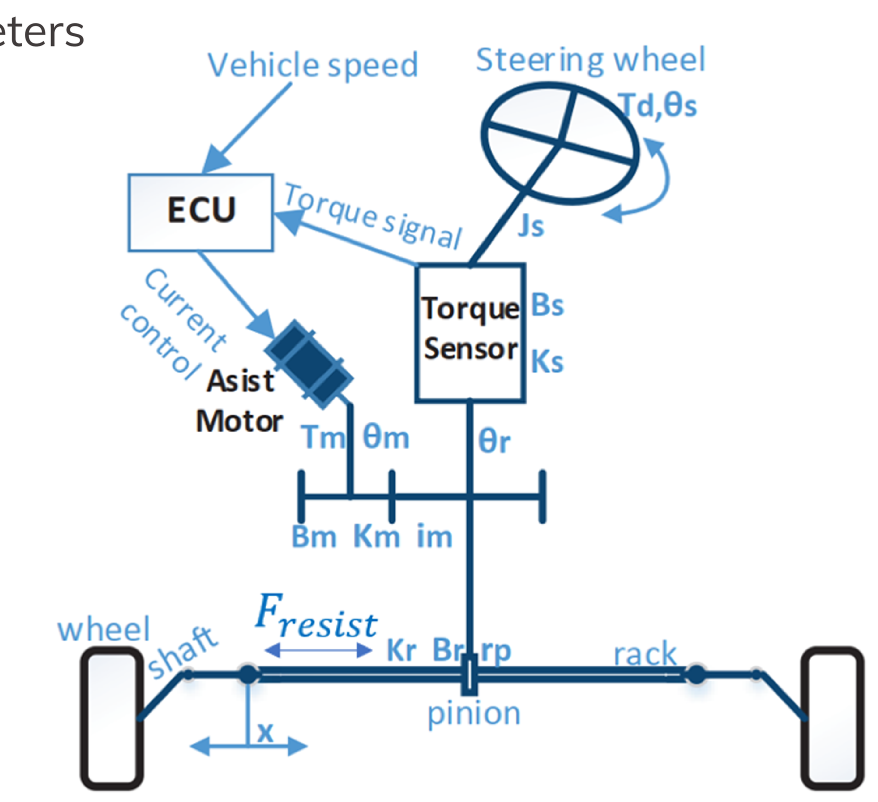


Figure: Full EPS Model

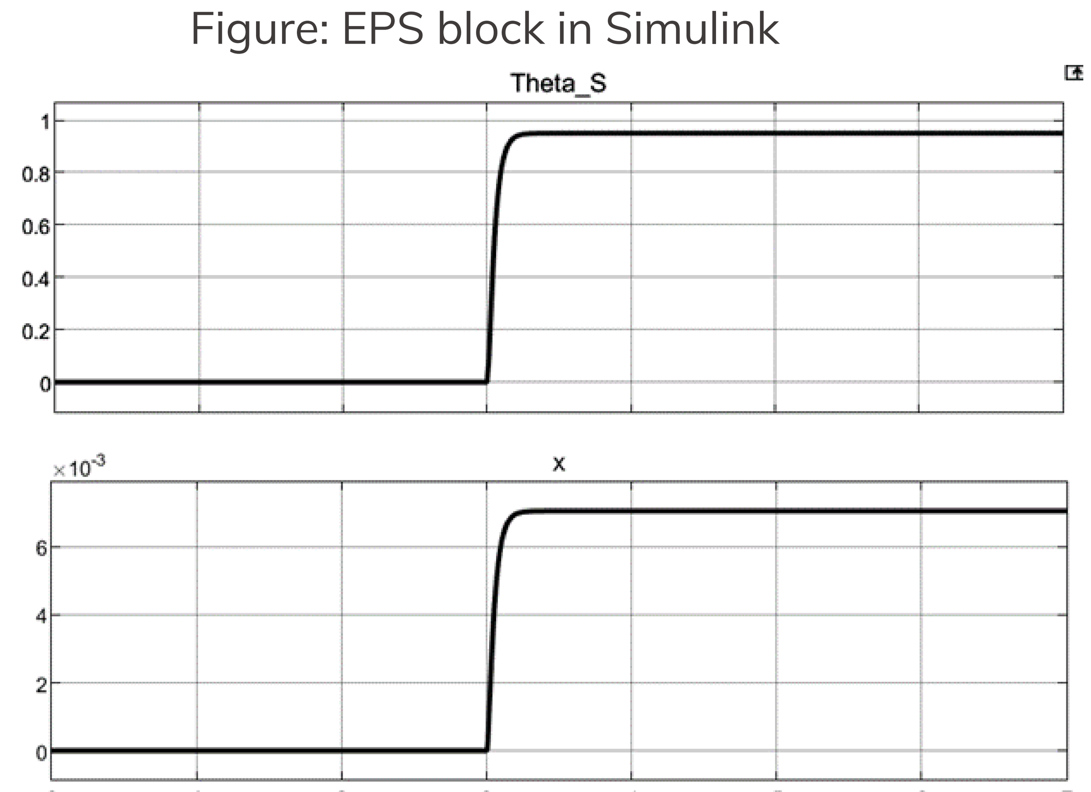


Figure: First Result

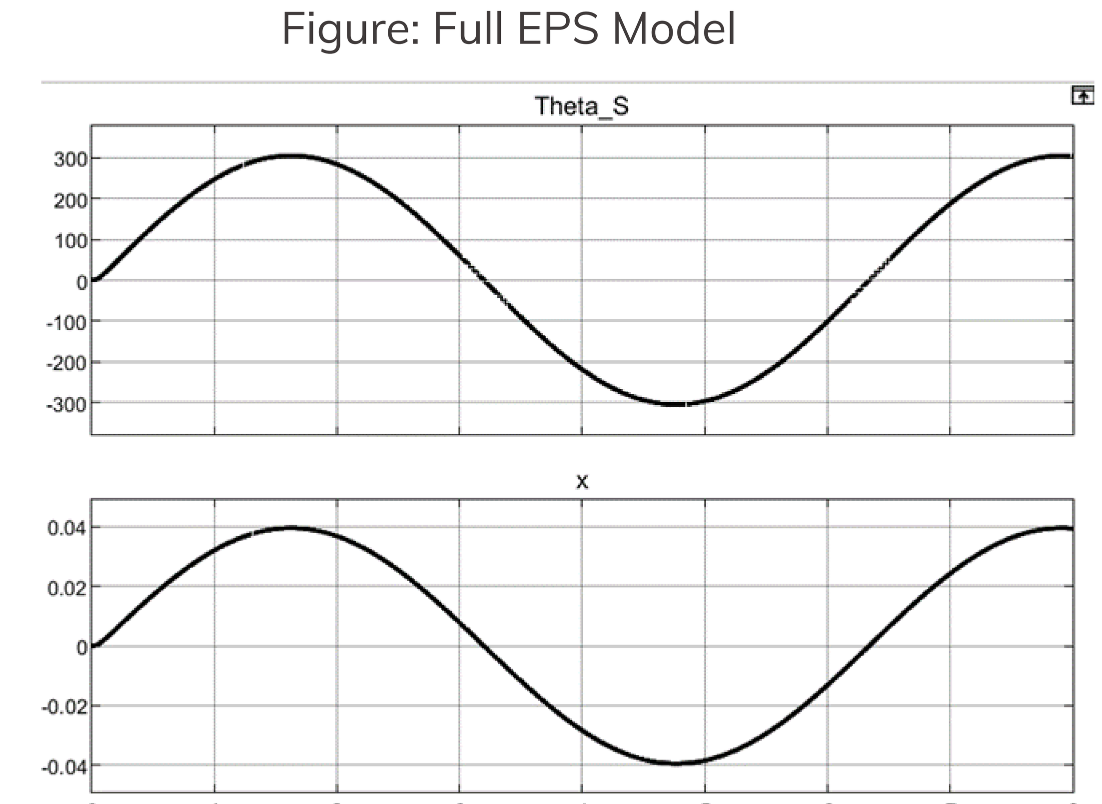


Figure: Second Result

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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