Analysis, 3D modeling and dynamic simulation of the vehicle steering system in the VIOS car.

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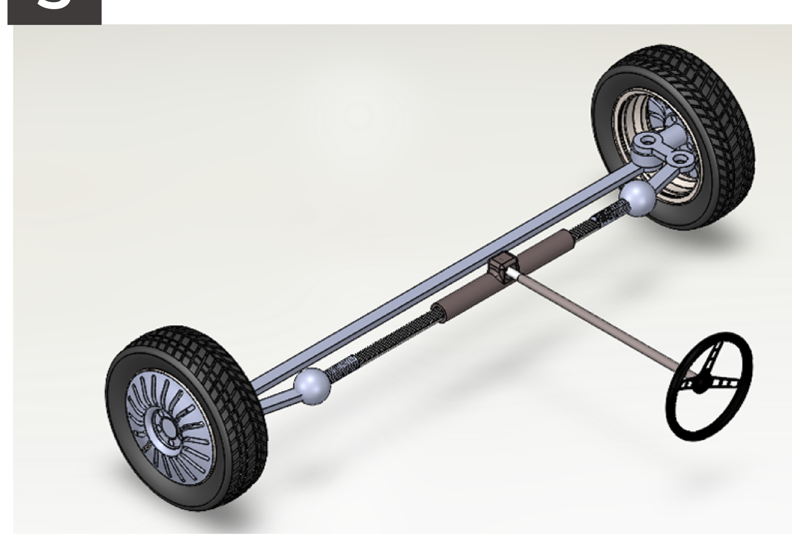
1 Abstract:

This study presents a simulation of an Electric Power Steering (EPS) system for a Toyota VIOS car using MATLAB Simulink and Simscape. Simulation results demonstrate that the EPS system provides responsive and accurate steering control and maintains vehicle stability under various driving conditions. The study evaluates the EPS system's responsiveness and torque adjustments needed to maintain a predefined driving situation. It also analyzes the impact of different parameters on the EPS system's performance. The study's findings provide insights into the design and evaluation of EPS systems for the Toyota VIOS car.

2 Objectives, scope and limitation:

- Objective: To demonstrate the process of building an EPS model using Solidworks and Simscape, simulating its dynamic behavior in Matlab/Simulink with Simscape, and validating the model for the control of an equivalent electric-powered steering system.
- Scope: Analyzing the dynamic behavior of the EPS system in the VIOS model by creating a simulation model in MATLAB/Simulink, excluding aerodynamic simulations and limiting the analysis to lower speeds.
- Limitation: The parameters based on the VIOS vehicle were measured at an automotive workshop at the HCM University of Technology, and their accuracy may be limited.

3 Theorical basicc and parameteres



General parameters of vehicle

- Vehicle mass : 1520kg(full load)
- Caster angle : 5 degree
- Camber angle : 9 degree

Rack	Pinion: Rack ratio	Track Width
0.37m	1:3	1.4m
Tie Rod	**Steering Linkage**	**Radius of steering wheel**
0.265m	0.1m	180mm
Steering gear ratio	**Number of teeth on the pinion**	**Number of teeth on the rack**
19.5	9	27

Table : Parameter of components

❖ **Kinematics of the steering trapezium**

$$\text{Cotg}\beta_i - \text{cotg}\alpha_i = \frac{B_0}{L}$$

❖ **Checking by algebraic method**

$$\delta_i = \frac{\sin\alpha_i . \sin\beta_i}{\sin(\alpha_i - \beta_i)} . \frac{B_0}{L}$$

4 Implementation process

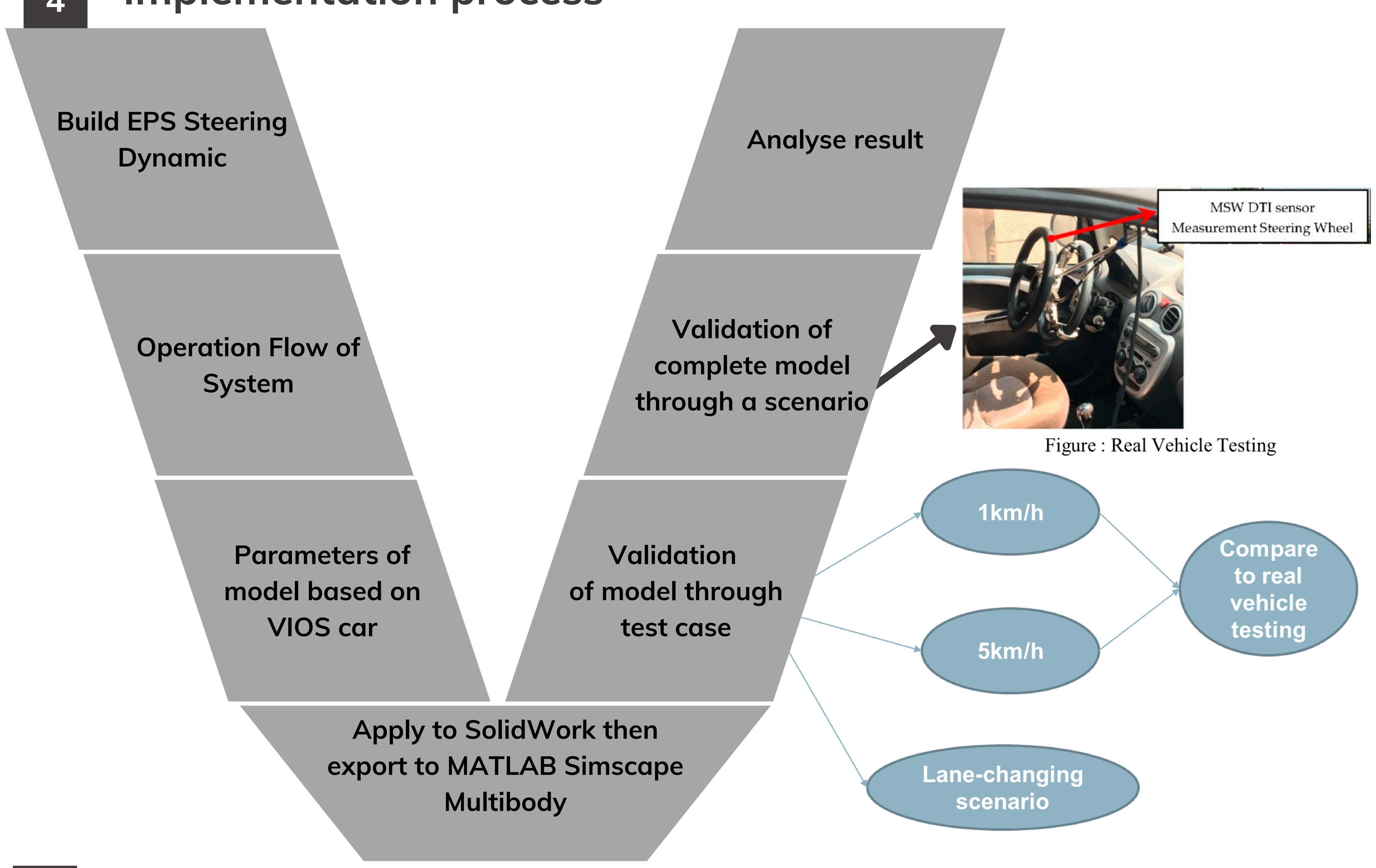
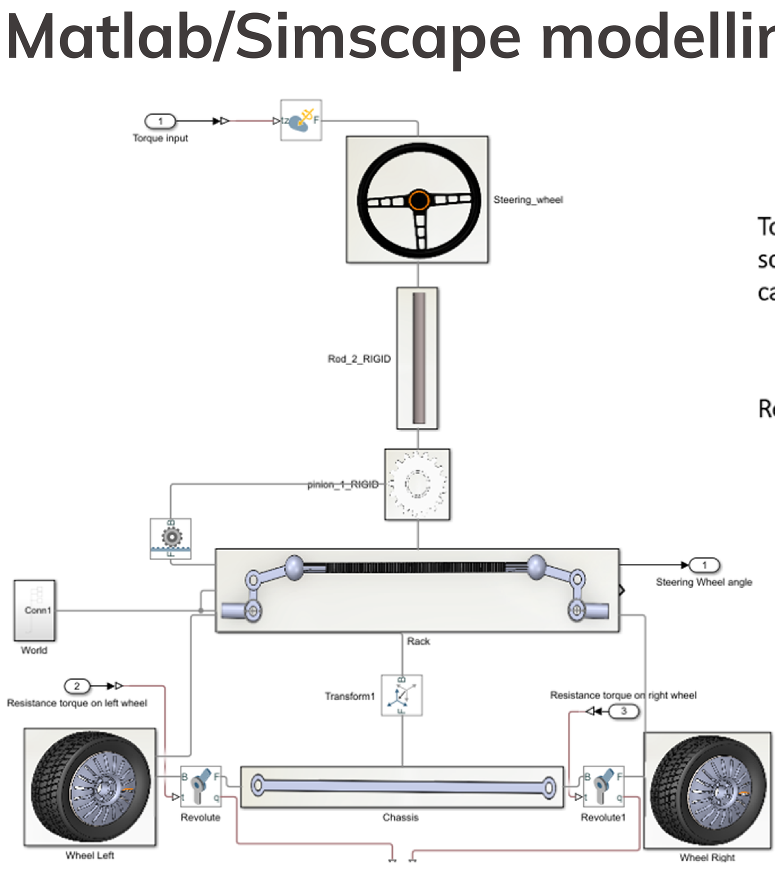


Figure : Real Vehicle Testing

5 Matlab/Simscape modelling:



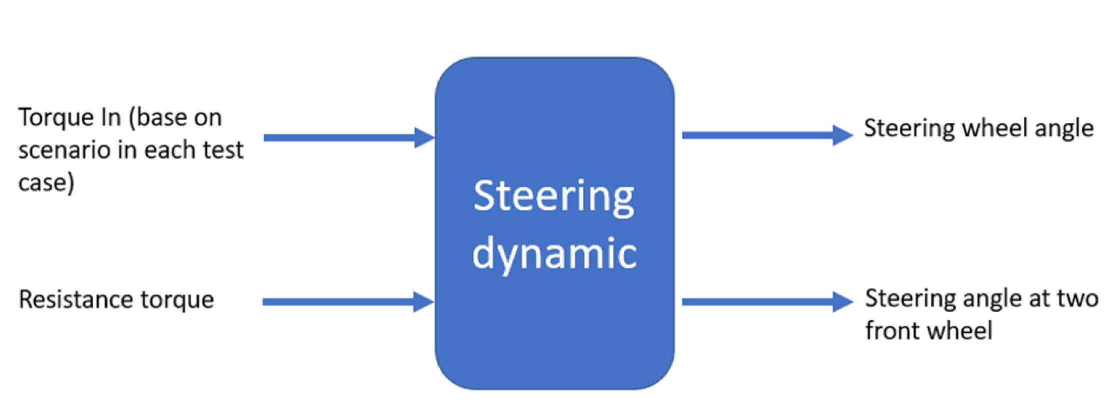


Figure: Complete Steering System

6 Specific results:

Test case 1 : working in various speed

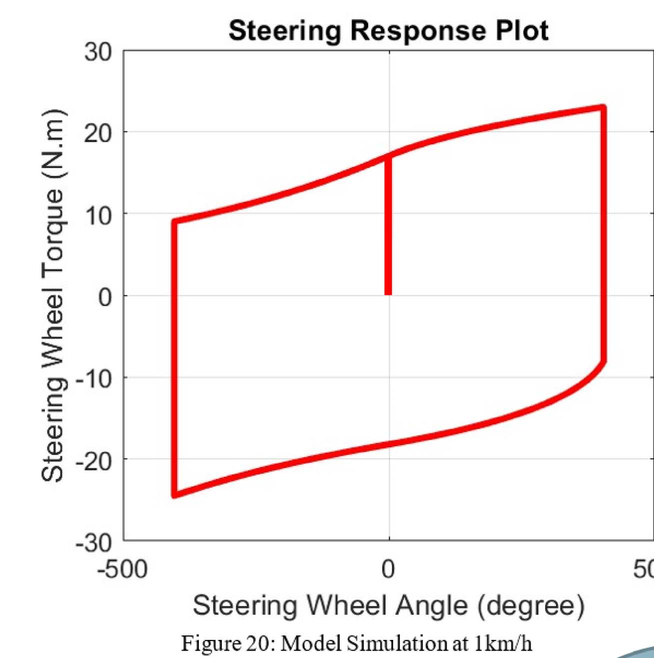


Figure : Simulation

1km/h

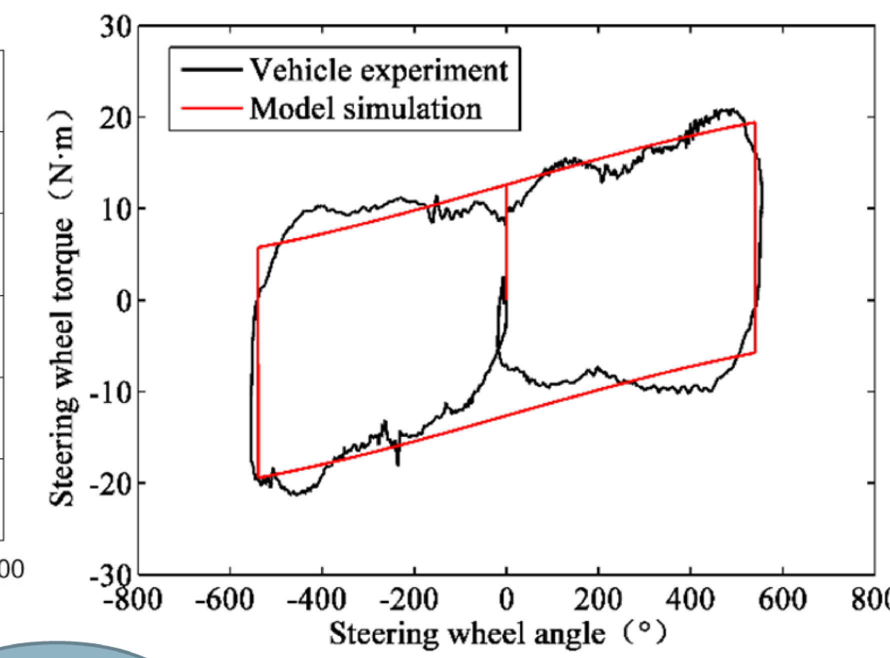


Figure : Real vehicle testing

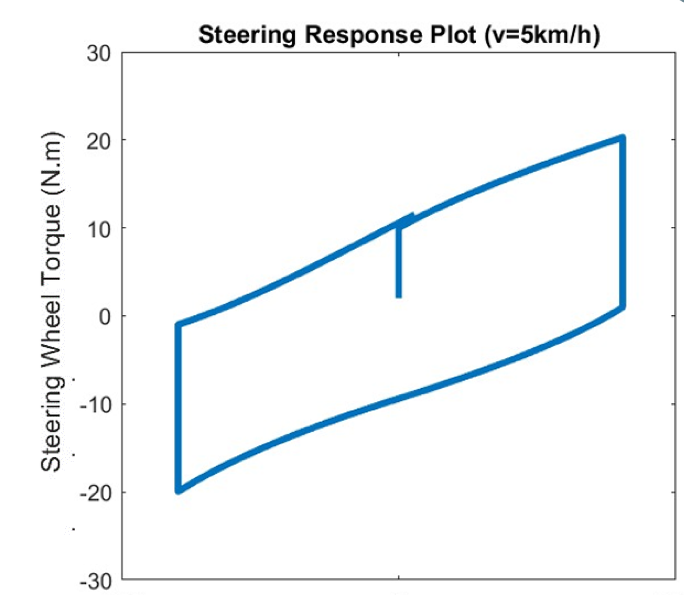


Figure : Simulation

5km/h

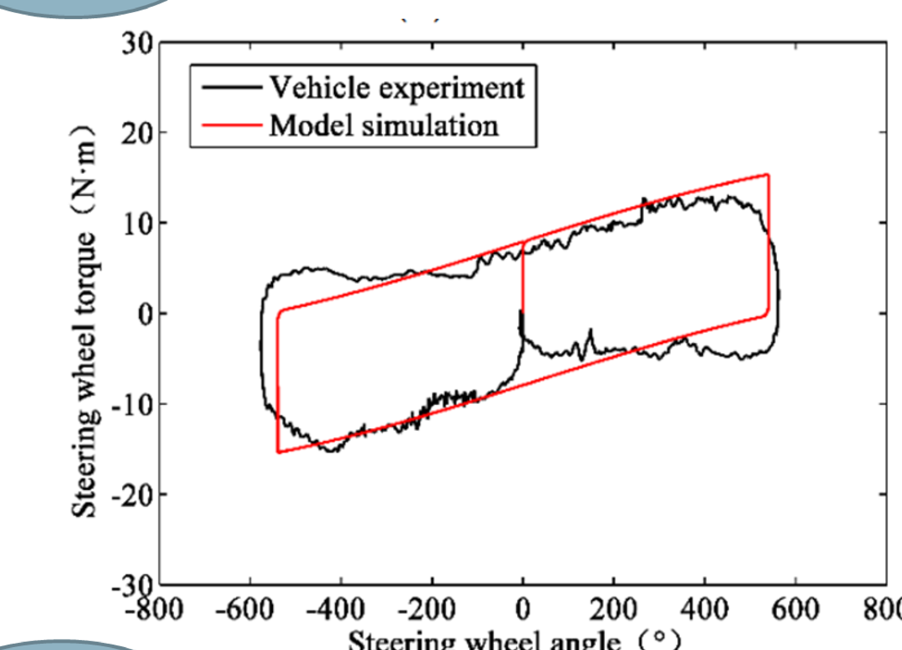


Figure : Real vehicle testing

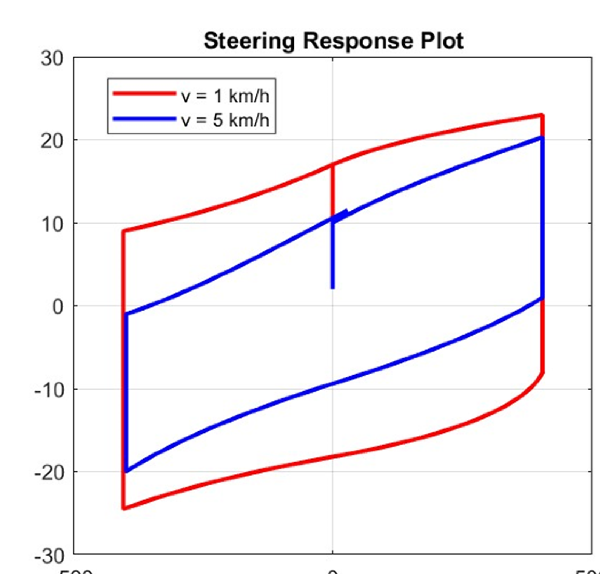


Figure : Comparison

The relationship between steering torque and vehicle speed is critical for designing and optimizing steering systems in vehicles. Studies have shown that steering torque decreases as vehicle speed increases due to factors like vehicle stability and steering system effectiveness. The simulation model has been confirmed as valid by comparing its results with data obtained from testing a real vehicle, supporting its accuracy in predicting steering system behavior.

Test case 2 : line-changing scenario

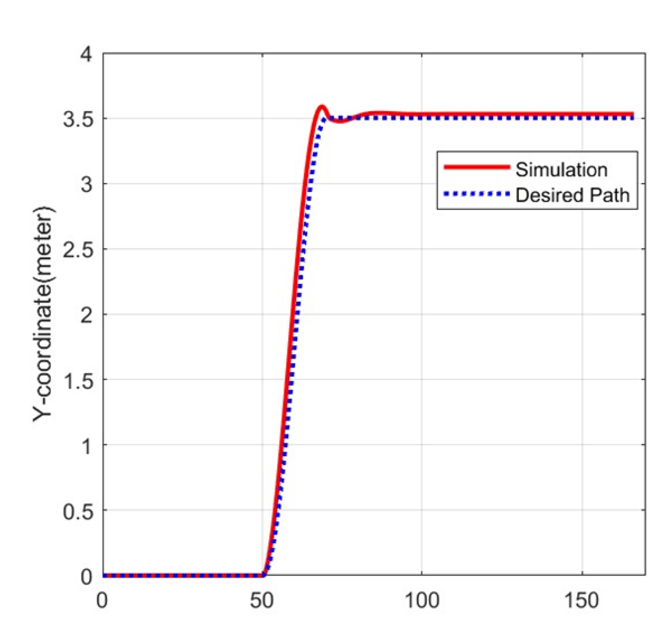


Figure: lane-changing scenario

The vehicle tracked the predefined path accurately with minimal error, validating the accuracy of the simulation model in Simscape. This is important for designing and optimizing vehicle control systems. The successful execution of the predefined path indicates that the simulation model is reliable and can be used confidently in future development.

The two test cases have successfully demonstrated the process of building an EPS model using Solidworks and Simscape, simulating its dynamic behavior in Matlab/Simulink with Simscape, and validating the model for the control of an equivalent electric-powered steering system.

7 Conclusion and future plan:

In conclusion, the objective of building and validating an EPS model using Solidworks and Simscape, and simulating its dynamic behavior in Matlab/Simulink with Simscape has been achieved. In order to improve the accuracy of the model, it is recommended to remove limitations in future testing and experimentation. Despite the limitation of the parameters based on the VIOS vehicle, the study demonstrates the potential of simulation models in optimizing vehicle control systems.

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