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Building Models, Modeling Electronic Power Steering Eps on Experimental Model

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ABSTRACT. Nowadays, the demand for electric power steering system is increased because it has a compact design (some components have been reduced), operating precisely to meet specific operating conditions, based on the reliability The study of sensor installation on the actual model and the reception of real-time signals transmitted to the computer became extremely important during the study of the steering system. Thanks to the signals from the sensor, researchers can put in the simulation model built on the computer. Thus, the cost of real-life testing is very expensive. Within the scope of the paper, the author examines the EPS electric drive system on experimental model.
Keywords: EPS, Electronic Power Steering, TOYOTA, Electric Power Assisted, System Steering.

I. INTRODUCTION

Due to the increasing requirements for automobile speed, better quality and the need to reduce energy consumption in vehicles, the research and development following the trend of improving the electric control system aims at the target further enhances its functions and characteristics [1, 2].

Electric Power Steering (EPS) consists of a vehicle speed sensor, a steering sensor (torque, angular velocity), an ECU electronic controller and a motor. The output signal from each sensor is sent to the ECU which calculates the steering control mode to control the operation of the servo motor [3]. This EPS consists of two basic types of power assistance: the Power Steering on the Drive (EPAS), the Power on the Steering Wheel (EPAS) [4].

The purpose of building a model to research and create an electronic controller to control the EPS steering system. The team used STM32 and Arduino communication cards to communicate between the Matlab software and the sensor system set on a semi-experimental model. All are built on HILS (Hardware-in-the-loop simulation) platform. As a result, the team has built a relationship between the load, the speed and the rotation of the steering wheel. Semi-empirical model based on electric power steering (EPS) on TOYOTA models [5, 6].

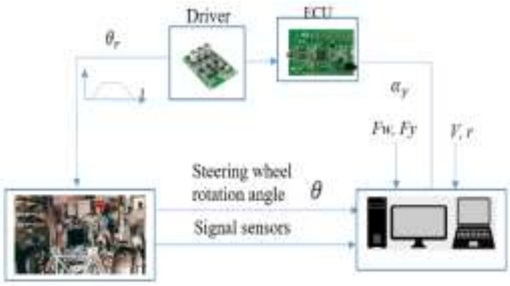

Fig. 1. HILS model

II. BUILDING 3D MODELS AND CONNECTED HARDWARE IN MATLAB

Building 3D Models in Solidworks and Matlab Simulink

Building 3D model of steering system in Solidworks:

Solidworks software is one of the 3D design software released by Dassault System for small and medium-sized enterprises, meeting most of today's mechanical design needs. Solidworks is known from the 1998 Solidworks [7] version and has been introduced to our country with the 2003 version and so far with the 2020 version and this software has developed a huge number of mechanical libraries and this software is not only for mechanical factories but also for other industries such as pipes, architecture, interior decoration, art, etc.

Fig. 2. Steering system model on Solidworks

Simulation of steering system on Matlab with SimMechanics:

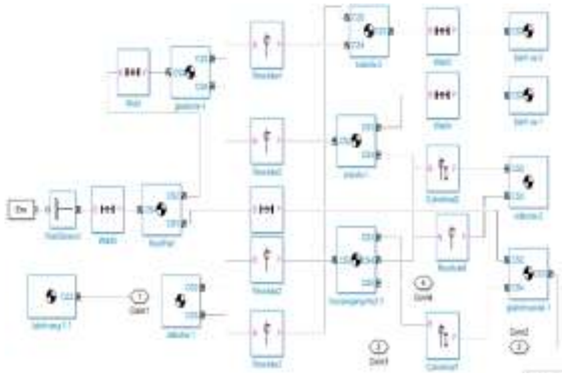

Fig. 3. Dynamic simulation block inMatlab Simulink

SimMechanics software is a block diagram modeling environment for engineering and simulation design of solid systems and their operations, using Newtonian kinematic standards for force and torque.

SimMechanics software can model and simulate mechanical systems with a system of tools to identify objects with their mass, activity, kinematic and coordinate systems characteristics. It helps the user to describe a mechanical system by means of a block diagram system that is linked together, like other Simulink models and also designed in conjunction with other subsystems. SimMechanics software presents and performs vividly 3-D machine geometry, before and during the simulation process [8, 9]. Besides simulating by SimMechanics software and calculating the kinematic problem for the model, the approach solving the reverse kinetic problem is also a problem to do to make the modeling and simulation more complete and complete, meeting the requirements set out in reality.

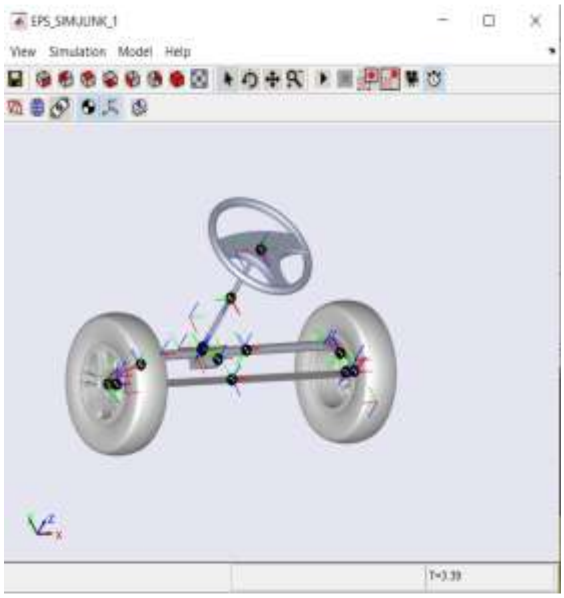

Fig.4. Simulation of steering system on Matlab Simulink Simmechanics

Controller Design Reads Sensor Data

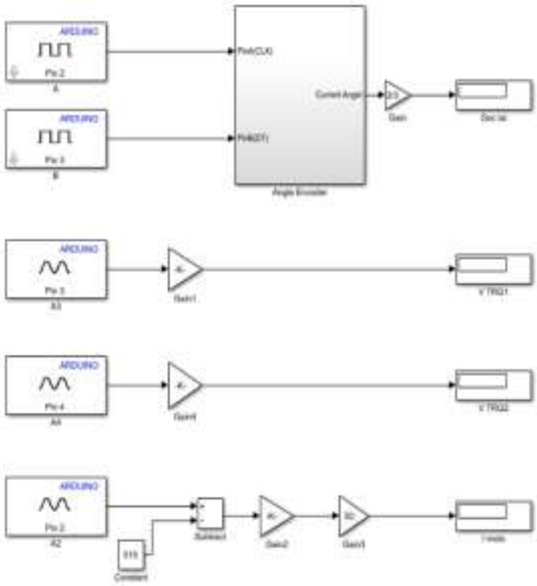

Fig.5. Block reading data steering wheel rotation angle

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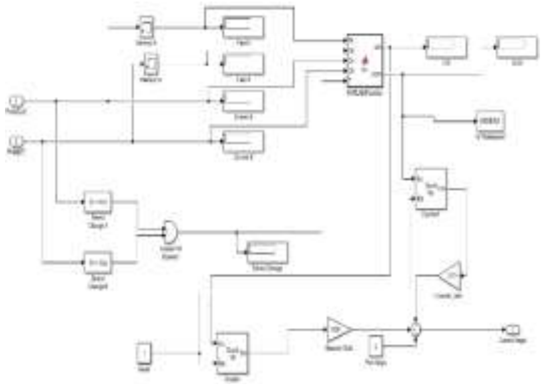

Fig.6. Subroutine of the block

Fig.7. Semi-empirical model of electric power steering (EPS)

Nonlinear models are frequently used to simulate the actual vehicle to test the correctness of the theoretical basis. In recent years studies [6, 10,] have used nonlinear models [Figure 13]. The model input signal is the front wheel steering angle δ_f .While the output variable is body rotation angle r, side deflection angle β

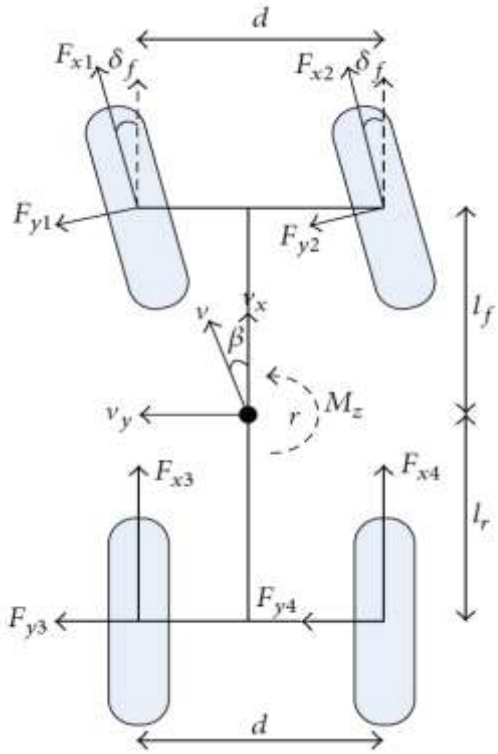

Fig.1. Two-trace model

Where:

- CG: center of gravity;
- lf và lr: distance from center of gravity to front and rear axles;
- V: vehicle speed;
- m : mass of vehicle;
- I_z : moment of inertia;
- Cf / Cr : stiffness in the front / rear tire;
- The wheels are numbered as a number below with (1) for the left front, (2) for the right front, (3) for the left rear, and (4) for the right rear.
- Fxi: Tire vertical force, Fxi, depends directly on the rate of tire slip, λi;
- Fyi, Tire lateral force depends directly on the tire angle,αi ;

For slip angles and proportion sliding small, lateral force of the tire is considered as linear with stiffness and angle tires tires while the vertical is described as a linear function of stiffness, brake and proportion tire slip. For larger slip angle and yaw rate, longitudinal force and side force with non-linear characteristics. The car engine moves with nonlinear tire force which represents a nonlinear system. The longitudinal force of the tire can be described using the model of tire Pacejka [6,7,8] or model Dugoff tires used in [9.10,], while studies in [11, 12] using both two tire models [13, 14].
Considering the balance in the x we have

$$ma_x = \left(F_{x1}+F_{x2}\right)\cos\delta_f + F_{x3}+F_{x4}-\left(F_{y1}+F_{y2}\right)\sin\delta f$$
(1)
Considering the balance in the y have
$$ma_y = \left(F_{x1}+F_{x2}\right)\sin\delta_f + F_{y3}+F_{y4}+\left(F_{y1}+F_{y2}\right)\cos\delta f$$
(2)
Moment of the COG
$$I_z\dot{r} = l_f\begin{pmatrix} F_{y1}\cos\delta_f + F_{y2}\cos\delta_f \\ +F_{x1}\sin\delta_f + F_{x2}\sin\delta_f \end{pmatrix} - l_r\left(F_{y3}+F_{y4}\right)+M_z$$
(3)

Including Mztorque rotating body, Mz> 0 if tires tend axial rotation z. In (2), side acceleration aycan be represented by the vehicle speed V, body rotation angle r, and lateral slip β as follows:
$$a_y = \dot{v}_y + rv_x = v(r+\dot{\beta})$$
(4)

Therefore, we obtain the lateral slip β of the 2-track model:
$$\dot{\beta} = \frac{1}{mv}\begin{pmatrix} \cos\beta\left(\cos\delta_f\left(F_{x1}+F_{x2}\right)-\sin\delta_f\left(F_{y1}+F_{y2}\right)\right) \\ -\sin\beta\left(\sin\delta_f\left(F_{x1}+F_{x2}\right)-\sin\delta_f\left(F_{y1}+F_{y2}\right)\right) \end{pmatrix} -$$
(5)
While the output variable of the body rotation speed r can be determined from (3) and obtained as follows:
$$\dot{r} = \frac{1}{I_z}\begin{pmatrix} l_f\left(F_{y1}\cos\delta_f + F_{y2}\cos\delta_f + F_{x1}\sin\delta_f + F_{x2}\sin\delta_f\right) \\ -l_r\left(F_{y3}+F_{y4}\right)+M_Z \end{pmatrix}$$
(6)
In the 7 degrees of freedom above model, each wheel is a degree of freedom. Now the motion of each cake is shown by the following formula
$$I_{wi}\dot{w}_i = -R_{wi}F_{xi}+T_{ei}-T_{bi}$$
(7)
$\dot{\omega}$: Angular acceleration of the wheel
R_w :Wheel radius
I_w :Inertial force of the wheel
T_{bi} : Brake torque
T_{ei}: Drive torque

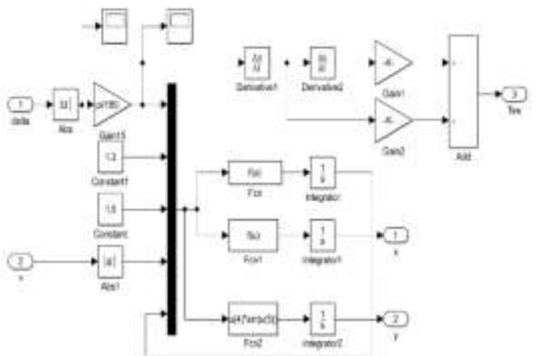

Fig.9. Block motion trajectorycar

III RELATIONSHIP BETWEEN LOAD, STEERING WHEEL ROTATION ANGLE AND MOTOR CURRENT INTENSITY WHEN THE VEHICLE IS TURNED

Case 1 Sets the Load as 2600 N

Vehicle speed before steering is 40km/h. After releasing the accelerator pedal, start steering at a speed of 0.4 [rad/s] (equivalent to 23 [degrees/s]) until it reaches a value of 90 degrees (turning angle of the steering wheel).
Based on the theoretical graph driving left 90 degrees:

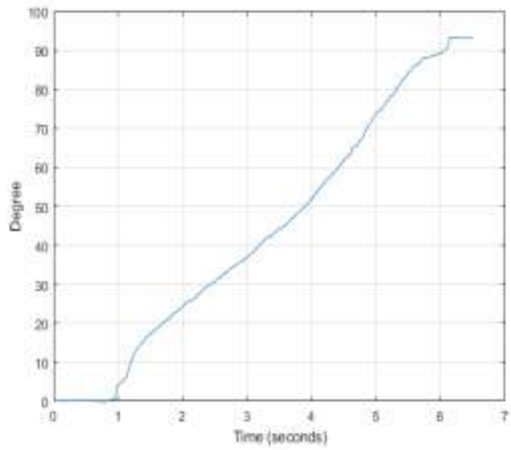

Fig.10. Graph of actual steering wheel rotation angle

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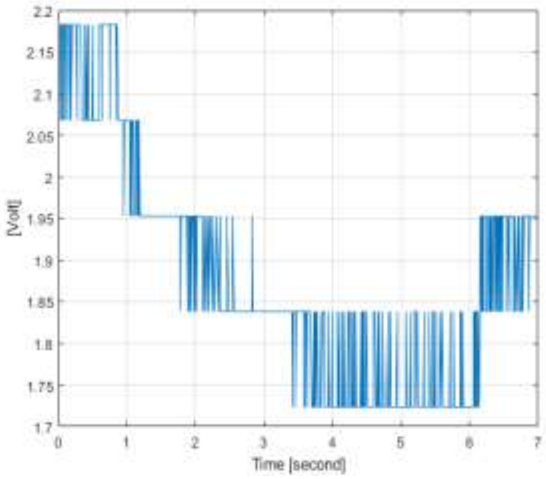

Fig.2. Graph of amperage of the actual motor

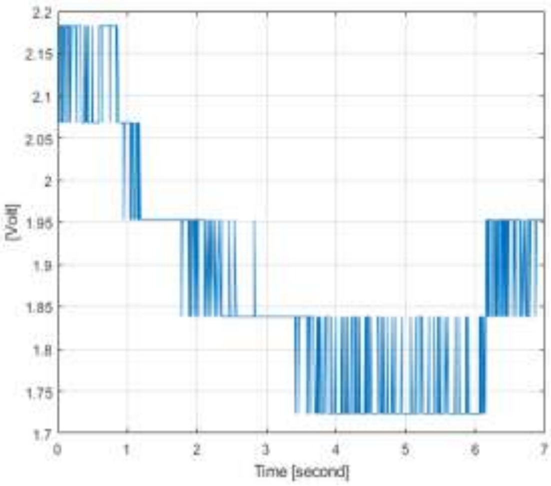

Fig.3. Torque sensor voltage graph TRQ 1 reality

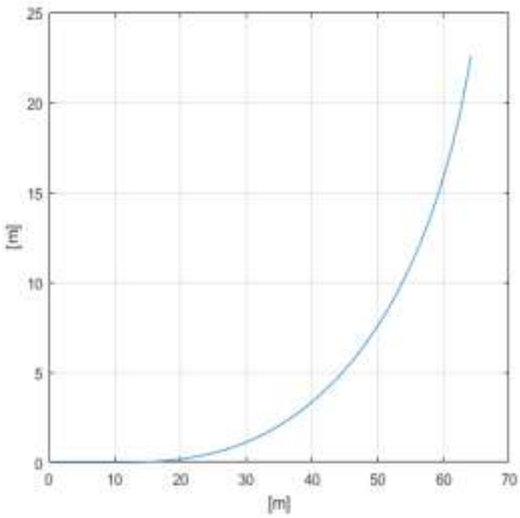

Fig.4. Graph of vehicle trajectory

Case 3 has Set Load of 3000 N

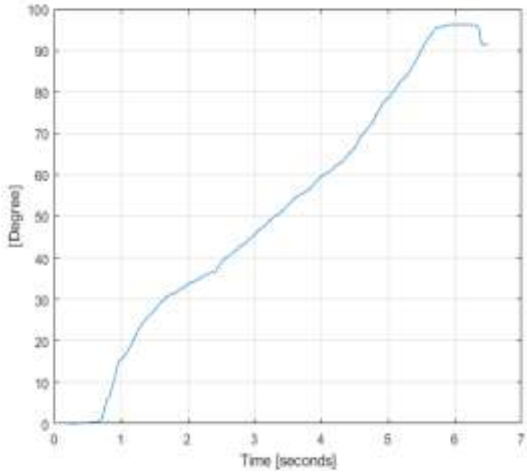

Fig.14. Graph of actual steering wheel rotation angle.

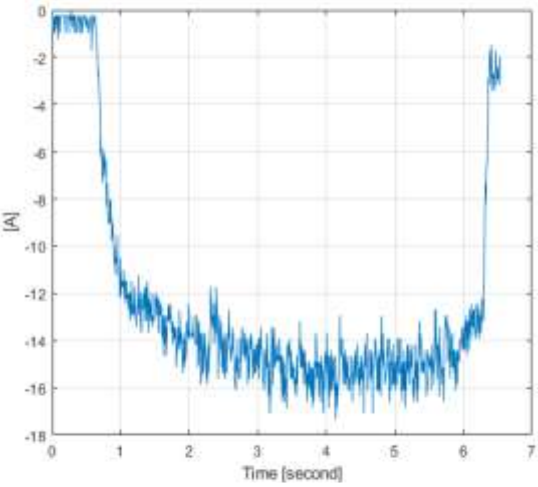

Fig.15. Graph of amperage of the actual motor

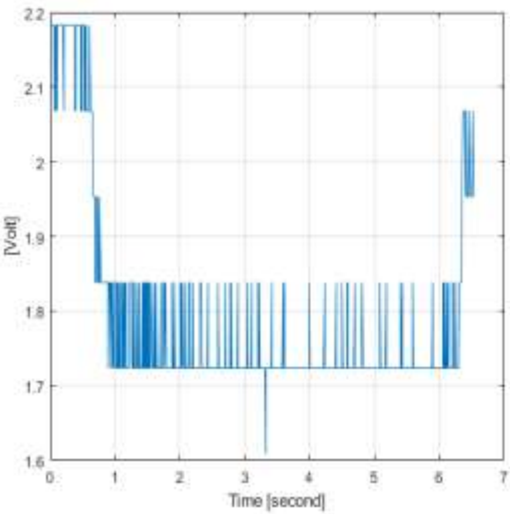

Fig.5. Torque sensor voltage graph TRQ 1 reality

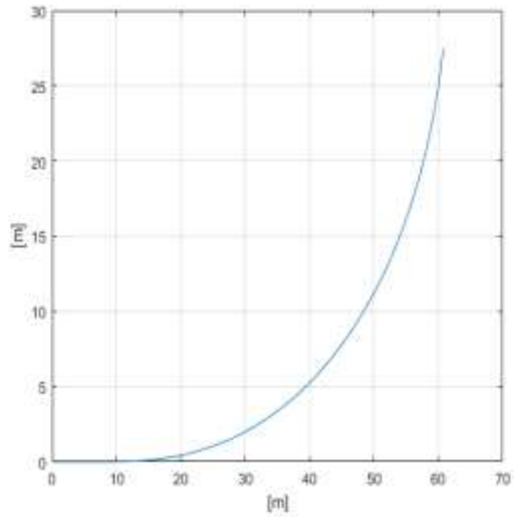

Fig.6. Graph of vehicle trajectory

IV.CONCLUSION

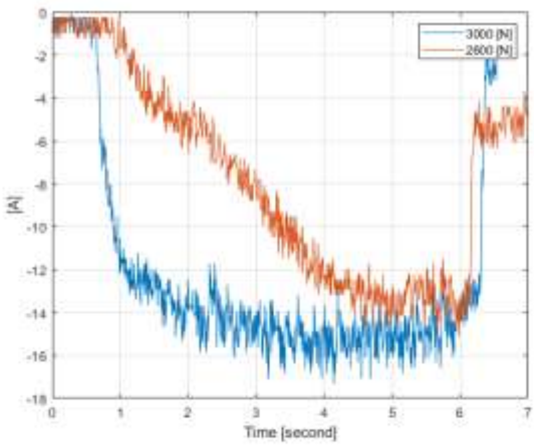

Fig.18. Graph comparing the electric current of the case of driving left to 90 degrees

The graph shows the electric current of the EPS electric motor (TOYOTA VIOS) with 2 load cases set at 2600 [N], and 3000 [N]

From the comparison graph above, we see in the first seconds that in the first 2 seconds, the amperage of case 3000 [N] has the maximum value of about -14A and the smallest is still the case 2600 [N] about -6A (the value of the negative current is caused by driving to the left. In general, the case of two loads acting on the largest vehicle so the effective current reaches the value greater than the other case is 2600 [N].

This is also one of the basis for designing the controller of the EPS steering system on TOYOTA VIOS

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