Improved Model of Electric Power Steering Control System

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Abstract- This paper presents the improved Model of Electric Power Steering (EPS) system. As Electric Power Steering has more advantage as compared with the Hydraulic Power Steering (HPS) system, such as less number of component is required so that weight of the steering will be less, does not required fuel for its operation, so that efficiency of the vehicle will be more. This paper presents with the improved model of micro-controller based EPS control unit. The main aim is to maintain the minimum oscillation during the turning of the vehicle. The proposed work has been simulated and implemented with MATLAb/Simulink 2014a.

Keywords- Electric Power Steering (EPS), Hydraulic Power Steering (HPS), EPS control unit, Assist torque (Ta), Driver Torque (Td), Motor Torque (Tm), Proportional drive control(PD-control).

1. INTRODUCTION

In any vehicle steering will be the most important part. Direction of the vehicle depends on the steering system. Proper working of the steering system is very important. In the earlier days, when vehicle came into market manual steering is used, where the entire torque is applied my driver itself. So that it becomes difficult for the driver to take a turn. Then power steering came into picture, basically there are 2 classification of power steering. They are

i) Hydraulic Power Steering System (HPS)

ii) Electric Power Steering System (EPS)

Hydraulic Power Steering System work by using an hydraulic system. It contains a hydraulic pump driven by belt, cylinder, reservoir and a driver control mechanism (rack and pinion). Both the wheels are connected to the rack with two separate tie rods on each end.

Electric Power Steering system requires less number of components as compared with the Hydraulic power Steering system. As it does not required fuel for its operation, hence the efficiency of the vehicle will be more. So EPS is used in many electric vehicles. In the HPS the steering column is driven by a hydraulic pump which takes the power from vehicle engine. The power is delivered to the steering system continuously irrespective of vehicle taking a turn or vehicle is moving straight on road, so lots of power gets wasted. If HPS is replaced by EPS, this loss can be minimized. EPS takes the power from battery.

2. EPS SYSTEM MODEL

Fig. 1 EPS System Model

Figure 1 represents the EPS system model. The components of EPS system are: steering wheel, input shaft mounted with a sensor torque to measure torque from steering wheel, an ECU (Electronic Control Unit) and motor. Function of the motor is to provide the assist torque, which results in the reduction of driver's torque. During turning of the steering wheel, a specific amount of torque must be applied and after completion of the turning of the vehicle, steering must return to its center place smoothly without oscillation and overshoot.

Assist torque curve is a dis-continuous parameter, according to the assist torque value it is divided into three parameters as

a. Straight Line Type
b. Broken Line Type
c. Quadratic Type

According to the different analysis of comfort in driving. The Straight Lin Type curve is commonly used and other two types classified based on the Straight Line type. Assist torque curve is divided into three intervals that has similar values weather steering rotates clock wise or anti clock wise and different values for different speed of the vehicle.

Equation for the straight line type structure of EPS is given by equation 1.

$$Tm(Td,V)=\begin{cases} 0\ 0 \le Td < Tdo \\ Kv(V) \times (Td - Tdo)\ Tdo \le Td < Tmax \\ Tmax\ Td \ge Tdmax \end{cases}$$

(1)

With:

T_m = Motor providing the assist torque

T_d = Steering torque

T_{do} = Steering wheel torque, when maximum power is supply by the motor.

$T_{d\,max}$ = Torque from steering wheel, when motor supplies the maximum power.

$K_v(V)$ = Coefficient of assist torque as a car's speed function.

T_{max} = Motor providing the maximum assist torque

T_{do} and $T_{d\,max}$ are connected to the driver's effort. As a result, their parameters may be calculated via experiments, according to steering portability and road feel

3. BLOCK DIAGRAM

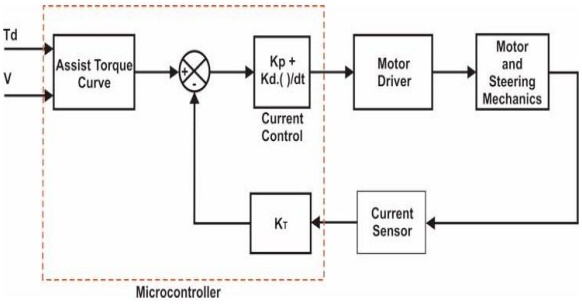

Fig. 2 Schematic Diagram of a Model EPS Control Unit

Above figure represents the schematic diagram of an EPS control unit. Vehicle speed and driver torque forms the input to the controller. An oscillation will be present in steering torque .Tuning the system will minimize the oscillation. As the driver applies the torque, the controller will give a voltage to motor. According to that motor will rotate any provide assist torque. An difference between actual motor torque and required motor torque create an error signal will be produce, and that signal through proportional integral controller to supply voltage and control to the motor (Permanent Magnet Synchronous Motor)

4. Simulation Diagram

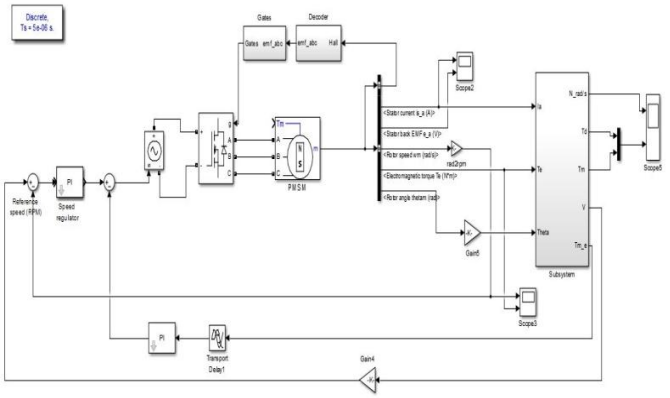

Fig 3: Simulation Diagram

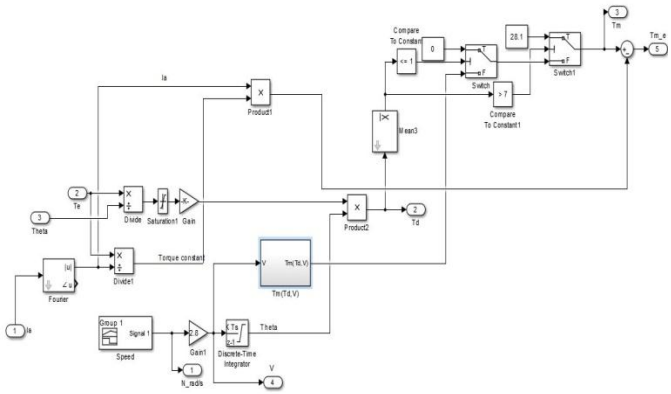

Fig 4: Sub-System of Simulation Diagram

Using MATLAB/Simulink 2014a, a simulation model is made and experiment results are carried out at different speed. Driver torque T_d and motor assist torque T_m is checked. The obtained are shown simulation result for different speed. This Electric Power Steering will provide comfort in driving with reduced oscillation. Gain of the controller can be changed based upon the real time experimental result. For simulation it is taken as 1.547.

5. SIMULATION RESULTS

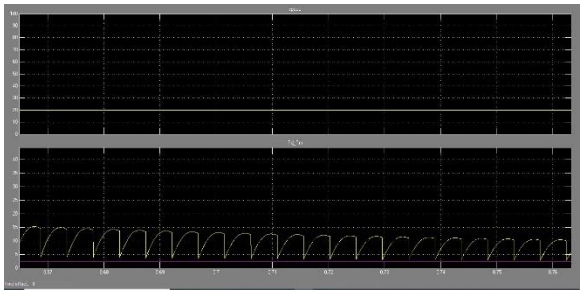

Fig. 5: Above figure 5 represent the driver torque T_d and assist torque form motor T_m, when vehicle is moving at 20kmph.

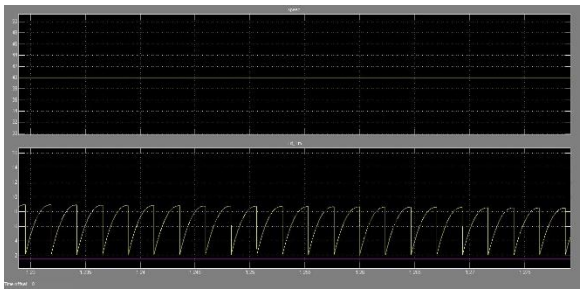

Fig. 6: Above figure 6 represent the driver torque T_d and assist torque form motor T_m, when vehicle is moving at 40kmph.

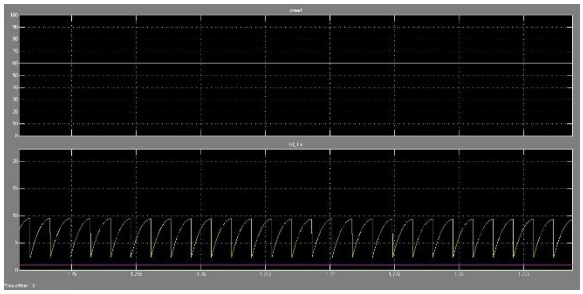

Fig. 7: Above figure 7 represent the driver torque T_d and assist torque form motor T_m, when vehicle is moving at 60kmph.

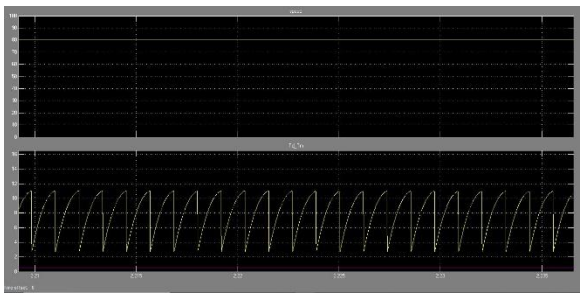

Fig. 8: Above figure 8 represent the driver torque T_d and assist torque form motor T_m, when vehicle is moving at 80kmph.

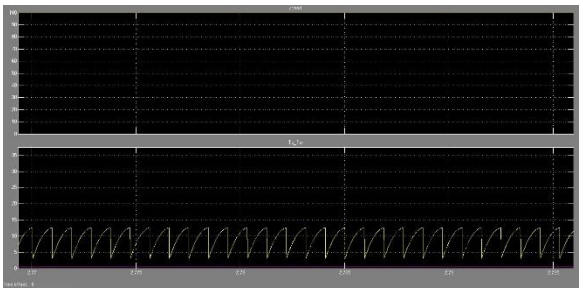

Fig. 9: Above figure 9 represent the driver torque T_d and assist torque form motor T_m, when vehicle is moving at 100kmph.

As seen from the above graphs, as the speed of the vehicle increases the assist torque provide by the motor will decreases. At the lower speed driver torque and the assist torque will be higher. Improved design of microcontroller of the EPS control unit will lead to less driver torque at lower speed of the vehicle and minimized the torque fluctuation due to reaction from the wheel of the vehicle. Such that force required by the driver will be less and hence driver feels comfortable while driving.

6. CONCLUSION

This paper represents the implementation of Electric Power Steering (EPS) in both the vehicles (Electric vehicles as well as non-electric vehicles). This model reduced the oscillation produced in the steering system as well as comfort in driving.

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