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HARDWARE-IN-THE-LOOP SIMULATION FOR AUTOMATIC RACK AND PINION STEERING SYSTEM

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Hardware-in-the-loop Simulation for automatic rack and pinion steering system

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Abstract. Vehicle handling behaviour is much influenced by the performance of steering system and its mechanism. In this paper, a Hardware-in-the-loop Simulations (HILS) test rig has been set up with Matlab XPC TARGET environment, LVDT and rotary encoder sensors installed onto actual rack and pinion steering mechanism, for data measurement at various steering angle. It can manipulate the steering mechanism with various control structure, decrease time with real experiment and trial risk as well as improve development efficiency. Results from experimental model demonstrate a linear pattern occurred from maximum lock-to-lock steering wheel angle and it is closely follow the sine input trend through HILS experiment with acceptable error.

Introduction

Automatic steering system is merging into vehicle model more focuses on lateral control which concerned with lane keeping, lane changing and turning [1]. It involves the driver looking ahead at the intended path relative to the car and somehow processing the preview information and the current position data to yield the steering wheel or control inputs needed to make the car follow the desired path. Steering linkages play a very importance role in manoeuvring of a vehicle. Amongst the steering linkages, the rack and pinion steering linkage is the most popular and widely used in automotive passenger vehicle [2-5]. This linkage consists of two steering arms (wheel knuckle), two tie rods end as well as a rack and pinion. In future automatic steering system, the electric power steering is a vital component for control and improving vehicle handling and stability [6, 7].A traditional method required long time and yet spend plenty of trial expenditure to test the new algorithm especially in steering system. Moreover the real test is extremely dangerous for test in vehicle under high speed condition. Therefore, it can be useful as a development tool since it more repeatable and cost effective than a full in-vehicle test [8, 9].

Hardware-in-the-loop- Simulation (HILS) test setup

A typical Hardware-in-the-loop simulation (HILS) system designed consist simulation and analysis platform (Host pc), man-machine interface (Target pc), controller and real time sensors. Fig. 1 a) shows the HILS structure developed for automatic steering system.

The relationship between rotation of pinion and displacement of rack can be defined by perform an experimental on actual rack and pinion steering system through HILS. The front tire is set in normal position, and Linear Variable Differential Transformer (LVDT) sensors used for calibration. The angular sensor collect the real time angle of the steering wheel .As a driving device, the DC motor as an actuator to generate desired steering wheel angle turn left or right respectively.

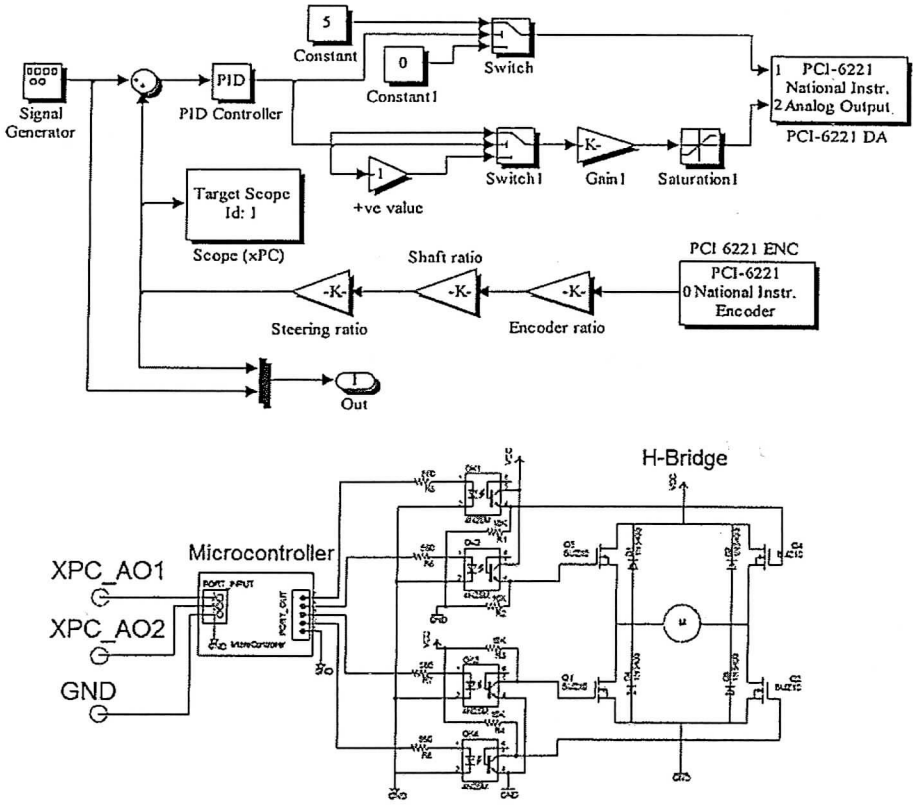

Figure 2 a) position controller develop for HIL via XPC target. b) DC motor circuit

The Output from XPC Target will be analog output voltage that used as input current driver motor circuit. The current driver consists of MOSFET H bridge circuit for DC motor and ATMEGA 32 microcontroller. The Microcontroller will receive 2 inputs from XPC. The first one is for reverse forward switch in H bridge and the second one is used for motor speed & torque analog signal that will be converted by microcontroller to generate PWM signal for DC motor.

Experimental results

The position tracking test for DC motor is performed to ensure the motor could follow the desired steering input. When steering wheel is turn by giving input signal, the DC motor tend to follow the desired signal by rotating the pinion angle which than pull or push the tie rod end to turn the tires to the desired angle.

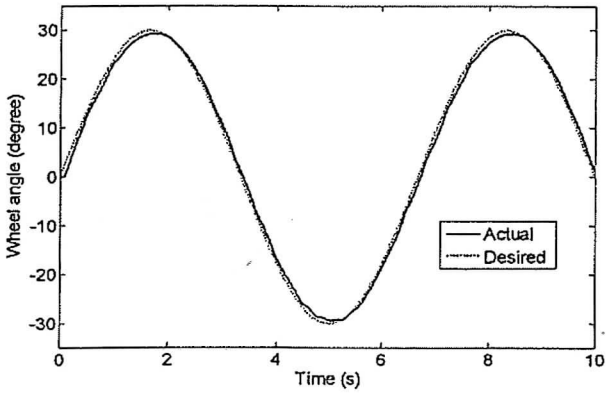

Figure 3. Positioning tracking for DC motor

To simplify the relationship between the rack and pinion steering mechanisms, the rack displacement is assumed directly proportional to the pinion rotational angle with relationship Y= 0.00005X - 0.001. From automatic steering system model, the correlation between displacement of rack and wheel angle can be defined as shown in Fig. 5 b. The maximum length of 60.5 mm will provide 30.5° tire angle from longitudinal axis.

Conclusion

The Hardware-in-the-loop Simulation (HILS) for automatic steering system have developed in this paper where provide a better tool to study the steering control system. The relationship of steering rack displacement and pinion angle is achieved by perform experimental measurement for actual rack and pinion steering linkage system. A result from sine input simulation demonstrates a good performance where it's closely follows the trend occurred through HILS experiment with acceptable error. The relation between rack displacement can be assumed directly proportional to the pinion angle with Y = 0.00005X – 0.001. The maximum rack displacement of Malaysia passenger car from normal position is 60.5 mm that provide maximum tire angle 30.5°.

Acknowledgement

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