Modeling and control of an electric power steering system

Nguyen, Kien-Trung、Lin Hai-Ping

E-mail: 9706983@mail.dyu.edu.tw

ABSTRACT

Power steering is now standard equipment on almost all vehicles. Power steering has evolved over the years from a simple control valve and external hydraulic ram on the regular steering mechanism to integrated rack and pinion systems with variable assist under different driving conditions. Recently, Electric Power Steering (EPS) is making inroads into the marketplace and increasingly applied due to several its advantages, example simplicity, fuel consumption and logistical benefits. Electric Power Steering adopts the motor to offer helping driver directly by certain assist torque. The amount of this assist torque is automatically controlled by the EPS system electric control unit (ECU) and depends on the vehicle speed and steering, wheel torque, angular position and turning rate, etc. The electric steering unit is still connected to the steering wheel by a steel shaft, but this is only used to provide input to the sensor during normal operation. If the steering module detects a fault, it shuts down the electric motor and the steel shaft allows the vehicle to still be steered. This thesis discussed the structure, operating principle, characteristics, and simulation of EPS system. The parameters for this simulation are from experiment on real system. And results of the simulation are compared with previous studies. The author develops a new control algorithm for an EPS system and designs an ECU for experimental system to validate that control algorithm. This ECU communicates with extended device, such as Angle Sensor, Torque Senor, to gets input signal via the vehicle's Controller Area Network (CAN) providing accurate, real-time data to other systems on the vehicle and can enable a high level of integration with other on-board systems for improved vehicle control. ECU controls the assist motor through H bridge circuit to produce assist torque for driver.

Keywords : Electric Power Steering, angle sensor, torque sensor, assist torque, H bridge circuit, control algorithm, CAN.

Table of Contents

REFERENCES

[1] Integrated Publishing " Construction Training and Maintenance Manuals- Chapter8 Automotive Chassis and Body- http://www.tpub.com/content/construction/14273/index.htm [2] Auto Zone " Suspension and Steering " - http://www.procarcare.com/icarumba/resourcecenter/encyclopedia/icar_resourcecenter_encyclopedia_suspsteer2.asp [3] Inner Auto Part " Steering system " - http://www.innerauto.com/Automotive_Systems/Steering_And_Suspension_System/Steering_Wheel/ [4] Matthew Beecham- " RESEARCH ANALYSIS: A review of electric powersteering systems " - http://www.just-auto.com/article.aspx?ID=92107 [5] Delphi " Electric Power Steering " - http://www.nav200.delphi.com/manufacturers/auto/other/steering/electric/eps/ [6] Auto speed " Electric Power Steering - Swapping hoses and pumps for electricmotors and electronic control " http://www.autospeed.com/cms/A_0484/article.html [7] Jim Kerr " Electric power steering is here to stay " - http://www.canadiandriver.com/articles/jk/030820.htm [8] " Toyota MR2 Electro Hydraulic Power Steering " - http://www.cameronsoftware.com/ev/EV_PowerSteering_Install.html [9] " Delphi " Electric Power Steering " - http://delphi.com/news/pressReleases/pressReleases_2005 [10] " How Car Steering Works " - http://auto.howstuffworks.com/steering1.htm [11] OPTO-PLUS – " Principles of Steering Geometry " - Autek Industri A/S, http://www.OPTO-PLUS.com [12] " Basic wheel Alignment " – MOTOR, pp 43 – 46, June 2002 http://www.niumotorsports.com/Learn/Suspension/ [13] Julian Edgar " Modifying Electric Power Steering " - http://www.autospeed.com/cms/A_2390/article.html [14] Ji-Hoon Kim and Jae-Bok Song, " Control logic for an electric power steeringsystem using assist motor, " Science Direct journal, Mechatronics, pp.447-459,April 2002.
[15] Toyota " Electric Power Steering, " Technical Manual – www.autoshop101.com/forms/Hybrid17.pdf [16] Roy McCann, " Variable Effort Steering for Vehicle Stability EnhancementUsing an Electric Power Steering System, " SAE Paper, No.2000-01-0817.
[17] Willy Klier - ZF Lenksysteme GmbH, " Active Front Steering (Part 1):Mathematical Modelling and Parameter Estimation, " SAE Paper, No.2004-01-1102.
[18] Paul Yih, " Steer-By-Wire - Implications For Vehicle Handling And Safety, " Lecture, December 2004.
[19] " What is Four Wheel Steering? " - http://www.wisegeek.com/what-is-fourwheel-steering.htm [20] " CAN Bus " http://www.interfacebus.com/Design_Connector_CAN.html#a [21] Jizhong Xiao " Motors and Control " - Department of Electrical EngineeringCity College of New York, 2001.
[22] Wikipedia, the free encyclopedia " Pulse-width modulation " - http://en.wikipedia.org/wiki/Pulse-width_modulation [23] National Instruments " NI USB-847x CAN Interfaces " - http://sine.ni.com/nips/cds/view/p/lang/en/nid/203382 [24] D.Iles-Klumpner, M.Risticevic, H.W.Hartkorn and G.Lahm, " Electric ActuationTechnologies for Automotive Steering Systems, " SAE Paper, No.2005-01-1275.
[25] A. Badawy, J. Zuraski, F. Bolourchi, and A. Chandy, " Modeling and analysis ofan electric power steering system, " SAE Paper, No. 982878, November 1998.
[26] Walid A. H. Oraby " Lateral Dynamic Response of Vehicle Equipped withElectric Power Steering System " [27] Du-Yeol Pang , Bong-Choon Jang and Seong-Cheol Lee, " Steering WheelTorque Control of Electric Power Steering by PD-Control, " ICCAS Paper, 2005.
[28] Dugoff, H., Fancher, P.S., Segel, L., "An Analysis of Tire Traction Propertiesand Their Influence on Vehicle dynamic Performance," SAE Paper, No.700377,1977.
[29] Masahiko Kurishige, Shunichi Wada, Takayuki Kifuku, Noriyuki Inoue, RyojiNishiyama and Shigeki Otagak, " A New EPS Control Strategy to ImproveSteering Wheel Returnability, " SAE Paper, No.2000-01-0815.
[30] CHEN Long, NIU Li-min, ZHAO Jing-bo, JIANG Hao-bin, " Application ofAMESim & MATLAB Simulation on Vehicle Chassis System Dynamics, " IEEE Paper, No.426995.
[31] Yasuo Shimizu and Yoshihiro Oniwa, " Control for Moment of Motor Inertia onEPS, " SAE Paper, No.2006-01-1179.
[32] Masahiko Kurishige, Takayuki Kifuku , Noriyuki Inoue, Susumu Zeniya andShigeki Otagaki, " A Control Strategy to Reduce Steering Torque for SationaryVehicles Equipped with EPS, " SAE Paper, No.1999-01-0403.
[33] Xiang Chen and Xiaoqun Chen, " Control-Oriented Model for Electric PowerSteering System, " SAE Paper, No.2006-01-0938.
[34] A. Emre Cetin, Banu Sinanoglu, Serdar Gungor and Ahmet Kanbolat, " Compliant Control of Electric Power Assisted Steering Systems, " SAE Paper,No.2005-01-3535.
[35] Frederick F.Ling " Vehicle Dynamics and Control " - Springer 2006.
[36] Thomas D.Gillespie " Fundamentals of Vehicle Dynamics " SAE International,March 1992