ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 6, April 2017

Control Of Friction in Power steering

Athira Vijayan
Mohandas College of engineering
Trivandrum,india
athirahari111@gmail.com

Renjitha G Nair
Mohandas College of engineering
Trivandrum,india
renjitha@gmail.com

***Abstract*—Frictional effects make dangerous problems in electric power steering systems. It produces severe accidents in foreign countries due to the high velocity. The driver cannot get accurate control over the steering while travelling through the road at high speed.The electric power steering system consists of an assist motor which can provide the torque to cancel the frictional undesired effects. This paper presents a hardware demonstration to get controllable steering effects and to avoid the consequences of friction on the road.**

***Keywords*—Hardware demonstration ; Circuit diagram description; Friction compensation; Electric power steering**

I. INTRODUCTION

Frictional conditions are varying from region to region. Its decrement and increment makes accidents while driving. The hydraulic power steering system is usually used in many vehicles which have some limitations. Power loss is very high in the case of hydraulic systems compared to electric power steering systems.

Electric power steering systems consist of an assist motor. It has a main role in reducing the fatigue of the driver. Additional torque, which depends on the region is required to cancel the effect of friction.

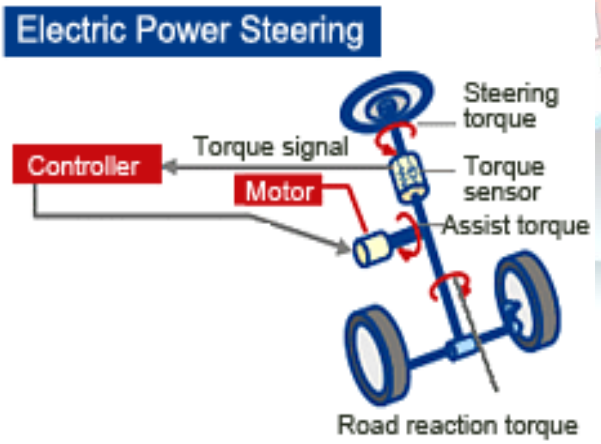

Fig.1. Column assist EPS

Column assist, electric power steering system is shown in fig. 1. It consists of a steering wheel, assist motor and tires. Torque sensor is placed to sense the torque. Assist torque reduces fatigue of the driver. Road reaction torque is acting from the road. That means same 30 will not get at the tires. It may be above 30 or below 30 according to the region.

Friction is a dynamic change which varies in every time. So it is very difficult to control the torque. A torque sensor and ECU providethe proper torque at assisting motor. A few years ago driver faced so many problems when go for a long drive. The effort makes quick tiredness and also made so many health problems. So an efficient method is provided to reduce these problems and to recover from health problems. This paper is organized as a hardware demonstration in section II, Components details in section III, Circuit diagram in section IV, Result in section V , finally conclusion in VI.

II. HARDWARE DEMONSTRATION

To demonstrate the compensation in friction , we can use a microcontroller, rotary encoder, friction sensor, LCD display and finally a servo motor. Each step of the process is given below:

Step 1:- Rotary encoder can be used to provide the input to the microcontroller. Same angle that is given to the rotary encoder should get at the tires by applying additional torque.

Step 2: - Microcontroller process the information which is coming from the rotary encoder, then the processed information is given to the servo motor driver.

Step 3: - Servomotor rotate according to the input given to the rotary encoder. Servo driver is also attached to the servo motor.

Step 4:- LCD displays showing actual angle and the angle required to compensate the friction.

III.COMPONENTS DETAILS

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 6, April 2017

rotary encoder input. It consists of analog to digital converter. By using ADC the analog inputs are converted into the digital outputs. The pin diagram of microcontroller is given below.This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications

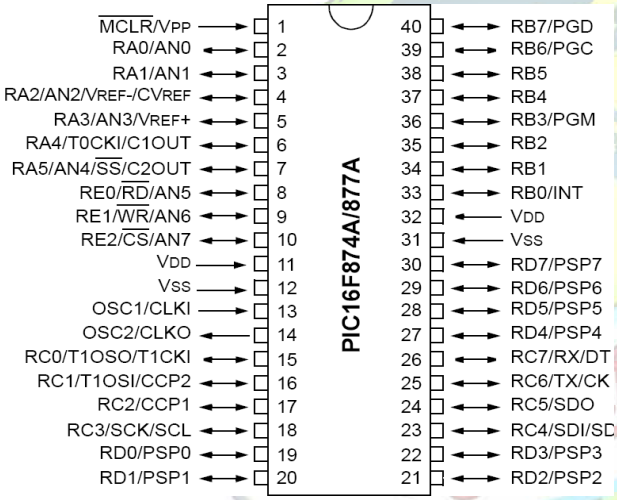

Fig.2. Pin diagram of microcontroller

B. Rotary Encoder

It can be considered as the steering wheel. We want to get the same angle given to the optical rotary encoder at the tires.

There are different types of encoders such as magnetic encoders, optical encoder, absolute encoder etc. Optical encoder is chosen here to provide input.

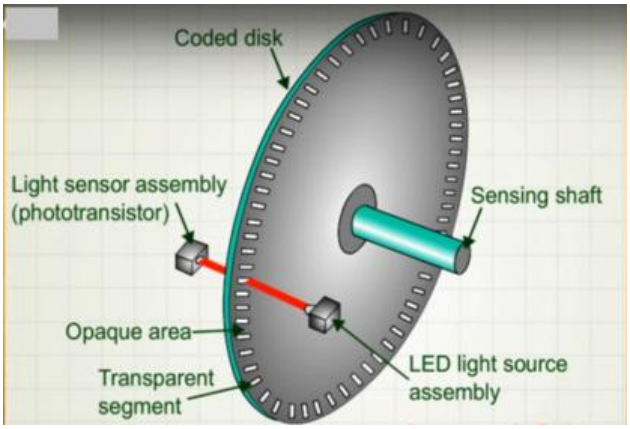

Fig.3.Rotary encoder working principal

Disc is mounted on a shaft. There is a LED light source to produce the light. Rotary disc has both opaque and transparent segments. Light passes through both the regions. Phototransistors are mounted on the other side of disc. Rotor having this type of optical patterns converts the rotating signals into digital signal.

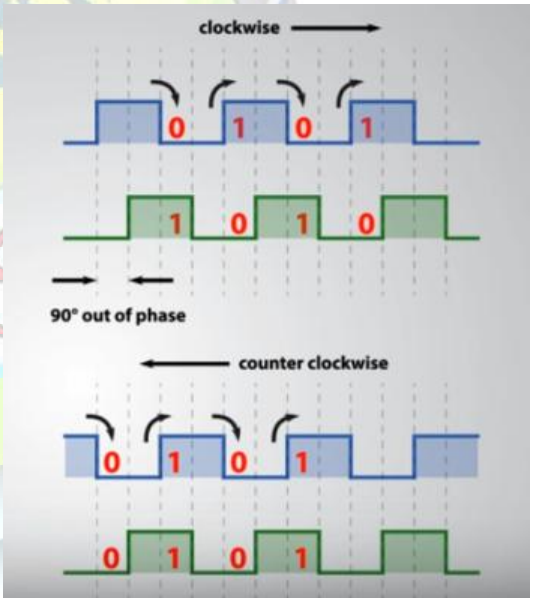

Fig.4. Waveforms of rotary encoder

The waveforms for clockwise and anticlockwise rotation are given above. The signals are changing in each rotation. The analogue rotary inputs are also converting into the digital inputs. Optical rotary encoder has many advantages like high reliability, resolution, simplicity in construction. So this component can be used in this hardware demonstration. [7] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 6, April 2017

unsettling influences.

C. Friction Sensor

Friction sensor can be used to sense the friction of tires. The characteristic curve showing the resistance and and friction force is shown in below:

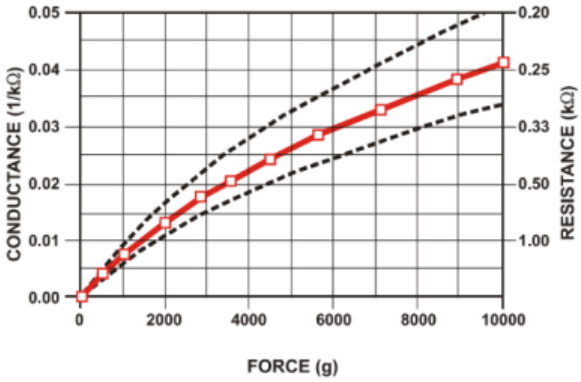

Fig.5. Characteristics curve of friction sensor

When we apply a force on friction sensor, its resistance varies with the input. Force increases with increasing resistance, but conductance decreases with force. This increased resistance converts to voltage by using a force to voltage converter.

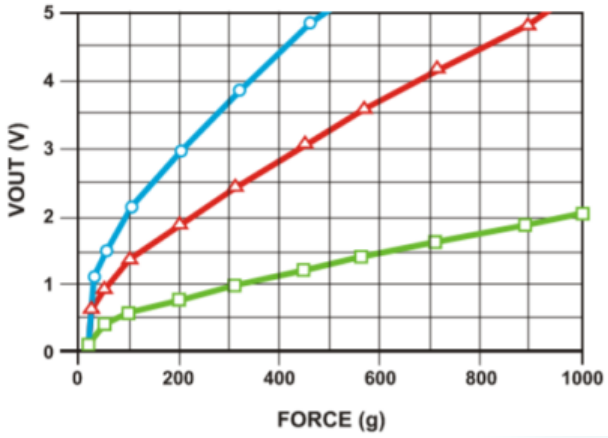

Fig.6. Voltage versus Force

This figure shows the variation of voltage with respect to the force applied at the frictional force.

D. Servo Motor

Servo motor is chosen as tire. It rotates according to the inputs. Servo driver is also attached with this motor. The servo motor is basically a DC motor. But it has some special features. Servo motor consists of a potentiometer, a DC motor and a gear arrangement. When the motor starts to rotate, there will generate an error signal. According to PWM signal generated by microcontroller can be used to rotate the servo motor as shown in figure.

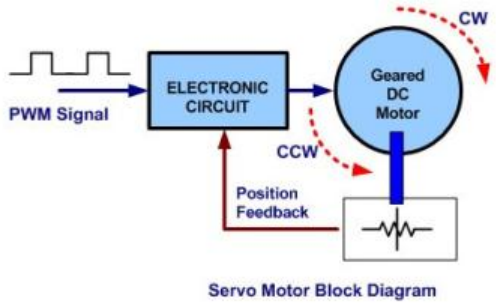

Fig.7. Servo Motor working principal

E. LCD Display

Here LCD display shows the actual value and compensated values. We can identify the value that is used to get same angle of rotary encoder at tires. Frictional effects can be avoided by giving the required amount of torque. 16 *2 LCD display is used here to show values.

F. Power Supply

Two type of IC is provided. One is used to provide 12V supply and the other one produces 5V supply. Both are require to microcontroller and motor section to work. A rectifier circuitry is also provided for converting AC supply to DC supply. 230V AC supply is given to AC transformer.

IV. CIRCUIT DIAGRAM

The circuit diagram of entire hardware is given below.Microcontroller is connected with an oscillator which provide clock for working. Capacitors are provided here to avoid ripples. There is a push button to reset the program.
Friction sensor is connected with microcontroller to sense the friction. Two other pushbuttons are also connected with the microcontroller to provide clockwise and anticlockwise rotations. Servo motor and servo driver are also connected with microcontroller.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 6, April 2017

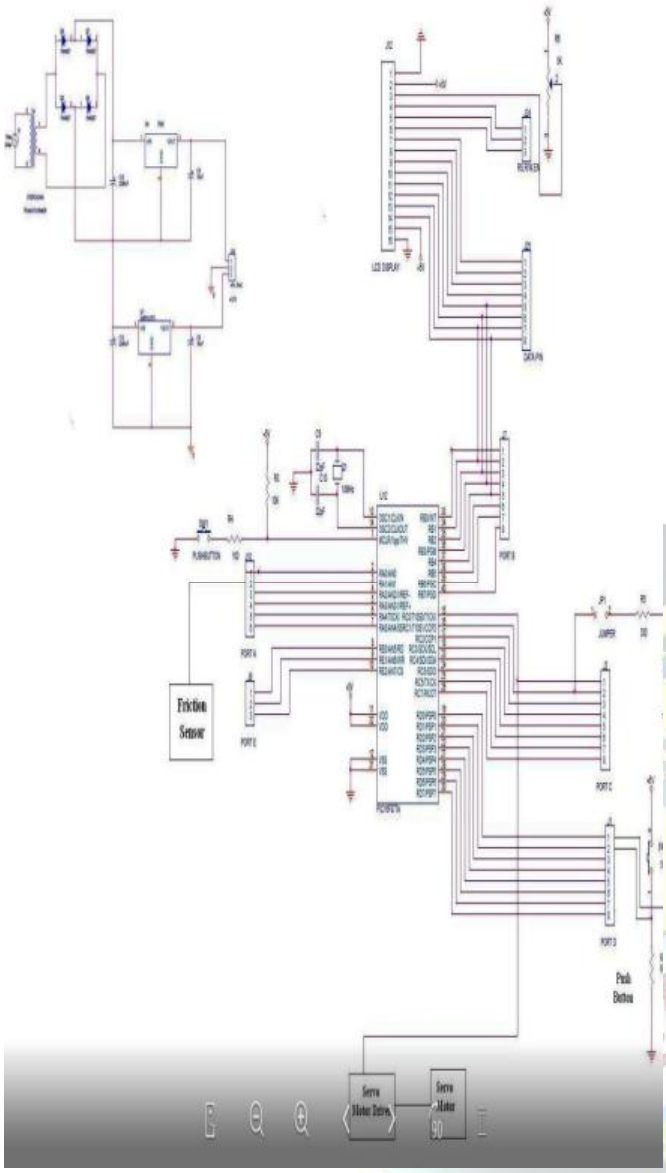

Fig.8. Circuit diagram

V. RESULT

When we rotate the rotary encoder, same angle will get at the servo motor by compensating the frictional force. By using this technique the driving will be very easy through any regions. Each component shows the efficiency and the accuracy of the work. Each values used for compensation is also shown in LCD display. In final result of this demonstration we can see servo motor rotates with the rotary encoder by compensating friction.

VI. .CONCLUSION

Compensation of friction in electric power steering system is very difficult. Here illustrated a technique to compensate the

REFERENCES

[1] C. Morton, C. M. Spargo, and V. Pickert, "Electrified hydraulic power steering system in hybrid electric heavy trucks," IET Elect. Syst. Transp., vol. 4, no. 3, pp. 70–77, Sep. 2014.
[2] H. Miyazaki, "Technical trends in steering systems," in Proc. 7th JFPS Int. Symp. Fluid Power, Toyama, Japan, Sep. 2008, pp. 133–136
[3] A. Badawy, J. Zuraski, F. Bolourchi, and A. Chandy, "Modeling and analysis of an electric power steering system," in Proc. Steering Suspension Technol. Symp., 1999, paper 1999-01-0399.
[4] J. T. Illán, V. Ciarla, and C. C. de Wit, "Oscillation annealing and driver/tire load torque estimation in electric power steering systems," in Proc. IEEE Int. Conf. Control Appl., Denver, CO, USA, Sep. 2011, pp. 1100–1105. [5] A. T. Zaremba, M. K. Liubakka, and R. M. Stuntz, "Vibration control based on dynamic compensation in an electric power steering system," in Proc. 1st Int. Conf. Control Oscillations Chaos, vol. 3. St. Petersburg, Russia, Aug. 1997, pp. 453–456.
[6] R. C. Chabaan and L. Y. Wang, "Control of electrical power assist systems: H∞ design, torque estimation and structural stability," JSAE Rev., vol. 22, no. 4, pp. 435–444, Oct. 2001.
[7] Christo Ananth,"A NOVEL NN OUTPUT FEEDBACK CONTROL LAW FOR QUAD ROTOR UAV",International Journal of Advanced Research in Innovative Discoveries in Engineering and Applications[IJARIDEA],Volume 2,Issue 1,February 2017,pp:18-26. [8] T. Kifuku and S. Wada, "An electric power-steering system," Mitsubishi Electr. Adv., vol. 78, pp. 20–23, Mar. 1997.
[9] T. Tamura, A. Maroonian, M. Higashi, and R. Fuchs, "Modeling and simulation for the dynamic analysis of an electric power steering," in Proc. 3rd Int. Munich Chassis Symp., Munich, Germany, Jun. 2012.
[10] T. Tamura, A. Maroonian, and R. Fuchs, "Active compensation of friction in electric power steering," in Proc. FISITA, Beijing, China, Nov. 2012, pp. 213–225.
[11] A. Marouf, M. Djemai, C. Sentouh, and P. Pudlo, "A new control strategy of an electric-power-assisted steering system," IEEE Trans. Veh. Technol., vol. 61, no. 8, pp. 3574–3589, Oct. 2012.
[12] Z. He and M. Gu, "Dynamic research on control strategy of electric power steering system," in Proc. SAE World Congr., 2012, doi: 10.4271/2012-01-0212.
[13] M. Heger and A. Heilig, "Verfahren zum Betrieb eines Lenksystems in einem Kraftfahrzeug," German Patent DE102007006232 A1, Aug. 14, 2008. [14] S. Endo, "Control unit for electric power steering apparatus," U.S. Patent 6744232 B2, Jun. 1, 2004.
[15] H. Olsson, K. J. Åström, C. C. de Wit, M. Gäfvert, and P. Lischinsky, "Friction models and friction compensation," Eur. J. Control, vol. 4, no. 3, pp. 176–195, 1998.
[16] M. Salaani, G. Heydinger, and P. Grygier, "Experimental steering feel performance measures," in Proc. SAE World Congr., 2004, doi: 10.4271/2004-01-1074.
[17] J. Zhao et al., "Optimal design of off-center steering characteristics based on subjective evaluation," in Proc. FISITA, Maastricht, The Netherlands, Jun. 2014
[18] I. Kushiro, S. Koumura, and H. Kawai, "A new approach in the study on-center handling," in Proc. 9th Int. Symp. Adv. Veh. Control, Kobe, Japan, Oct. 2008.
[19] Y.-H. J. Hsu, S. M. Laws, and J. C. Gerdes, "Estimation of tire slip angle and friction limits using steering torque," IEEE Trans. Control Syst. Technol., vol. 18, no. 4, pp. 896–907, Jul. 2010.
[20] H. Chen, L. Zhang, and B. Gao, "Active return control of EPS based on model reference fuzzy adaptive control," in Proc. IEEE Int. Conf. Mechatronics, Istanbul, Turkey, Apr. 2011, pp. 194–199.
[21] A. Zaremba and R. I. Davis, "Dynamic analysis and stability of a power assist steering system," in Proc. Amer. Control Conf., vol. 6. Seattle, WA, USA, Jun. 1995, pp. 4253–4257

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Special Issue 6, April 2017

[23] R. Pastorino, M. A. Naya, J. A. Pérez, and J. Cuadrado, "X-by-wire vehicle prototype: A steer-by-wire system with geared PM coreless motors," in Proc. 7th EUROMECH Solid Mech. Conf., Lisbon, Portugal, Sep. 2009, pp. 1–3.

[24] M. E. Dohring, E. Lee, and W. S. Newman, "A load-dependent transmission friction model: Theory and experiments," in Proc. IEEE Int. Conf. Robot. Autom., vol. 3. Atlanta, GA, USA, May 1993, pp. 430–436.

[25] C. C. de Wit, H. Olsson, K. J. Åström, and P. Lischinsky, "A new model for control of systems with friction," IEEE Trans. Autom. Control, vol. 40, no. 3, pp. 419–425, Mar. 1995.

[26] H. Olsson, "Control systems with friction," Ph.D. dissertation, Dept. Automat. Control, Lund Univ., Lund, Sweden, 1996.

[27] M. Aberger and M. Otter, "Modeling friction in modelica with the Lund-Grenoble friction model," in Proc. 2nd Int. Modelica Conf., Oberpfaffenhofen, Germany, Mar. 2002, pp. 285–294.

[28] L. Lu, B. Yao, Q. Wang, and Z. Chen, "Adaptive robust control of linear motor systems with dynamic friction compensation using modified LuGre model," in Proc. IEEE/ASME Int. Conf. Adv. Intell. Mechatronics, Xi'an, China, Jul. 2008, pp. 961–966.

[29] G. Rill, Road Vehicle Dynamics: Fundamentals and Modeling (Ground Vehicle Engineering Series). New York, NY, USA: Taylor & Francis, Sep. 2011.

[30] F. Nenglian, P. Jiankun, Z. Xiaolong, Y. Jiawang, and T. Yanrong, "Research on electric power steering system simulation based on 3-DOF vehicle model," in Proc. Int. Conf

[31] T. Yang, "A new control framework of electric power steering system based on admittance control," IEEE Trans. Control Syst. Technol., vol. 23, no. 2, pp. 762–769, Mar. 2015.

[32] J.-H. Kim and J.-B. Song, "Control logic for an electric power steering system using assist motor," Mechatronics, vol. 12, no. 3, pp. 447–459, Apr. 2002.

[33] S. Amberkar, F. Bolourchi, J. Demerly, and S. Millsap, "A control system methodology for steer by wire systems," in Proc. SAE World Congr., 2004.

[34] D. Putra and H. Nijmeijer, "Limit cycling in observer-based controlled mechanical systems with friction," in Proc. Eur. Control Conf., Cambridge, U.K., Sep. 2003, pp. 312–317.

[35] D. Putra, H. Nijmeijer, and N. van de Wouw, "Analysis of undercompensation and overcompensation of friction in 1DOF mechanical systems," Automatica, vol. 43, no. 8, pp. 1387–1394, 2007.

[36] H. K. Khalil, Nonlinear Systems, 3rd ed. Englewood Cliffs, NJ, USA: Prentice-Hall, 2002.

[37] R. H. A. Hensen, M. J. G. van de Molengraft, and M. Steinbuch, "Frequency domain identification of dynamic friction model parameters," IEEE Trans. Control Syst. Technol., vol. 10, no. 2, pp. 191–196, Mar. 2002.

[38] D.-P. Liu, "Parameter Identification for LuGre friction model using genetic algorithms," in Proc. Int. Conf. Mach. Learn. Cybern., Dalian, China, Aug. 2006, pp. 3419–34

[39] M. Peden, R. Scurfield, D. Sleet, D. Mohan, A. A. Hyder, and E. Jarawan, "World report on road traffic injury prevention," World Health Organization, Geneva, Switzerland, 2004.