



REVIEW ON VEHICLE STEER-BY-WIRE TECHNOLOGY

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Abstract

There is much advancement in steering control technology with time. Steering –by-wire (SBW) system is the most modern and efficient technique, the steer-by-wire is replacing the traditional steering device of the vehicle in which the conventional steering system is replaced by electronic system. This paper focus to introduce steer-by-wire technology and methodology and angle sensor is preferred to have the good accuracy. Finally steer-by-wire technology is better than conventional system with respect to their advantage over conventional system.

Introduction

In recent years, important efforts have been undertaken in drive –by-wire technologies [1]. The application of the various kind of active and power steering system improve the steering angle's transfer characteristics, steering response characteristic and the stability of steering for vehicle[2-4]. According to the Institute of Electrical and Electronics Engineers (IEEE), in 2010 one in three cars will feature electronic steering [5].Recent advances in dependable embedded framework innovation, and also proceeding with interest for enhanced taking care of and passive and active safety improvements, have vehicle manufacturers and suppliers to actively pursue development programs in computer-controlled, by wire subsystems [6].Steer-by-wire system is a new power steering system appeared after the electrical power steering system(EPS),which gets away from the structural constraints of mechanical coupling, and has good riding and handling safety, energy saving the environment protection . The key technology of the steer-by-wire system is variable steering ratio control, road-feeling motor control and front wheel steering angle control [7]. However, nowadays the mechanical connect of the steering system leads that the steering performance has a strong non-linear time-varying characteristic with the change of speed, steering angle and the condition of the road adhesion. To make the vehicle drive along the expected path, drivers must adjust the characteristics of themselves frequently, so it would increase the mental and physical burden, and the non-professional driver would not adapt it especially [8]. So many researchers from different countries are studying the new technology for the steering system to solve the above problems [2]. The next requirement of the steer-by-wire system is that must be compact and non-intrusive to the driver, if the steering system is hidden and protected, which is less interface of testing from the driver and this will ensure safety[9]. With the advanced of technology, intelligence and automation become the new target in automobile driving. For this reason, specialists and researchers are focusing on the development of a new generation of steering system called Steering-by-wire(SBW) system[9]. The safe and stable control of a vehicle undoubtedly belongs to one of the most important requirements that relate to the vehicle's design and operation. Consequently, in the near future, so called steer-by wire systems could become the next stage in the control system development [10].

Generic steer-by-wire system description

A steer-by-wire system replaces the traditional mechanical linkage between the steering wheel and the road wheel actuator (e.g., a rack and pinion steering system) with an electronic connection [2,8,11-13,15]. The system provides precise control over the direction of the front wheel, moderates the correct amount of effort required to turn the front wheel, transmits feedback to the driver and absorbs intrusive shocks and bumps [15]. In Fig.1 the conventional steering system is shown. A conventional steering system Fig.1. typically consists of the hand wheel (steering wheel), the steering column, intermediate shaft, rotary spool valve (an integral part of the hydraulic power assist system), the Rack and pinion, and steering linkages [13,14]. The steer-by-wire implementation makes use of all the conventional steering system components except for the intermediate steering shaft, which is cut fifty-fifty with the upper end totally uprooted [5,10,13,16,17].SBW system eliminate the mechanical linkage between the steering wheel and the front wheels, and supplant them with electronic sensors, control system ,and actuator .

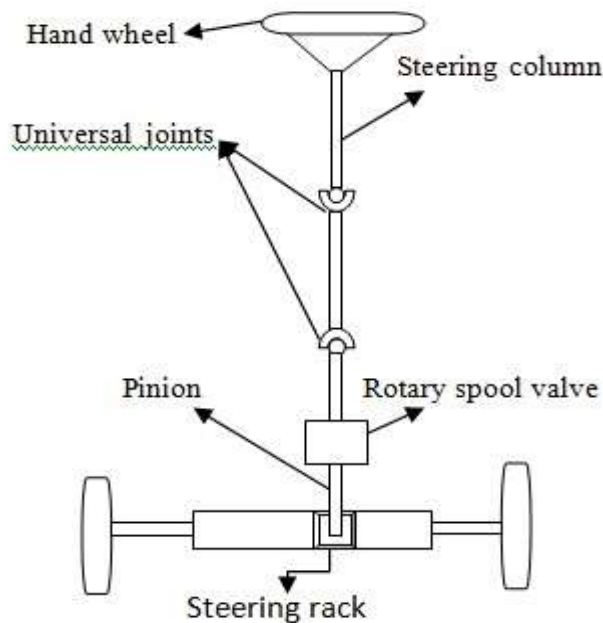


Fig.1. Conventio steering system

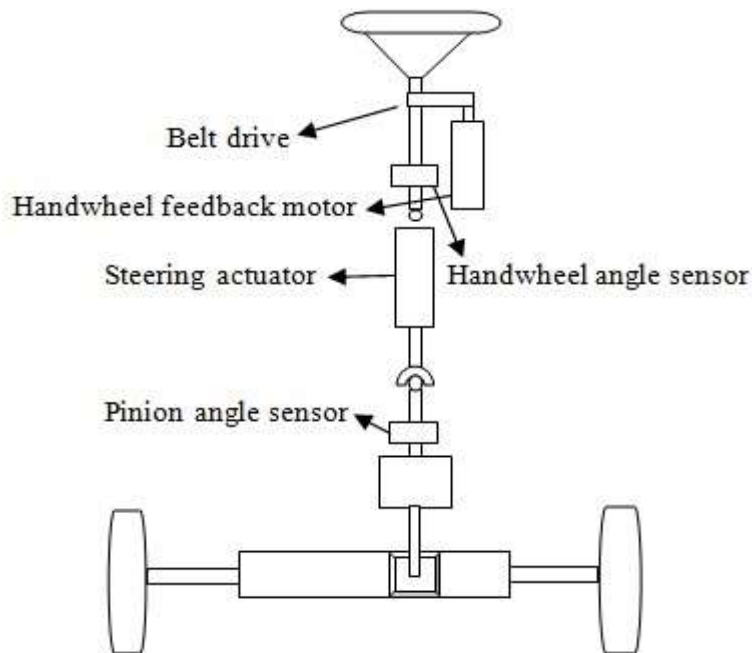


Fig.2. Steer-by-wire steering system

In addition to reducing the mass of the vehicle, the risk of injury to the driver due to the steering column entering the cockpit in the event of a frontal crash is reduced [15]. Releasing the rigid link between the steering wheel and wheels offers several possibilities of solving the vehicle’s higher active safety in combination with other electronic systems which have already been applied to vehicles [10]. Such a system would offer a number of advantages in terms of packaging, noise performance and occupant crash protection by eliminating the steering column. Drive-by-wire is the same basic concept implemented in the automotive field, with purely mechanical/hydraulic steering, braking, and engine control systems replaced by mechatronic (combining mechanical, electronic, and software elements) components. These components allow higher performance, extended functionality, and reduced fuel consumption resulting from both the control functions and weight reduction. Steer-by-wire is a



subset of the drive-by-wire concept. Conventional steering systems in automobiles use various forms of mechanical and hydraulic connections between the steering wheel and the steering valve, with the steering wheel rotation amplified by the steering valve to obtain a proportional articulation angle at the front wheels, therefore loss is more but in steer-by-wire technology no physical contact between steering and wheel. The steer by wire system is getting popular because of its efficient and accurate operations the efficient and accurate operation because it is control by automatically compare mechanical system.

History & development of steer-by- wire technology

The steer-by-wire technology first appeared in aviation, NASA's digital fly-by-wire aircraft in 1972 [13]. In history of steer-by-wire system there are three phase first proposal than prototype design and development of concept car with the steer-by-wire technology. In 1950s, TRW Automotive (Germany),and in 1969, Kesselman J. et al, have floated the nation of steer-by-wire technology, at that time the electronic and computer is was not so advanced but in 90s period ,rapid development in automatic and computer technology, the major company started the design of steer-by-wire system technology's prototype modal ,a number universities and technical institute s continued theoretical research on steer-by-wire technology. Bracbec and Maly [10] design a simulation modal of steer-by-wire technology and Paul [13] proposed a vehicle handling and safety in this paper he define the handling characteristic determined by physical properties and also define the condition of Under steering and Natural steering and over steering. Ying et al. observe a steering ratio for steer-by-wire based on simulation test [7]. Shuvra Das [16] offered a mechatronic modeling of steer –by-wire technology and giving a bond graph model and simulate it on 20-SimTM .Park et al. [18] proposed a method of steer-by –wire using semi-active actuator Markus [19] offered a solution of many design challenge in steer-by-wire technology.

Methodology

In the steer-by-wire technology system the mechanical link between steering and wheel is replaced by electronic link, which is shown in Fig.3 is shown here the mechanical and hydraulic system is replaced by the sensor and electronic devices. In Fig.5 the steering angle sensor is connected to a steering wheel and steering angle sensor also connected to feedback motor, angle sensor measure the angle of rotation of steering system, the angle sensor is a gadget that detects the orientation of the object is pointing in a certain direction and angle range [19]. The steering angle sensor measuring the steering wheel position angle rate of turn, there two types of angle sensor- Analog steering angle sensor and digital angle sensor [20]. It can be categorized as Contact type and non-contact type, the best category is non-contact because there are no mechanical connection between steering shaft and sensor therefore no mechanical loss. In market many types of angle sensor found in steer-by-wire technology we preferred CMOS chip angle sensor and magnetic rotary encoder sensor with a Membrane Coil ,it is a contact less and low cost sensor [21], but for good accuracy in measurement of angle, the angle sensor should be a small and capable of absolute angle detection for steer-by-wire technology, so we preferred single-chip CMOS magnetic rotator system, Commonly used angle sensor using magneto-resistive device or hall device combine with a multi-pole magnet have difficulty in meeting these requirements because they have large cylindrical structure and need a fine pitched magnetic scale therefore they cannot detect absolute angles ,the single –chip CMOS angle sensor overcome these disadvantage, and a another region of preferred this sensor because, in this sensor the developed chip can detect the absolute angle at a resolution of 10 bits per rotation, which leads to a promising solution for compact high-resolution rotary encoders, the single-chip CMOS angle sensor also win the Beatrice Winner Award for Editorial Excellence in International Solid State Circuit Conference (ISSCC) held in February-2005 [22]. The Permanent magnet at connect at the tip of a rotary shaft , when shaft rotate the Zero line position also rotate with that and we can measure the angle by

$$\theta = \tan^{-1} \left(\frac{\Delta y}{\Delta x} \right)$$

The angle calculator, calculate the angle and generate 10 bit output. This sensor is capable of detecting an absolute angle of ± 0.36 , since multiple sensor signal are statistically processed, The effect of signal noise is minimized, resulting in the improved angle detection accuracy, and in this technique the angle calculated by the position of Zero-line or there coordinates of two zero-crossing points , so this sensor is not much affected by the positional difference between the magnet and the sensor elements, the MAGFET magnetic sensor chip can be manufactured by a common CMOS process. As a result ,related circuit can be incorporated into the same chip, reducing manufacturing cost [23]. Due to these features the CMOS is a suitable angle sensor for the steering angle sensor The angle sensor measure the position of steering angle sensor ,it convert the rotation of steering into voltage and other parameter which can be readable by ECU(Electronic Control Unit), and it send the signal to steering actuator the actuator convert the input signal into the motion then its transfer the motion to the Pinion and rack system and this system control the Left-Right rotation of the wheel and an feedback is given to the feedback motor ,the function of it to control the rotation of in left or right direction according the speed of vehicle ,it has major role for controlling and maintain the accuracy and stability in steer-by –wire technology.

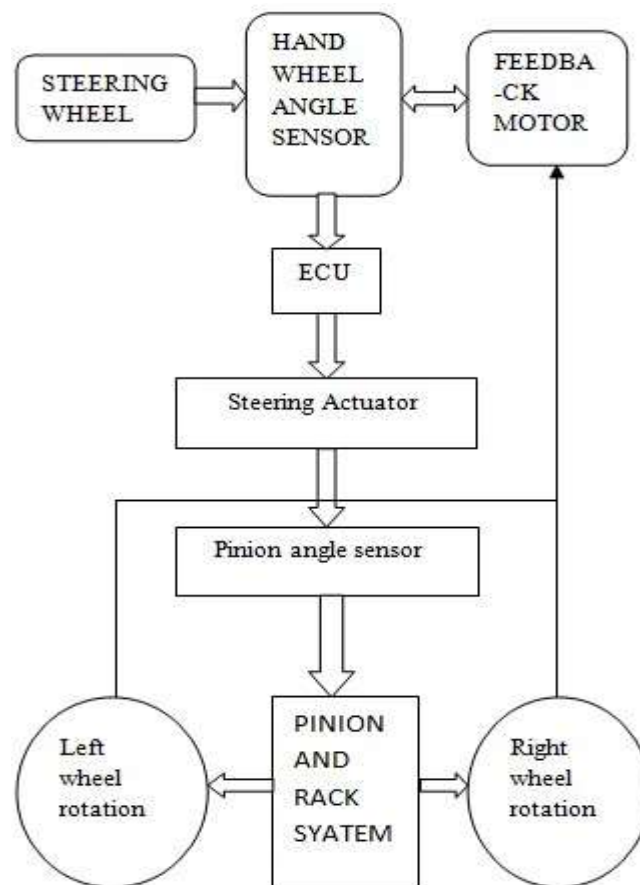


Fig. 3.

Advantage

1. Steer-by-wire is an advanced and purely electronic therefore it has a positive impact on environment-since no hydraulic pump is needed, no hydraulic fluid need to be disposed of and energy consumption can be optimized [19].
2. In steer-by wire technology the mechanical link is eliminate, therefore ,noise due to mechanical link is reduce as well as vibration are reduce [19].
3. It has selectable steering characteristics, and steering unit may be placed where needed, and it also help to making driver seat position variable.
4. Maintain the steer ratio according to the requirement, by varying the characteristics it is possible to generate a high angle high steering angle with only a small deviation of the steering device, and it is also possible to improve the handling of working machine at low speed.
5. In conventional vehicle a long metal rod in the steering column at a dangerous position and angle , its make the job of assembling the car much more difficult ,and it makes a danger for driver in the case of crash , these disadvantage are removed by steer-by-wire technology.
6. Steer-by-wire system eliminate the mechanical or hydraulic system there it makes the vehicles lighter because less space take by steer-by-wire technology compare to the conventional system.
7. It increase the features such as automatic lane keeping, park assist, and requirement and advanced vehicle dynamics, it may enable or enhance vehicle control technologies related to collision avoidance.

Conclusion

By using the steer-by-wire technology the performance of steering system can be increase and fixed the steering ratio according to the requirement. In this technology replace the mechanical link of steering system by electric connections, therefore it have many advantage over conventional steering system like fuel free, environment friendly, less space required, the position of steering system varying according to requirement, improve the handling at low speed .For increase the characteristics and features of SBW



the contact less angle sensor preferred because it is reduce the mechanical link losses and CMOS single chip angle sensor can measure the absolute angle at resolution 10 bit par rotation.

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