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X-By-Wire System and Lighting Control Using Can Protocol

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***Abstract*—The X By Wire system is a modern approach to automotive steering systems that offers several advantages over conventional mechanical setups. One of the key benefits of the X By Wire system is its optimized packaging, which allows for more efficient use of space in the vehicle. By eliminating the need for bulky mechanical parts and connecting links, the X By Wire system can free up space, reduce weight, and simplify the overall design of the vehicle.**

Another advantage of the X By Wire system is its modular control. The system uses a dual-motor configuration that is connected within the automotive electronics architecture. One of the motors is responsible for providing a more immersive driving experience, while the other is focused on enhancing maneuverability and improving vehicle direction. This modular approach allows for greater customization and flexibility in terms of how the system is configured, which can lead to a more tailored and responsive driving experience.

In terms of technical performance, the X By Wire system also offers high-end capabilities. The use of electronic controls and sensors allows for more precise and accurate steering, acceleration, and braking, which can enhance safety and performance. Additionally, the X By Wire system can be integrated with other advanced driver-assistance systems, such as adaptive cruise control and lane-keeping assist, to provide a more comprehensive and seamless driving experience.

The proposed paper outlines an approach to designing and implementing the X By Wire system on a prototyping model. The model features a CAN controller and transceiver, as well as required actuators, sensors, switches, and displays. The X By Wire system represents a significant advancement in automotive steering technology, offering benefits such as optimized packaging, modular control, and high-end performance capabilities. As automakers continue to adopt this technology, we can expect to see vehicles that are more efficient, safer, and more enjoyable to drive.

***Keywords*—Controller Area Network (CAN), X-by-wire, IC engine, Electric vehicle, Dash board electronics.**

I. INTRODUCTION

In recent years, drive-by-wire technology has become increasingly popular in the automotive industry, as it offers several advantages over traditional mechanical systems. The term "drive-by-wire" refers to the use of electronic controls to operate various functions in a vehicle, such as steering, acceleration, and braking, rather than relying on mechanical linkages.

Automakers are adopting drive-by-wire capabilities to keep pace with evolving consumer preferences and regulatory requirements, such as improved fuel efficiency, reduced emissions, and enhanced safety features. While current systems still incorporate some mechanical components, such as a backup hydraulic brake system, the trend is toward fully electronic actuators that can operate independently of traditional mechanisms.

One of the primary benefits of drive-by-wire technology is its flexibility and efficiency. By eliminating the need for bulky mechanical components, such as steering columns and brake pedals, automakers can reduce the weight of the vehicle, which can improve fuel economy and handling. Moreover, the electronic controls can be customized to suit different driving conditions and driver preferences, allowing for greater precision and responsiveness.

Another advantage of drive-by-wire technology is its ability to enable more compact designs. The electronic actuators and sensors can be integrated into the vehicle's architecture more seamlessly than traditional mechanical systems, which can free up space and reduce the overall size of the vehicle. The drive-by-wire technology is an innovative and promising trend in the automotive industry. As more automakers adopt this technology, we can expect to see vehicles that are more efficient, more maneuverable, and more responsive to driver inputs.

A. Steer By Wire

The Steer-By-Wire system is a revolutionary technology that is designed to eliminate the traditional mechanical connection between the steering wheel and the driving wheels of a vehicle. Instead of relying on physical linkages, the system uses sensors and actuators to control the steering, providing a more flexible and customizable experience for the driver.

With a Steer-By-Wire system, the steering feel can be adjusted to match the preferences of the driver, allowing for a more personalized driving experience. This is achieved by manipulating the inputs from the sensors and actuators, which can be programmed to respond in a specific way depending on the driver's preferences.

In addition to providing greater control and flexibility for the driver, Steer-By-Wire technology also has the potential to facilitate the development of autonomous driving features. By relying on electronic sensors and actuators, the system can be integrated with other technologies, such as cameras and GPS, to enable advanced driving features like lane-keeping assistance and automated parking.

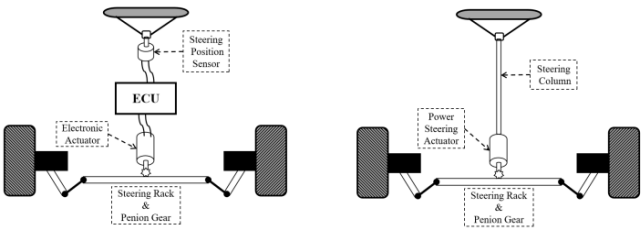

Fig. 1. Steer By Wire system vs Conventional steering mechanism

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Compared to conventional steering systems, the Steer-By-Wire system is more efficient, compact, and reliable, as it eliminates the need for mechanical linkages that can wear down and require maintenance over time. The system is also safer, as it can provide a quicker response to potential hazards on the road. Overall, the Steer-By-Wire system represents a significant step forward in the evolution of automotive technology, offering drivers greater control and flexibility while also paving the way for the development of advanced autonomous driving features.

B. Brake By Wire

The integration of an electronic system in the traditional hydraulic braking system of modern automobiles is transforming the way cars brake. The addition of an electronic system eliminates the need for a vacuum booster that uses the engine's vacuum. Instead, the Brake-By-Wire system includes a sensor attached to the brake pedal and an electronic actuator attached to the hydraulic system, which is typically the Master Cylinder. The actuator applies the brakes based on the position of the sensor on the brake pedal.

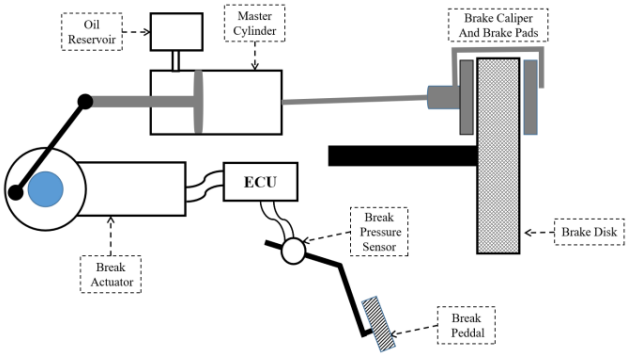

Fig. 2. Brake By Wire system concept

Moreover, the Brake-By-Wire system can also be used in electric vehicles to control the motor speed, in combination with an Electro-hydraulic system. The Electro-hydraulic braking system diagram shows how the system works. The Brake-By-Wire system can be used in electric vehicles also. For e-vehicles, the motor speed can be reduced using the same system along with an Electro-hydraulic system. The above diagram shows an Electro-hydraulic braking system.

C. Throttle By Wire

The throttle-by-wire system is an electronic system that replaces the traditional mechanical linkage between the accelerator pedal and the throttle body with an electronically controlled system. This system consists of a throttle position sensor that detects the position of the accelerator pedal and sends a signal to an actuator attached to the throttle plate shaft. The actuator then opens or closes the throttle plate, depending on the signal received, thereby controlling the airflow to the engine.

The throttle-by-wire system offers several benefits over conventional mechanical systems, such as improved fuel efficiency, reduced emissions, and better response times. Additionally, in electric vehicles, this system can be used to regulate the motor's speed, making it a key component in the vehicle's propulsion system. By controlling the flow of electricity to the motor, the system can adjust the vehicle's speed and power output, providing a smoother and more efficient driving experience. The following shows diagram for the Throttle-By-Wire system.

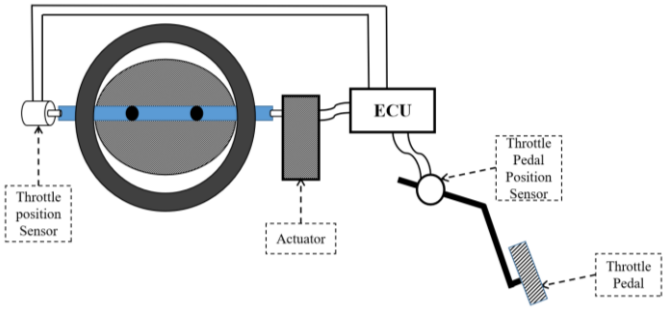

Fig. 3. Throttle By Wire system concept

D. Controller Area Network(CAN Protocol)

CAN, which stands for Controller Area Network, is a communication protocol that was initially created by Bosch in the 1980s for use in automotive applications. However, it has since been implemented in other industries as well. The main benefit of the CAN protocol is that it enables electronic control units (ECUs) to communicate with each other using a single bus, eliminating the need for a dedicated point-to-point connection between each ECU. This reduces the amount of wiring required and simplifies the design of the system. CAN is a message-based protocol, which means that data is transmitted in frames containing both the data and information about how it should be handled.

The protocol includes prioritization of different message types and error detection and correction mechanisms to ensure reliable communication between ECUs. CAN is widely used in automotive applications, particularly for low and moderate speeds. Initially, it was designed with a speed limit of 1Mbps and a maximum payload of 8 data bytes. However, it was later improved and released as CAN Fixed Data Rate, with an increased speed limit and payload capacity of up to 64 bytes. Today, it remains the most common protocol used in vehicles for communication between various ECUs due to its reliability, simplicity, and efficiency.

II. LITERATURE REVIEW

[1]In this paper, the researcher is analyzing the performance of the PID-based steer by wire system using CAN bus protocol. Vehicle dynamics and steering, the steer by wire model is developed. For performance analysis, they considered several parameters of vehicles like the velocity of vehicles, disturbance in CAN data, misfit of data, etc. Matlab and Simulink are used to perform simulations.

[2]In this paper, the researcher is introducing some applications related to X-By-Wire in the field of aeronautics as well as automobiles. Nowadays as the technology is going more and more advanced, conventional bulky mechanical and hydraulic systems are getting replaced by more compact and light in weight electronics systems. Further in this paper, the researcher is discussing fault-tolerant construction of safety systems.

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[3]The researcher is presents a study about CAN and TT/C network based X-By-Wire system. Matlab based simulation is used to present the system output. To get the required result, fault tolerant properties with distributed real time systems must be used.
[4]Use electronics inside vehicles for driver assistance features increasing conscientiously for autonomous driving features. The researcher in this paper is describing the transformation of SAE formula car with autonomous features. Steering, braking and accelerator are used to modify the existing setup of the vehicle.
[5]The X by wire system will replace the traditional mechanical linked mechanism with electronics control. This system is inspired by fly by wire system used inside an aircraft. This system has advantages like fault tolerance and reliability. In this paper, steer by wire system is presented with the use of the FlexRay protocol. The proposed system in this paper uses two ECU and the system was implemented on real small size vehicle

III. METHODOLOGY

The paper presents a concept of utilizing a Controller Area Network (CAN) to introduce the X-by-wire system into both internal combustion engine vehicles and electric vehicles. The proposed system consists of three nodes, with the inclusion of dashboard electronics such as displays and control switches for functions like headlamps (high and low beam), turning lamps, and brake lamps.
Furthermore, various sensors are connected to these nodes to gather data on parameters such as temperature, throttle position, brake position, steering position, etc. The nodes are then connected with each other using the CAN protocol for communication. This proposed system has the potential to revolutionize the automobile industry by enabling greater control and automation, leading to increased safety and efficiency.

The following diagram shows a basic architecture of implemented CAN network.

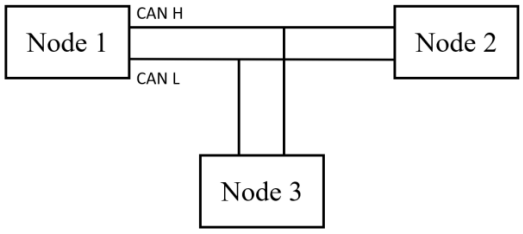

Fig. 4. System architecture

A. Node 1

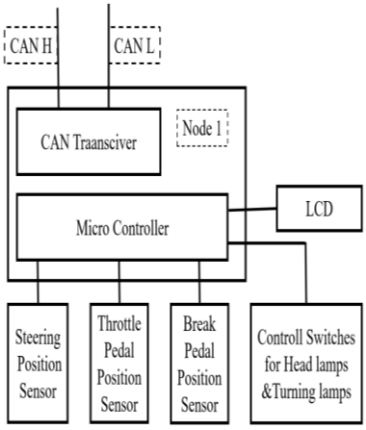

Fig. 5. Node 1 architecture

This node is system used fop controlling purpose. This node is utilized for sensing the controlling switches and position sensors for steering, brake and throttle, etc. The sensed parameters are framed and transited on the network. This node is also receives parameter for node 2 and node 3. The received parameters are displayed on the LCD. Following shows a diagram.

B. Node2

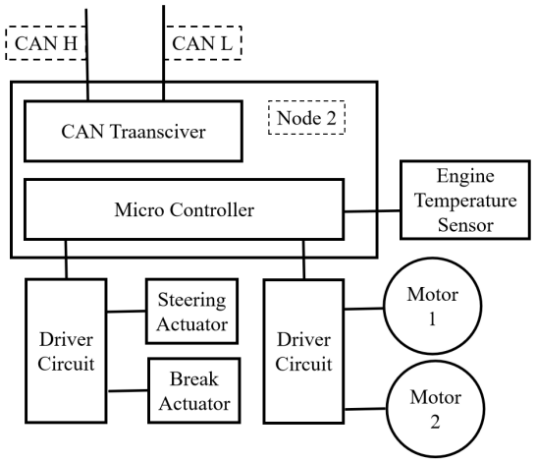

Fig. 6. Node 2 architecture

The node 2 is responsible for controlling steering, brakes and accelerator. The position sensor data transmitted by node 1 is received here and utilized for controlling the actuators and vehicle speed after pee-processing on the received signals. This node transmits temperature and humidity information to the node 1.Following shows a diagram.

C. Node3

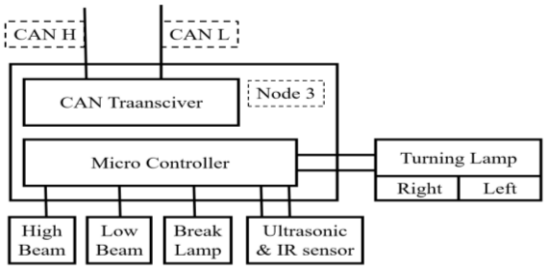

Fig. 7. Node 3 architecture

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Node 3 controls lighting system of the vehicle. The lighting system includes headlamps, Turning lamps and brake lamps as shown in the following figure. Control signals are received from node 1 that activates the required lighting in the vehicle. This node also responsible for front side collision detection system and and this system controls the speed of vehicle. For this purpose, node 3 have to communicate with node 2 which controls the speed. The sensor data is transmuted to node 1 to display purpose.

IV. SYSTEM DESIGN AND IMPLEMENTATION

In the CAN protocol, control in the system can transmit the data if the line is free. It is a broadcast-type protocol, in which the message is transmitted over the network and received by a specific receiver only, while other nodes reject the message. The CAN data frame consists of an Identification Field (Identifier), which is detected by the receiver side. The receiver compares the identifier field with the required identifier, if matches, then the frame is accepted by the receiver. If not, then discarded.

One CAN node is having three parts as

1. Micro-controller
2. CAN controller
3. CAN Transceiver

A. Arduino Uno

Arduino Uno is an 8-bit microcontroller that has onboard ADC, and protocols like I2C, SPI, UART, etc. The main purpose of Arduino is to take the reading from sensors and give the reading to other nodes for further actions.
The Arduino is also responsible for controlling the actuators in the system like the Brake actuator, Throttle actuator, steering system actuation, etc.

Fig. 8. Arduino Uno

B. MCP2515(CAN Module)

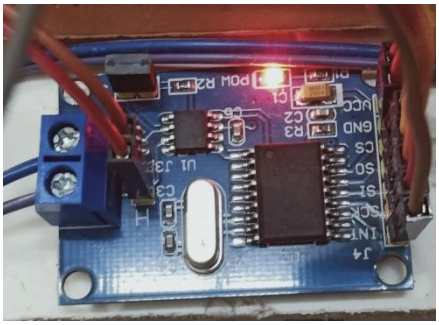

Fig. 9. MCP2515 CAN module

A CAN controller communicates with Arduino with SPI protocol and takes the signal to transmit on the bus. The maximum data rate for this controller is 1Mbps, and capable of handling up to data lengths up to 8 bytes. This module has the following sections:

- CAN transceiver and protocol engine
- Configuration registers and controlling logic
- SPI communication block.

C. Liquid Crystal Display(LCD)

Fig. 10. Liquid Crystal Display

In order to display parameters like engine temperature, braking force, steering angle, etc, LCD is used. For this experiment, 20x4 LCD is used.

D. DHT11(Temperature and Humidity sensor)

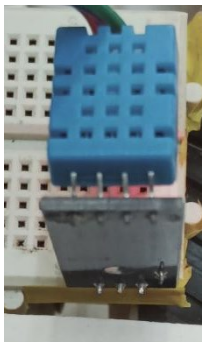

Fig. 11. DHT11

It is a temperature and humidity sensor mainly used here to monitor the engine temperature and in the case of electric vehicles, it can be used to monitor the battery temperature. If the sensor reading crosses the threshold value, it shut down the engine or cuts off the battery in case of an EV.

E. HCSR04(Ultrasonic sensor) and IR Sensor

Fig. 12. Ultrasonic and IR sensor

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These sensors work together to form a collision-avoidance system. The IR sensor first detects the proximity of any obstacle within the set range, then the ultrasonic sensor(HCSR04) checks the distance to the obstacle. If distance reduces gradually, vehicle speed also reduces accordingly to a particular set range, and if too close, the automatic braking system stops the vehicle to a complete halt. This phenomenon of two or more sensors working together for a single function is known as Sensor Fusion.

F. Other Components

1.Potentiometer: Used as a position sensor for steering, brake, and throttle position

2.Switches: Used as control switches for the lighting system

3.DC motor: Used to the electric vehicle drive train

4.Driving Card: L298N is used for driving the dc motor and controlling the speed of the motor given by the throttle position sensor.

5.Servo Motor: SG90 180-degree servo motors are used here as steering and brake actuators.

CONCLUSION

In this research paper, we are demonstrating the successful implementation of three node CAN network which is demonstrating conventional controls inside the vehicle as lighting control system using CAN network along with communication between sensors and actuators for X-by-wire technology along with the implementation of sensor fusion technique for front end collision detection and to control the vehicle speed. All the vehicle parameters considered are displayed on the LCD for monitoring purpose and also to demonstrate the vehicle dashboard.

The implemented hardware shows expected behavior of the completer system without any lag, and all the functionality works independent of each other. The addition of sensor fusion technology for fronted collision detection is adding a extra layer of protection and also observed to improve a system responsiveness.

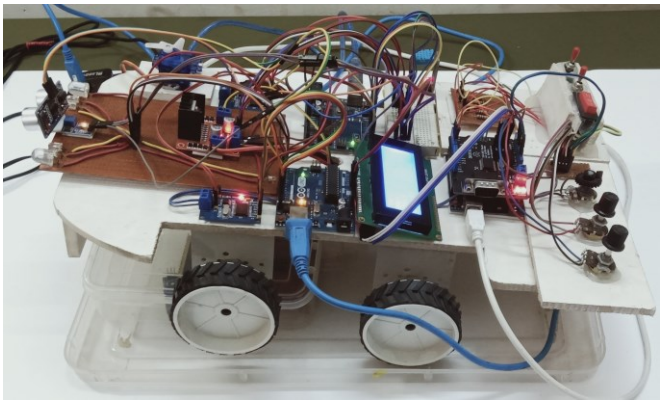

Fig. 13. Experimental Setup

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