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Drive-By-Wire Systems In Automobiles

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***Abstract*- A technology known as "x-by-wire", also called drive by wire or simply "by-wire". A car with this type of system mainly on electronics, to control a wide range of vehicle operations, including, braking, acceleration, and steering. Conventional cars mainly use hydraulic and mechanical technology to conduct these basic vehicle operations, and although the systems are powerful, they can be overly complex, inefficient and conducive to wear and tear over the years**

Key words- Throttle-by-wire, steer-by-wire, brake-by-wire, ECM (Electronic control module),

I. INTRODUCTION

Drive-by-wire is a catch-all term that can refer to a number of electronic systems that take the place of old mechanical controls. Instead of using cables, hydraulic pressure, and other things that provide the driver with direct, physical control over the speed or direction of a vehicle, drive-by-wire technology uses electronic controls to activate the brakes, control the steering, and operate other systems.

The term also might be familiar to aviation, since airplanes have used systems called "fly-by-wire" since the 1990s. That technology, just like drive-by-wire, uses electrical wires to control the normal operations of a plane.

Over the years, manufacturers and outside researchers and inventors have been integrating computers and electronics into modern cars. If drivers could simply get accustomed to the idea, drive-by-wire systems have the potential to increase comfort, functionality and safety during the drive. Computers and sensors would analyze commands and instruct vehicles on exactly what to do. And by-wire systems have an environmental angle, too, since the technology could improve fuel economy and reduce or improve engine emissions.

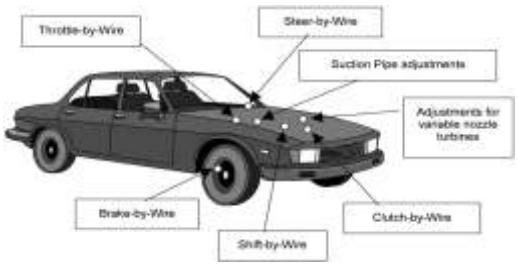
II. BASIC DESCRIPTION

There is a trend in the automotive industry towards eliminating mechanical and hydraulic control systems and replacing them with electronic controls. Many traditional mechanical components can be eliminated such as shafts, pumps, hoses, fluids, coolers, cylinders, etc., which reduces the weight of the vehicle and improves efficiency. Electronic controls can also improve safety by facilitating more automated control functions like stability control. They also enhance the flexibility of automotive systems, making it easier to modify or upgrade vehicles. Electronic controls improve handling, enable better fuel efficiency and exhibit shorter response times in emergency situations.

The complexity of the system control functions enabled by electronic systems can make vehicle performance more difficult to model. Integrating these complex systems, while achieving predictable, fail-safe performance represents a significant challenge for the automotive industry

III. TYPES OF DRIVE-BY-WIRE SYSTEMS

In a drive-by-wire system, most of mechanical control would be replaced by electrical wires. In any type of by-wire system, sensors record information and pass data to a computer or a series of computers, which transfer the electrical energy into mechanical motion. There are several different types of drive-by-wire systems, which is why it's sometimes referred to generally as x-by-wire. Here are the main by-wire systems:
A. Steer by Wire B. Throttle by Wire C. Brake by Wire



A. STEER BY WIRE

The proliferation of electronic control systems is nowhere more apparent than in the modern automobile. During the last two decades, advances in electronics have revolutionized many aspects of automotive engineering, especially in the areas of engine combustion management and vehicle safety systems such as anti-lock brakes (ABS) and electronic stability control (ESC).

The benefits of applying electronic technology are clear: improved performance, safety, and reliability with reduced manufacturing and operating costs. However, only recently has the electronic revolution begun to find its way into automotive steering systems in the form of electronically controlled variable assist and, within the past two years, fully electric power assist.[2]

The recent introduction of electric power steering in production vehicles eliminates the need for the hydraulic pump. Electric power steering is more efficient than conventional power steering, since the electric power steering motor only needs to provide assist when the steering wheel is turned, whereas the hydraulic pump must run constantly. The assist level is also easily tunable to the vehicle type, road speed, and even driver preference An added benefit is the elimination of environmental hazard posed by leakage and disposal of hydraulic power steering fluid.

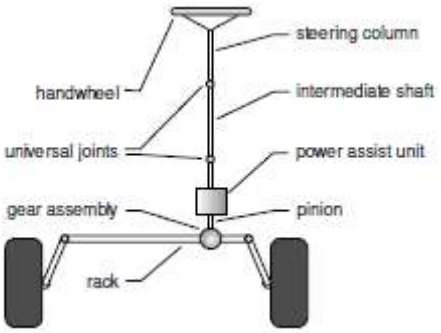


Figure 1 Convectional steering system

Most vehicles use a rack and pinion unit or worm and sector steering gear that is physically connected to the steering wheel. When the steering wheel is rotated, the rack and pinion unit or steering box also turns. A rack and pinion unit can then apply torque to the ball joints via tie rods, and a steering box will typically move the steering linkage via a pitman arm.

In vehicles that are equipped with steer-by-wire technology, there is no physical connection between the steering wheel and the tires. In fact, steer-by-wire systems don't technically need to use steering wheels at all. When a steering wheel is used, some type of steering feel emulator is typically used to provide the driver with feedback.

a. Technical advantages of steer-by-wire

A number of current production vehicles already employ by-wire technology for the throttle and brakes A few supplement conventional front steering with rear steer-by-wire to improve low speed maneuverability and

high speed stability Completely replacing conventional steering systems with steer-by-wire, while a more daunting concept than throttle- or brake-by-wire for most drivers, holds several advantages. The absence of a steering column greatly simplifies the design of car interiors. The steering wheel can be assembled modularly into the dashboard and located easily for either left- or right-hand drive.

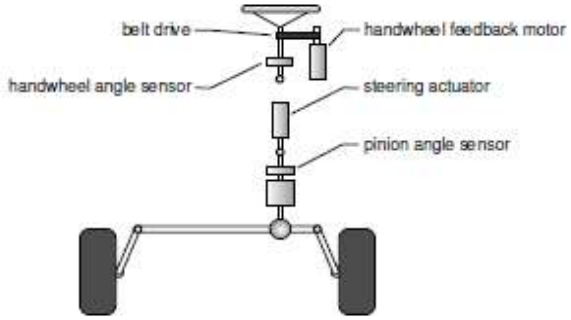


Figure 2 Convectional steering converted in to steer-by-wire

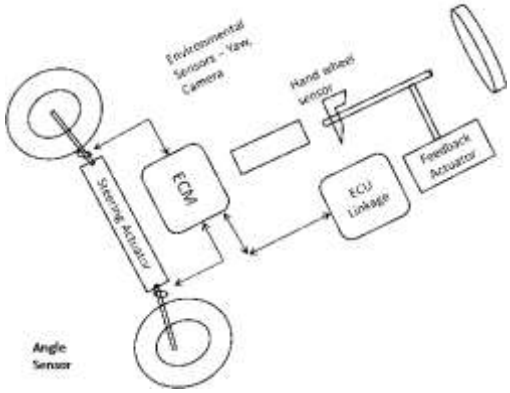


Figure 3 Conceptualization of steer-by-wire

Sensors : Torque sensor, steering angle sensors, yaw sensor, wheel speed sensor, and wheel angle sensor

Actuators : Steering actuator, feedback actuator, pinion actuator.

B. THROTTLE BY WIRE

Throttle-by-wire, or accelerate-by-wire, was the first type of drive-by-wire system introduced. These systems use a pedal unit and an engine management system. The pedal uses sensors that measure how much or how little the driver moves the accelerator, and the sensors send that information to the engine management system. The engine management system is a computer that, among other tasks, determines how much fuel is required, and it provides this input to an actuator -- a device that converts energy into mechanical motion. The pedal could be the same pedal drivers have become accustomed to using today, an easy-to-reach pad placed near the foot that's pressed down in order to accelerate the car. The same operation could also be incorporated into a joystick or videogame-like controller, which would get rid of the need for a foot pedal completely. Of course, this would require drivers to use their hands for acceleration, braking and steering.[12]

Throttle-by-wire is an automotive technology that is widely used on vehicles today. It replaces the traditional throttle linkage (a cable between the accelerator pedal and the throttle) with an accelerator pedal position sensor and an electronically operated throttle. It provides several advantages over mechanical systems are:

1. Eliminates binding problems in mechanical linkages preventing the throttle from sticking
2. Allows automated control of the throttle that helps to reduce emissions and improve fuel economy
3. This system can be modeled and installed as a modular system
4. Allows the ECM to integrate torque management with cruise control, traction control and stability control[1]

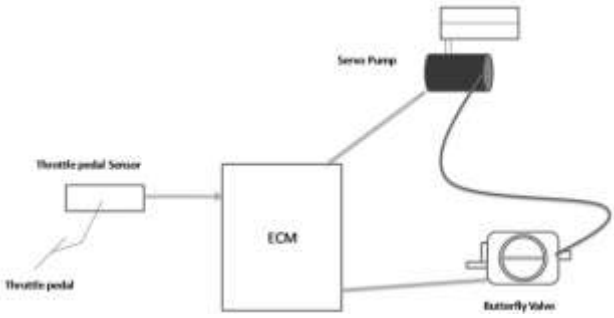


Figure 4 Conceptualization: throttle by wire [13]

The accelerator pedal sensor senses the position of the accelerator pedal. This information is conveyed to the ECM as a change in the electrical resistance. The ECM actuates a servo-motor, which actuates the butterfly valve in the throttle assembly. The position of the throttle is continuously monitored and the information is conveyed to the ECM using a feedback circuit.

Sensors: accelerator pedal position sensor, throttle valve position sensor

Actuators: motor controlling throttle valve position

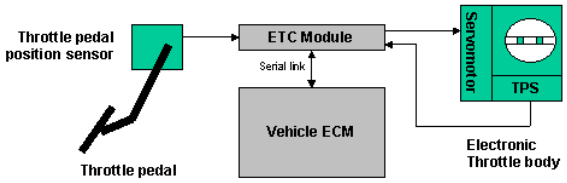


Figure 5: Electronic Throttle Control (ETC)

The most common type of throttle control uses a cable that is directly connected to both the gas pedal and the throttle. When the gas pedal is pressed down, the cable pulls the throttle open. In vehicles that use electronic throttle control (ETC), there is no physical connection between the gas pedal and the throttle. Like brake-by-wire systems, the gas pedal sends a signal that causes an electromechanical actuator to open the throttle.

C. BRAKE BY WIRE

Brake-by-wire is an automotive technology that completely eliminates traditional mechanical and hydraulic components and replaces them with electronic sensors and actuators to control the brakes in vehicles. Some of the advantages of brake-by-wire systems are:

1. Reacts more quickly resulting in shorter stopping distance and time
2. Loss of mechanical systems results in noiseless operation and elimination of vibration
3. Lesser space consumed making the engine compartment and compact and helping in better space utilization
4. Allows the ECM to integrate torque management with cruise control, traction control and stability control
5. Reduces the weight of the overall system thus improving fuel efficiency
6. Lack of mechanical power may facilitate the need the introduction of hybrid and fuel cells based vehicles[1]

Brake-by-wire systems are still under development and cannot be found on passenger cars that are currently on the market. One of several concepts for brake-by-wire systems is illustrated below:

This systems consists of a rheostat that senses the position of the brake pedal. This signal is interpreted by the brake computer, which generates signals to operate a servo pump. The pump pressurizes the secondary circuit and

brake fluid pushes against a slave piston that activates the brake. The pressure is monitored and a signal is sent back to the brake computer, which applies a mechanical force to the pedal as feedback to the driver.

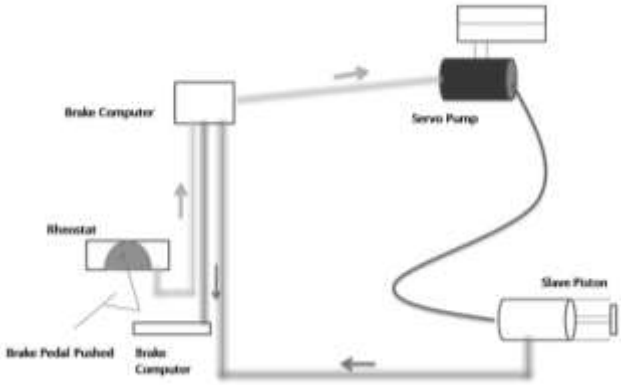


Figure 6 Conceptualization: brake by wire[13]

Sensors: brake pedal position sensor
Actuators: Servomotor/pump

III. BENEFITS AND DRAWBACKS OF DRIVE-BY-WIRE SYSTEMS

We are excited about the prospect of more drive-by-wire systems in cars. By replacing conventional throttle systems, drive-by-wire systems can significantly reduce the number of moving parts in a vehicle. This reduces weight, increases operational accuracy and stretches out the time between service visits for things like mechanical maintenance and other adjustments. Some by-wire systems wouldn't even require service at all. Less weight and better accuracy would equal better fuel efficiency and fewer emissions, too.[12]

It's well-established in the airline industry; drive-by-wire has been slow in its introduction to the car. The problem for some car manufacturers is in convincing drivers that the systems are safe. Because of the complexity of drive-by-wire systems, some people worry about potential electronic malfunctions in sensors and computers, leading to vehicle damage or even car accidents and passenger injury.

One argument against drive-by-wire is that any system using software has the ability to fail regardless of how many times that software has been tested. In a worst-case scenario, for example, the sensors on a brake-by-wire system could make an error in calculation, causing the brake caliper and pads to apply an incorrect amount of pressure -- either too light or too strong -- to the rotor. Unaware of any internal system problems, the driver using the brake-by-wire system could potentially get into an accident, even though he or she thought the correct amount of pressure was being placed on the brake pedal.[4]

In any case, most people refer to the saying that any software is only as good as the programmers and manufacturers who built and designed it. Because of the reliability of fly-by-wire in airplanes, it's likely that experience and product testing could bring more drive-by-wire systems safely to everyday cars. Several car companies are already using (or have used) various drive-by-wire systems in use their vehicles, including BMW, Mercedes-Benz, Land Rover, Toyota, GM, Volkswagen and Nissan.

IV. THE FUTURE OF DRIVE-BY-WIRE

Safety concerns have slowed the adoption of drive-by-wire technologies. Mechanical systems can and do fail, but regulatory authorities still see them as being more reliable than electronic systems. Drive-by-wire systems are also more expensive than mechanical controls due to the fact that they are significantly more complex.

However, the future of drive-by-wire technology could lead to a number of interesting developments. The removal of mechanical controls could allow automakers to design vehicles that are radically different from the cars and trucks that are on the road today. Concept cars like the By-Wire have even allowed the seating configuration to be moved around, since there are no mechanical controls that dictate the position of the driver.

Drive-by-wire technology could also be integrated with driverless car technology, which would allow vehicles to be operated remotely or by a computer. Current driverless car projects use electromechanical actuators to control steering, braking, and acceleration, which could be simplified by connecting directly to drive-by-wire technology.[11]

IV. CONCLUSION

The complexity of drive-by-wire systems is a concern to many automotive customers who worry about the failure of software and possible electronic

malfunctions in sensors resulting in car accidents and passenger injury. On the other hand drive-by-wire systems have been used by commercial aircraft for many years and have an excellent safety record. Ultimately, the enhanced safety features and the other benefits of automated electronic controls are expected to outweigh concerns about the complexity and reliability of these controls and drive-by-wire systems will be widely used in automotive designs.

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