Chapter II
Drive by Wire Systems: Impact on Vehicle Safety and Performance

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ABSTRACT

An overview of the drive by wire technology is presented along with in-depth coverage of salient drive by systems such as throttle-by-wire, brake-by-wire, and steer-by-wire systems, and hybrid-electric propulsion. A review of drive by wire system benefits in performance enhancements and vehicle active safety is then discussed. This is followed by in-depth coverage of technological challenges that must be overcome before drive-by-wire systems can be production ready. Current state of the art of possible solutions to these technological hurdles is then discussed. Future trends in the drive-by-wire systems and economic and commercialization aspects of these system are presented at the conclusion of the chapter.

INTRODUCTION

Drive by wire (DBW) systems are relatively new technology that are increasingly finding their place in modern automobiles. A drive by wire system is an automotive system that interprets driver’s inputs and executes the commands to produce desired vehicle behavior, typically via a microprocessor-based control system. A typical drive-by-wire system comprises of redundant sensors, actuators, microprocessors, and communication channels for fault tolerance. There are no mechanical or hydraulic connections between driver’s input interface (e.g. throttle, brake, steering) and vehicle system (e.g. engine/traction motor, brake/steering actuators) in a drive by wire equipped vehicle.

A broadened definition of drive by wire systems will include other microprocessor based automotive control systems such as anti-lock braking system (ABS), traction control system (TCS), yaw stability control (YSC), etc. These systems are designed to enhance the safety of the vehicle by continuously monitoring various
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vehicle states and taking corrective action and/or warning the driver upon detection of an impending unsafe vehicle condition. The first such system came into commercialization is ABS in early 1970’s. It was followed by traction control system and electronic stability control in the 1980’s and 1990’s (Margolin, 1997; Stanton & Marsden, 1997; Wagstaff, 1999; Davis, 2001; Higgins & Koucky, 2002; Anon, 2003; Fowler, 2003; Ross, 2003; Lee, 2003; Daniels, 2005; Kendall, 2005).

The first true drive by wire system to come to the market was Throttle By Wire (TBW) which was incorporated in high end vehicles such as Audi A6, Mercedes Benz, Lexus, and BMW models in the late 1990’s and early 2000’s. The TBW systems were advantageous in stability control applications where the throttle deactivation may be needed in order to improve the traction so that sufficient brake torque can be generated.

Electro-hydraulic brake (EHB) system, a form of brake by wire (BBW), was first introduced in Mercedes Benz SL series in 2001-02 (Higgins & Koucky, 2002). Although hydraulically actuated, these brakes operate on commands from sensors at the brake pedal and generate the necessary brake pressure at the wheel cylinders via a set of electronically controlled valves and a pump. However, the brake by wire system was decommissioned and removed from the vehicle due to a number of field problems a few years later. Work on the electro-mechanical brakes (EMB), another form of brake by wire system that does not use hydraulic fluid, was done in the late 1990’s by number of automotive companies such as Bosch, Continental, and TRW. However, issues related to their reliability and fault tolerance still remain which must be addressed before these system can be used in an automobile.

Steer by wire (SBW) system is by far the most complex drive by wire system which is also the most safety critical by-wire system in an automobile. In a pure steer by wire system, the steering column is eliminated. Sensors mounted on the steering wheel are interpreted by the controller to generate the correct amount of road wheel angle using electric motors based on the vehicle velocity. If a sensor stops functioning properly, the controller will not be able to actuate the motors to generate the correct road wheel angle, potentially causing hazardous situation.

Figure 1 shows a brief chronology of the drive by wire system introduction into the modern automobile with the broadened definition (Isermann et al, 2002). As shown, the steer by wire system will likely be the last of the drive by wire system to be introduced in the automobile due to its complexity and safety criticality.

In an even broader definition, hybrid electric vehicles, electric vehicles, and plug-in hybrid electric vehicles can also be classified as drive by wire equipped automobiles due to the electronic control of various subsystems in these vehicles. Electric vehicles (EV) by their very nature are drive by wire that is propelled by electronic control of the electric traction motor based on the sensor information from the throttle pedal. However, the steering and brakes of an EV may still be hydromechanically operated. In case of hybrid electric vehicle (HEV), a sophisticated microprocessor based control system channels the power flow between the internal combustion (IC) engine, the battery, the electric motor/generator, and the vehicle wheels (Lu & Hedrick, 2005). All of these functions are done via a central controller for optimal performance. Plug-in hybrid electric vehicles are very similar to hybrid electric vehicle, except that a more powerful battery extends the vehicle range in pure electric mode.

This chapter is organized as follows: A more detailed coverage on drive by wire system is covered in the next section. The performance and safety benefits of the drive by wire systems are illustrated in the following section. This is followed by the section on technological challenges and possible solutions associated with DBW system. Future trends for the DBW system is presented in the next section. Lastly, some final thought will be presented in the conclusion section.
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