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# Design of the Steering Feedback Controller of a Steer-by-Wire System Using Admittance Model

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**Abstract**
The steer-by-wire (SbW) system is a promising system in the realm of automotive engineering. It substitutes the mechanical connection between the steering wheel and the front road wheels with an electronic signal-based functional connection. The SbW system offers several advantages over conventional steering systems, including weight reduction, reduced vibration, and enhanced steering functionality configuration. However, the absence of a mechanical linkage in the SbW system gives rise to certain challenges. The SbW system requires endowing adequate steering feel such as damping and reaction force using feedback motor, and the road wheel needs robust control of pinion motor for normal load variation by passengers and self-aligning torque as external disturbance. The SbW system is composed of the steering feedback module (SFM) and the road wheel module (RWM). This paper proposes a control approach to generate steering feel for SFM, in which steering feel is generated using an admittance model based on velocity control. A disturbance observer is applied to ensure robustness of velocity control. The steering wheel torque versus steering wheel angle (T–A) curve is used to analyze steering feel characteristic and evaluate steering feel. The proposed steering system is validated through experiments that confirm its ability to provide satisfactory steering feel for vehicles. This work may offer a novel solution for the design of advanced steering systems in the field for the future mobility such as an autonomous driving.

**Keywords** Steer-by-wire system · Steering feedback module · Robust control · Disturbance observer · Admittance model

## 1 Introduction

A steering system is a crucial mechanism that allows a driver to control the direction of a vehicle by turning the front road wheels. There are different types of steering systems, such as mechanical, hydraulic, and electric with respect to power source. A hydraulic power steering (HPS) uses a pump driven by the engine or motor to provide hydraulic pressure that assists the steering wheel inputs. In comparison with HPS systems, an electric power steering (EPS) systems have been applied in modern vehicles because of their fuel efficiency and simple structure. An EPS uses an electric motor to aid without relying on any other auxiliary system. Recently, the SbW system has drawn attention, since the first passenger vehicle that implemented this technology was introduced in 2013.

One of the advantages of an SbW system over a conventional power steering system is that it eliminates the need for mechanical linkages, hydraulic hoses, fluids, and pumps. An SbW system uses sensors, electric actuators, and electronic controllers to transmit the steering commands from the driver to the wheels. This reduces the weight, complexity, and maintenance of the steering system. It also improves the fuel efficiency, performance, and safety of the vehicle. An SbW system can also offer more flexibility and customization for different driving modes and preferences. The feedback motor of the steering wheel generates steering feel such as damping and reaction torque. The road wheels are moved by a motor mounted on a rack or pinion gearbox.

One of the main challenges of the SbW system, which offers many advantages over traditional steering systems, is to create a suitable steering feel for the driver. Several

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