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The future of driving.

Deliverable D23.2
Steer-by-wire for challenge 4.1, electric steering for 5.1

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Executive summary

This deliverable describes the technical realisation of the steering actuators designed for the demonstration vehicles WP4100 (FASCar – extended joint system demonstrator) and WP5100 (automated assistance in roadworks and congestion). The deliverable contains the actuator descriptions from the technical side and focuses on their integration in the vehicles. Also the basic functionality of the actuators has been proven by demonstrating the measurement results of tests performed in the vehicles. The main result is that in both vehicles the actuators are ready to be operated by the use case applications.

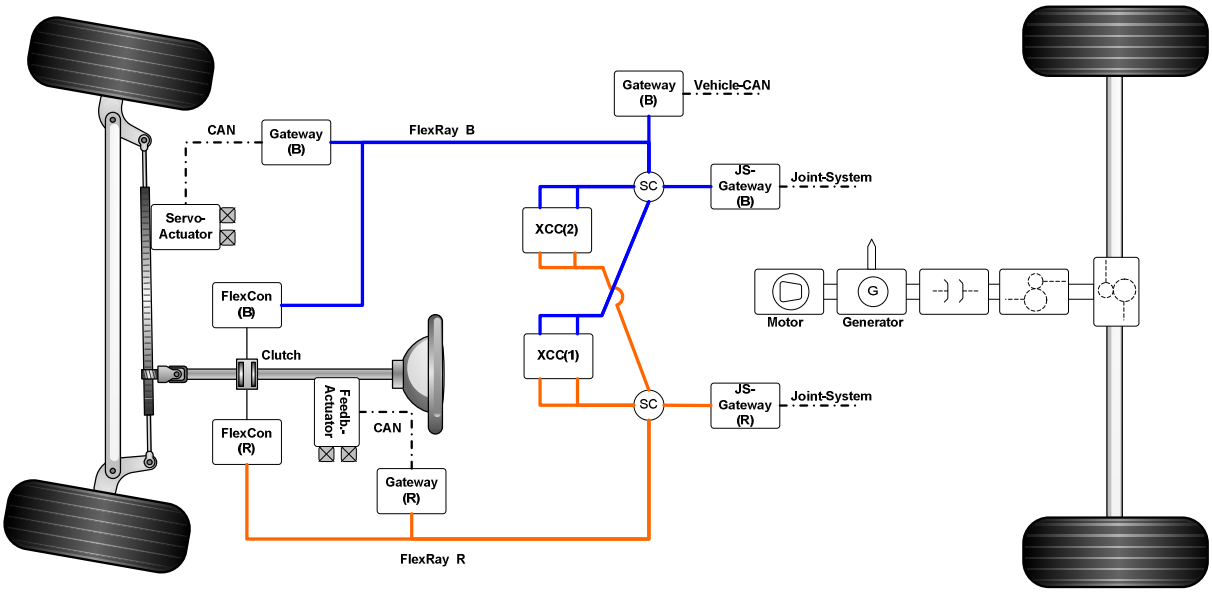
In both work packages (WP4100 and WP5100) a VW Passat is used to demonstrate the highly automated driving scenarios but there are many differences concerning the steer-by-wire (SbW) functionality and configuration in both vehicles. While the steering system in the WP5100 demonstrator only contains a direct interface to the serial steering system, the SbW-system in WP4100 is extended with a partly redundant control system (see D21.3) and with a driver feedback actuator. The steering actuator and the feedback actuator are mechanically decoupled in normal operation mode but during fault operation a clutch will perform a mechanical closure of the steering column. The main features of the two steering actuator systems are described as follows:

Steer-by-wire for challenge 4100

The steering actuator system mainly bases on three components, the serial steering system of the vehicle (opened for CAN control), the electromechanical clutch and the driver feedback actuator. While the feedback actuator and the clutch are external devices to be installed, the serial steering system is part of the vehicle itself.

Between the driver's feedback actuator and the steering pinion the electromagnetic clutch is installed in the steering column (compare to fig SbW). For safety reasons the clutch is kept open by an electromagnetic coil, thus coupling automatically through a spring or permanent magnet when the electric power is shut off. Even in the unlikely case of a total power failure, the vehicle still stays controllable. The steer-by-wire system mainly consists of two steering actuators – separated from each other by the clutch – several input sources as well as the computing units (XCCs) which will perform on the one hand the control laws and on the other hand the redundancy management of the whole platform.

The general functionality of the depicted system is described as follows: The demanded steering angle is detected by the actuators themselves or provided by the Joint System. Regarding the current state, steering commands are calculated within the XCCs and sent to the actuators. These commands are adapted regarding (1) the vehicle speed and (2) the current failure state of the system (e.g. in case of the loss of the servo actuator, the clutch is commanded to close and the remaining feedback actuator takes over the steering action). In addition, in case of no failure, the feedback actuator is used to provide haptic feedback to the driver, initiated by the Joint System.



FASCar steer-by-wire communication architecture

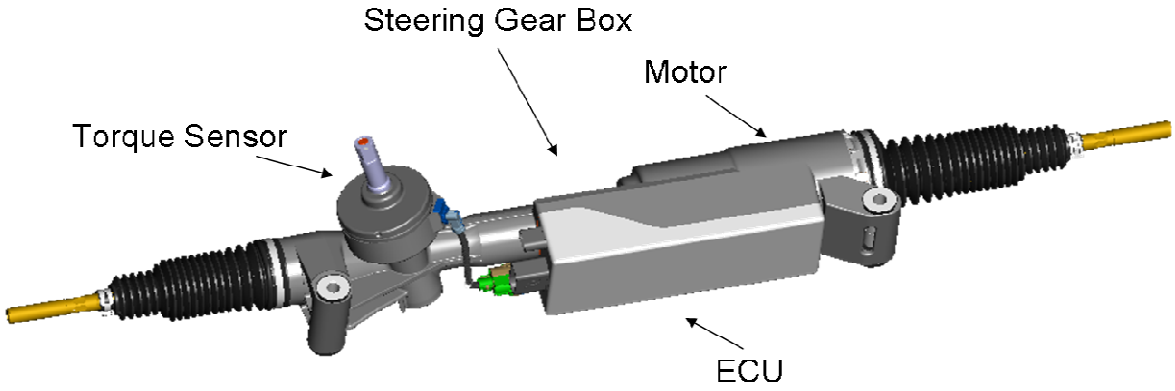
Electric steering for challenge 5100

The basic vehicle for the WP5100 application "automated assistance in roadworks and congestion" is a VW Passat CC that has been modified in order to perform a drive-by-wire approach using serial components. The additional sensors and the corresponding control units of this vehicle are explained in D51.1 in detail. For the drive-by-wire approach there are not only sensors installed but also actuators. Whilst the force-feedback gas pedal and the active brake booster are part of D51.2, the active steering actuator and corresponding control units are described in detail here.

In the automotive industry there is an ongoing trend to increase driving safety and comfort by the development of new driver assistance systems. A powerful impact on vehicle lateral dynamics can be achieved by accessing and influencing the steering system. In modern vehicles traditional hydraulic steering servo mechanisms are replaced by electrical power steering systems (EPS) in an increasing manner entailing various possibilities of manipulation of steering characteristics with a high degree of freedom up to active steering functionalities.

In order to provide a flexible setup for research and development activities concerning these topics following an interface of the EPS system to an external device (e.g. a rapid prototyping system) is specified, that allows reading of internal steering control related signals and manipulation of state variables via CAN bus.

Because of the highly safety critical character of the steering application only trained persons being aware of the effects of the interventions on the vehicle dynamics are allowed to make use of these interface capabilities.



Schematic view of the electric steering actuator

The actuator contains of a mechanically high-integrated solution (see figure above). The torque sensor is built in a redundant way. If one sensor fails, the other takes over the signal acquisition task. The motor angle sensor is a sin/cos encoder which ensures high dynamic rates with high-precision accuracy. Both, motor and power stages are thermally protected by temperature sensors. The controller concept consists of two controllers with mutual supervision so that the whole electric steering package is fault tolerant. This component is a serial production device. Thus accuracy and robustness are characteristic properties of the actuator.

Conclusions

The Steer-by-Wire system developed for the FASCar Joint System Demonstrator (WP4100) has been realized and tested in the vehicle. The corresponding devices and their integration in the vehicle are described in detail in this document supplemented by the results of specific measurements. Additionally, the corresponding basic software was developed so that the basic steer-by-wire functionality could be performed in real driving tests. Hence, the objectives of this deliverable are achieved.

The serial electric power steering system (EPS) of the WP5100 demonstration car is used as active steering actuator hardware. So the steering system has the benefit of the robustness and reliability of a serial proved system. The extension to external, i.e. not driver-initiated active steering is done by overlapping or replacing the driver-initiated steering torque by an external steering and motor torque request. These torque requests are handed over to the system via CAN, the actual torques are output on the CAN bus. Thus, an external steering control circuit can be attached to the steering actuator. This external lateral control system is to be developed in WP5100 and is described in D51.2 [7].

References

[1] D11.2 Specification, HAVEit deliverable, 2009

[2] D12.1 Architecture, HAVEit deliverable, 2009

[3] D21.1 HW development complete (XCC and CSC), HAVEit deliverable, 2009

[4] D21.3 Communication specification, HAVEit deliverable, 2009

[5] D22.1 Communication specification, HAVEit deliverable, 2009

[6] D51.1 Sensors installed in ARC vehicle, HAVEit deliverable, 2009

[7] D51.2 Components in ARC vehicle installed, working and tested, HAVEit deliverable, 2010

[8] D51.3 First system functionality in ARC vehicle, HAVEit deliverable 2010