

Porsche – Virtual Manual Transmission

- **Shift force simulator for that authentic gear-shift feel**
- **Porsche relies on dSPACE real-time hardware**
- **Force feedback for realistic tests**

▼ *The shift force simulator closes the gap between virtual simulation and the actual drivetrain.*

The feel of a manual transmission is a brand-specific feature, and an important factor in customer test drives. Development of a specific gear-shift feel begins right back at the definition stage, when real prototype parts are not yet available. And virtual simulations cannot provide feel. Porsche closed the gap between virtual simulation and the actual drivetrain by developing a shift force simulator. At its core is powerful dSPACE real-time hardware that uses a Porsche simulation model to control the simulator actuators so as to provide a realistic gear-shift feel.

Brand-Specific Gear-Shift Feel

The gear stick is one of the controls in a vehicle that still gives the driver direct contact with the drive mechanism.

The basic aim of development work is to ensure good shifting quality in technical terms, but another is to provide a brand-specific gear-shift feel with a high recognition factor, to differentiate the vehicle from the competition in the same way as the engine sound does. Both static and dynamic effects are at work

on the gear-shift feel.

Shift Simulation and Shift Force Simulator

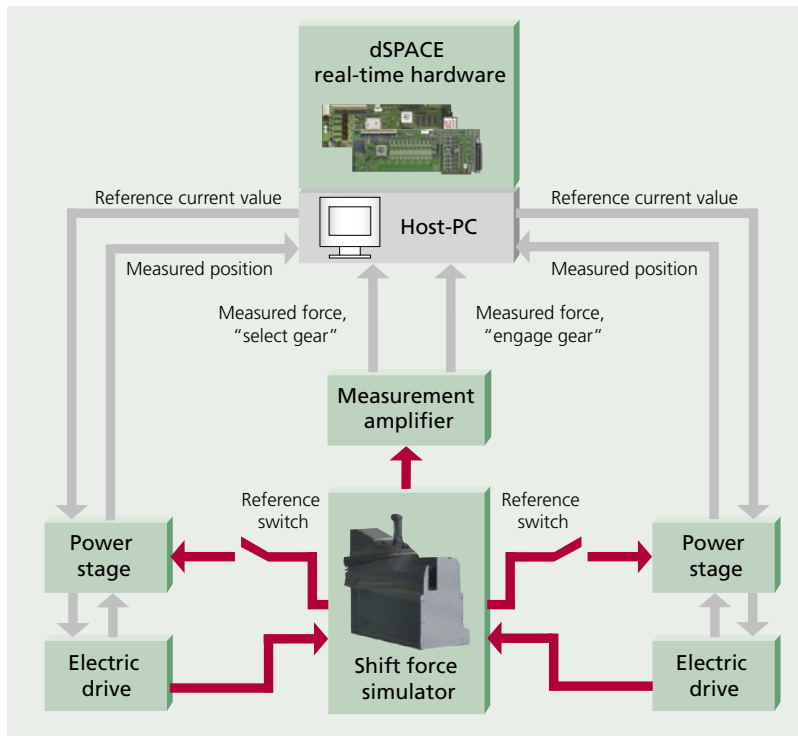
At various stages of development, simulation tools make it possible to determine what the shifting quality will be, if there will be any malfunctions, and whether the specifications are fulfilled, without having any real prototype parts available. However, up to now there were some factors that could not be evaluated in virtual simulation, such as direct gear-to-gear shifting, the gear stick guidance through the gates, and the engagement motion. But it is these very features that will later determine how a potential customer judges the subjective feel of a gear during a test drive. To give developers a flexible means of evaluation at an early stage, the idea of the shift force simulator was born. When effects have been determined in theory, the shift force simulator makes them “feelable”, so they can be evaluated subjectively.

Force Feedback Provides Answers

The shift force simulator is a real-time system with force feedback like that used in joysticks for computer games and also in flight simulators. Two electric drives coupled to the shift lever provide the force feedback. The core of the simulator is dSPACE real-time hardware and a Porsche simulation model of a virtual transmission modeled in MATLAB®/Simulink®. The hardware is a DS1104 R&D Controller Board, which calculates the complex Porsche model in real-time, and also serves the sensors and actuators. An even more powerful combination will be used in future, consisting of a DS1006 Processor Board and a DS2211 HIL I/O Board. Parameter variations can be run on the simulator, and their effects on gear-shifting can be felt immediately.



- Static effects are evaluated when the vehicle is stationary (with engine switched off) and the gear stick is operated slowly.
- Dynamic effects on the gear-shift feel are caused by the rotating gears and the oscillatable drivetrain, and also by the speed at which the gear stick is handled.



▲ *Shift force simulator: The electric drives are controlled by the dSPACE real-time hardware via power stages.*

To make conditions as realistic as possible, visualization and sound can also be integrated via an Ethernet interface from dSPACE and other hardware.

How the Shift Force Simulator Works

The inputs to the simulation model are the gear selection and engagement motions in relation to the force contact point. The gear stick position signals are provided by the power stages of the drives, which evaluate the signals of the high-resolution gear stick position measurement systems of the drives. The simulation model uses these position signals and the speeds derived from them to calculate the reaction forces which would affect the shift lever in reality. Pedal inputs (clutch, brake, and accelerator) are also read in and included in the simulation in addition to the operating variables at the gear lever. Thus, the simulator is an interactive system that reacts to user input. The forces calculated by the simulation model are the reference values for the force controller, which together with the measured force signals (actual forces) adjust the actuating values for the electric drives, in other words, the desired force. The force signals are measured at the shift lever and transmitted to the host PC and the dSPACE real-time hardware.

Summary and Outlook

The shift force simulator gives Porsche numerous application options in every stage of development, regardless of vehicle or transmission variant. Powerful dSPACE real-time hardware and the real-time simulation model (virtual transmission) form the core of the shift force simulator. The simulator is independent of real prototype parts and can be deployed flexibly in widely varying locations. Ergonomic aspects, such as the driver's position in relation to the gear stick, can be adjusted in many ways. Porsche uses the simulator not only for its own products, but also in custom development at Porsche Engineering.

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