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RECORDING AND AUTOMATED EXECUTION OF DRIVING CYCLES BY MEANS OF FUNCTIONAL EXPANSIONS IN THE EXISTING CONTROL UNIT NETWORK

Verena Blunder
Bertrandt Ingenieurbüro GmbH

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Technical task:
In the development of aggregates it is essential to coordinate and test the aggregate in combination with the complete vehicle. For this purpose, in addition to test drives on test sites, the vehicle is also driven on chassis dynamometers. Usually, defined driving cycles are driven on the chassis dynamometers, which mostly correspond to those of the later homologation of the vehicle. Here a visual driving curve (speed over time within a tolerance band) is displayed to a human driver, which must be driven by the driver. Preferably on endurance roller test benches, mechanical driving robots are also used, to which the driving curve is transmitted digitally. The driver or the robot accelerates and brakes the vehicle on the chassis dynamometer in such a way that the vehicle follows the driving curve within the specified tolerance. Subsequent evaluation of the measured data generated allows the parameterization or design of the unit to be checked. In addition, specific operating points or driving conditions are specifically approached on the test site to check defined applications or designs. Usually such measurements have a recursive character in order to optimize the design or parameterization of the unit.

Initial situation:
For an evaluation of the measurement results of a test on the chassis dynamometer, it is essential that the tests have been driven in an exactly reproducible manner. Due to the use of the human driver this is not completely guaranteed. Driving errors in the form of deviations from the specified driving curve lead to follow-up costs as the test has to be repeated. But also the different dynamics with which the vehicle is driven within the tolerance band can lead to different measurement results. By using mechanical driving robots, which operate the accelerator and brake pedal via servo motors, these driving errors or variations are already minimized.
However, the controlled system is very long when using a travelling robot and the robot's actuators are subject to tolerances. A complete reproducibility of the driving cycles can therefore not be guaranteed. The measurement results can therefore not be used to compare two parameterizations or designs. Furthermore, driving robots cause costs, both in the procurement and in the introduction into the vehicle and maintenance.

Modern vehicles are often equipped with a cruise control system (GRA or cruise control) or Adaptive Cruise Control (ACC) or control units that enable autonomous driving. This accesses the various other control units of the drive units (engine, transmission) and the chassis (ESP, brake) via software on a control unit, thus adjusting a driving speed set by the driver. For this purpose, interfaces are provided in the individual control units which, for example, in the case of the engine control unit, specify the torque required for the set speed, in the case of the (automatic) transmission control unit, the gear to be set and in the case of the ESP control unit, the desired negative acceleration or braking torque. The driver's desired speed is usually transmitted by bus signals to the speed control system's control unit.

Solution:

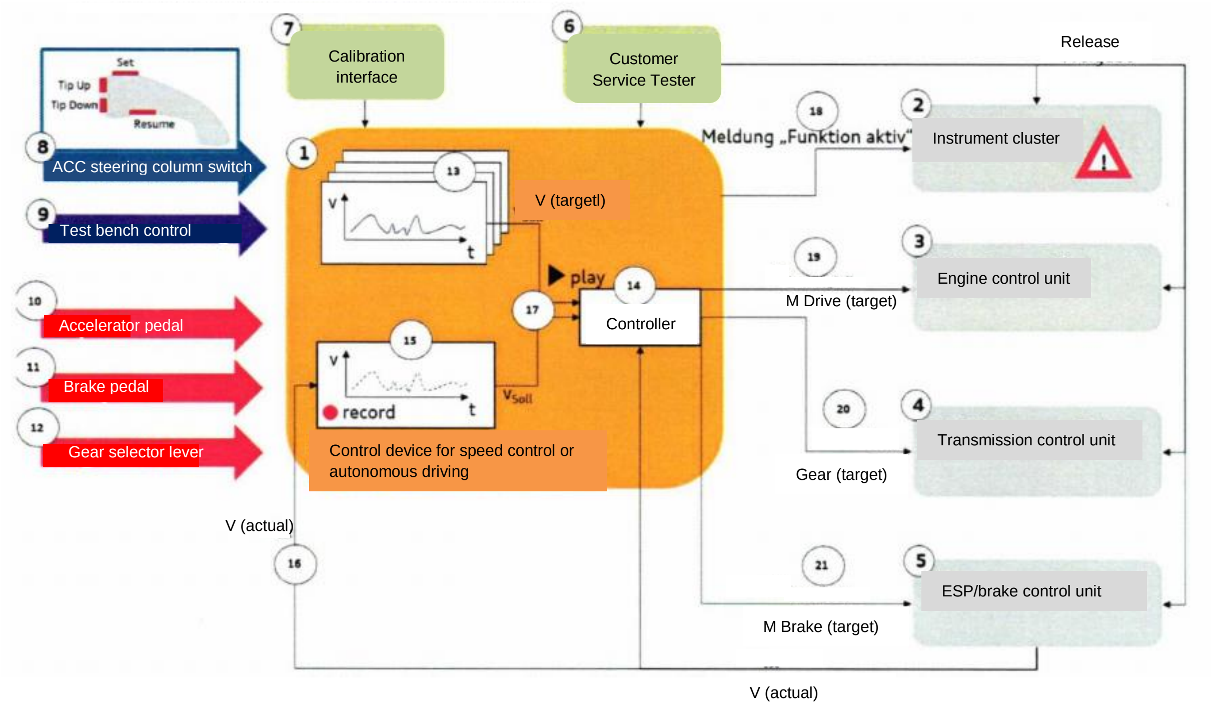

Figure 1: Control unit architecture, signal flows

Note: In the following, the numbers in square brackets refer to figure 1.

As a new functionality, one or more parameterizable travel curve(s) [13] are additionally stored in the software (e.g. in the form of a speed versus time characteristic), which can be activated by an external control unit via bus communication. The driving curves are parameterized via a calibration interface [7] via which the development engineer can access the control unit.

Release of the functionality:
The basic release of the functionality in the control unit for the cruise control system [1] and also the other control units involved [2-5] is carried out either via the calibration interface [7] of the control unit or via the customer service tester [6] (password-protected access is necessary for safety reasons). If the function is enabled, this is sent [18] via a bus interface to the instrument cluster [2] of the vehicle and indicated to the driver by means of a warning lamp and/or an information text.

<u>Selection of the driving curve and start trigger:</u>
There are two ways to select the driving curve and the start trigger for the functionality:

1. if a driver is sitting in the vehicle, he can trigger the selection of the stored driving curve and the start of the driving curve via the steering column switch [8] (selection of the driving curve e.g. via the "TipUp" and "TipDown" buttons, start via the "Set" button) The start signal is transmitted via bus communication to the control unit of the cruise control system [1]. The driving curve can also be selected via the service tester [6] or the calibration interface [7].
2. if no driver is sitting in the vehicle (e.g. on a chassis dynamometer), the selection of the driving curve, its number of repetitions as well as the start of the driving curve can be carried out via the test bench control unit [9] using a so-called residual bus simulation, in which the signal of the steering column switch is deactivated and overwritten via an external bus interface.

Subsequently, the temporal reference speed curve [17] is read out and transmitted to the speed controller [14]. By means of a comparison with the actual speed [16] received from the ESP/brake control unit [5], the target speed [17] is controlled via the manipulated variables drive torque [19], transmission ratio (gear [20]) and braking torque [21].

<u>Recording and running an individual travel curve</u>
The new functionality also offers a driving speed recording function [15], which records the current actual vehicle speed and then repeats this speed exactly reproducibly.

This can be used especially for non-standard driving cycles, i.e. for any driving cycles that are not parameterization or the design of the vehicle, it would be useful to repeat this with different parameterizations or designs in order to compare the differences in the measurement results. For this purpose the driver starts the recording via the steering column switch [8] (e.g. via the "Resume" button), drives the desired driving cycle manually, ends the recording also via the steering column switch (e.g. via the "Resume" button) and can then drive through the driving curve automatically. (Start also via the "Set" button).

Mandatory safety functions:
If the driver intervenes during an active driving cycle using the accelerator pedal [10], brake pedal [11] or gear selector lever [12], the function is immediately deactivated for safety reasons.

Advantages:

- A human driver is no longer necessary (cost reduction)
- There is no need for a driving robot that has to be laboriously installed in the vehicle (cost reduction).
- Acceleration of the development process: repeat measurements due to driving errors are excluded (cost reduction)
- The control quality and thus the reproducibility of driving cycles or driving manoeuvres is optimal due to the software-based control without additional hardware in the controlled system, since a sophisticated control parameterization of the cruise control system software is used. (quality increase)
- Objectification of measurement results and quality criteria as a basis for the further development process (quality improvement).
- No additional hardware is required to implement the idea.

Remark: The representability of this idea has already been proven with a fully rapid-prototypical implementation.