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Bench Drivability Calibration Method by Parameter optimization using Empirical model

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In automotive development, it is important to improve development efficiency and reduce development costs and times as much as possible. For example, in order to solve the problem of increasing the number of man-hours required for calibration due to the complexity of the control system, many approaches which is based on MBD (Model Based Development) have been proposed. Especially, in the field of drivability calibration, attempts have been made to develop a method for quantitative and objective evaluation of drivability, which is the feeling of the driver, by replacing the drivability with physical parameter. In this paper, as one of the methods to improve the efficiency of development, a front-loading method is proposed using MBD, especially for drivability calibration.

First, for the quantification and indexing of driver feeling in the driveability assessment, AVL-DRIVE, a commercially available driveability assessment tool, was used. This tool calculates objective drivability score from physical parameters that correlate with subjective driving feeling, based on driving operation (input) and vehicle response (output) during vehicle driving. The parameters used to calculate the score require the informations such as vehicle specifications, vehicle acceleration, engine speed, vehicle speed, accelerator pedal position, etc. These signals can usually be obtained from sensors that can be mounted on the vehicle or from the vehicle CAN (Controller Area Network). The scope of application of AVL-DRIVE is not limited to in-vehicle usage, but is also assumed to be used for bench evaluation. For example, in the case of four-axis dynamometer bench that measures the output from each wheel of a vehicle, simulation of the vehicle longitudinal acceleration using vehicle model is used instead of actual acceleration measurement by sensors. By importing the simulated longitudinal acceleration into AVL-DRIVE, objective evaluation of drivability can be conducted on the bench.

As the second solution of improving development efficiency, calibration supporting tool AVL CAMEO was used in the evaluation methodology. The tool enables automated bench calibration, planning Design of Experimants (DoE), response sensitivity modelling and parameter optimisation based on empirical models. Especially the DoE, AVL CAMEO can perform Active DoE. It is a method which iteratively adapts the test design during the testrun. On the basis of already measured data, models are calculated online. These models are used to adapt the test design during the testrun in such a way that measurements are executed within the required ranges. The testrun is continued until the model quality matches a termination criterion. This has the advantage that it is not necessary to specify the number of required measurement points in advance and that only as much measurements as required are executed.

The calibration methodology described in this paper is called Advanced Calibration for Driveability (ACD). The basic experimental environment of the ACD consists of AVL-DRIVE, AVL CAMEO and vehicle simuration model. These tools communicate with each other to form a processing loop and create the automated experimental environment. After all the experimental points defined in the DoE have been obtained by the automated experiment sequence, the sensitivity model of the drivability ratings for the calibration parameter is created. Using the sensitivity model, calibration parameters are optimized to maximise pre-defined driveability index.

A demonstration project collaborating with SUBARU Corporation has been carried out to calibrate drivability on a bench using the ACD methodology. In the project, vehicle acceleration behavior in Tip-in operation was assessed by AVL-DRIVE, then the vehicle was calibrated on Powertarin Testbed with ACD methodology. As the result, it was confirmed that the method enables front-loading of the vehicle calibration process and sufficient improvement in drivability can be achieved similarly to the calibration on proving ground.

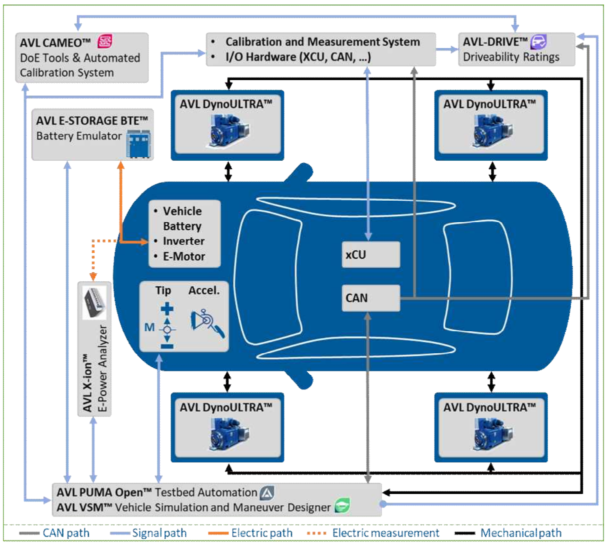

Fig.1 Bench Drivability Calibration environment