

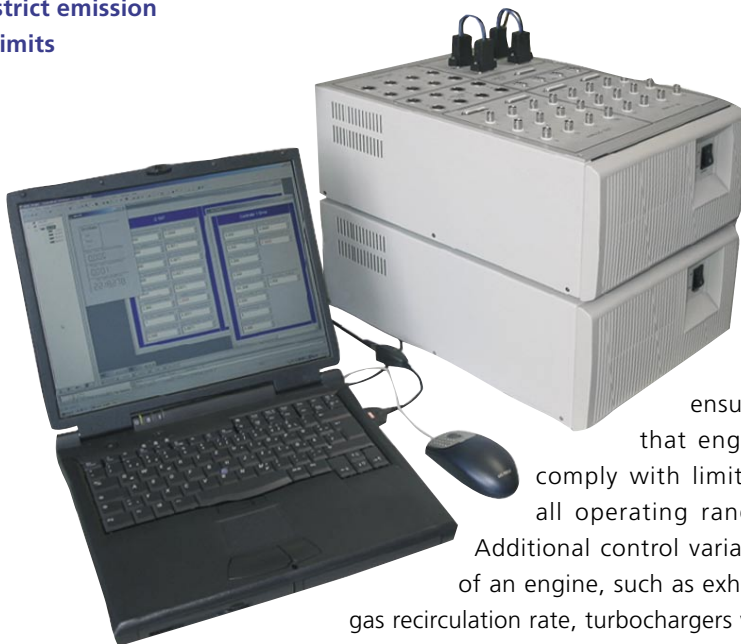
Clean Air with RCP

- // **Cooperation between DaimlerChrysler AG and TU Darmstadt**
- // **New measurement strategy with rapid control prototyping**
- // **Compliance with strict emission limits**

DaimlerChrysler AG in Stuttgart greatly speeded up function design for its new engine series for commercial vehicles by the systematic use of dSPACE-based rapid control prototyping (RCP) systems. Developed at the Institut für Automatisierungstechnik (IAT), the institute for automation technology in Darmstadt, the model-based measurement strategy is implemented on modular dSPACE hardware, which allows the engine's actuators and sensors to be connected directly. Added to this system are MicroAutoBoxes connected to existing ECUs via XCP.

With the increasing strictness of statutory emission regulations, engine designers face the task of

We first designed a new function under MATLAB®/ Simulink®, and then tested it on an engine test bench in bypass mode. Bypassing means that only the new function is performed by the RCP system, while all the other functions remain on the ECU.



▲ Modular RCP system with the IAT's sensor/ actuator interface for commercial vehicles.

ensuring that engines comply with limits in all operating ranges. Additional control variables of an engine, such as exhaust gas recirculation rate, turbochargers with adjustable vanes, injection parameters, and so on, also play a major role. As the number of variables to be controlled increases, so does the workload involved in developing the necessary functions in the ECU. Because around 60% of emissions arise during

Data Acquisition with RCP

To obtain the data needed for the function, we tested an engine dynamically on the test bench. The measurement strategy designed here at the IAT partly

“Without these systems, the time needed for engine development would be far greater, and in some respects we could not achieve the same quality of results at all.”

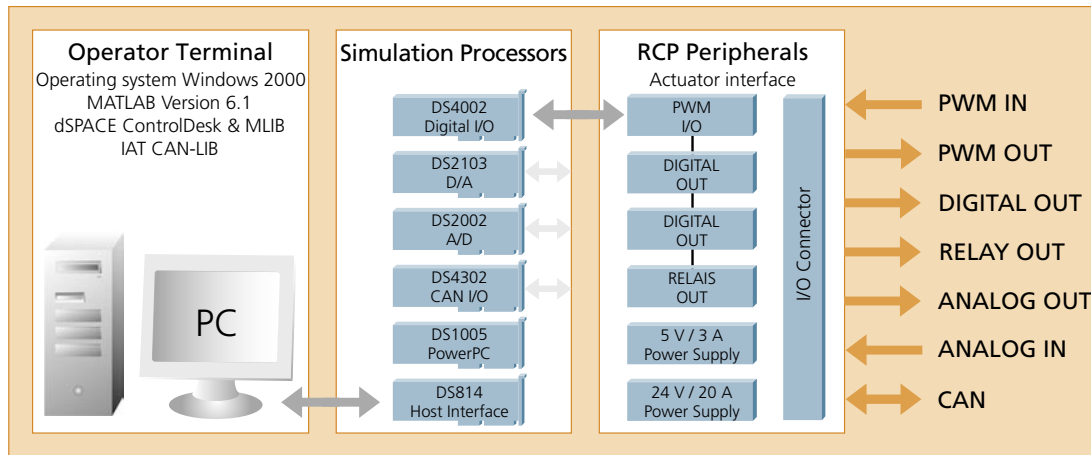
Dipl.-Ing. Peter Renninger

“We are currently running more than 10 dSPACE systems in engine development for commercial vehicles.”

Dipl.-Ing. Peter Renninger

the acceleration and deceleration phases, performing optimization in dynamic engine operation is growing in importance. The development process is now far more efficient with the RCP system from dSPACE.

ignores the engine's transient behavior, which considerably reduces measurement times. This type of measurement is only possible if a real-time-capable RCP system is used. The RCP system overwrites the output signals from the engine control with special excitation signals and records the corresponding measurement variables at a high sampling rate. In contrast to conventional measurement, this procedure allows continuous recording of the sensor data, which we took as a basis for designing a model of the parameters and the control maps. We used both block-oriented modeling approaches (polynomial equations with external dynamics) and neural networks of the LOLIMOT type (local linear model tree), which provide a very simple approximation of nonlinear processes. The control maps are optimized offline by means of these models.



◀ Structure of the modular RCP system with the sensor/ actuator interface developed at the IAT.

This allows systematic testing of the requirements regarding consumption, response behavior, and emission, and also takes different dynamic test cycles into account.

This development chain was successfully applied at DaimlerChrysler in the development of a combined EGR/WG (exhaust gas recirculation/wastegate) control for a 6-cylinder diesel engine for the 900 series.

We developed and automatically calibrated a control that meets all the requirements regarding emission and dynamics in a very short time.

The RCP System from dSPACE

The RCP system used by IAT is based on modular dSPACE hardware consisting of different plug-on boards. These are given a hardware interface, which we used to connect the sensor and actuator systems,

“The RCP systems not only speed up function development but also reduce measurement times on the test bench, by enabling us to use new, dynamic measurement strategies on the engine test bench.”

Dipl.-Ing. Matthias Weber

and a CAN interface with a truck voltage (24 volt). For greater flexibility, additional 12-volt and 42-volt voltage levels were also provided.

Where a prototype ECU is already available for an application, we use a MicroAutoBox, which communicates with the engine control via CAN and the XCP protocol. It performs sensor measurement and also controls the connected actuators.

The programs required for function development and measurement were written under MATLAB/Simulink. We were able to monitor the experiment conveniently on a graphical user interface, via ControlDesk from dSPACE.

With this combined system of modular hardware and MicroAutoBox, the test bench engineer can record all the relevant engine control variables in real time via the dSPACE system and replace signals from the engine control by signals from the RCP system at suitable entry points.

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Glossary

XCP – CP stands for Calibration Protocol, X for various types of communication such as CAN and USB.

Neural networks – A computation model for information processing inspired by biological systems (such as the nervous system and the brain).

Transient behavior – The behavior of a forced vibration from the start of excitation to the start of a stationary vibration state.