Advanced Engine Control Algorithms

ETAS provides a flexible and portable prototyping solution

ETAS rapid prototyping and calibration tools have been simultaneously deployed at Clemson University's research engine dynamometer and within Fiat Chrysler Automobiles' (FCA) powertrain controls development team. Advanced engine control algorithms are able to be developed with high quality and short development times.

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Advanced powertrain control algorithms are a critical part of the solution to meet future emissions and fuel economy regulations as well as to reduce development time and cost. Modern engine technologies utilize multiple actuators, many of which either directly or indirectly affect the same operating parameters such as engine airflow, residual mass, and in-cylinder turbulence.

This high degree-of-freedom situation presents significant challenges for the engine control algorithms. Traditional empirically derived algorithms are not well suited to these high degree-of-freedom engines when the actuators are operating in combinations that the system was not originally designed for. Algorithms designed around the physical principle of the engine and its actuators are being developed which can determine the optimal control parameters for any combination of actuator positions, thereby improving efficiency.

FCA is utilizing multiple university partnerships to perform research in this vital area. One such partnership is with the Clemson University International Center for Automotive Research (CU-ICAR) in Greenville, South Carolina.

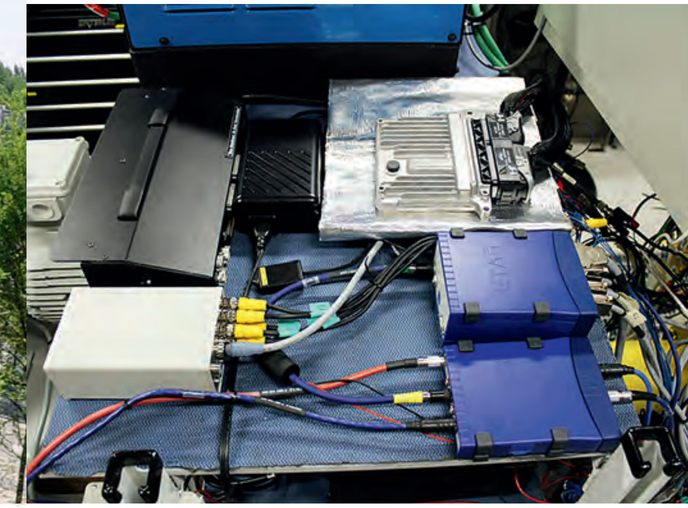
FCA leverages external partnership

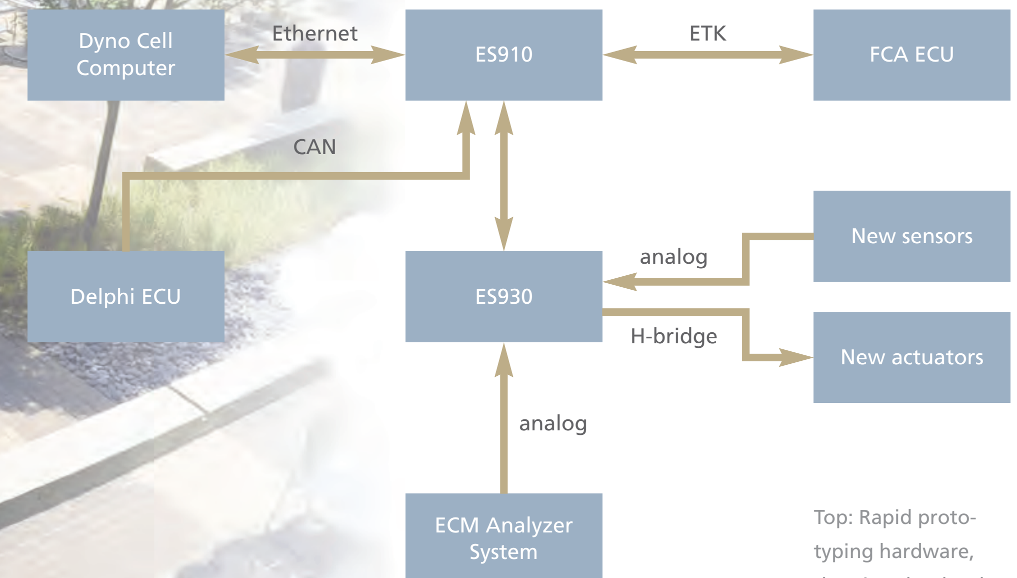
FCA and CU-ICAR entered into a partnership to create advanced engine control algorithms with the goal of improving engine operation efficiency under all operating conditions by utilizing physics-based solutions. FCA supplied CU-ICAR with a 3.6-l Pentastar engine to install in a dynamometer test cell for use in developing and validating the algorithms. Additionally, the project includes additional ECUs, sensors, and actuators that require dedicated I/O to sample and control.

These physics-based algorithms are being developed at the Chrysler Technology Center (CTC) and at CU-ICAR. Therefore, the algorithms need to be shared between both locations for testing in vehicles at CTC and in CU-ICAR's test cell. Due to the physical distance between CTC and CU-ICAR, a flexible and portable development environment was needed.

Project components

The electronic engine-related hardware in the CU-ICAR dyno cell includes:





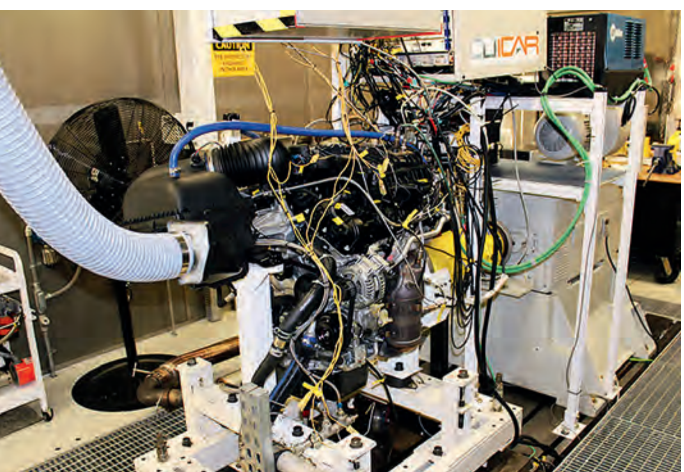
Top: Rapid prototyping hardware, showing the development ECU connected to the ETAS ES910.3 Prototyping and Interface Module and the ES930 Multi-I/O Module.

A combination of ETAS ES910 and ES930 modules was chosen to facilitate communication between the various devices (diagram).

- FCA ECU
- Delphi ECU
- Dyno Cell Computer
- ECM (Engine Control and Monitoring) Analyzer System
- New sensors
- New actuators

A combination of the ETAS ES910 and ES930 was chosen to facilitate communication between the various devices. As shown in the diagram on the previous page, the ES910 communicates with the FCA ECU via an ETK11 and to the Delphi ECU via CAN.
The ES930 is used to sample the new sensors utilizing traditional 0-5 V analog to digital sampling as well as PWM sampling as appropriate. The ES930 also powers new actuators with its on-board H-bridge drivers. The ECM Analyzer System is configured to send its information as analog outputs which are sampled and converted by the ES930.

Engine test cell setup in the laboratory at CU-ICAR.



The ETAS Solution

Collaborative development of advanced engine control algorithms between FCA and its university partners requires a flexible and portable prototyping solution. ETAS rapid prototyping and calibration tools have been simultaneously deployed at Clemson University's research engine dynamometer and within FCA's powertrain controls development team. Advanced engine control algorithms, collaboratively developed between FCA and Clemson University, are able to be developed with high quality and short development times.

The algorithm development is performed in the MathWorks MATLAB®/Simulink® environment. ETAS INTECRIO was chosen as the tool to convert the models into real-time capable code to run on the ES910. The interfacing to the model and ECU parameters is done on the dyno cell computer through ETAS INCA with the INCA-EIP add-on. This allows for a single interface to all measurement and calibration values and allows time-aligned data collection of algorithms running on each module.
The same system configuration exists in a test vehicle at FCA to allow validation of the algorithms as they are delivered. By utilizing the same environment in both locations the teams are able to share algorithms and software packages.

Efficiency and quality increase

This development environment has allowed FCA and CU-ICAR to work in a highly efficient collaborative manner. FCA is able to develop and test prototype engine code at CTC prior to sending it to CU-ICAR for usage in the dyno cell. CU-ICAR can quickly develop algorithms in Simulink® and test them on the engine in the ETAS environment. The system allows for rapid model iteration to resolve issues and optimize the control system on the dyno engine. The resulting Simulink® and/or INTECRIO models can be sent to FCA for system validation directly in the development vehicle. FCA is then able to modify the model, if required, and send the resultant algorithm back to CU-ICAR for further development. This model of operation has significantly increased the quality of the algorithms delivered to FCA and has reduced travel costs typically associated with projects such as these.

Conclusion

FCA is committed to developing cutting edge powertrain control technologies. Collaborative development environments require a flexible tool chain to enable sharing between locations and platforms. The ETAS tool chain is being utilized to facilitate this effort and to allow algorithm portability between FCA and CU-ICAR, resulting in faster development cycles with increased quality.