

Jaguar Reduces Development Costs with MathWorks Rapid Prototyping and Code Generation Tools

To meet demands for increasingly complex new vehicles while continuing to reduce costs, where possible Jaguar develops and tests new functionality using existing production vehicles instead of building expensive prototypes. This approach involves adding a special-purpose electronic control unit (ECU) to the vehicle.

Jaguar, based in Coventry, England, uses MathWorks products to generate control software and deploy it on commercially available, general-purpose ECU hardware based on the Freescale™ MPC555 microcontroller. Jaguar selected the MICROGen product from the UK company add2 Limited as their hardware platform.

Jaguar can now develop new features in an offline mode on a desktop in the lab and then try them out in a vehicle. They can support a variety of application areas, such as the transmission, driver entertainment, and body system. By testing the new features on real hardware, they improve the quality of specifications that they provide to their suppliers.



MPC555-based electronic control module, pictured on the vehicle dashboard. Photo courtesy of add2 Ltd.

would deal with this problem by commissioning a special-purpose ECU that would perform “protocol conversion” between a new ECU and an existing network on the production vehicle. This work was subcontracted to external code developers, which was a slow and costly option. It involved giving specifications to a vendor, who would write software and send them the code. On-vehicle debugging would identify problems with the code, requiring Jaguar to go through several iterations before implementation.

Jaguar needed a quicker, more cost-effective approach.

THE SOLUTION

In proposing a solution, it soon became apparent that the resulting system could be used, not only for protocol conversion, but also as a rapid prototyping system for implementing and testing new control algorithms or diagnostic features. The scope of the project was widened accordingly.

For targeting MICROGen, their general purpose ECU, Jaguar selected the MathWorks complete software environment,

THE CHALLENGE

To reduce the costs of testing new product functionality by adding a general-purpose ECU to an existing vehicle

THE SOLUTION

Use MathWorks tools to generate control software and deploy it on general-purpose ECU hardware

THE RESULTS

- Significant time and cost savings
- Ability to test more design options
- Faster development of embedded control designs

THE CHALLENGE

Most vehicles today contain several control units that are interconnected via real-time network standards such as CAN and J1850. Messages sent over these networks are used to continually transfer vehicle data and control information between ECUs. When a new ECU is received, by Jaguar, from a supplier, the ECU “expects” to be installed in a vehicle with other ECUs that use the same message format and network protocol. However, initial development of systems with the new ECUs begins on existing production vehicles, presenting problems with incompatible message formats and protocols. Previously, Jaguar

based on Simulink®, Stateflow®, and Real-Time Workshop®. The MathWorks created a new product to support Freescale™ MPC5xx, called Target Support Package™ FM5. Jaguar used these MathWorks products to design, simulate, and test control algorithms and generate custom code that was downloaded to MICROGen hardware. For a typical project, they build the control system as a block diagram in Simulink and Stateflow. To access I/O such as PWM, analog input, or CAN that is incorporated in the MPC555 microcontroller, they use blocks that are included with Target Support Package FM5. Additional Simulink blocks have been developed by add2 Ltd to provide access to I/O devices that are external to the MPC555 chip.

In this way, the control algorithms that Jaguar developed could process signals received via a CAN or J1850 bus or directly from sensor inputs. The algorithm output could be transmitted as a bus message or used to drive output devices directly.

Because the Simulink and Stateflow model was an executable specification, algorithms could be simulated and tested offline as they were being developed. Once the algorithm was validated in simulation, a complete application could be automatically generated and downloaded to ECU hardware.

Once the code was generated, test engineers downloaded the application over CAN into either RAM or flash memory on the target ECU.

Jaguar can customize, document, test, and validate the algorithm model, and then generate code for MICROGen, all within the MathWorks environment. For example, Target Support Package FM5, in conjunction with Jaguar's ECU hardware, allows some prototype work to be completed in-house, which in turn allows more complete and

accurate specifications to be sent to suppliers for them to develop the actual system. Jaguar is now using the code with general-purpose ECU hardware to aid in the development of control strategies. For example, during Engine Management Systems (EMS) development, they ran code on MICROGen to simulate the vehicle transmission control unit. This allowed the engine and EMS to be tested through a number of drive cycles. The cycles were simulated by using the ECU hardware to send transmission position information to the EMS, which in turn "thought" it was in a certain gear. The gear selected was easily controlled by the test engineer or by an automated test procedure.

THE RESULTS

▪ Significant time and cost savings.

Using MathWorks tools cuts several weeks from a typical development project. Without the general-purpose ECU, Jaguar would have had to ask the supplier to provide special, development-grade ECUs and software updates every time they wanted to test a new strategy. Today they can test many more design iterations and save a great deal of time and money.

▪ Ability to test more design options.

Reduced validation effort and the increased use of general-purpose and cost-effective ECU hardware allow the simultaneous trial of prototype control modules across a fleet of engineering vehicles, thereby enabling more rapid evaluation of proposed features.

▪ **Faster development of embedded control designs.** MathWorks products enable Jaguar to test innovative new vehicle features faster and more effectively.

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- Automotive engineering
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- Modeling and simulation
- Code generation

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- MATLAB®
- Simulink®
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- Real-Time Workshop®
- Target Support Package™ FM5
- Real-Time Workshop Embedded Coder™

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