Driving with no emissions

First Mitsubishi electric vehicle ready for launch

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Mitsubishi's new electric vehicle, i-MiEV, lives and breathes by its complex electronics. Mitsubishi ran rigorous tests to ensure the quality of the software, yet still managed to cut the time-to-market.

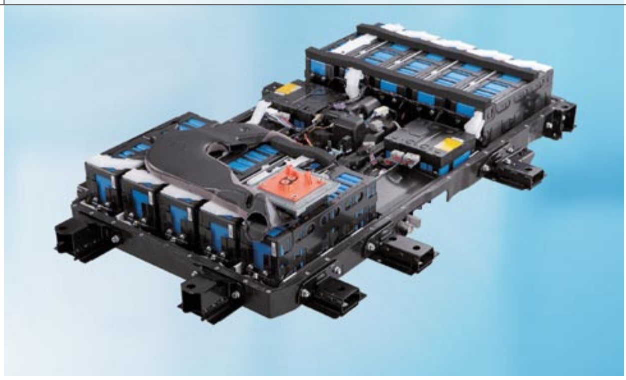


Figure 1: The battery pack and electric motor of the i-MiEV enable emission-free driving.

> "In accordance with design content, dSPACE Simulator offers a very high level of general versatility and can be used for almost any vehicle and ECU."
>
> *Dr. Kazuya Hayafune, MITSUBISHI MOTORS CORPORATION*

Development Outline

The i-MiEV (Mitsubishi innovative electric vehicle) next-generation electric vehicle is literally an aggregation of electric and electronic components. Because its various functions are achieved by distributed control using an onboard network, ensuring the quality of the total vehicle system as well as that of the electronic control unit (ECU) software is vital. And at the production development stage, the quality of complex systems has to be verified within the limited time available.
As a means of ensuring quality in the shortest possible time, software reliability testing was conducted using a hardware-in-the-loop (HIL) simulator made by dSPACE.

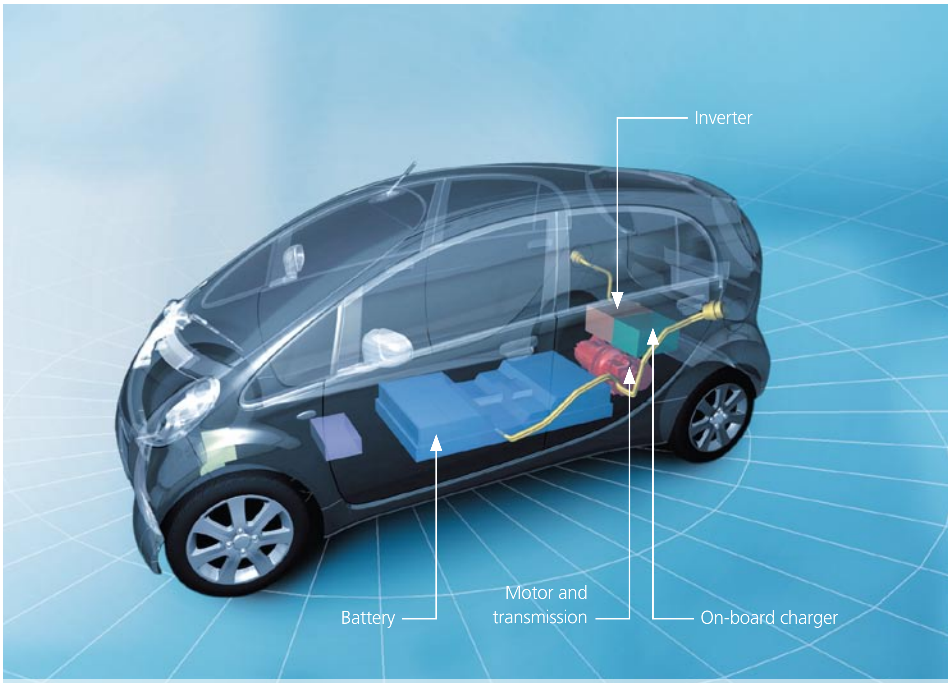
ECU Structure and System Specifications

The i-MiEV's electronic platform is characterized by a distributed control format that uses five dedicated ECUs.

In addition to performing the conventional vehicle functions of driving, cornering, and stopping, electric vehicles also need the ability to recharge from a home power socket and rapid charger, and to run on an electric motor.
For all this to be possible, the ECUs that control the electric vehicle

Figure 2: Recharging the battery.

Figure 3: Schematic of the power train.



Technical Details for 2009 Japan Spec

Max. power	64PS/47kW
Max. torque	180 Nm
Max. speed	130 km/h
Battery	Lithium ion
Total voltage	330 V
Total energy	16 kWh
Range	160 kilometers (Japan 10-15 driving pattern)
Curb weight	1100 kg
Battery recharge	Approx. 7 hours (AC 200V/15A)
Fast battery recharge	Approx. 30 minutes (80% charged)

Figure 4: Team members responsible for electrical reliability of the i-MiEV.

require reliable means to transmit vehicle control information.

System Design Outline

The five ECUs are connected through a key bus – a controller area network (CAN) bus. Multiple communication lines are provided as backups for when the key bus malfunctions.

Issues and Corresponding Requirement

- *Issue 1:* Ensure the quality of the software of Mitsubishi's first dedicated electric vehicle ECUs.
- *Issue 2:* Ensure the quality of the software of the overall electric vehicle system.
- *Issue 3:* Achieve issue 2 within a limited development period.
- *Requirement:* No defect should occur during any user operation whatsoever.

Solutions

- *Issues 1 and 2:* In line with the requirement specifications, the focus was on software processing as well as the branch conditions and state transitions of the vehicle's total system. Specifically, we designed software tests for all inputs to the ECUs and vehicle systems.
- *Issue 3:* Targeting all inputs resulted in an enormous number of test patterns. To reduce this number efficiently, an orthogonal design was used. dSPACE Simulator was used to reduce the number of testing man hours by automatic test execution.

> "A dSPACE HIL simulator consists of visually easy-to-understand components like AutomationDesk. We found that this test automation software is extremely easy to use."
>
> *Masahiro Kaneda, MITSUBISHI MOTORS CORPORATION*

The Role of, and Expectations for dSPACE Simulator

In executing the testing, it was necessary to adapt the test design content for the test patterns quickly and accurately. For the sake of analysis, a high level of replication was needed when software bugs were detected.
Therefore, a dSPACE Simulator Mid-Size was used to simulate user operation and the inputs to the ECUs accompanying it during the design process. An actual vehicle was used for the real load on the HIL simulator. The test automation software AutomationDesk was used as a means of creating test patterns quickly.

Evaluation of dSPACE Simulator

dSPACE Simulator proved extremely effective in ensuring the quality of the software of the i-MiEV on schedule. If it had not been for the dSPACE Simulator, verifying software quality within the time available would have been problematic.

Future Development

While HIL-based verification was used on the right-hand side of the V-cycle in vehicle development, in the future a means of assuring software quality at a more upstream stage (left-hand side of the V-cycle) will be sought. ■

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