Honda: Testing Automatic Transmission ECUs

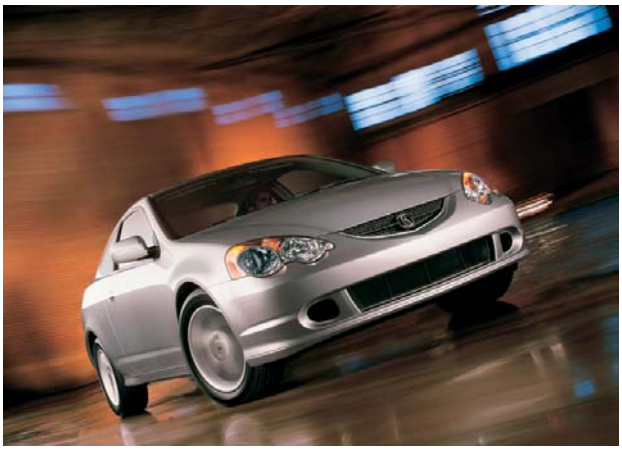
- 5-speed automatic transmission system
- dSPACE Simulator to develop the transmission's electronic control unit
- Fewer durability tests and dramatically reduced development time

Honda has developed a direct control 5-speed automatic transmission system for front engine, front-wheel drive vehicle applications, which can be regarded as a new generation of automatic transmission for passenger cars. In addition to conventional simulation technology, Honda utilized a dSPACE Simulator to develop the transmission's electronic control unit (ECU). Using hardware-in-the-loop (HIL) technology dramatically reduced the overall development time.

Five-Speed Automatic Transmission

The new five-speed automatic transmission (AT) provides smooth gearshifting and a good response, along with great fuel economies in various driving conditions. Moreover, it has a sequential mode called S-MATIC, which drivers find fun to use because it gives them a real "gearshift" feeling. The new AT system is more compact in size, yet provides higher performance and higher quality compared to existing transmission systems.

This is all made possible by employing advanced technology such as ultra-flat torque converters, which make the transmission more compact, and the world's first ever clutch pressure control system using linear solenoids.



Honda Acura RSX, equipped with the new 5-speed automatic transmission system.

The AT is used in several models, for example, Honda's 2001 Acura RSX model.

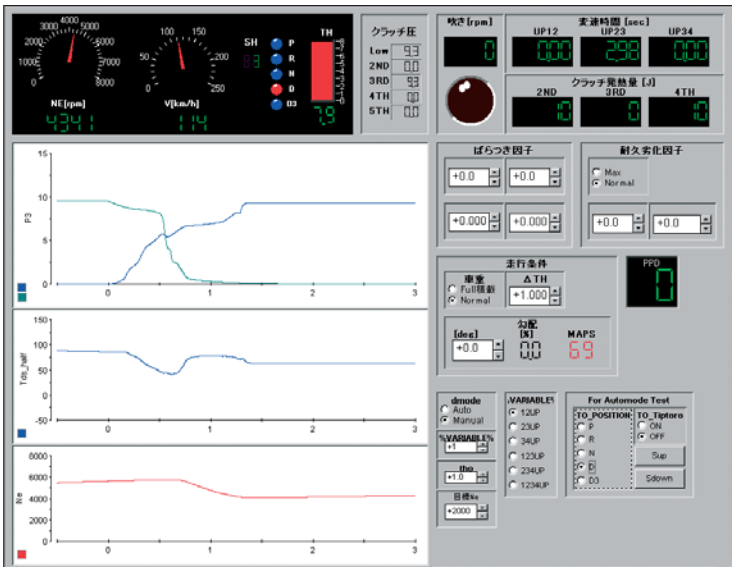
The Need for HIL

Previously, too much time and manpower would have been required to determine the ECU specifications for the AT. We had to do validation tests with actual vehicles, and some of the tests really caused trouble.

We felt that if the tests were implemented via simulation, we could expect a huge decrease in the amount of manpower required. We therefore incorporated the existing high-accuracy AT gearshift feeling simulation model into the system.

To find the best solution for our HIL system, we carefully compared and evaluated the various products available. The choice fell on dSPACE Simulator because of its mature technology both in overall functionality and in the built-in support structure for customization.

Our HIL environment consists of the actual ECU, a diagnostic monitor, dSPACE Simulator to run the simulation, and a host computer. There is an interface box for handling the communication processes by adjusting the signal levels between dSPACE Simulator and the ECU. Finally, there is a relay box that generates wire breaks and short circuits with arbitrary signals to simulate system failures.



ControlDesk is essential software for Honda's production AT development.

Regarding the electrical interface, we were able to build a highly accurate HIL system in a short time using dSPACE's high-performance I/O boards, for example, the DS5101 Digital Waveform Output Board. These modular dSPACE boards are capable of responding to the many input and output signals required for connection to the ECU, for example, the complex pulse patterns required by an engine or for data communication. We also constructed a new relay box in-house. This recreates electrical failure modes and is controlled from ControlDesk.

Simulating the Shift Feeling

In manual operation, parameters are specified by using the cockpit panel on the interface box and the ControlDesk software. Simulations are executed under the desired conditions by setting parameters for throttle angle signals, AT shift-lever signals, control signals for the relay box and simulation conditions.

In automatic mode, the operation signals are created by a driver model. The simulations are automatically executed by referring to a driving mode table and a failure mode table, generated in advance with ControlDesk's Stimulus Editor. The ECU connection information table was created in advance with Microsoft Excel.

However, some problems needed to be overcome. Because the offline simulation model for the AT transmission shift feeling required enormous computing power, it was actually impossible to run the model in real time. By analyzing the necessary computation sampling rate for each component of the simulation model, we found that the model part for the AT torque transmission required the lowest execution time. By using a multirate system, we finally achieved satisfactory accuracy and real-time operation.

ECU Development for Mass Production

We also used our dSPACE Simulator to test our newly designed 5-speed automatic transmission systems, which are now going into production, for example, in the Honda Acura RSX. Through simulation, we were able to reduce the number of durability tests carried out with actual vehicles, especially because dSPACE Simulator was able to reproduce the vehicle conditions at the end of the durability tests.

HIL systems face constantly growing demands for computation power caused by increasingly complex real-time models. The number of automatic test patterns and models an HIL system must handle is also growing.

We could not have developed the system without the integrated development environment, including dSPACE Simulator, the functionality and flexibility of its integrated I/O boards, and the powerful software, above all ControlDesk. We plan to widen the application range of dSPACE Simulator in our production AT development, and are anticipating a further reduction in the time required to determine the ECU specifications.

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