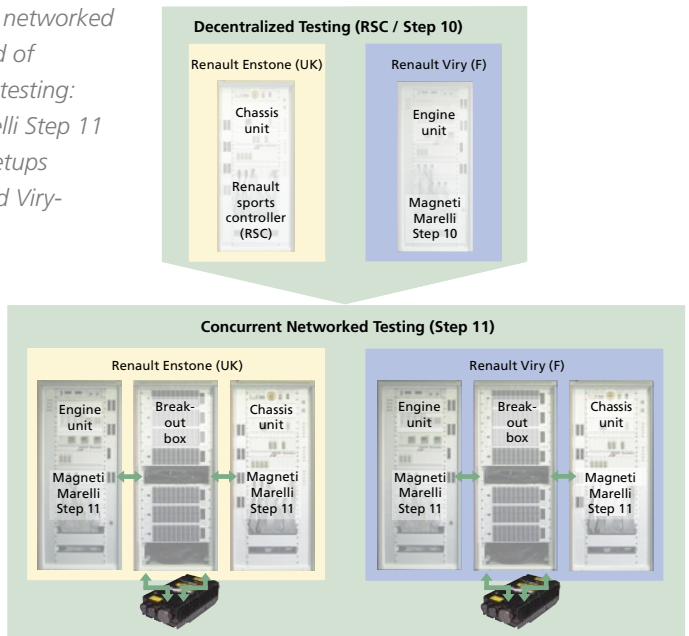
Renault F1 Team Wins With Step 11

- **Renault F1 Team uses new Magneti Marelli ECU**
- **Controller and dSPACE Simulator Full-Size designed in parallel**
- **Simultaneous testing at different places**

The Renault F1 Team got off to a highly successful start in the current Formula One season, using a new electronic control system. Wanting a more powerful platform for the engine and chassis control, but also to simplify the electrical and electronic installations, the team had decided on a combined chassis and engine controller. Called "Step 11", the new racing controller was developed in partnership with Magneti Marelli according to the team's requirements. Simultaneously, dSPACE designed a Simulator Full-Size, two identical setups of which were produced for the Renault F1 Team technical centers in the United Kingdom and France.

Renault is one of the few Formula One manufacturers to produce both the chassis and engine in-house. The team in Enstone is responsible for chassis development and so far we have tested the chassis electronic control unit (ECU) with the corresponding simulator, while the engine team in Viry-Châtillon also tested the Magneti Marelli Step 10 controller on two dSPACE engine simulators. Last year, the Renault F1 Team decided to develop the all-new electronic control system, Step 11. Step 11 is physically lighter, representing a quarter of the total weight saving in the new car, and gives us more scope for further development.



Completely networked testing instead of decentralized testing: Magneti Marelli Step 11 on identical setups in Enstone and Viry-Châtillon.

It has four times the processing power, and ten times the data acquisition capacity, all of which will help to improve control systems compared with 2004. On that score, the new R25 is certainly the best-integrated racing car the team has ever produced.

HIL Testing of the New Racing Controller

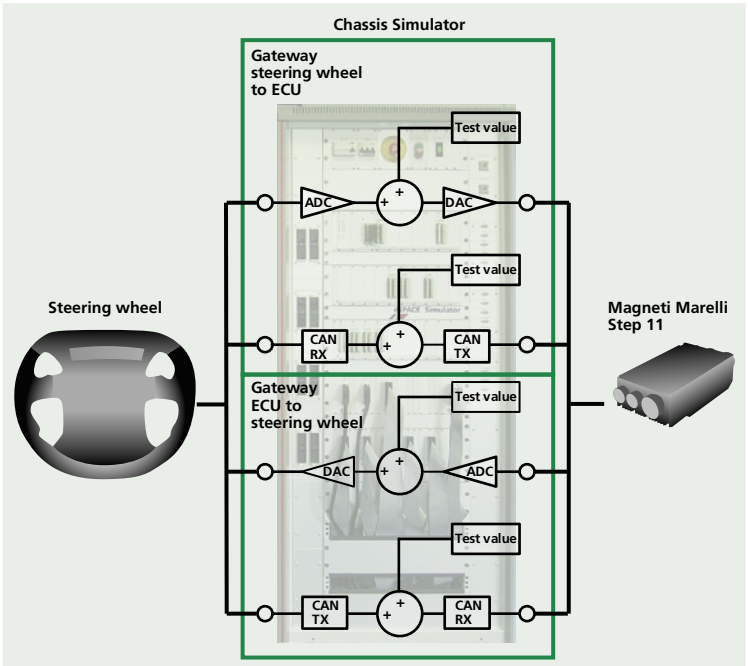
The requirement was to create an overall hardware-in-the-loop (HIL) system that integrated the chassis and engine HIL test systems in the United Kingdom and France to test the Step 11 controller. dSPACE was the company that offered everything we needed. The dSPACE Simulator Full-Size consists of three racks: engine rack, chassis rack, and break-out box (BOB) rack. The optional BOB rack makes all the ECU pins directly accessible, enabling every signal to be measured with great precision. The dSPACE Simulator Full-Size can be run either with the BOB rack attached or with Step 11 directly connected to the engine or chassis rack. The simulator is hosted by a PC with dSPACE standard software: the ControlDesk experiment software to control the real-time hardware and failure insertion capabilities, and a Simulink model as the basis for the real-time application. The real-time hardware comprises four DS1006 Processor Boards with several dSPACE I/O boards connected to them. Interprocessor communication is via high-speed Gigalink modules, which are connected by fiber-optic cables. Various signal conditioning, load, and failure insertion modules are connected to interface the I/O hardware to signals to and from the ECU.

The simulator also has all the relevant car components connected, such as:

- Magneti Marelli Step 11
- Two lambda modules
- Four upright boxes
- Voltage regulator box
- Lap trigger
- A real steering wheel and pedals can be connected, too.

The dSPACE Simulator Setup

The engine and chassis racks are networked for testing networked functions. They have extremely fast model components, each running at different sample rates to handle model dynamics. Computing specific components requires only 50 µs (20 kHz) to achieve sufficient stability and accuracy. Renault F1 and dSPACE jointly defined the entire topology and signal routing on the individual CPUs. The simulator has a failure insertion unit (FIU) for feeding forward electrical faults for all ECU outputs and inputs: open wire, short to GND, and short to V_{BAT}, which can be set manually or automatically by the host PC. Another FIU is used to feed forward faults on the ignition channel and to keep permanent short-circuit currents. In addition, the simulator features a special sensor simulation. With the appropriate sensor scaling, any sensor value can be set and monitored in engineering units in the ControlDesk experiment software. Signal conditioning modules are available for simulating highly specialized sensors, such as thermocouples, linear lambda probes, and LVDT sensors (Linear Variable Differential Transformer). The simulator comprises a complete steering wheel gateway for all discrete and CAN signals. The steering wheel generates signals. The simulator picks the signals up, falsifies them if necessary and forwards them to the ECU for failure simulation, and vice versa. The simulator also includes a noise generator for generating an explicitly bad environment. Any sensor signal in the ControlDesk layout can be chosen for "noising", for example, with a loose sensor connector, even during run time. The tough requirements on the HIL D/A channels in terms of high precision and marginal noising have been met. The noise on signal channels was reduced to a minimum by several measures such as signal topology and shielding.



▲ *The F1 steering wheel as an example of gateway operation.*

▲ *The ControlDesk screen shows the validation of the ignition and injection timing.*

with our simulator here in the United Kingdom. If the team in France modifies the ECU code in terms of ignition and injection strategy, the ECU will also be flashed with the new code in the United Kingdom, so that we can simultaneously test that it is correctly implemented in terms of chassis functionality. Constant data exchange between the United Kingdom and France allows us to produce the same test results at both sites, with automated testing 24/7.

Simultaneous Testing at Different Locations

The ECU software is constantly undergoing further developments – there are new software releases every few days – and the interaction of all the ECU functions has to be tested again and again before the software is released for use on the race track. dSPACE Simulator is used to run the ECU function tests both in the software development phase and between races. HIL tests on engine functionality implemented with the simulator in France can now be verified and reproduced

▲ *Twin dSPACE Simulators: Renault F1 tests new functions on the new Magneti Marelli Step 11 controller simultaneously in the United Kingdom and France.*

Excellent Cooperation with dSPACE

We started the simulator project with dSPACE in early June 2004. Only 4 months later, in September, the first simulator was supplied to us here in the United Kingdom, followed by the second system in October, which was delivered to the Renault F1 Team in Viry-Châtillon, France. Formula One is a very fast-moving business, so flexibility was vital. dSPACE was always quick to respond to any new specifications for the Step 11 racing controller, which was being developed in parallel – at the start of simulator design, there was not even a prototype of the Step 11 controller available. dSPACE was always closely integrated into the Renault F1 Team development process and proved to be a very competent development partner with regard to project management and engineering support.

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