

Eco-Friendly Starter-Alternator

- Micro-hybrid concept developed with dSPACE aid
- Reduced fuel consumption and CO₂ emissions
- Engine's behavior simulated with dSPACE Simulator

Valeo Systèmes Électriques, a member of the Valeo group, used dSPACE tools according to the standardized V-cycle to develop a reversible, belt-driven starter-alternator. This innovative concept brings together the features of an alternator and a starter in one product to reduce fuel consumption and CO₂ emissions. During the development process, Valeo first descended the V-cycle using automatic code generation with TargetLink, then ascended the V-cycle using dSPACE tools combined with Valeo facilities and methodologies.

The StARS Micro-Hybrid Concept

Electrical energy in the vehicle is a key factor in meeting the requirements of motorists and the general public for more comfort, enhanced mobility and less pollution. Valeo's micro-hybrid concept combines the functions of a starter and an alternator in one unit: the starter-alternator StARS. The StARS system is made up of an electric machine, an associated control box, and a three-phase cable linking the two, all fitted under the hood.

The electric machine is reversible. It is a traditional alternator which is made to operate like an electric motor by controlling the phases. In alternator mode, part of the mechanical energy of the internal combustion engine is converted into electrical energy, which is stored in the battery and feeds the on-board power supply network. In starter mode, the electrical energy is taken from the battery to produce mechanical energy used to start the combustion engine. Valeo uses the system's capacity to stop and then

restart the vehicle's engine immediately, silently, and in a transparent way for the driver. This technology therefore saves fuel and avoids pollution when the vehicle stops at a red light, in a traffic jam, or when making a delivery. The vehicle starts up again quietly and automatically as soon as a gear is engaged or, in automatic vehicles, when the foot is released from the brake; the system operates discreetly without disrupting the driver's normal driving habits. Consumers will benefit from up to ten percent fuel savings, zero emissions when the vehicle is at a standstill, and reduced noise levels.



▲ The StARS micro-hybrid system: Electric machine, three-phase cable, and control box.

Code Generation with TargetLink

The StARS system and the associated control box contain embedded software which can be divided into basic software, abstraction layer, and application components. The basic software consists of standard interfaces. The abstraction layer above it gives access to variables via get and set functions. It was generated by a proprietary tool. All application components were generated automatically by the TargetLink code generator and tested extensively with its test features.

Validation Bench with dSPACE Simulator

We integrated a dSPACE Simulator with a mechanical test bench to validate the StARS system. The complete validation bench consists of a dSPACE Simulator Full-Size, a control cabinet for the mechanical test bench including the load bench, and the mechanical test bench including an interface for the electric machine and the battery.

The dSPACE hardware-in-the-loop simulator is equipped with a processor board which runs the environment model, a set of I/O boards and signal conditioning cards, a set of power supplies and switches, a fault insertion unit, and network resources (for example, CAN,



▲ The validation bench based on dSPACE Simulator Full-Size.

LIN), etc. The mechanical test bench simulates the internal combustion engine as viewed from the StARS system. It contains an electric motor with its variable-speed controller. The loads connected to the bench may be simulated or real. The load bench used is in fact an electronic load used to dissipate energy. It simulates the current consumers in a vehicle, and contains a real battery and a set of power supplies. We have access to a single 12 V battery, or a 36 V battery. The battery can also be simulated if necessary.

Used Validation Software

A number of programs are required to operate the validation bench. Some are supplied by dSPACE,

the others have been developed by our team. The following programs are used with the bench:

- MATLAB®/Simulink®/Stateflow® to design the environment model
- Real-Time Workshop® from The MathWorks combined with dSPACE's Real-Time Interface to generate, compile and load code into the test bench
- dSPACE's ControlDesk to control the validation bench
- dSPACE's AutomationDesk to automate the actions carried out under ControlDesk

Brilliant Support

The aim of the StARS validation process was to optimize the supply and management of the electricity, and to ensure that the engine starts and restarts quickly and

quietly. Whether descending or ascending through the standardized V-cycle), dSPACE provided a solution to our requirements. In general, a standard solution from any one supplier never exactly meets the requirements of the customer. What we appreciate about dSPACE is that it allows us to add

to their environment by using simple proprietary solutions and without having to do too much development. For validation, the service provided by dSPACE is not only hardware and software, but also intellectual, with the creation of a solution specific to our application.

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