Twice the Power with Hybrid Drives

- HIL simulation of a hybrid drive
- Special hardware for PWM measurement
- Throughput time 7 microseconds

Soaring fuel prices and tougher emission guidelines are presenting automobile manufacturers with new challenges. For many of them, the hybrid electric vehicle (HEV) is the answer to both problems. Combining a combustion engine with an electric motor reduces fuel consumption and toxic emissions, and at the same time makes driving more fun. Interest in this alternative form of propulsion is growing, especially in Asia and the USA. To test the electronic control units (ECU) for the hybrid drive, special dSPACE boards are used in hardware-in-the-loop (HIL) simulation, drawing on dSPACE's years of experience in simulating electric drives.

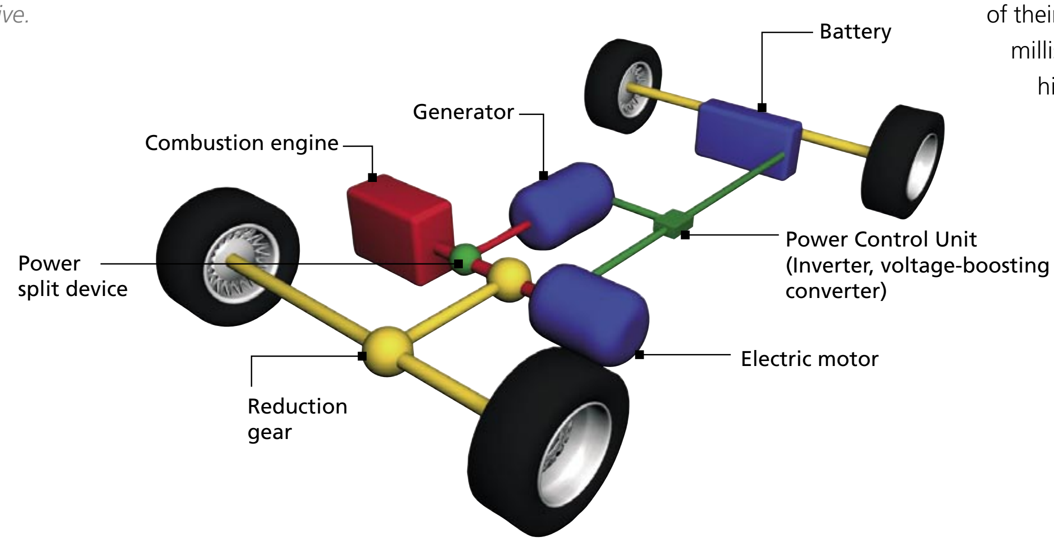
Hybrid Drives in Brief

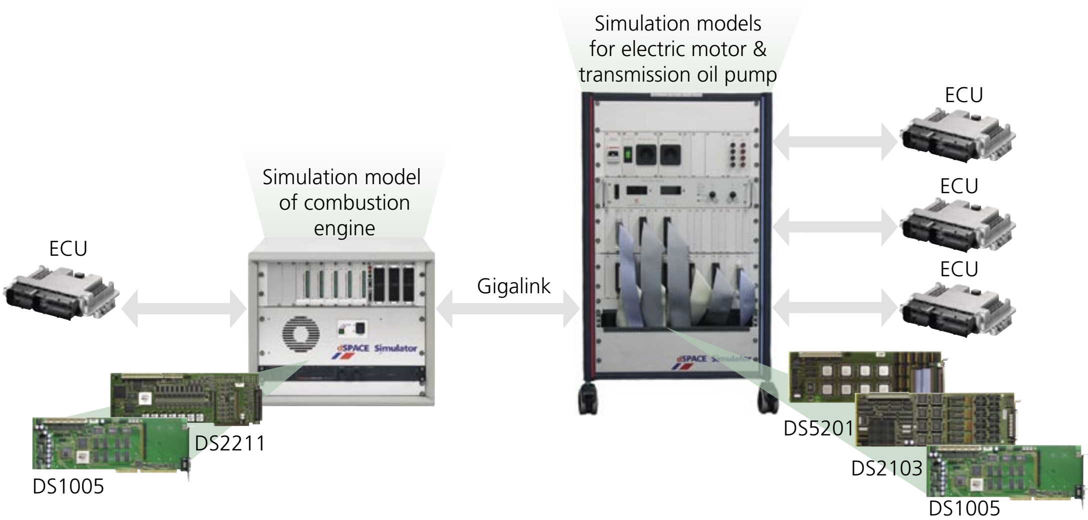
Most vehicles with hybrid drives combine a combustion engine with one or more electric motors to utilize the strengths of both kinds of drive. An electric motor has the advantage of being able to accelerate straight from zero to a very high torque. When the vehicle brakes, and while the combustion engine is running, the electric motor functions as a generator and recharges the battery. A combustion engine usually has good efficiency only in a restricted engine speed range. The interaction between the two different systems results in high torque across a very large engine speed range, which additionally reduces fuel consumption and toxic emissions. The combustion engine in HEVs delivers the necessary propelling force for high-speed driving on the open road, and the electric motor provides additional drive torque during the acceleration phase. In town, where starting and braking alternate constantly, the vehicle automatically switches over to the electric motor, which is supplied by the battery.

Hardware-in-the-Loop Simulation

One typical customer application is simulation of a combined combustion engine and electric motor to represent the longitudinal dynamics of a hybrid drive. The two torques, one for each drive, are computed from the ECU signals and then coupled via a transmission model to form a single drive torque. This loose form of coupling has the advantage that the submodels are computed in separate tasks, so that real-time conditions can be achieved for each ECU independently. Electric motors act much faster than conventional combustion engines and can reach 90% of their maximum torque in only a few milliseconds, which requires a very high sampling rate. Thus, typical ECUs for electric machines have cycle times of approx. 60 to 200 microseconds. The throughput time for simulating an electric motor and its associated I/O signals on a DS1005 PPC Board is usually 7 microseconds.

▼ *Combustion engine and electric motor can work separately or together in this hybrid drive.*





▲ *Custom setup of dSPACE simulators for simulating the combustion engine and electric motor.*

This speed is achieved in conjunction with components such as the DS5201 IGBT Pulse Measurement Board (IGBT = insulated gate bipolar transistor), which has been optimized for this application area. This measures the PWM control signals (PWM = pulse width modulation) of the electric machines with a resolution of 25 nanoseconds. It has over 64 channels, on which parallel input signals can be measured and evaluated by means of a field-programmable gate array (FPGA). The motor angle and the required current are determined in the electric motor model and fed back to the ECUs via the DS2103 Multi-Channel D/A Board. Unlike the simulators for combustion engines, the electric motor simulators do not fetch the signals from the actual connections to the drive electronics, but instead, the control loop is closed via the control signal of the power electronics. In future, it will be possible to map 3-phase electric motors for further processing by simulating inductive loads. The inductive loads will be represented by special motor load simulation hardware with an integrated analog processor. The simulation of electric drives will then no longer be restricted to automotive applications, see also dSPACE NEWS, Fall 1997.

A Typical Customer Project

One specific customer project involved constructing a multiprocessor system in which two simulators were linked. The first simulates the combustion engine and the transmission on a DS1005 PPC Board. The necessary inputs and outputs are provided by a DS2211 HIL I/O Board with integrated signal conditioning (at a sampling rate of 1 millisecond). The second simulator computes the electric components of the hybrid drive. These consist of the simulation models for two electric motors and one electrically driven transmission oil pump. The ECUs of the electric motor have a cycle time of 125 microseconds, so with a throughput time of 7 microseconds, it is no problem to compute all the electric machines on one processor board. The electric motors concerned are permanently excited synchronous machines (PSMs). They interact in a complex manner, coordinated by the drive management feature. In this system too, the simulation systems of the combustion engine and of the electric motor are coupled by computing the resulting total drive torque.

Glossary

IGBT – Semiconductor component used in power electronics.

FPGA – Freely programmable logic circuits.

Gigalink – High-speed serial data transmission via fiber-optic cable and 1.25 Gbit/s technology.