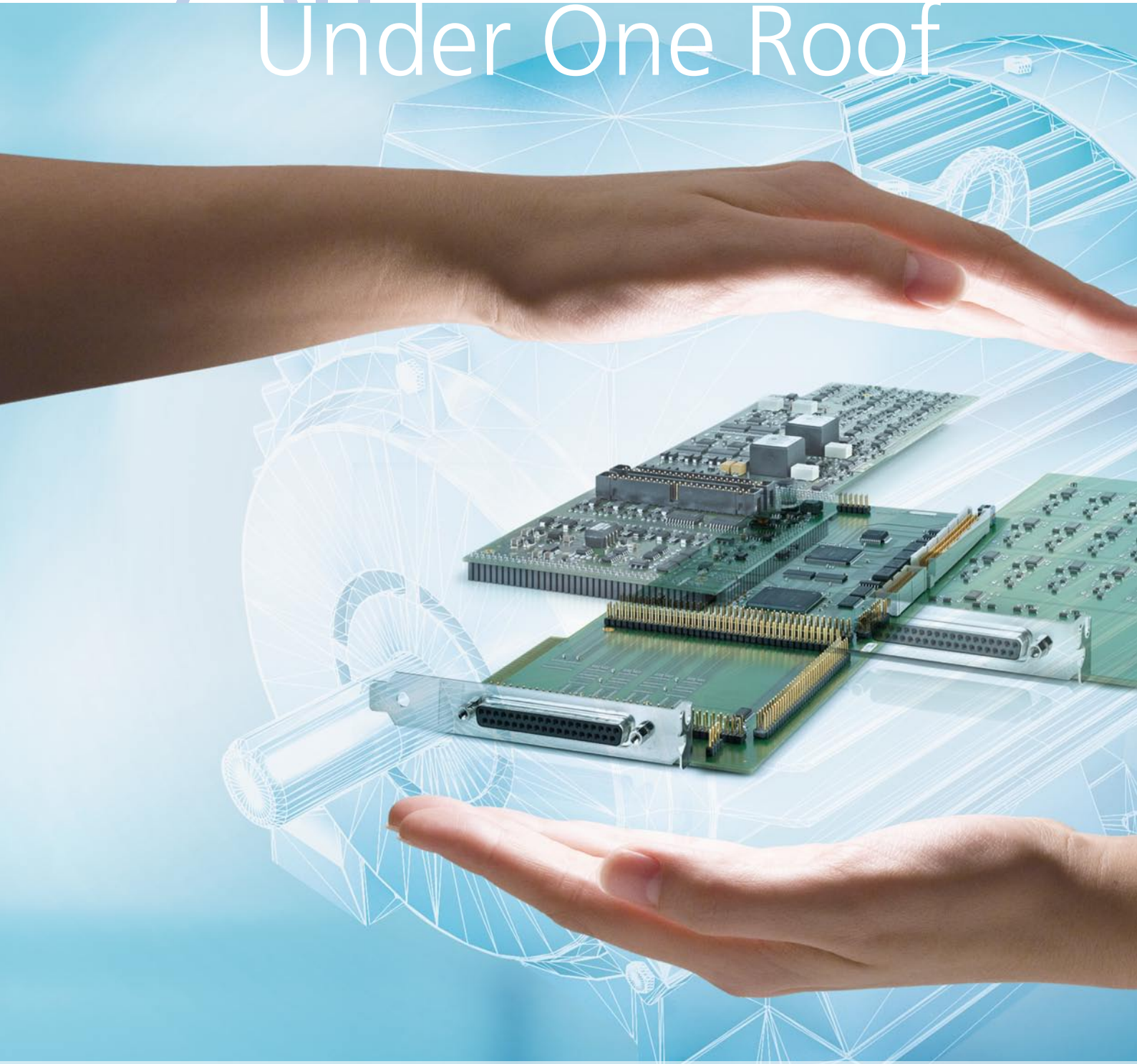
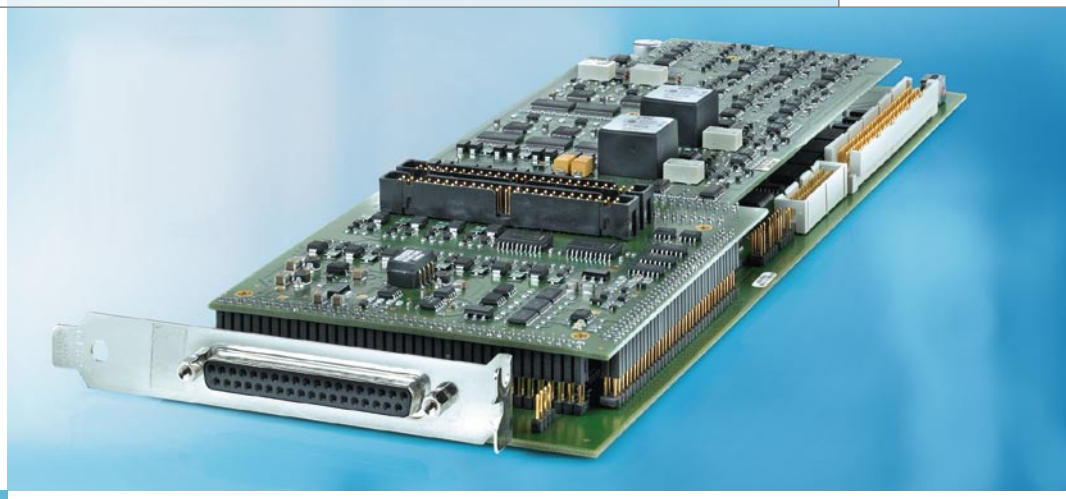
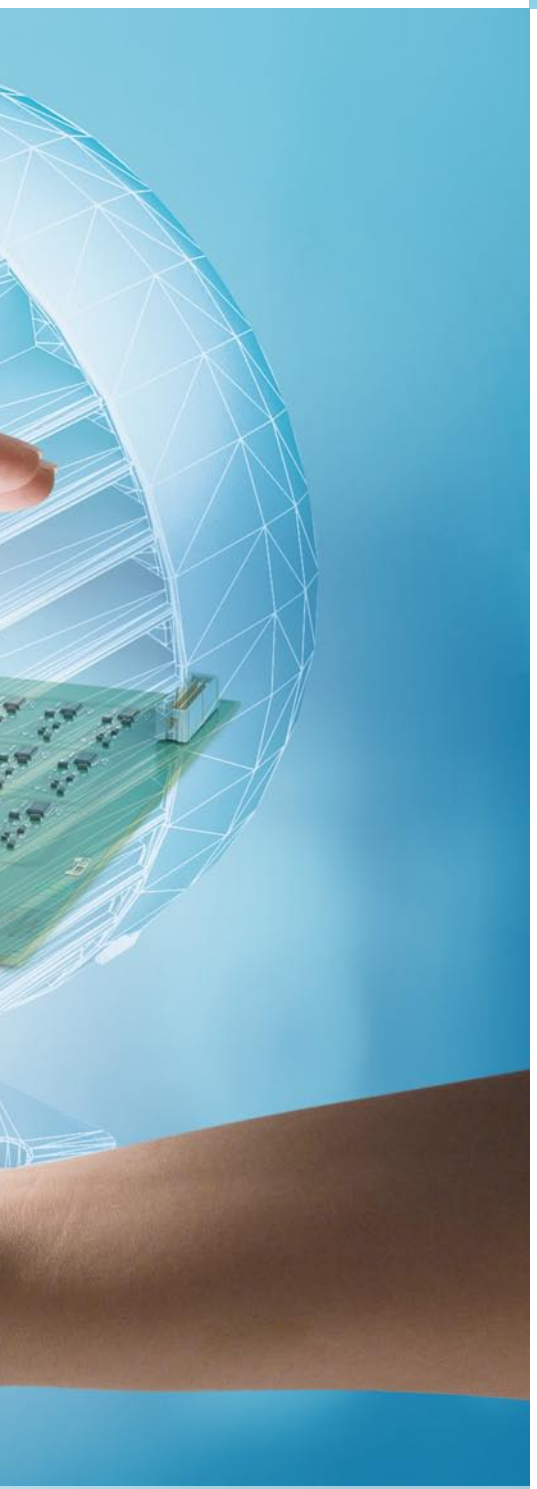
All Under One Roof

EMH Solution – New integrated HIL simulation of electric motors







For HIL simulation of electric motors, numerous inputs and outputs are necessary for the control variables and sensor signals. dSPACE now offers an integrated FPGA-based solution that combines all of the essential I/O functions on just one board.

There are currently many control system interfaces available to connect hardware-in-the-loop (HIL) systems to the ECU of an electric motor. For low-performance motors, i.e. for electric steering, the electrical performance level of the ECU or the mechanical level is often suitable as an interface to the HIL system. However, for drive motors of hybrid vehicles and electric vehicles, the signal level is the preferred choice; especially when emphasis is placed on testing the ECU software and when operating the power stage is not necessary.

Simulating a 3-Phase Motor and Service Calls at Signal Level

When simulating at the signal level, the power electronics is removed, and only the signal processing portion of the ECU are connected to the simulator. The control signals of the power switch of the inverter stage are read in by the simulator and serve as the basis for the real-time simulation of the power electronics and electric motor. To close the control loop in the HIL simulation, the simulator must calculate the sensor signals for the rotor position and the motor voltages. dSPACE's product range has long included special boards for this connection at signal level, for creating and measuring PWM signals (pulse width modulation) and PSS signals (position sensor simulation).

New Integrated I/O Solution

For the first time ever, the new electric motor HIL (EMH) solution, based on the dSPACE DS5202 FPGA Board, offers several necessary I/O channels to simulate up to two electric motors "under one roof." This gives users a compact, cost-effective way to start working with the HIL simulation of electric motors.

Highly Precise PWM Signal Measurement

To simulate a B6 inverter stage, for example, measurement of the 6 gate control signals of the ECU (figure 2) must be highly precise. With the EMH solution, measure-

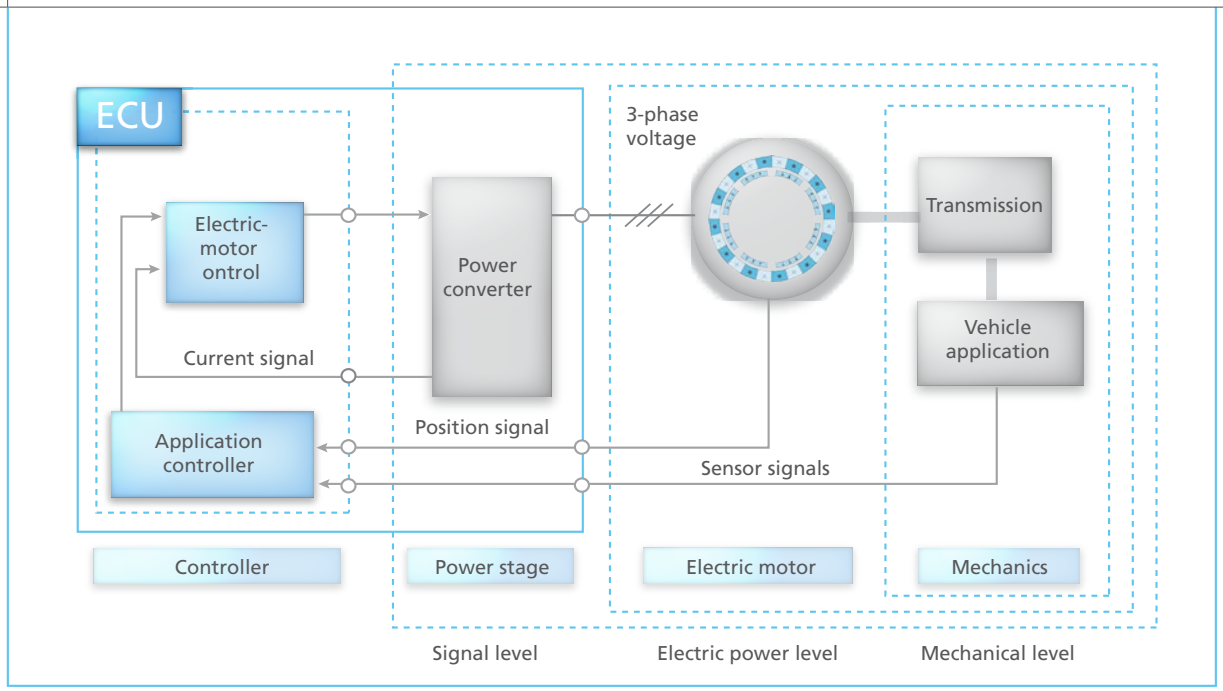


Figure 1: Interfaces for electric motor simulation.

ment is done at a time resolution of 25 ns. At defined sampling times, the duty cycle, period times and power-up times of individual signals, as well as the dead times between neighboring signals are determined in a bridge arm, and made available for the real-time model on the processor of the HIL simulators (i.e., a DS1006 Processor Board). The EMH solution usually determines the sampling times independently at the middle of the PWM period, whereby an interrupt is triggered on the processor, depending on the operating mode, so that the model of the power electronics of the electric motor is calculated synchronously with the PWM frequency. This avoids any beats. During this, the oversampling and the downsampling can be modified. Depending on the PWM frequency, the sampling times lie between approx. 30-60 µs. With the 16 channels of the EMH board, all the gate signals for two 3-phase electric motors can be read in.

> The EMH solution combines all necessary I/O functions for electric motor simulation – compact, high-performance, cost-effective.

Simulating the Position Sensor Signals

Because the control of electric motors must have an exact rotor angle position to control the voltage and calculate the speed, this must be simulated by the HIL system at a high resolution. The position sensor simulation offered by the EMH solution is based on the proven angle processing unit (APU) principle, which is already reliably used with the DS2211 HIL I/O Board. The EMH board has 4 independent APUs (figure 3), which users can allocate to different sensor simulation channels. This flexibility enables, for example, the simulation of two electric motors with independent or independent axles. The EMH solution offers:

- An analog sensor simulation group with 3 analog outputs to simulate resolver, sine encoder, or analog user-defined signals
- A digital sensor simulation group with 3 digital outputs to simulate incremental encoders, Hall sensors or digital user-defined signals
- 3 further independently usable digital outputs

All analog signals are resolved at 100 ns, all digital signals at 25 ns. Because the board contains comprehensive signal conditioning, an electric motor ECU can be connected directly at signal level.
With the universal RS485 UART interface, many different protocols can be implemented. In addition to the TwinSync protocol by LTi, further protocols for incremental encoders, such as SSI (synchronous serial inter-

Glossary

B6 inverter – Inverter with a switch bridge of 6 switch elements for 3-phase alternating current.

SSI (synchronous-serial interface) – Standard for protocol-based incremental encoder. Other variants are Hiperface and EnDat.

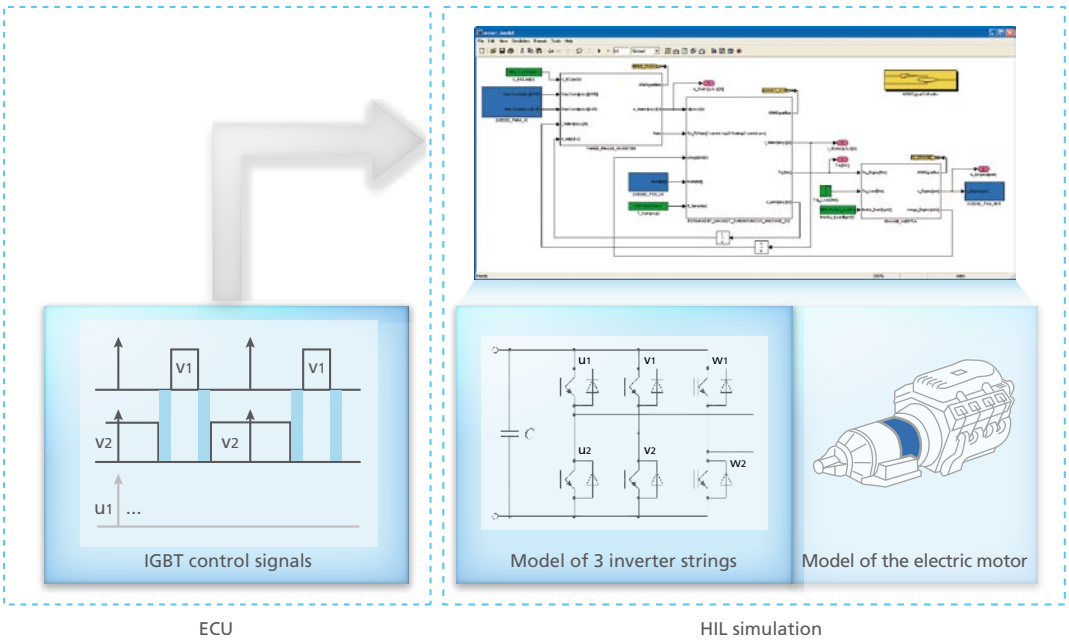


Figure 2: Highly precise PWM measurement is just one of the functionalities of the electric motor HIL solution.

face), Hiperface and EnDat will soon be available.

Additional I/O Solutions

Besides PWM sensor signals and position sensor signals, the EMH solution offers other signals which are usually necessary to simulate electric motors.

For example, 6 fast, bipolar DAC (digital analog converter) channels can be used to simulate the engine voltage. The resolution is 12 bit, the output drivers cover a voltage range of +/-10 V. An additional unipolar DAC channel controls an external battery simulation power unit – no further I/O board is necessary in the HIL system when pure E-motor simulation is being performed. 4 bipolar analog inputs are also available altogether, which, for example, can be used to measure the current of the power supply unit.

Besides this, there are 13 digital outputs for universal tasks (i.e., to control the relay box). 3 of these digital outputs are multifunctional. Besides the PWM output functions and digital output functions, they also provide a way to perform angle-synchronous signal generation. ■

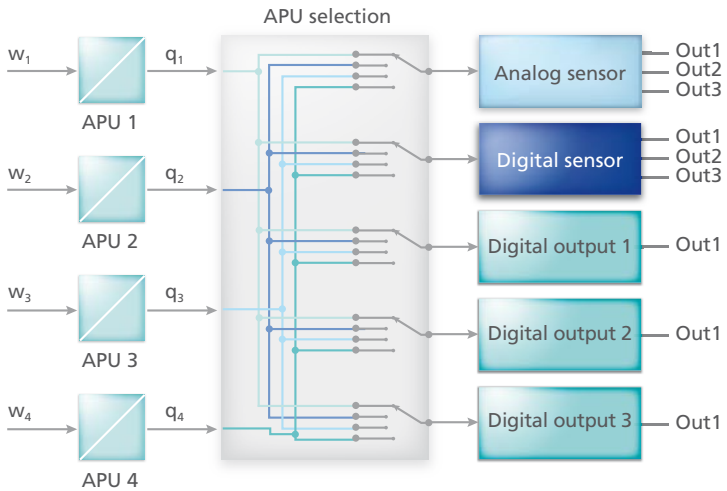


Figure 3: Four independent APUs allow a incredibly precise simulation of the position sensor signals with regard to time.

Summary

The new electric motor HIL solution is a cost-effective, high-performance solution for the HIL simulation of electric motors at signal level. It can be used in dSPACE Simulator Mid-Size and in dSPACE Simulator Full-Size for individual ECU tests, or for integration tests with network simulators containing several dSPACE simulators to simulate hybrid vehicles and even electro-mechanical drives.

It also lets users set up compact systems for industrial applications, such as for testing industrial servo converters.