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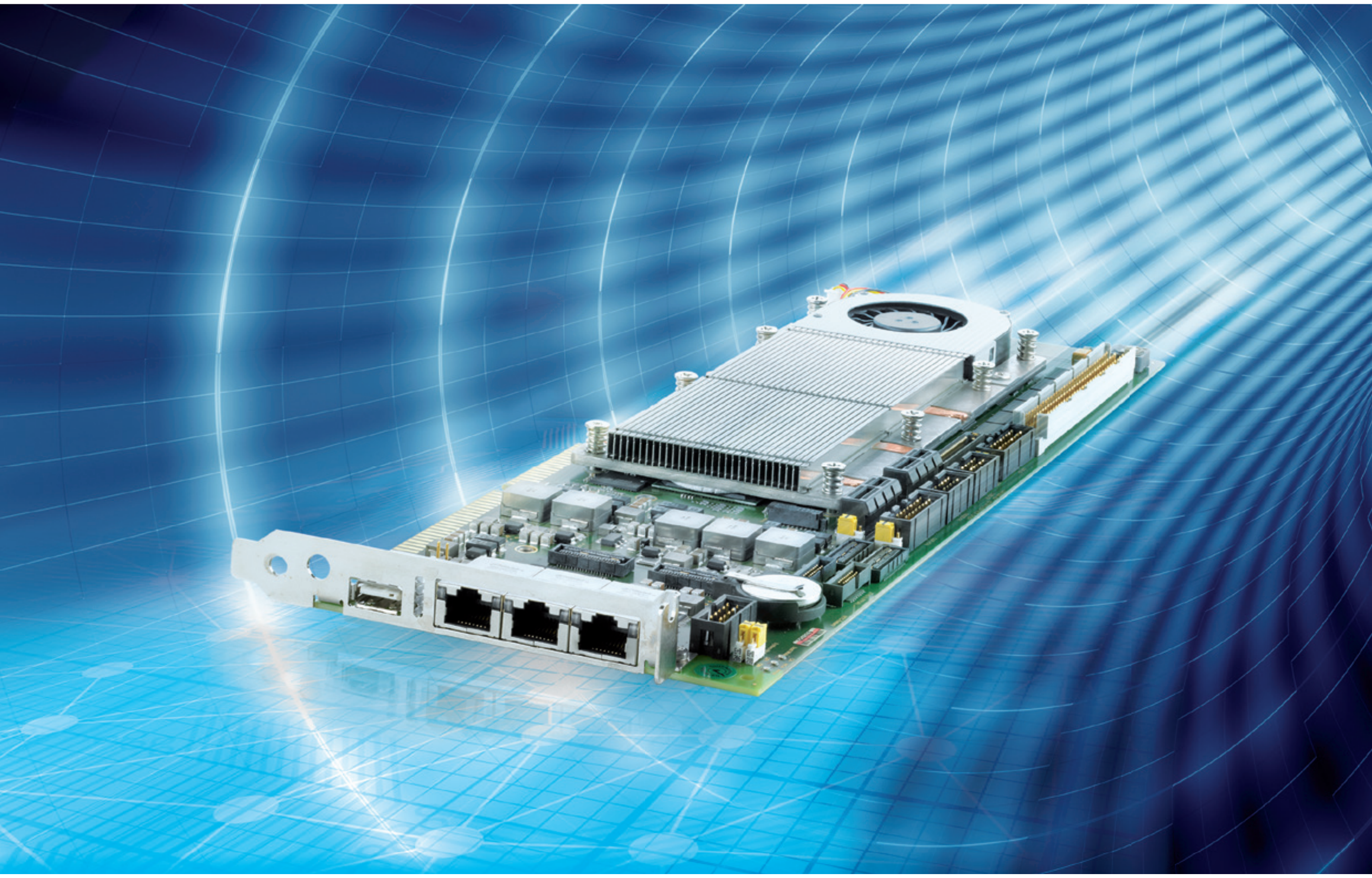

Power Boost for Control Engineering Applications

Translation of "Prozessor-Board für schnelle Regelkreise"

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Embedded Success dSPACE

Control engineering applications in the areas of audio and signal processing or electric drive control require rapid control prototyping (RCP) systems that allow fast model sampling rates with low I/O latencies and provide high computing power for processing complex algorithms. The following article presents the new DS1007 PPC Processor Board from dSPACE. This combines computing power and minimal I/O access times to enable convenient processor-based real-time simulation for applications that up to now could only be implemented as FPGA-based simulations.

RCP systems are the established way to perform the fast, model-based design and evaluation of new controller and signal processing concepts. With powerful hardware and support for the model-based development process with MATLAB®/Simulink®, developers can very quickly determine the potential of any new approach. They can do this in early development phases by substituting RCP platforms for ECUs that are not yet available. The platforms are based on powerful embedded processors with PowerPC or x86 architectures and on operating systems that ensure real-time behavior, fast boot times and reliable, autonomous operation in a vehicle or on a test bench.

RCP systems can basically be categorized in system classes according to their areas of use and scalability (Figure 1). Compact systems for use in automotive applications (right column, Figure 1), often with clearly defined required functionality, are in very widespread use. For particularly demanding prototyping tasks, modular systems are available. The I/O interfaces and computing power of these can be scaled to fit specific applications.

Modular systems are mainly used on a test bench and in a laboratory

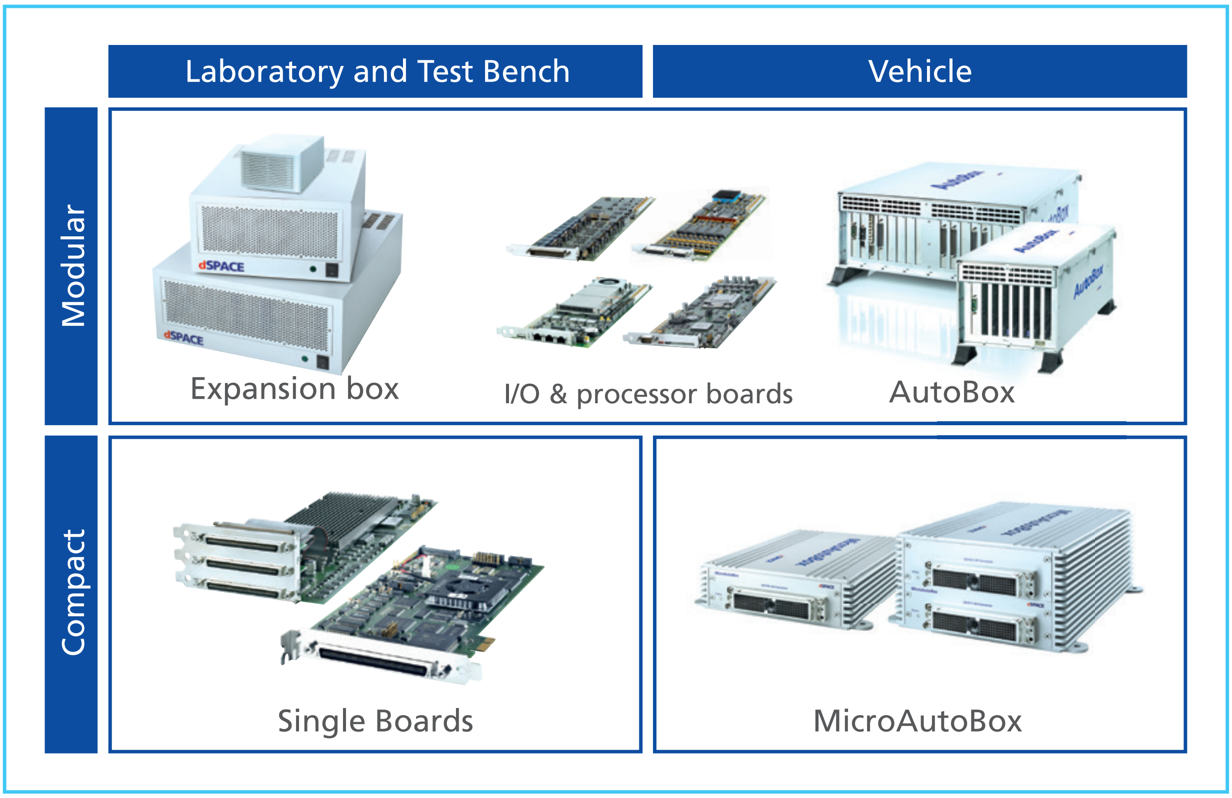

Figure 1: RCP system classes for laboratory/test bench and vehicle applications.

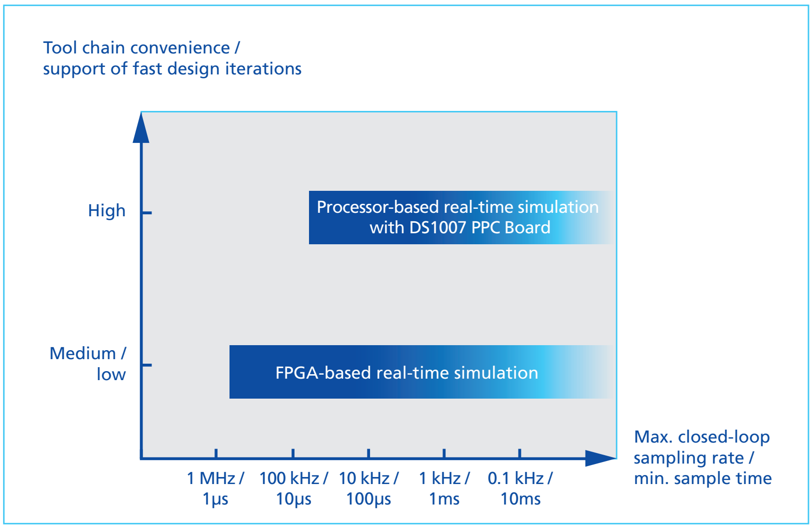

Figure 2: Comparison of FPGA-based and processor-based real-time simulation.

environment, though mobile use is also possible with special robust enclosures like that of the AutoBox. Modular systems provide high investment protection because they can be extended. Suppliers offer an extensive, long-term portfolio of processors and I/O boards with typical interfaces such as analog and digital inputs and outputs and automotive buses like CAN, LIN, FlexRay and Ethernet.

Application Areas with Special Challenges

Modular systems are preferred for control tasks that make particularly tough demands on the computing power and closed-loop sampling rates of the controller models. One example is active noise suppression by means of phase-shifted canceling signals. Incoming sound wave pressures are captured by an array of microphones, complex signal processing algorithms are calculated, and loudspeakers are triggered to generate canceling waves. The basic principle of active noise suppression is employed in various industries. The interiors of cars, trucks, airplanes and helicopters are "quietened" by this technology, and research and development is also being carried out on applying it to exhaust systems or to improve voice quality in mobile telecommunications. These commonly involve model sampling rates of up to 48 kHz to ensure sufficiently high audio signal oversampling. Researching and applying this technology requires real-time systems that can deliver these model sampling rates and that have sufficient reserve computing power to implement even complex signal processing algorithms.

Another broad field with highly dynamic control systems and very high requirements regarding real-time behavior is the development of control methods for electric drives. The generation of multiphase alternating magnetic fields and the implementation of electric controls with observer structures for adaptive parameter estimation (for example, to estimate the phase currents in sensorless commutation methods) can lead to complex real-time models that have to be implemented on a development system at sampling rates of 20 KHz and more.

Processor-Based and FPGA-Based Real-Time Simulation

An alternative solution is to implement a control or signal processing algorithm either partly or completely on an FPGA for what is called FPGA-based real-time simulation. Extensive aids to performing model-based implementation for this are now available. For example, the Xilinx System Generator Blockset makes it possible to model functions in MATLAB®/Simulink® and implement them directly on a dSPACE FPGA board without any intermediate manual steps. Users can therefore continue using their familiar development environment and concentrate completely on function design. With FPGA-based real-time simulation, models can be implemented with I/O accesses at closed-loop sampling rates of several 100 kHz (see Figure 2).

In contrast, the maximum model sampling rates allowed by processor-based real-time simulation are in the mid-kHz range (up to 50 kHz). However, many users prefer this RCP method despite this, for a variety of reasons. For example, processor-based real-time simulation supports fast design iterations in a range of minutes, while synthesis and configuration for FPGA-based real-time simulation require considerably more time and can even take several hours, depending on the complexity of the model. Another reason is that processor-based real-time systems provide the ability to visualize the variables and parameters of a Simulink model with experiment software such as ControlDesk® and to modify the graphical instruments. This increases the efficiency of the development workflow because it is very easy to optimize the system behavior of a controller system iteratively without having to modify the Simulink model. Moreover, there is often also C code that has to be integrated in the real-time environment. With processor-based simulation, this is easy to do by means of a Simulink S-function. Thus, the performance of processor-based real-time systems still needs to be as high as possible so that users can make full use of the convenience of the tool chain with very fast design iterations,

even at very high model sampling rates close to the system's limits.

Advantages with the DS1007 PPC Processor Board

The recently released DS1007 PPC Processor Board has been developed specifically for implementing fast control loops. It combines the required high computing power and lowest possible latencies in I/O accesses by means of a PowerPC architecture (Freescale QorIQ P5020, DualCore, 2 Ghz). The processor features a parallel interface between the I/O peripherals and computing cores to allow fast single I/O accesses with low latencies. Because the latencies of single I/O accesses have a major impact on the overall speed of high-performance control technology, this has advantages over x86 architectures, where the I/O is connected in series via PCI Express. Higher maximum closed-loop sampling rates can be achieved despite lower computing power.

Controller and environment models created with MATLAB®/Simulink® can be intuitively distributed to the processor cores of the DS1007 by means of the dSPACE Real-Time Interface Blockset. They can also be conveniently connected to host PCs or notebooks via a Gigabit Ethernet interface. This provides a high bandwidth especially for large-volume data capture. Another Gigabit Ethernet interface allows data to be exchanged between the real-time model and other Ethernet-based systems. Either the TCP/IP or the UDP protocol can be used. Another new feature now available for modular dSPACE hardware is the ability to make long-duration data recordings on USB hard disks or USB sticks independently of the host PC. The DS1007 has a USB port for this. The DS1007 is robust in construction and fulfills the applicable requirements with regard to impact and vibration in vehicles, so it can be installed in the AutoBox (Figure 1) to perform in-vehicle experiments.

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