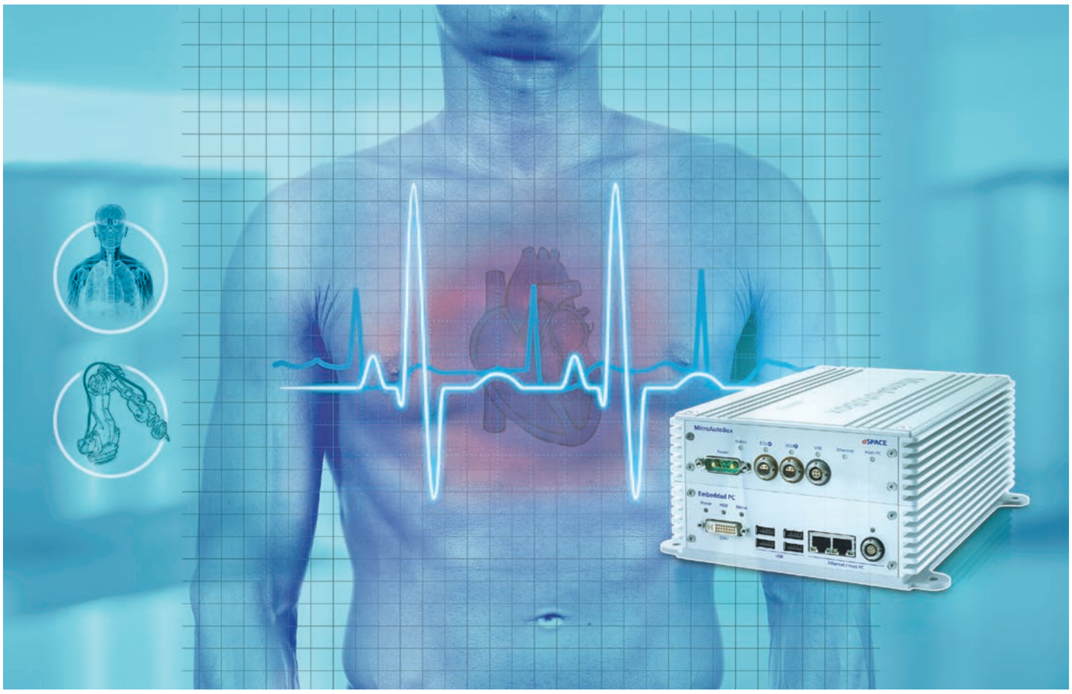
Fast and Economically Efficient from Idea to Prototype



Dipl.-Ing. Frank Mertens, dSPACE GmbH, Germany
Dipl.-Ing. Holger Ross, dSPACE GmbH, Germany

Translation of "Schnell und kostengünstig von der Idee zum Prototyp"
Published at: MED engineering, 06/2011

dSPACE

In many cases, having a good idea takes the least amount of effort and costs nearly nothing at all. However, due to time and cost factors, many good ideas fail before their implementation even starts, because they are rejected before their true benefits and potential can be investigated, for example, in a field test. As a result, many truly promising innovations never become a reality. In control engineering, this is frequently due to the high costs of producing suitable hardware in small quantities, and the considerable amount of time needed to manually program a testable prototype.

When a prototype is developed, the question is often "make or buy": Which components do I want or have to develop myself, and which should I additionally buy? The answer is actually quite simple: If a component is part of my core area of expertise, I will develop it myself. If the component is not available commercially in the form I need, then I must decide between time-consuming in-house development and outsourcing, which is often expensive. In all other cases, the best general advice is to rely on commercial products that minimize the costs, the time and the risks, so that you can concentrate on your main tasks.

This is why rapid prototyping systems are so widely used in electronic development in the different industries. They provide the ability to set up the initial prototypes, test them under real conditions, and optimize them time- and cost-effectively, without extensive hardware development and without any specialized programming knowledge.

Rapid prototyping systems from dSPACE have proven their capabilities in many areas of medical engineering. They help achieve decisive improvements in areas such as diagnosis, treatment, care, rehabilitation and physiotherapy. Typical applications are found in fields such as positioning, acoustics, dosage, rapid or time-critical calculations, as well as in complete system control.

MicroAutoBox by dSPACE is a universal rapid prototyping system whose flexible, high-performance hardware architecture and comprehensive, intuitive software support enable fast prototype development (Fig. 1).

What are the points to consider when using a rapid prototyping system to develop a prototype? First of all, a suitable installation location needs to be found in the device. One point to consider is that a certain degree of ruggedness is necessary, especially when the system is in mobile equipment that experiences vibrations and mechanical shocks.

In addition, the available space is frequently tight in such mobile equipment, nearly silent operation is often a basic prerequisite, and active ventilation is seen as an unnecessary luxury. These are the reasons why MicroAutoBox was designed to be robust, making it suitable for stationary as well as mobile applications. Its compact design and passive cooling, combined with an operating temperature range up to +85 °C, make it ideal for use in equipment that has only a limited amount of space available.

Figure 1: The compact, robust rapid prototyping system MicroAutoBox is available as different variants: for example, with an extension for model-based FPGA programming, or with MicroAutoBox Embedded PC.

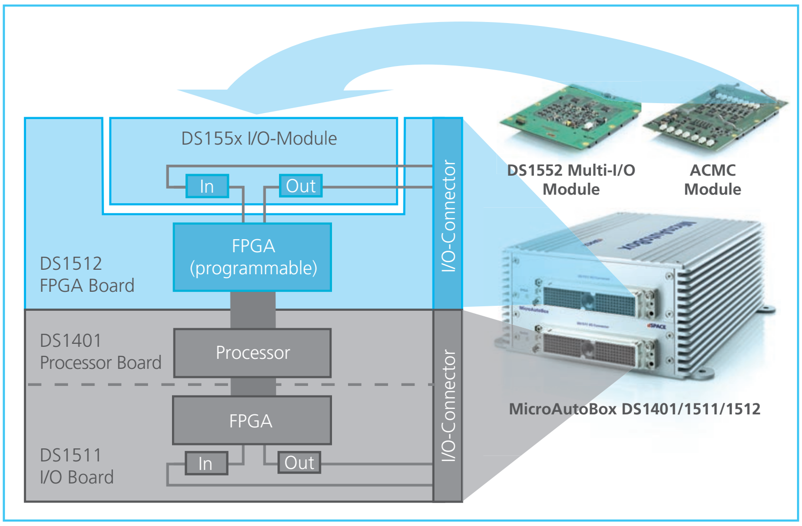
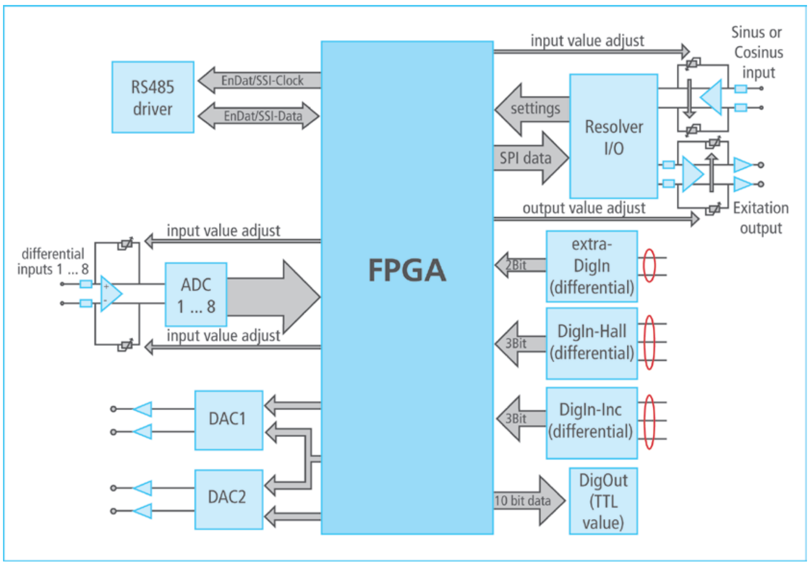


Figure 2: DS1401/1511/1512 variant of MicroAutoBox II with user-programmable FPGA and slot for I/O modules.

Obviously, the rapid prototyping system's characteristic features have to meet certain expectations. Typical tasks in medical engineering include data acquisition, control and visualization. There is a preferred method for technical implementation for each kind of task. For example, FPGAs should be used for data acquisition and data preprocessing to reach a high level of flexibility and determinism with minimum delay times. Open- and closed-loops controls are executed on high-performance embedded controllers with a real-time operating system. For the actual visualization, Windows-based PC systems are used.To cover the range of tasks, dSPACE offers different variants of MicroAutoBox. The base unit for open- and closed-loop control tasks consists of a 900 MHz embedded controller (PowerPC) designed for real-time applications, and an I/O board with many analog and digital I/O interfaces. For more special I/O requirements, there is a variant whose base unit was extended with an additional user-programmable FPGA (Xilinx Spartan 6). With this variant, signal preprocessing, such as filtering, can be executed beforehand on the FPGA, without loading the embedded controller unnecessarily. Since the FPGA is connected to an embedded controller via a parallel bus optimized for low latencies, the latency times for I/O processing can be kept to a minimum. For flexibility, the I/O converters themselves are located on separate I/O modules that can be plugged onto the FPGA board and replaced if the application changes. To address a broad range of applications, dSPACE offers the DS1552 Multi-I/O Module, a universal I/O module with a large number of fast, powerful I/O converters and different serial interfaces.

In addition to the above-mentioned universal applications, the FPGA can also provide the basis for application-specific I/O extensions. The AC Motor Control Module (ACMC) is a solution tailored to controlling electric motors (Fig. 3). It has a large number of spe-

Figure 3: Interfaces of the ACMC FPGA plug-on module to connect electric motors.



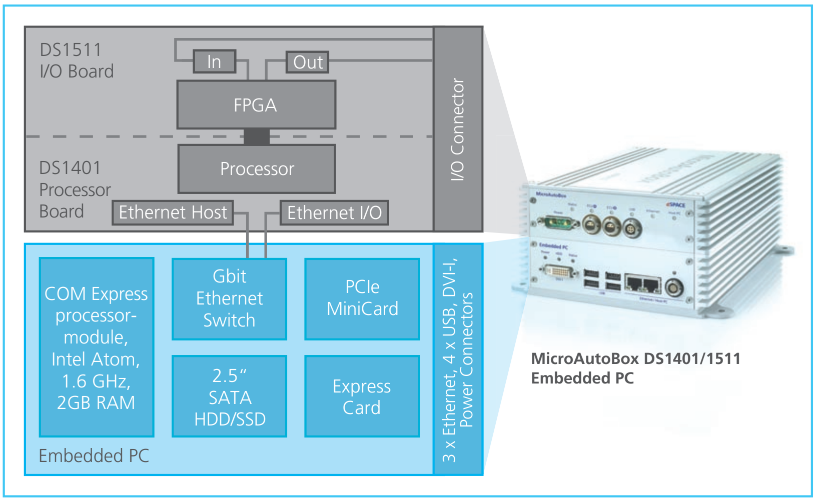


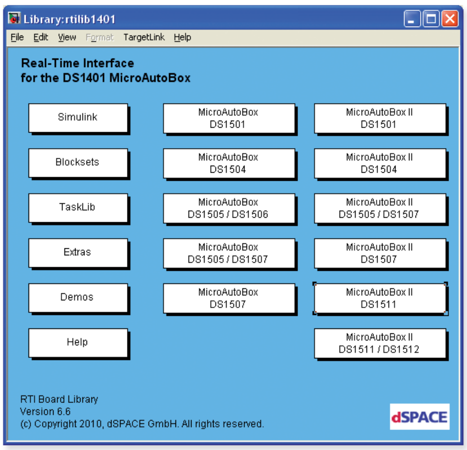
Fig. 4: A MicroAutoBox variant with an Embedded PC extension.

cific interfaces for the different types of rotor position capture (interfaces for Hall sensors, encoders, resolvers, EnDat, SSI and others) and for addressing the power stages.

In cases where an application requires additional support for particular I/O interfaces, customer-specific solutions can be developed. Thanks to the modular design, they are easily integrated.

Not only the typical I/O interfaces are important, but also integrating the rapid prototyping system in an existing infrastructure. This includes connections to in-house LAN, keyboards, operating panels, camera systems and other existing devices. Quite often, such additional devices require a PC with its usual interfaces, and a conventional operating system to install the drivers and additional software.

dSPACE therefore offers MicroAutoBox variants that have an integrated embedded PC (Fig. 4). These are connected internally so that only one host connection and power supply are necessary, and synchronized power-up is possible. MicroAutoBox Embedded PC is standardly equipped with a passively cooled, low power consumption Intel® Atom™ processor with a 1.6 GHz clock rate and 2 GB RAM. Extensions are possible via a PCIe Minicard slot as well as an Express Card slot. 2.5" HDD or SSD storage devices can be integrated. The front panel provides four USB 2.0 interfaces and a DVI-I output for transmitting video data. The operating system can be either Windows 7 or Linux. Even the most powerful and flexible hardware cannot reach its full potential if it does not have comprehensive, user-friendly software. In the past few years, model-based software design has significantly changed the traditional development process. Instead of using programming languages like C or even assemblers, today's developers are able to create and verify their measuring and control software in an



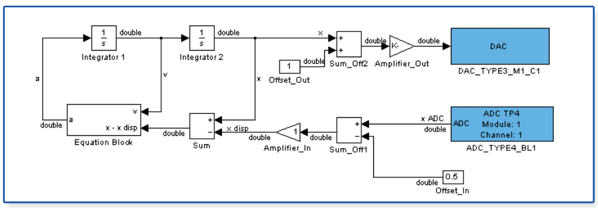


Fig. 5: A MicroAutoBox RTI block library to connect I/O interfaces to a Simulink model

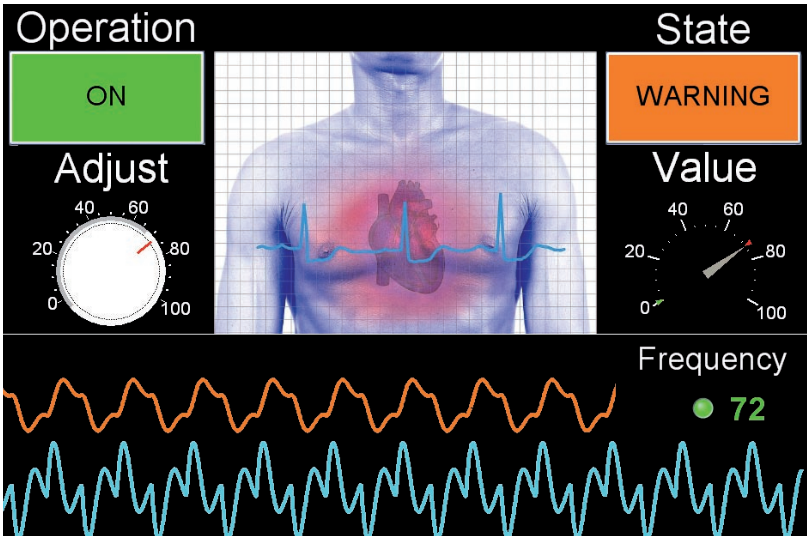


Fig. 6: Visualization of graphical instruments in ControlDesk.

intuitive graphical environment such as MATLAB®/Simulink®/Stateflow®. The software can be implemented on the rapid prototyping system by using implementation software and automation code generation, and executed under real conditions.

The implementation software has to cover aspects such as model code generation, real-time framework and I/O interfaces. All the aspects should preferably be provided to the user in automated form, as graphical blocksets, and without much manual implementation work. Implementation software like dSPACE's Real-Time Interface (RTI) therefore provides a comprehensive, configurable block library of I/O drivers for Simulink® (Fig. 5). Time-consuming manual programming of I/O drivers is no longer required.

To optimize the software functionalities, dedicated experiment tools allow users to capture signals and change parameters during run time. An intuitive working environment can be achieved by using graphical instruments. Experiment tools like dSPACE's ControlDesk therefore offer libraries of instruments such as plotters, gauges, displays, sliders, and knobs that can be individually configured and placed on a workspace (Fig. 6). Variables can be assigned to instruments by dragging them from an automatically generated variable list. These features let users set up all kinds of informative user interfaces with just a few clicks to gain an initial impression of the prototype device's operability at an early stage.

After the prototype is finished, optimized and approved, developers must decide how to transfer the created functionalities onto a potential production platform. The MicroAutoBox prototyping system supports developers here as well: C code can be generated from the Simulink/Stateflow models for any target controllers with the help of the production code generator TargetLink. Sections that were developed on the FPGA can be transferred to other FPGAs. The same applies to the PC software. After that, there's no stopping the next idea.

Dipl.-Ing. Frank Mertens
is Lead Product Manager for Rapid Control Prototyping Systems at dSPACE GmbH.

Dipl.-Ing. Holger Ross
is Product Engineer for Rapid Control Prototyping Systems at dSPACE GmbH.

www.dspace.com

Company Headquarters in Germany

dSPACE GmbH
Rathenaustraße 26
33102 Paderborn
Tel.: +49 5251 1638-0
Fax: +49 5251 16198-0
info@dspace.de

United Kingdom

dSPACE Ltd.
Unit B7 · Beech House
Melbourn Science Park
Melbourn
Hertfordshire · SG8 6HB
Tel.: +44 1763 269 020
Fax: +44 1763 269 021
info@dspace.co.uk

France

dSPACE SARL
7 Parc Burospace
Route de Gisy
91573 Bièvres Cedex
Tel.: +33 169 355 060
Fax: +33 169 355 061
info@dspace.fr

China

dSPACE Mechatronic Control
Technology (Shanghai) Co., Ltd.
Jinling Haixin Building Unit B, 25F/L
Fuzhou Road 666
200001 Shanghai
Tel.: +86 21 6391 7666
Fax: +86 21 6391 7445
infochina@dspace.com

Japan

dSPACE Japan K.K.
10F Gotenyama Trust Tower
4-7-35 Kitashinagawa
Shinagawa-ku
Tokyo 140-0001
Tel.: +81 3 5798 5460
Fax: +81 3 5798 5464
info@dspace.jp

USA and Canada

dSPACE Inc.
50131 Pontiac Trail
Wixom · MI 48393-2020
Tel.: +1 248 295 4700
Fax: +1 248 295 2950
info@dspaceinc.com

06/2011

Embedded Success dSPACE