dSPACE

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Company Background

dSPACE, founded in Germany in 1988, develops and manufactures DSP-based hardware and support software for rapid control prototyping and real-time Hardware-in-the-Loop simulation. Our systems are used in automotive, aerospace, mechatronics, vibration control, motion control/robotics, and university R&D applications where ease-of-use, rapid development, and "zero error" results are project requirements.

dSPACE offices are worldwide, including a subsidiary in the US and distributors in Japan, Korea, Taiwan, India, Czech Republic, Poland, UK, and France.
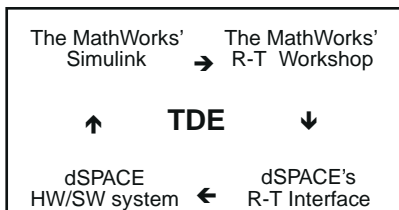
Development Hardware

Product Name: **dSPACE Development System**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30, TMS320C31, TMS320C40

Features and Benefits

- Total Development Environment with The MathWorks' software (MATLAB®, SIMULINK®, and Real-time Workshop™) as a front end.
- Automatic code generation for single and multiprocessor systems from SIMULINK.
- Other front ends (AutoCode®, F2C, hand-written, etc.) also supported.
- Full line of support software.
- High-performance I/O cards.

Product Description

The MathWorks' Simulink	The MathWorks' R-T Workshop
↑	**TDE** ↓
dSPACE HW/SW system	dSPACE's R-T Interface

The dSPACE Development System consists of DSP-based hardware and support software for rapid controller prototyping and Hardware-in-the-Loop simulation. Systems are available from an entry-level single-unit controller with on-board I/O-to-modular configurations with multiprocessor capabilities.

In conjunction with The MathWorks, dSPACE offers a Total Development Environment (TDE), which combines powerful analysis and modeling software with our high-performance, flexible real-time hardware for a seamless integration from modeling to code generation to test. Support software for data capture, GUI, long-term data logging, and to control the DSP from MATLAB is available.

Other front-ends for modeling and analysis can also be used with the dSPACE Development System. Interface libraries are available to link these systems to dSPACE hardware. Support software for data capture and GUI is offered.

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Development Hardware

Product Name: **DS1102**
Platforms Supported: PC, Sun, HP
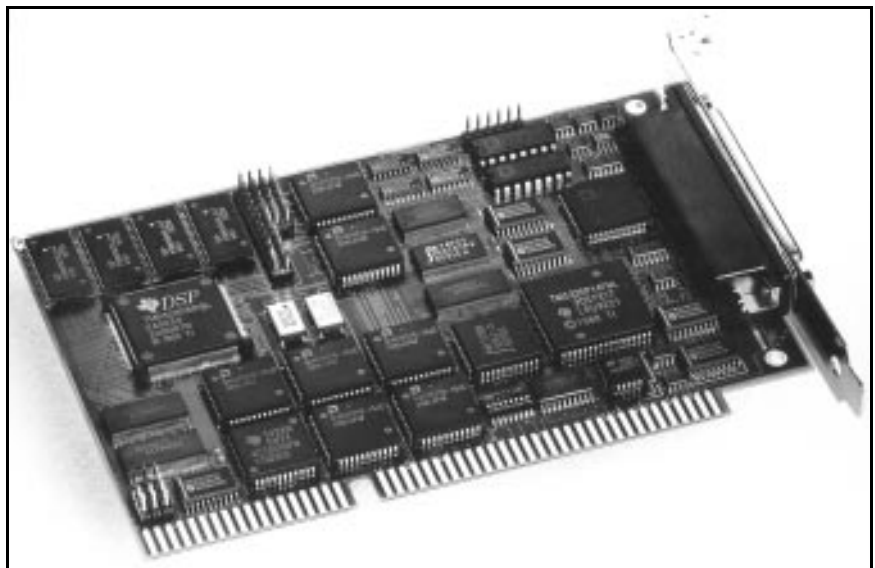Devices Supported: TMS320C31

Features and Benefits

- Single-unit controller.
- TI 'C31 running at 40 MHz.
- Four on-board A/D converters, four on-board D/A converters.
- Two incremental encoder interfaces.
- 'P14 working as an intelligent I/O subsystem.

Product Description

As the entry-level board for the dSPACE development system, the DS1102 combines the 'C31's computing performance of up to 40 MFLOPS with a versatile set of on-board I/O: four analog input channels (16 bit, 10 μs, and 12 bit, 3 μs), four analog output channels (12 bit), two incremental encoder channels, and a complete subsystem for digital I/O, based on a TMS320P14 DSP. Using provided software, this subsystem can be accessed like conventional I/O channels, and/or programmed as a slave DSP.

The high performance design of the DS1102 supports the maximum usage of the 'C31's 50-ns cycle time. 128 k × 32-bit zero-wait-state memory are on-board. This on-board memory can be accessed by the host for program download as well as data transfer while the DSP is running.

All boards are standard ISA cards. For Sun and HP hosts, a network interface to an expansion box is required.

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Development Hardware

Product Name: **DS1002**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30

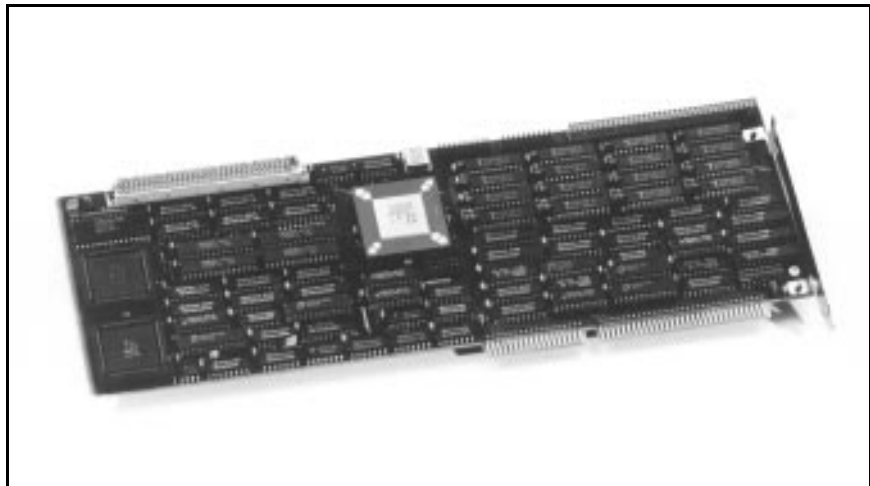## Features and Benefits

- Floating-point processor.
- 'C30 running at 33 MHz.
- Operates with user-selectable dSPACE I/O cards.
- Up to 512 KB zero-wait-state SRAM.
- PHS-bus interface with 16-Mbps transfer rate to I/O boards.

Product Description

The DS1002 is the processor board for a basic modular dSPACE development system. It is based on TI's 'C30 DSP, and has a computing performance of 33 MFLOPS. The 'C30's 60-ns cycle time is fully accessible. Separate primary and expansion memory support the 'C30's parallel data fetch capability. Peripheral cards are attached to the board's 32-bit-wide PHS-bus interface, supporting the full word length of the 'C30 at a 16-Mbps transfer speed.

All boards are standard ISA cards. For Sun and HP hosts, a network interface to an expansion box is required.

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Development Hardware

Product Name: **DS1003**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C40

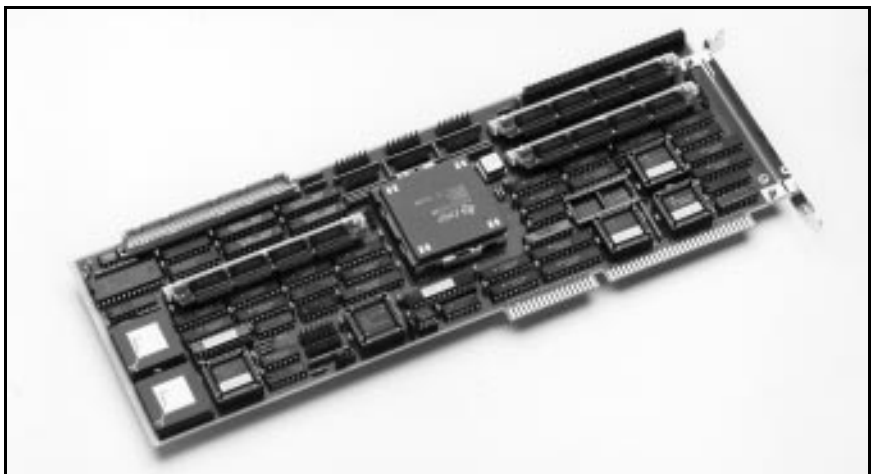## *Features and Benefits*

- Floating-point processor.
- 'C40 running at 50 MHz.
- Operates with user-selectable dSPACE I/O cards.
- Up to 768 KBytes zero-wait-state SRAM, expandable to 3 Mwords.
- PHS-bus interface with 16-Mbps transfer rate to I/O boards.

Product Description

dSPACE's higher-end processor board for modular development systems is built around the 'C40 floating-point DSP, with a 40-ns cycle time and 50 MFLOPS of peak computing performance. The DS1003 provides a powerful memory-mapped host interface, as well as a separate 32-bit wide PHS-bus interface to our I/O boards. It can be used as a base for both single or multi-processor systems. On-board memory is expandable to 3 Mwords (32 bit). Separate busses for primary and global memory allow simultaneous access to local and global memory components for concurrent data and instruction fetch. The complete DSP memory is simultaneously accessible by the host and DSP. 8 kwords are built in as a true dual-port memory for concurrent DSP/host access. Six on-chip, byte-wide communication links on the 'C40 allow multiprocessor systems to be configured with virtually no computational limits.

All boards are standard ISA cards. For Sun and HP hosts, a network interface to an expansion box is required.

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Development Hardware

Product Name: **DS1201**
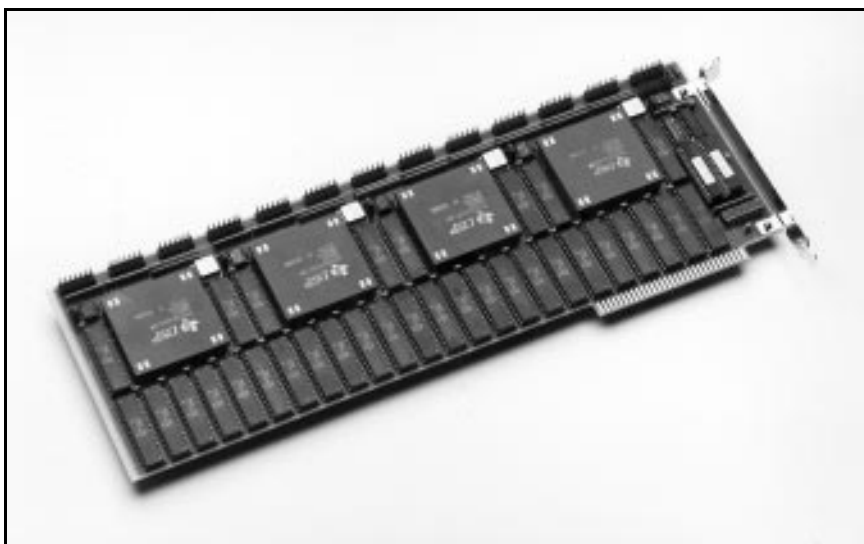
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C40

Features and Benefits

- Accessory board for multiprocessor systems.
- 200 MFLOPS of computing power on a single PC/AT-compatible board.
- Based on four 'C40s.
- 12 20-Mbps communication ports.

Product Description

The DS1201 is a powerful companion board for multiprocessor systems. Based on four TI 'C40 DSPs, its 200 MFLOPS of performance make it especially useful for very computationally-intensive and time-consuming applications like Hardware-in-the-Loop simulation.

Each DSP is equipped with 256 Kwords of zero-wait-state memory. Two independent busses support concurrent data fetch from local and global memory. On-board 'C40s are interconnected via byte-wide communication ports. 12 remaining ports are user accessible. The communication ports, with a 20-Mbps transfer rate, are used for data transfer and program loading. The DS1201 is designed as an accelerator board for the DS1003 processor board, which provides the host and the I/O bus interface.

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Product Name: **A/D - D/A Peripheral Boards**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- User-selectable performance level.
- A/D board to 32 multiplexed channels, 2 ADCs (16 bit, 5 μs) with simultaneous sample and hold.
- D/A board to 6 DAC channels (16 bit, 1.5 μs), with 6 TMS320C31 DSPs on-board.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

dSPACE peripheral boards for modular development systems provide high-speed, high-resolution A/D-D/A converters designed to provide you with a range of choices to meet your application requirements. All I/O boards can be connected to all dSPACE processor boards with our PHS-bus interface. See Table for I/O product specifications.

I/O Boards	A/D Channels	D/A Channels	Digital I/O	Incr. Encoder Interface
DS2001	5 ADCs (5 μs in 16-bit mode or 3.8 μs in 12-bit mode)			
DS2002	32 multiplexed, 2 ADCs (16-bit, 5 μs)			
DS2003	32 multiplexed, 2 ADCs (16-bit 5 μs) simultaneous sample & hold for all channels			
DS2101		5 DACs (12 bit, 3 μs)		
DS2102		5 DACs (12 bit, 2.5 μs)		
DS2201	20 multiplexed, 4 ADCs (12 bit, always 32.5 μs for 20 channels)	6 DACs (12 bit, 4 μs)	TMS320E14 on-chip I/O	
DS2301		6 DACs (16 bit, 1.5 μs) 6 TMS320C31 DSPs		
DS3001				5 parallel 24 bit, 5 MHz)
DS4001			32-bit I/O lines 5 timers	
DS4201-S	Four channels for serial communication, equipped with RS-232, RS-422, or RS-485 transceivers			
DS4301	CAN/VAN Interface			
DS5001	Digital Waveform Capture board			

All boards are standard ISA cards. For Sun and HP hosts, a network interface to an expansion box is required.

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Development Hardware

Product Name: **Digital I/O Boards**

Platforms Supported: PC, Sun, HP

Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- User-selectable performance level.
- Boards with either on-chip I/O based on TMS320E14 DSP or 32-bit I/O lines with five timers.
- Utilize dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

dSPACE digital I/O boards support control applications with sensors that provide a parallel TTL digital output signal with switch polling, frequency input, and PWM output. Digital I/O is available on the DS4001 and DS2201. See table on page 3-95 for specifications.

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Development Hardware

Product Name: **DS2301 Direct Digital Synthesis Board**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- Six 16-bit analog output channels.
- Six 'C31s for intelligent digital and analog I/O.
- Supports DDS (Direct Digital Synthesis).
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

The DS2301 was developed to support Hardware-in-the-Loop (HIL) simulation. It has six 16-bit analog output channels served by six 'C31 floating-point DSPs for intelligent digital and analog I/O. The signal-generation algorithm is computed in real time (Direct Digital Synthesis, or DDS) and can be modified on-line. It can be used as a peripheral board on the PHS bus, or as a separate board providing an interface to the host PC/AT. Refer to Table on page 3-95 for additional board specifications.

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Development Hardware

Product Name: **DS3001 Incremental Encoder Board**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- Supports position-control applications.
- Five fully parallel input channels at 24 bit, 5 MHz.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

The DS3001 is a peripheral board for the dSPACE system designed to support position-control applications with incremental encoder position sensors providing square-wave phase information. The DS3001 has five fully parallel input channels with everything to connect an incremental encoder and process its output signals. Special noise rejection logic yields high noise immunity for encoder signals. A fourfold pulse multiplication direction sensing logic provides high resolution; a 24-bit counter for each channel allows wide-range position signals. Index pulse counter reset and interrupt capabilities are available for system initialization.

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Development Hardware

Product Name: **DS4110 Memory Expansion Board**

Platforms Supported: PC, Sun, HP

Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- Supports high-speed data acquisition.
- Up to 32 M $\times$ 32-bit memory expansion.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

The Memory Expansion Board provides memory expansion for high-speed data acquisition through a connection to the processor board via our PHS-bus. Input data from input boards or data from the DSP's on-board memory can be stored and read with the highest transfer of speed supported from the processor being utilized. Memory size is selectable between 4 M and 32 M of 32-bit words in steps of 4 Mwords, and can be easily upgraded.

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Development Hardware

Product Name: **DS4201 Prototyping Board**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- Supports the integration of custom electronics into the dSPACE system.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

For effective product development, it is often necessary to incorporate proprietary or custom electronics into the system. The DS4201 prototyping board supports the integration of customized circuits into the dSPACE system. Interface electronics include bidirectional buffered 32-bit PHS-bus data lines, an interrupt controller, and I/O-error detection and generation logic. Up to 13 custom ports are selected by the DSP, either via pre-defined chip-select lines or by using PHS-bus addresses directly. When several DS4201s are used in concert, a switch-selectable board sub-identification number can be specified.

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Development Hardware

Product Name: **DS4201-S Serial Communication Board**

Platforms Supported: PC, Sun, HP

Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- Four-channel serial communication, equipped with RS-232, RS-422, or RS-485 transceivers.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

The DS4201-S expands the capabilities of the DS4201 by providing four channels for serial communication, which can be equipped with RS-232, RS-422, or RS-485 transceivers, specified by the customer when ordering the board. DS4201-S UARTs support data transfer rates of up to 116 KBaud. Input FIFOs allow buffering up to 16 bits per channel. The Serial Communication Board comes with a C language library, including I/O-functions for DSP to serial interface communication.

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Development Hardware

Product Name: **DS4301 CAN/VAN Interface**

Platforms Supported: PC, Sun, HP

Devices Supported: TMS320C30- and TMS320C40-based processor boards

Features and Benefits

- Provides direct access to CAN and VAN busses.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

dSPACE's CAN/VAN interface provides modular systems with direct access to the CAN or VAN bus. This is particularly useful for HIL in the automotive industry, where these communication protocols are common. No additional external electronics are required.

Basic, full, and extended CAN protocols are supported. The full VAN protocol is available. Data transfer rates can be programmed for each section independently, up to a maximum transfer rate of 0.25 MBd for the VAN bus and 1 MBd for the CAN bus.

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Development Hardware

Product Name: **DS5001 Digital Waveform Capture Board**

Platforms Supported: PC, Sun, HP

Devices Supported: TMS320C30- and TMS320C40-based processor boards
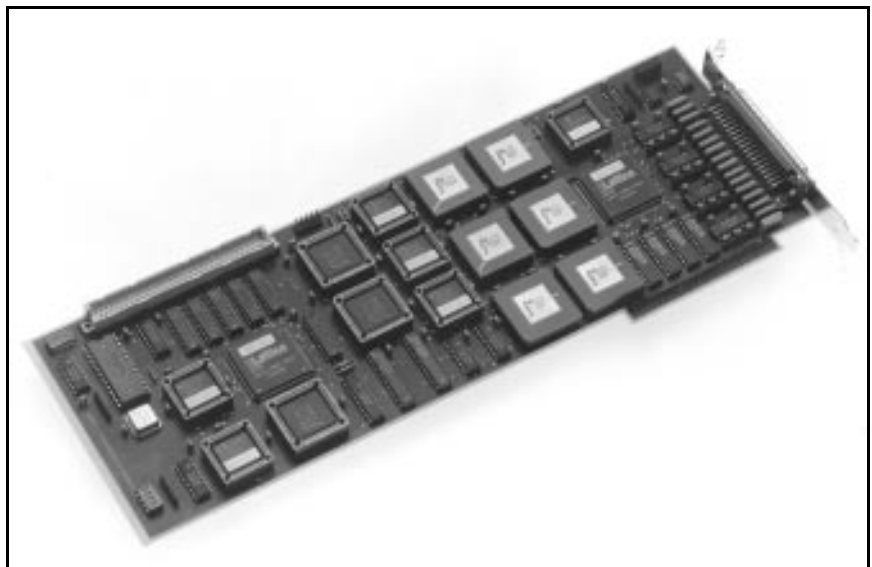
Features and Benefits

- 16 high-speed digital input channels for waveform capture.
- Supports waveform capture for frequency and phase analysis, modulation parameters, jitter, or missing pulses.
- Software for analysis is supplied with the board.
- Utilizes dSPACE proprietary PHS-bus interface with up to 20-Mbps transfer rate to processor boards.

Product Description

The DS5001 provides 16 input channels for high-speed digital data recording. Specified trigger events are detected with a 25-ns timer resolution. Up to 512 events per channel can be stored by the on-board event buffer for complex analysis by the DSP after the capture process. Trigger edge and trigger level are specified for each input channel separately. For a trigger event, edge polarity and a 31-bit resolution time stamp are stored by the on-board event buffer. If more than 16 input signals are needed, any number of DS5001s can be used in synchronization.

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Product Name: **Expansion Boxes (PX6, PX20, AutoBox, MiniBox)**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards and accessory I/O

Features and Benefits

- Rugged tabletop or in-vehicle chassis for modular dSPACE systems.
- Portable.
- Enhanced power supply, cooling, and all interface electronics included.

Product Description

The PX6 and PX20 support up to 5 and 19 additional boards for dSPACE modular systems, respectively. Both have a rugged tabletop chassis, complete with backplane, enhanced power supply, fan cooling, and the interface electronics to expand the PC/AT host bus or a network interface kit.

The AutoBox is used for in-vehicle control systems tests. Up to five boards for a dSPACE modular system can be added. The AutoBox has a ruggedized design, forced-air cooling, and a power supply with superior load-dump protection, specifically developed for in-vehicle use.

The MiniBox is dSPACE's economical solution for the direct connection of our introductory single-unit controller (DS1102) to a workstation or PC through an Ethernet® card. A DS1102 is included in the MiniBox package.

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Development Hardware/Connector Panel

Product Name: **Connector Panels**
Platforms Supported: PC, Sun, HP
Devices Supported: I/O for TMS320C30-, TMS320C31-, and TMS320C40-based processor boards

Features and Benefits

- Supports all dSPACE hardware.
- Provides easy access to dSPACE I/O.
- Rack and desk versions.

Product Description

dSPACE connector panels provide easy access to all input and output signals on dSPACE I/O boards. Analog signals are accessed via BNC connectors. All digital and TTL signal are accessed via SUB-D connectors. The SUB-D connectors are low density and grouped with respect to I/O channels and functional units on board.

All connector panels can be grouped into a 19-inch wide desktop box, or 19-inch rack mounts.
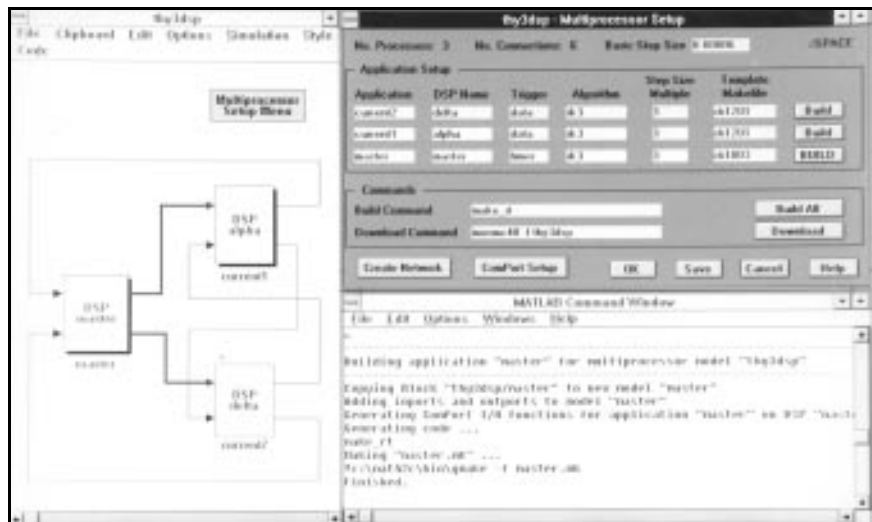
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Development Software

Product Name: **Real-Time Interface (RTI)**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards, TDE System

Features and Benefits

- Supports the dSPACE/MathWorks TDE system for automatic code generation and download to the DSP.
- Complete I/O specification from SIMULINK block diagrams.
- RTI postprocessor modifies C-coded model generated by Real-Time Workshop (RTW).
- Option to support multiprocessor dSPACE systems.

Product Description

dSPACE's Real-Time Interface extends the SIMULINK C-code generator, Real-Time Workshop, for automatic implementation of SIMULINK models on dSPACE systems. All I/O specifications for real-time implementation can be defined within the SIMULINK environment. RTI modifies the code generated by RTW according to these I/O specs and processes it to load to the DSP system automatically. Supported by RTI, block diagram parameters in the real-time program can be changed through SIMULINK's external simulation facility without regenerating code.
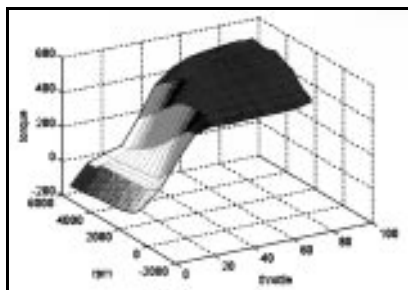
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Development Software

Product Name: **MLIB (MATLAB-DSP Interface Library)**
Platforms Supported: PC, Sun, HP
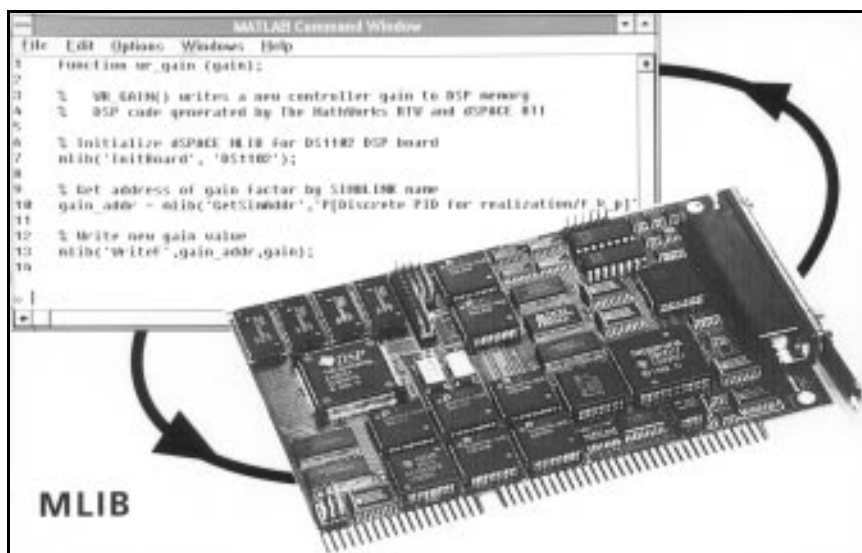Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards, TDE System

Features and Benefits

- Supports the dSPACE/MathWorks TDE system.
- Allows the user to read/write from/to DSP memory from MATLAB.
- DSP control functions.
- Interrupt control functions.

Product Description

dSPACE's MATLAB-DSP Interface Library allows TDE system users to directly access the DSP memory from the MATLAB environment. MLIB is ideally suited to automate experiment control by writing test sequences to the DSP at certain time intervals, reading the results, and stopping and starting the test according to these results. MLIB functions are also used for algorithm-based, on-line parameter tuning. MATLAB can automatically calculate the new values from the current system behavior and send new parameters to the DSP.

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Development Software

Product Name: **MTRACE (MATLAB-Callable TRACE)**
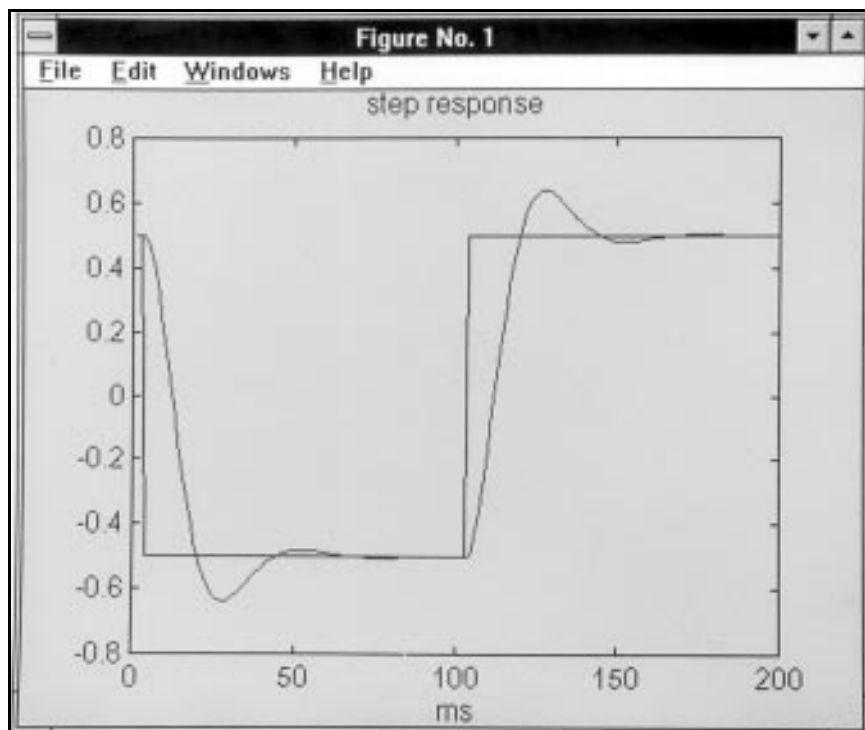
Platforms Supported: PC, Sun, HP

Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards, TDE System

Features and Benefits

- Supports the dSPACE/MathWorks TDE system.
- Supports long-term data logging.
- Trace capture configurations (variables, trigger, and timeframe).
- Trace capture control commands (start, current state, data fetch).

Product Description

dSPACE's MTRACE offers real-time data recording capabilities for users of the dSPACE/MathWorks TDE, callable directly from MATLAB. Users can program the whole trace process from MATLAB M-files using a set of MEX-file commands. MTRACE is specifically designed for logging large amounts of data over long periods, and is required for real-time data collection for on-line parameter tuning from MATLAB.

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Product Name: **TRACE**
Platforms Supported: PC, Sun, HP
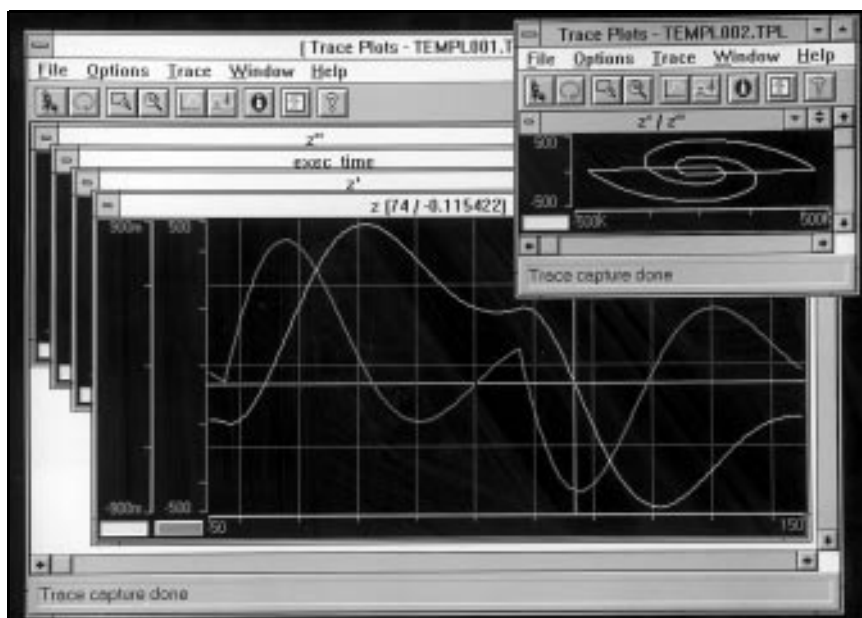Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards

Features and Benefits

- Supports all dSPACE development systems.
- Real-time, "on-the-fly" data capture from the DSP.
- Trace capture configurations and commands.

Product Description

The TRACE program module is a non-intrusive data capture tool for uninterrupted closed-loop operation under true operating conditions. Any signal or parameter that is represented as a variable in the DSP's program can be traced and graphically displayed.

TRACE offers free-running and triggered modes, pre- and post-triggers, auto-trace, downsampling, and table data export. The most important masks and control buttons are directly accessible on the TRACE control panel. The plot facilities include zoom and auto-scaling, as well as cursor readout and grids.

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Development Software

Product Name: **COCKPIT**
Platforms Supported: PC, Sun, HP
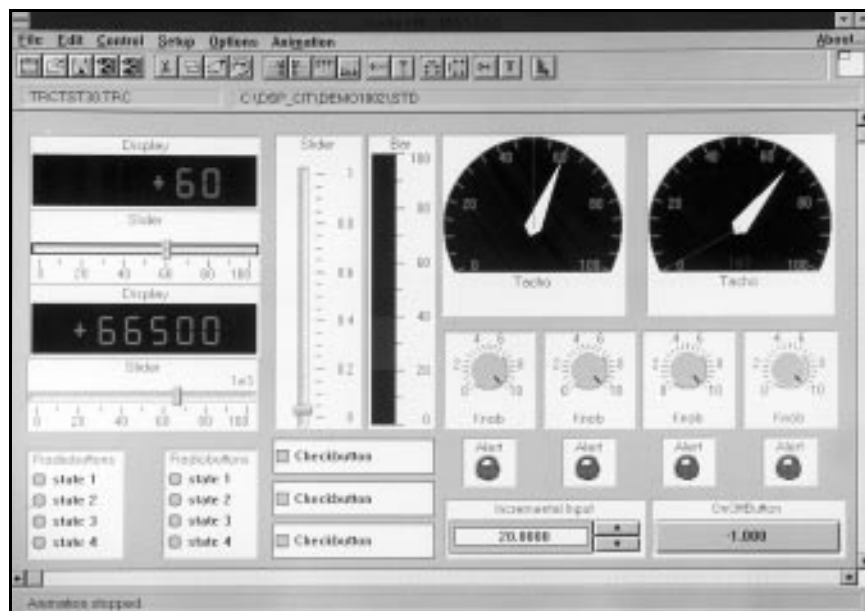Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards

Features and Benefits

- Supports all dSPACE development systems.
- Graphical User Interface for real-time, "on-the-fly" parameter tuning.
- Direct access to DSP.

Product Description

COCKPIT is a ready-to-use solution for monitoring and interacting with a DSP application running on a dSPACE processor or controller board. With the built-in COCKPIT editor, an instrument panel can be built for a DSP application without any additional programming. Parameters can be observed and modified using an intuitive user interface with graphical elements like bars, sliders, and gauges.

COCKPIT has two operating modes: edit and animation. Within the edit mode, a widget can be selected from the control menu, sized, and placed at any spot on the panel. A DSP program variable is connected to an instrument by selecting from a list of variable names used in the current DSP application program.

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Development Software

Product Name: **CLIB (C Language Host-DSP Interface Library)**
Platforms Supported: PC, Sun, HP
Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards

Features and Benefits

- Supports dSPACE development systems.
- Provides basic C language functions for Host-DSP interaction.

Product Description

CLIB provides a set of basic C language functions for interchange between the host and the DSP for data transfer and processor control. Functions can be integrated in user programs to build customer-specific user interfaces. Feature functions include: DSP board control, processor control, interrupt control, and DSP memory and I/O access.

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Product Name: **Debugger**

Platforms Supported: PC

Devices Supported: TMS320C31- and TMS320C40-based processor boards

Features and Benefits

- Supports dSPACE DS1102 and DS1003 processor boards, multiprocessor systems.
- Supports both C code and assembly language debugging.

Product Description

The dSPACE debugger maintains all standard features in PC debuggers, including a memory, CPU register, watch, command, and C source code windows, among others. The user can set breakpoints in code, execute code until defined events, and change a variable's value from within the debugger environment.

If the debugger is invoked in profile mode, the profiler window displays execution time statistics of the selected code portions. All commands can be pulled down from menus for ease-of-use.

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Application Software/Debugging Tools

Product Name: **TextIO**
Platforms Supported: PC
Devices Supported: TMS320C30-, TMS320C31-, and TMS320C40-based processor boards

Features and Benefits

- Supports all dSPACE processor boards.
- Designed to debug a DSP program under real-time conditions.

Product Description

TextIO is dSPACE's DSP library for Text I/O, used for "software probing" to analyze any problems that may occur; for example, during the initialization phase of a DSP program. The library provides standard C functions, including "printf" or "scanf" for formatted input and output of data, plus more basic functions for simple character and string I/O.

These library functions are complemented by a program for the host PC, used to display the output generated by the DSP program and to read the keyboard and forward the typed characters to the DSP. This program can run at the DOS prompt or under Windows, and is real-time capable.

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Development Software/Simulator

Product Name: **Real Motion 3-D Animator**
Platforms Supported: PC
Devices Supported: TMS320C40-based processor boards

Features and Benefits

- Real-time animation for dSPACE development systems for Hardware-in-the-Loop (HIL) simulation.
- Displays animated wireframe or solid models.

Product Description

dSPACE's 3-D animation component takes data from the user's running HIL simulation and displays animated wireframe or solid models at real-time frame rates. Graphics objects can be easily defined by the user in standard CAD data format prior to animation. During animation, the user can switch between viewpoints and change other parameters like colors and individual graphics objects.