dSPACE Simulator Full-Size\textsuperscript{1)}

Modular simulator concept, with off-the-shelf components according to your needs

Highlights

- HIL systems tailored to your needs
- No limit regarding application range
- For testing complex single ECUs to large ECU networks in any kind of application field
- Flexible and open hardware concept
- Freely expandable by any dSPACE I/O board
- High-current applications (hybrid drives)

Hardware Details

dSPACE Simulator Full-Size is mounted in a 19” cabinet. Its height can be adjusted to your requirements. The dSPACE processor boards and I/O boards are mounted in a standard PX20 Expansion Box. The PX20 Expansion Box provides 20 slots for dSPACE boards. An additional Expansion Box can be integrated on request. Several PX20 Expansion Boxes can be integrated in a multirack system, so you never face restrictions on expandability.

Typical Fields of Application

- Engine, powertrain, chassis, and body
- Comprehensive closed-loop tests on ECUs, release/acceptance tests
- Networked ECUs
- Special requirements, e.g., with high system flexibility, or for high-current applications
- Truck applications
- Racing applications (Formula One, rally)
- Electric motor simulation for hybrid or electric powertrains and electric steering systems
- Battery management systems
- Mechanical test benches

Open Hardware Concept

The simulation model runs on the processor hardware (single-processor or multiprocessor systems). dSPACE Simulator generates and measures I/O signals via the integrated dSPACE I/O boards. The signal conditioning, loads, Failure Insertion Units and power supply are also mounted in the 19” cabinet. The number of components, and their types, depend on your requirements and are configured to fit your application.

Connection to Host PC

All dSPACE software for setting up and controlling experiments or test automation runs on your host PC or notebook. The dSPACE Simulator hardware is connected to your PC via Link Boards.

\textsuperscript{1)} The end of life of the dSPACE Simulator Full-Size is planned for December 31, 2024. You can still buy the product until December 31, 2021. New releases of dSPACE software are guaranteed to continue supporting the dSPACE Simulator Full-Size until at least the end of 2023. After the end of life, no services of any kind will be available for this product. We advise against using the dSPACE Simulator Full-Size in new projects. For new projects we recommend that you use the successor, a SCALEXIO rack system which is available in different sizes according to your needs. For general information on the dSPACE product life cycle, please see www.dspace.com/go/LifeCycle.
# Hardware Summary

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form factor</td>
<td>19&quot; cabinet, 17 ... 41 U</td>
</tr>
<tr>
<td>Mass</td>
<td>More than 100 kg, depending on the installed components</td>
</tr>
<tr>
<td>Processor hardware</td>
<td>DS1006 Processor Board or DS1007 PPC Processor Board</td>
</tr>
<tr>
<td>I/O hardware</td>
<td>Any number and type of dSPACE I/O boards</td>
</tr>
<tr>
<td>Signal conditioning</td>
<td></td>
</tr>
<tr>
<td>Substitute loads</td>
<td></td>
</tr>
<tr>
<td>Real-load connector</td>
<td></td>
</tr>
<tr>
<td>Failure Insertion Unit</td>
<td></td>
</tr>
<tr>
<td>Integration of simulator extensions (p. 7, p. 8)</td>
<td></td>
</tr>
<tr>
<td>Integration of third-party hardware, e.g., load panels</td>
<td></td>
</tr>
<tr>
<td>ECU connectors</td>
<td>One or more 90-pin connectors for each ECU (standardized)</td>
</tr>
<tr>
<td></td>
<td>Additional connectors optional</td>
</tr>
<tr>
<td>Break-out box</td>
<td></td>
</tr>
<tr>
<td>OBDII diagnostic connector / connection to diagnostic tools</td>
<td>Standard 16-pin CARB connector</td>
</tr>
<tr>
<td></td>
<td>Diagnostic connectors (CAN, K-line)</td>
</tr>
<tr>
<td></td>
<td>Others on request</td>
</tr>
<tr>
<td>Truck applications-capable (24 V/36 V)</td>
<td></td>
</tr>
<tr>
<td>48 V-capable</td>
<td></td>
</tr>
<tr>
<td>Power supply (remote controlled)</td>
<td>One or two power supplies for simulating 1- or 2-voltage systems</td>
</tr>
</tbody>
</table>

- **included**
- **optional**

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1) Devices connected to the dSPACE HIL system, for example, electronic control units, can feed in high currents and high voltages (voltages over 60 V DC or 30 V ACRMS), which can be dangerous for the user. This can happen, for example, in systems for piezoelectric or hybrid applications. Such currents and voltages can result in property damage, personal injury, or death. Under all circumstances, you must observe all the safety precautions described in the documentation. Please contact dSPACE for additional safety-related equipment, such as electrically safe interface cables.
**PHS Hardware**
- Single-processor or multiprocessor systems
- Freely expandable with any dSPACE I/O board, according to your requirements
- PX20 Expansion Box for PHS hardware (processor and I/O boards)
- Modular signal conditioning concept (customer-specific configuration)
- Expandable, e.g., with hardware for fault insertion and load simulation (customer-specific configuration)

**Signal Conditioning**
- Signal conditioning for all dSPACE I/O boards
- Supports almost any signal type: e.g., digital in, digital out, analog in, analog out, relay simulation, current sink/source, LVDT simulation, resistance simulation, and linear lambda probe simulation
- Additional modules on request
Expandability
- Maximum flexibility thanks to a modular concept
- Minimum hardware modifications if requirements change
- Supersets with spare signals, allowing tests on several ECU variants, even after ECU pinout changes
- All signals accessible on terminal strips for additional measurement tasks and for a flexible response to changing specifications
- Clear and transparent system architecture
- Multirack systems possible

Power Supply
- Simulation of car battery
- Programmable switched-mode power supply
- Remote-controlled
- 48 V and truck-capable: 0 ... 60 V voltage range

Other Hardware Components
- Break-out box (optional, integrated in cabinet or external)
- Optional inclusion of third-party hardware; e.g., load panels, signal routing units, GPIB instruments
- Power switch modules (p. 7)

Load Capabilities
- Modular load concept (customer-specific configuration)
- Support of single-ended and double-ended loads
- Resistive loads or other kinds of equivalent loads
- Connection of electrically equivalent loads or low-power resistive loads
- Connection of real loads, can optionally be integrated in the cabinet
- Integration of customers’ load panels
- High-speed electronic loads, e.g., for emulating electric motors

Failure Insertion Units
- Modular FIU concept (customer-specific configuration)
- Failure Insertion Unit (FIU) for ECU inputs and outputs
- Remotely controlled with the ControlDesk Failure Simulation Module (or, optionally, with AutomationDesk)
- Broken wire simulation (open circuit)
- Simulation of shorts: shorts from ECU pins to ground, battery voltage, or switched rail
- Simulation of cross-wired short circuits between ECU pins
- Simultaneous activation of multiple faults (latch mode)
- For more information on high-current fault simulation please see p. 5.
Fault Simulation

The dSPACE Simulator Full-Size offers different options for carrying out fault simulation. This enables you to tailor the system to your project-specific requirements. You can either perform the standard fault simulation using relay boards (Fault Simulation Variant 1) or a second variant of fault simulation using a central relay switching matrix (Fault Simulation Variant 2).

In addition, the dSPACE Simulator Full-Size can be equipped with a high-current fault simulation unit, which allows for failures with currents of up to 50 A.

For electrical fault insertion for the physical layer of buses, dSPACE offers the DS1450 Bus FIU Board.

Fault Simulation Variant 1

The standard variant for fault simulation on dSPACE Simulator Full-Size supports fault simulation on all ECU input and output pins. All digital and analog I/O boards from dSPACE can be used for fault simulation. The relay boards (DS291) for fault simulation can be used on their own for fault simulation on sensor signals (ECU inputs) or in conjunction with load boards (DS281) on actuator signals (ECU outputs). Fault relays are controlled via a serial RS232.

Fault Simulation Variant 2

The second fault simulation variant uses a central relay switching matrix (DS293) for fault simulation on ECU inputs and outputs. Five different system potentials (for example, Terminal 30, Terminal 31, Terminal 15) can be switched on three different rails via load modules (DS282). Further devices can be connected, including various measurement devices (Meas0-4), an electronic source (Source), and Rsim modules for transition impedance. Fault simulation is controlled via a CAN interface.

High-Current Fault Simulation

Our high-current fault simulation unit on dSPACE Simulator supports fault simulation on ECU inputs and outputs. One FIU controller card (DS5355) supports up to 19 signal channels on two high-current FIU relay trays (DS5390). Due to its modularity, the FIU controller card can be expanded to increase the number of channels. These relay trays allow for failures with currents of up to 50 A and voltages of up to 300 V. The FIU is controlled from ControlDesk via a serial RS232 or CAN.
Fault Simulation Summary

<table>
<thead>
<tr>
<th>Feature</th>
<th>Variant 1</th>
<th>Variant 2</th>
<th>High-Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIU cards</td>
<td>DS291</td>
<td>DS282</td>
<td>DS5355/DS5390</td>
</tr>
<tr>
<td>Number of cards per simulator</td>
<td>Configurable</td>
<td>Configurable</td>
<td>Configurable</td>
</tr>
<tr>
<td>Number of channels per card</td>
<td>10</td>
<td>10</td>
<td>Up to 19</td>
</tr>
<tr>
<td>Switch type</td>
<td>Relay</td>
<td>Relay</td>
<td>Relay</td>
</tr>
<tr>
<td>Central modules</td>
<td>—</td>
<td>1 x DS293</td>
<td>—</td>
</tr>
<tr>
<td>Simulation of transition impedence</td>
<td>—</td>
<td>1 x DS289 Rsim Module (simulates a resistance in the range 1 Ω ... 131 kΩ in steps of 1 Ω)</td>
<td>—</td>
</tr>
<tr>
<td>Max. continuous current</td>
<td>8 A</td>
<td>8 A</td>
<td>50 A</td>
</tr>
</tbody>
</table>

Possible fault types

- Cable break
- Short circuit to ground
- Short circuit to battery voltage
- Short circuit to another ECU pin via common fail plane
- Cable break with additional hardware (Rsim, Meas or Source) in series
- Short circuit to another ECU pin via additional hardware (Rsim, Meas or Source)
- Short circuit to 5 reference points (potential 0 ... 4) directly or via additional hardware (Rsim, Meas or Source)

- included
- not available

DS1450 Bus FIU Board

Offers the essential options of electrical fault insertion for the physical layer of buses such as FlexRay. These options include short circuits, open circuits, and varying termination resistance.

<table>
<thead>
<tr>
<th>DS1450 Bus FIU Board</th>
<th>Specification</th>
</tr>
</thead>
</table>
| Hardware             | - Supports 4 bus channels in parallel  
                      | - Usable for dSPACE Simulator Mid-Size and Full-Size as well as HIL systems based on expansion boxes  
                      | - Suitable for differential bus systems (FlexRay, CAN, etc.)  
                      | - Relay-based  |
| Software             | - Uses a specialized ControlDesk failure pattern |
| Fault insertion options | - Short circuit to ground and to any user-defined potential (typically U_{BAT})  
                      | - Open circuit  
                      | - Varying termination resistance  
                      | - Switching cross short-circuits |
Examples of Simulator Extensions

Tailor-made Solutions
Further simulator-specific hardware can be integrated into your dSPACE Simulator in addition to the PHS hardware listed in this catalog. This simulator-specific hardware can include real system components, as well as measurement and diagnostic tools. The components and tools can be built and integrated by dSPACE, or you can do it yourself. 
dSPACE Simulator Full-Size can be equipped with simulator-specific hardware for optimum tailoring to your specific needs. 
dSPACE Simulator Mid-Size can be similarly equipped to a certain extent.

The following list is typical of many application areas, and you can also add or remove as many components as you like.
- Interfaces to diagnostic and calibration hardware to supplement the default interfaces
- Real system components
- Programmable power supplies
- Power switch module
- Simulation of linear lambda probes
- CAN gateway
- Others

Customized Interfaces to Diagnostic and Calibration Hardware
Many companies have their own diagnostic and calibration hardware to perform tasks, such as reading out internal ECU variables from the fault memory. If you want to use your own diagnostic and calibration hardware, you need to use a special interface for dSPACE Simulator. In some cases, some engineering might be necessary. You can connect any kind of measuring device, digital scope, and diagnostic device with special protocols such as GPIB or RS232.

Real System Components
In some cases, the real system components (such as injection valves, hydraulic components, and sensors) have to be integrated into dSPACE Simulator. This is necessary, for example, if components for the same ECU are provided by different suppliers and have to be checked together with the ECU within the simulated environment. Moreover, not every vehicle component can be simulated accurately enough with a justifiable amount of time and money. Some ECUs require real loads at their outputs to function.

Power Switch Module
ECUs consume power even when the vehicle is parked. Many modern ECUs have a sleep mode to avoid draining the vehicle’s electrical system unnecessarily. Some ECUs therefore contain a CAN transceiver capable of wake-up/sleep mode, which allows the ECU to run only if it is needed and switches it off otherwise. Power switch modules provide the possibility to connect each ECU to the standard battery terminals (e.g., T30, T15, T50) and to measure the current consumption of each ECU separately in different current ranges from μA up to 50 A. Moreover, systems with networked ECUs often require different power supply voltage levels. Each power switch module can therefore handle two power supply lines to simulate different vehicle electrical systems within dSPACE Simulator. Even the sequence when a vehicle is starting up can be simulated.
A measurement unit allows the precise current measurement of each ECU supply line in different current ranges, even in the microampere range. For example, current consumption during ECU sleep mode can be compared with normal operation mode consumption. The module is controlled by software via a CAN interface.
Programmable Power Supplies
The programmable power supply unit feeds the components to be tested and allows for simulating real voltages such as a vehicle’s battery voltage during start-up. The power supply unit is remotely controlled from within the real-time model. Various power supplies are available for different applications, for example:
- 0 ... 20 V
- 0 ... 60 V

Simulation of Linear Lambda Probes
LSU (Lambda Sonde Universal, universal lambda probe) is a signal conditioning module for dSPACE Simulator Full-Size and Mid-Size that simulates the behavior of linear lambda probes. These probes measure the air-fuel ratio in a car’s exhaust system. The engine ECU reacts by varying the injection time, so the catalytic converter can operate at an optimal performance rate.
The LSU module allows for generating Nernst cell voltage on four independent channels based on pump current and Nernst cell inner resistance. The module functions as a linear probe or as a jump probe. Parameters such as maximum/minimum Nernst cell voltage can be adjusted.

CAN Gateway
In large-scale CAN networks, testing bus communication plays a key role. Engineers need to test the behavior of ECUs and distributed functions if an expected CAN message fails to arrive or contains unexpected signals.
To simulate faults, a CAN gateway module is inserted into the CAN network (see illustration). Each ECU can be connected individually to one of the two CAN controllers in the dSPACE Simulator. Signal manipulation via software allows you to change any CAN messages from any ECU to achieve a predefined effect on the other ECUs in the CAN network. The CAN software (RTI CAN MultiMessage Blockset) offers a wide range of typical error situations right up to the message or individual signal level.

CAN gateway for simulating errors in large ECU networks.