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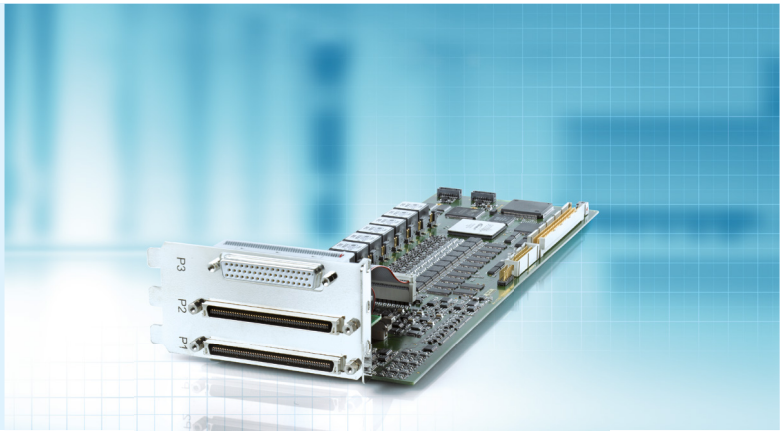
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DS2211 HIL I/O Board

Central I/O board for hardware-in-the-loop simulation

Highlights

- Simulates and measures all engine signals (for up to 8 cylinders)
- Signal conditioning for signal levels of 12 V, 24 V, and 48 V automotive systems; support of 2-voltage systems
- Ideally suited for engine, powertrain, and vehicle dynamics applications



Key Benefits

The DS2211 HIL I/O Board is the central I/O board for hardware-in-the-loop simulation, especially in the field of automotive electronics. The DS2211 HIL I/O Board is tailored to the simulation and measurement of automotive signals, particularly for engine and vehicle dynamics applications, and combines a variety of typical HIL I/O signals on one board. The board contains signal conditioning for typical signal levels of 12 V, 24 V, and 48 V automotive systems and supports 2-voltage systems.

Building a HIL Simulator

Together with a processor board (the DS1006 or DS1007), the DS2211 HIL I/O Board constitutes the hardware core of dSPACE Simulator. The processor board performs the calculation of the real-time model, for example, of an engine, while the DS2211 measures and stimulates all the required I/O signals. The simulator can be expanded from 8-cylinder up to 96 cylinders by using two or more DS2211 HIL I/O Boards.

Angular Processing Unit

The DS2211 HIL I/O Board features a unique angular processing unit which supports high-speed generation and measurement of crank angle-related signals to simulate engines up to 29,000 rpm.

Angle-Synchronous Cascading

For tougher I/O requirements, several boards, for example, several DS2211s, can be cascaded. The boards operate angle-synchronously if their time base connectors are connected. One DS2211 board acts as the time base (angle master), and the other boards read out its time base, which allows signals to be generated and measured angle-synchronously on several boards. The same applies to the DS4002 Timing and Digital I/O Board (p. 416), the DS5001 Digital Waveform Capture Board (p. 440), and the DS5203 FPGA Board (p. 450), which can all be connected to the time base, too.

See p. 402 for an application example.

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Technical Details

Parameter		Specification
General		■ Angular processing unit (APU) to handle all crankshaft-angle-related signals (ignition, injection, crankshaft, camshaft, etc.) ■ Simulation of crankshaft sensors that detect the direction of rotation ■ 1 crankshaft signal output (programmable analog and digital waveforms) ■ Max. 4 camshaft signal outputs (2 with programmable analog and digital output plus 2 with digital output only, shared with 2 digital outputs) ■ Complex comparator functionality support for ignition and injection signals ■ Support for the SAE standard J2716 (SENT) ■ Time-base connector
Slave processor	DSP (digital signal processor)	■ Texas Instruments TMS320VC33 floating-point DSP ■ 150 MFLOPS ■ 13.3 ns cycle time
Interrupt controller		■ 6 angle position interrupts (can be set at any engine position in 0.01 degree increments) ■ 1 CAN controller interrupt ■ 1 serial interface (universal asynchronous receiver and transmitter) interrupt
Angular processing unit (APU)	Angular resolution	■ 0.011° crank angle
	Speed range	■ ±29,000 rpm
	Speed resolution	■ 0.112 rpm
A/D channels	Channels	■ 16 differential A/D channels (multiplexed)
	Resolution	■ 14 bits
	Conversion time[1)]	■ 1.1 µs per channel
	Input voltage range	■ 0 … 60 V, differential inputs
	Offset error	■ ±10 mV
	Gain error	■ ±0.5 %
	Input impedance	■ > 1 MΩ
D/A channels	Channels	■ 20 D/A channels with individual ground sense line
	Output voltage range	■ 0 … 10 V (with internal reference, or ratiometric with 5 … 10 V external reference) ■ Sense lines allow differential outputs with DACx[2)] output swing -10 V … +12 V from system ground
	Resolution	■ 12 bits
	Settling time	■ 20 µs (full scale to 1 LSB)
	Analog outputs	■ 1 crankshaft signal (angular processing unit) ■ 2 camshaft signals (angular processing unit) ■ 4-channel wheel speed or 4-channel knock signal generation (based on DSP); up to 8 knock signals per cycle ■ 4 additional analog waveform outputs (from DSP, no sense line, ±10 V)
	Output current	■ ±5 mA
	Offset error	■ ±5 mV
	Gain error	■ ±0.5 % (with internal reference)
Slave DSP DAC	Settling time	■ 10 µs (full scale to 1 LSB)
	Output voltage range	■ ±10 V
	Output current	■ ±5 mA
Transformer outputs	Output voltage range	■ ±20 V (transformer output mode) ■ ±10 V (DC output mode)
	Output current	■ ±5 mA

[1)] *Speed and timing specifications describe the capabilities of the hardware components and circuits of dSPACE products. Depending on the software complexity, the attainable overall performance can deviate significantly from the hardware specification.*

[2)] *Output swing referenced to ground, when $\overline{DACx}$ is connected to a potential other than GND.*

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Technical Details

Parameter		Specification
Resistive output channels	Channels	■ 10 channels
	Topology	■ 16-bit switched resistor ladder
	Resistance range	■ 15.8 Ω … 1 MΩ
	Resistance error	■ ±2% or ±3 Ω, whichever is greater, with RESx– pin within ±5 V of system ground
	Voltage range	■ Each terminal must stay within ±10 V of system ground
	Output current range	■ Max. ±80 mA
	Power per channel	■ Max. 250 mW
Digital inputs	Channels	■ Max. 24 PWM measurement inputs (16 inputs shared with digital inputs, 2 inputs shared with injection inputs), up to 50 ns resolution, 0.01 Hz … 100 kHz ■ Max. 16 digital inputs (all inputs shared with PWM measurement inputs) ■ Max. 8 ignition inputs (2 inputs shared with auxiliary capture inputs), up to 64 sparks per event window, or up to 64 events buffered for continuous readout ■ Max. 8 injection inputs (2 inputs shared with PWM measurement inputs), up to 64 pulses per event-window, or up to 64 events buffered for continuous readout ■ Max. 2 auxiliary capture inputs (all inputs shared with ignition inputs) ■ PWM measurement input channels can also be used for frequency measurement ■ Max. 4 SENT receive channels (revision SENT2010)
	Input voltage	■ 0 … +60 V
	Threshold voltage level	■ 1 V … 22.65 V or 23.8 V (dependent on I/O circuit)
	Input impedance	■ 390 kΩ
Digital outputs	Channels	■ Max. 16 digital outputs (2 pins shared with digital camshaft signal outputs) ■ 9 PWM outputs, resolution 16 bit, 0.01 Hz … 100 kHz, push/pull outputs ■ PWM outputs can also be used for square wave signal generation ■ Max. 5 SENT transmit channels (revision SENT2010)
	External supply voltage	■ +5 V … +60 V ■ Supplied from two independent rails (V_{BAT1} and V_{BAT2}) ■ 2-voltage support for digital outputs, selectable pin-wise
	Output current range	■ Max. ±50 mA
	$V_{out\ high,\ min.}$	■ (VBATx – 1.2 V) at +50 mA
	$V_{out\ low,\ max.}$	■ 0.4 V at -50 mA
Interfaces	Serial interface	■ TL16C550C single UART (universal asynchronous receiver and transmitter) ■ RS232, RS422 compatibility
		■ Up to 115.2 Kbaud (RS232) ■ Up to 1 Mbaud (RS422)
	CAN bus interface	■ 2 CAN channels based on ST10F269 microcontroller ■ ISO DIN 11898-2 CAN High-Speed standard
		■ Max. 1 Mbaud
Physical connections		■ I/O connection via 2 x 100 pin high-density connectors and a 50-pin female Sub-D connector
Host interface		■ One 8- or 16-bit ISA slot (power supply only) ■ Requires three brackets (for I/O connectors)
Physical characteristics	Physical size	■ 340 x 125 x 61 mm (13.4 x 4.9 x 2.4 in) ■ The board requires three brackets.
	Ambient temperature	■ 0 … 55 °C (32 … 131 °F)
	Power supply	■ +5 V ±5%; 1.5 A ■ +12 V ±5%; 0.25 A typical (max. 0.5 A with load on all analog and transformer outputs) ■ -12 V ±5%; 0.2 A typical (max. 0.5 A with load on all analog and transformer outputs)
		■ Two V_{BAT} rails (5 V … 60 V DC) ■ Each rail (V_{BATx}): 0.05 A + load current on digital outputs ■ V_{BATx} has to be supplied from an external source.

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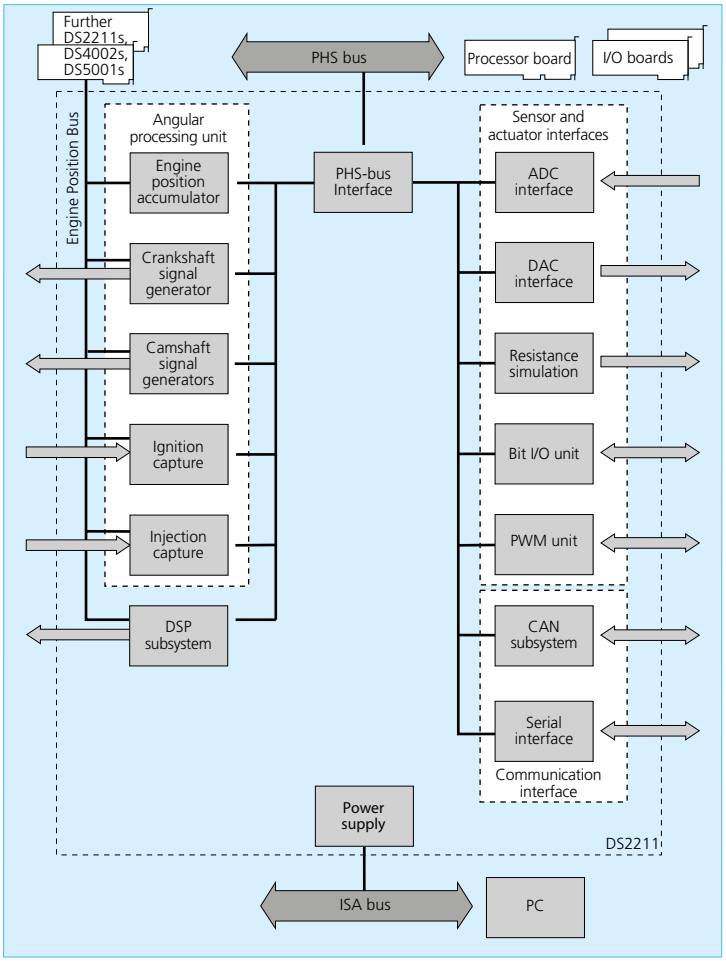
Order Information

Product	Order Number
DS2211 HIL I/O Board	■ DS2211

Relevant Software

Software		Order Number
Required	■ Real-Time Interface (RTI) (p. 56)	■ RTI
Optional	■ RTI CAN Blockset (p. 64)	■ RTICAN_BS
	■ RTI CAN MultiMessage Blockset (p. 67)	■ RTICANMM_BS
	■ Texas Instruments C3X/4X Code Composer (p. 105)	■ TMDS3240130

Block Diagram

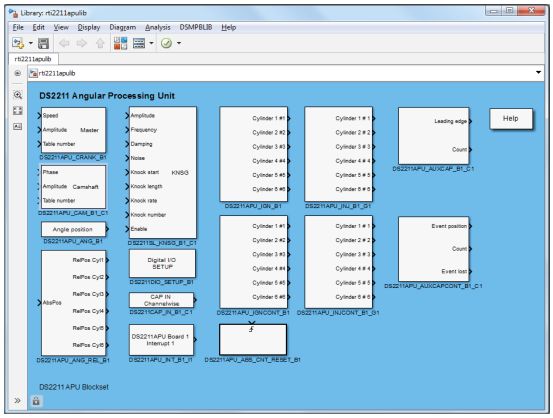


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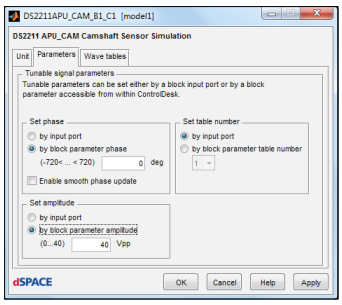
Graphical Programming

Programming from MATLAB®/Simulink®/Stateflow®

Programming and connecting to I/O is simple with our Real-Time Interface (p. 56), which enables you to program all your I/O graphically in Simulink, even the angular processing unit.



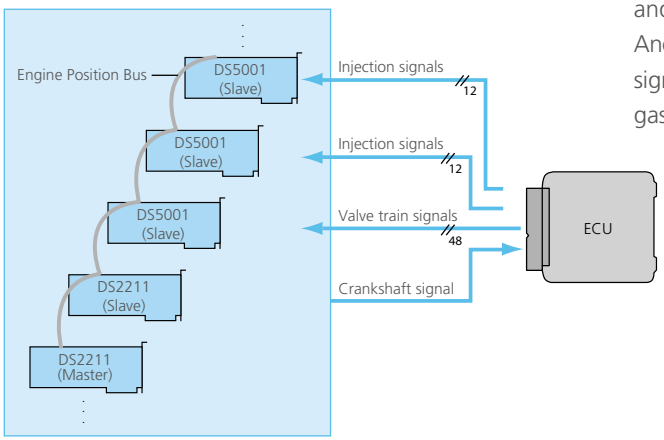
For connection to the CAN bus, for example, the optional RTI CAN Blockset extends Real-Time Interface for easy, graphical CAN configuration from Simulink. The blockset comprises CAN controller configuration and dialog-based parameterization of messages in receive and transmit modes (p. 64).



Application Example: Simulating a 12-Cylinder EVT Engine

The Challenge: Immense I/O

HIL simulation of a 12-cylinder, 48-valve engine with an electromagnetic valve train (EVT) is a real challenge, especially as regards I/O. The engine ECU generates 12 injection signals plus 12 ignition signals. In addition, 4 valve signals are needed for each of the 12 cylinders to control the electromagnetic valve actuators. This means that if the engine is simulated, 72 signals generated by the ECU have to be captured – angle-synchronously.



Cascading Several I/O Boards

The DS2211 HIL I/O Board is designed to be the heart of such applications. The hardware can be cascaded via the Engine Position Bus, with further boards operating angle-synchronously. In this case, the dSPACE Simulator hardware consists of a further DS2211 and three DS5001 Digital Waveform Capture Boards. The DS2211s are ready to capture injection and ignition signals of 6 (up to 8) cylinders each, while each DS5001 provides 16 capture channels for the valve signals. One board is the time base (angle master) for the other boards, so that all signals can be generated and captured angle-synchronously.

Another example in which you might need angle-synchronous signal capturing is a rail pressure actuator for direct injection gasoline engines.

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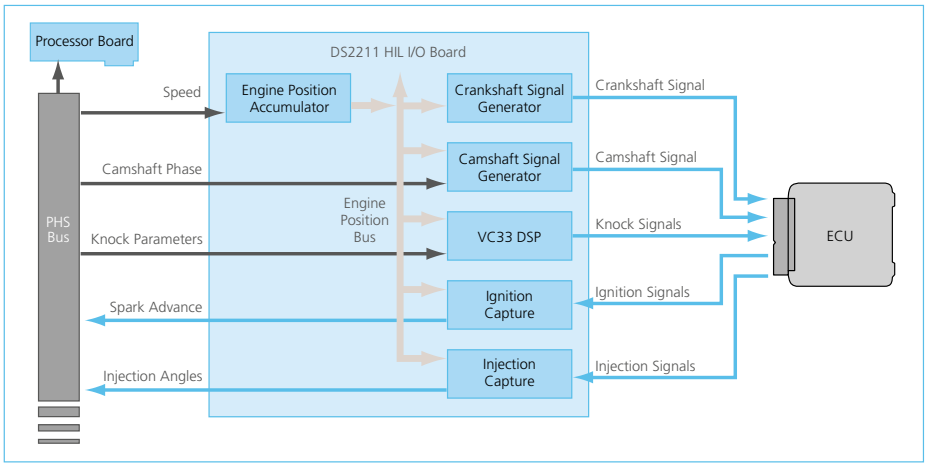
Application Example: HIL Simulation of a 6-Cylinder Engine

A HIL System with Just Two Boards

Together with a processor board (the DS1006 or DS1007), the DS2211 provides a compact, yet powerful dSPACE Simulator for hardware-in-the-loop simulation, for example, for function or system testing.

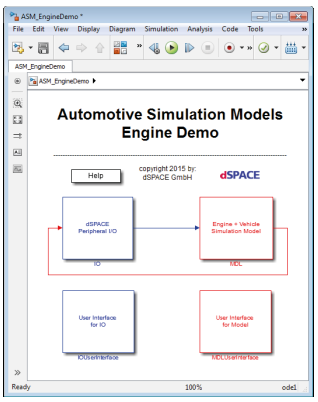
Engine Position Based Signal Generation

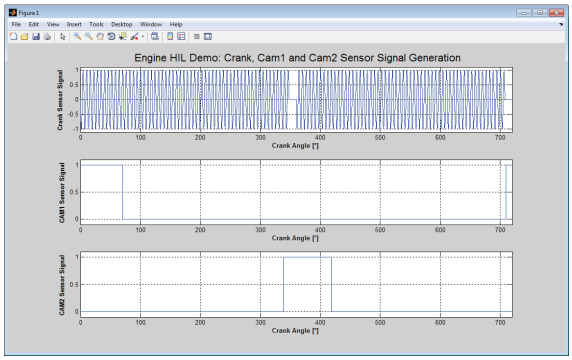
The processor board performs the calculation of an engine model and sends all the calculated engine data to the DS2211 (for example, engine speed, camshaft phase, and engine knock parameters). The DS2211 processes this data with an engine position accumulator that constantly calculates the engine position according to the current engine speed. With a 16-bit angle resolution and an engine speed resolution of 0.112 rpm, this engine position is the basis for all further signal generation.



Engine I/O Performed by the DS2211

The DS2211 HIL I/O Board uses the engine position and other model parameters to generate all the required signals (for example, crankshaft, camshaft, and knock signals). To simulate the complexity of an engine, the signals have to be highly realistic so that they can be processed by the ECU. In parallel, the DS2211 reads out the ECU's reactions to the simulation (for example, ignition and injection signals), and preprocesses them for the real-time model running on the processor board.





Simulated crankshaft and camshaft signals.

The engine model is calculated by the processor board, while the DS2211 performs the challenging I/O tasks.

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