DS2003 Multi-Channel A/D Board

Features

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dSPACE

How to Contact dSPACE

Mail:	dSPACE GmbH Rathenaustraße 26 33102 Paderborn Germany
Tel.:	+49 5251 1638-0
Fax:	+49 5251 16198-0
E-mail:	info@dspace.de
Web:	http://www.dspace.com

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  Tel.: +49 5251 1638-941 or e-mail: support@dspace.de

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dSPACE strongly recommends that you download and install the most recent patches for your current dSPACE installation. Visit http://www.dspace.com/go/patches for software updates and patches.

Important Notice

Contents

About This Document

Content

This document provides feature-oriented access to the information you need to implement the functions of the DS2003.

Symbols

dSPACE user documentation uses the following symbols:

Symbol	Description
DANGER	Indicates a hazardous situation that, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazardous situation that, if not avoided, could result in death or serious injury.
CAUTION	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.
NOTICE	Indicates a hazard that, if not avoided, could result in property damage.
Note	Indicates important information that you should take into account to avoid malfunctions.
Tip	Indicates tips that can make your work easier.
	Indicates a link that refers to a definition in the glossary, which you can find at the end of the document unless stated otherwise.
	Precedes the document title in a link that refers to another document.

Naming conventions

dSPACE user documentation uses the following naming conventions:

%name% Names enclosed in percent signs refer to environment variables for file and path names.

< > Angle brackets contain wildcard characters or placeholders for variable file and path names, etc.

Special folders

Some software products use the following special folders:

Common Program Data folder A standard folder for application-specific configuration data that is used by all users.

`%PROGRAMDATA%\dSPACE\<InstallationGUID>\<ProductName>`

or

`%PROGRAMDATA%\dSPACE\<ProductName>\<VersionNumber>`

Documents folder A standard folder for user-specific documents.

`%USERPROFILE%\Documents\dSPACE\<ProductName>\<VersionNumber>`

Local Program Data folder A standard folder for application-specific configuration data that is used by the current, non-roaming user.

`%USERPROFILE%\AppData\Local\dSPACE\<InstallationGUID>\<ProductName>`

Accessing dSPACE Help and PDF Files

After you install and decrypt dSPACE software, the documentation for the installed products is available in dSPACE Help and as PDF files.

dSPACE Help (local) You can open your local installation of dSPACE Help:

- On its home page via Windows Start Menu
- On specific content using context-sensitive help via **F1**

dSPACE Help (Web) You can access the Web version of dSPACE Help at www.dspace.com.

To access the Web version, you must have a *mydSPACE* account.

PDF files You can access PDF files via the icon in dSPACE Help. The PDF opens on the first page.

Introduction to the Features of the DS2003

Introduction

The DS2003 Multi-Channel A/D Board provides two independent A/D converters and 32 input channels. All inputs are multiplexed to both converters to permit load balancing for minimum total conversion times, independent from the inputs actually used.

For the data sheet of the DS2003 and the connector panel CP2003, refer to Data Sheets (PHS Bus System Hardware Reference 🕮).

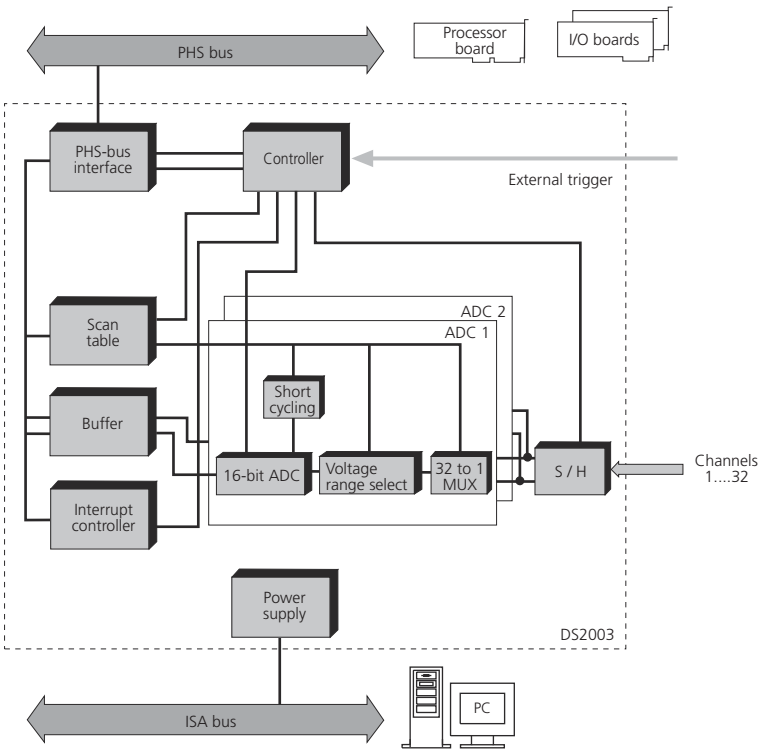
Where to go from here

Information in this section

Board Architecture

Board overview

The following illustration gives an overview of the functional units and architecture of the DS2003:



Integration Into a PHS-Bus-Based System

Basics

To be used, the DS2003 must be integrated into a PHS-bus-based system. While the DS2003 performs the required input tasks, the processor board takes over the calculation of the real-time model. That is, applications using DS2003 I/O features are implemented on the processor board.

Communication between processor board and I/O board is performed via the peripheral high speed bus: that is the PHS bus for connection to a dSPACE processor board.

Partitioning the PHS bus with the DS802 With the DS802 PHS Link Board you can spatially partition the PHS bus by arranging the I/O boards in several expansion boxes.

The DS802 can be used in combination with many types of available dSPACE I/O boards. However, some I/O boards and some functionalities of specific I/O boards are not supported.

The I/O board support depends on the dSPACE software release which you use. For a list of supported I/O boards, refer to DS802 Data Sheet (PHS Bus System Hardware Reference 🕮).

Connection to External Devices

Basics

There are two different ways to connect external devices to the DS2003. To access the ADC unit of the DS2003, connect external devices:

- To the 50-pin ADC connector P1 of the DS2003
- To the optional connector panel CP2003, equipped with BNC connectors CP1 … CP33

ADC Unit

Where to go from here

Information in this section

Basics on the ADC Unit

Characteristics

The DS2003 controls an ADC unit featuring 2 parallel A/D converters (ADC1, ADC2) multiplexed to 32 channels each (signals VIN1 … VIN32). Both ADCs can convert all input channels, but only up to 16 at a time. The A/D converters have the following characteristics:

- 32 sample&hold circuits allowing all 32 inputs to be sampled simultaneously
- Programmable scan table
- External trigger
- ±5 V or ±10 V input voltage range (selectable for each channel individually)
- 4-, 8-, 10-, 12-, 13-, 14-, 15- or 16-bit resolution (selectable for each channel individually)

After conversion, the converted values are stored in the board's ADC data buffer, which is a 512 x 32 bit FIFO buffer.

Adjustable ADC resolution

To perform faster conversion, you can lower the resolution to 4, 8, 10, 12, 13, 14 or 15 bits, see Faster A/D Conversion via Short-Cycling on page 15.

Scan table mechanism

The DS2003 uses a scan table to store the information required for A/D conversion.

Information provided by the scan table The scan table specifies:

- The channel numbers of the channels to be used for conversion
- The ADC resolution for the respective channels
- The input voltage range for the respective channels

Using a scan table, the input signals of all the 32 input channels can be converted within one scan process.

Autonomous A/D conversion via scan table Once A/D conversion is started, the DS2003 autonomously executes the commands contained in the scan table. The processor board does not need to be used for this, which saves execution time.

If you work with RTI, the scan table mechanism is used automatically. If you work with RTLib, use the ds2003_init_scantbl function to implement a scan table.

Starting A/D conversion

A/D conversion on the DS2003 can be started in two ways:

Conversion start by software Use the functions ds2003_start or ds2003_conversion_start to start A/D conversion.

On each call to ds2003_start, the ADC data buffer is cleared, and a scan process is started. The ds2003_conversion_start function does not clear the ADC data buffer before it starts the scan process.

RTI's DS2003_Bx block automatically uses the ds2003_start function.

Conversion start by external trigger You can let A/D conversion on the DS2003 be started by an external clock source. For details, see Starting A/D Conversion via External Trigger on page 16.

Scan process

On A/D conversion start, the DS2003 converts the input signals according to the settings specified in the scan table. The conversion results are stored in the ADC data buffer. This completes a scan process.

Reading out the ADC data buffer

There are two methods of reading out conversion results from the ADC data buffer to the processor board:

Reading out the results of one scan process Use the ds2003_start function together with the function ds2003_read or ds2003_in. On each call to ds2003_start, the ADC data buffer is cleared, and a scan process is started. The function ds2003_read or ds2003_in reads out the conversion results of this scan process to the processor board.

This method is automatically used by RTI's DS2003_Bx block.

Reading out the results of several scan processes The ADC data buffer is a 512 x 32 bit FIFO buffer. Working with all the 32 input channels of the

DS2003, the buffer can therefore store the conversion results of up to 32 scan processes before a buffer overflow occurs. Working with only one or two channels of the DS2003, the buffer can store the results of up to 512 scan processes.

To implement this method, start A/D conversion with the ds2003_conversion_start function or by an external trigger. In contrast to starting A/D conversion with the ds2003_start function, the ADC data buffer is not cleared in this case. Then the conversion results of several scan processes can be read out with the functions ds2003_block_read or ds2003_fifo_half_full_block_read. You can use ds2003_buffer_clear to clear the buffer.

To use this method within an RTI model, you have to program it with the above mentioned RTLib functions, and incorporate your C code in a Simulink S-Function block. For details, refer to Implementing S-Functions (RTI and RTI-MP Implementation Guide 🕮).

Conversion state interrupts

The DS2003 provides 4 hardware interrupts that are related to the current A/D conversion state. For information on interrupt handling, refer to Interrupts on page 19.

RTI/RTLib support

You can access the ADC unit via DS2003 Blockset and RTLib. For details, refer to:

- ADC Unit in the *DS2003 RTI Reference*
- ADC Unit in the *DS2003 RTLib Reference*

Execution times

For details on the execution times and the corresponding measurement setup, refer to Function Execution Times.

Connecting external devices

An excerpt from the circuit diagram that shows the I/O circuit and information on the electrical characteristics of the ADC unit are available. You can also get information on signal conditioning and the external trigger. Refer to Signal Connection to External Devices (PHS Bus System Hardware Reference 🕮).

I/O mapping

The following table shows the mapping between the RTI block and RTLib functions and the corresponding pins used by the ADC unit:

Related RTI Block	Ch (RTI)	Related RTLib Functions	Ch (RTLib)	Conn. Pin	Pin on CP	Signal
DS2003_Bx	Ch 1	See ADC Unit	Ch 1	P1 1	P1	VIN1
	Ch 2		Ch 2	P1 34	P2	VIN2
	Ch 3		Ch 3	P1 2	P3	VIN3
	Ch 4		Ch 4	P1 35	P4	VIN4
	Ch 5		Ch 5	P1 3	P5	VIN5
	Ch 6		Ch 6	P1 36	P6	VIN6
	Ch 7		Ch 7	P1 4	P7	VIN7
	Ch 8		Ch 8	P1 37	P8	VIN8
	Ch 9		Ch 9	P1 5	P9	VIN9
	Ch 10		Ch 10	P1 38	P10	VIN10
	Ch 11		Ch 11	P1 6	P11	VIN11
	Ch 12		Ch 12	P1 39	P12	VIN12
	Ch 13		Ch 13	P1 7	P13	VIN13
	Ch 14		Ch 14	P1 40	P14	VIN14
	Ch 15		Ch 15	P1 8	P15	VIN15
	Ch 16		Ch 16	P1 41	P16	VIN16
	Ch 17		Ch 17	P1 9	P17	VIN17
	Ch 18		Ch 18	P1 42	P18	VIN18
	Ch 19		Ch 19	P1 10	P19	VIN19
	Ch 20		Ch 20	P1 43	P20	VIN20
	Ch 21		Ch 21	P1 11	P21	VIN21
	Ch 22		Ch 22	P1 44	P22	VIN22
	Ch 23		Ch 23	P1 12	P23	VIN23
	Ch 24		Ch 24	P1 45	P24	VIN24
	Ch 25		Ch 25	P1 13	P25	VIN25
	Ch 26		Ch 26	P1 46	P26	VIN26
	Ch 27		Ch 27	P1 14	P27	VIN27
	Ch 28		Ch 28	P1 47	P28	VIN28
	Ch 29		Ch 29	P1 15	P29	VIN29
	Ch 30		Ch 30	P1 48	P30	VIN30
	Ch 31		Ch 31	P1 16	P31	VIN31
	Ch 32		Ch 32	P1 49	P32	VIN32

Faster A/D Conversion via Short-Cycling

ADC short-cycling

To perform faster conversion, ADC short-cycling may be used.

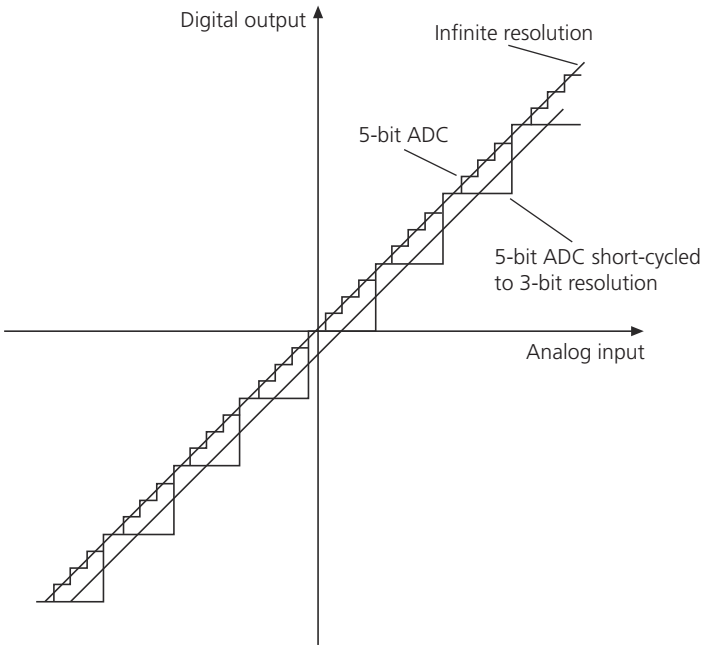
Faster conversion by lowering A/D resolution

The converters ADC1/ADC2 use the successive-approximation conversion technique.

The successive-approximation method performs 16 successive comparisons to provide the full 16-bit resolution. Short-cycling terminates the comparison sequence after a programmed number of steps. On a DS2003, you can short-cycle the conversion to 4-, 8-, 10-, 12-, 13-, 14- and 15-bit resolution.

Using ADC short-cycling to reduce the conversion time is only possible at the expense of lower resolution.

The following illustration shows the effects of ADC short-cycling:



For information on reducing conversion times, refer to Function Execution Times (DS2003 RTLib Reference 🕮).

The execution time describes the conversion time (the time needed for conversion itself) plus the time needed for executing the access functions like starting the converter or reading data, for example.

Related topics

Basics

ADC Unit 11
Introduction to the Features of the DS2003 7

Starting A/D Conversion via External Trigger

Basics

You can let the scan process be started by an external clock source (like the DS4002 Timing and Digital I/O Board). For this purpose, the DS2003 provides an external trigger input.

Enabling external triggering

After initialization of the DS2003, external triggering is disabled. To enable external triggering, use RTLib's ds2003_set_trigger function.

Note

Using RTI, external triggering cannot be enabled.

Timing requirements

The external trigger signal must be a TTL signal with a high level. To start the conversion, there must be an active low pulse with a duration of at least 50 ns. This pulse should be shorter than a complete conversion.

The time for scanning depends on:

- Number of channels
- Resolution

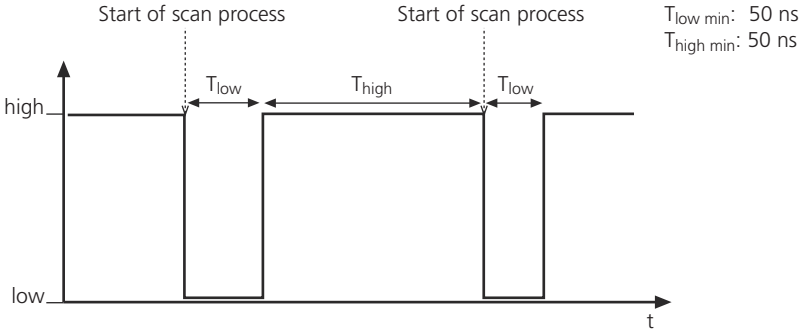
The following table contains some values for the scan time using a DS2003 board with the fast ADCs delivered since July 2009 in a PHS-bus-based system. The scan time contains the time from starting the conversion till setting the *ready* bit.

Number of Channels[1)]	Resolution[2)]	Time for Scanning
2	4/8/12/16	3.24/3.74/4.38/4.84 µs
8	4/8/12/16	8.56/10.47/12.54/14.61 µs
16	4/8/12/16	15.54/19.50/23.46/27.63 µs
32	4/8/12/16	29.49/37.62/45.54/53.49 µs

1) The channel number can be specified within the range 1 … 32.
2) The A/D converter can be used with a 4-, 8-, 10-, 12-, 13-, 14-, 15-, 16-bit resolution.

The frequency of the external trigger signal may not be higher than the reciprocal of the scan time. The scan process starts on the falling edge of the external trigger signal.

The following illustration shows the timing of an external trigger.



Note

If you start several scan processes using external triggering and if you do not read out the ADC data buffer, the buffer will overflow.

I/O mapping

The following table shows the mapping between the RTLib function and the corresponding pin used for the external trigger:

Related RTLib Function	Conn. Pin	Pin on CP	Signal
ds2003_set_trigger	P1 50	P33	ExtTrigger

Related topics

Basics

ADC Unit 11
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References

ds2003_set_trigger (DS2003 RTLib Reference 🕮)
Measured Execution Times (DS2003 RTLib Reference 🕮)

Interrupts

Interrupts Provided by the DS2003

Characteristics

The DS2003 provides access to 4 hardware interrupts that indicate the current A/D conversion state:

Interrupt Type	Description	See Also
Scan process complete	Interrupt on end of scan process.	ADC Unit on page 11
ADC data buffer not empty	Interrupt indicates that the ADC data buffer contains data. Each ADC has converted at least one input.At least one ADC data pair is available in the ADC data buffer.	
ADC data buffer half full	Interrupt indicates that the ADC data buffer is filled to half its capacity. At least 256 ADC data pairs are in the ADC data buffer. This interrupt is only possible if the A/D conversion is started by the external trigger. In this case, the buffer is not cleared before the conversion starts.	
ADC data buffer full	Interrupt indicates that the capacity limit has been reached. 512 ADC data pairs are available in the ADC data buffer. The values of further conversions will be lost. This interrupt is only possible if the A/D conversion is started by the external trigger. In this case, the buffer is not cleared before the conversion starts.	

Note

There is a limitation for performing A/D conversion and using hardware interrupts of the DS2003 in the same application. Refer to A/D Conversion and Interrupt Usage on page 21.

Interrupt processing

Via the interrupt lines of the PHS bus, interrupts from the DS2003 are sent to the interrupt controller of the connected dSPACE processor board. Using RTI, the interrupts of the DS2003 can therefore be used to implement interrupt-driven tasks. For details see Tasks Driven by Interrupt Blocks (RTI and RTI-MP Implementation Guide 🕮).

RTI/RTLib support

With RTI, you can easily implement interrupt-driven subsystems by means of a specific interrupt block provided by DS2003 Blockset. For handcoded applications, you can use RTLib functions to handle interrupts. For details, see

- DS2003_HWINT_Bx_Iy in the *DS2003 RTI Reference*
- ADC Unit in the *DS2003 RTLib Reference*

Related topics

Basics

Introduction to the Features of the DS2003 7

References

ADC Unit (DS2003 RTLib Reference 🕮)
DS2003_HWINT_Bx_Iy (DS2003 RTI Reference 🕮)

Limitations

A/D Conversion and Interrupt Usage

Basics

By default, the DS2003 board works in polling mode. This means, that the software is waiting until the conversion results are available. If you want to use one of the DS2003 interrupts in your application, the polling functions cannot be used at the same time. You have to use non-polling functions instead.

Polling the SCAN_RDY flag

The board's interrupt control unit holds a *scan process complete* flag that indicates whether or not the A/D conversion scan process, which is specified by the scan table, has finished.

RTLib's ds2003_in and ds2003_block_read functions, and RTI's DS2003_Bx block poll the SCAN_RDY flag, and do not read the converted values until the flag is set.

Limitations

Implementing one of the DS2003 hardware interrupts in your application conflicts with the polling mode, because the flags to be polled are no longer accessible. Polling and interrupt-driven functions therefore cannot be used at the same time. You must note the following limitations:

- With RTI, you cannot use the DS2003_Bx block and the DS2003_HWINT_Bx_Iy block in the same model.
- With RTLib, you cannot use the ds2003_in and ds2003_block_read functions and implement a DS2003 interrupt service routine in the same program.

Workaround

Using RTLib To implement one or more DS2003 hardware interrupts and read converted values in the same application, use the ds2003_read function within a *scan process complete* interrupt service routine, or the ds2003_fifo_half_full_block_read function within a *FIFO half full* interrupt service

routine. These functions are designed for the use in interrupt service routines and do not poll the SCAN_RDY flag.

Using RTI If your model contains the DS2003_HWINT_Bx_Iy block, you have to program the reading of the converted values with the above mentioned RTLib functions, and incorporate your C code in a Simulink S-Function block. For more information, refer to Implementing S-Functions (RTI and RTI-MP Implementation Guide 🕮).