# DS4002 Timing and Digital I/O Board

# RTI Reference

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# About This Reference

## Contents

This reference provides a full description of the Real-Time Interface (RTI) software support for the DS4002 Timing and Digital I/O Board.

# 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.
<b>▲</b> WARNING	Indicates a hazardous situation that, if not avoided, could result in death or serious injury.
<b>▲</b> 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.
· C	Indicates a link that refers to a definition in the glossary, which you can find at the end of the document unless stated otherwise.
<u> </u>	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.

## Examples:

- Where you find terms such as rti<XXXX> replace them by the RTI platform support you are using, for example, rti1007.
- Where you find terms such as <model> or <submodel> in this document, replace them by the actual name of your model or submodel. For example, if the name of your Simulink model is smd\_1007\_sl.slx and you are asked to edit the <model>\_usr.c file, you actually have to edit the smd\_1007\_sl\_usr.c file.

**RTI block name conventions** All I/O blocks have default names based on dSPACE's board naming conventions:

- Most RTI block names start with the board name.
- A short description of functionality is added.
- Most RTI block names also have a suffix.

Suffix	Meaning
В	Board number (for PHS-bus-based systems)
М	Module number (for MicroAutoBox II)
С	Channel number
G	Group number
CON	Converter number
BL	Block number
Р	Port number
1	Interrupt number

A suffix is followed by the appropriate number. For example, DS2201IN\_B2\_C14 represents a digital input block located on a DS2201 board. The suffix indicates board number 2 and channel number 14 of the block. For more general block naming, the numbers are replaced by variables (for example, DS2201IN\_Bx\_Cy).

## 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>

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

A standard folder for user-specific documents. Documents folder %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.

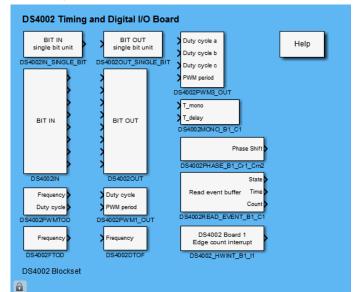
**PDF files** You can access PDF files via the 🔼 icon in dSPACE Help. The PDF opens on the first page.

# General Information on the DS4002 Blockset

# 

# Overview of the DS4002 Blockset

About this board	The DS4002 Timing and Digital I/O Board provides 24 bidirectional plus 4 input and 4 output TTL digital I/O lines. It can also be used for the analysis and generation of square-wave signals or pulse-width modulated (PWM) signals.
Access	The Real-Time Interface (RTI) board library for the DS4002 Timing and Digital I/O Board provides the RTI blocks that implement the functionality and I/O capabilities of the DS4002 board in Simulink models.
	DS4002



After you double-click the corresponding board library icon in the rtilibm library, the Library: rtilibm/DS4002 opens:

## Library components

The following I/O units can be accessed by the RTI blockset for the DS4002:

- Digital I/O Unit on page 13
- Timing I/O Unit on page 25
- Interrupts on page 53

## **Related topics**

## References

Digital I/O Unit	13
Interrupts	53
Timing I/O Unit	25

# Demo Models Using the DS4002

## Demo model

For Simulink models that show how to use the RTI blocks of the DS4002 board, refer to the RTI demo library of your processor board. You can also find the model files at <RCP\_HIL\_InstallationPath>\Demos\ds100x\RTI.

Digital I/O unit	For a demo model using the digital I/O unit, refer to <a href="RCP_HIL_InstallationPath">RCP_HIL_InstallationPath</a> \Demos\DS100x\RTI\demom_ds4002_1.mdl This is the DS4002_1 model, which you can find in the processor board's RTI demo library.
Timing I/O unit	For a demo model using the timing I/O unit, refer to demom_ds4002_2.mdl, demom_ds4002_3.mdl, or demom_ds4002_4.mdl in the <rcp_hil_installationpath>\Demos\DS100x\RTI directory. You can also find these models, called DS4002_2, DS4002_3, and DS4002_4 in the processor board's RTI demo library.</rcp_hil_installationpath>
Interrupts	For a demo model using interrupts, refer to the TaskLib demo models.

# Digital I/O Unit

## Introduction

The Library: rtilibm/DS4002 provides access to the digital I/O unit of the DS4002.

You can configure each 8-bit group of the DS4002 board freely for input or output. However, all the bits in one group can be used either for input or for output only.

# Where to go from here

# Information in this section

DS4002IN To provide byte-wise read access to the 8 bits of a group.	14
DS4002IN_SINGLE_BIT To provide single-bit read access to the 4 input bits 28 31.	17
DS4002OUT To provide byte-wise write access to the 8 bits of a group.	19
DS4002OUT_SINGLE_BIT  To provide single-bit write access to the 4 output bits 24 27.	22

# Information in other sections

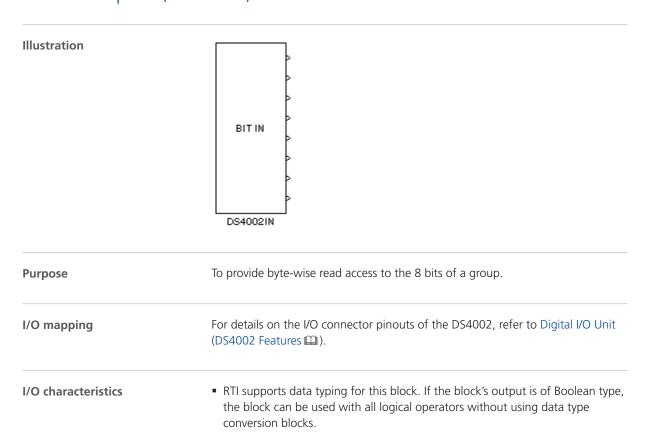
# 

Digital I/O Unit (DS4002 Features (LLL)) Explains the digital I/O unit of DS4002.

# **DS4002IN**

Purpose	To provide byte-wise read access to the 8 bits of a group.	
Where to go from here	here Information in this section	
	Block Description (DS4002IN)	
	To specify the byte-wise read access.	

# Block Description (DS4002IN)



• Relationship between the digital input and the output of the block:

Digital Input (TTL)	Simulink Output	
	Without Data Typing	With Data Typing
High	1 (double)	1 (boolean)
Low	0 (double)	0 (boolean)

**Dialog pages** 

The dialog settings can be specified on the Parameters Page.

**Related RTLib functions** 

ds4002\_init, ds4002\_dio\_init, ds4002\_dio\_bit\_in

**Related topics** 

#### References

ds4002\_dio\_bit\_in (DS4002 RTLib Reference (11)) ds4002\_dio\_init (DS4002 RTLib Reference (12)) ds4002\_init (DS4002 RTLib Reference (13))

# Parameters Page (DS4002IN)

**Purpose** 

To specify the byte-wise read access.

**Dialog settings** 

**Board number** Lets you select the board number in the range  $1 \dots 16$ . If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Group number** Lets you select a group of 8 bits. The valid group numbers are:

<b>Group Number</b>	Input Bits
1	0 7
2	8 15
3	16 23

# **▲** WARNING

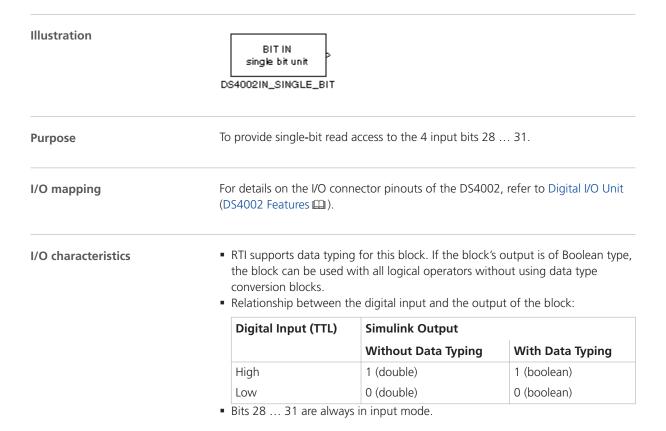
You must not configure the same group for different I/O blocks! There is no warning or error message in case of improper use.

**Strobed Input Mode** If the checkbox is selected, all input signals are latched at once on an external strobe signal. In strobed mode the strobe input PSTB must be connected. Input data is latched with the rising edge of PSTB.

# DS4002IN\_SINGLE\_BIT

Purpose	To provide single-bit read access to the 4 input bits 28 31.
Where to go from here	Information in this section
	Block Description (DS4002IN_SINGLE_BIT)
	Parameters Page (DS4002IN_SINGLE_BIT)

# Block Description (DS4002IN\_SINGLE\_BIT)



**Dialog pages**The dialog settings can be specified on the Parameters Page.

Related RTLib functions	ds4002_init, ds4002_dio_init, ds4002_dio_bit_in	
Related topics	References	
	ds4002_dio_bit_in (DS4002 RTLib Reference (11)) ds4002_dio_init (DS4002 RTLib Reference (12)) ds4002_init (DS4002 RTLib Reference (13))	

# Parameters Page (DS4002IN\_SINGLE\_BIT)

Purpose	To specify the single bit to be read.		
Dialog settings	<b>Board number</b> Lets you select the board number in the range 1 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.		
	<b>Bit</b> Lets you select a bit in the range 28 31.		

# **DS4002OUT**

Purpose	To provide byte-wise write access to the 8 bits of a group.
Where to go from here	Information in this section
	Block Description (DS4002OUT)

# Block Description (DS4002OUT)



• Relation between the digital output and the input of the block:

Digital Output (TTL)	Simulink Input	
	Without Data Typing	With Data Typing
High	> 0 (double)	1 (boolean)
Low	≤ 0 (double)	0 (boolean)

**Dialog pages** 

The dialog settings can be specified on the Parameters Page.

**Related RTLib functions** 

ds4002\_init, ds4002\_dio\_init, ds4002\_dio\_bit\_out

**Related topics** 

#### References

ds4002\_dio\_bit\_out (DS4002 RTLib Reference (L))
ds4002\_dio\_init (DS4002 RTLib Reference (L))
ds4002\_init (DS4002 RTLib Reference (L))

# Parameters Page (DS4002OUT)

#### **Purpose**

To specify the initialization and termination states of the selected group.

#### Description

During the model initialization phase, an initial digital output value is written to each bit. This is especially useful if a bit is written from within a triggered or enabled subsystem which is not executed right from the start of the simulation. With the initialization value all bits have defined outputs during this simulation phase.

When the simulation terminates, all bits hold their last digital output by default. You can set user-defined bit output on termination to drive your external hardware into a safe final condition.

The specified termination values of I/O channels are set when the simulation executes its termination function by setting the simState variable to STOP. If you stop the real-time application by using ControlDesk's Stop RTP command, the processor resets immediately without executing termination functions. The current values of the I/O channels are kept and the specified termination values are not set.

# **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Group number** Lets you select a group of 8 bits. The valid group numbers are:

<b>Group Number</b>	Output Bits
1	0 7
2	8 15
3	16 23

# **MARNING**

You must not configure the same group for different I/O blocks! There is no warning or error message in case of improper use.

**Initialization state** Lets you specify the initial digital output at the start of the simulation. Each number in the matrix represents a bit in the selected group.

**Set termination values** Lets you keep the current digital output or write the specified termination values to the selected group when the simulation terminates.

**Termination state** Lets you specify the digital output when the simulation terminates. Each number in the matrix represents a bit in the selected group. These values will be used only if you select Set termination values.

# **Related topics**

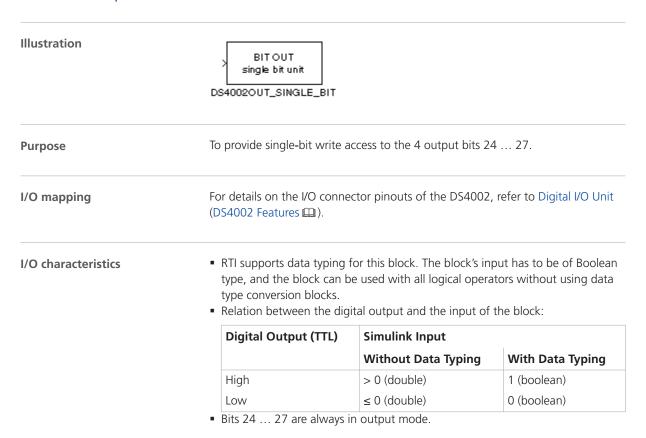
## References

simState (RTI and RTI-MP Implementation Reference  $\square$ ) Stop RTP (ControlDesk Platform Management  $\square$ )

# DS4002OUT\_SINGLE\_BIT

Purpose	To provide single-bit write access to the 4 output bits 24 27.
Where to go from here	Information in this section
	Block Description (DS4002OUT_SINGLE_BIT)
	Parameters Page (DS4002OUT_SINGLE_BIT)

# Block Description (DS4002OUT\_SINGLE\_BIT)



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The dialog settings can be specified on the Parameters Page.

**Dialog pages** 

## **Related RTLib functions**

ds4002\_init, ds4002\_dio\_init, ds4002\_dio\_bit\_out

## **Related topics**

#### References

ds4002\_dio\_bit\_out (DS4002 RTLib Reference (1))
ds4002\_dio\_init (DS4002 RTLib Reference (1))
ds4002\_init (DS4002 RTLib Reference (1))

# Parameters Page (DS4002OUT\_SINGLE\_BIT)

#### **Purpose**

To specify the initialization and termination states of the selected bit.

## Description

During the model initialization phase, an initial digital output value is written to each bit. This is especially useful if a bit is written from within a triggered or enabled subsystem which is not executed right from the start of the simulation. With the initialization value all bits have defined outputs during this simulation phase.

When the simulation terminates, all bits hold their last digital output values by default. You can set a user-defined bit output on termination to drive your external hardware into a safe final condition.

The specified termination values of I/O channels are set when the simulation executes its termination function by setting the simState variable to STOP. If you stop the real-time application by using ControlDesk's Stop RTP command, the processor resets immediately without executing termination functions. The current values of the I/O channels are kept and the specified termination values are not set.

## **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Bit** Lets you select a single bit in the range 24 ... 27.

**Initialization state** Lets you specify the initial digital output at the start of the simulation.

**Set termination value** Lets you keep the current digital output or write the specified termination value to the selected bit when the simulation terminates.

**Termination state** Lets you specify the digital output when the simulation terminates. This value will be used only if you select **Set** termination value.

# **Related topics**

## References

simState (RTI and RTI-MP Implementation Reference  $\mbox{\ \, \square})$  Stop RTP (ControlDesk Platform Management  $\mbox{\ \, \square})$ 

# Timing I/O Unit

# Introduction

The Library: rtilibm/DS4002 provides access to the timing I/O unit of the DS4002.

# Where to go from here

# Information in this section

DS4002PWM1_OUT	7
DS4002PWM3_OUT	<b>O</b>
DS4002DTOF	4
DS4002MONO_Bx_Cy	7
DS4002FTOD	1
DS4002PHASE_Bx_Cry_Cmz	3
DS4002PWMTOD	5
DS4002READ_EVENT_Bx_Cy	3

# Information in other sections

# Demo Models Using the DS4002......10

Some demo models are available in the RTI demo library that demonstrate how to use the DS4002.

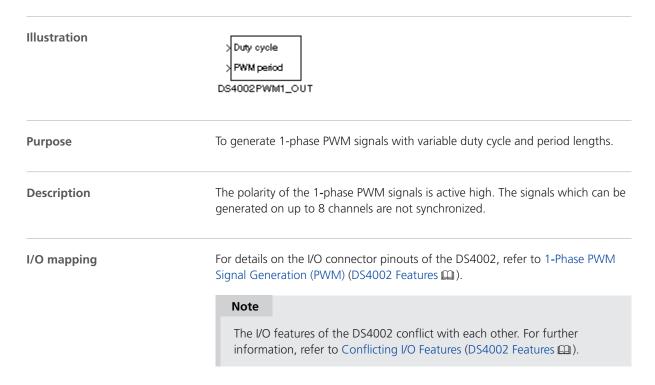
# Timing I/O Unit (DS4002 Features □)

The DS4002 has a timing I/O unit that you can use to generate and measure digital signals.

# DS4002PWM1\_OUT

# 

# Block Description (DS4002PWM1\_OUT)



#### I/O characteristics

• Scaling between the duty cycle and the input of the block:

Duty Cycle	Simulink Input
0 100%	0 1

• The PWM period block input may range from a value between 1.2 μs and 8 μs up to 107 s. The minimum period length depends on the number of active DS4002 channels. For further information about the relationship between period length and the number of active channels, refer to 1-Phase PWM Signal Generation (PWM) (DS4002 Features 🚇).

#### Dialog pages

The dialog settings can be specified on the Parameters Page.

#### **Related RTLib functions**

ds4002\_init, ds4002\_pwm\_init, ds4002\_pwm\_int\_init,
ds4002\_pwm\_update

## **Related topics**

#### References

ds4002\_init (DS4002 RTLib Reference (1))
ds4002\_pwm\_init (DS4002 RTLib Reference (1))
ds4002\_pwm\_int\_init (DS4002 RTLib Reference (1))
ds4002\_pwm\_update (DS4002 RTLib Reference (1))

# Parameters Page (DS4002PWM1\_OUT)

#### **Purpose**

To specify the 1-phase PWM signal generation.

## Description

During the model initialization phase, an initial duty cycle and an initial period length are set for PWM signal generation. This is especially useful if the PWM signal is generated from within a triggered or enabled subsystem which is not executed right from the start of the simulation. With the initialization value all channels have defined outputs during this simulation phase.

When the simulation terminates, all channels hold their signal shape by default. You can set a user-defined duty cycle and period length on termination to drive your external hardware into a safe final condition.

The specified termination values of I/O channels are set when the simulation executes its termination function by setting the simState variable to STOP. If you stop the real-time application by using ControlDesk's Stop RTP command, the processor resets immediately without executing termination functions. The current values of the I/O channels are kept and the specified termination values are not set.

For further information about the relationship between period length and the number of active channels, refer to 1-Phase PWM Signal Generation (PWM) (DS4002 Features 1).

# **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Channel number** Lets you select the channel number in the range 1 ... 8.

**Interrupt mode** Lets you specify whether PWM interrupts are generated at either the rising or the falling edge of the PWM signal.

#### Note

- You can only use channel 1 or 2 for interrupt generation. If you have specified channels 3 ... 8, interrupt generation is disabled.
- The model has to contain the DS4002\_HWINT\_Bx\_ly on page 54 block, where interrupt channel 1 or 2 must be selected according to the specified channel of the DS4002PWM1\_OUT block.

**Initial duty cycle** Lets you specify the initial duty cycle of the output at the start of the simulation. The duty cycle must remain within the range 0 ... 1. The default value is 0.5.

**Initial period** Lets you specify the initial period length of the output at the start of the simulation. The unit of measure is second(s). The minimum period length is 1.2  $\mu$ s to 8  $\mu$ s depending on the number of active DS4002 channels. The maximum period length is 107 s. The default value is 0.01 s.

**Set termination values** Lets you keep the current output for the duty cycle and the period length when the simulation terminates or select the **Set** termination values checkbox to specify the termination values.

**Duty cycle on termination** If Set termination values is selected, the Duty cycle on termination can be specified. The duty cycle must remain within the range 0 ... 1.

**Period on termination** If Set termination values is selected, the Period on termination can be specified. The unit of measure is second(s). The minimum period length is  $1.2 \, \mu s$  to  $8 \, \mu s$  depending on the number of active DS4002 channels. The maximum period length is  $107 \, s$ .

## **Related topics**

#### Basics

1-Phase PWM Signal Generation (PWM) (DS4002 Features (LLL))

# References

simState (RTI and RTI-MP Implementation Reference (LAP)
Stop RTP (ControlDesk Platform Management (LAP)

# DS4002PWM3\_OUT

# Purpose

To generate symmetric 3-phase PWM signals with variable duty cycles and period lengths.

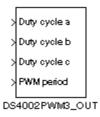
# Where to go from here

#### Information in this section



# Block Description (DS4002PWM3\_OUT)

#### Illustration



# **Purpose**

To generate symmetric 3-phase PWM signals with variable duty cycles and period lengths.

# I/O mapping

For details on the I/O connector pinouts of the DS4002, refer to 3-Phase PWM Signal Generation (PWM3) (DS4002 Features 

.

## Note

The I/O features of the DS4002 conflict with each other. For further information, refer to Conflicting I/O Features (DS4002 Features 

...

## I/O characteristics

• Scaling between the duty cycle and the input of the block:

<b>Duty Cycle</b>	Simulink Input
0 100%	0 1

The PWM period block input may range from a value between 2.8 μs and 8 μs up to 107 s. The minimum period depends on the number of active DS4002 channels.

#### Dialog pages

The dialog settings can be specified on the Parameters Page.

#### **Related RTLib functions**

ds4002\_init, ds4002\_pwm3\_init, ds4002\_pwm3\_int\_init,
ds4002\_pwm3\_update, ds4002\_pwm3\_int\_update

## **Related topics**

#### References

ds4002\_init (DS4002 RTLib Reference (11))
ds4002\_pwm3\_init (DS4002 RTLib Reference (12))
ds4002\_pwm3\_int\_init (DS4002 RTLib Reference (12))
ds4002\_pwm3\_int\_update (DS4002 RTLib Reference (12))
ds4002\_pwm3\_update (DS4002 RTLib Reference (12))

# Parameters Page (DS4002PWM3\_OUT)

## Purpose

To specify the 3-phase PWM signal generation.

#### Description

During the model initialization phase, initial values for the duty cycle and the period length are set for PWM signal generation. This is especially useful if the PWM signal is generated from within a triggered or enabled subsystem which is not executed right from the start of the simulation. With the initialization value all channels have defined outputs during this simulation phase.

When the simulation terminates, all channels hold their signal shape by default. You can set a user-defined duty cycle and period length on termination to drive your external hardware into a safe final condition.

The specified termination values of I/O channels are set when the simulation executes its termination function by setting the simState variable to STOP. If you stop the real-time application by using ControlDesk's Stop RTP command, the processor resets immediately without executing termination functions. The current values of the I/O channels are kept and the specified termination values are not set.

For further information about the relationship between period length and the number of active channels, refer to 3-Phase PWM Signal Generation (PWM3) (DS4002 Features 🕮).

## **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Channel numbers** Lets you specify an array of 3 different channels within the range 1 ... 8.

**Interrupt mode** Lets you specify whether PWM interrupts are generated in the middle of either the high or the low period of the first specified channel.

#### Note

- You can only use channel 1 or 2 as the first channel for interrupt generation. If you have specified channels 3 ... 8 as the first channel, the interrupt generation is disabled.
- The model has to contain the DS4002\_HWINT\_Bx\_Iy on page 54 block, where interrupt channel 1 or 2 must be selected according to the specified channel of the DS4002PWM3\_OUT block.
- When you generate PWM signals with a higher frequency, the interrupt may not occur exactly in the middle of the high period. The difference can reach one counter tick (200 ns) at maximum.

**Initial duty cycle** Lets you specify the initial duty cycle of the outputs at the start of the simulation. The duty cycles must remain within the range 0 ... 1. You have to specify an array of three values. The default values for all channels specified is 0.5.

**Initial period** Lets you specify the initial period length of the outputs at the start of the simulation. The unit of measure is second(s). The minimum period length is 2.8  $\mu$ s to 8  $\mu$ s depending on the number of active DS4002 channels. The maximum period length is 107 s. The default value is 0.01 s.

**Set termination values** Lets you keep the current output for the duty cycles and the period length when the simulation terminates or select the Set termination values checkbox to specify the termination values.

**Duty cycle on termination** If Set termination values is selected, the Duty cycle on termination can be specified. Their values must remain within the range 0 ... 1. You have to specify an array of three values.

**Period on termination** If Set termination values is selected, the Period on termination can be specified. The unit of measure is second(s). The minimum period length is 2.8  $\mu$ s to 8  $\mu$ s depending on the number of active DS4002 channels. The maximum period length is 107 s.

## **Example**

- If you want to generate PWM signals on channels 1, 5 and 6, you must specify the array [1 5 6] for the channel numbers.
  - When the DS4002HWINT\_Bx\_Iy block is included, you can use channel 1 for interrupt generation.
- If you want to generate PWM signals on channels 2, 4 and 5 you must specify the array [2 4 5] for the channel numbers.

When the DS4002HWINT\_Bx\_ly block is included, you can use channel 2 for interrupt generation.

• If you want to generate PWM signals on channels 5, 1 and 6, you must specify the array [5 1 6] for the channel numbers.

You cannot use this configuration for interrupt generation, because the first specified channel is channel 5. Interrupt generation is disabled in this case.

# **Related topics**

#### Basics

3-Phase PWM Signal Generation (PWM3) (DS4002 Features 🕮)

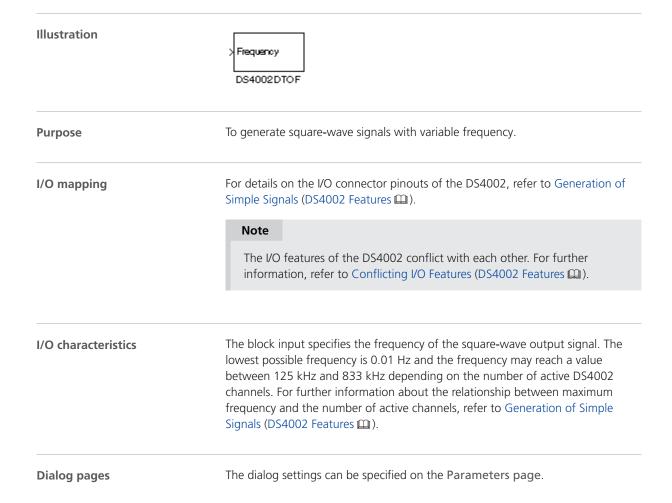
## References

simState (RTI and RTI-MP Implementation Reference  $\square$ ) Stop RTP (ControlDesk Platform Management  $\square$ )

# DS4002DTOF

Purpose	To generate square-wave signals with variable frequency.	
Where to go from here	Information in this section	
	Block Description (DS4002DTOF)	34
	Parameters Page (DS4002DTOF)  To specify the square-wave signal generation.	35

# Block Description (DS4002DTOF)



## **Related RTLib functions**

ds4002\_init, ds4002\_d2f\_init, ds4002\_d2f\_int\_init,
ds4002 d2f update

## **Related topics**

#### References

ds4002\_d2f\_init (DS4002 RTLib Reference (11))
ds4002\_d2f\_int\_init (DS4002 RTLib Reference (12))
ds4002\_d2f\_update (DS4002 RTLib Reference (12))
ds4002\_init (DS4002 RTLib Reference (12))

# Parameters Page (DS4002DTOF)

## **Purpose**

To specify the square-wave signal generation.

# Description

During the model initialization phase, an initial frequency is set for square-wave generation. This is especially useful if the square-wave signal is generated from within a triggered or enabled subsystem which is not executed right from the start of the simulation. With the initialization value all channels have defined outputs during this simulation phase.

When the simulation terminates, all channels hold their signal shape by default. You can set a user-defined frequency on termination to drive your external hardware into a safe final condition.

The specified termination values of I/O channels are set when the simulation executes its termination function by setting the simState variable to STOP. If you stop the real-time application by using ControlDesk's Stop RTP command, the processor resets immediately without executing termination functions. The current values of the I/O channels are kept and the specified termination values are not set.

For further information about the relationship between maximum frequency and the number of active channels, refer to Generation of Simple Signals (DS4002 Features (12)).

# **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Channel number** Lets you select the channel number in the range 1 ... 8.

**Interrupt mode** Lets you specify whether interrupts are generated at either the rising or the falling edge of the square-wave signal.

#### Note

- You can only use channels 1 and 2 for interrupt generation. If you have specified channels 3 ... 8, the interrupt generation is disabled.
- The model has to contain the DS4002\_HWINT\_Bx\_Iy on page 54 block, where interrupt channel 1 or 2 must be selected according to the specified channel of the DS4002DTOF block.

**Initial frequency** Lets you specify the frequency of the output signal at the start of the simulation. The unit of measure is hertz (Hz). The minimum frequency is 0.01 Hz. Depending on the number of active DS4002 channels, the maximum frequency may reach 125 kHz or 833 kHz. The default value is 100 Hz.

**Set termination value** Lets you keep the current output signal shape when the simulation terminates or select the **Set termination value** checkbox to specify the termination value.

**Frequency on termination** If Set termination value is selected, the signal frequency on termination can be specified. The unit of measure is hertz (Hz). The minimum frequency is 0.01 Hz. Depending on the number of active DS4002 channels, the maximum frequency may reach 125 kHz or 833 kHz.

## **Related topics**

## Basics

Generation of Simple Signals (DS4002 Features 🕮)

#### References

simState (RTI and RTI-MP Implementation Reference (11) Stop RTP (ControlDesk Platform Management (12))

# DS4002MONO\_Bx\_Cy

## **Purpose**

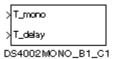
To generate a monoflop signal on a DS4002 channel.

## Where to go from here

## Information in this section

## Block Description (DS4002MONO\_Bx\_Cy)

#### Illustration



## **Purpose**

To generate a monoflop signal on a DS4002 channel.

## I/O mapping

For details on the I/O connector pinouts of the DS4002, refer to Monoflop Signal Generation (DS4002 Features 🕮).

#### Note

The I/O features of the DS4002 conflict with each other. For further information, refer to Conflicting I/O Features (DS4002 Features 

...

### I/O characteristics

This block provides two input ports:

Input Port	Simulink Input	Description	Output Signal
T_mono (input 1)	1 channel used: 0.6 µs 107 s 8 channels used: 4 µs 107 s	This port defines the monoflop pulse length.	Digital monoflop signal (TTL) For further information, refer to Timing I/O (PHS

Input Port	Simulink Input	Description	Output Signal
T_delay (input 2)	1 channel used: 0.6 µs 107 s 8 channels used: 4 µs 107 s	This port defines the delay time of the monoflop pulse output.	Bus System Hardware Reference (11).

### **Dialog pages**

The dialog settings can be specified on the Parameters Page.

### **Related RTLib functions**

ds4002\_init, ds4002\_delayed\_mono\_int\_init,
ds4002\_mono\_init,ds4002\_delayed\_mono\_int\_update,ds4002\_mono\_upda
te,ds4002\_mono\_start

#### **Related topics**

#### References

ds4002\_delayed\_mono\_int\_init (DS4002 RTLib Reference (1))
ds4002\_delayed\_mono\_int\_update (DS4002 RTLib Reference (2))
ds4002\_init (DS4002 RTLib Reference (1))
ds4002\_mono\_init (DS4002 RTLib Reference (1))
ds4002\_mono\_start (DS4002 RTLib Reference (1))
ds4002\_mono\_update (DS4002 RTLib Reference (1))

## Parameters Page (DS4002MONO\_Bx\_Cy)

## **Purpose**

To specify the monoflop behavior on the DS4002 channel.

### Description

During the model initialization phase, initial values for pulse length and delay are set for monoflop signal generation. This is especially useful if the monoflop signal is generated from within a triggered or enabled subsystem which is not executed right from the start of the simulation. With the initialization values all channels have defined outputs during this simulation phase.

When the simulation terminates, all channels hold their signal shape by default. You can set a user-defined pulse length and delay on termination to drive your external hardware into a safe final condition.

The specified termination values of I/O channels are set when the simulation executes its termination function by setting the simState variable to STOP. If you stop the real-time application by using ControlDesk's Stop RTP command, the processor resets immediately without executing termination functions. The current values of the I/O channels are kept and the specified termination values are not set.

For further information about the relationship between the monoflop signal paramteters and the number of active channels, refer to Monoflop Signal Generation (DS4002 Features 🕮).

#### **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Channel number** Lets you select the channel number in the range 1 ... 8.

**Interrupt mode** Lets you specify the interrupt mode. You can choose between:

- No interrupt
- Rising edge interrupt
- Falling edge interrupt

#### Note

- You can only use channel 1 or 2 for interrupt generation. If you have specified channel 3 ... 8, the interrupt generation is disabled.
- The model has to contain the DS4002\_HWINT\_Bx\_Iy on page 54 block, where interrupt channel 1 or 2 must be selected according to the specified channel of the DS4002MONO\_B block.

**Initial T\_mono[sec] (0.6e-6 - 107)** Lets you specify the pulse width of a monoflop signal for initialization in the range 0.6  $\mu$ s ... 107 s. If you work with 8 channels, the minimum time value is 4  $\mu$ s. The default value is 0.1 s.

**Set delay time values** Lets you select if the delay width of a monoflop pulse generation is enabled for initialization or not. By default, the delay width is enabled and the default value is taken.

**Initial T\_delay[sec] (0.6e-6 - 107)** Lets you specify the delay width of a monoflop pulse generation for initialization in the range 0.6  $\mu$ s ... 107 s. If you work with 8 channels, the minimum time value is 4  $\mu$ s. The default value is 0.001 s

**Set termination values** Lets you select if the specification of the termination values is enabled or not. By default, the specification is not enabled and the termination values are not specified.

**Termination T\_mono[sec] (0.6e-6 - 107)** Lets you specify the pulse width of a monoflop signal during termination in the range 0.6  $\mu$ s ... 107 s. If you work with 8 channels, the minimum time value is 4  $\mu$ s. The default value is 0.1 s.

**Termination T\_delay[sec] (0.6e-6 - 107)** Lets you specify the delay width of a monoflop pulse generation during termination in the range 0.6  $\mu$ s ... 107 s. If you work with 8 channels, the minimum time value is 4  $\mu$ s. The default value is 0.001 s.

## **Related topics**

### Basics

Monoflop Signal Generation (DS4002 Features 🛄)

### References

simState (RTI and RTI-MP Implementation Reference (LLI) Stop RTP (ControlDesk Platform Management 🕮)

# DS4002FTOD

Purpose	To measure the average frequency of a square-wave input signal.		
Where to go from here	Information in this section		
	Block Description (DS4002FTOD)		
	Parameters Page (DS4002FTOD)		

# Block Description (DS4002FTOD)

Illustration	Frequency > DS4002FTOD
Purpose	To measure the average frequency of a square-wave input signal.
I/O mapping	For details on the I/O connector pinouts of the DS4002, refer to Square-Wave Signal Measurement (F2D) (DS4002 Features (1)).  Note  The I/O features of the DS4002 conflict with each other. For further information, refer to Conflicting I/O Features (DS4002 Features (1)).
I/O characteristics	The block output is the average signal frequency measured in Hz.
Dialog pages	The dialog settings can be specified on the Parameters Page.
Related RTLib functions	ds4002_init, ds4002_f2d_init, ds4002_f2d_overl

## **Related topics**

#### References

ds4002\_f2d\_init (DS4002 RTLib Reference (LL) ds4002\_f2d\_overl (DS4002 RTLib Reference (LL) ds4002\_init (DS4002 RTLib Reference (LL)

## Parameters Page (DS4002FTOD)

## **Purpose**

To specify the measurement of the average square-wave input signal.

## **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

Channel number Lets you select the channel number in the range 1 ... 8.

**Number of periods** Lets you specify the number of signal periods the average frequency of the input signal is calculated from. The default number is

**Minimal frequency** Lets you specify a minimal frequency as the below-zero indicator. Any signal with a smaller frequency results in an output value of 0.0 Hz and the duty cycle follows the input signal. The unit of measure is hertz (Hz).

#### Note

You can measure the duty cycles correctly only if the minimal frequency is greater than 0 Hz.

# DS4002PHASE\_Bx\_Cry\_Cmz

## Purpose

To measure an average phase shift of two digital input signals.

## Where to go from here

## Information in this section

Block Description (DS4002PHASE_Bx_Cry_Cmz)	.43
Parameters Page (DS4002PHASE_Bx_Cry_Cmz)	. 44

## Block Description (DS4002PHASE\_Bx\_Cry\_Cmz)

### Illustration



### **Purpose**

To measure an average phase shift of two digital input signals.

## I/O mapping

For details on the I/O connector pinouts of the DS4002, refer to Phase-Shift Measurement (DS4002 Features (LD)).

## Note

The I/O features of the DS4002 conflict with each other. For further information, refer to Conflicting I/O Features (DS4002 Features  $\square$ ).

## I/O characteristics

This block provides one output port. The input signal uses two channels, one for the reference signal and one for the measured signal.

Output Port	Simulink Output	Description	Input Signal
Phase Shift	-π π (Rad)	This port outputs the average phase shift between the two input	Digital signal (TTL) For further information, refer to Timing I/O (PHS

Output Port	Simulink Output	Description	Input Signal
		signals in overlapped mode.	Bus System Hardware Reference (11).

Dialog pages	The dialog settings can be specified on the Parameters Page.
Related RTLib functions	ds4002_init, ds4002_phase_init, ds4002_phase_overl
Related topics	References
	ds4002_init (DS4002 RTLib Reference (12)) ds4002_phase_init (DS4002 RTLib Reference (12)) ds4002_phase_overl (DS4002 RTLib Reference (13))

# Parameters Page (DS4002PHASE\_Bx\_Cry\_Cmz)

Purpose	To specify the phase shift measurement.	
Description	The measured signal is compared to the reference signal. You can choose if the measurement starts at the rising or falling signal edge and how many periods are to be compared.	
Dialog settings	<b>Board number</b> Lets you select the board number in the range 1 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.	
	<b>Channel number of reference signal</b> Lets you select the channel number of the reference signal in the range 1 8.	
	<b>Channel number of measured signal</b> Lets you select the channel number of the signal to be measured in the range 1 8.	
	<b>Trigger mode</b> Lets you specify if the measurement starts at the rising or falling edge. By default, the measurement starts at the rising edge.	
	<b>Number of periods</b> Lets you specify the number of measurements in the range 1 509. The default value is 10.	

## DS4002PWMTOD

To measure the average frequency and duty cycle of a PWM input signal.

## Where to go from here

**Purpose** 

### Information in this section

## Block Description (DS4002PWMTOD)

#### Illustration



### **Purpose**

To measure the average frequency and duty cycle of a PWM input signal.

### I/O mapping

For details on the I/O connector pinouts of the DS4002, refer to PWM Signal Measurement (PWM2D) (DS4002 Features (LLL)).

## Note

The I/O features of the DS4002 conflict with each other. For further information, refer to Conflicting I/O Features (DS4002 Features 

...

#### I/O characteristics

Scaling between the duty cycle and the output of the block:

Duty Cycle	Simulink Output	
0 100%	0 1	

#### Note

You can measure the duty cycles of 0% and 100% correctly only if the minimal frequency is greater than 0 Hz.

The measurement algorithm used is accurate if the PWM period starts with the falling or rising edge of the corresponding PWM signal (asymmetric signal).

The DS4002 can also be used to measure PWM signals that are centered around the middle of the PWM period (symmetric signals). However, the measurement of the PWM frequency of symmetric PWM signals is faulty if the duty cycle of the PWM signal changes during measurement. For details, refer to Limitation for the Measurement of Symmetric PWM Signals (DS4002 Features ).

**Dialog pages** 

The dialog settings can be specified on the Parameters Page.

**Related RTLib functions** 

ds4002 init, ds4002 pwm2d init, ds4002 pwm2d overl

**Related topics** 

#### References

ds4002\_init (DS4002 RTLib Reference (1))
ds4002\_pwm2d\_init (DS4002 RTLib Reference (1))
ds4002\_pwm2d\_overl (DS4002 RTLib Reference (1))

## Parameters Page (DS4002PWMTOD)

### **Purpose**

To specify the measurement of average frequency and duty cycle of a PWM-type input signal.

## **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Channel number** Lets you select a channel number in the range 1 ... 8.

**Number of periods** Lets you specify the number of signal periods the average frequency and duty cycle are computed from. The default number is 10.

**Minimal frequency** Lets you specify a minimal frequency as the below-zero indicator. Any signal with a smaller frequency will output a frequency of 0.0 Hz and the duty cycle follows the input signal. The unit of measure is hertz (Hz).

## Note

You can measure the duty cycles of 0% and 100% correctly only if the minimal frequency is greater than 0~Hz.

# DS4002READ\_EVENT\_Bx\_Cy

## **Purpose**

To provide channel-wise read access to the event buffer and configure the read event interrupt.

## Where to go from here

#### Information in this section

To configure the read access to the event buffer and the interrupt generation.

## Block Description (DS4002READ\_EVENT\_Bx\_Cy)

## Illustration



## **Purpose**

To provide channel-wise read access to the event buffer and configure the read event interrupt.

## I/O mapping

For details on the I/O connector pinouts of the DS4002, refer to Event Capture (DS4002 Features 🚇).

## Note

The I/O features of the DS4002 conflict with each other. For further information, refer to Conflicting I/O Features (DS4002 Features  $\square$ ).

## I/O characteristics

The block provides three output ports:

Output Port	Simulink Output	Data Type	Description
State (output 1)	-1 1 -1: no edge detected 0: falling edge detected	double	Edge direction. If fewer edges were counted than specified,

Output Port	Simulink Output	Data Type	Description
	1: rising edge detected		the remaining vector elements are filled with -1.
Time (output 2)	0 2 <sup>30</sup> ·200 ns (~214.75 s)	double	Time stamp of captured events (detected edges) in seconds. If fewer edges were counted than specified, the remaining vector elements are filled with 0.
Count (output 3)	0 511	double	Number of actually detected edges.

#### Note

- The minimum difference between 2 time stamps is 200 ns.
- If the Time output port reaches the maximum value of  $2^{30} \cdot 200$  ns (~214.75 s), the value starts counting at 0 again.
- If the event buffer contains fewer than the specified number of events, only the available events are read. Unused elements of the State output port are filled with -1, unused elements of the Time output port are filled with 0.

Dialog pages	The dialog settings can be specified on the Parameters Page.	
Related RTLib functions	ds4002_init, ds4002_read_init, ds4002_read_overl,	

ds4002\_read\_contig

## Related topics

#### References

ds4002\_init (DS4002 RTLib Reference (11))
ds4002\_read\_contig (DS4002 RTLib Reference (12))
ds4002\_read\_init (DS4002 RTLib Reference (13))
ds4002\_read\_overl (DS4002 RTLib Reference (14))

## Parameters Page (DS4002READ\_EVENT\_Bx\_Cy)

## **Purpose**

To configure the read access to the event buffer and the interrupt generation.

## **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Channel number** Lets you select the channel number in the range 1 ... 8.

**Read mode** Lets you select the method for reading the event buffer:

Contiguous mode

In the contiguous mode, the captured event data is stored in increasing order, i.e. the time stamps increase with increasing index. The first element of the time vector contains the time stamp of the first event since the last call to the related RTLib read function.

Overlapped mode

In the overlapped mode, the captured event data is stored in reverse order, i.e. the time stamps decrease with increasing index. The first element of the time vector contains the time stamp of the most recent event. Deviating from the contiguous mode, segments of event data being read may overlap.

For details on the read modes, refer to Measurement of Digital Signals and Event Capture (DS4002 Features Q).

**Trigger mode** Lets you select the edges where the trigger for capturing is activated. You can specify the rising edge, the falling edge or both edges.

**Number of expected events** Lets you specify the maximum number of events to be captured. The range of the event number depends on the read mode.

Read mode	<b>Expected Event Number</b>
Contiguous	1 300
Overlapped	1 511

#### Note

If the event buffer contains fewer than the specified number of expected events, only the available events are read. Unused elements of the State output port are filled with -1, unused elements of the Time output port are filled with 0.

If the event buffer contains more than the specified number of expected events, the oldest values are read in the contiguous mode. In this case, you should use the overlapped mode.

**Interrupt trigger threshold** Lets you specify the number of captured events at which a hardware interrupt must be generated. The trigger mode parameter specifies which edges should be counted. The range of the event number depends on the read mode.

Read mode	Captured Event Number	
Contiguous	0 300	
Overlapped	0 511	

If you specify 0 as interrupt trigger threshold, interrupt generation is disabled.

### Note

The model has to contain the DS4002\_HWINT\_Bx\_Iy block, where interrupt channel 1 ... 8 must be selected according to the specified channel of the DS4002READ\_EVENT\_Bx\_Cy block.

## **Related topics**

#### References

# Interrupts

Introduction	The Library: rtilibm/DS4002 provides access to the hardware interrupts of the DS4002.
Where to go from here	Information in this section
	DS4002_HWINT_Bx_ly
	Information in other sections
	Interrupts Provided by the DS4002 (DS4002 Features (1)) The DS4002 provides access to various hardware interrupts – originating either from on-board devices, or from external devices connected to the DS4002.

demonstrate how to use the DS4002.

Demo Models Using the DS4002......10

Some demo models are available in the RTI demo library that

# DS4002\_HWINT\_Bx\_ly

Purpose	To make the hardware interrupts of the DS4002 board available as trigger sources in a block diagram.
Where to go from here	Information in this section
	Block Description (DS4002_HWINT_Bx_ly)
	Parameters Page (DS4002_HWINT_Bx_ly)

# Block Description (DS4002\_HWINT\_Bx\_ly)

Illustration	DS4002 Board 1 Edge count interrupt DS4002_HWINT_B1_I1
Purpose	To make the hardware interrupts of the DS4002 board available as trigger sources in a block diagram.
Description	The DS4002 hardware interrupt block provides access to the channel-wise read event interrupt requests, and to the signal generation interrupts of channels 1 and 2.
	For further information on these topics, refer to Interrupts Provided by the DS4002 (DS4002 Features (1)).
Dialog pages	The dialog settings can be specified on the Parameters Page.

## Parameters Page (DS4002\_HWINT\_Bx\_ly)

### **Purpose**

To specify the interrupt type.

## **Dialog settings**

**Board number** Lets you select the board number in the range 1 ... 16. If your system contains several boards of the same type, RTI uses the board number to distinguish between them.

**Type** Lets you select the type of the interrupt source, see the following table on the next page.

Interrupt No.	Interrupt Type	Required RTI block
1	Edge count interrupt (At least one channel has captured a predefined number of edges.)	No RTI support
2	Read event interrupt channel 1	DS4002READ_EVENT_Bx_Cy
3	Read event interrupt channel 2	
4	Read event interrupt channel 3	
5	Read event interrupt channel 4	
6	Read event interrupt channel 5	
7	Read event interrupt channel 6	
8	Read event interrupt channel 7	
9	Read event interrupt channel 8	
10	Interrupt channel1 (Channel 1 executes a state containing the DS4002 interrupt directive.)	DS4002PWM1_OUT, DS4002PWM3_OUT, DS4002DTOF,
11	Interrupt channel2 (Channel 2 executes a state containing the DS4002 interrupt directive.)	DS4002MONO_Bx_Cy, user-specific S-function

### Note

As the edge count interrupt cannot be initialized completely by means of RTI blocks, it is not ready to use. To enable the use of the DS4002 edge count interrupt, application-specific interrupt directives have to be set manually. This interrupt type is only available for backward compatibility. It is therefore strongly recommended to use the read event interrupt.

The read event interrupts for channels 1 ... 8 are triggered, if a specified number of captured events is reached. The number of captured events can be specified by the DS4002READ\_EVENT\_Bx\_Cy block.

The interrupt channels 1 and 2 can also be used for user-specific S-functions. For further information, refer to Signal Generation Interrupt (DS4002 Features (L.)).

## **Related topics**

### References

DS4002DTOF	34
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DS4002PWM3_OUT	30
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