

DS2103 Multi-Channel D/A Board

RTLib Reference

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About This Reference

Content

This RTLib Reference (Real-Time Library) gives detailed descriptions of the C functions needed to program a DS2103 Multi-Channel D/A Board. The C functions can be used to program RTI-specific Simulink S-functions, or to implement your control models manually using C programs.

Symbols

dSPACE user documentation uses the following symbols:

Symbol	Description
	Indicates a hazardous situation that, if not avoided, will result in death or serious injury.
	Indicates a hazardous situation that, if not avoided, could result in death or serious injury.
	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.
	Indicates a hazard that, if not avoided, could result in property damage.
	Indicates important information that you should take into account to avoid malfunctions.
	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.

Macros



Introduction

The base address of an I/O board in a PHS-bus-based system has to be defined by using the `DSxxxx_n_BASE` macro.

Base Address of the I/O Board

DSxxxx_n_BASE Macros

When using I/O board functions, you always need the board's base address as a parameter. This address can easily be obtained by using the `DSxxxx_n_BASE` macros, where `DSxxxx` is the board name (for example, `DS2001`) and `n` is an index which counts boards of the same type. The board with the lowest base address is given index 1. The other boards of the same type are given consecutive numbers in order of their base addresses.

The macros reference an internal data structure which holds the addresses of all I/O boards in the system. The initialization function of the processor board (named `init`) creates this data structure. Hence, when you change an I/O board base address, it is not necessary to recompile the code of your application. For more information on the processor board's initialization function, refer to [ds1006_init](#) (DS1006 RTLib Reference ) or `init` (DS1007 RTLib Reference ).

Note

The `DSxxxx_n_BASE` macros can be used only after the processor board's initialization function `init` is called.

Example

This example demonstrates the use of the `DSxxxx_n_BASE` macros. There are two `DS2001` boards, two `DS2101` boards, and one `DS2002` board connected to a PHS bus. Their base addresses have been set to different addresses. The following table shows the I/O boards, their base addresses, and the macros which can be used as base addresses:

Board	Base Address	Macro
DS2001	00H	DS2001_1_BASE
DS2002	20H	DS2002_1_BASE
DS2101	80H	DS2101_1_BASE
DS2001	90H	DS2001_2_BASE
DS2101	A0H	DS2101_2_BASE

Board Initialization

Introduction

Before you can use the DS2103, you have to perform the initialization process.

Note

The initialization function of the processor board must be called before the DS2103's initialization function.

ds2103_init

Syntax

```
void ds2103_init(phs_addr_t base)
```

Include file

ds2103.h

Purpose

To initialize the DS2103.

Description

All DS2103 registers are initialized to default values:

- -10 ... +10 V output voltage range
- Transparent output mode
- All DAC data and latch registers are set to zero
- Zero output on I/O error

Note

This function must be called before any other DS2103 function can be used.

Parameters **base** Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

Return value None

Messages The following messages are defined:

ID	Type	Message	Description
201	Error	ds2103_init(): Invalid PHS-bus base address 0x???????	The value of the base parameter is not a valid PHS-bus address. This error may be caused if the PHS-bus connection of the I/O board is missing. Check the connection.
-148	Error	ds2103_init(0x??): Board not found!	No DS2103 board could be found at the specified PHS-bus address. Check if the DSxxx_n_BASE macro corresponds to the I/O board used.
-53	Warning	ds2103_init(0x??): Jumper setting is not matching SW default initialization! STP register: 0x???????? instead of 0x????????	The value of the STP register could not be verified successfully. May be the DS2103 jumper setting is not correct. Remove all jumpers.

Execution times For information, refer [Function Execution Times](#) on page 25.

Example This example shows how to use the function:

```
void main(void)
{
    init();
    ds2103_init(DS2103_1_BASE);
    ...
}
```

The DS2103 at address DS2103_1_BASE is initialized.

Related topics

References

[Base Address of the I/O Board](#)..... 7
[Macros](#)..... 7

DAC Unit

Introduction

The DS2103 Multi-Channel D/A Board features 32 parallel D/A channels with 14-bit resolution.

Note

You have to initialize the DS2103 with the `ds2103_init` function before you can use one of these functions.

Where to go from here

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ds2103_set_errmode

Syntax

```
void ds2103_set_errmode(  
    phs_addr_t base,  
    int group,  
    int errmode)
```

Include file `ds2103.h`

Purpose To set the I/O error mode of the D/A converter.

Description The error mode can be set in groups of 4 channels each. The group number must be within the range 1 ... 8.

The error mode can be set either to reset outputs to zero on I/O error or to keep the output voltage.

Note

The `ds2103_init` function must be called before this function can be used.

I/O mapping For details on the I/O mapping, refer to [DAC Unit \(DS2103 Features !\[\]\(c694a3ff3b077d76910920a6a1593ab4_img.jpg\)\)](#).

Parameters

base Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

group Specifies the channel group number within the range 1 ... 8. The `DS2103_CH_ALL` symbol selects all 8 channel groups.

errmode Specifies the I/O error mode. The following symbols are predefined:

Symbol	Description
<code>DS2103_ZERO</code>	Zero output on I/O error
<code>DS2103_KEEP</code>	Keeping output voltage on I/O error

Return value None

Messages The following message is defined:

ID	Type	Message	Description
-50	Error	<code>ds2103_set_errmode(0x??): Board not initialized!</code>	The DS2103 has not been initialized by a preceding call to the <code>ds2103_init</code> function.

Execution times For information, refer to [Function Execution Times](#) on page 25.

Example

This example shows how to use the function:

```
ds2103_set_errmode(DS2103_1_BASE, 4, DS2103_KEEP);
```

Channel group 4 of the DS2103, including channels 13 ... 16, is set to keeping output voltage on I/O error.

Related topics**References**

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ds2103_set_outmode

Syntax

```
void ds2103_set_outmode(
    phs_addr_t base,
    int group,
    int outmode)
```

Include file

ds2103.h

Purpose

To select the output mode of the D/A converters.

Description

The output mode can be set in groups of 4 channels each. A group number in the range 1 ... 8 selects one of the 8 channel groups.

Either transparent output mode or latched output mode can be selected. If transparent output mode is selected, the output delay between individual channels depends on the actual output sequence. Latched output mode can be used to update all outputs at the same time.

Note

The `ds2103_init` function must be called before this function can be used.

I/O mapping

For details on the I/O mapping, refer to [DAC Unit \(DS2103 Features !\[\]\(e119fc79c8f448683d20ba4c873025a2_img.jpg\)](#)).

Parameters

base Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

group Specifies the channel group number within the range 1 ... 8. The DS2103_CH_ALL symbol selects all 8 channel groups.

outmode Specifies the output mode. The following symbols are predefined:

Symbol	Output Mode
DS2103_TRANS	Transparent
DS2103_LATCH	Latched

Return value None

Messages The following message is defined:

ID	Type	Message	Description
-50	Error	ds2103_set_outmode(0x??): Board not initialized!	The DS2103 has not been initialized by a preceding call to the <code>ds2103_init</code> function.

Execution times For information, refer to [Function Execution Times](#) on page 25.

Example This example shows how to use the function:

```
ds2103_set_outmode(DS2103_1_BASE, 1, DS2103_LATCH);
```

The channel group 1, including channels 1 ... 4, is set to latched output mode.

Related topics

References

Base Address of the I/O Board.....	7
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ds2103_set_range

Syntax

```
void ds2103_set_range(  
    phs_addr_t base,  
    int channel,  
    int range)
```

</

Channel 1 of the DS2103 is set to the –5 ... +5 V output voltage range.

Related topics

References

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ds2103_init.....	9

ds2103_init_scantbl

Syntax

```
void ds2103_init_scantbl(
    phs_addr_t base,
    int scantbl,
    int count,
    int *channels)
```

Include file

ds2103.h

Purpose

To initialize the DS2103 scan table.

Description

Before data can be output through the DS2103, a scan table specifying the required output channel sequence must be initialized.

Up to 4 individual scan tables containing different output channel sequences can be selected by the **scantbl** parameter. Scan tables may be re-initialized by multiple calls to **ds2103_init_scantbl**. Valid scan table numbers range from 1 ... 4.

The **count** parameter specifies the number of channels to be used. It must be in the range 1 ... 32.

The array pointed to by the **channels** parameter must contain a list of **count** channel numbers to be put into the selected scan table. Because the DS2103 can convert pairs of output channels (1/17, 2/18, ..., 16/32) in parallel, channel numbers are automatically sorted and paired, where possible, in order to save conversion time. The channel number array must be allocated by the calling program. Valid channel numbers range from 1 ... 32. 16 channel entries in the range 1 ... 16 and 16 channel entries in the range 17 ... 32 are allowed.

Note

- The actual conversion sequence is affected by re-organization into channel pairs. You may use latched output mode if this behavior is not suitable.
- The `ds2103_init` function must be called before this function can be used.

I/O mapping

For details on the I/O mapping, refer to [DAC Unit \(DS2103 Features !\[\]\(c3d993ca47bfe2a953c700506ce31fa0_img.jpg\)](#)).

Parameters

base Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

scantbl Specifies the scan table selection number within the range 1 ... 4.

count Specifies the number of output channels being used within the range 1 ... 32.

channels Specifies the pointer of the array of channel numbers.

Return value

None

Messages

The following messages are defined:

ID	Type	Message	Description
-50	Error	ds2103_init_scantbl(0x??): board at offset 0x?? not initialized!	The DS2103 has not been initialized by a preceding call to the <code>ds2103_init</code> function.
-149	Error	ds2103_init_scantbl(0x??): Memory allocation error!	The allocation of some dynamic memory for internal data storage has failed.
-160	Error	ds2103_init_scantbl(0x??): Initialization error!	If the channel numbers given in the channel number array cause a scan table index overflow, this error is set. Only 16 channels within the range 1 ... 16 and 16 channels within the range 17 ... 32 can be specified in the channel number array.
-191	Error	ds2103_init_scantbl(0x??): Scan-table nr. must be in range 1 .. 4!	An invalid scan table selection number has been specified from the range 1 ... 4.

Execution times

For information, refer to [Function Execution Times](#) on page 25.

Example

This example shows how to use this function:

```
#define SCNTBL 1 /* scan table number */
#define COUNT 5 /* number of channels being used */
Int32 channels[COUNT] = { 1, 3, 32, 17, 8 }; /* channel numbers */

void main()
{
    init();
    ds2103_init(DS2103_1_BASE); /* DS2103 initialization */
    ds2103_init_scantbl(DS2103_1_BASE, SCNTBL, COUNT, channels); /* scan-table initialization */
}
```

Channels 1, 3, 8, 17, and 32 are used for output.

Related topics**References**

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ds2103_load.....	18
ds2103_out.....	20
ds2103_strobe.....	21
Macros.....	7

ds2103_load

Syntax

```
void ds2103_load(
    phs_addr_t base,
    int scantbl,
    dsfloat *data)
```

Include file

ds2103.h

Purpose

To set the D/A channels in latched mode.

Description

This function writes output data to the DS2103 in latched output mode.

The scan table selected by the **scantbl** parameter is used to control the output channel sequence.

The output data array pointed to by the **data** parameter must contain the output data. The number and sequence of the data values must match the channel numbers being specified during initialization of the selected scan table.

The data array must be allocated by the calling program. Valid output data values range from $-1.0 \dots +1.0$.

The outputs can be updated simultaneously using the `ds2103_strobe` function.

Note

- The DS2103 and the selected scan table must have been initialized by using the `ds2103_init` and `ds2103_init_scantbl` functions before `ds2103_load` can be used for latched data output. Otherwise the function will cause unpredictable results.
- The DS2103 must have been initialized to latched output mode by using the `ds2103_set_outmode` function.
- This function is not reentrant.

I/O mapping For details on the I/O mapping, refer to [DAC Unit \(DS2103 Features !\[\]\(a03a7eb2f4046e1d3c76772003e549ea_img.jpg\)](#)).

Parameters

base Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

scantbl Specifies the scan table selection number within the range 1 ... 4.

data Specifies the pointer to the source data array.

Return value None

Execution times For information, refer to [Function Execution Times](#) on page 25.

Example See example in [ds2103_strobe](#) on page 21.

Related topics

References

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ds2103_init	9
ds2103_init_scantbl	16
ds2103_set_outmode	13
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ds2103_out

Syntax

```
void ds2103_out(
    phs_addr_t base,
    int scantbl,
    dsfloat *data)
```

Include file

ds2103.h

Purpose

To write to the D/A converters.

Description

This function writes output data to the DS2103.

The scan table selected by the `scantbl` parameter is used to control the output channel sequence.

The output data array pointed to by the `data` parameter must contain the output data. The number and sequence of the data values must match the channel numbers being specified during initialization of the selected scan table. The data array must be allocated by the calling program. Valid output data values range from $-1.0 \dots +1.0$.

Note

- The DS2103 and the selected scan table must have been initialized by using the `ds2103_init` and `ds2103_init_scantbl` functions before `ds2103_out` can be used for data output. Otherwise the function will cause unpredictable data output.
- The function is not reentrant.

I/O mapping

For details on the I/O mapping, refer to [DAC Unit \(DS2103 Features !\[\]\(248b91fcdac4810ffd15cf33fb6aec6f_img.jpg\)](#)).

Parameters

base Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

scantbl Specifies the scan table selection number within the range 1 ... 4.

data Specifies the pointer to the source data array.

Return value

None

Execution times

For information, refer to [Function Execution Times](#) on page 25.

Example

This example shows how to use the function:

```
#include <brtenv.h>          /* basic real-time environment */
#define SCNTBL 1             /* scan table number */
#define COUNT 5             /* number of channels being used */
int channels[COUNT] = { 1, 3, 32, 17, 8 }; /* channel numbers */
dsfloat data[COUNT];        /* DAC output data */

void isr_t0()               /* timer0 interrupt service routine */
{
    data[...] = ...
    ds2103_out(DS2103_1_BASE, SCNTBL, data);
    /* write data to DACs */
}

void main()
{
    init();
    ds2103_init(DS2103_1_BASE); /* DS2103 initialization */
    /* set output voltage ranges to ±5V */
    ds2103_set_range(DS2103_1_BASE, DS2103_CH_ALL, DS2103_RNG5);
    /* scan table initialization */
    ds2103_init_scantbl(DS2103_1_BASE, SCNTBL, COUNT, channels);
    start_isr_t0(1.0e-3);
    for (;;)
    {
        RTLIB_BACKGROUND_SERVICE();
    }
}
```

In the example, the output values `data[0]` to `data[4]` are output via channels 1, 3, 8, 17 and 32, respectively. An output voltage range of ± 5 V is selected for all channels.

Related topics**References**

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ds2103_init_scantbl.....	16
Macros.....	7

ds2103_strobe

Syntax

```
void ds2103_strobe(phs_addr_t base)
```

Include file

ds2103.h

Purpose To strobe the D/A channels.

Description The output of the D/A channels is updated simultaneously.

Note

- The DS2103 and the selected scan table must have been initialized by using the `ds2103_init` and `ds2103_init_scantbl` functions.
- The output data must have been written to the channels using the `ds2103_load` function before `ds2103_strobe` can be used to update the data output. Otherwise the function will cause unpredictable data output.
- The DS2103 must have been initialized to latched output mode by using the `ds2103_set_outmode` function.

I/O mapping For details on the I/O mapping, refer to [DAC Unit \(DS2103 Features\)](#).

Parameters **base** Specifies the PHS-bus base address. Refer to [Base Address of the I/O Board](#) on page 7.

Return value None

Execution times For information, refer to [Function Execution Times](#) on page 25.

Example This example shows how to use the function:

```
#include <brtenv.h>                /* basic real-time environment */
#define SCNTBL 1                  /* scan table number */
#define COUNT 5                  /* number of channels being used */
int channels[COUNT] = { 1, 3, 8, 17, 32}; /* ch. numbers */
dsfloat data[COUNT];             /* DAC output data */

void isr_t0()                    /* timer0 interrupt service routine */
{
    data[...] = ...
    ds2103_load(DS2103_1_BASE, SCNTBL, data);
    ds2103_strobe(DS2103_1_BASE); /*write data to DACs */
}
```

```

void main()
{
    init();
    ds2103_init(DS2103_1_BASE);          /* DS2103 initialization */
                                         /* set output voltage ranges to  $\pm 5V$  */
    ds2103_set_range(DS2103_1_BASE, DS2103_CH_ALL, DS2103_RNG5);
                                         /* scan-table initialization */
    ds2103_init_scantbl(DS2103_1_BASE, SCNTBL, COUNT, channels);
    start_isr_t0(1.0e-3);
    for (;;)
    {
        RTLIB_BACKGROUND_SERVICE();
    }
}

```

In the example, the output values `data[0]` to `data[4]` are loaded to channels 1, 3, 32, 17, and 8, respectively. An output voltage range of ± 5 V is selected for all channels. The output of the specified channels is updated simultaneously.

Related topics

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Function Execution Times

Objective The execution times of the C functions can vary, since they depend on different factors. The measured execution times are influenced by the test environment used. This section gives you basic information on the test environment and contains the mean function execution times.

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Information on the Test Environment

Test environment The execution time of a function can vary, since it depends on different factors, for example:

- CPU clock and bus clock frequency of the processor board used
- Optimization level of the compiler
- Use of inlining parameters

The test programs that are used to measure the execution time of the functions listed below have been generated and compiled with the default settings of the **down<xxx>** tool (optimization and inlining). The execution times in the tables below are always the mean measurement values.

The properties of the processor boards used are:

	DS1006
CPU clock	2.6 GHz / 3.0 GHz
Bus clock	133 MHz

Measured Execution Times

Introduction

Execution times are available for the following RTLib units:

- Initialization
- DAC unit

Note

The following execution times contain mean values for a sequence of I/O accesses. The execution time of a single call might be lower because of buffered I/O access.

Initialization

The following execution time has been measured for the initialization function

Function	Mean Execution Time	
	DS1006 with 2.6 GHz	DS1006 with 3.0 GHz
ds2103_init	51.12 μ s	63.08 μ s

DAC unit

The following execution times have been measured for the DAC unit

Function	Mean Execution Time	
	DS1006 with 2.6 GHz	DS1006 with 3.0 GHz
ds2103_set_range	1.40 μ s	1.39 μ s
ds2103_set_outmode	1.41 μ s	1.39 μ s
ds2103_set_errmode	1.39 μ s	1.38 μ s
ds2103_init_scantbl	$0.009 + c^{(1)} \cdot 0.062$ μ s	$0.02 + c^{(1)} \cdot 0.031$ μ s
ds2103_out	$0.003 + c^{(1)} \cdot 0.101$ μ s	$-0.056 + c^{(1)} \cdot 0.092$ μ s
ds2103_load	$-0.008 + c^{(1)} \cdot 0.096$ μ s	$-0.059 + c^{(1)} \cdot 0.092$ μ s
ds2103_strobe	0.03 μ s	0.01 μ s

¹⁾ c stands for the number of channels used.

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