

# **24DSI16WRC**

**24-bit, 4 to 16 channel, 105KS/S/Ch Delta-Sigma A/D Input**

## **PMC66-24DSI16WRC**

### **Linux Device Driver And API Library User Manual**

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## Preface

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# 1. Introduction

## 1.1. Purpose

The purpose of this document is to describe the interface to the 24DSI16WRC API Library and to the underlying Linux device driver. The API Library software provides the interface between "Application Software" and the device driver. The driver software provides the interface between the API Library and the actual 24DSI16WRC hardware. The API Library and driver interfaces are based on the board's functionality.

## 1.2. Acronyms

The following is a list of commonly occurring acronyms which may appear throughout this document.

Acronyms	Description
ADC	Analog-to-Digital Converter
API	Application Programming Interface
BMDMA	Block Mode DMA
DMA	Direct Memory Access
DMDMA	Demand Mode DMA
GSC	General Standards Corporation
PCI	Peripheral Component Interconnect
PIO	Programmed I/O
PMC	PCI Mezzanine Card
PMC66	This is a PMC formfactor device that can operate at up to 66MHz over the PCI bus.

## 1.3. Definitions

The following is a list of commonly occurring terms which may appear throughout this document.

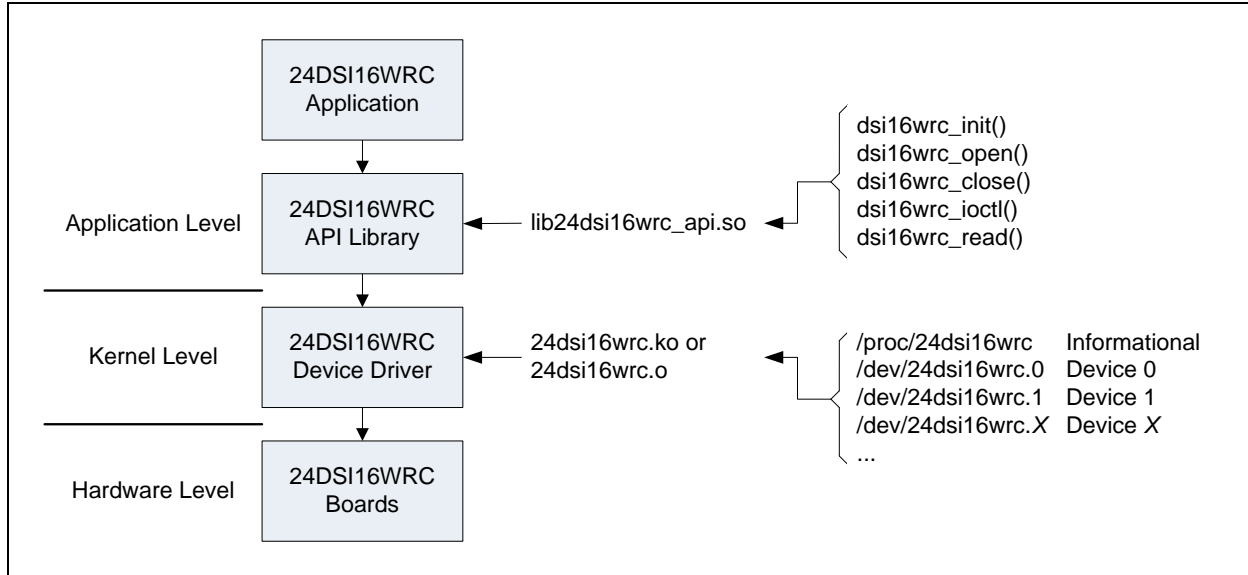
Term	Definition
...	This is a shortcut representation of the 24DSI16WRC installation directory or any of its subdirectories.
24DSI16WRC	This is used as a general reference to any device supported by this driver.
API Library	This is a library that provides application-level access to 24DSI16WRC hardware.
Application	This is a user mode process, which runs in user space with user mode privileges.
Driver	This is the 24DSI16WRC device driver, which runs in kernel space with kernel mode privileges.
Library	This is usually a general reference to the API Library.

## 1.4. Software Overview

### 1.4.1. Basic Software Architecture

This section describes the general architecture for the basic components that comprise 24DSI16WRC applications. The overall architecture is illustrated in Figure 1 below.





**Figure 1** Basic architectural representation.

### 1.4.2. API Library

The primary means of accessing 24DSI16WRC boards is via the 24DSI16WRC API Library. This library forms a layer between the application and the driver. Additional information is given in section 3.2.3 (page 17). With the library, applications are able to open and close a device and, while open, perform I/O control and read operations.

### 1.4.3. Device Driver

The device driver is the host software that provides a means of communicating directly with 24DSI16WRC hardware. The driver executes under control of the operating system and runs in Kernel Mode as a Kernel Mode device driver. The driver is implemented as a standard dynamically loadable Linux device driver written in the C programming language. While applications can access the driver directly without use of the API Library, it is recommended that all access is made through the library.

## 1.5. Hardware Overview

The 24DSI16WRC is a high-performance, 24-bit analog input board that incorporates from four to 16 input channels. The host side connection is PCI based and the form factor is according to the model ordered. The board is capable of acquiring data at up to 105K samples per second over each channel. Internal clocking permits sampling rates from 105K samples per second down to 200 samples per second. Onboard storage permits data buffering of up to 256K samples, for all channels collectively, between the cable interface and the PCI bus. This allows the 24DSI16WRC to sustain continuous throughput from the cable interface independent of the PCI bus interface. The 24DSI16WRC also permits multiple boards to be synchronized so that all boards sample data in unison. In addition, the board includes autocalibration capability.

## 1.6. Reference Material

The following reference material may be of particular benefit in using the 24DSI16WRC. The specifications provide the information necessary for an in depth understanding of the specialized features implemented on this board.

- The applicable *24DSI16WRC User Manual* from General Standards Corporation.
- The *PCI9056 PCI Bus Master Interface Chip* data handbook from PLX Technology, Inc.

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870 Maude Avenue  
Sunnyvale, California 94085 USA  
Phone: 1-800-759-3735  
WEB: <http://www.plxtech.com>

## **1.7. Licensing**

For licensing information please refer to the text file `LICENSE.txt` in the root installation directory.

## 2. Installation

### 2.1. CPU and Kernel Support

The driver is designed to operate with Linux kernel versions 6.x, 5.x, 4.x, 3.x, 2.6, 2.4 and 2.2 running on a PC system with one or more x86 processors. This release of the driver supports the below listed kernels.

Kernel	Distribution
6.2.9	Red Hat Fedora Core 38
6.0.7	Red Hat Fedora Core 37
5.17.5	Red Hat Fedora Core 36
5.14.10	Red Hat Fedora Core 35
5.11.12	Red Hat Fedora Core 34
5.8.15	Red Hat Fedora Core 33
5.6.6	Red Hat Fedora Core 32
5.3.7	Red Hat Fedora Core 31
5.0.9	Red Hat Fedora Core 30
4.18.16	Red Hat Fedora Core 29
4.16.3	Red Hat Fedora Core 28
4.13.9	Red Hat Fedora Core 27
4.11.8	Red Hat Fedora Core 26
4.8.6	Red Hat Fedora Core 25
4.5.5	Red Hat Fedora Core 24
4.2.3	Red Hat Fedora Core 23
4.0.4	Red Hat Fedora Core 22
3.17.4	Red Hat Fedora Core 21
3.11.10	Red Hat Fedora Core 20
3.9.5	Red Hat Fedora Core 19
3.6.10	Red Hat Fedora Core 18
3.3.4	Red Hat Fedora Core 17
3.1.0	Red Hat Fedora Core 16
2.6.38	Red Hat Fedora Core 15
2.6.35	Red Hat Fedora Core 14
2.6.33	Red Hat Fedora Core 13
2.6.31	Red Hat Fedora Core 12
2.6.29	Red Hat Fedora Core 11
2.6.27	Red Hat Fedora Core 10
2.6.25	Red Hat Fedora Core 9
2.6.23	Red Hat Fedora Core 8
2.6.21	Red Hat Fedora Core 7
2.6.18	Red Hat Fedora Core 6
2.6.15	Red Hat Fedora Core 5
2.6.11	Red Hat Fedora Core 4
2.6.9	Red Hat Fedora Core 3
2.4.18	Red Hat 8.0

**NOTE:** Some older kernel versions are supported (the sources are maintained), but are not tested.

**NOTE:** While only Red Hat Fedora distributions are listed, numerous other distributions are supported and have been tested on an as needed basis.

**NOTE:** The driver will have to be built before being used as it is provided in source form only.

**NOTE:** The driver has not been tested with a non-versioned kernel.

**NOTE:** The driver is designed for SMP support, but has not undergone SMP specific testing.

### 2.1.1. 32-bit Support Under 64-bit Environments

This driver supports 32-bit applications under 64-bit environments. The availability of this feature in the kernel depends on a 64-bit kernel being configured to support 32-bit application compatibility. Additionally, 2.6 kernels prior to 2.6.11 implemented 32-bit compatibility in a way that resulted in some drivers not being able to take advantage of the feature. (In these kernels a driver's IOCTL command codes must be globally unique. Beginning with 2.6.11 this requirement has been lifted.) If the driver is not able to provide 32-bit support under a 64-bit kernel, the "32-bit support" field in the `/proc/24dsi16wrc` file will be "no".

## 2.2. The `/proc/` File System

While the driver is running, the text file `/proc/24dsi16wrc` can be read to obtain information about the driver and the boards it detects. Each file entry includes an entry name followed immediately by a colon, a space character, and the entry value. Below is an example of what appears in the file, followed by descriptions of each entry.

```
version: 2.7.111.50
32-bit support: yes
boards: 1
models: 24DSI16WRC
```

Entry	Description
version	This gives the driver version number in the form <code>x.x.x.x</code> .
32-bit support	This reports the driver's support for 32-bit applications. This will be either "yes" or "no" for 64-bit driver builds and "yes (native)" for 32-bit builds.
boards	This identifies the total number of boards the driver detected.
models	This gives a comma separated list of the basic model number for each board the driver detected. The model numbers are listed in the same order that the boards are accessed via the API Library's open function.

## 2.3. File List

This release consists of the below listed primary files. The archive content is described in following subsections.

File	Description
<code>24dsi16wrc.linux.tar.gz</code>	This archive contains the driver, the API Library and all related files.
<code>24dsi16wrc_linux_um.pdf</code>	This is a PDF version of this user manual, which is included in the archive.

## 2.4. Directory Structure

The following table describes the directory structure utilized by the installed files. During installation the directory structure is created and populated with the respective files.

Directory	Description
<code>24dsi16wrc/</code>	This is the driver root directory. It contains the documentation, the Overall Make Script (section 2.7, page 13) and the below listed subdirectories.
<code>.../api/</code>	This directory contains the API Library source files (section 3.2.3, page 17).
<code>.../docsrc/</code>	This directory contains the source files for the code samples given in this document (section 6, page 49).
<code>.../driver/</code>	This directory contains the device driver source files (section 5, page 45).
<code>.../include/</code>	This directory contains the header files for the various libraries.

.../lib/	This directory contains all of the libraries built from the installed sources.
.../samples/	This directory contains the sample application subdirectories and all of their corresponding source files (section 9, page 55).
.../utils/	This directory contains the source files for the utility libraries used by the sample applications (section 7, page 50).

## 2.5. Installation

Perform installation following the below listed steps. This installs the device driver, the API Library and all related sources and documentation.

1. Create and change to the directory where the files are to be installed, such as `/usr/src/linux/drivers/`. (The path name may vary among distributions and kernel versions.)
2. Copy the archive file `24dsi16wrc.linux.tar.gz` into the current directory.
3. Issue the following command to decompress and extract the files from the provided archive. This creates the directory `24dsi16wrc` in the current directory, and then copies all of the archive's files into this new directory.

```
tar -xzvf 24dsi16wrc.linux.tar.gz
```

## 2.6. Removal

Perform removal following the below listed steps. This removes the device driver, the API Library and all related sources and documentation.

**NOTE:** The following steps may require elevated privileges.

1. Shutdown the driver as described in section 5.6 (page 48).
2. Change to the directory where the driver archive was installed, which may have been `/usr/src/linux/drivers/`. (The path name may vary among distributions and kernel versions.)
3. Issue the below command to remove the driver archive and all of the installed driver files.

```
rm -rf 24dsi16wrc.linux.tar.gz 24dsi16wrc
```

4. Issue the below command to remove all of the installed device nodes.

```
rm -f /dev/24dsi16wrc.*
```

5. If the automatic startup procedure was adopted (section 5.3.2, page 46), then edit the system startup script `rc.local` and remove the line that invokes the 24DSI16WRC's `start` script. The file `rc.local` should be located in the `/etc/rc.d/` directory.

## 2.7. Overall Make Script

An Overall Make Script is included in the root installation directory. Executing this script will perform a make for all build targets included in the release. The script also loads the driver and copies the API Library to `/usr/lib/`. The script is named `make_all`. Follow the below steps to perform an overall make and to load the driver.

**NOTE:** The following steps may require elevated privileges.

1. Change to the driver root directory (.../24dsi16wrc/).
2. Remove existing build targets using the below command. This does not unload the driver.

```
./make_all clean
```

3. Issue the following command to make all archive targets and to load the driver.

```
./make_all
```

## 2.8. Environment Variables

Some build environments may require compiler or linker options not present in the provided make files. To accommodate local environment specific requirements, the provided make files incorporate support for the following set of GSC specific environment variables.

### 2.8.1. GSC\_API\_COMP\_FLAGS

This environment variable accommodates adding compiler command line options when compiling source files for the API Library. The compiler used by the API Library make file is “gcc”. The content of this environment variable is noted in the make file’s output to the screen. The table below shows a portion of the screen output. The “xxx” in the table refers to the contents of the environment variable. This environment variable has no effect on compiling any other distributed source files or linking of any object files.

<b>Undefined or Empty</b>	== Compiling: init.c	
	== Compiling: ioctl.c	
	== Compiling: open.c	
<b>Defined and Not Empty</b>	== Compiling: init.c (added 'xxx')	
	== Compiling: ioctl.c (added 'xxx')	
	== Compiling: open.c (added 'xxx')	

### 2.8.2. GSC\_API\_LINK\_FLAGS

This environment variable accommodates adding linker command line options when linking object files for the API Library. The linker used by the API Library make file is “ld”. The content of this environment variable is noted in the make file’s output to the screen. The table below shows a portion of the screen output. The “xxx” in the table refers to the contents of the environment variable. This environment variable has no effect on compiling of any source files or linking of any other object files.

<b>Undefined or Empty</b>	==== Linking: ../lib/lib24dsi16wrc_api.so
<b>Defined and Not Empty</b>	==== Linking: ../lib/lib24dsi16wrc_api.so (added 'xxx')

### 2.8.3. GSC\_LIB\_COMP\_FLAGS

This environment variable accommodates adding compiler command line options when compiling source files for the utility libraries. The compiler used by the utility library make files is “gcc”. The content of this environment variable is noted in the make files’ output to the screen. The table below shows a portion of the screen output. The “xxx” in the table refers to the contents of the environment variable. This environment variable has no effect on compiling any other distributed source files or linking of any object files.

<b>Undefined or Empty</b>	== Compiling: close.c == Compiling: init.c == Compiling: ioctl.c
<b>Defined and Not Empty</b>	== Compiling: close.c (added 'xxx') == Compiling: init.c (added 'xxx') == Compiling: ioctl.c (added 'xxx')

#### 2.8.4. GSC\_LIB\_LINK\_FLAGS

This environment variable accommodates adding linker command line options when linking object files for the utility libraries. The linker used by the utility library make files is “ld”. The content of this environment variable is noted in the make files’ output to the screen. The table below shows a portion of the screen output. The “xxx” in the table refers to the contents of the environment variable. This environment variable has no effect on compiling of any source files or linking of any other object files.

<b>Undefined or Empty</b>	==== Linking: ../lib/24dsi16wrc_utils.a
<b>Defined and Not Empty</b>	==== Linking: ../lib/24dsi16wrc_utils.a (added 'xxx')

#### 2.8.5. GSC\_APP\_COMP\_FLAGS

This environment variable accommodates adding compiler command line options when compiling source files for the sample applications. The compiler used by the sample application make files is “gcc”. The content of this environment variable is noted in the make files’ output to the screen. The table below shows a portion of the screen output. The “xxx” in the table refers to the contents of the environment variable. This environment variable has no effect on compiling any other distributed source files or linking of any object files.

<b>Undefined or Empty</b>	== Compiling: main.c == Compiling: perform.c
<b>Defined and Not Empty</b>	== Compiling: main.c (added 'xxx') == Compiling: perform.c (added 'xxx')

#### 2.8.6. GSC\_APP\_LINK\_FLAGS

This environment variable accommodates adding linker command line options when linking object files for the sample applications. The linker used by the sample application make files is “gcc”. The content of this environment variable is noted in the make files’ output to the screen. The table below shows a portion of the screen output. The “xxx” in the table refers to the contents of the environment variable. This environment variable has no effect on compiling of any source files or linking of any other object files.

<b>Undefined or Empty</b>	==== Linking: id
<b>Defined and Not Empty</b>	==== Linking: id (added 'xxx')

### 3. Main Interface Files

This section gives general information on the suggested device interface files to use when developing 24DSI16WRC based applications.

#### 3.1. Main Header File

Throughout the remainder of this document references are made to various header files included as part of the 24DSI16WRC driver installation. For ease of use it is suggested that applications include only the single header file shown below rather than individually including those headers identified separately later in this document. Including this header file pulls in all other pertinent 24DSI16WRC specific header files. Therefore, sources may include only this one 24DSI16WRC header and make files may reference only this one 24DSI16WRC include directory.

Description	File	Location
Header File	24dsi16wrc_main.h	.../include/

#### 3.2. Main Library File

Throughout the remainder of this document references are made to various statically linkable libraries included as part of the 24DSI16WRC driver installation. For ease of use it is suggested that applications link only the single library file shown below rather than individually linking those libraries identified separately later in this document. Linking this library file pulls in all other static libraries included with the driver. Therefore, make files may reference only this one 24DSI16WRC static library and only this one 24DSI16WRC library directory.

Description	File	Location
Static Library	24dsi16wrc_main.a	.../lib/
	24dsi16wrc_multi.a	

**NOTE:** For applications using the 24DSI16WRC and no other GSC devices, link the 24dsi16wrc\_main.a library. For applications using multiple GSC device types, link the xxxx\_main.a library for one of the devices and the xxxx\_multi.a library for the others. Linking multiple xxxx\_main.a libraries may likely produce link errors due to duplicate symbols being defined. While it may make little or no difference, it is recommended that one choose the xxxx\_main.a library from the driver with the largest number in positions three (x.x.X.x.x) and/or four (x.x.x.X.x) in the driver release version number.

**NOTE:** The 24DSI16WRC API Library is implemented as a shared library and is thus not linked with the 24DSI16WRC Main Library. The API Library must be linked with applications by adding the argument -l24dsi16wrc\_api to the linker command line.

##### 3.2.1. Build

The main library is built via the Overall Make Script (section 2.7, page 13). However, the main library can be built separately following the below steps.

1. Change to the directory where the main library resides (.../lib/).
2. Remove existing build targets using the below command.

```
make clean
```

3. Build the main library by issuing the below command.

```
make
```



### 3.2.2. System Libraries

In addition to linking the static library named above, as well as the API Library shared object file, applications may need to also link in additional system libraries as noted below.

Library	gcc Link Flag
Math	-lm
POSIX Thread	-lpthread
Real Time	-lrt

### 3.2.3. Shared Object Script: Build the Main Libraries as Shared Object Files

The main libraries built via the Overall Make Script (section 2.7, page 13) are static library files. Some applications however, require that the Main Libraries be accessed as shared object files. Generating shared object files require that all of the static libraries be recompiled for this purpose and linked as .so files. This is done using the Shared Object Script named below. When run, the script invokes the Overall Make Script to clean all existing build targets, deletes the two shared object files named below, if they exist, defines an environment variable used by all of the static library make files, invokes the Overall Make Script again to rebuild all existing build targets then invokes make on the library make file (.../lib/makefile) to link the shared object files. The required manual steps are as follows.

1. Change to the directory where the main library files reside (.../lib/).
2. Execute the below script.

```
./static_to_shared.sh
```

Running the above-named Shared Object Script produces the files given in the table below. These shared object files fulfill the same purpose as the similarly named static libraries as described in the note under section 3.2 above. Refer to that note when selecting which shared object file to use.

Description	File	Location
Shared Object Files	lib24dsi16wrc_main.so	.../lib/
	lib24dsi16wrc_multi.so	
	lib24dsi16wrc_all.so†	

† This library includes all generated libraries, including the API Library shared object file content.

The shared object files can be linked via two different methods. In the first method, the application linker command line can explicitly name the file in the same manner as is done were it a static library. This is the method used by the sample applications, all of which use the 24DSI16WRC API Library, which itself is a shared object file. This file is also found in the .../lib/ subdirectory. In the second method, the .so files are copied to the /usr/lib/ subdirectory and are referenced on the application's linker command line as given in the table below.

Library	gcc Link Flag
lib24dsi16wrc_main.so	-l24dsi16wrc_main
lib24dsi16wrc_multi.so	-l24dsi16wrc_multi
lib24dsi16wrc_all.so†	-l24dsi16wrc_all

† This library includes all generated libraries, including the API Library shared object file content.

## 4. API Library

The 24DSI16WRC API Library is the software interface between user applications and the 24DSI16WRC device driver. The interface is accessed by including the header file `24dsi16wrc_api.h`.

**NOTE:** Contact General Standards Corporation if additional library functionality is required.

### 4.1. Files

The library files are summarized in the table below.

Description	File	Location
Source Files	*.c, *.h ...	.../api/
Header File	<code>24dsi16wrc_api.h</code>	.../include/
Library File	<code>lib24dsi16wrc_api.so</code>	.../lib/ /usr/lib/ †

† The shared object library is automatically copied to `/usr/lib/` when it is built.

### 4.2. Build

The API Library is built via the Overall Make Script (section 2.7, page 13), but can be built separately following the below steps.

**NOTE:** The following steps may require elevated privileges.

1. Change to the directory where the library sources are installed (`.../api/`).
2. Remove existing build targets using the below command.

```
make clean
```

3. Compile the source files and build the library by issuing the below command. This step copies the API Library file to `/usr/lib/`.

```
make
```

### 4.3. Library Use

The library is used at application compile time, at application link time and at application run time. At compile time include the below listed header file in each source file using a component of the Library interface. Also, edit the include file search path to locate the header file in the below listed directory. At link time the Library's shared object file is linked via the linker command line. This can be done by naming the `.so` file explicitly or by adding the below linker command line argument. At run time the library is found in the directory `/usr/lib/`. (The shared object file is automatically copied to `/usr/lib/` when it is built.)

Description	File	Location	Linker Argument
Header File	<code>24dsi16wrc_api.h</code>	.../include/	
Shared Object Library	<code>lib24dsi16wrc_api.so</code>	.../lib/	
		/usr/lib/	<code>-l24dsi16wrc_api</code>

### 4.4. Macros

The API Library and driver interfaces include the following macros, which are defined in `24dsi16wrc.h`.

#### 4.4.1. IOCTL Services

The IOCTL macros are documented in section 4.7 (page 24).

#### 4.4.2. Registers

The following gives the complete set of 24DSI16WRC registers.

##### 4.4.2.1. GSC Registers

The following table gives the complete set of GSC specific 24DSI16WRC registers. Please note that the set of registers supported by any given device may vary according to model and firmware version. For the set of supported registers and their detailed definitions refer to the appropriate *24DSI16WRC User Manual*.

**NOTE:** Refer to the output of the “id” sample application (.../id/) for a complete list of the registers supported by the device being accessed.

Macro	Description
DSI16WRC_GSC_ASIOCR	Aux Sync I/O Control Register (ASIOCR)
DSI16WRC_GSC_AVR	Autocal Values Register (AVR)
DSI16WRC_GSC_BCFGR	Board Configuration Register (BCFGR)
DSI16WRC_GSC_BCTLR	Board Control Register (BCTLR)
DSI16WRC_GSC_BUFCR	Buffer Control Register (BUFCR)
DSI16WRC_GSC_BUFSR	Buffer Size Register (BUFSR)
DSI16WRC_GSC_CSAR	Clock Source Assignment Register (CSAR)
DSI16WRC_GSC_IDBR	Input Data Buffer Register (IDBR)
DSI16WRC_GSC_MCAR	Master Clock Adjust Register (MCAR)
DSI16WRC_GSC_RCR	Rate Control Register (RCR)
DSI16WRC_GSC_RDR	Rate Divisors Register (RDR)

##### 4.4.2.2. PCI Configuration Registers

Access to the PCI registers is seldom required so these registers are not listed here. For the complete list of the PCI register identifiers refer to the driver header file `gsc_pci9056.h`, which is automatically included via `24dsi16wrc_api.h`.

##### 4.4.2.3. PLX Feature Set Registers

Access to the PLX registers is seldom required so these registers are not listed here. For the complete list of the PLX register identifiers refer to the driver header file `gsc_pci9056.h`, which is automatically included via `24dsi16wrc_api.h`.

### 4.5. Data Types

The data types used by the API Library are described with the IOCTL services with which they are used. For additional information refer to section 4.7 (page 24).

### 4.6. Functions

The interface includes the following functions. The return values reflect the completion status of the requested operation. A return value less than zero always reflects an error condition. The table below summarizes the error status values. For the I/O function, read, non-negative return values reflect the number of bytes transferred between the application and the interface. A value equal to the requested transfer size indicates complete success. Return

values less than the requested transfer size indicate that the I/O timeout expired. For the other API function calls a return value of zero indicates success.

Return Value	Description
< 0	This is the value “(-errno)” (see errno.h).

#### 4.6.1. dsi16wrc\_close()

This function is the entry point to close a connection made via the API's open call (section 4.6.4, page 22). The device is put in an initialized state before this call returns.

##### Prototype

```
int dsi16wrc_close(int fd);
```

Argument	Description
fd	This is the file descriptor obtained from the open service (section 4.6.4, page 22).

Return Value	Description
0	The operation succeeded.
< 0	An error occurred. See error value description above.

##### Example

```
#include <stdio.h>

#include "24dsi16wrc_dsl.h"

int dsi16wrc_close_dsl(int fd)
{
    int errs;
    int ret;

    ret = dsi16wrc_close(fd);

    if (ret)
        printf("ERROR: dsi16wrc_close() returned %d\n", ret);

    errs = ret ? 1 : 0;
    return(errs);
}
```

#### 4.6.2. dsi16wrc\_init()

This function is the entry point to initializing the 24DSI16WRC API Library and must be the first call into the Library. This function may be called more than once, but only the first successful call actually initializes the library. Subsequent calls perform no operation at all. All other API calls return a failure status when the API Library is not initialized.

##### Prototype

```
int dsi16wrc_init(void);
```

Return Value	Description
0	The operation succeeded.
< 0	An error occurred. See error value description above.

**Example**

```
#include <stdio.h>

#include "24dsi16wrc_dsl.h"

int dsi16wrc_init_dsl(void)
{
    int errs;
    int ret;

    ret = dsi16wrc_init();

    if (ret)
        printf("ERROR: dsi16wrc_init() returned %d\n", ret);

    errs = ret ? 1 : 0;
    return(errs);
}
```

**4.6.3. dsi16wrc\_ioctl()**

This function is the entry point to performing setup and control operations on a 24DSI16WRC. This function should only be called after a successful open of the respective device. The specific operation performed varies according to the `request` argument. The `request` argument also governs the use and interpretation of the `arg` argument. The set of supported options for the `request` argument consists of the IOCTL services supported by the driver, which are defined in section 4.7 (page 24).

**NOTE:** IOCTL operations are not supported for an open on device index `-1`.

**NOTE:** Some of the driver's IOCTL services wait for the board's Ready Bit in the Board Control Register to become set after applying the requested settings. If the respective board feature requires a clock source and the clock source is absent or disabled, then the service may fail with a timeout error. This is most likely to occur if the required clock source is disabled or if the external source is not providing a clock.

**Prototype**

```
int dsi16wrc_ioctl(int fd, int request, void* arg);
```

Argument	Description
<code>fd</code>	This is the file descriptor obtained from the open service (section 4.6.4, page 22).
<code>request</code>	This specifies the desired operation to be performed (section 4.7, page 24).
<code>arg</code>	This is specific to the IOCTL operation specified by the <code>request</code> argument.

Return Value	Description
0	The operation succeeded.
< 0	An error occurred. See error value description above.

**Example**

```
#include <stdio.h>

#include "24dsi16wrc_dsl.h"

int dsi16wrc_ioctl_dsl(int fd, int request, void* arg)
{
    int errs;
    int ret;

    ret = dsi16wrc_ioctl(fd, request, arg);

    if (ret)
        printf("ERROR: dsi16wrc_ioctl() returned %d\n", ret);

    errs    = ret ? 1 : 0;
    return(errs);
}
```

**4.6.4. dsi16wrc\_open()**

This function is the entry point to open a connection to a 24DSI16WRC board. Before returning, the initialize IOCTL service is called to reset all hardware and software settings to their defaults.

**Prototype**

```
int dsi16wrc_open(int device, int share, int* fd);
```

Argument	Description						
device	This is the zero-based index of the 24DSI16WRC to access. †						
share	Open the device in Shared Access Mode? If non-zero the device is opened in Shared Access Mode (see below). If zero the device is opened in Exclusive Access Mode (see below).						
fd	The device handle is returned here. The pointer cannot be NULL. Values returned are as follows. <table border="1"> <tr> <th>Value</th><th>Description</th></tr> <tr> <td>&gt;= 0</td><td>This is the handle to use to access the device in subsequent calls.</td></tr> <tr> <td>-1</td><td>There was an error. The device is not accessible.</td></tr> </table>	Value	Description	>= 0	This is the handle to use to access the device in subsequent calls.	-1	There was an error. The device is not accessible.
Value	Description						
>= 0	This is the handle to use to access the device in subsequent calls.						
-1	There was an error. The device is not accessible.						

† The index value -1 can also be given to acquire driver information (section 2.2, page 12).

Return Value	Description
0	The operation succeeded.
< 0	An error occurred. See error value description above.

**Example**

```
#include <stdio.h>

#include "24dsi16wrc_dsl.h"

int dsi16wrc_open_dsl(int device, int share, int* fd)
{
    int errs;
```

```

int ret;

ret = dsil6wrc_open(device, share, fd);

if (ret)
    printf("ERROR: dsil6wrc_open() returned %d\n", ret);

errs    = ret ? 1 : 0;
return(errs);
}

```

#### 4.6.4.1. Access Modes

The value of the `share` argument determines the device access mode, as follows.

##### Shared Access Mode:

Shared Access Mode allows multiple applications to access the same device simultaneously. In this mode, the first successful open request returns with the device in an initialized state. Subsequent successful Shared Access Mode open requests do not affect the state of the device. Once opened in Shared Access Mode, the device access remains in this mode until all Shared Access Mode accesses release the device with a close request.

##### Exclusive Access Mode:

Exclusive Access Mode allows a single application to acquire exclusive access to a device. In this mode, a successful open request returns with the device in an initialized state. While open in this mode all subsequent open requests will fail regardless of the access mode requested. Once opened in Exclusive Access Mode, the device access remains in this mode until released by the application with a close request.

#### 4.6.5. `dsi16wrc_read()`

This function is the entry point to reading data from an open connection. The function reads up to `bytes` bytes.

**NOTE:** If an open was performed using an index of `-1`, then read requests will acquire information from the driver (section 2.2, page 12) rather than data from a device.

**NOTE:** For additional information refer to the Data Transfer Modes section (section 8.3, page 51).

##### Prototype

```
int dsi16wrc_read(int fd, void* dst, size_t bytes);
```

Argument	Description
<code>fd</code>	This is the file descriptor obtained from the open service (section 4.6.4, page 22).
<code>dst</code>	The data read is put here.
<code>bytes</code>	This is the desired number of bytes to read. When reading from a device, this must be a multiple of four (4).

Return Value	Description
0 to <code>bytes</code>	The operation succeeded. When reading from a device, a value less than <code>bytes</code> indicates that the I/O timeout period lapsed (section 4.7.44, page 39) before the entire request could be satisfied.
< 0	An error occurred. See error value description above.

**Example**

```

#include <stdio.h>

#include "24dsi16wrc_dsl.h"

int dsi16wrc_read_dsl(int fd, void* dst, size_t bytes, size_t* qty)
{
    int errs;
    int ret;

    ret = dsi16wrc_read(fd, dst, bytes);

    if (ret < 0)
        printf("ERROR: dsi16wrc_read() returned %d\n", ret);

    if (qty)
        qty[0] = (ret < 0) ? 0 : (size_t) ret;

    errs = (ret < 0) ? 1 : 0;
    return(errs);
}

```

**4.7. IOCTL Services**

The 24DSI16WRC API Library and device driver implement the following IOCTL services. Each service is described along with the applicable `dsi16wrc_ioctl()` function arguments.

**4.7.1. DSI16WRC\_IOCTL\_ADC\_MODE**

This service configures the ADC operating mode.

**NOTE:** Before returning the driver will wait for up to 800 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_ADC_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_ADC_MODE_HI_RES	This option selects the high-resolution mode, in which the sampling rate is from 200 to 52,500 S/S.
DSI16WRC_ADC_MODE_HI_SPEED	This option selects the high-speed mode, in which the sampling rate is from 400 to 105,000 S/S and offers lower noise.

**4.7.2. DSI16WRC\_IOCTL\_AI\_BUF\_CLEAR**

This service immediately clears the current content from the input buffer. It also clears the associated overflow and underflow status bits. This service does not halt sampling.



**NOTE:** Before returning the driver will wait for up to 25 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_CLEAR
arg	Not used.

#### 4.7.3. DSI16WRC\_IOCTL\_AI\_BUF\_ENABLE

This service enables or disables input to the analog input buffer.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_ENABLE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_AI_BUF_ENABLE_NO	This option disables input to the input buffer.
DSI16WRC_AI_BUF_ENABLE_YES	This option enables input to the input buffer.

**NOTE:** With this service the buffer input stream is affected immediately. This is not timed to occur at a scan boundary and may result in a partial scan entering the buffer. For additional information on clearing the input buffer refer to section 8.5 on page 53.

#### 4.7.4. DSI16WRC\_IOCTL\_AI\_BUF\_FILL\_LVL

This service reports the analog input buffer's current fill level.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_FILL_LVL
arg	s32*

Valid return values are from zero to 0x40000 (256K).

#### 4.7.5. DSI16WRC\_IOCTL\_AI\_BUF\_OVERFLOW

This service operates on the Analog Input Overflow status.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_OVERFLOW
arg	s32*

Valid argument values provided to the service are as follows.

Value	Description
DSI16WRC_AI_BUF_OVERFLOW_CLEAR	This option clears the overflow status.
DSI16WRC_AI_BUF_OVERFLOW_TEST	This option reports if an overflow has occurred.

Valid returned values are as follows.

Value	Description
DSI16WRC_AI_BUF_OVERFLOW_NO	An overflow did not occur.
DSI16WRC_AI_BUF_OVERFLOW_YES	An overflow did occur.

#### 4.7.6. DSI16WRC\_IOCTL\_AI\_BUF\_THR\_STS

This service reports the input buffer threshold status. The status is active (or asserted or set) while the buffer fill level exceeds the buffer threshold setting. The status is idle (or negated or clear) while the buffer fill level is equal to or below the buffer threshold setting.

Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_THR_STS
arg	s32*

Valid returned values are as follows.

Value	Description
DSI16WRC_AI_BUF_THR_STS_ACTIVE	The threshold flag is set.
DSI16WRC_AI_BUF_THR_STS_IDLE	The threshold flag is not set.

#### 4.7.7. DSI16WRC\_IOCTL\_AI\_BUF\_THRESH

This service sets the fill level at which the input buffer threshold status is asserted.

Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_THRESH
arg	s32*

Valid argument values are from zero to 0x40000, and -1. A value of -1 will return the current threshold level setting.

#### 4.7.8. DSI16WRC\_IOCTL\_AI\_BUF\_UNDERFLOW

This service operates on the Analog Input Underflow status.

Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_BUF_UNDERFLOW
arg	s32*

Valid argument values are as follows.

Value	Description
DSI16WRC_AI_BUF_UNDERFLOW_CLEAR	Clear the underflow status.
DSI16WRC_AI_BUF_UNDERFLOW_TEST	Report if an underflow has occurred.

Valid returned values are as follows.

Value	Description
DSI16WRC_AI_BUF_UNDERFLOW_NO	An underflow did not occur.
DSI16WRC_AI_BUF_UNDERFLOW_YES	An underflow did occur.

#### 4.7.9. DSI16WRC\_IOCTL\_AI\_CHANNEL\_TAG

This service configures the appearance of the channel tag in the input data stream.

Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_CHANNEL_TAG
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Request the current setting.
DSI16WRC_AI_CHANNEL_TAG_DISABLE	This option causes the channel tag to not appear.
DSI16WRC_AI_CHANNEL_TAG_ENABLE	This option causes the channel tag to appear.

#### 4.7.10. DSI16WRC\_IOCTL\_AI\_MODE

This service configures the analog input mode.

Usage

Argument	Description
request	DSI16WRC_IOCTL_AI_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_AI_MODE_DIFF	This option selects differential operation.
DSI16WRC_AI_MODE_VREF	This option connects the input channels to the onboard VREF signal.
DSI16WRC_AI_MODE_ZERO	This option connects the input channels to the onboard zero voltage signal.

#### 4.7.11. DSI16WRC\_IOCTL\_AUTOCAL

This service initiates an autocalibration cycle. Most configuration setting should be made before running an autocalibration cycle. The driver waits for the operation to complete before returning.

**NOTE:** This service overwrites the current interrupt selection in order to detect the Autocalibration Done interrupt.

**NOTE:** When an error is encountered, the service writes a brief, descriptive error message to the system log.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AUTOCAL
arg	Not used.

#### 4.7.12. DSI16WRC\_IOCTL\_AUTOCAL\_STATUS

This service reports the autocalibration status.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AUTOCAL_STATUS
arg	s32*

Valid argument values returned are as follows.

Value	Description
DSI16WRC_AUTOCAL_STATUS_ACTIVE	An autocalibration cycle is in progress.
DSI16WRC_AUTOCAL_STATUS_FAIL	The most recent autocalibration cycle failed.
DSI16WRC_AUTOCAL_STATUS_PASS	The most recent autocalibration cycle passed.

#### 4.7.13. DSI16WRC\_IOCTL\_AUX\_CLK\_CTL\_MODE

This service configures the Auxiliary Clock Control Mode.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AUX_CLK_CTL_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_AUX_CLK_CTL_MODE_INACTIVE	This option configures the signal to be inactive.
DSI16WRC_AUX_CLK_CTL_MODE_INPUT	This option configures the signal to be an input.
DSI16WRC_AUX_CLK_CTL_MODE_OUTPUT	This option configures the signal to be an output.

#### 4.7.14. DSI16WRC\_IOCTL\_AUX\_SYNC\_CTL\_MODE

This service configures the Auxiliary Sync Control Mode.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_AUX_SYNC_CTL_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_AUX_SYNC_CTL_MODE_INACTIVE	This option configures the signal to be inactive.
DSI16WRC_AUX_SYNC_CTL_MODE_INPUT	This option configures the signal to be an input.
DSI16WRC_AUX_SYNC_CTL_MODE_OUTPUT	This option configures the signal to be an output.

#### 4.7.15. DSI16WRC\_IOCTL\_BURST

This service enables or disables input bursting.

Usage

Argument	Description
request	DSI16WRC_IOCTL_BURST
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_BURST_DISABLE	This option disables input bursting.
DSI16WRC_BURST_ENABLE	This option enables input bursting.

#### 4.7.16. DSI16WRC\_IOCTL\_BURST\_RATE\_DIV

This service adjusts the Burst Rate Divisor.

Usage

Argument	Description
request	DSI16WRC_IOCTL_BURST_RATE_DIV
arg	s32*

Valid argument values are from zero to 0xFFFFFFFF, and -1. The value -1 retrieves the current setting.

#### 4.7.17. DSI16WRC\_IOCTL\_BURST\_SIZE

This service adjusts the Burst Size, which is the number of scans in a single burst operation.

Usage

Argument	Description
request	DSI16WRC_IOCTL_BURST_SIZE
arg	s32*

Valid argument values are from zero to 0xFFFFFFFF, and -1. The value -1 retrieves the current setting.

#### 4.7.18. DSI16WRC\_IOCTL\_BURST\_TIMER

This service enables or disables the input bursting timer.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_BURST_TIMER
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_BURST_TIMER_DISABLE	This option disables the input burst timer.
DSI16WRC_BURST_TIMER_ENABLE	This option enables the input burst timer.

**4.7.19. DSI16WRC\_IOCTL\_BURST\_TRIGGER**

This service initiates a burst operation.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_BURST_TRIGGER
arg	Not used.

**4.7.20. DSI16WRC\_IOCTL\_CHANNELS\_READY**

This service operates on the Channel Ready status.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_CHANNELS_READY
arg	s32*

Valid argument values are as follows.

Value	Description
DSI16WRC_CHANNELS_READY_TEST	This reports if the status is <i>ready</i> .
DSI16WRC_CHANNELS_READY_WAIT	This requests that the driver wait for the status to become <i>ready</i> . The driver waits for up to one second.

Valid returned values are as follows.

Value	Description
DSI16WRC_CHANNELS_READY_NO	The status is <i>not ready</i> .
DSI16WRC_CHANNELS_READY_YES	The status is <i>ready</i> .

**4.7.21. DSI16WRC\_IOCTL\_CH\_GRP\_x\_SRC**

This service configures the clocking source for the respective channel group.

NOTE: Refer to the board user manual for additional information.

Value	Description
DSI16WRC_IOCTL_CH_GRP_0_SRC	This refers to Channel Group 0.
DSI16WRC_IOCTL_CH_GRP_1_SRC	This refers to Channel Group 1.

**NOTE:** Before returning the driver will wait for up to 25 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_CH_GRP_X_SRC
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_CH_GRP_SRC_DIR_EXTERN	This option selects the Direct External configuration.
DSI16WRC_CH_GRP_SRC_DISABLE	This option disables the respective channel group.
DSI16WRC_CH_GRP_SRC_EXTERN	This option selects the External configuration.
DSI16WRC_CH_GRP_SRC_RATE_GEN	This option selects the internal Rate Generator.

#### 4.7.22. DSI16WRC\_IOCTL\_CONTROL\_MODE

This service configures the board for initiator or target mode operation.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_CONTROL_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_CONTROL_MODE_INITIATOR	This option selects initiator mode operation.
DSI16WRC_CONTROL_MODE_TARGET	This option selects target mode operation.

#### 4.7.23. DSI16WRC\_IOCTL\_DATA\_FORMAT

This service configures the data encoding format.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_DATA_FORMAT
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.

DSI16WRC_DATA_FORMAT_2S_COMP	This option selects the Twos Compliment data format.
DSI16WRC_DATA_FORMAT_OFF_BIN	This option selects the Offset Binary encoding format.

#### 4.7.24. DSI16WRC\_IOCTL\_DATA\_WIDTH

This service configures the bit width of the converted input data.

Usage

Argument	Description
request	DSI16WRC_IOCTL_DATA_WIDTH
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_DATA_WIDTH_16	This option selects 16-bits of resolution.
DSI16WRC_DATA_WIDTH_18	This option selects 18-bits of resolution.
DSI16WRC_DATA_WIDTH_20	This option selects 20-bits of resolution.
DSI16WRC_DATA_WIDTH_24	This option selects 24-bits of resolution.

#### 4.7.25. DSI16WRC\_IOCTL\_DIO\_DIR\_OUT

This service sets the Digital I/O Port pins as either input or output.

Usage

Argument	Description
request	DSI16WRC_IOCTL_DIO_DIR_OUT
arg	s32*

Valid argument values are from zero to 0xF, and -1. A value of -1 will return the current setting. A port pin is an output if the bit is set and it is an input if the bit is clear. Bit D0 refers to port pin zero.

#### 4.7.26. DSI16WRC\_IOCTL\_DIO\_READ

This service reads the value of the Digital I/O Port pins. If a pin is configured as an output the value returned is the output value. If a pin is configured as an input the value returned is the value on the pin at the cable interface. Bit D0 refers to port pin zero.

Usage

Argument	Description
request	DSI16WRC_IOCTL_DIO_READ
arg	s32*

Valid values returned are from zero to 0xF.

#### 4.7.27. DSI16WRC\_IOCTL\_DIO\_WRITE

This service writes to the Digital I/O Port pins.



## Usage

Argument	Description
request	DSI16WRC_IOCTL_DIO_WRITE
arg	s32*

Valid argument values are from zero to 0xF, and -1. A value of -1 will return the current setting. Writes to output pins appear immediately at the cable interface. Writes to input pins are latched and will appear when the pin is subsequently configured as an output. Bit D0 refers to port pin zero.

**4.7.28. DSI16WRC\_IOCTL\_EXT\_CLK\_SRC**

This service configures the source for the external clock output.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_EXT_CLK_SRC
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_EXT_CLK_SRC_GEN	This option selects the internal Rate Generator.
DSI16WRC_EXT_CLK_SRC_GRP_0	This option selects the Channel Group 0 sample clock.

**4.7.29. DSI16WRC\_IOCTL\_EXT\_SYNC\_IN**

This service configures the External SYNC Input at the cable interface.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_EXT_SYNC_IN
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_EXT_SYNC_IN_DISABLE	This option disables the input.
DSI16WRC_EXT_SYNC_IN_ENABLE	This option enables the input.

**4.7.30. DSI16WRC\_IOCTL\_INITIALIZE**

This service resets all hardware and software settings to their defaults.

**NOTE:** Before returning the driver will wait for up to 25 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

**NOTE:** If the initialization service returns an error status, an error message will be posted to the system log briefly describing the error condition.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_INITIALIZE
arg	Not used.

**4.7.31. DSI16WRC\_IOCTL\_IRQ\_SEL**

This service selects which firmware interrupt source may generate an interrupt.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_IRQ_SEL
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_IRQ_AI_BUF_THRESH_H2L	This refers to a high-to-low transition of the input buffer threshold flag.
DSI16WRC_IRQ_AI_BUF_THRESH_L2H	This refers to a low-to-high transition of the input buffer threshold flag.
DSI16WRC_IRQ_AUTOCAL_DONE	This refers to autocalibration completion.
DSI16WRC_IRQ_CHAN_READY	This refers to assertion of the Channel Ready status.
DSI16WRC_IRQ_AI_BURST_DONE	This refers to completion of a burst operation.

**4.7.32. DSI16WRC\_IOCTL\_MASTER\_CLK\_ADJ**

This service adjusts the master clock frequency to the degree indicated by the argument. Read the hardware user manual for additional information.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_MASTER_CLK_ADJ
arg	s32*

Valid argument values are from zero to 0xFFFF, and -1. The value -1 retrieves the current setting. The midrange value is 0x8000. The value 0x0000 lowers the reference frequency by up to 50 to 80 PPM from nominal. The value 0xFFFF raises the reference frequency by up to 50 to 80 PPM from nominal.

**4.7.33. DSI16WRC\_IOCTL\_NDIV**

This service configures the internal rate generator's NDIV value.

**NOTE:** Before returning the driver will wait for up to 25 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_NDIV
arg	s32*

Valid argument values are from one to 300, and -1. The value -1 returns the current setting.

**4.7.34. DSI16WRC\_IOCTL\_NREF**

This service configures the internal rate generator's NREF value.

**NOTE:** Before returning the driver will wait for up to 25 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_NREF
arg	s32*

Valid argument values are from 25 to 300, and -1. The value -1 returns the current setting.

**4.7.35. DSI16WRC\_IOCTL\_NVCO**

This service configures the internal rate generator's NVCO value.

**NOTE:** Before returning the driver will wait for up to 25 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_NVCO
arg	s32*

Valid argument values are from 25 to 300, and -1. The value -1 returns the current setting.

**4.7.36. DSI16WRC\_IOCTL\_QUERY**

This service queries the driver for various pieces of information about the board and the driver.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_QUERY
arg	s32*

Valid argument values are as follows.

Value	Description
DSI16WRC_QUERY_AUTOCAL_MS	This returns the maximum duration of the autocalibration cycle

	in milliseconds.
DSI16WRC_QUERY_CHANNEL_MAX	This returns the maximum number of input channels supported by all boards of the same model as the board accessed.
DSI16WRC_QUERY_CHANNEL_QTY	This returns the actual number of input channels on the current board.
DSI16WRC_QUERY_COUNT	This returns the number of query options supported by the IOCTL service.
DSI16WRC_QUERY_DEVICE_TYPE	This returns the identifier value for the board's type. The value should equal GSC_DEV_TYPE_24DSI16WRC.
DSI16WRC_QUERY_EXT_SYNC_IN	This indicates if the External SYNC Input feature is supported.
DSI16WRC_QUERY_FGEN_MAX	This returns the maximum rate generator output (FGEN) in hertz.
DSI16WRC_QUERY_FGEN_MIN	This returns the minimum rate generator output (FGEN) in hertz.
DSI16WRC_QUERY_FIFO_SIZE	This returns the size of the input buffer in samples.
DSI16WRC_QUERY_FILTER_FREQ	This returns the installed filter frequency in hertz. The value zero is returned if no filter is installed and -1 is returned if the filter frequency is not known to the driver.
DSI16WRC_QUERY_FREF_DEFAULT	This gives the default reference frequency (FREF) in hertz.
DSI16WRC_QUERY_FSAMP_MAX	This gives the maximum sample rate (FSAMP) in S/S.
DSI16WRC_QUERY_FSAMP_MIN	This gives the minimum sample rate (FSAMP) in S/S.
DSI16WRC_QUERY_INIT_MS	This returns the duration of a board initialization in milliseconds.
DSI16WRC_QUERY_NDIV_MAX	This returns the maximum supported NDIV value.
DSI16WRC_QUERY_NDIV_MIN	This returns the minimum supported NDIV value.
DSI16WRC_QUERY_NREF_MAX	This returns the maximum supported NREF value.
DSI16WRC_QUERY_NREF_MIN	This returns the minimum supported NREF value.
DSI16WRC_QUERY_NVCO_MAX	This returns the maximum supported NVCO value.
DSI16WRC_QUERY_NVCO_MIN	This returns the minimum supported NVCO value.
DSI16WRC_QUERY_V_RANGE	This returns the board's factory configured voltage range. See the options values below.

The values returned for the DSI16WRC\_QUERY\_V\_RANGE query option are as follows.

Value	Description
DSI16WRC_QUERY_V_RANGE_10_BY_2	The board supports the voltage ranges of $\pm 10$ volts, $\pm 5$ volts, $\pm 2.5$ volts and $\pm 1.25$ volts.
DSI16WRC_QUERY_V_RANGE_10_BY_10	The board supports the voltage ranges of $\pm 10$ volts, $\pm 1$ volt, $\pm 0.1$ volts and $\pm 0.01$ volts.

#### 4.7.37. DSI16WRC\_IOCTL\_RANGE

This service configures the analog input voltage range.

##### Usage

Argument	Description
request	DSI16WRC_IOCTL_RANGE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.

DSI16WRC_RANGE_10MV	This option selects the $\pm 0.01$ volt range. †
DSI16WRC_RANGE_100MV	This option selects the $\pm 0.1$ volt range. †
DSI16WRC_RANGE_1V	This option selects the $\pm 1$ volt range. †
DSI16WRC_RANGE_1_25V	This option selects the $\pm 1.25$ volts range. ‡
DSI16WRC_RANGE_2_5V	This option selects the $\pm 2.5$ volts range. ‡
DSI16WRC_RANGE_5V	This option selects the $\pm 5$ volts range. ‡
DSI16WRC_RANGE_10V	This option selects the $\pm 10$ volts range.

† This option is available only on boards factory configured for ranges of  $\pm 10V$ ,  $\pm 1V$ ,  $\pm 0.1V$  and  $\pm 0.01V$ .

‡ This option is available only on boards factory configured for ranges of  $\pm 10V$ ,  $\pm 5V$ ,  $\pm 2.5V$  and  $\pm 1.25V$ .

#### 4.7.38. DSI16WRC\_IOCTL\_REG\_MOD

This service performs a read-modify-write of a 24DSI16WRC register. This includes only the GSC firmware registers. The PCI and PLX Feature Set Registers are read-only. Refer to `24dsi16wrc.h` for a complete list of the GSC firmware registers.

##### Usage

Argument	Description
request	DSI16WRC_IOCTL_REG_MOD
arg	<code>gsc_reg_t*</code>

##### Definition

```
typedef struct
{
    u32 reg;
    u32 value;
    u32 mask;
} gsc_reg_t;
```

Fields	Description
reg	This is set to the identifier for the register to access.
value	This contains the value for the register bits to modify.
mask	This specifies the set of bits to modify. If a bit here is set, then the respective register bit is modified. If a bit here is zero, then the respective register bit is unmodified.

#### 4.7.39. DSI16WRC\_IOCTL\_REG\_READ

This service reads the value of a 24DSI16WRC register. This includes the PCI registers, the PLX Feature Set Registers and the GSC firmware registers. Refer to `24dsi16wrc.h` and `gsc_pci9056.h` for the complete list of accessible registers.

##### Usage

Argument	Description
request	DSI16WRC_IOCTL_REG_READ
arg	<code>gsc_reg_t*</code>

##### Definition

```
typedef struct
{
    u32 reg;
```

```

    u32 value;
    u32 mask;
} gsc_reg_t;

```

Fields	Description
reg	This is set to the identifier for the register to access.
value	This is the value read from the specified register.
mask	This is ignored for read request.

#### 4.7.40. DSI16WRC\_IOCTL\_REG\_WRITE

This service writes a value to a 24DSI16WRC register. This includes only the GSC firmware registers. The PCI and PLX Feature Set Registers are read-only. Refer to `24dsi16wrc.h` for a complete list of the GSC firmware registers.

##### Usage

Argument	Description
request	DSI16WRC_IOCTL_REG_WRITE
arg	gsc_reg_t*

##### Definition

```

typedef struct
{
    u32 reg;
    u32 value;
    u32 mask;
} gsc_reg_t;

```

Fields	Description
reg	This is set to the identifier for the register to access.
value	This is the value to write to the specified register.
mask	This is ignored for write request.

#### 4.7.41. DSI16WRC\_IOCTL\_RX\_IO\_ABORT

This service aborts an ongoing `read()` request. The service will wait for up to the read I/O timeout period for the request to complete.

##### Usage

Argument	Description
request	DSI16WRC_IOCTL_RX_IO_ABORT
arg	s32*

The results are reported as one of the following values.

Value	Description
DSI16WRC_IOCTL_RX_IO_ABORT_NO	A <code>read()</code> request was not aborted as none were ongoing.
DSI16WRC_IOCTL_RX_IO_ABORT_YES	An ongoing <code>read()</code> request was aborted.

**4.7.42. DSI16WRC\_IOCTL\_RX\_IO\_MODE**

This service sets the I/O mode used for data read requests.

**NOTE:** Applications may experience improved responsiveness with read requests by coordinating the Buffer Threshold with the number of samples requested. Refer to the DSI16WRC\_IOCTL\_AIN\_BUF\_THRESH service of section 4.7.6 on page 26.

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_RX_IO_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
GSC_IO_MODE_BMDMA	Use Block Mode DMA.
GSC_IO_MODE_DMDMA	Use Demand Mode DMA (transfer data as it becomes possible to do so).
GSC_IO_MODE_PIO	Use PIO mode, which is repetitive register access.

**4.7.43. DSI16WRC\_IOCTL\_RX\_IO\_OVERFLOW**

This service configures the read service to check for a data buffer overflow before performing read operations. Sampled data is lost when there is an overflow

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_RX_IO_OVERFLOW
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_IO_OVERFLOW_CHECK	This option specifies that the check be performed.
DSI16WRC_IO_OVERFLOW_IGNORE	This option specifies that the check not be performed.

**4.7.44. DSI16WRC\_IOCTL\_RX\_IO\_TIMEOUT**

This service sets the timeout limit for read requests. The value is expressed in seconds.

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_RX_IO_TIMEOUT
arg	s32*

Valid argument values are in the range from zero to 3600, -1, and DSI16WRC\_IO\_TIMEOUT\_INFINITE. A value of zero tells the driver not to sleep in order to wait for more data, and should only be used with PIO mode reads. A value of -1 is used to retrieve the current setting. If the option DSI16WRC\_IO\_TIMEOUT\_INFINITE is used, then the driver will wait indefinitely rather than timing out. The default is 10 seconds.

**4.7.45. DSI16WRC\_IOCTL\_RX\_IO\_UNDERFLOW**

This service configures the read service to check for a data buffer underflow before performing read operations. Indeterminate data is returned when there is an underflow

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_RX_IO_UNDERFLOW
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_IOCTL_UNDERFLOW_CHECK	This option specifies that the check be performed.
DSI16WRC_IOCTL_UNDERFLOW_IGNORE	This option specifies that the check not be performed.

**4.7.46. DSI16WRC\_IOCTL\_SW\_SYNC**

This service initiates an ADC sync operation and, if in initiator mode, also generates an external sync output. The result of issuing a sync is dependent on the DSI16WRC\_IOCTL\_SW\_SYNC\_MODE setting (refer to section 4.7.47 on page 40). When initiating this operation, it is the application's responsibility to wait for the Channel Ready bit to be asserted.

**NOTE:** Before returning the driver will wait for up to 1,100 milliseconds for the Channels Ready bit to become set. If the bit does not become set during this period, then the driver will post an error message to the system log.

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_SW_SYNC
arg	Not used.

**4.7.47. DSI16WRC\_IOCTL\_SW\_SYNC\_MODE**

This service sets the context of the Software Sync operation.

**Usage**

Argument	Description
request	DSI16WRC_IOCTL_SW_SYNC_MODE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_SW_SYNC_MODE_CLR_BUF	This option causes a sync to clear the input buffer when there is a Software Sync request. The clearing of the buffer is timed to occur on a scan boundary. Refer to section 8.5 on page 53 for addition buffer clearing information.
DSI16WRC_SW_SYNC_MODE_SYNC	Synchronize input channel scanning when there is a



Software Sync request.
------------------------

#### 4.7.48. DSI16WRC\_IOCTL\_WAIT\_CANCEL

This service resumes all threads blocked via the `DSI16WRC_IOCTL_WAIT_EVENT` IOCTL service (section 4.7.49, page 41), according to the provided criteria. When a blocked thread is waiting for any event specified in the structure, then the thread is resumed.

**NOTE:** The driver itself makes use of the wait services for various internal operations. Driver initiated waits are unaffected by application cancel requests.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_WAIT_CANCEL
arg	gsc_wait_t*

#### Definition

```
typedef struct
{
    u32  flags;
    u32  main;
    u32  gsc;
    u32  alt;
    u32  io;
    u32  timeout_ms;
    u32  count;
} gsc_wait_t;
```

Fields	Description
flags	This is unused by wait cancel operations.
main	This specifies the set of <code>GSC_WAIT_MAIN_*</code> events whose wait requests are to be cancelled. Refer to section 4.7.49.2 on page 42.
gsc	This specifies the set of <code>DSI16WRC_WAIT_GSC_*</code> events whose wait requests are to be cancelled. Refer to section 4.7.49.3 on page 43.
alt	This is unused by the 24DSI16WRC driver and should be zero.
io	This specifies the set of <code>GSC_WAIT_IO_*</code> events whose wait requests are to be cancelled. Refer to section 4.7.49.4 on page 43.
timeout_ms	This is unused by wait cancel operations.
count	Upon return this indicates the number of waits that were cancelled.

#### 4.7.49. DSI16WRC\_IOCTL\_WAIT\_EVENT

This service blocks a thread until any one of a specified set of events occurs, or until a timeout lapses, whichever occurs first. The set of possible events to wait for are specified in the structure's `main`, `gsc`, `alt` and `io` fields. All field values must be valid and at least one event must be specified. If the thread is resumed because one of the referenced events has occurred, then the bit for the respective event is the only event bit that will be set. All other event bits and fields will be zero. (Multiple event bits will be set only if the events occur simultaneously.)

**NOTE:** The service waits only for the first of the specified events, not for all specified events.

**NOTE:** A wait timeout is reported via the `gsc_wait_t` structure's `flags` field having the `GSC_WAIT_FLAG_TIMEOUT` flag set, rather than via an `ETIMEDOUT` error.

## Usage

Argument	Description
request	DSI16WRC_IOCTL_WAIT_EVENT
arg	gsc_wait_t*

## Definition

```
typedef struct
{
    u32  flags;
    u32  main;
    u32  gsc;
    u32  alt;
    u32  io;
    u32  timeout_ms;
    u32  count;
} gsc_wait_t;
```

Fields	Description
flags	This must initially be zero. Upon return this indicates the reason that the thread was resumed. Refer to section 4.7.49.1 on page 42.
main	This specifies any number of GSC_WAIT_MAIN_* events that the thread is to wait for. Refer to section 4.7.49.2 on page 42.
gsc	This specifies any number of DSI16WRC_WAIT_GSC_* events that the thread is to wait for. Refer to section 4.7.49.3 on page 43.
alt	This is unused by the 24DSI16WRC driver and must be zero.
io	This specifies any number of GSC_WAIT_IO_* events that the thread is to wait for. Refer to section 4.7.49.4 on page 43.
timeout_ms	This specified the maximum amount of time, in milliseconds, that the thread is to wait for any of the referenced events. A value of zero means do not timeout at all. If non-zero, then upon return the value will be the approximate amount of time actually waited.
count	This is unused by wait event operations and must be zero.

## 4.7.49.1. gsc\_wait\_t.flags Options

Upon return from a wait request the wait structure's flags field will indicate the reason that the thread was resumed. Only one of the below options will be set.

Fields	Description
GSC_WAIT_FLAG_CANCEL	The wait request was cancelled.
GSC_WAIT_FLAG_DONE	One of the referenced events occurred.
GSC_WAIT_FLAG_TIMEOUT	The timeout period lapsed before a referenced event occurred.

## 4.7.49.2. gsc\_wait\_t.main Options

The wait structure's main field may specify any of the below primary interrupt options. These interrupt options are supported by the 24DSI16WRC and other General Standards products.

Fields	Description
GSC_WAIT_MAIN_DMA0	This refers to the DMA Done interrupt on DMA engine number zero.
GSC_WAIT_MAIN_DMA1	This refers to the DMA Done interrupt on DMA engine number one.
GSC_WAIT_MAIN_GSC	This refers to any of the Interrupt Control/Status Register interrupts.

GSC_WAIT_MAIN_OTHER	This generally refers to an interrupt generated by another device sharing the same interrupt as the 24DSI16WRC.
GSC_WAIT_MAIN_PCI	This refers to any interrupt generated by the 24DSI16WRC.
GSC_WAIT_MAIN_SPURIOUS	This refers to board interrupts which should never be generated.
GSC_WAIT_MAIN_UNKNOWN	This refers to board interrupts whose source could not be identified.

#### 4.7.49.3. gsc\_wait\_t.gsc Options

The wait structure's `gsc` field may specify any combination of the below interrupt options. These are the interrupt options referenced in the Board Control Register. Applications are responsible for selecting the desired interrupt options. Refer to `DSI16WRC_IOCTL_IRQ_SEL` (section 4.7.31, page 34).

Value	Description
DSI16WRC_WAIT_GSC_AI_BUF_THRESH_H2L	This refers to a high-to-low transition of the input buffer threshold flag.
DSI16WRC_WAIT_GSC_AI_BUF_THRESH_L2H	This refers to a low-to-high transition of the input buffer threshold flag.
DSI16WRC_WAIT_GSC_AUTOCAL_DONE	This refers to autocalibration completion.
DSI16WRC_WAIT_GSC_CHAN_READY	This refers to completion of an input burst operation.
DSI16WRC_WAIT_GSC_CHAN_READY	This refers to assertion of the Channel Ready status.
DSI16WRC_WAIT_GSC_INIT_DONE	This refers to initialization completion.

#### 4.7.49.4. gsc\_wait\_t.io Options

The wait structure's `io` field may specify any of the below event options. These events are generated in response to application read requests.

Fields	Description
GSC_WAIT_IO_RX_ABORT	This refers to read requests which have been aborted.
GSC_WAIT_IO_RX_DONE	This refers to read requests which have been satisfied.
GSC_WAIT_IO_RX_ERROR	This refers to read requests which end due to an error.
GSC_WAIT_IO_RX_TIMEOUT	This refers to read requests which end due to the timeout period lapse.

#### 4.7.50. DSI16WRC\_IOCTL\_WAIT\_STATUS

This service count all threads blocked via the `DSI16WRC_IOCTL_WAIT_EVENT` IOCTL service (section 4.7.49, page 41), according to the provided criteria. A match is made when a waiting thread's wait criteria matches any of the criteria specified in the structure passed to this service.

**NOTE:** The driver itself makes use of the wait services for various internal operations. Driver initiated waits are ignored by application status requests.

#### Usage

Argument	Description
request	DSI16WRC_IOCTL_WAIT_STATUS
arg	gsc_wait_t*

#### Definition

```
typedef struct
{
    u32  flags;
    u32  main;
```

```

u32 gsc;
u32 alt;
u32 io;
u32 timeout_ms;
u32 count;
} gsc_wait_t;

```

Fields	Description
flags	This is unused by wait status operations.
main	This specifies the set of GSC_WAIT_MAIN_* events whose wait requests are to be counted. Refer to section 4.7.49.2 on page 42.
gsc	This specifies the set of DSI16WRC_WAIT_GSC_* events whose wait requests are to be counted. Refer to section 4.7.49.3 on page 43.
alt	This is unused by the 24DSI16WRC driver and should be zero.
io	This specifies the set of GSC_WAIT_IO_* events whose wait requests are to be counted. Refer to section 4.7.49.4 on page 43.
timeout_ms	This is unused by wait status operations.
count	Upon return this indicates the number of waits that met any of the specified criteria.

#### 4.7.51. DSI16WRC\_IOCTL\_XCVR\_TYPE

This service configures the transceiver type for the digital interface signals.

##### Usage

Argument	Description
request	DSI16WRC_IOCTL_XCVR_TYPE
arg	s32*

Valid argument values are as follows.

Value	Description
-1	Retrieve the current setting.
DSI16WRC_XCVR_TYPE_LVDS	This option selects LVDS signaling.
DSI16WRC_XCVR_TYPE_TTL	This option selects TTL signaling.

## 5. The Driver

**NOTE:** Contact General Standards Corporation if additional driver functionality is required.

### 5.1. Files

The device driver files are summarized in the table below.

Description	Files	Location
Source Files	*.c, *.h ...	.../driver/
Header File	24dsi16wrc.h	
Driver File	24dsi16wrc.ko † 24dsi16wrc.o ‡	

† This is for kernel versions 2.6 and later.

‡ This is for kernel versions 2.4 are earlier.

### 5.2. Build

**NOTE:** Building the driver requires installation of the kernel headers and possibly other packages.

The device driver is built via the Overall Make Script (section 2.7, page 13), but can be built separately following the below steps.

1. Change to the directory where the driver and its sources are installed (.../driver/).
2. Remove existing build targets by issuing the below command.

```
make clean
```

3. Build the driver by issuing the below command.

```
make
```

**NOTE:** Due to the differences between the many Linux distributions some build errors may occur. These errors may include system header location differences, which should be easily corrected.

### 5.3. Startup

**NOTE:** The driver will have to be built before being used as it is provided in source form only.

The startup script used in this procedure is designed to load the device driver and create fresh device nodes. This is accomplished by unloading the current driver, if loaded, and then loading the accompanying driver executable. In addition, the script deletes and recreates the device nodes. This is done to ensure that the device nodes in use have the same major number as assigned dynamically to the driver by the kernel, and so that the number of device nodes corresponds to the number of boards identified by the driver.

#### 5.3.1. Manual Driver Startup Procedures

Start the driver manually by following the below listed steps.

**NOTE:** The following steps may require elevated privileges.

1. Change to the directory where the driver sources are installed (.../driver/).
2. Install the driver module and create the device nodes by executing the below command. If any errors are encountered then an appropriate error message will be displayed.

```
./start
```

**NOTE:** This script must be executed each time the host is booted.

**NOTE:** The 24DSI16WRC device node major number is assigned dynamically by the kernel. The minor numbers and the device node suffix numbers are index numbers beginning with zero, and increase by one for each additional board installed.

3. Verify that the device driver module has been loaded by issuing the below command and examining the output. The module name `24dsi16wrc` should be included in the output.

```
lsmod
```

4. Verify that the device nodes have been created by issuing the below command and examining the output. The output should include one node for each installed board.

```
ls -l /dev/24dsi16wrc.*
```

### 5.3.2. Automatic Driver Startup Procedures

Start the driver automatically with each system reboot by following the below listed steps.

1. Locate and edit the system startup script `rc.local`, which should be in the `/etc/rc.d/` directory. Modify the file by adding the below line so that it is executed with every reboot. The example is based on the driver being installed in `/usr/src/linux/drivers/`, though it may have been installed elsewhere.

```
/usr/src/linux/drivers/24dsi16wrc/driver/start
```

**NOTE:** For `systemd` installations the file `rc.local` may be located under the `/etc/` directory rather than under `/etc/rc.d/`.

2. Load the driver and create the required device nodes by rebooting the system.
3. Verify that the driver is loaded and that the device nodes have been created. Do this by following the verification steps given in the manual startup procedures.

#### 5.3.2.1. File `rc.local` Not Present

Some distributions may not install a default version of `rc.local`. Some may not even create the directory `/etc/rc.d/`. If the directory is not present, then it may be created. The directory must be created with the owner and group set to `root`. The directory permissions must be set to `rwxr-xr-x`. If the file `/etc/rc.d/rc.local` is not present, then it too may be created. The file must also be created with the owner and group set to `root`. Additionally, the file permissions must also be set to `rwxr-xr-x`. After the directory and file are created as described, reboot to verify boot time loading of the driver. Here is an example of a default version of `rc.local`.

```
#!/bin/bash

# Add your local content here.
```

### 5.3.2.2. Default `rc.local` File Permissions

The `rc.local` script may fail to run at boot time because some distributions install a default version of the file without execute permissions. Without execute permissions, boot time invocation of the script fails, which inhibits boot time loading of the driver. If this is the case, then change the file permissions to `rxwxr-xr-x`. After the file permissions are adjusted as described, reboot to verify boot time loading of the driver.

### 5.3.2.3. `systemd` Installations

With the advent of the `systemd` startup implementation, `rc.local` may be accessed via a `systemd` startup service. The service name may be `rc-local`, `rc-local.service` or something similar. This service may or may not be enabled by default. If the service is disabled, then the script will not execute, which prevents boot time loading of the driver. The service can be enabled with the below command line. After the service is enabled, reboot to verify boot time loading of the driver.

```
systemctl enable rc-local
```

**NOTE:** For `systemd` installations the file `rc.local` may be located under the `/etc/` directory rather than under `/etc/rc.d/`.

### 5.3.2.4. `systemd` and `rc.local` Timing

If the above steps have been performed but the driver still does not start then examine the `dmesg` output for driver messages. If the output shows that the driver starts and immediately stops, then the problem may be timing. That is, since `systemd` doesn't serialize startup initialization as done in the past, driver loading may fail if required services have not completed their own initialization. If this is the problem, then it may be corrected simply by inserting a delay in `rc.local` prior to it calling the driver's start script (i.e., sleep for one or more seconds).

### 5.3.2.5. SELinux Implications

If not disabled, then SELinux may prevent boot time loading of the driver. If this is the case, then it can be verified and corrected using SELinux related tools and utilities. First, install the necessary software using the below command. (As necessary, replace the `yum` command line with that which is available for your distribution.)

```
yum install setroubleshoot setools
```

Next, run the below command to determine if SELinux is preventing the driver from loading at boot time.

```
sealert -a /var/log/audit/audit.log
```

If SELinux is preventing the driver from loading, then the output from the above command should include a reference to the driver's start script, the `insmod` command that loads the driver or the name of the driver executable. If so, then the output should also indicate the commands necessary to resolve the issue. The following is an example of the instructions given when the culprit is `insmod`, which is the start script command that loads the driver. After running these commands reboot the system to verify boot time loading of the driver.

```
ausearch -c 'insmod' --raw | audit2allow -M my-insmod
semodule -X 300 -i my-insmod.pp
```

## 5.4. Verification

Follow the below steps to verify that the driver has been properly installed and started.

1. Verify that the file `/proc/24dsi16wrc` is present. If the file is present then the driver is loaded and running. Verify the file's presence by viewing its content with the below command.

```
cat /proc/24dsi16wrc
```

## 5.5. Version

The driver version number can be obtained in a variety of ways. It is reported by the driver both when the driver is loaded and when it is unloaded (depending on kernel configuration options, this may be visible only in places such as `/var/log/messages`). It is reported in the text file `/proc/24dsi16wrc` while the driver is loaded and running. The version number is also given in the file `release.txt` in the root install directory.

## 5.6. Shutdown

Shutdown the driver following the below listed steps.

**NOTE:** The following steps may require elevated privileges.

1. If the driver is currently loaded then issue the below command to unload the driver.

```
rmmod 24dsi16wrc
```

2. Verify that the driver module has been unloaded by issuing the below command. The module name `24dsi16wrc` should not be in the listed output.

```
lsmod
```



## 6. Document Source Code Examples

The source code examples included in this document are built into a statically linkable library usable with console applications. The purpose of these files is to verify that the documentation samples compile and to provide a library of working sample code to assist in a user's learning curve and application development effort.

### 6.1. Files

The library files are summarized in the table below.

Description	Files	Location
Source Files	*.c, *.h ...	.../docsrc/
Header File	24dsi16wrc_dsl.h	.../include/
Library File	24dsi16wrc_dsl.a	.../lib/

### 6.2. Build

The library is built via the Overall Make Script (section 2.7, page 13), but can be built separately following the below steps.

1. Change to the directory where the documentation sources are installed (.../docsrc/).
2. Remove existing build targets by issuing the below command.

```
make clean
```

3. Compile the sample files and build the library by issuing the below command.

```
make
```

4. Rebuild the Main Library (section 3.2.1, page 16).

### 6.3. Library Use

The library is used both at application compile time and at application link time. At compile time include the above listed header file in each source file using a component of the library interface. At link time include the above listed static library file with the objects being linked with the application.

## 7. Utilities Source Code

The API Library installation includes a body of utility source code designed to aid in the understanding and use of the interface calls and IOCTL services. Utility sources are also included for device independent and common, general-purpose services. Most of the utilities are implemented as visual wrappers around the corresponding services to facilitate structured console output for the sample applications. The utility sources are compiled and linked into static libraries to simplify their use. An additional purpose of these utility services is to provide a library of working sample code to assist in a user's learning curve and application development effort.

For each API function there is a corresponding utility source file with a corresponding utility service. As an example, for the API function `dsi16wrc_open()` there is the utility file `open.c` containing the utility function `dsi16wrc_open_util()`. The naming pattern is as follows: API function `dsi16wrc_xxxx()`, utility file name `xxxx.c`, utility function `dsi16wrc_xxxx_util()`. Additionally, for each IOCTL code there is a corresponding utility source file with a corresponding utility service. As an example, for IOCTL code `DSI16WRC_IOCTL_QUERY` there is the utility file `util_query.c` containing the utility function `dsi16wrc_query()`. The naming pattern is as follows: IOCTL code `DSI16WRC_IOCTL_XXXX`, utility file name `util_xxxx.c`, utility function `dsi16wrc_xxxx()`.

### 7.1. Files

The utility files are summarized in the table below.

Description	Files	Location
Source Files	*.c, *.h ...	.../utils/
Header File	24dsi16wrc_utils.h	.../include/
Library Files	24dsi16wrc_utils.a gsc_utils.a os_utils.a plx_utils.a	.../lib/

### 7.2. Build

The libraries are built via the Overall Make Script (section 2.7, page 13), but can be built separately following the below steps.

1. Change to the directory where the utility sources are installed (.../utils/).
2. Remove existing build targets by issuing the below command.

```
make clean
```

3. Compile the sample files and build the library by issuing the below command.

```
make
```

4. Rebuild the Main Library (section 3.2.1, page 16).

### 7.3. Library Use

The library is used both at application compile time and at application link time. At compile time include the above listed header file in each source file using a component of the library interface. At link time include the above listed static library file with the objects being linked with the application.

## 8. Operating Information

This section explains some basic operational procedures for using the 24DSI16WRC. This is in no way intended to be a comprehensive guide. This is simply to address a very few issues relating to their use.

### 8.1. Debugging Aids

The driver package includes the following items useful for development and/or debugging aids.

#### 8.1.1. Device Identification

When communicating with technical support complete device identification is virtually always necessary. The *id* example application is provided for this specific purpose. This is a text only console application. The output can be piped to a file, which can then be emailed to GSC technical support when requested. Locate the application as follows.

Description	File	Location
Application	id	.../id/

#### 8.1.2. Detailed Register Dump

Among the utility services provided is a function to generate a detailed listing of device registers to the console. When used, the function is typically used to verify device configuration. In these cases, the function should be called after complete device configuration and before the first I/O call. When intended for sending to GSC tech support, please set the *detail* arguments to 1. The function arguments are as follows. The utility location is given in the subsequent table.

Argument	Description
fd	This is the file descriptor used to access the device.
detail	If non-zero the register dump will include details of each register field.

Description	File/Name	Location
Function	dsi16wrc_reg_list()	Source File
Source File	util_reg.c	.../utils/
Header File	24dsi16wrc_utils.h	.../include/
Library File	24dsi16wrc_utils.a	.../lib/

### 8.2. Analog Input Configuration

The basic steps for Analog Input configuration are illustrated in the utility function noted below. The table also gives the location of the source file, the header file and the corresponding library containing the executable code. The referenced files are included via the Main Header and Main Library.

Item	Name/File	Location
Function	dsi16wrc_config_ai()	Source File
Source File	util_config_ai.c	.../utils/
Header File	24dsi16wrc_utils.h	.../include/
Library File	24dsi16wrc_utils.a	.../lib/

### 8.3. Data Transfer Modes

All device I/O requests move data through intermediate driver buffers on its way between the device and application memory. The data is processed in chunks no larger than the size of this intermediate buffer. The process used to

perform this transfer is according to the I/O mode selection. Movement of data between the application buffers and the intermediate driver buffers is performed by the kernel.

### 8.3.1. PIO - Programmed I/O

In this mode data is transferred using repetitive register accesses. This is most applicable for low throughput requirements or for small transfer requests. The driver continues the operation until either the I/O request is fulfilled or the I/O timeout expires, whichever occurs first. This is generally the least efficient mode, but for very small transfers it is more efficient than DMA.

### 8.3.2. BMDMA - Block Mode DMA

For Block Mode DMA the driver initiates DMA transfers only after a sufficient volume of data has been received into the input buffer. After that amount of data is in the input buffer the driver initiates a DMA then sleeps until the DMA Done interrupt is received. Using this DMA mode, a user request is typically satisfied via a number of smaller DMA transfers.

### 8.3.3. DMDMA - Demand Mode DMA

This DMA mode is similar to the Block Mode, except that the DMA transfer is initiated immediately. Here however, the actual movement of data occurs as the data becomes available in the input buffer instead of after it has been received. Using this DMA mode, a user request is divided into smaller DMA transfers only if the request exceeds the size of the driver's transfer buffer.

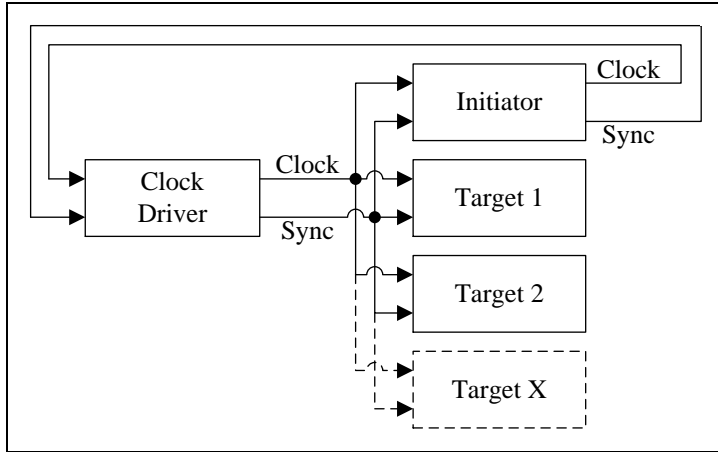
## 8.4. Multi-Board Synchronization

Multi-board synchronization is a feature of the 24DSI16WRC that enables two or more boards to sample analog input data in lock-step. Exercising this feature requires the boards to operate synchronously from the same clock source. This is done using the clock and sync signals on the cable interface. Though there are numerous varying ways of configuring the boards and of wiring the signals, the two basic configurations are described below.

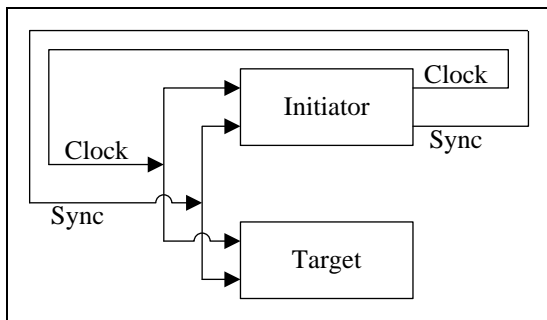
### 8.4.1. Star Configuration

The *star* configuration generally permits all boards in the setup to operate with the least possible phase shift from one board to the next. This is accomplished by configuring all the boards in an identical manner and by wiring the clock and sync signals so that they follow as identical a path as possible from the initiator's output to the input of the initiator and the targets. If there are three or more boards in the setup, then the clock and sync signal must go directly from the initiator's output to a Clock Driver board, as illustrated in Figure 2. If there are only two boards in the setup, then a Clock Driver board is not needed, as illustrated in Figure 3. The table below shows the board programming that is specific to the *star* configuration. See the Multi- Board Sync sample application source code for additional programming requirements (section 9, page 55).

Setting	Initiator	Target(s)
Control Mode	Initiator	Initiator
Channel Group Clock Source	Direct External	Direct External
External Clock Output Source	Rate Generator	N/A



**Figure 2** The *star* configuration with three or more boards requires a Clock Driver board.

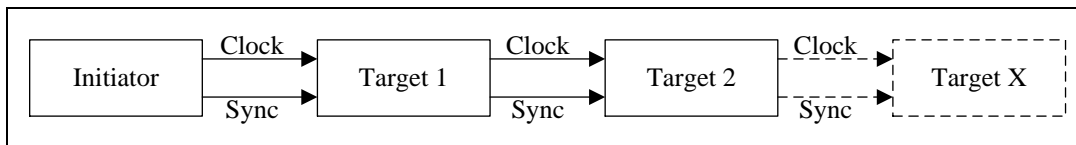


**Figure 3** The *star* configuration with only two boards does not require a Clock Driver board.

#### 8.4.2. Daisy Chain Configuration

The *daisy chain* configuration generally permits the most flexible placement of boards and wiring, and does not require a Clock Driver board. This is accomplished by configuring the boards and the wiring so that the clock and sync signals go from the initiator to the first target, then sequentially from the first target to the second and so on. This setup is applicable for any number of boards, as illustrated in Figure 4. The table below shows the board programming that is specific to the *daisy chain* configuration.

Setting	Initiator	Target(s)
Control Mode	Initiator	Target
Channel Group Clock Source	Rate Generator	Direct External
External Clock Output Source	Group 0	N/A (signals are passed through automatically)



**Figure 4** In this configuration the clock and sync signals are daisy chained from one board to the next.

### 8.5. Clearing the Input Buffer

The subsections below address a few of the basic options for input buffer clearing.

### 8.5.1. Clear Immediately

One method of clearing the buffer is to use the Clear Buffer IOCTL service (see `DSI16WRC_IOCTL_AI_BUF_CLEAR` in section 4.7.2 on page 24). This service immediately clears the input buffer of any content. However, since this feature is not timed to occur at a scan boundary, it can result in the input buffer containing a partial scan. This method is typically applicable when the input does not need to be cleared at a scan boundary and when only a single board is to be affected.

### 8.5.2. Clear At a Scan Boundary

Another method of clearing the input buffer is to request that it occur at a scan boundary. This method uses a number of services together. First, configure the board as an Initiator (see `DSI16WRC_IOCTL_CONTROL_MODE` in section 4.7.22 on page 31). Second, configure the board to clear the buffer when there is a Software Sync pulse (see `DSI16WRC_IOCTL_SW_SYNC_MODE` in section 4.7.47 on page 40). Finally, to clear the buffer, initiate a Software Sync pulse (see `DSI16WRC_IOCTL_SW_SYNC` in section 4.7.46 on page 40). After initiating the Software Sync pulse wait for the Channels Ready bit to be set. This method of clearing the input buffer is applicable either when using a single board, to simplify some data stream processing, or when multiple boards are configured for synchronized operation. (For multi-board synchronization refer to section 8.4 on page 52.)

## 9. Sample Applications

The driver archive includes a variety of sample and test applications located under the `samples` subdirectory. While they are provided without support and without any external documentation, any problems reported will be addressed as time permits. The applications are command line based and produce text output for display on a console. All of the applications are built via the Overall Make Script (section 2.7, page 13), but each may be built individually by changing to its respective directory and issuing the commands “`make clean`” and “`make`”. The initial output from each application includes information on its supported command line arguments. The following gives a brief overview of each application.

### 9.1. billion - Billion Byte Read - `.../billion/`

This application configures the designated board then reads in a billion bytes. The data is discarded after it is read.

### 9.2. din - Digital Input - `.../din/`

This application reads the cable’s digital I/O signals and reports the values read to the console.

### 9.3. dout - Digital Output - `.../dout/`

This application writes a pattern to the cable’s digital output lines as it is displayed to the console.

### 9.4. fsamp - Sample Rate - `.../fsamp/`

This application reports the device configuration required to produce a user specified sample rate.

### 9.5. id - Identify Board - `.../id/`

This application reports detailed board identification information. This can be used with tech support to help identify as much technical information about the board as possible from software.

### 9.6. irq – Interrupt Tests - `.../irq/`

This application tests the board’s interrupts and reports the results to the screen.

### 9.7. mbsync – Multi-Board Synchronization - `.../mbsync/`

This application demonstrates how to synchronize input sampling across two or more boards using either the Daisy Chain configuration or the Star configuration.

### 9.8. regs - Register Access - `.../regs/`

This application provides menu based interactive access to the board’s registers, and reports other pertinent information to the console.

### 9.9. rxrate - Receive Rate - `.../rxrate/`

This application configures the board for its highest ADC sample rate then reads the input as fast as possible. The purpose is to measure the peak sustainable input rate for the host, per the provided command line arguments.

### **9.10. savedata - Save Acquired Data - .../savedata/**

This application configures the board for a modest sample rate, reads a megabyte of data, then saves the data to a hex file.

### **9.11. signals - Digital Signals - .../signals/**

This application configures the board to drive the digital output signals for a user specified period of time. This is done to facilitate setup of test equipment to capture those signals during actual use.

### **9.12. stream - Stream Rx Data to Disk - .../stream/**

This application uses multiple threads with an intermediate buffer manager to stream data from the device to a data file. Numerous options are available for measuring performance of device reads, disk writes and buffer handling. Refer to the application file `readme.txt` for example information.

### **9.13. sw\_sync - Software Sync - .../sw\_sync/**

This application repetitively activates the board's Software Sync feature and drives the output clock signal for a user specified period of time. This is done to facilitate setup of test equipment to capture those signals during actual use.



## Document History

Revision	Description
August 20, 2024	Updated to version 2.7.111.50.0. Numerous, minor editorial changes. Updated the kernel support table. Updated the description of the Input Buffer Clear service. Updated the description of the Autocalibration service. All Auto Cal content is renamed to Autocal. All Auto Cal Sts content is renamed to Autocal Status.
April 21, 2023	Updated to version 2.6.102.45.1. Various editorial changes.
March 1, 2023	Updated to version 2.6.102.45.0. Updated the kernel support table. Added section on environment variables. Updated the information for the open and close calls.
August 16, 2021	Updated to version 2.5.94.36.0. Added <code>stream</code> sample application.
April 30, 2021	Updated to version 2.5.93.36.0. Updated the kernel support table. Minor editorial changes. Added <code>WAIT_EVENT</code> note. Expanded automatic startup information. Added the <code>irq</code> sample application. Added the <code>mbsync</code> sample application. Added the <code>sbtest</code> sample application. Added query option <code>DSI16WRC_QUERY_EXT_SYNC_IN</code> . Added IOCTL service <code>DSI16WRC_IOCTL_EXT_SYNC_IN</code> . Added noted about various services waiting for the Channels Ready bit.
July 24, 2019	Updated to version 2.4.87.28.0. Updated the kernel support table. Minor editorial changes. Added a licensing subsection. Some reorganization.
January 29, 2019	Updated to version 2.3.81.26.0. Updated the inside cover page. Updated the CPU and kernel support section. Minor editorial changes. Updated Block Mode DMA macro and associated information. Added <code>dsi16wrc_init()</code> documentation. Minor editorial changes.
September 14, 2017	Updated to version 2.2.72.20.0.
August 22, 2017	Updated to version 2.2.71.20.0. Document, interface and directory restructured.
December 5, 2016	Updated to version 2.1.68.18.0. Removed the <code>built</code> field from the <code>/proc/</code> file. Updated the kernel support table. Updated the command line arguments for the <code>din</code> , <code>fsamp</code> and <code>rxrate</code> , <code>savedata</code> sample applications. Organized sample applications alphabetically. Removed all references to the <code>sbtest</code> sample application as it was never developed. Updated the usage of the Wait Event <code>timeout_ms</code> field. Updated material on the open call. Added open access mode descriptions. Added support for infinite I/O timeouts. Updated the operating information section. Made various miscellaneous updates. Some document reorganization.
September 15, 2015	Updated to version 2.0.60.8. Updated the device node name to include a period before the device index. Removed double underscore that prefaced various data types.
February 28, 2014	Updated to version 1.5.52.0. Updated the kernel support data.
January 8, 2014	Updated to version 1.4.51.0. Updated the kernel support data.
November 6, 2013	Updated to version 1.4.48.0.
July 18, 2013	Updated to version 1.4.45.0. Updated the kernel support data.
July 23, 2012	Updated to version 1.4.39.0.
May 22, 2012	Updated to version 1.3.37.0.
May 3, 2012	Updated to version 1.2.37.0. Updated the kernel support data. Added arguments to the <code>savedata</code> sample application. Updated the upper input buffer threshold limit value.
April 3, 2011	Updated to version 1.1.23.0. Various editorial changes. Removed some IOCTL services and added others.
November 24, 2010	Initial release.