DS1104 R&D Controller Board

Hardware Installation and Configuration

For DS1104 and CP1104/CLP1104 Connector Panels

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dSPACE

How to Contact dSPACE

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

How to Contact dSPACE Support

If you encounter a problem when using dSPACE products, contact your local dSPACE representative:

- Local dSPACE companies and distributors: http://www.dspace.com/go/locations
- For countries not listed, contact dSPACE GmbH in Paderborn, Germany.
  Tel.: +49 5251 1638-941 or e-mail: support@dspace.de

You can also use the support request form: http://www.dspace.com/go/supportrequest. If you are logged on to mydSPACE, you are automatically identified and do not need to add your contact details manually.

If possible, always provide the relevant dSPACE License ID or the serial number of the CmContainer in your support request.

Software Updates and Patches

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

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dSPACE GmbH
Rathenaustraße 26
33102 Paderborn
Germany

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Contents

About This Document

Contents

This document will show you the installation and hardware configuration of the DS1104 R&D Controller Board and CP1104/CLP1104 Connector Panels.

It describes the hardware installation procedure and shows how to configure the hardware. It also gives you information about connecting external devices to the dSPACE system.

Required knowledge

Knowledge in handling computer hardware and Microsoft Windows operating systems is presupposed.

Symbols

dSPACE user documentation uses the following symbols:

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

Naming conventions

dSPACE user documentation uses the following naming conventions:

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

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

Special folders

Some software products use the following special folders:

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

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

or

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

Documents folder A standard folder for user-specific documents.

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

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

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

Accessing dSPACE Help and PDF Files

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

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

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

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

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

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

Safety Precautions

Introduction

To avoid risk of injury and/or damage to the dSPACE hardware, read and ensure that you comply with the following safety precautions. These precautions must be observed during all phases of system operation.

dSPACE General Safety Precautions

In addition to the safety precautions given in this document, read the dSPACE General Safety Precautions. This document describes the risks of injury and damage to the dSPACE hardware in general.

A printed document of the dSPACE General Safety Precautions is delivered together with your hardware. You can also find the document in PDF format on the dSPACE DVD.

Where to go from here

Information in this section

Intended Use

Intended use of DS1104 R&D Controller Board

The DS1104 R&D Controller Board is intended to be used as rapid control prototyping (RCP) system for the development, research, and test of functions for electronic control units (ECU).

Using the DS1104 R&D Controller Board for purposes other than these is considered to be improper and non-contractual use.

Safety Precautions for Installing and Connecting the Hardware

User qualification

Only qualified persons with experience in installing computer hardware and electric devices are allowed to install or uninstall hardware.

Installation sequence

- Read the instructions carefully before starting installation.
- Note all given warnings.
- Install the components of your system in the exact order stated.

  Any other sequence may lead to unpredictable results or even damage the system. For the installation and configuration procedure, refer to Installation and Configuration Overview on page 15.

Handling hardware with electrostatic sensitive devices

dSPACE hardware contains sensitive electronic devices. There is a risk of damaging the hardware or reducing its lifetime due to electrical fields or electrostatic discharge (ESD) that occur on touch. To avoid this risk, take the following precautions:

- Only qualified persons with knowledge of protective measures for electrostatic sensitive devices are allowed to unpack, install, or remove sensitive electronic devices.
- During the transport and storage of a sensitive electronic device, place it in closed ESD packaging.
- While handling a sensitive electronic device, place it on a properly grounded workstation, such as a special ESD desk or desk mat.
- You must ensure potential equalization between the environment and you, e.g., by wearing a grounded ESD wristband.
- Do not touch the board or the contacts of the connectors, even after installing the sensitive electronic device.

Handling boards with fans

Improper handling will damage the fan of the board:

- Do not touch any components of the fan, neither during operation nor when it has stopped.
- Do not try to stop a rotating fan with your fingers or with the help of tools.
- Do not apply pressure to the fan bearing during installation and removal of the board.

Installing or uninstalling hardware

You install and uninstall dSPACE hardware at your own risk. Any damage to or malfunction of dSPACE hardware caused by improper installation or

uninstallation is not covered by the warranty, unless the handling and installation instructions are shown to be defective.

Before doing any installation or uninstallation work, make sure that:

- The power supply of the host PC is switched off.
- No external devices are connected to the dSPACE system.

  In case of a fault, connected external devices might conduct dangerous high voltage to the dSPACE system or parts of the circuitry.

Connecting and disconnecting devices

To prevent damage to the hardware:

- Do not apply voltages or currents outside the specified ranges to the connector pins.
- Do not connect or disconnect any devices while the dSPACE system is powered up and/or external devices are switched on. Make sure that external devices are turned off beforehand.

Safe In-Vehicle Use of dSPACE Products

Guidelines for safe in-vehicle use of dSPACE products

Any in-vehicle use of dSPACE products in line with the contractual purposes requires the use of enclosed test tracks that are specially safety-secured for the specific purpose, i.e., with appropriately restricted access and additional appropriate safety measures.

If you intend to use dSPACE products outside enclosed tracks, you have to check with the relevant authorities in your country under which circumstances this is possible. You and the local authorities involved bear full responsibility for this type of use.

You must take appropriate measures to ensure that the overall system enters a safe state if a dangerous situation occurs, e.g., by implementing emergency shutdown or a limp-home mode. This particularly applies in the following cases:

- Where safety-critical interventions that affect vehicle behavior are performed, e.g., the stimulation of a bus system, such as CAN, or the calibration or bypassing of in-vehicle electronic control units (ECUs) that control powertrain, chassis, or body systems.
- Where dSPACE products are deployed in conjunction with ECUs that can pose a hazard if they malfunction.

Accordingly, the guidelines apply to the use of dSPACE products in aircraft or vessels in compliance with the contractual purposes.

Safety Precautions for Using Connector Panels

Guidelines for trouble-free use

- Before connecting a panel to a board, make sure that the PC is turned off and no external devices are connected to the panel.
- No chemicals other than alcohol (ethanol or isopropanol) should be used to remove writing from the panel templates, since they might damage the permanent print on the templates or even corrode the panel.
- Guard against foreign objects (staples, etc.) falling or blowing into the unit, or liquids being spilled into it.
- Do not expose the panel to excessive dust.

Notes on Disposal

Disposing dSPACE hardware

You must ensure that dSPACE hardware is disposed of in accordance with the applicable regional rules and regulations. You are strongly recommended to contact the regional waste management authorities to find a disposal or recycling center for the proper and environmentally sound disposal of dSPACE hardware (e-waste). Recycle or reuse dSPACE hardware wherever possible.

Introduction to the DS1104

Objective

The dSPACE system based on DS1104 R&D Controller Board comprises hardware and software.

Where to go from here

Information in this section

Hardware

Board description

The DS1104 R&D Controller Board is a standard board that is available in two variants: one with a PCI host interface and one with a PCIe (PCI Express) host interface. It can be plugged into a PCI slot or a PCI Express (PCIe) slot of a PC. The DS1104 is specifically designed for the development of high-speed multivariable digital controllers and real-time simulations in various fields. It is a complete real-time control system based on a 603 PowerPC floating-point processor running at 250 MHz. For advanced I/O purposes, the board includes a slave-DSP subsystem based on the TMS320F240 DSP microcontroller.

For purposes of rapid control prototyping (RCP), specific interface connectors and connector panels (see below) provide easy access to all input and output signals of the board. Thus, the DS1104 R&D Controller Board is the ideal hardware for the dSPACE Prototyper development system for cost-sensitive RCP applications.

To demonstrate control design and implementation, demo equipment (VCFP Simulator) is available for the DS1104.

Easy access to input and output signals

Using an *adapter cable* you can link your external signals from the 100-pin I/O connector on the board to Sub-D connectors. So you can make a high-density connection between the board and the devices of your application via Sub-D connectors.

Specific interface *connector panels* provide easy access to all the input and output signals of the DS1104 R&D Controller Board:

- The CP1104 *C*onnector *P*anel provides easy-to-use connections between the DS1104 R&D Controller Board and devices to be connected to it. Devices can be individually connected, disconnected or interchanged without soldering via BNC connectors and Sub-D connectors. This simplifies system construction, testing and troubleshooting.
- In addition to the CP1104, the CLP1104 *C*onnector/*L*ED Combi *P*anel provides an array of LEDs indicating the states of the digital signals.

Shipment

The DS1104 R&D Controller Board is a single-board system. The hardware package contains:

- One PCI-slot (or PCIe-slot) board with a bracket including a 100-pin I/O connector.
- One adapter cable with two 50-pin female Sub-D connectors. The adapter cable is optional.
- Only if ordered: CP1104 (or CLP1104) Connector Panel with adapter cable to the I/O connector of the board.

Software

Host PC software

The dSPACE software, such as the implementation and the experiment software, comes on DVD and has to be installed first. For further information, refer to Basics on dSPACE Software Installation (Installing dSPACE Software 🕮). You can find the document in PDF format on the dSPACE DVD.

Before You Start

First steps

Make yourself familiar with the installation and configuration procedures of the DS1104 R&D Controller Board and check if your system fulfills the system requirements.

Where to go from here

Information in this section

Installation and Configuration Overview

Installation sequence

NOTICE

Changing the installation sequence may lead to unpredictable results or even damage the system.

- Install the components of your system in exactly the order stated.
- Read the instructions carefully before starting installation.
- Consider all given warnings.

Installing the DS1104 requires the following steps in the specified order.

1. Check whether the software has been installed on the host PC.

   You must first install the software before installing any hardware component to the host PC. For detailed instructions on installing the software, refer to Installing dSPACE Software 🕮.

Note

You need administrator rights to install dSPACE software.

2. Check whether your hardware meets the requirements for DS1104. Refer to Checking the System Requirements on page 17.
3. Now you can install the hardware. Refer to Installing the Hardware on page 19.

Installation problems

Tip

If you encounter any problems during installation and configuration:

- Check the Support section of our website.
  See http://www.dspace.com/go/support.
- The FAQ section and application notes provide a lot of useful information.
  See http://www.dspace.com/go/FAQ.
- To stay up-to-date with information on possible problems, you should periodically check the known problem reports.
  See http://www.dspace.com/go/ProblemReports.

If self-help does not solve the problem, contact dSPACE Support and give them information about your dSPACE environment and the problems you have. The best way to do this is with the support request form provided on the website at http://www.dspace.com/go/supportrequest, but you can also send an e-mail or phone us. For details, refer to Providing Diagnostic Information 🕮.

Next steps

After you install and configure your system, you are ready to implement a model – either via a Simulink model including blocks from dSPACE's Real-Time Interface (RTI) or via a handcoded algorithm – and download the corresponding application to your real-time hardware. You can use ControlDesk to experiment with your real-time application. Refer to DS100x, DS110x, MicroAutoBox II, MicroLabBox – Software Getting Started 🕮.

External devices

For information on connecting external devices of your application to the dSPACE system, refer to Connecting External Devices to the dSPACE System on page 25.

Related topics

Basics

Checking the System Requirements

Introduction

Before installing dSPACE's hardware, you have to check whether your hardware meets the system requirements.

Host PC

Your host PC must fulfill the system requirements concerning the dSPACE software, other required third-party software and the hardware equipment.

For details, refer to Appendix (Installing dSPACE Software 🕮).

Note

It is not possible to install the DS1104 in an expansion box.

Installing the Hardware

Where to go from here

Information in this section

Information in other sections

Installing the DS1104

Objective

You can install as many DS1104 boards as free PCI (or PCIe) slots are available in your host PC.

How to Install the DS1104

Objective

The following instructions will guide you through the installation of the DS1104 R&D Controller Board.

Important notes

Note

You install dSPACE hardware at your own risk. Only qualified persons with experience in installing computer hardware and electric devices should perform the installation. Any damage to or malfunction of dSPACE hardware caused by improper installation is not covered by the warranty, unless the handling and installation instructions are shown to be defective.

Note

Working with more than one dSPACE board in plug & play configuration may cause assignment problems. For details, refer to Problems with Multiple Plug & Play Boards on page 96.

Preconditions

- The host PC is switched off.
- Precautions are taken to avoid damage by high electrostatic voltages. For details, refer to Safety Precautions for Installing and Connecting the Hardware on page 10.

Method

To install the DS1104 in the host PC

⚠ WARNING

Hazardous voltages

Risk of electric shock and/or damage to the hardware

Before doing any installation work, make sure that:

- The power supply of the host PC is switched off.
- No external device is connected to the dSPACE system.

1 Open the enclosure of the PC.

NOTICE

Improper handling will damage the fan of the board.

- Do not touch any components of the fan, neither during operation nor when it has stopped.
- Do not apply pressure to the fan bearing during installation and deinstallation of the board.

2 Select an unused PCI or PCIe slot.

3 Unscrew and remove the bracket that covers the card-slot opening on the rear side of the enclosure.

4 Insert the board in the slot. Press it down firmly so that the contacts are securely seated in the slot.

5 When the board is firmly seated in the slot, secure the bracket with the screw you removed in step 4.

6 Close the enclosure and reconnect the PC to the power supply.

7 Turn on the host PC.

Result

- The host PC should boot as usual. Now you can run ControlDesk to verify the installation. Refer to How to Measure Variable Values (DS100x, DS110x, MicroAutoBox II, MicroLabBox – Software Getting Started 🕮).
- If the PC does not boot, switch off the power supply immediately and check that the board is inserted firmly.

Installing a Connector Panel

Objective

The CP and CLP connector panels provide easy-to-use connections between the board and external devices. Devices can be individually connected, disconnected or interchanged without soldering. This simplifies system construction, testing and troubleshooting.

The CLPs additionally provide arrays of LEDs, which indicate the states of the digital signals.

Where to go from here

Information in this section

How to Connect a Panel (CP, CLP) to a Board

Safety precautions

For safe and trouble-free operation of the panels, various guidelines must be observed. For details, refer to Safety Precautions for Using Connector Panels on page 12.

Preconditions

- The system is switched off.
- If the panel is to be mounted in a 19" rack, this should be done first (see How to Mount a Panel in a 19" Rack on page 23).

Method

To connect a panel to the DS1104

NOTICE

Connecting external devices while the power supply is switched on may damage the dSPACE hardware.

- Do not connect or disconnect any device while the power supply is switched on.
- Turn off the host PC and the external devices beforehand.

1 Plug the CP1104 or CLP1104 to the DS1104 and tighten the lock screws. Take care not to mix up the connectors of the DS1104. Connectors are installed correctly when ribbon cables are not twisted and do not cross over each other. Furthermore, the connectors are marked by labels P1A, P1B, etc.

2 Put templates on the panel. Turn the black clips on the panel through 90 degrees to secure the templates to the panel.

Next steps

Now you can:

- Connect devices to the panel. For detailed instructions, refer to How to Connect External Devices to a Connector Panel on page 27.
- Switch on the dSPACE system.

Related topics

Basics

Safety Precautions for Using Connector Panels 12

HowTos

How to Connect External Devices to a Connector Panel 27

How to Mount a Panel in a 19" Rack

Objective

As a standard, the CP1104 or CLP1104 Connector Panels are installed in a desktop box made from aluminum profiles. They can optionally be mounted in a 19" industry rack.

Preconditions

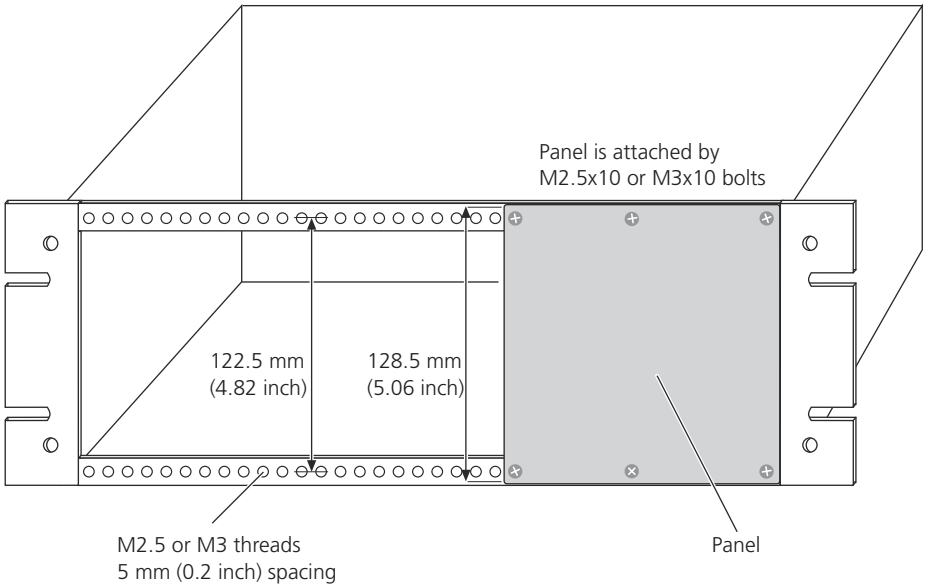
- The system is switched off.
- All connections to external devices are removed.

Method

To mount panels in a standard 19" industry rack

1 Remove the aluminum box. To do so, unscrew one of its side panels (4 screws). If there is a ribbon cable strain relief at the bottom of the box, it must be cut open.

2 Bolt the panel to the front of a 19" rack as shown below. Depending on the rack used, several M2.5x10 or M3x10 bolts are required.



Connecting External Devices to the dSPACE System

Objective

Prior to connecting external devices to the board or a connector panel, make sure that you are familiar with the related instructions.

Where to go from here

Information in this section

How to Connect External Devices to a Board

Method

To connect external devices to the DS1104

⚠ CAUTION

Connected components can cause fire

electrical energy at the I/O pins, which can cause a fire if external components such as sensors/actuators are not appropriately connected. This particularly concerns the VSENS, VBATprot, and the USB ports pins.

- To prevent a fire, apply the general fire safety regulations, e.g., supervise the operation, remove fire loads, and use fire-proof materials and enclosures.

NOTICE

Connecting external devices while the power supply is switched on may damage the dSPACE hardware.

- Do not connect or disconnect any device while the power supply is switched on.
- Turn off the host PC and the external devices beforehand.

1. Turn off all external devices which are to be connected to the dSPACE system.
2. Turn off the host PC.
3. Disconnect the host PC and all devices connected to it from the power supply.

⚠ WARNING

Hazardous voltages

Risk of electric shock and/or damage to the hardware

- Do not connect any high-voltage devices to the I/O connectors of the hardware.
- Do not apply voltages/currents outside the specified ranges to the connector pins.

4. Connect the devices belonging to your application to the DS1104 via the adapter cable.

Note

Do not mix up the connectors of the adapter cable. They are labeled P1A, P1B.

5. Reconnect the host PC and all external devices to the power supply.
6. Turn on the host PC.
   The host PC should boot as usual.
7. Turn on all external devices connected to the dSPACE system.

Related topics

HowTos

How to Connect External Devices to a Connector Panel.....27

How to Connect External Devices to a Connector Panel

Method

To connect external devices to a connector panel

⚠ CAUTION

Connected components can cause fire

electrical energy at the I/O pins, which can cause a fire if external components such as sensors/actuators are not appropriately connected. This particularly concerns the VSENS, VBATprot, and the USB ports pins.

- To prevent a fire, apply the general fire safety regulations, e.g., supervise the operation, remove fire loads, and use fire-proof materials and enclosures.

NOTICE

Connecting external devices while the power supply is switched on may damage the dSPACE hardware.

- Do not connect or disconnect any device while the power supply is switched on.
- Turn off the host PC and the external devices beforehand.

1. Turn off all external devices which are to be connected to the dSPACE system.
2. Turn off the host PC.
3. Disconnect the host PC and all devices connected to it from the power supply.

   ⚠ WARNING

   Hazardous voltages

   Risk of electric shock and/or damage to the hardware

   - Do not connect any high-voltage devices to the I/O connectors of the hardware.
   - Do not apply voltages/currents outside the specified ranges to the connector pins. The isolation of the panels has been designed for low-voltage operation only.

4. Connect the devices belonging to your application to the panel.
5. Reconnect the host PC and all external devices to the power supply.
6. Turn on the host PC.

   The host PC should boot as usual.
7. Turn on all external devices connected to the dSPACE system.

Related topics

HowTos

How to Connect External Devices to a Board 25

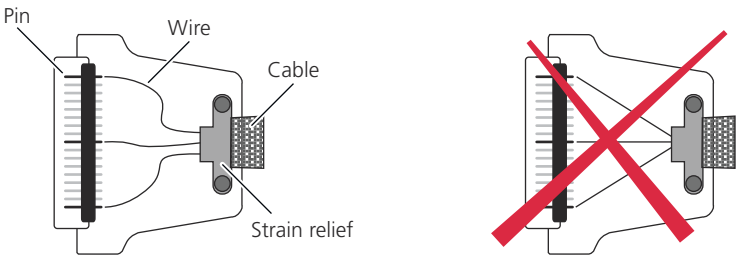
Using Sub-D Connectors

Checking connectors before first use

Before you use a crimped or soldered connector for the first time, check the following points:

- The pins are straight and not deformed.
- The contact surfaces of the male and female connectors are clean.

  Especially the contact surfaces of soldered connectors must be free from solder and flux.
- Inside the connector, the wires of the connector cable are long enough and do not stretch the connector pins.



  To easily plug the connector the pins are loosely mounted. When the connector pins are stretched, it might not be possible to connect the connector to its counterpart.
- The connector shell is mounted.

  This helps you hold the connector straight for plugging.

Plugging the connector

NOTICE

Improper plugging might deform connector pins

Using connectors with deformed connector pins might result in defective contacts and disturbed signals.

- Hold the connector shell straight and do not force the connector.

  Holding the connector at an angle might deform pins.

Uninstalling the System

Uninstallation order

All components of a dSPACE system, software and hardware, can be removed from the host PC in the following order:

1. You have to remove the software first.
2. Afterwards you can remove the hardware from the host PC.

Where to go from here

Information in this section

Removing the Hardware.....30

Information in other sections

Removing dSPACE Software (Installing dSPACE Software 🕮)

Removing the Hardware

How to Remove the Hardware

Preconditions

- The host PC is switched off.
- Precautions are taken to avoid damage by high electrostatic voltages. For details, refer to Safety Precautions for Installing and Connecting the Hardware on page 10.

Method

To remove the dSPACE board from the host PC

⚠ WARNING

Hazardous voltages

Risk of electric shock and/or damage to the hardware

Before removing any board, make sure that:

- The power supply of the host PC is switched off.
- No external device is connected to the dSPACE system.

1. Disconnect the host PC and all external devices connected to them from the power supply.
2. Unplug any external devices or connector panels from the I/O connector of the DS1104.
3. Open the enclosure of the host PC.
4. Unscrew the bracket of the DS1104.
5. Remove the DS1104 from the slot.
6. Reinstall the original bracket to cover the opening at the rear side of the enclosure.
7. Close the enclosure, reconnect the PC to the power supply, and turn it on.

Result

The host PC should boot as usual.

Related topics

Basics

Safety Precautions for Installing and Connecting the Hardware..... 10

Connector Pinouts and LEDs

Objective

This chapter provides hardware-related, reference information on the components of the DS1104 and its optional accessories, the CP1104 Connector Panel and the CLP1104 Connector/LED Combi Panel.

Where to go from here

Information in this section

Information in other sections

DS1104 Components

Connecting external devices

Note

Prior to connecting external devices to the board, ensure you have familiarized yourself with the relevant instructions provided in Connecting External Devices to the dSPACE System on page 25.

Where to go from here

Information in this section

Overview

Contains an illustration of the board, showing the location of connectors, jumpers and LEDs.

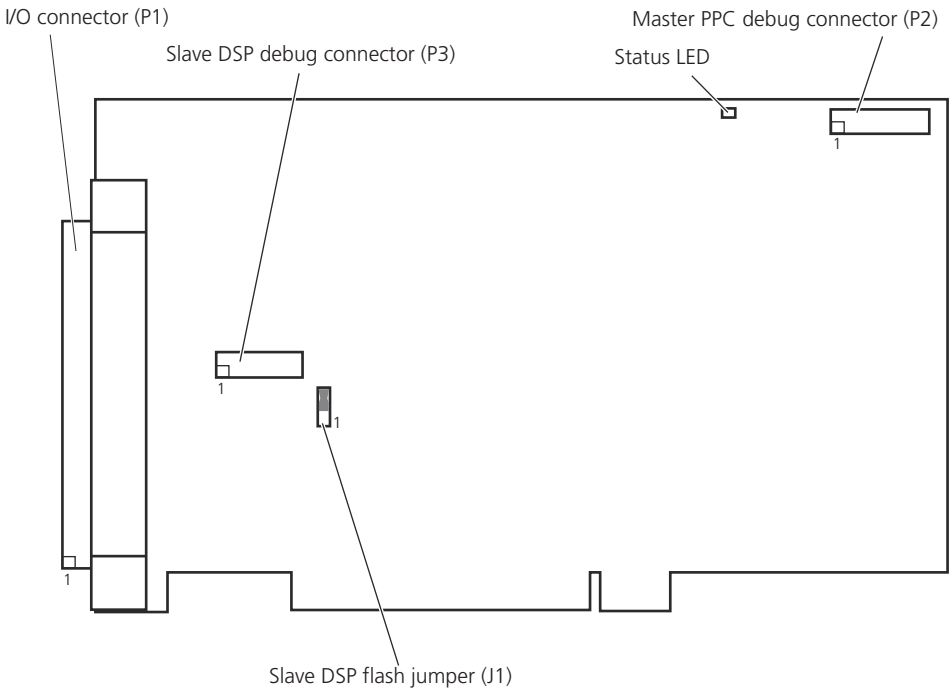
I/O connectors of the DS1104

Other components

Board Overview

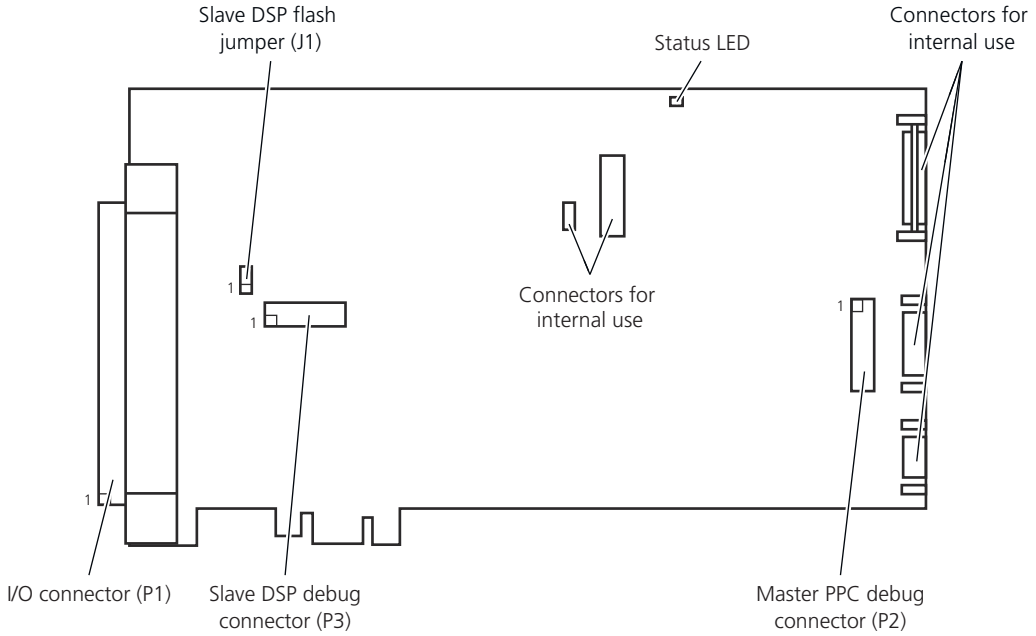
PCI-slot variant: overview illustration

The illustration shows the locations of connectors, jumpers and LEDs on the DS1104 PCI-slot variant. The illustration is not to scale.



PCIe-slot variant: overview illustration

The illustration shows the locations of connectors, jumpers and LEDs on the DS1104 PCIe-slot variant. The illustration is not to scale.



Components

Both variants of the DS1104 contain the following important elements:

- The *I/O connector (P1)* is a 100-pin connector. The signals available at this connector are described in I/O Connector (P1) on page 35.
- The *slave DSP debug connector (P3)* is a JTAG 1149.1 hardware debug connector and can be used for slave DSP debugging. The signals available at this connector are described in Slave DSP Debug Connector (P3) on page 39.
- The *slave DSP flash jumper (J1)* is used to control the protection mode of the flash memory and the watchdog mode: see Slave DSP Flash Jumper (J1) on page 40.
- The red *status LED* is equipped for troubleshooting purposes. For details, see Checking the DS1104 on page 96.
- The *master PPC debug connector (P2)* is a JTAG 1149.1 hardware debug connector and can be used for master PPC debugging. The signals available at this connector are described in Master PPC Debug Connector (P2) on page 38.

I/O Connector (P1)

Purpose

The I/O connector (P1) is a 100-pin, high density KEL connector. It is used to obtain access to the I/O signals of the board. The connector is located on the bracket of the DS1104, see DS1104 Components on page 32.

Adapter cable

Using the adapter cable supplied with the board, the I/O connector (P1) can be linked to two 50-pin, female Sub-D connectors (labeled P1A, P1B).

Signal specification

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at the I/O connector, see Signal Connection to External Devices on page 65.

Note

- For the DS1104, the total load of the connector pins providing VCC (P1 19 and P1 20; P1A 4 and P1B 4 on the Sub-D connectors) must not exceed 500 mA.
- The VCC lines are protected against short circuits by a common multifuse on the DS1104.
- If VCC is overloaded or shorted, the multifuse on the DS1104 is heated up by the overcurrent and abruptly raises its resistance. To reset the multifuse to its initial low resistance, turn off the power for some minutes to allow the multifuse to cool down.

Pinout of I/O connector

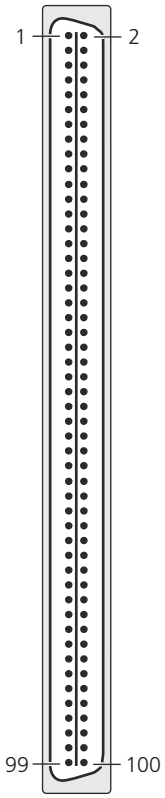
Because the pin numbering used for KEL connectors is not standardized, the following illustration shows the numbering scheme used (front view of the board connector).

Note

Do not rely on the numbers written on the KEL connectors.

The following table shows the pin assignment of the I/O connector (P1). It also provides the mapping to the Sub-D connectors of the adapter cable.

Signal names in parentheses apply when the UART is set to the RS422 or RS485 mode.

I/O Connector (P1)	Pin	Sub-D Pin	Signal	Pin	Sub-D Pin	Signal
	P1 1	P1B 1	GND	P1 2	P1A 1	GND
	P1 3	P1B 34	DCD (CTS)	P1 4	P1A 34	(RTS)
	P1 5	P1B 18	CTS ($\overline{\text{CTS}}$)	P1 6	P1A 18	RTS ($\overline{\text{RTS}}$)
	P1 7	P1B 2	DSR (RXD)	P1 8	P1A 2	DTR (TXD)
	P1 9	P1B 35	RXD ($\overline{\text{RXD}}$)	P1 10	P1A 35	TXD ($\overline{\text{TXD}}$)
	P1 11	P1B 19	SSOMI	P1 12	P1A 19	SCAP4
	P1 13	P1B 3	SSIMO	P1 14	P1A 3	SCAP3
	P1 15	P1B 36	SSTE	P1 16	P1A 36	SCAP2
	P1 17	P1B 20	SSCLK	P1 18	P1A 20	SCAP1
	P1 19	P1B 4	VCC (+5 V)	P1 20	P1A 4	VCC (+5 V)
	P1 21	P1B 37	ST3PWM	P1 22	P1A 37	SPWM6
	P1 23	P1B 21	ST2PWM	P1 24	P1A 21	SPWM5
	P1 25	P1B 5	ST1PWM	P1 26	P1A 5	SPWM4
	P1 27	P1B 38	SPWM9	P1 28	P1A 38	SPWM3
	P1 29	P1B 22	SPWM8	P1 30	P1A 22	SPWM2
	P1 31	P1B 6	SPWM7	P1 32	P1A 6	SPWM1
	P1 33	P1B 39	GND	P1 34	P1A 39	GND
	P1 35	P1B 23	$\overline{\text{IDX(2)}}$	P1 36	P1A 23	$\overline{\text{IDX(1)}}$
	P1 37	P1B 7	IDX(2)	P1 38	P1A 7	IDX(1)
	P1 39	P1B 40	$\overline{\text{PHI90(2)}}$	P1 40	P1A 40	$\overline{\text{PHI90(1)}}$
	P1 41	P1B 24	PHI90(2)	P1 42	P1A 24	PHI90(1)
	P1 43	P1B 8	$\overline{\text{PHI0(2)}}$	P1 44	P1A 8	$\overline{\text{PHI0(1)}}$
	P1 45	P1B 41	PHI0(2)	P1 46	P1A 41	PHI0(1)
	P1 47	P1B 25	GND	P1 48	P1A 25	GND
	P1 49	P1B 9	IO19	P1 50	P1A 9	IO18
	P1 51	P1B 42	IO17	P1 52	P1A 42	IO16
	P1 53	P1B 26	IO15	P1 54	P1A 26	IO14
	P1 55	P1B 10	IO13	P1 56	P1A 10	IO12
	P1 57	P1B 43	IO11	P1 58	P1A 43	IO10
	P1 59	P1B 27	IO9	P1 60	P1A 27	IO8
	P1 61	P1B 11	IO7	P1 62	P1A 11	IO6
	P1 63	P1B 44	IO5	P1 64	P1A 44	IO4
	P1 65	P1B 28	IO3	P1 66	P1A 28	IO2
	P1 67	P1B 12	IO1	P1 68	P1A 12	IO0
	P1 69	P1B 45	GND	P1 70	P1A 45	GND
	P1 71	P1B 29	DACH8	P1 72	P1A 29	DACH7
	P1 73	P1B 13	GND	P1 74	P1A 13	GND
	P1 75	P1B 46	DACH6	P1 76	P1A 46	DACH5
	P1 77	P1B 30	GND	P1 78	P1A 30	GND

I/O Connector (P1)	Pin	Sub-D Pin	Signal	Pin	Sub-D Pin	Signal
	P1 79	P1B 14	DACH4	P1 80	P1A 14	DACH3
	P1 81	P1B 47	GND	P1 82	P1A 47	GND
	P1 83	P1B 31	DACH2	P1 84	P1A 31	DACH1
	P1 85	P1B 15	GND	P1 86	P1A 15	GND
	P1 87	P1B 48	ADCH8	P1 88	P1A 48	ADCH7
	P1 89	P1B 32	GND	P1 90	P1A 32	GND
	P1 91	P1B 16	ADCH6	P1 92	P1A 16	ADCH5
	P1 93	P1B 49	GND	P1 94	P1A 49	GND
	P1 95	P1B 33	ADCH4	P1 96	P1A 33	ADCH3
	P1 97	P1B 17	GND	P1 98	P1A 17	GND
	P1 99	P1B 50	ADCH2	P1 100	P1A 50	ADCH1

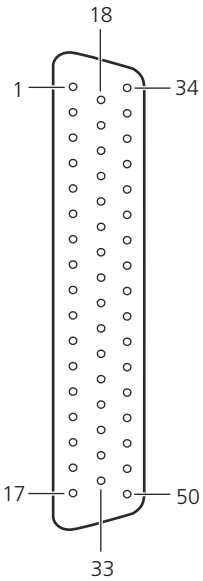
Pinout of Sub-D connectors

Because the pin numbering used for Sub-D connectors is not standardized, the following illustrations show the numbering scheme used (front view).

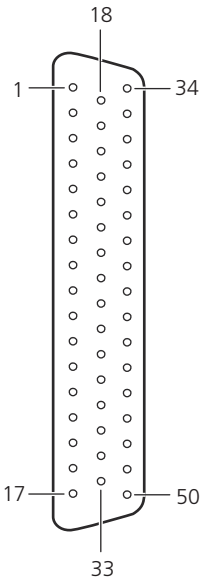
Note

Do not rely on the numbers written on Sub-D connectors.

The table below shows the pin assignment of the *Sub-D connector P1A*. Signal names in parentheses apply when the UART is set to the RS422 or RS485 mode.

Connector P1A	Pin	Signal	Pin	Signal	Pin	Signal
	1	GND			34	(RTS)
	2	DTR (TXD)	18	RTS ($\overline{\text{RTS}}$)	35	TXD ($\overline{\text{TXD}}$)
	3	SCAP3	19	SCAP4	36	SCAP2
	4	VCC (+5 V)	20	SCAP1	37	SPWM6
	5	SPWM4	21	SPWM5	38	SPWM3
	6	SPWM1	22	SPWM2	39	GND
	7	IDX(1)	23	$\overline{\text{IDX(1)}}$	40	$\overline{\text{PHI90(1)}}$
	8	$\overline{\text{PHI0(1)}}$	24	PHI90(1)	41	PHI0(1)
	9	IO18	25	GND	42	IO16
	10	IO12	26	IO14	43	IO10
	11	IO6	27	IO8	44	IO4
	12	IO0	28	IO2	45	GND
	13	GND	29	DACH7	46	DACH5
	14	DACH3	30	GND	47	GND
	15	GND	31	DACH1	48	ADCH7
	16	ADCH5	32	GND	49	GND
	17	GND	33	ADCH3	50	ADCH1

The table below shows the pin assignment of the *Sub-D connector P1B*. Signal names in parentheses apply when the UART is set to the RS422 or RS485 mode.

Connector P1B	Pin	Signal	Pin	Signal	Pin	Signal
	1	GND			34	DCD (CTS)
	2	DSR (RXD)	18	CTS ($\overline{\text{CTS}}$)	35	RXD ($\overline{\text{RXD}}$)
	3	SSIMO	19	SSOMI	36	SSTE
	4	VCC (+5 V)	20	SSCLK	37	ST3PWM
	5	ST1PWM	21	ST2PWM	38	SPWM9
	6	SPWM7	22	SPWM8	39	GND
	7	IDX(2)	23	$\overline{\text{IDX(2)}}$	40	$\overline{\text{PHI90(2)}}$
	8	$\overline{\text{PHI0(2)}}$	24	PHI90(2)	41	PHI0(2)
	9	IO19	25	GND	42	IO17
	10	IO13	26	IO15	43	IO11
	11	IO7	27	IO9	44	IO5
	12	IO1	28	IO3	45	GND
	13	GND	29	DACH8	46	DACH6
	14	DACH4	30	GND	47	GND
	15	GND	31	DACH2	48	ADCH8
	16	ADCH6	32	GND	49	GND
	17	GND	33	ADCH4	50	ADCH2

Related topics

References

DS1104 Components....32
Signal Connection to External Devices....65

Master PPC Debug Connector (P2)

Objective

The master PPC features a superset of the IEEE 1149.1 JTAG standard emulation port, which can be used for software debugging.

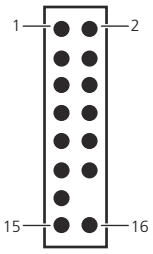
Note

The dSPACE software does not support the master PPC debug connector.

Location

For the location of the connector on the board, see DS1104 Components.

Pinout

Connector (P2)	Pin	Signal	Pin	Signal
	1	TDO	2	N/C
	3	TDI	4	$\overline{\text{TRST}}$
	5	$\overline{\text{RUN\_STP}}$	6	VDD_SENSE
	7	TCK	8	$\overline{\text{CHKSTP\_IN}}$
	9	$\overline{\text{TMS}}$	10	N/C
	11	N/C	12	N/C
	13	$\overline{\text{HRESET}}$	14	
	15	$\overline{\text{CKSTP\_OUT}}$	16	GND

Slave DSP Debug Connector (P3)

Objective

The TMS320F240 slave DSP features a superset of the IEEE 1149.1 JTAG standard emulation port. This emulation port can be used for software debugging. The DS1104 contains a JTAG connector to connect an external emulator such as the Texas Instruments XDS510.

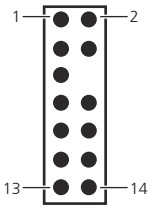
Note

The dSPACE software does not support the slave DSP debug connector.

Location

For the location of the connector on the board, see Board Overview on page 33.

Pinout

Connector	Pin	Signal	Pin	Signal
	1	TMS	2	$\overline{\text{TRST}}$
	3	TDI	4	GND
	5	VCC	6	
	7	TDO	8	GND
	9	TCK	10	GND
	11	TCK	12	GND
	13	EMU0	14	EMU1

Slave DSP Flash Jumper (J1)

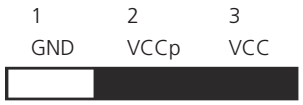
Objective

The slave DSP contains an on-chip flash memory. The flash jumper (see Board Overview on page 33) is used to set the protection mode of the flash memory and the slave DSP watchdog mode.

Jumper settings

The VCCp pin of the TMS320F240 slave DSP selects the protection mode of the flash memory and the slave DSP watchdog mode:

- If the jumper connects VCCp to VCC (default setting):
  - erase/write operations to the flash memory are enabled
  - the watchdog is disabled
- If the jumper connects VCCp to GND:
  - erase/write operations to the flash memory are disabled
  - the watchdog is enabled



Note

The dSPACE software does not support the watchdog of the slave DSP. For this reason, do not change the jumper's default setting shown above.

CP1104/CLP1104 Components

Objective

The connector panels CP1104 and CLP1104 provide easy-to-use connections between the DS1104 and devices to be connected to it. Devices can be individually connected, disconnected or interchanged without soldering. This simplifies system construction, testing and troubleshooting.

Where to go from here

Information in this section

Panel Overview

Connecting devices

Note

Prior to connecting external devices to the connector panel, ensure you have familiarized yourself with the relevant instructions provided in How to Connect External Devices to a Connector Panel on page 27.

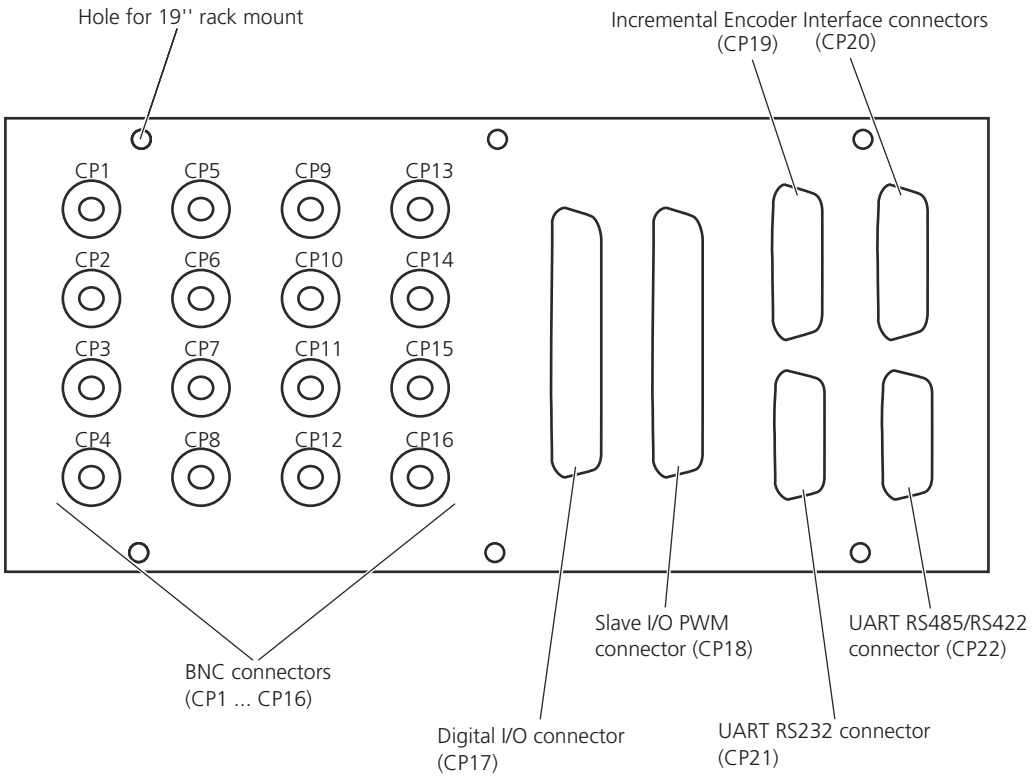
⚠ WARNING

Hazardous voltages

Risk of electric shock and/or damage to the hardware

- Do not connect any high-voltage devices to the I/O connectors of the panel.

Connectors



Note

- For the CP1104 and CLP1104 Connector Panels, the total load of *all* connector pins that provide access to the PC power supply must not exceed 500 mA (CP1104) or 400 mA (CLP1104).
- The VCC lines are protected against short circuits by a common multifuse on the DS1104.
- If VCC is overloaded or shorted, the multifuse on the DS1104 is heated up by the overcurrent and abruptly raises its resistance. To reset the multifuse to its initial low resistance, turn off the power for some minutes to allow the multifuse to cool down.

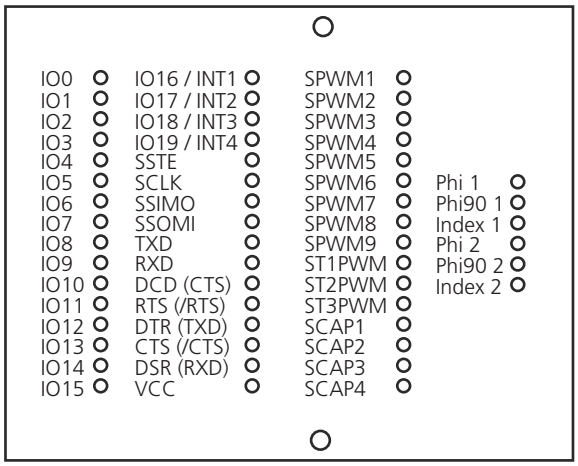
CLP1104 LED Assignments

Objective

The CLP1104 Connector/LED Combi Panel additionally provides an array of 54 LEDs, which indicate the states of the digital signals.

LED assignment

In the illustration below you will find the signal names as labeled on the panel template.



Note

The LEDs display the TTL signal level, not the active status of the signal. (TTL "high" → LED is on; TTL "low" → LED is off).

Electrical characteristics

In order to keep the loading of the signals as low as possible, the LEDs are run through buffers.

For the incremental sensor signals, there are buffers with true differential inputs. The pulse length of data signals of the UART (RXD, TXD) is extended to make even small blocks of data visible.

The power required by the LEDs is taken from the DS1104's supply voltage (VCC).

BNC Connectors (CP1 ... CP16)

Objective

The CP1 ... CP16 connectors are female BNC connectors. Their shells are connected to GND.

Pinout

Connector	Signal	Connector	Signal	Connector	Signal	Connector	Signal
CP1	ADCH1	CP5	ADCH5	CP9	DACH1	CP13	DACH5
CP2	ADCH2	CP6	ADCH6	CP10	DACH2	CP14	DACH6

Connector	Signal	Connector	Signal	Connector	Signal	Connector	Signal
CP3	ADCH3	CP7	ADCH7	CP11	DACH3	CP15	DACH7
CP4	ADCH4	CP8	ADCH8	CP12	DACH4	CP16	DACH8

Note

In order to avoid poor performance of the analog subsystems, do not create ground loops within the BNC wiring.

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at the BNC connectors, see Analog Inputs on page 66 and Analog Outputs on page 68.

Related topics

References

Digital I/O Connector (CP17)

Objective

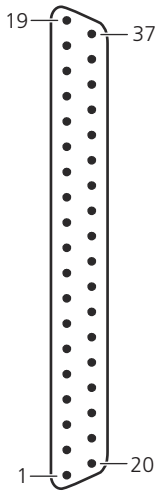
The digital I/O connector (CP17) is a 37-pin, male Sub-D connector located on the front of the connector panel.

Pinout

Because the pin numbering used for Sub-D connectors is not standardized, the following illustration shows the numbering scheme used (front view).

Note

Do not rely on the numbers written on Sub-D connectors.

Connector (CP17)	Pin	Signal	Pin	Signal
	19	GND		
	18	GND	37	VCC (+5 V)
	17	GND	36	VCC (+5 V)
	16	GND	35	GND
	15	IO19	34	GND
	14	IO17	33	IO18
	13	GND	32	IO16
	12	IO15	31	GND
	11	IO13	30	IO14
	10	GND	29	IO12
	9	IO11	28	GND
	8	IO9	27	IO10
	7	GND	26	IO8
	6	IO7	25	GND
	5	IO5	24	IO6
	4	GND	23	IO4
	3	IO3	22	GND
	2	IO1	21	IO2
	1	GND	20	IO0

Note

For the CP1104 and CLP1104 Connector Panels, the total load of *all* connector pins that provide access to the PC power supply must not exceed 500 mA (CP1104) or 400 mA (CLP1104).

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at this connector, see Bit I/O on page 70.

Related topics

References

Bit I/O 70

Slave I/O PWM Connector (CP18)

Objective

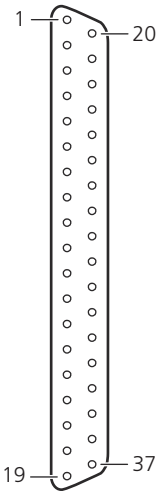
The slave I/O PWM connector (CP18) is a 37-pin, female Sub-D connector located on the front of the connector panel.

Pinout

Because the pin numbering used for Sub-D connectors is not standardized, the following illustration shows the numbering scheme used (front view).

Note

Do not rely on the numbers written on Sub-D connectors.

Connector (CP18)	Pin	Signal	Pin	Signal
	1	GND		
	2	SCAP1	20	GND
	3	SCAP3	21	SCAP2
	4	GND	22	SCAP4
	5	ST2PWM	23	ST1PWM
	6	GND	24	ST3PWM
	7	SPWM1	25	GND
	8	SPWM3	26	SPWM2
	9	SPWM5	27	SPWM4
	10	SPWM7	28	SPWM6
	11	SPWM9	29	SPWM8
	12	GND	30	GND
	13	GND	31	GND
	14	GND	32	GND
	15	GND	33	GND
	16	SSIMO	34	SSOMI
	17	SCLK	35	SSTE
	18	VCC (+5 V)	36	GND
	19	VCC (+5 V)	37	GND

Note

For the CP1104 and CLP1104 Connector Panels, the total load of *all* connector pins that provide access to the PC power supply must not exceed 500 mA (CP1104) or 400 mA (CLP1104).

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at this connector, see Slave DSP Digital I/O on page 73.

Related topics

References

Slave DSP Digital I/O 73

Incremental Encoder Interface Connectors (CP19, CP20)

Objective

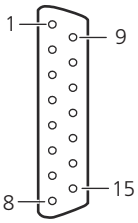
The incremental encoder interface connectors CP19 and CP20 are 15-pin, female Sub-D connectors located on the front of the connector panel. Each of the connectors provides the signals for one of the two available incremental encoder channels.

Pinout

Because the pin numbering used for Sub-D connectors is not standardized, the following illustration shows the numbering scheme used (front view).

Note

Do not rely on the numbers written on Sub-D connectors.

Connector (CP19, CP20)	Pin	Signal	Pin	Signal
	1	VCC (+5 V)		
	2	PHI0(x)	9	VCC (+5 V)
	3	$\overline{\text{PHI0(x)}}$	10	GND
	4	PHI90(x)	11	GND
	5	$\overline{\text{PHI90(x)}}$	12	GND
	6	IDX(x)	13	GND
	7	$\overline{\text{IDX(x)}}$	14	GND
	8	GND	15	GND

x corresponds to the two available incremental encoder channels: Channel 1 is connected to CP19 (x = 1), channel 2 is connected to CP20 (x = 2).

Note

For the CP1104 and CLP1104 Connector Panels, the total load of *all* connector pins that provide access to the PC power supply must not exceed 500 mA (CP1104) or 400 mA (CLP1104).

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at this connector, see Incremental Encoder Interface on page 76.

Related topics

References

Incremental Encoder Interface 76

UART RS232 Connector (CP21)

Objective

The UART RS232 connector CP21 is a 9-pin, male Sub-D connector located on the front of the connector panel. The pinout has been adapted from the 9-pin RS232 connector of a PC.

Note

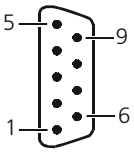
The DS1104 supports one serial interface. In RS232 mode the signals are available from the RS232 connector CP21. In RS422/485 mode the signals are available from the RS422/485 connector CP22. CP21 and CP22 are mutually exclusive and cannot be used at the same time.

Pinout

Because the pin numbering used for Sub-D connectors is not standardized, the following illustration shows the numbering scheme used (front view).

Note

Do not rely on the numbers written on Sub-D connectors.

Connector (CP21)	Pin	Signal	Pin	Signal
	5	GND		
	4	DTR (TXD)	9	Not used
	3	TXD ($\overline{\text{TXD}}$)	8	CTS ($\overline{\text{CTS}}$)
	2	RXD ($\overline{\text{RXD}}$)	7	RTS ($\overline{\text{RTS}}$)
	1	DCD (CTS)	6	DSR (RXD)

Signal names in parentheses apply when the UART is set to the RS422 or RS485 mode. However, you should use the UART RS422/RS485 Connector (CP22) on page 49 instead, when you are using RS422/485 mode.

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at this connector, see Serial Interface on page 82.

Related topics

References

UART RS422/RS485 Connector (CP22)

Objective

The UART RS422/RS485 connector CP22 is a 9-pin, male Sub-D connector located on the front of the connector panel.

Note

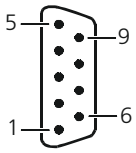
The DS1104 supports one serial interface. In RS232 mode the signals are available from the RS232 connector CP21. In RS422/485 mode the signals are available from the RS422/485 connector CP22. CP21 and CP22 are mutually exclusive and cannot be used at the same time.

Pinout

Because the pin numbering used for Sub-D connectors is not standardized, the following illustration shows the numbering scheme used (front view).

Note

Do not rely on the numbers written on Sub-D connectors.

Connector (CP22)	Pin	Signal	Pin	Signal
	5	GND		
	4	$\overline{\text{RXD}}$	9	$\overline{\text{CTS}}$
	3	RXD	8	CTS
	2	TXD	7	RTS
	1	$\overline{\text{TXD}}$	6	$\overline{\text{RTS}}$

For detailed information (I/O circuits, electrical characteristics, etc.) on the I/O lines terminating at this connector, see Serial Interface on page 82.

Related topics

References

Serial Interface.....82

Mapping of I/O Signals

Objective

Various connector pins can be assigned to RTI blocks and RTLib functions.

Where to go from here

Information in this section

Signal Mapping to I/O Pins

Objective

The following table lists the I/O signals of the DS1104 by function groups, their electrical specifications, and the mapping of these signals to RTI blocks and RTLib functions.

The table also provides the mapping of the I/O signals to the I/O pins on the DS1104, on the Sub-D connectors (P1A, P1B), and on the CP1104/CLP1104 connector panels.

Conflicting I/O features

Some I/O features of the DS1104 conflict with other I/O features. In the table below, these signals are marked with an asterisk "*".

For an overview, see Conflicting I/O Features on page 58.

Signal mapping

Signal	Channel/Bit Numbers of Related RTI Blocks/RTLib Functions				I/O Pin on …		
	Related RTI Block(s)	Ch/Bit (RTI)	Related RTLib Functions	Ch/Bit (RTLib)	DS1104	Sub-D Conn.	CP/CLP
ADC Unit							
▪ Input voltage range: ±10 V ▪ ADCH1 … ADCH4: input for A/D converter with 16-bit resolution ▪ ADCH5 … ADCH8: input for A/D converter with 12-bit resolution ▪ I/O circuit and further electrical characteristics: see Analog Inputs on page 66							
ADCH1	DS1104MUX_ADC	Ch 1	See *ADC Unit (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 100	P1A 50	CP1
ADCH2		Ch 2		Ch 2	P1 99	P1B 50	CP2
ADCH3		Ch 3		Ch 3	P1 96	P1A 33	CP3
ADCH4		Ch 4		Ch 4	P1 95	P1B 33	CP4
ADCH5	DS1104ADC_Cx	Ch 5	See *ADC Unit (DS1104 RTLib Reference* 🕮*)*	Ch 5	P1 92	P1A 16	CP5
ADCH6		Ch 6		Ch 6	P1 91	P1B 16	CP6
ADCH7		Ch 7		Ch 7	P1 88	P1A 48	CP7
ADCH8		Ch 8		Ch 8	P1 87	P1B 48	CP8
DAC Unit							
▪ Output voltage range: ±10 V ▪ Output current range: ±5 mA ▪ DACH1 … DACH8: D/A converter output with 16-bit resolution ▪ I/O circuit and further electrical characteristics: see Analog Outputs on page 68							
DACH1	DS1104DAC_Cx	Ch 1	See *DAC Unit (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 84	P1A 31	CP9
DACH2		Ch 2		Ch 2	P1 83	P1B 31	CP10
DACH3		Ch 3		Ch 3	P1 80	P1A 14	CP11
DACH4		Ch 4		Ch 4	P1 79	P1B 14	CP12
DACH5		Ch 5		Ch 5	P1 76	P1A 46	CP13
DACH6		Ch 6		Ch 6	P1 75	P1B 46	CP14
DACH7		Ch 7		Ch 7	P1 72	P1A 29	CP15
DACH8		Ch 8		Ch 8	P1 71	P1B 29	CP16
Bit I/O Unit							
▪ TTL voltage range ▪ Output current range: ±5 mA							

Signal	Channel/Bit Numbers of Related RTI Blocks/RTLib Functions				I/O Pin on …		
	Related RTI Block(s)	Ch/Bit (RTI)	Related RTLib Functions	Ch/Bit (RTLib)	DS1104	Sub-D Conn.	CP/CLP
▪ I/O circuit and further electrical characteristics: see Bit I/O on page 70							
IO0	DS1104BIT_IN_Cx/ DS1104BIT_OUT_Cx	Bit 0	See *Bit I/O Unit (DS1104 RTLib Reference* 🕮*)*	Bit 0	P1 68	P1A 12	CP17 20
IO1		Bit 1		Bit 1	P1 67	P1B 12	CP17 2
IO2		Bit 2		Bit 2	P1 66	P1A 28	CP17 21
IO3		Bit 3		Bit 3	P1 65	P1B 28	CP17 3
IO4		Bit 4		Bit 4	P1 64	P1A 44	CP17 23
IO5		Bit 5		Bit 5	P1 63	P1B 44	CP17 5
IO6		Bit 6		Bit 6	P1 62	P1A 11	CP17 24
IO7		Bit 7		Bit 7	P1 61	P1B 11	CP17 6
IO8		Bit 8		Bit 8	P1 60	P1A 27	CP17 26
IO9		Bit 9		Bit 9	P1 59	P1B 27	CP17 8
IO10		Bit 10		Bit 10	P1 58	P1A 43	CP17 27
IO11		Bit 11		Bit 11	P1 57	P1B 43	CP17 9
IO12		Bit 12		Bit 12	P1 56	P1A 10	CP17 29
IO13		Bit 13		Bit 13	P1 55	P1B 10	CP17 11
IO14		Bit 14		Bit 14	P1 54	P1A 26	CP17 30
IO15		Bit 15		Bit 15	P1 53	P1B 26	CP17 12
IO16 *		Bit 16		Bit 16	P1 52	P1A 42	CP17 32
IO17 *		Bit 17		Bit 17	P1 51	P1B 42	CP17 14
IO18 *		Bit 18		Bit 18	P1 50	P1A 9	CP17 33
IO19 *		Bit 19		Bit 19	P1 49	P1B 9	CP17 15
Incremental Encoder Interface							
▪ TTL or RS422 input voltage range ▪ PHI0(x): digital incremental encoder interface input 0° ($\overline{\text{PHI0(x)}}$: inverted signal) ▪ PHI90(x): digital incremental encoder interface input 90° ($\overline{\text{PHI90(x)}}$: inverted signal) ▪ IDX(x): digital incremental encoder interface index input ($\overline{\text{IDX(x)}}$: inverted signal) ▪ I/O circuit and further electrical characteristics: see Incremental Encoder Interface on page 76							
PHI0(1)	DS1104ENC_SETUP/ DS1104ENC_POS_Cx/ DS1104ENC_SET_POS_Cx	Ch 1	See *Incremental Encoder Interface (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 46	P1A 41	CP19 2
$\overline{\text{PHI0(1)}}$					P1 44	P1A 8	CP19 3
PHI90(1)					P1 42	P1A 24	CP19 4
$\overline{\text{PHI90(1)}}$					P1 40	P1A 40	CP19 5
PHI0(2)		Ch 2		Ch 2	P1 45	P1B 41	CP20 2
$\overline{\text{PHI0(2)}}$					P1 43	P1B 8	CP20 3
PHI90(2)					P1 41	P1B 24	CP20 4
$\overline{\text{PHI90(2)}}$					P1 39	P1B 40	CP20 5
IDX(1)	DS1104ENC_SETUP/ DS1104ENC_HW_INDEX_Cx/ DS1104ENC_SW_INDEX_Cx	Ch 1	See *Incremental Encoder Interface (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 38	P1A 7	CP19 6
$\overline{\text{IDX(1)}}$					P1 36	P1A 23	CP19 7
IDX(2)		Ch 2		Ch 2	P1 37	P1B 7	CP20 6
$\overline{\text{IDX(2)}}$					P1 35	P1B 23	CP20 7

Signal	Channel/Bit Numbers of Related RTI Blocks/RTLib Functions				I/O Pin on …		
	Related RTI Block(s)	Ch/Bit (RTI)	Related RTLib Functions	Ch/Bit (RTLib)	DS1104	Sub-D Conn.	CP/CLP
Serial Interface *(RS232 mode)*							
▪ RS232 voltage range ▪ DCD (data carrier detect), CTS (clear to send), RTS (ready to send), DSR (data set ready), DTR (data terminal ready), RXD (receive), TXD (transmit) ▪ I/O circuit and further electrical characteristics: see Serial Interface on page 82							
DCD *	DS1104SER_SETUP/ DS1104SER_STAT/ DS1104SER_TX/ DS1104SER_RX/ DS1104SER_INT_ly/ DS1104SER_INT_REC_LEV		See Serial Interface Communication (DS1104 RTLib Reference 🕮)		P1 3	P1B 34	CP21 1
CTS *					P1 5	P1B 18	CP21 8
RTS *					P1 6	P1A 18	CP21 7
DSR *					P1 7	P1B 2	CP21 6
DTR *					P1 8	P1A 2	CP21 4
RXD *					P1 9	P1B 35	CP21 2
TXD *					P1 10	P1A 35	CP21 3
Serial Interface *(RS422/RS485 mode)*							
▪ RS422/RS485 voltage range ▪ CTS, $\overline{\text{CTS}}$ (clear to send and inverted signal), RTS, $\overline{\text{RTS}}$ (ready to send and inverted signal), RXD, $\overline{\text{RXD}}$ (receive and inverted signal), TXD, $\overline{\text{TXD}}$ (transmit and inverted signal) ▪ I/O circuit and further electrical characteristics: see Serial Interface on page 82							
CTS *	DS1104SER_SETUP/ DS1104SER_STAT/ DS1104SER_TX/ DS1104SER_RX/ DS1104SER_INT_ly/ DS1104SER_INT_REC_LEV		See Serial Interface Communication (DS1104 RTLib Reference 🕮)		P1 3	P1B 34	CP22 8
RTS *					P1 4	P1A 34	CP22 7
$\overline{\text{CTS}}$ *					P1 5	P1B 18	CP22 9
$\overline{\text{RTS}}$ *					P1 6	P1A 18	CP22 6
RXD *					P1 7	P1B 2	CP22 3
TXD *					P1 8	P1A 2	CP22 2
$\overline{\text{RXD}}$ *					P1 9	P1B 35	CP22 4
$\overline{\text{TXD}}$ *					P1 10	P1A 35	CP22 1
Slave DSP Bit I/O Unit							
▪ TTL voltage range ▪ Output current range: ±13 mA ▪ I/O circuit and further electrical characteristics: see Slave DSP Digital I/O on page 73							
SPWM7 *	DS1104SL_DSP_BIT_IN_Cx/ DS1104SL_DSP_BIT_OUT_Cx	Bit 0	See *Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)*	Group 2 bit 0	P1 31	P1B 6	CP18 10
SPWM8 *		Bit 1		Group 2 bit 1	P1 29	P1B 22	CP18 29
SPWM9 *		Bit 2		Group 2 bit 2	P1 27	P1B 38	CP18 11
ST1PWM *		Bit 3		Group 2 bit 3	P1 25	P1B 5	CP18 23
ST2PWM *		Bit 4		Group 2 bit 4	P1 23	P1B 21	CP18 5
ST3PWM		Bit 5		Group 2	P1 21	P1B 37	CP18 24

Signal	Channel/Bit Numbers of Related RTI Blocks/RTLib Functions				I/O Pin on …		
	Related RTI Block(s)	Ch/Bit (RTI)	Related RTLib Functions	Ch/Bit (RTLib)	DS1104	Sub-D Conn.	CP/CLP
				bit 5			
SCAP1 *		Bit 6		Group 3 bit 4	P1 18	P1A 20	CP18 2
SCAP2 *		Bit 7		Group 3 bit 5	P1 16	P1A 36	CP18 21
SCAP3 *		Bit 8		Group 3 bit 6	P1 14	P1A 3	CP18 3
SCAP4 *		Bit 9		Group 3 bit 7	P1 12	P1A 19	CP18 22
SCLK *		Bit 10		Group 4 bit 0	P1 17	P1B 20	CP18 17
SSTE *		Bit 11		Group 4 bit 1	P1 15	P1B 36	CP18 35
SSIMO *		Bit 12		Group 4 bit 2	P1 13	P1B 3	CP18 16
SSOMI *		Bit 13		Group 4 bit 3	P1 11	P1B 19	CP18 34
1-Phase PWM Signal Generation (PWM), 3-Phase PWM Signal Generation (PWM3), Space Vector PWM Signal Generation (PWMSV)							
▪ TTL output voltage range ▪ Output current range: ±13 mA ▪ I/O circuit and further electrical characteristics: see Slave DSP Digital I/O on page 73							
ST2PWM *	DS1104SL_DSP_PWM	Ch 1	See *Slave DSP PWM Generation (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 23	P1B 21	CP18 5
SPWM7 *		Ch 2		Ch 2	P1 31	P1B 6	CP18 10
SPWM8 *		Ch 3		Ch 3	P1 29	P1B 22	CP18 29
SPWM9 *		Ch 4		Ch 4	P1 27	P1B 38	CP18 11
SPWM1 *	DS1104SL_DSP_PWM3/ DS1104SL_DSP_PWMSV	Phase 1	See *Slave DSP PWM3 Generation (DS1104 RTLib Reference* 🕮*)*/ *Slave DSP PWMSV Generation (DS1104 RTLib Reference* 🕮*)*	Phase 1	P1 32	P1A 6	CP18 7
SPWM3 *		Phase 2		Phase 2	P1 28	P1A 38	CP18 8
SPWM5 *		Phase 3		Phase 3	P1 24	P1A 21	CP18 9
SPWM2		Phase 1 (inverted)		Phase 1 (inverted)	P1 30	P1A 22	CP18 26
SPWM4		Phase 2 (inverted)		Phase 2 (inverted)	P1 26	P1A 5	CP18 27
SPWM6		Phase 3 (inverted)		Phase 3 (inverted)	P1 22	P1A 37	CP18 28
Slave DSP Square-Wave Signal Generation (D2F)							
▪ TTL output voltage range ▪ Output current range: ±13 mA							

Signal	Channel/Bit Numbers of Related RTI Blocks/RTLib Functions				I/O Pin on …		
	Related RTI Block(s)	Ch/Bit (RTI)	Related RTLib Functions	Ch/Bit (RTLib)	DS1104	Sub-D Conn.	CP/CLP
▪ I/O circuit and further electrical characteristics: see Slave DSP Digital I/O on page 73							
SPWM1 *	DS1104SL_DSP_D2F	Ch 1	See *Square Wave Signal Generation (D2F) (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 32	P1A 6	CP18 7
SPWM3 *		Ch 2		Ch 2	P1 28	P1A 38	CP18 8
SPWM5 *		Ch 3		Ch 3	P1 24	P1A 21	CP18 9
ST2PWM *		Ch 4		Ch 4	P1 23	P1B 21	CP18 5
Slave DSP PWM Signal Measurement (PWM2D)							
▪ TTL input voltage range ▪ I/O circuit and further electrical characteristics: see Slave DSP Digital I/O on page 73							
SCAP1 *	DS1104SL_DSP_PWM2D	Ch 1	See *Slave DSP PWM Measurement (PWM2D) (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 18	P1A 20	CP18 2
SCAP2 *		Ch 2		Ch 2	P1 16	P1A 36	CP18 21
SCAP3 *		Ch 3		Ch 3	P1 14	P1A 3	CP18 3
SCAP4 *		Ch 4		Ch 4	P1 12	P1A 19	CP18 22
Slave DSP Square-Wave Signal Measurement (F2D)							
▪ TTL input voltage range ▪ I/O circuit and further electrical characteristics: see Slave DSP Digital I/O on page 73							
SCAP1 *	DS1104SL_DSP_F2D	Ch 1	See *Square Wave Signal Generation (D2F) (DS1104 RTLib Reference* 🕮*)*	Ch 1	P1 18	P1A 20	CP18 2
SCAP2 *		Ch 2		Ch 2	P1 16	P1A 36	CP18 21
SCAP3 *		Ch 3		Ch 3	P1 14	P1A 3	CP18 3
SCAP4 *		Ch 4		Ch 4	P1 12	P1A 19	CP18 22
Slave DSP Serial Peripheral Interface (SPI)							
▪ TTL voltage range ▪ Output current range: ±13 mA ▪ SSOMI: SPI slave out, master in ▪ SSIMO: SPI slave in, master out ▪ SSTE: SPI slave transmit enable ▪ SSCLK: SPI clock ▪ I/O circuit and further electrical characteristics: see Slave DSP Digital I/O on page 73							
SSOMI *	–		See *Slave DSP Serial Peripheral Interface (DS1104 RTLib Reference* 🕮*)*		P1 11	P1B 19	CP18 34
SSIMO *	–				P1 13	P1B 3	CP18 16
SSTE *	–				P1 15	P1B 36	CP18 35
SSCLK *	–				P1 17	P1B 20	CP18 17
User Interrupts							
▪ TTL input voltage range ▪ I/O circuit and further electrical characteristics: see Bit I/O on page 70							
IO16 *	DS1104MASTER_HWINT_Ix	User int 1	See *Interrupt Handling (DS1104 RTLib Reference* 🕮*)*	Ext int 0	P1 52	P1A 42	CP17 32
IO17 *		User int 2		Ext int 1	P1 51	P1B 42	CP17 14
IO18 *		User int 3		Ext int 2	P1 50	P1A 9	CP17 33
IO19 *		User int 4		Ext int 3	P1 49	P1B 9	CP17 15

GND pins

The following I/O pins provide GND potential:

Connector		Pin
DS1104		
I/O Connector	P1	1, 2, 33, 34, 47, 48, 69, 70, 73, 74, 77, 78, 81, 82, 85, 86, 89, 90, 93, 94, 97, 98
Sub-D Connector	P1A	1, 13, 15, 17, 25, 30, 32, 39, 45, 47, 49
	P1B	1, 13, 15, 17, 25, 30, 32, 39, 45, 47, 49
CP1104/CLP1104 Connector Panel		
BNC	CP1 … CP16	Shell
Digital I/O	CP17	1, 4, 7, 10, 13, 16 … 19, 22, 25, 28, 31, 34, 35
Slave I/O	CP18	1, 4, 6, 12 … 15, 20, 25, 30 … 33, 36, 37
Incremental Encoder Interface	CP19, CP20	8, 10 … 15
UART RS232 and RS485/422	CP21, >CP22	5

GND of the DS1104 is internally connected to PC ground.

VCC pins

The following I/O pins provide access to the PC power supply VCC (+5 V):

Connector		Pin
DS1104		
I/O Connector	P1	19, 20
Sub-D Connector	P1A	4
	P1B	4
CP1104/CLP1104 Connector Panel		
Digital I/O	CP17	36, 37
Slave I/O	CP18	18, 19
Incremental Encoder Interface	CP19, CP20	1, 9

Note

- For the DS1104, the total load of the connector pins P1 19 and P1 20 (pins P1B 4 and P1A 4 on the Sub-D connector) must not exceed 500 mA.
- For the connector panels CP1104 and CLP1104, the total load of all connector pins that provide access to the PC power supply must not exceed 500 mA (CP1104) or 400 mA (CLP1104).

Conflicting I/O Features

Types of I/O conflicts

There are I/O features that share the same board resources.

Conflicts concerning single I/O channels There are conflicts that concern single channels of an I/O feature. The dSPACE board provides only a limited number of I/O pins. The same pins can be shared by different I/O features. However, a pin can serve as the I/O channel for only one feature at a time.

Conflicts concerning an I/O feature as a whole There are conflicts that concern the use of an I/O feature as a whole. Suppose two I/O features of the dSPACE board use the same on-board timer device. In this case, only one of the two I/O features can be used at a time. The other feature is completely blocked.

Conflicts for the DS1104

The following I/O features of the DS1104 conflict with other I/O features:

- Conflicts for the Bit I/O Unit on page 58
- Conflicts for the Serial Interface on page 59
- Conflicts for External Triggering on page 59
- Conflicts for the Slave DSP Bit I/O Unit on page 59
- Conflicts for Slave DSP 1-Phase PWM Signal Generation (PWM) on page 60
- Conflicts for Slave DSP 3-Phase PWM Signal Generation (PWM3) on page 61
- Conflicts for Slave DSP Space Vector PWM Signal Generation (PWMSV) on page 61
- Conflicts for Slave DSP Square-Wave Signal Generation (D2F) on page 62
- Conflicts for Slave DSP PWM Signal Measurement (PWM2D) on page 63
- Conflicts for Slave DSP Square-Wave Signal Measurement (F2D) on page 63
- Conflicts for the Slave DSP Serial Peripheral Interface (SPI) on page 64

Conflicts for the Bit I/O Unit

The following I/O features of the DS1104 conflict with the Bit I/O unit:

Bit I/O Unit *)		**Signal**	**Conflicting I/O Feature **)**		
Bit (RTI)	**Bit (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning Single Bits					
Bit 16	Bit 16	IO16	User interrupt	User Int 1	Ext Int 0
Bit 17	Bit 17	IO17	User interrupt	User Int 2	Ext Int 1
Bit 18	Bit 18	IO18	User interrupt	User Int 3	Ext Int 2
Bit 19	Bit 19	IO19	User interrupt	User Int 4	Ext Int 3
*) Related RTI blocks and RTLib functions: ▪ DS1104BIT_IN_Cx DS1104BIT_OUT_Cx ▪ See Bit I/O Unit (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: ▪ DS1104MASTER_HWINT_Ix ▪ See Interrupt Handling (DS1104 RTLib Reference 🕮)		

Conflicts for the Serial Interface

The master PPC of the DS1104 supports only one serial interface. It can be configured as either RS232 or RS422/RS485 transceiver.

Conflicts for External Triggering

Enabling the external trigger conflicts with the slave DSP bit I/O unit. You cannot use the following bits for digital I/O purposes at the same time:

External Trigger Signal		**Signal**	**Conflicting I/O Feature **)**		
Bit (RTI)	**Bit (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning External Triggering					
External Trigger			SPWM7	Bit 0	Group 2 bit 0
			SPWM8	Bit 1	Group 2 bit 1
			SPWM9	Bit 2	Group 2 bit 2
			ST1PWM (used for triggering)	Bit 3	Group 2 bit 3
			ST2PWM	Bit 4	Group 2 bit 4
			ST3PWM	Bit 5	Group 2 bit 5
*) Related RTI blocks and RTLib functions: ▪ DS1104SYNC_IO_SETUP ▪ See Synchronous I/O Trigger			**) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ See Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)		

Conflicts for the Slave DSP Bit I/O Unit

The following I/O features of the DS1104 conflict with the Slave DSP Bit I/O unit:

Slave DSP Bit I/O Unit *)		**Signal**	**Conflicting I/O Feature **)**		
Bit (RTI)	**Bit (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning Single Bits					
Bit 0	Group 2, bit 0	SPWM7	▪ PWM ▪ External Trigger	Ch 2	Ch 2
Bit 1	Group 2, bit 1	SPWM8	▪ PWM ▪ External Trigger	Ch 3	Ch 3
Bit 2	Group 2, bit 2	SPWM9	▪ PWM ▪ External Trigger	Ch 4	Ch 4
Bit 3	Group 2, bit 3	ST1PWM	▪ Slave DSP PWM int ▪ External Trigger		
Bit 4	Group 2, bit 4	ST2PWM	▪ PWM ▪ D2F ▪ External Trigger	▪ Ch 1 ▪ Ch 4	▪ Ch 1 ▪ Ch 4
Bit 5	Group 2, bit 5	ST3PWM	External Trigger		
Bit 6	Group 3, bit 4	SCAP1	PWM2D/F2D	Ch 1	Ch 1

Slave DSP Bit I/O Unit *)		Signal	Conflicting I/O Feature **)		
Bit (RTI)	**Bit (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Bit 7	Group 3, bit 5	SCAP2	PWM2D/F2D	Ch 2	Ch 2
Bit 8	Group 3, bit 6	SCAP3	PWM2D/F2D	Ch 3	Ch 3
Bit 9	Group 3, bit 7	SCAP4	PWM2D/F2D	Ch 4	Ch 4
Bit 10	Group 4, bit 0	SCLK	SPI	–	
Bit 11	Group 4, bit 1	SSTE	SPI	–	
Bit 12	Group 4, bit 2	SSIMO	SPI	–	
Bit 13	Group 4, bit 3	SSOMI	SPI	–	
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ See Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: PWM: ▪ DS1104SL_DSP_PWM ▪ See Slave DSP PWM Generation (DS1104 RTLib Reference 🕮) Slave DSP PWM int: ▪ DS1104SLAVE_PWMINT ▪ See ds1104_slave_dsp_pwm3_int_init (DS1104 RTLib Reference 🕮) D2F: ▪ DS1104SL_DSP_D2F ▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮) PWM2D/F2D: ▪ DS1104SL_DSP_PWM2D DS1104SL_DSP_F2D ▪ See Slave DSP PWM Measurement (PWM2D)/Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮) SPI: ▪ See Slave DSP Serial Peripheral Interface (DS1104 RTLib Reference 🕮)		

Conflicts for Slave DSP 1-Phase PWM Signal Generation (PWM)

The following I/O features of the DS1104 conflict with Slave DSP 1-Phase PWM Signal Generation:

Slave DSP 1-Phase PWM Signal Generation (PWM) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	**Ch (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning Slave DSP 1-Phase PWM Signal Generation as a Whole					
▪ If you use channel 4 of D2F, you cannot generate 1-phase PWM signals at the same time.					
Conflicts Concerning Single Channels					
Ch 1	Ch 1	ST2PWM	Slave DSP Bit I/O unit	Bit 4	Group 2, bit 4
Ch 2	Ch 2	SPWM7	Slave DSP Bit I/O unit	Bit 0	Group 2, bit 0
Ch 3	Ch 3	SPWM8	Slave DSP Bit I/O unit	Bit 1	Group 2, bit 1
Ch 4	Ch 4	SPWM9	Slave DSP Bit I/O unit	Bit 2	Group 2, bit 2
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_PWM			**) Related RTI blocks and RTLib functions: D2F: ▪ DS1104SL_DSP_D2F		

Slave DSP 1-Phase PWM Signal Generation (PWM) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	Ch (RTLib)			Ch (RTI)	Ch (RTLib)
▪ See Slave DSP PWM Generation (DS1104 RTLib Reference 🕮)			▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮) Slave DSP Bit I/O Unit: ▪ DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ See Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)		

Conflicts for Slave DSP 3-Phase PWM Signal Generation (PWM3)

The following I/O features of the DS1104 conflict with Slave DSP 3-Phase PWM Signal Generation:

Slave DSP 3-Phase PWM Signal Generation (PWM3) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	Ch (RTLib)			Ch (RTI)	Ch (RTLib)
Conflicts Concerning Slave DSP 3-Phase PWM Signal Generation as a Whole					
▪ If you perform space vector PWM signal generation (PWMSV) or square-wave signal generation (D2F), you cannot generate 3-phase PWM signals at the same time.					
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_PWM3 ▪ See Slave DSP PWM3 Generation (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: PWMSV: ▪ DS1104SL_DSP_PWMSV ▪ See Slave DSP PWMSV Generation (DS1104 RTLib Reference 🕮) D2F: ▪ DS1104SL_DSP_D2F ▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮)		

Conflicts for Slave DSP Space Vector PWM Signal Generation (PWMSV)

The following I/O features of the DS1104 conflict with Slave DSP Space Vector PWM Signal Generation:

Slave DSP Space Vector PWM Signal Generation (PWMSV) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	Ch (RTLib)			Ch (RTI)	Ch (RTLib)
Conflicts Concerning Slave DSP 3-Phase PWM Signal Generation as a Whole					
▪ If you perform 3-phase PWM signal generation (PWM3) or square-wave signal generation (D2F), you cannot generate space vector PWM signals at the same time.					
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_PWMSV ▪ See Slave DSP PWMSV Generation (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: 3-phase PWM signal generation (PWM3): ▪ DS1104SL_DSP_PWM3 ▪ See Slave DSP PWM3 Generation (DS1104 RTLib Reference 🕮) D2F: ▪ DS1104SL_DSP_D2F		

Slave DSP Space Vector PWM Signal Generation (PWMSV) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	**Ch (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
			▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮)		

Conflicts for Slave DSP Square-Wave Signal Generation (D2F)

The following I/O features of the DS1104 conflict with Slave DSP Square-Wave Signal Generation:

Slave DSP Square-Wave Signal Generation (D2F) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	**Ch (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning Slave DSP Square-Wave Signal Generation as a Whole					
▪ If you perform 3-phase or space vector PWM signal generation (PWM3 or PWMSV), you cannot generate square-wave signals at the same time.					
Conflicts Concerning Single Channels					
Ch 4	Ch 4	ST2PWM	▪ Slave DSP Bit I/O unit ▪ PWM	▪ Bit 4 ▪ Ch 1	▪ Group 2, bit 4 ▪ Ch 1
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_D2F ▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: PWM3/PWMSV: ▪ DS1104SL_DSP_PWM3 DS1104SL_DSP_PWMSV ▪ See Slave DSP PWM3 Generation/Slave DSP PWMSV Generation (DS1104 RTLib Reference 🕮) Slave DSP Bit I/O Unit: ▪ DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ See Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮) PWM: ▪ DS1104SL_DSP_PWM ▪ See Slave DSP PWM Generation (DS1104 RTLib Reference 🕮)		

Conflicts for Slave DSP PWM Signal Measurement (PWM2D)

The following I/O features of the DS1104 conflict with Slave DSP PWM Signal Measurement:

Slave DSP PWM Signal Measurement (PWM2D) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	**Ch (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning Slave DSP PWM Signal Measurement as a Whole					
▪ If you perform square-wave signal measurement (F2D), you cannot measure PWM signals at the same time.					
Conflicts Concerning Single Channels					
Ch 1	Ch 1	SCAP1	Slave DSP Bit I/O unit	Bit 6	Group 3, bit 4
Ch 2	Ch 2	SCAP2	Slave DSP Bit I/O unit	Bit 7	Group 3, bit 5
Ch 3	Ch 3	SCAP3	Slave DSP Bit I/O unit	Bit 8	Group 3, bit 6
Ch 4	Ch 4	SCAP4	Slave DSP Bit I/O unit	Bit 9	Group 3, bit 7
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_PWM2D ▪ See Slave DSP PWM Measurement (PWM2D) (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: F2D: ▪ DS1104SL_DSP_F2D ▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮) Slave DSP Bit I/O Unit: ▪ DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ See Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)		

Conflicts for Slave DSP Square-Wave Signal Measurement (F2D)

The following I/O features of the DS1104 conflict with Slave DSP Square-Wave Signal Measurement:

Slave DSP Square-Wave Signal Measurement (F2D) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	**Ch (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
Conflicts Concerning Slave DSP Square-Wave Signal Measurement as a Whole					
▪ If you perform PWM signal measurement (PWM2D), you cannot measure square-wave signals at the same time.					
Conflicts Concerning Single Channels					
Ch 1	Ch 1	SCAP1	Slave DSP Bit I/O unit	Bit 6	Group 3, bit 4
Ch 2	Ch 2	SCAP2	Slave DSP Bit I/O unit	Bit 7	Group 3, bit 5
Ch 3	Ch 3	SCAP3	Slave DSP Bit I/O unit	Bit 8	Group 3, bit 6
Ch 4	Ch 4	SCAP4	Slave DSP Bit I/O unit	Bit 9	Group 3, bit 7
*) Related RTI blocks and RTLib functions: ▪ DS1104SL_DSP_F2D ▪ See Square Wave Signal Generation (D2F) (DS1104 RTLib Reference 🕮)			**) Related RTI blocks and RTLib functions: PWM2D: ▪ DS1104SL_DSP_PWM2D ▪ See Slave DSP PWM Measurement (PWM2D) (DS1104 RTLib Reference 🕮)		

Slave DSP Square-Wave Signal Measurement (F2D) *)		Signal	Conflicting I/O Feature **)		
Ch (RTI)	**Ch (RTLib)**			**Ch (RTI)**	**Ch (RTLib)**
			Slave DSP Bit I/O Unit: ▪ DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ See Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)		

Conflicts for the Slave DSP Serial Peripheral Interface (SPI)

The following I/O features of the DS1104 conflict with the Slave DSP Serial Peripheral Interface (SPI):

Slave DSP Serial Peripheral Interface *)	Signal	Conflicting I/O Feature **)		
			Bit (RTI)	**Bit (RTLib)**
Conflicts Concerning the Slave DSP Serial Peripheral Interface (SPI) as a Whole				
▪ If you use the following bits of the Slave DSP Bit I/O Unit you cannot use the SPI.				
	SCLK	Slave DSP Bit I/O unit	Bit 10	Group 4, bit 0
	SSTE	Slave DSP Bit I/O unit	Bit 11	Group 4, bit 1
	SSIMO	Slave DSP Bit I/O unit	Bit 12	Group 4, bit 2
	SSOMI	Slave DSP Bit I/O unit	Bit 13	Group 4, bit 3
*) Related RTLib functions: ▪ See Slave DSP Serial Peripheral Interface (DS1104 RTLib Reference 🕮)		**) Related RTI blocks and RTLib functions: ▪ Related RTI blocks: DS1104SL_DSP_BIT_IN_Cx DS1104SL_DSP_BIT_OUT_Cx ▪ Related RTLib functions: see Slave DSP Bit I/O Unit (DS1104 RTLib Reference 🕮)		

Signal Connection to External Devices

Objective

This chapter provides descriptions of the on-board I/O circuits, lists important electrical characteristics and gives notes and tips on signal conditioning and signal connection to external devices.

The information given is sorted according to the I/O units of the DS1104.

Where to go from here

Information in this section

Analog Inputs

Objective

The DS1104 contains two different types of analog/digital converters (ADCs) for the analog input channels:

- One 16-bit ADC with four multiplexed input signals: *ADCH1* ... *ADCH4*
- Four 12-bit parallel ADCs with one input signal each: *ADCH5* ... *ADCH8*

Where to go from here

Information in this section

Hardware details

I/O Circuit and Electrical Characteristics 66

Feature description

ADC Unit (DS1104 Features 🕮)

Noise, crosstalk and inductive effects can degrade the signal and lead to incorrect results if you do not perform the following correctly:

Grounding and Shielding 88

Proper grounding and shielding reduces noise and inductive effects.

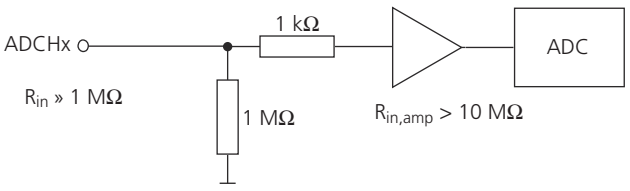
Reducing Crosstalk 91

Wiring Up External Devices 91

I/O Circuit and Electrical Characteristics

Input circuit

The following illustration is a simplified diagram of the input circuitry of the ADCs.



Electrical characteristics

The analog inputs are single-ended bipolar inputs with the following characteristics.

Parameter		**Value**	
Input voltage		Min. –10 V	Max. +10 V
Input resistance		Approx. 1 MΩ	
SNR (signal-to-noise ratio)	▪ 16-bit muxed ADCs ▪ 12-bit parallel ADCs	▪ > 80 dB ▪ > 65 dB	

Analog Outputs

Objective

The DS1104 provides a digital/analog converter (DAC) with 8 parallel DAC channels. The analog output channels are called *DACH1* ... *DACH8*.

Where to go from here

Information in this section

Hardware details

I/O Circuit and Electrical Characteristics..... 68

Feature description

DAC Unit (DS1104 Features 🕮)

Noise, crosstalk and inductive effects can degrade the signal and lead to incorrect results if you do not perform the following correctly:

Grounding and Shielding..... 88
Proper grounding and shielding reduces noise and inductive effects.

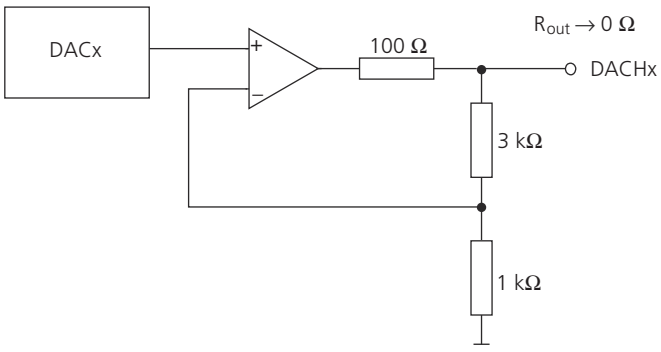
Reducing Crosstalk..... 91

Wiring Up External Devices..... 91

I/O Circuit and Electrical Characteristics

Output circuit

The following illustration is a simplified diagram of the output circuitry of the DACs.



Electrical characteristics

The analog outputs are single-ended bipolar outputs with the following characteristics.

Parameter	Value	
	Min.	Max.
Output voltage	–10 V	+10 V
Output current	–5 mA	+5 mA
Output resistance	→ 0 Ω	
Power-up default	0 V	
SNR (signal-to-noise ratio)	> 80 dB	

DAC outputs are low-impedance outputs.

Bit I/O

Objective

The DS1104 contains a bit I/O unit with 20 digital I/O pins called *IO0* ... *IO19*. You can select the direction for each bit individually by software.

Where to go from here

Information in this section

Hardware details

Feature description

Bit I/O Unit (DS1104 Features 🕮)

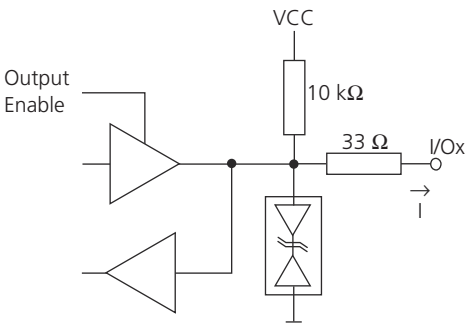
Noise, crosstalk and inductive effects can degrade the signal and lead to incorrect results if you do not perform the following correctly:

Proper grounding and shielding reduces noise and inductive effects.

I/O Circuit and Electrical Characteristics

I/O circuit

The following illustration is a simplified diagram of the input/output circuitry of the bit I/O.



Electrical characteristics

The bit I/O has TTL output/input levels with the following characteristics.

Parameter		Value	
		Min.	Max.
Input voltage	High Low	2.0 V 0 V	5.0 V 0.8 V
Output voltage	High Low	2.4 V 0 V	5.0 V 0.4 V
Output current		–5 mA	+5 mA
Input current [1)]			500 µA
Power-up default		All bit I/O output circuits are disabled and driven to VCC by the built-in 10 kΩ pull-up resistors.	

[1)] The current direction is shown in the circuit diagram above.

Changing Power-up Default

Default configuration

After power-up the bit I/O unit is configured to input mode. In this case, the I/O pins have a defined logical high level because of the built-in pull-up resistors.

Changing the configuration

If you want to change the power-up default, you can set the I/O pins to a defined logical low level by connecting a 1 kΩ pull-down resistor from ground to each I/O pin.

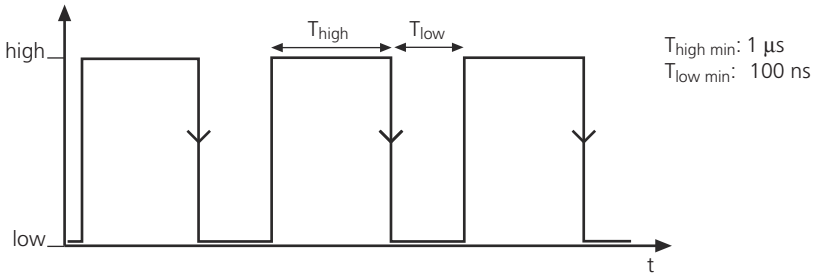
Recognizing User Interrupts

Objective

IO16 ... *IO19* can be used as external interrupt inputs.

Requests for recognizing

To allow the interrupt controller to recognize incoming user interrupts, the input of the interrupts must be kept high for at least 1 µs. The interrupt is activated by the high to low transition of the signal. The signal must remain low for at least 100 ns after the transition.


high
low
t
T_{high}
T_{low}
$T_{high\ min}$: 1 µs
$T_{low\ min}$: 100 ns

Slave DSP Digital I/O

Objective

The slave DSP of the DS1104 provides the following I/O:

- Slave DSP Bit I/O Unit
- Slave DSP Timing I/O Unit
- Slave DSP Serial Peripheral Interface

The pins of the slave DSP digital I/O are called:

- *SPWM1 ... SPWM9*
- *ST1PWM ... ST3PWM*
- *SCAP1 ... SCAP4*
- *SSOMI*
- *SSIMO*
- *SSTE*
- *SSCLK*

Where to go from here

Information in this section

Hardware details

I/O Circuit and Electrical Characteristics 74

Changing Power-up Default 74

Using the ST1PWM Pin 75

Feature description

Features Provided by the Slave DSP (DS1104 Features 🕮)

Noise, crosstalk and inductive effects can degrade the signal and lead to incorrect results if you do not perform the following correctly:

Grounding and Shielding 88

Proper grounding and shielding reduces noise and inductive effects.

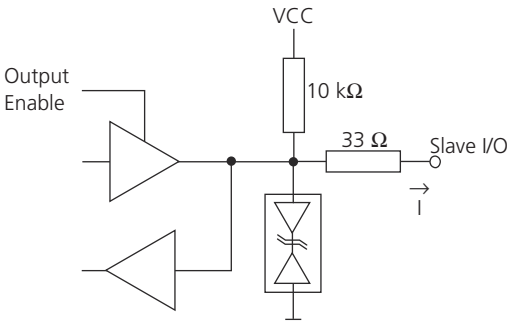
Reducing Crosstalk 91

Wiring Up External Devices 91

I/O Circuit and Electrical Characteristics

I/O circuit

The following illustration is a simplified diagram of the input/output circuitry of the slave DSP digital I/O.



Electrical characteristics

The slave DSP digital I/O have TTL output/input levels with the following characteristics.

Parameter		Value	
		Min.	Max.
Input voltage	High Low	2.0 V 0 V	5.0 V 0.8 V
Output voltage	High Low	2.4 V 0 V	5.0 V 0.4 V
Output current		–13 mA	+13 mA
Input current [1)]			500 µA
Power-up default		All digital I/O output circuits are disabled and driven to VCC by the built-in 10 kΩ pull-up resistors.	

[1)] The current direction is shown in the circuit diagram above.

Changing Power-up Default

Default configuration

After power-up the digital I/O are configured to input mode. In this case, the I/O pins have a defined logical high level because of the built-in pull-up resistors.

Changing the configuration

If you want to change the power-up default, you can set the I/O pins to a defined logical low level by connecting a 1 kΩ pull-down resistor from ground to each I/O pin.

Using the ST1PWM Pin

Objective

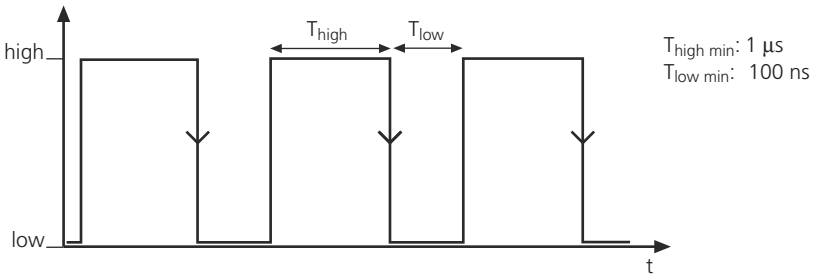
The ST1PWM pin is lead to the interrupt controller of the DS1104, so it is possible to generate interrupts that are synchronous to PWM signal generation. You can also use the pin as a further external interrupt input (user interrupt). In this case the ST1PWM pin has to be configured as an input (using RTLib1104).

Strobing I/O

In addition, you can use the ST1PWM pin for strobing the I/O (ADCs, DACs and incremental encoder signals). The required trigger signal can be either generated by the slave DSP or driven externally. In the second case the ST1PWM pin has to be configured as an input or the slave DSP must be in reset mode.

Recognizing signals at the ST1PWM pin

To allow the interrupt controller to recognize an incoming signal at the ST1PWM pin (PWM interrupt, external interrupt or trigger for strobing), the interrupt signal must be kept high for at least 1 µs. The interrupt is activated by the high to low transition of the signal. The signal must remain low for at least 100 ns after the transition.



Incremental Encoder Interface

Objective

The DS1104 provides a digital incremental encoder interface with input channels for two incremental encoders. The pins which make up the inputs are called:

- *IDX(1), $\overline{IDX(1)}$, PHI90(1), $\overline{PHI90(1)}$, PHI0(1), $\overline{PHI0(1)}$*
- *IDX(2), $\overline{IDX(2)}$, PHI90(2), $\overline{PHI90(2)}$, PHI0(2), $\overline{PHI0(2)}$*

The incremental encoder interface supports single-ended TTL and differential RS422 signals (selectable by software).

Where to go from here

Information in this section

Hardware details

I/O Circuit and Electrical Characteristics..... 77

Recognizing Encoder Index Interrupts..... 78

Connecting Encoders..... 78

Supplying Power to Encoders..... 80

Feature description

Incremental Encoder Interface (DS1104 Features 🕮)

Noise, crosstalk and inductive effects can degrade the signal and lead to incorrect results if you do not perform the following correctly:

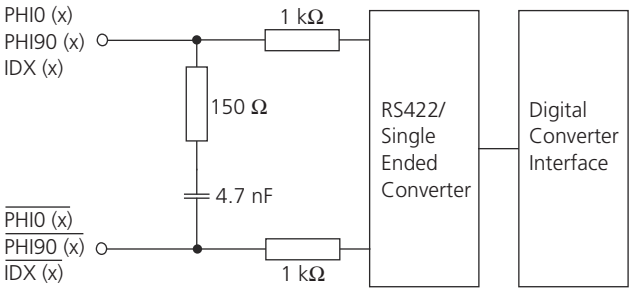
Shielding..... 90

Provides notes on cabling and connecting the shield as well as further background information.

I/O Circuit and Electrical Characteristics

Input circuit

The following illustration is a simplified diagram of the input circuitry of the digital incremental encoders.



Electrical characteristics

The encoder interface supports single-ended TTL and differential RS422 signals with the following characteristics.

Parameter		Value	
		Min.	Max.
TTL input voltage	High	2.0 V	5.0 V
	Low	0 V	0.8 V
TTL input resistance		12 kΩ	
RS422 input voltage	High	Diff > +0.2 V	
	Low	Diff < -0.2 V ▪ Diff = Voltage difference between non-inverted and inverted signal ▪ The input signal, together with the corresponding inverted signal, must be in the range 0 ... 5 V.	
RS422 input resistance		The input resistance gradually drops from 8.5 kΩ at the corner frequency of 28 kHz to 210 Ω at the corner frequency of 225 kHz.	

Encoder power supply lines

The DS1104 offers a 5 V supply voltage for the incremental encoders. These voltage outputs (*VCC*) are connected to the PC's 5 V power supply via a multifuse.

If a supply output is overloaded or shorted, the multifuse is heated by the overcurrent and abruptly increases its resistance. To reset the multifuse to its initial low resistance, remove the power for some minutes to allow the multifuse to cool down.

You should use the *VCC* supply voltages for all connected incremental sensors.

Related topics

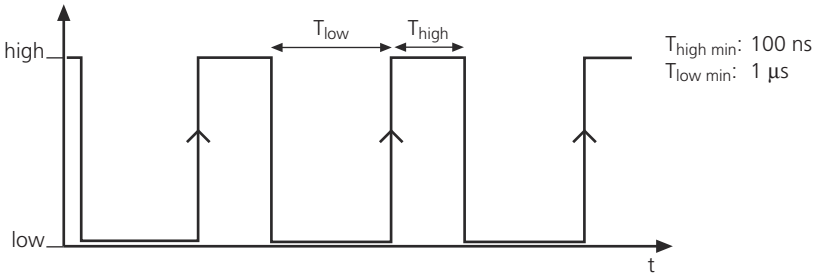
References

Connecting Encoders....78
Recognizing Encoder Index Interrupts....78
Supplying Power to Encoders....80

Recognizing Encoder Index Interrupts

Requests for recognizing

To allow the interrupt controller to recognize incoming index interrupts (IDX1, IDX2), the input of the index interrupts must be kept low for at least 1 µs. The interrupt is activated by the low to high transition of the signal. The signal must remain high for at least 100 ns after the transition from low to high.



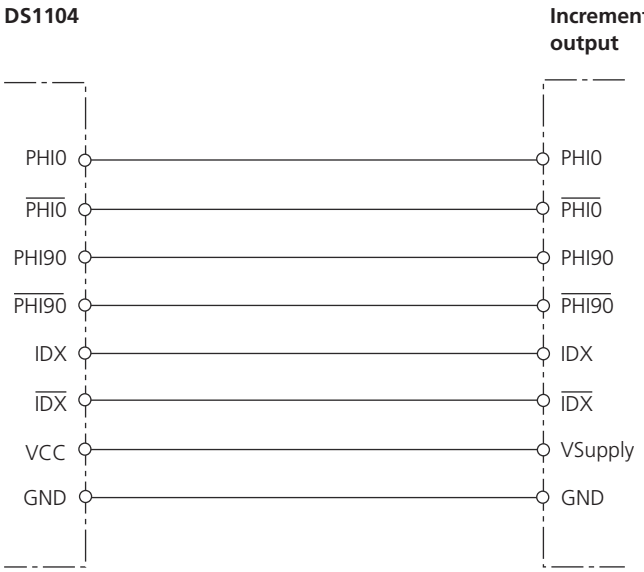
Connecting Encoders

General

To allow proper operation, do not connect the outputs of your encoder to an AC-coupling network. The input signals must be DC signals.

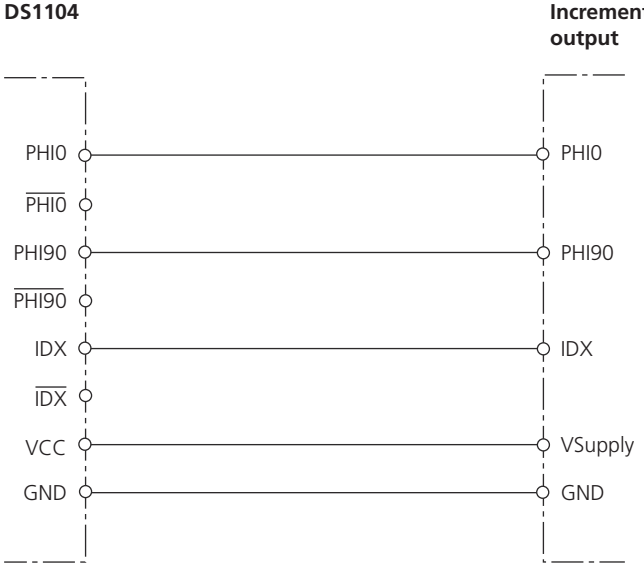
Encoder providing differential RS422 signals

Connect encoders that provide differential RS422 signals to the DS1104 as shown in the illustration below.



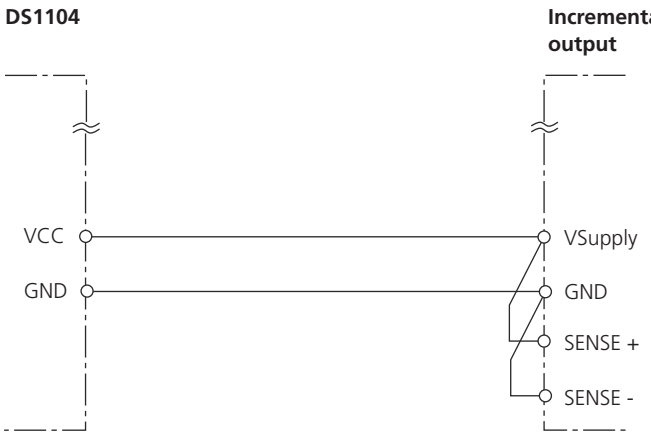
Encoder providing single-ended TTL mode

If the single ended TTL mode is used, the inverted pins PHI90, PHI0 and IDX must be left unconnected (see below).



Encoder providing SENSE lines

If your encoder has sense lines, connect SENSE+ to Vsupply and SENSE– to GND. Connect the sense lines directly within the connector of the encoder (see below).



Encoder without index signal

You can leave the IDX and $\overline{\text{IDX}}$ pins unconnected if your encoder does not provide an index signal. In this case, you cannot use RTLib functions or RTI blocks that require an index signal.

Related topics

References

Recognizing Encoder Index Interrupts 78
Supplying Power to Encoders 80

Supplying Power to Encoders

Using VCC pins

The DS1104 offers two VCC pins. You should use these supply voltages for all connected incremental encoders.

Connect both pins so that the current is shared evenly by both pins. Use wires of sufficient diameter to avoid voltage drops.

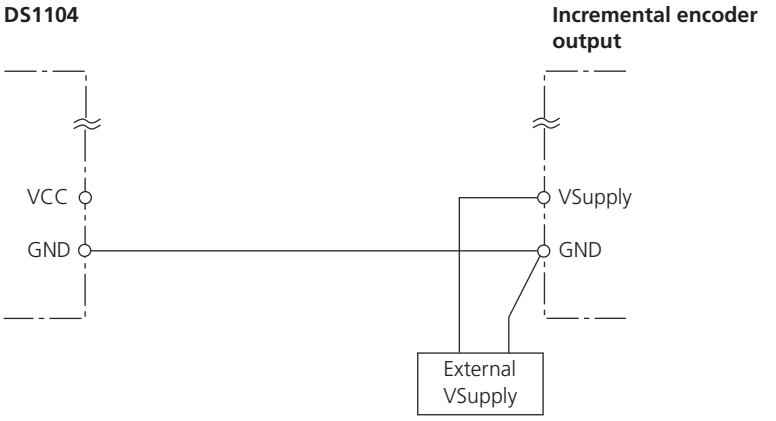
The total load of *all* connector pins that provide access to the PC power supply must not exceed 500 mA (DS1104 or via CP1104) or 400 mA (CLP1104).

Using an external power supply

If you use an external supply voltage, you have:

- To guarantee that no input voltages are fed to the DS1104 while it is switched off

- To connect the encoder's ground line to a ground pin of the board (see example below).



Related topics

References

Connecting Encoders....78
Recognizing Encoder Index Interrupts....78

Serial Interface

Objective

The DS1104 contains a Universal Asynchronous Receiver and Transmitter (UART) to perform communication with external devices. The UART can be configured as a RS232, RS422 or RS485 transceiver.

The pins of the UART are called:

- *RXD*, $\overline{RXD}$
- *TXD*, $\overline{TXD}$
- *RTS*, $\overline{RTS}$
- *CTS*, $\overline{CTS}$
- *DCD, DTR, DSR*

Where to go from here

Information in this section

Hardware details

Connecting RS232 Devices.....82

Connecting RS422/RS485 Devices.....83

Feature description

Serial Interface (DS1104 Features 🕮)
The board contains a universal asynchronous receiver and transmitter (UART) to communicate with external devices.

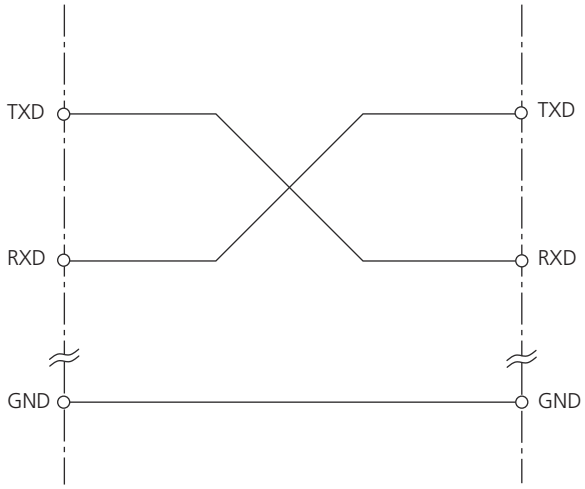
Connecting RS232 Devices

Guidelines

If you use the UART interface as an RS232 transceiver, you have to cross-connect the TXD and RXD signals for connecting external devices.

To do this, connect the pin of the TXD (output) signal to the pin of the RXD (input) signal as shown below.

DS1104 (RS232 mode) **External device** or another DS1104



Note

For some devices (e.g., modems), you should not cross-connect the TXD and RXD signals. For the correct connection refer to the manual of the device you want to connect to the DS1104.

Related topics

References

Connecting RS422/RS485 Devices 83

Connecting RS422/RS485 Devices

Objective

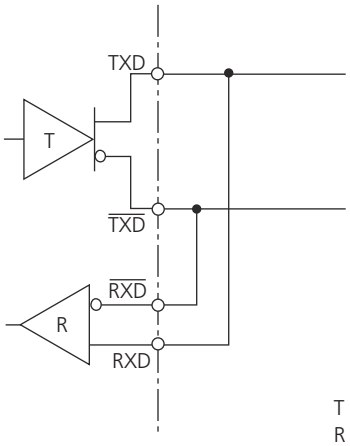
For proper operation of the UART interface you have to pay attention to *line termination* and *grounding*.

Configuration

By default, the UART interface of the DS1104 is configured as an RS422 transceiver. To use the UART as an RS485 transceiver you have to connect the following pins (see below):

- TXD signal to RXD signal
- $\overline{\text{TXD}}$ signal to $\overline{\text{RXD}}$ signal

DS1104 (RS485 mode)



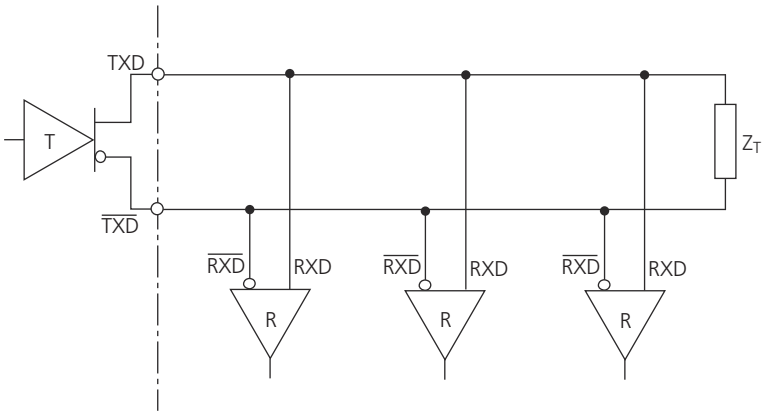
T = Transmitter
R = Receiver

Line termination

The UART chip of the DS1104 does not provide line termination. If you use the UART as an RS422 or RS485 transceiver, line termination is essential, especially for faster data transfer rates and long cables. The main reasons for correct termination are reflections at the ends of the line, and the minimum transmitter load requirement.

Because RS422 allows only one transmitter in the bus, the termination resistor is placed only at the end of the cable near the last receiver (see figure below).

DS1104 (RS422 mode)

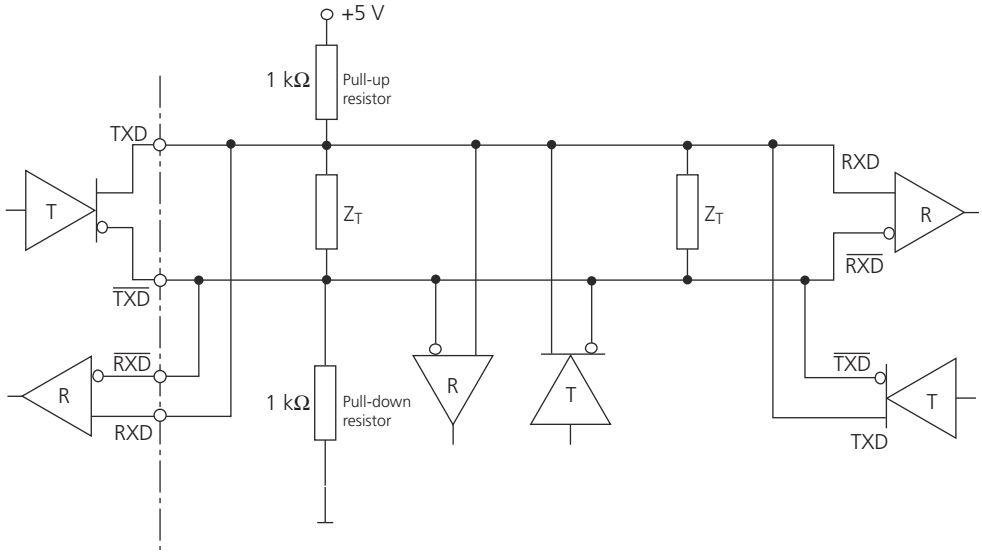


T = Transmitter
R = Receiver

The termination resistor Z_T, must be within 20% of the characteristic impedance of the cable (Z_0) and can vary from 90 Ω to 120 Ω

The figure below shows a typical 485-compliant network, with a transceiver at both ends of the cable and transmitters/receivers placed along the length of the cable. Since each device communicates bidirectionally, it is impossible to determine where the transmitter is and to which device the transmitter is currently transmitting at the moment. Moreover, it is also possible for the transmitter to be in the middle of the line. So, both ends of the line have to be terminated with a terminator.

DS1104 (RS485 mode)



T = Transmitter
R = Receiver

The termination resistor Z_T, must be within 20 % of the characteristic impedance of the cable (Z_0) and can vary from 90 Ω to 120 Ω

Avoiding undefined conditions (RS485)

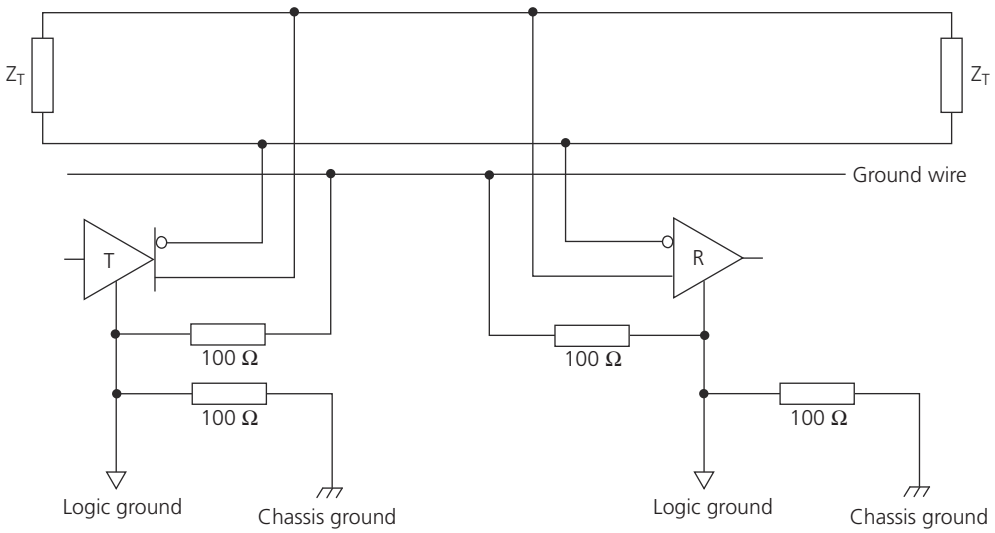
If no transmitter is currently active in an RS485 network, undefined conditions may occur. To avoid these conditions, you must provide a pull-up and a pull-down resistor (each 1 kΩ) as shown above.

Ground connection

For correct operation of the transmitter and the receiver, a return signal path between the grounding of the individual devices is required.

This has to be realized by a third wire. Here a resistor can be connected in series to limit unwanted high currents resulting from ground potential differences.

The figure below shows the grounding arrangement in an RS485 network.



T = Transmitter
R = Receiver

General Notes and Tips on Signal Conditioning

Where to go from here

Information in this section

Grounding and Shielding

Objective

Proper grounding and shielding reduces noise and inductive effects.

Tip

The advice given here also applies to the cabling of the devices inside your test bench. It is better to eliminate the cause, than to reduce the effects.

Where to go from here

Information in this section

Definitions of Different Ground Signals

Terms and their definitions

There are four classes of signals often referred to as ground signals, i.e. signal return, power ground and shield. To achieve the best results regarding signal quality, noise rejection and EMC behavior, these different ground signals must not be mixed.

- A *signal return line* is the reference potential of a signal. It should carry the same current as the corresponding signal line, and this current should be kept small.
- *Power supply ground* is the return path for the supply voltage. It carries large and varying currents resulting in significant (AC) voltage drops along the cable. Never use the same wire for signal return and power supply ground.
- *Shield* is a barrier to keep in everything inside and keep out everything outside. It is usually connected to the device enclosures at both ends to form a closed cage around all signals and cards. It is not necessarily connected to power ground.
- *Protective earth (PE)* is a reference point, which has the same potential as the surrounding earth. Connections to protective earth are intended for safety purposes.

Grounding Signals

General

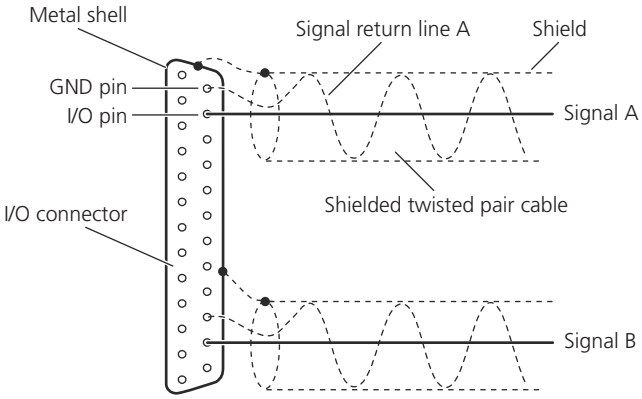
Do not use a ground line for more than one purpose. A grounding scheme has to be evaluated based on its AC current flow and not on its DC behavior. The DC resistance of a cable has only minor impact. Cable inductance plays a major role.

Avoiding ground loops and ground bounces

To avoid ground loops and ground bounces, use separate signal return (ground) lines for all connected sensors and actuators.

Each signal should have its own return line. The best results can be achieved with a shielded twisted pair cable. A twisted pair cable has the lowest inductance.

On the sensor/actuator side, connect one of the twisted wires to the signal and the other one to ground. On the board side, connect the first wire to the input/output and the second one to ground. The shield should be connected to the housing of the sensor/actuator and to the metal shell of the board connector. Do not connect the shield to ground anywhere.



If not enough ground pins are available at the connector, several return lines can be attached to a common ground pin. However, this common ground lead should be kept as short as possible to reduce ground line inductance.

If a cable contains unused leads, connect them to signal return (ground) lines at both ends to lower the inductance of the ground path between the dSPACE system and the sensor/actuator.

Star ground configuration

In a star ground configuration, ground loops are of no concern, if the signal return (ground) lines within the external devices are not connected to protective ground.

Always connect all signal return (ground) lines at both ends of a cable, i.e. board connector and sensor/actuator.

Shielding

General

The best shield is a low-inductance conductive barrier surrounding the complete setup of the device, cable and system, keeping in everything inside and keeping out everything outside (faraday cage). Low resistance, and most especially low inductance, are the key to a good shield.

EMC radiation and immunity are mostly affected by the outer cable shield. Individual lead shielding has only a minor effect if a common outer shield is present. Individual shielding is only necessary to reduce crosstalk.

Cabling

For cabling you should use shielded, twisted pair cables. The inner twisted-pair leads are used for the signal line and the return line (ground line). The return line should be connected to the ground pins of the respective board connector.

Ideally, each signal should be twisted with its return line so that any electromagnetic fields cancel one another.

Using the encoder interface with differential signals, the PHI90 line should be twisted with $\overline{\text{PHI90}}$, PHI0 with $\overline{\text{PHI0}}$ et cetera.

Connecting shield to the dSPACE system

Use a metal shell connector to the dSPACE board connector and connect the shield to the connector shell so that shield, connector shell and system enclosure form a closed shield surrounding all electronics. Use a large area connection and avoid pigtails.

Note

Do not connect the shield to the GND pins of the dSPACE system.

Connecting shield to the external device

At the other end, the shield should be connected directly to the sensor/actuator housing. Sometimes sensors and actuators have dedicated shield pins available at their connector. The idea is to form one closed shielding cage consisting of the cable shield and sensor/actuator enclosure, which is ideally nowhere connected to signal ground. Use a large area connection and avoid pigtails.

Avoiding Noise and Crosstalk

Objective

Noise and/or crosstalk can be reduced and maybe avoided by the measures listed below.

Where to go from here

Information in this section

Reducing Crosstalk

Measures

Crosstalk occurs if a signal with steep edges runs close to a high impedance analog signal. The main reason for crosstalk is inductive coupling. It can be reduced by the following measures:

- Twist each signal line with its return line (ground).
- Never twist two signal lines.
- Separate digital and analog signal lines. Keep fast-changing signals far away from analog inputs.
- Avoid connecting high-impedance sources to the inputs of the dSPACE boards.
- If you use multiconductor cables, the individual twisted pairs should be shielded.
- You should also note the advice in Wiring Up External Devices on page 91.

Wiring Up External Devices

Objective

Noise and/or crosstalk can be reduced and maybe avoided by the following measures.

Using connector panels

- Do not use a connector panel in areas of strong electromagnetic radiation. Note that a ribbon cable may pick up some of this radiation.
- If optimum signal quality is a must, avoid using connector panels. Connect your external devices to the board connectors directly.

Using BNC cables

- If your dSPACE hardware offers BNC cables: If noise is a problem, avoid the use of BNC connectors. BNC connectors use the outside of the connector for ground. They do not permit shielding.
- To avoid poor signal performance, do not create ground loops within the BNC wiring.

Cabling

- Use connections as short as possible between your test bench and the dSPACE board.
- Keep cabling away from noise sources.
- Separate signal lines from high-current or high-voltage lines. These lines are capable of inducing currents on the signal lines if they run parallel and close to them. To reduce the magnetic coupling between lines, separate them by a reasonable distance if they run in parallel, or run the lines at right angles to each other.
- Do not route signal lines through conduits that also contain power lines.
- Protect signal lines from magnetic fields caused by devices such as monitors, electric motors, welding equipment, transformers, and so on, by running these through special metal conduits.

ADC Performance of dSPACE Boards

Introduction

Data sheets of dSPACE boards with ADC measurement give you ADC performance values such as the resolution and SNR (signal-to-noise ratio). These values are given for measuring input signals that come near to an ideal signal with hardly background noise and suitable for the board's full scale input voltage range. Electromagnetic disturbances from outside are shielded or eliminated.

When you sample an A/D input traced in ControlDesk that is unconnected, you are looking at a 'signal' with background noise. Even if you are looking at a 'signal' that is shorted to ground, you might see backgroind noise. This might give an incorrect impression of the noise when you are measuring an input signal. However, unconnected or shorted to ground signals are not suitable to calculate the SNR.

Another common misunderstanding is that theoretical optimum performance values of ideal ADCs, such as the resolution, are expected from real-world components in real-world board designs. In the real world, ideal ADC and ideal signals cannot be expected.

Tip

For more details on noise reduction, refer to 'Noise Reduction Techniques in Electronic Systems' by Henry W. Ott, John Wiley & Sons, Inc.

Where to go from here

Information in this section

Definition of SNR

Objective

SNR (signal-to-noise-ratio) is defined as a true rms (root mean square) ratio between the input signal and the noise. SNR is usually expressed in dB.

Calculation of SNR

The SNR for a sinusoidal input signal can be described as:

$$SNR = 20 \cdot \log \frac{\text{signal (rms)}}{\text{noise (rms)}} \text{dB}$$

An application note from the ADC manufacturer MAXIM describes the formula used and explains how the SNR parameter correlates with ADC performance: *Defining and Testing Dynamic Parameters in High-Speed ADCs, Part 1*. It is available at https://www.maximintegrated.com/en/design/technical-documents/tutorials/7/728.html.

Notes on calculation of SNR

Often the peak-to-peak values of the signal and the noise are mistakenly taken to calculate the SNR with the formula shown above. However, this results in much lower performance than the A/D converter really obtains. While the rms value of a sine wave can be obtained by dividing its peak-to-peak value by 2.828, the peak-to-peak value of a noise signal must be divided by approximately 6 … 8 to obtain its rms value (occasional extreme peaks must be ignored using this equation). Furthermore, the peak-to-peak noise theoretically might equal the full scale range of the used input channel (even if the inputs are shorted) without decreasing the SNR, assuming that such high peaks appear rarely enough.

Notes on Measuring Noise

Objective

There might be the impression that a noisy signal measured with the dSPACE board looks much better when measured with an oscilloscope.

Possible reason

A reason might be that you are using the wrong "voltage range" for the dSPACE system.

dSPACE boards have an input voltage range of several volts and you are looking at signals with a voltage range of a few mV. This is similar to using a ruler to measure 1/1,000 inches.

Measures

When you use your oscilloscope, you select an appropriate voltage range for the signal you are watching. You should do the same with the dSPACE system: You should adapt your input signal to the input voltage range of the dSPACE board before converting it. Use external amplifiers to ensure that the maximum amplitude range of the signal to be measured is mapped to the full scale range of the board's ADC.

Make sure that you use twisted pair cables and the measuring set up and cabling is shielded against electromagnetic disturbances.

Troubleshooting

Objective

If any problem related to the hardware and software of your system occurs, refer to the information given in this section.

Getting further support

Support Knowledge Base If the information in this section does not help you to solve the problem, check the Support Knowledge Base on our website. See http://www.dspace.com/go/kb.

dSPACE Support If self-help does not help you to solve the problem, contact dSPACE Support and provide information about your dSPACE environment and the problems you have. It is recommended to use the support request form provided on the website at http://www.dspace.com/go/supportrequest. However, you can also send an e-mail or phone us.

Where to go from here

Information in this section

Hardware Problems

Where to go from here

Information in this section

Checking the DS1104

Check list

Perform the following checks if the DS1104 does not operate correctly:

- Check whether the host PC is running correctly.
- Use the Platform Manager of ControlDesk to check the board properties (see Board Details Properties (ControlDesk Platform Management 🕮))
- Only valid for PCI-slot variant: Check the PCI interface clock rate by the status of the red LED on the board:
  - If the LED is lit, the host PC's PCI bus for the DS1104 is over- or underclocked. The LED is lit whenever the clock rate is lower than 5 MHz or higher than 35 MHz.

    Tip

    For PCI interfaces, 33 MHz is the standard frequency. The host interface of the DS1104 is therefore designed to handle frequencies in the range 33 MHz ±5%.

  - For the location of the status LED, see DS1104 Components on page 32.

Problems with Multiple Plug & Play Boards

Introduction

Working with more than one dSPACE board in plug & play configuration presents us with two problems. The first is that the logical name of a board as assigned by the software must be associated with a physical board. The second is that under certain conditions, assignment of the names to the boards may change unexpectedly. It is vital to detect this situation, because otherwise an application to be loaded to a certain board might be loaded to another board of the same type by mistake.

For example, assume you have one board connected to the engine ECU and another connected to the ESP system of a vehicle. In order to avoid severe damage to the car, you must avoid loading the program intended for the ECU-related board to the ESP-related board, and vice versa.

Affected boards

The problem described always applies to *DS1104* boards (and *MicroAutoBox* via DS815, DS817, DS819 or DS821) because plug & play mode cannot be disabled.

Not affected boards

The problem never applies to *DS1006* boards, to *MicroAutoBox II* and to *MicroAutoBox III* , because these boards cannot be installed in a host PC.

Handling plug & play boards in ControlDesk

The Platforms/Devices controlbar of ControlDesk handles the boards by detecting their type (DS1104, MicroAutoBox via DS815, DS817, DS819, or DS821) and their actual I/O address. For plug & play boards, the actual I/O address is dynamically assigned by the PC BIOS or the plug & play components of the operating system. If you add hardware components to your host PC or remove them from it, or enable or disable motherboard components, the PC's BIOS and/or the operating system's plug & play components assign new resources such as I/O addresses to all plug & play components, including dSPACE boards in plug & play mode.

ControlDesk To avoid the problem described above, select the Assign to identical platform assignment mode when you configure the related platform in ControlDesk. This lets you specify the serial number of the platform hardware.

ControlDesk assigns the platform to registered dSPACE hardware with a particular serial number, according to the specified connection type. You must specify the serial number of the platform hardware. Optionally you can also specify the Port address as a hexadecimal number.

Refer to Assignment Properties (ControlDesk Platform Management 🕮).

Method

To restore a consistent dSPACE board configuration

1. On the Platforms ribbon, click Platform Management – Clear System.
   Boards setup in plug & play mode are then reregistered automatically.
2. In the Platforms/Devices controlbar, select the corresponding board icon.
   The Properties controlbar displays detailed information on the currently selected platform.
3. Compare the serial number of each dSPACE board (label on each board's bracket) with the one shown in the Board Details property page of the Platforms/Devices controlbar to make sure that your applications are still loaded to the correct dSPACE boards.

Note

- After using the **Clear System** command, you must reregister all installed dSPACE boards that do not support plug & play or where plug & play mode is disabled by means of the address switches.
- It is your responsibility to check and ensure that all applications are still loaded to the correct board. Since this is not under complete control of the dSPACE software it might even be necessary to change external connections to the boards! In a subsequent release of the **Platforms/Devices** controlbar it will be possible to assign board names to the particular boards as needed.

Checking the Host PC

Check list

If the host PC does not operate correctly after installation of the DS1104, check that the board is installed firmly.

Problems Related to the Firmware

Firmware Update

Further Instructions

If you are prompted to update your firmware when downloading an application to your real-time processor(s), refer to the Firmware Manager Manual 🕮 for further information.

Data Sheets

Where to go from here

Information in this section

DS1104 Data Sheet

Technical data

The following table shows the data sheet of the DS1104 R&D Controller Board.

Parameter	Characteristics [1]
Processor	▪ MPC8240 processor with PPC603e core and on-chip peripherals ▪ 64-bit floating-point processor ▪ 250 MHz CPU ▪ 2 x 16 KB cache; on-chip
Memory	▪ Global memory: 32 MB SDRAM ▪ Flash memory: 8 MB
Timer	▪ 1 sample rate timer (decrementer): 32-bit down counter, reload by software, 40 ns resolution ▪ 4 general purpose timer: 32-bit down counter, reload by hardware, 80 ns resolution ▪ 1 time base counter: 64-bit up counter, 40 ns resolution, range 23400 years
Interrupt controller	▪ 5 timer interrupts ▪ 2 incremental encoder index line interrupts ▪ 1 UART interrupt ▪ 1 slave DSP interrupt

Parameter	Characteristics [1)]
	▪ 1 slave DSP PWM interrupt ▪ 5 ADC end of conversion interrupts ▪ 1 host interrupt ▪ 4 user interrupts from the I/O connector
ADC 1 x 16-bit ADC with mux	▪ 4 muxed channels equipped with one 16-bit sample & hold ADC Note: 5 ADC channels (1 x 16-bit + 4 x 12-bit) can be sampled simultaneous ▪ 16-bit resolution ▪ ±10 V input voltage range ▪ 2 µs conversion time ▪ ±5 mV offset error ▪ ±0.25 % gain error ▪ 4 ppm/K offset drift ▪ 25 ppm/K gain drift ▪ >80 dB signal-to-noise ratio (SNR)
ADC 4 x 12-bit ADC	▪ 4 channels each equipped with one 12-bit sample & hold ADC Note: 5 ADC channels (1 x 16-bit + 4 x 12-bit) can be sampled simultaneous ▪ 12-bit resolution ▪ ±10 V input voltage range ▪ 800 ns conversion time ▪ ±5 mV offset error ▪ ±0.5 % gain error ▪ 4 ppm/K offset drift ▪ 25 ppm/K gain drift ▪ >65 dB signal-to-noise ratio (SNR)
DACs 8 x 16-bit DAC	▪ 16-bit resolution ▪ ±10 V output voltage range ▪ ±5 mA maximum output current ▪ Max. 10 µs settling time (full scale, accuracy 1/2 LSB) ▪ ±1 mV offset error ▪ ±0.1 % gain error ▪ 13 ppm/K offset drift ▪ 25 ppm/K gain drift ▪ >80 dB signal-to-noise ratio (SNR)
Digital I/O	▪ 20-bit parallel I/O ▪ Single bit selectable for input or output ▪ ±5 mA maximum output current ▪ TTL output/input levels
Digital Incremental Encoder Interface (2 x 24 bit)	▪ 2 channels ▪ Selectable single-ended (TTL) or differential (RS422) input ▪ Fourfold line subdivision ▪ Max. 1.65 MHz input frequency, i.e. fourfold pulse counts up to 6.6 MHz ▪ 24-bit loadable position counter ▪ Reset on index ▪ 5 V/0.5 A sensor supply voltage

Parameter	Characteristics [1]
Serial interface	▪ 1 serial UART (universal asynchronous receiver and transmitter) ▪ Selectable transceiver mode: RS232/RS422/RS485 ▪ Max. baudrate RS232: 115.2 kBaud ▪ Max. baudrate RS422/RS485: 1 MBaud
Slave DSP subsystem	▪ Texas Instruments TMS320F240 DSP ▪ 16-bit fixed-point processor ▪ 20 MHz clock frequency ▪ 64 K x 16 external program memory ▪ 28 K x 16 external data memory ▪ 4 K x 16 dual-port memory for communication ▪ 16 K x 16 flash memory ▪ 1 x 3-phase PWM output ▪ 4 x 1-phase PWM output ▪ 4 capture inputs ▪ SPI (serial peripheral interface) ▪ Max. 14-bit digital I/O ▪ TTL output/input levels for all digital I/O pins ▪ ±13 mA maximum output current
Host interface	PCI-slot variant: ▪ 32-bit PCI host interface ▪ 5 V PCI slot ▪ 33 MHz ±5 %
	PCIe-slot variant: ▪ PCI Express x1 interface (complies with PCI Express Specification Revision 1.0a)
Physical size	▪ PCI-slot variant: 179 x 107 mm (7.05 x 4.2 in) ▪ PCIe-slot variant: 208 x 111 mm (8.2 x 4.3 in)
Ambient temperature	0 … 55 °C (32 ... 131 °F)
Cooling	Active cooling by fan
Power supply	PCI-slot variant: ▪ +5 V ±5 %, 2.5 A ▪ +12 V ±5 %, 0.3 A ▪ –12 V ±5 %, 0.2 A
	PCIe-slot variant: ▪ +3.3 V ±5 %, 2.4 A ▪ +12 V ±5 %, 0.9 A
Power consumption	▪ PCI-slot variant: 18.5 W ▪ PCIe-slot variant: 18.8 W

[1] Unless stated otherwise, the specifications are valid only if the dSPACE hardware is correctly powered, switched on, and ready for operation.

CP1104 Data Sheet

Technical data

The following table shows the data sheet of the CP1104 Connector Panel.

Parameter	Characteristics [1]
Grounding	The enclosure and the front panel are not grounded.
Cable length	2 m (6.6 ft) standard
Physical size (with desktop enclosure) (length x depth x height)	281 x 142.5 x 70 mm (11.06 x 5.61 x 2.75 in)
Space needed for 19" rack mount	Height 3 U; width 10.8"
Weight	Approx. 2.2 kg (4.8 lbs); incl. enclosure and shielded ribbon cables

[1] Unless stated otherwise, the specifications are valid only if the dSPACE hardware is correctly powered, switched on, and ready for operation.

CLP1104 Data Sheet

Technical data

The following table shows the data sheet of the CLP1104 Connector/LED Combi Panel.

Parameter	Characteristics [1]
Power consumption	5 V; max. 100 mA (via DS1104 board)
Grounding	The enclosure and the front panel are not grounded.
Cable length	2 m (6.6 ft) standard
Physical size (with desktop enclosure) (length x depth x height)	433.5 x 142.5 x 70 mm (17.07 x 5.61 x 2.75 in)
Space needed for 19" rack mount	Height 3 U; width 16.8"
Weight	Approx. 2.5 kg (5.5 lbs); incl. enclosure and shielded ribbon cables

[1] Unless stated otherwise, the specifications are valid only if the dSPACE hardware is correctly powered, switched on, and ready for operation.

Accessories

Connector Panel Enclosures

Connector and LED Panels

Objective

The connector and LED panels are installed in a 19" desktop box made from aluminum profiles as standard. They can optionally be mounted in a 19" industry rack.

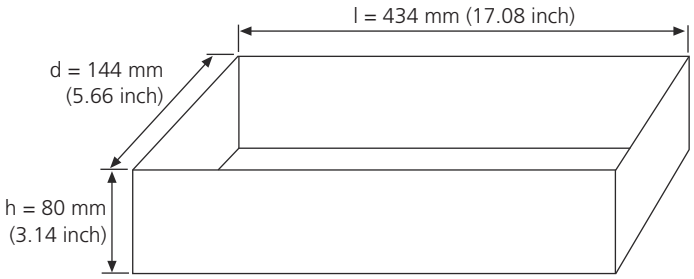
Where to go from here

Information in this section

19" Desktop Enclosure

Dimensions

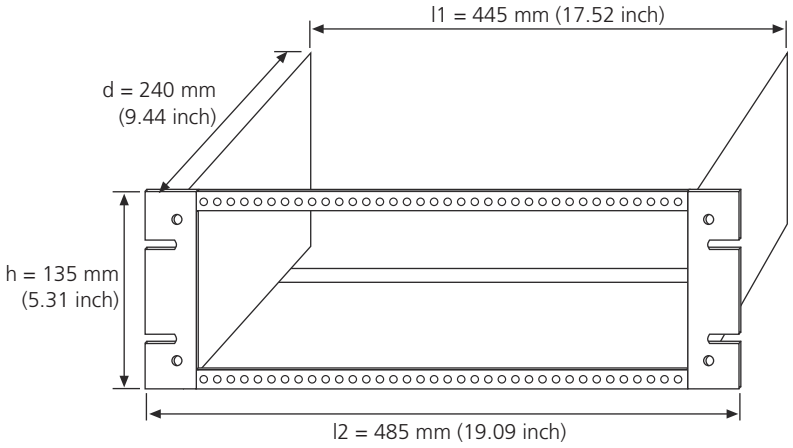
The illustration below shows the outer dimensions of the 19" desktop enclosure for connector and LED panels (CPs, CLPs and LPs).



19" Rack Enclosure

Dimensions

The illustration below shows the outer dimensions of a 19" rack enclosure for alternative installation of connector and LED panels (CPs, CLPs and LPs).



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