ADDI-DATA®
PARTNER FÜR PRÄZISION

Technical Description

APCIe-3121 / APCIe-3126 / CPCIs-3121 and APCIe-3021 / APCIe-3521

Multifunction board and analog input board / output board, optically isolated

DIN EN ISO 9001:2015 certified

Edition: 03.06-06/2022

Product information

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Warning!

The following risks result from the improper implementation of the board and from use contrary to the regulations:



Personal injury



Damage to the board, the PC and peripherals



Pollution of the environment.

- Protect yourself, others and the environment!
- Read the safety precautions (yellow leaflet) carefully!

  If this leaflet is not enclosed with the documentation, please contact us and ask for it.
- Observe the instructions of this manual!

  Make sure that you do not forget or skip any step!
  We are not liable for damages resulting from the wrong use of the board.
- Pay attention to the following symbols:



NOTICE!
Designates hints and other useful information.



NOTICE!
Designates a possibly dangerous situation.
If the instructions are ignored, the board, the PC and/or peripherals may be **destroyed**.



WARNING!
Designates a possibly dangerous situation.
If the instructions are ignored, the board, the PC and/or peripherals may be **destroyed** and persons may be **endangered**.

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Chapter overview

In this manual, you will find the following information:

Chapter	Content
1	Important information on the application, the user and on handling the board
2	Brief description of the board
3	Detailed information on the insertion of the board, connection of the accessories (including pin assignment) and driver installation **Tip:** Print out this chapter to have help at hand for inserting and installing the board.
4	Description of the individual functions of the board
5	Standard software: Information on the API software functions
6	Procedure for returning (repairing, etc.) or disposing of the board
7	List of technical data and limit values of the board
8	Appendix with glossary and index
9	Contact and support address

1 Definition of application, user, handling

1.1 Definition of application

1.1.1 Intended use

The board **APCIe-3x2x**[1] must be inserted in a personal computer (PC) with PCI Express slots which is used as electrical equipment for measurement, control and laboratory pursuant to the standard DIN EN IEC 61010-1.
The board **CPCIs-3121** must be inserted in a CompactPCI Serial computer or corresponding hybrid system with CompactPCI Serial slots which is used as electrical equipment for measurement, control and laboratory pursuant to the standard DIN EN IEC 61010-1.

The used personal computer (PC) or CompactPCI Serial computer or corresponding hybrid system must fulfil the requirements of DIN EN IEC 62368-1 and DIN EN 55032 or IEC/CISPR 32 and DIN EN 55024 or IEC/CISPR 24.

The use of the boards **APCIe-3x2x** and **CPCIs-3121** in combination with external screw terminal panels requires correct installation according to the standard DIN EN IEC 61439-1 (Low-voltage switchgear and controlgear assemblies).

1.1.2 Usage restrictions

The boards **APCIe-3x2x** and **CPCIs-3121** must not be used as safety-related parts (SRP).

The boards **APCIe-3x2x** and **CPCIs-3121** must not be used for safety-related functions, such as emergency stop functions.

The boards **APCIe-3x2x** and **CPCIs-3121** must not be used in potentially explosive atmospheres.

The boards **APCIe-3x2x** and **CPCIs-3121** must not be used as electrical equipment according to the Low Voltage Directive 2014/35/EU.

1.1.3 Limits of use

All safety information and the instructions in the manual must be followed to ensure proper intended use.

Uses of the board beyond these specifications are considered as improper use. The manufacturer is not liable for damages resulting from improper use.

The board must remain in its anti-static packaging until it is installed.

Please do not delete the identification numbers of the board or the warranty claim will be invalid.

[1] APCIe-3x2x = APCIe-3021, APCIe-3121, APCIe-3126 and APCIe-3521

1.2 User

1.2.1 Qualification

Only persons trained in electronics are entitled to perform the following works:

- Installation
- Commissioning
- Use
- Maintenance.

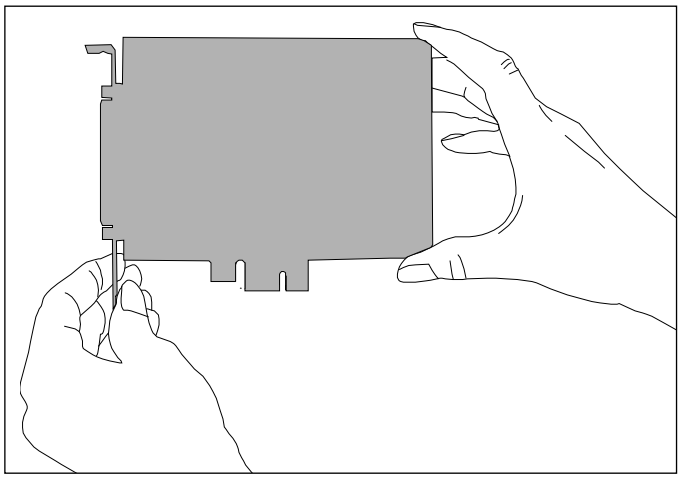
1.2.2 Country-specific regulations

Do observe the country-specific regulations regarding

- the prevention of accidents
- electrical and mechanical installations
- Electromagnetic compatibility (EMC).

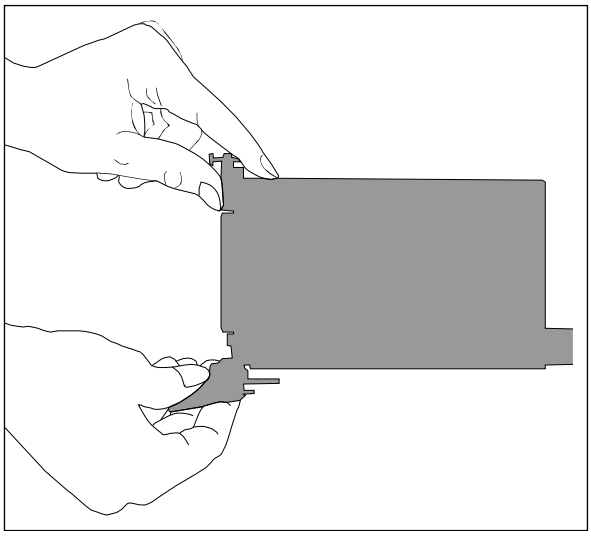
1.3 Handling of the board

Fig. 1-1: APCIe-3x2x: Correct handling



Hold the board cautiously at the outer end and at the slot bracket.
Do not touch the surface of the board!

Fig. 1-2: CPCIs-3121: Correct handling



Hold the board cautiously at the outer end and at the front panel. Do not touch the surface of the board!

1.4 Questions and updates

If you have any questions, do not hesitate to call us or to send us an e-mail:

Phone: +49 7229 1847-0
E-mail: info@addi-data.com

Manual and software download from the Internet

The latest versions of the technical manual and the standard software for the board **APCIe-3x2x** or **CPCIs-3121** can be downloaded for free at: https://drivers.addi-data.com.

NOTICE!
Before using the board and in case of malfunction during operation, check if there is an update (manual, driver) available. Current data can be found on our website or contact us directly.

2 Brief description

2.1 Technical features

Table 2-1: Technical features: Overview

Technical features	APCIe-3021	APCIe-3121 CPCIs-3121	APCIe-3126	APCIe-3521
Analog inputs: Single-ended (SE) or differential (diff.)	4, 8 or 16 (SE) 2, 4 or 8 (diff.)	8 or 16 (SE) 4 or 8 (diff.)	16 (SE) 8 (diff.)	-
Resolution	16-bit	16-bit	16-bit	-
Optical isolation (500 V)	x	x	x	-
Throughput rate	100 kHz	100 kHz	200 kHz	-
Analog outputs: Voltage or current	-	4 or 8	8	4 or 8
Resolution	-	16-bit	16-bit	16-bit
Optical isolation (500 V)	-	x	x	x
Digital inputs/outputs: 24 V, optically isolated	4 inputs 4 outputs	4 inputs 4 outputs	4 inputs 4 outputs	4 inputs 4 outputs
TTL I/O: Digital inputs/outputs	4 inputs 4 outputs (option)	4 inputs 4 outputs (option)	24 inputs/ outputs	4 inputs 4 outputs (option)
Timer: 16-bit	1	2	2	2
Watchdog: 16-bit	-	1 (timer 1)	1 (timer 1)	1 (timer 1)

Other features:

- Input range and gain can be programmed for each channel
- Various acquisition modes (with DMA function as well) and trigger settings
- Digital 24 V trigger input for hardware trigger
- Input filters
- Output voltage after reset: 0 V
- Short-circuit protection and EMI filters for the analog outputs
- Separate ground line for each analog output
- Overvoltage protection
- Protection against high-frequency EMI
- **CPCIs-3121:** Extended operating temperature range from -40 °C to +85 °C

2.2 Block diagrams

Fig. 2-1: APCIe-3021: Block diagram

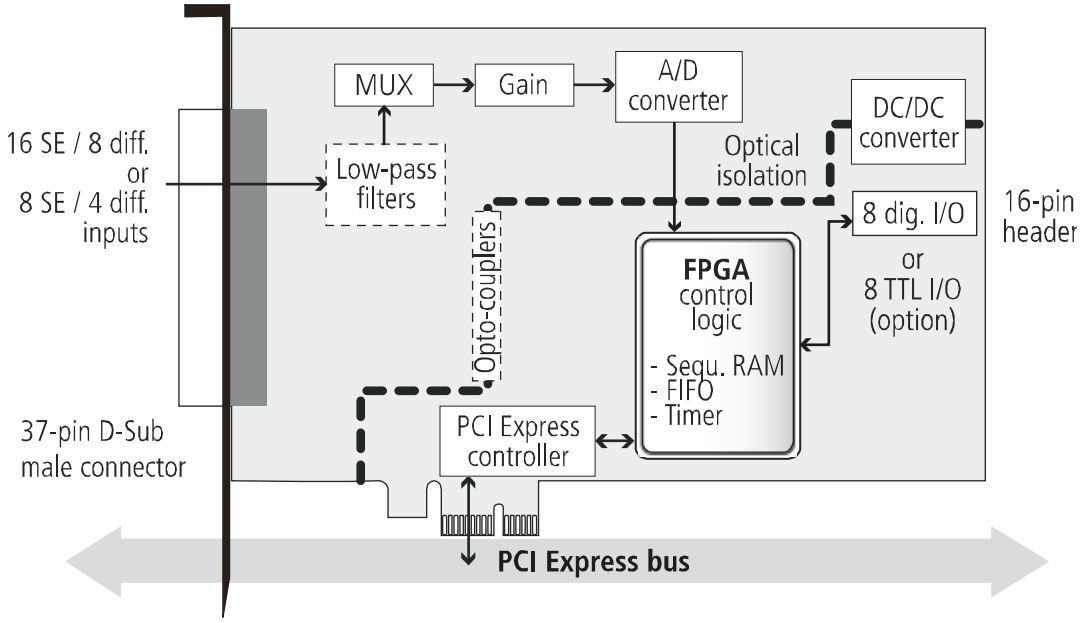


Fig. 2-2: APCIe-3121: Block diagram

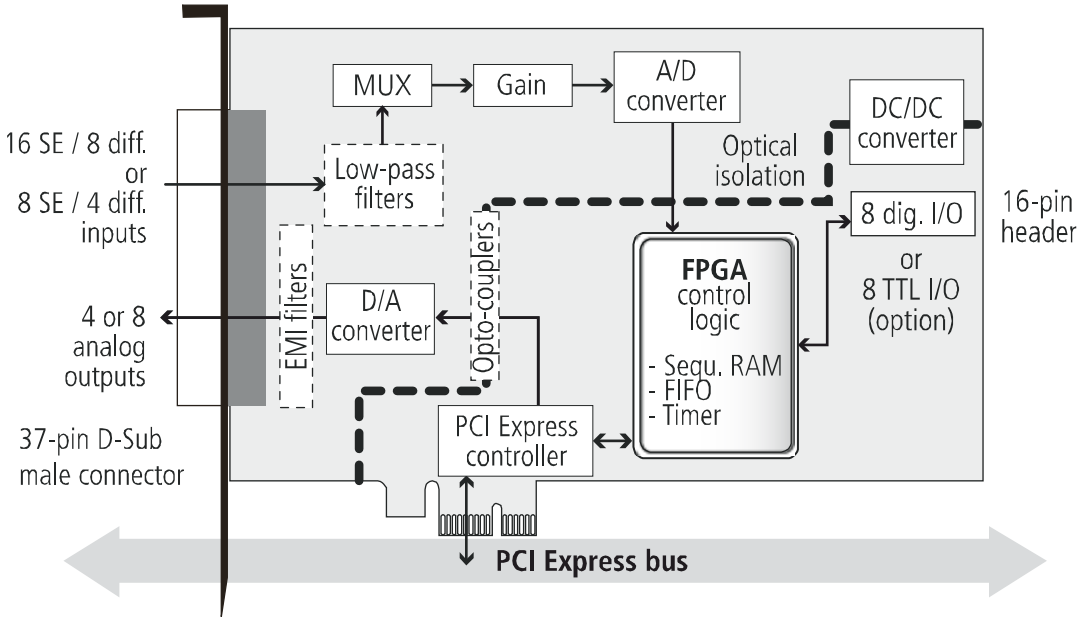


Fig. 2-3: APCIe-3126: Block diagram

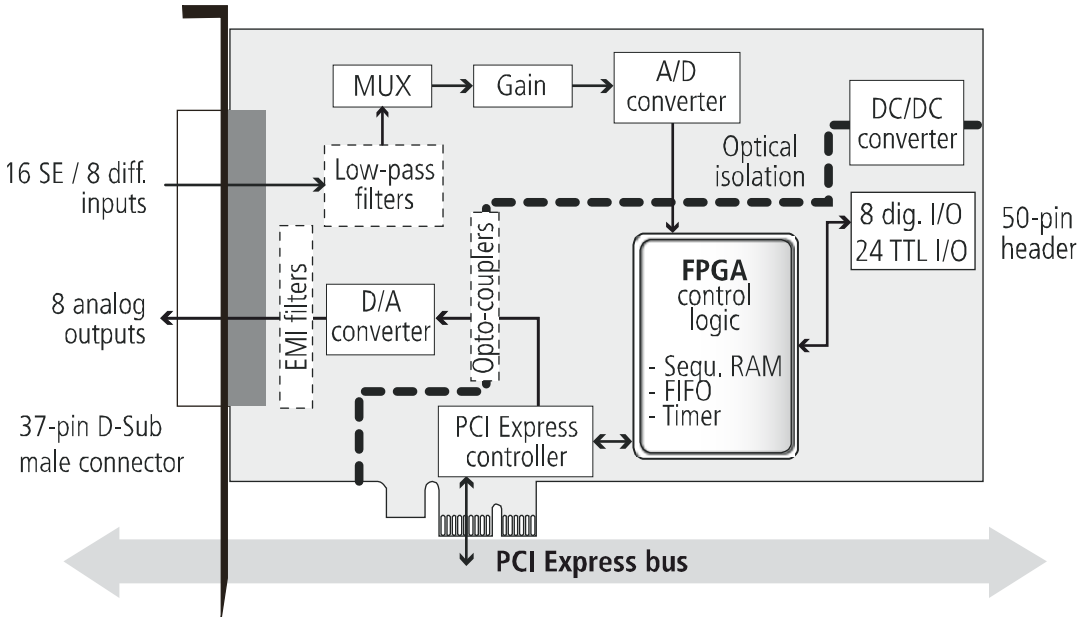


Fig. 2-4: APCIe-3521: Block diagram

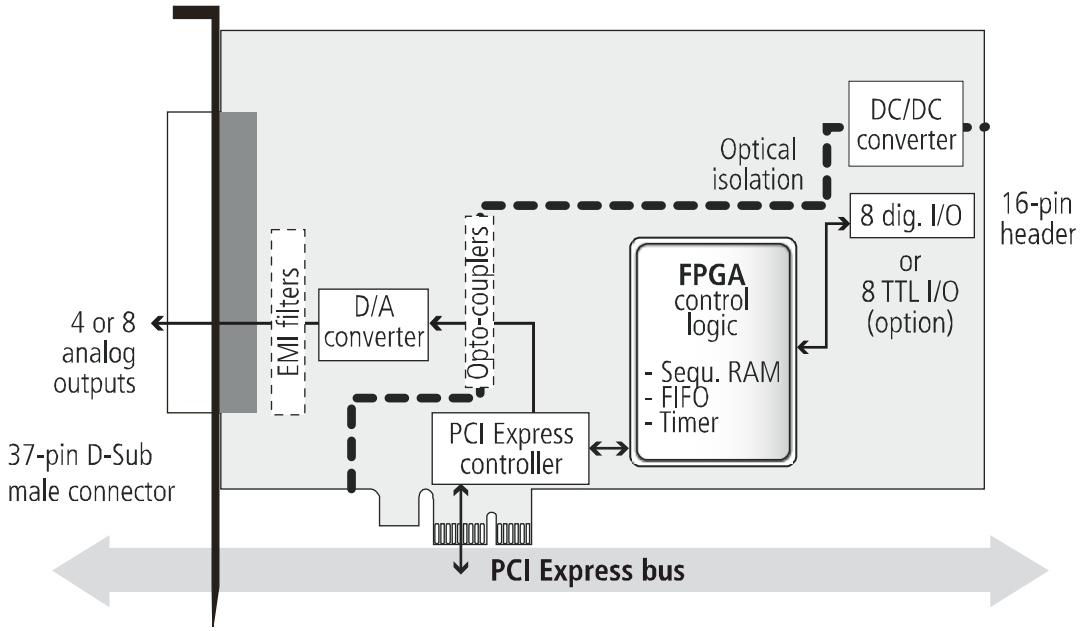
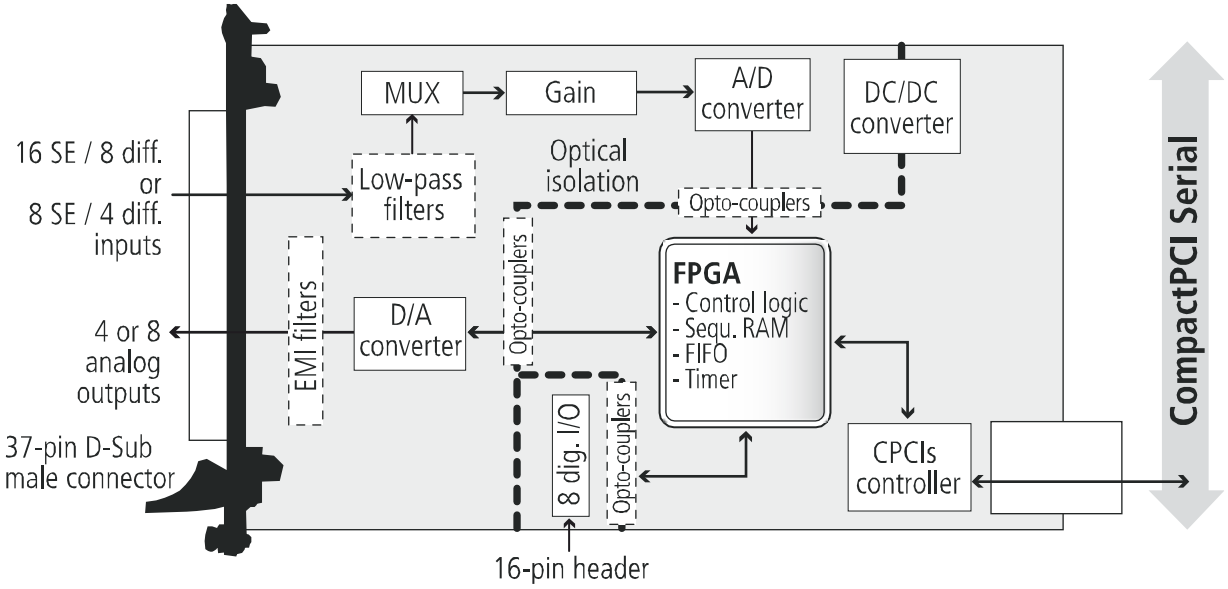


Fig. 2-5: CPCIs-3121: Block diagram



3 Insertion and installation of the board

3.1 Insertion of the APCIe board

Risk of injury!
Be sure to follow the safety precautions!
Improper use of the board may lead to property damage and personal injury.

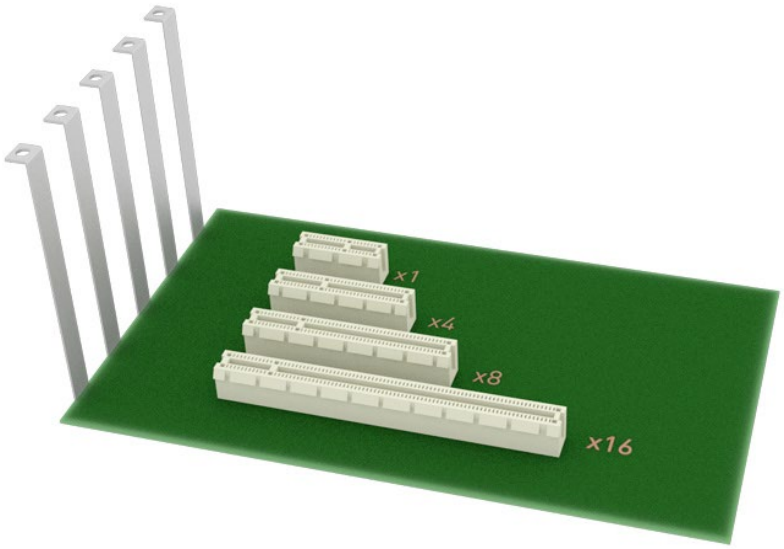
3.1.1 Opening the PC

- Switch off the PC and all the units connected to it.
- Pull the PC mains plug from the socket.
- Open the PC as described in the manual of the PC manufacturer.

3.1.2 Selecting a slot

- Select a free 1-lane (x1), 4-lane (x4), 8-lane (x8) or 16-lane (x16) PCI Express slot for the board.

Fig. 3-1: PCI Express slot types

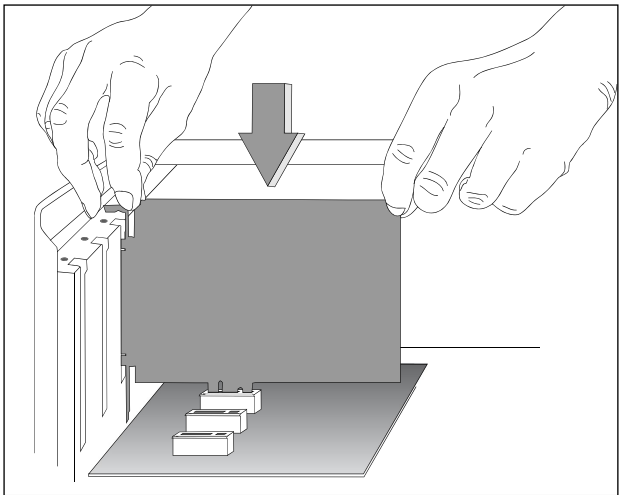


- Unscrew the back cover from the selected slot. For this, follow the operating instructions provided by the PC manufacturer!
  Keep the back cover in a safe place. You will need it if you remove the board
- Provide for potential equalisation.
- Take the board out of its protective packaging.

3.1.3 Inserting the board

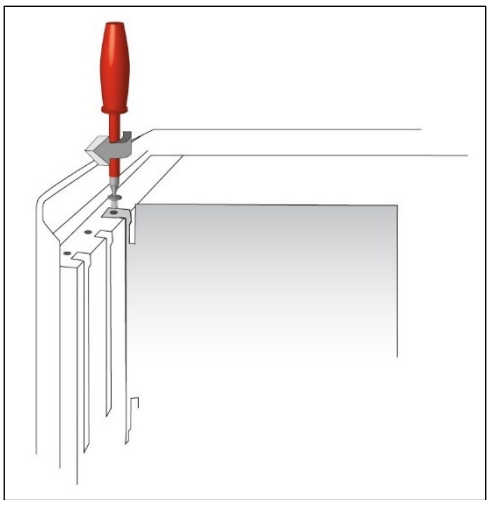
- Insert the board vertically from above into the selected slot.

Fig. 3-2: Slot: Insert the board



- Fasten the board to the rear of the PC housing using the screw which held the back cover in place.

Fig. 3-3: PC housing: Fasten the board



- Tighten all loose screws.

3.1.4 Closing the PC

- Close the PC as described in the manual of the PC manufacturer.

3.2 Insertion of the CPCIs board

Risk of injury!
Be sure to follow the safety precautions!
Improper use of the board may lead to property damage and personal injury.

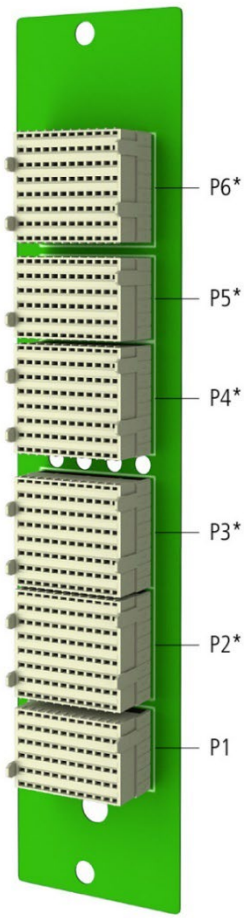
3.2.1 Opening the system

- Switch off the CompactPCI Serial system and all the units connected to it.
- Pull the mains plug of the CompactPCI Serial system from the socket.
- Remove the front cover from a free CompactPCI Serial slot.

3.2.2 Selecting a slot

- Select a free CPCIs slot for the board (* P2-P6 = optional).

Fig. 3-4: CPCIs slot types

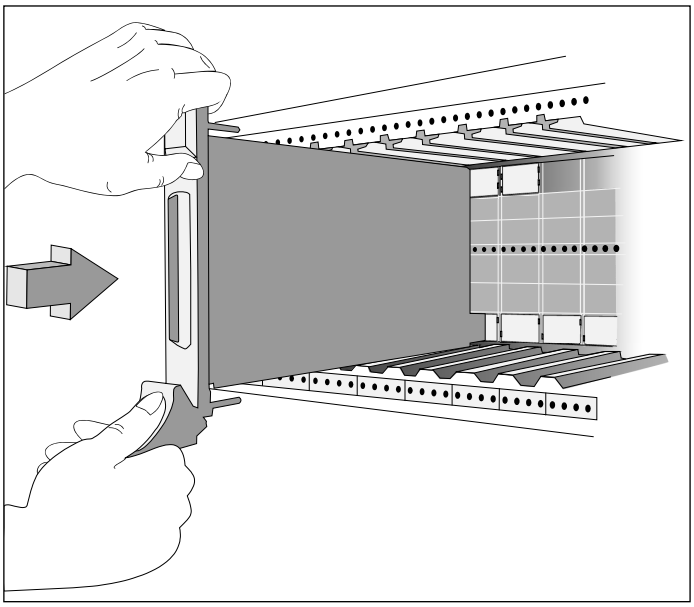


- Provide for potential equalisation.
- Take the board out of its protective packaging.

3.2.3 Inserting the board

- Insert the board into the guiding rails of the rack and push it forward to the rear of the housing. In order to plug it in, a slight resistance has to be overcome.

Fig. 3-5: Slot: Insert the board



- If there is a screw at the front panel of the board, fasten the board at the upper part of the housing with it.

NOTICE!
To pull the board out of the rack, the fold-away handle (if available) at the front panel has to be pushed slightly upwards. After that, you can pull out the board.

3.3 Connecting the accessories

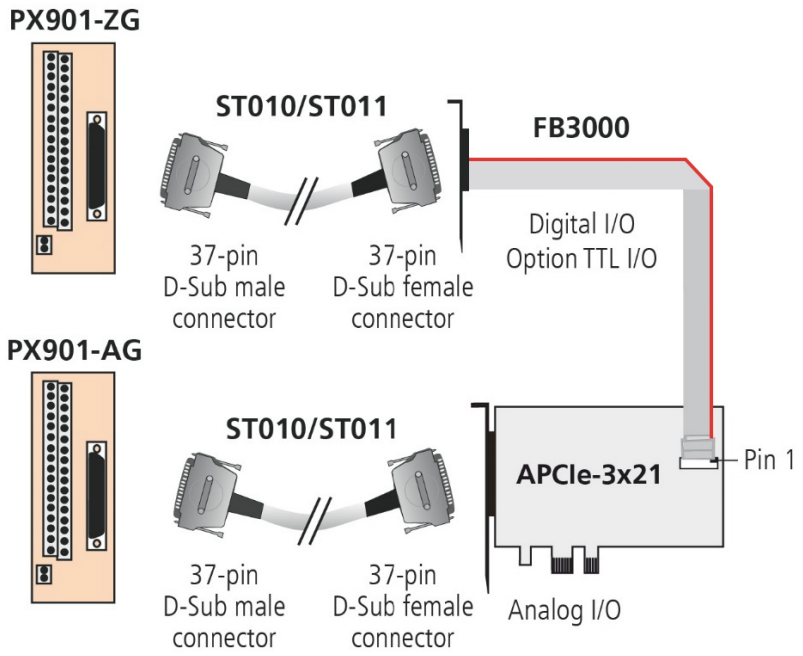
3.3.1 Connection of the screw terminal panels

Between the board **APCIe-3x21, APCIe-3126** or **CPCIs-3121** and the peripherals, analog signals are exchanged via the screw terminal panel **PX901-AG** and the cable **ST010** or **ST011**, which needs to be connected to the 37-pin D-Sub male connector of the board. In terms of electromagnetic compatibility (EMC), these cables have the following properties:

- Metallised connector housing
- Shielded cable
- Cable shield folded back over insulation and firmly screwed on both sides to the connector housing.

For the digital inputs and outputs of the **APCIe-3x21** or **CPCIs-3121**, the ribbon cable **FB3000** or **FB3001** is connected to the 16-pin header of the board. The **FB3000** cable is also used for the option **TTL I/O** of the **APCIe-3x21**. For the digital or TTL inputs and outputs of the **APCIe-3126**, the ribbon cable **FB8001** is connected to the 50-pin header.
The ribbon cable **FB3000** or **FB3001** has a 37-pin D-Sub male connector for the connection of the cable **ST010** or **ST011**, i.e. a second slot is required. The **FB8001** is fitted with a 50-pin D-Sub male connector for the cable **ST370-16**.

Fig. 3-6: APCIe-3x21: Connection of the screw terminal panels



NOTICE!
Plug the **FB3000** cable into the connector by inserting the red (or blue or black) cable line into pin 1.

Fig. 3-7: APCIe-3126: Connection of the screw terminal panels

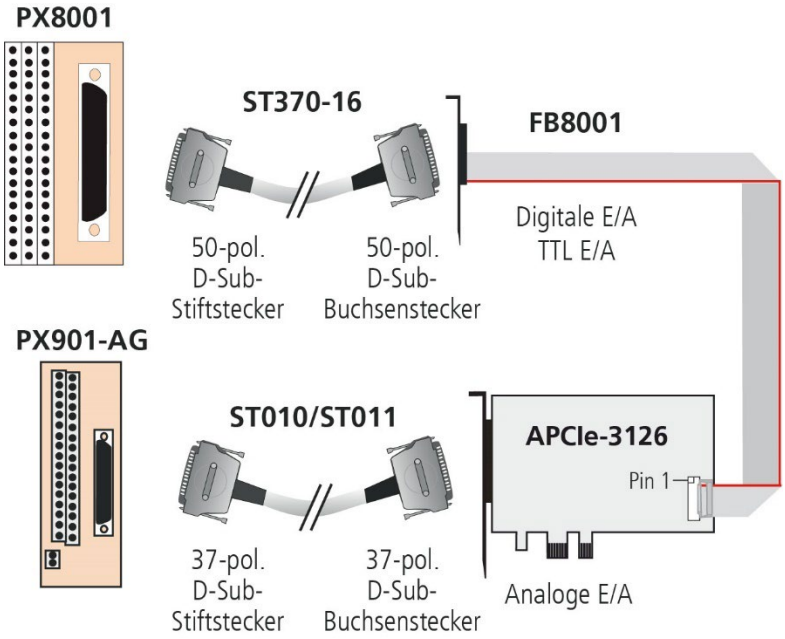
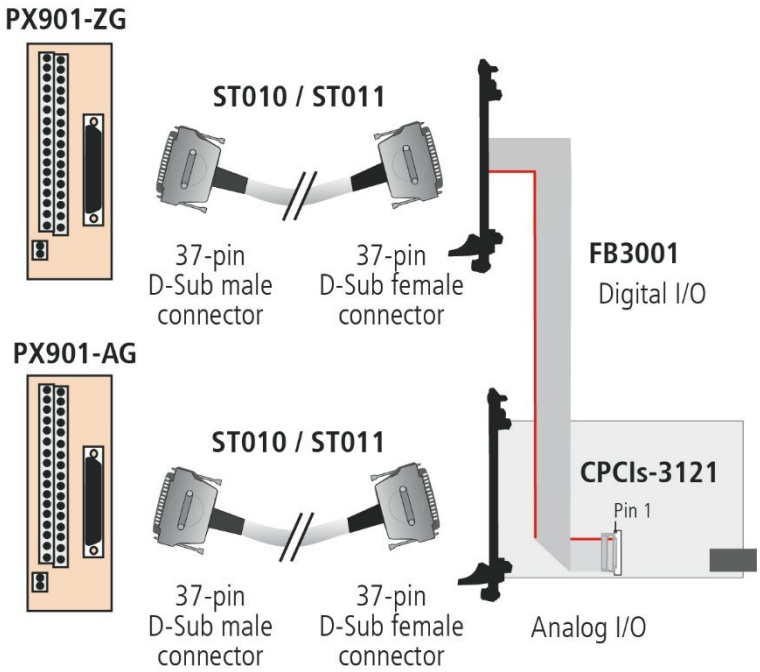


Fig. 3-8: CPCIs-3121: Connection of the screw terminal panels

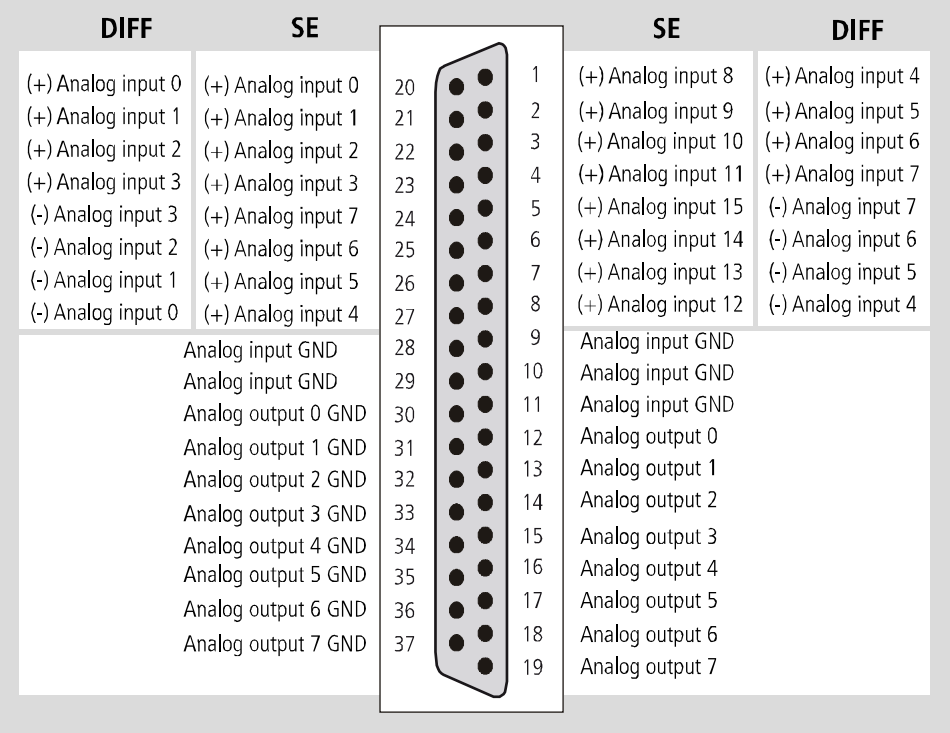


NOTICE!

Plug the **FB8001** or **FB3001** cable into the connector by inserting the red (or blue or black) cable line into pin 1.

3.3.2 Pin assignment

Fig. 3-9: 37-pin D-Sub male connector (analog I/O)



The analog inputs have a common ground line (“Analog input GND”), whereas each analog output x has its own ground line (“Analog output x GND”).

Fig. 3-10: 37-pin D-Sub male connector (digital I/O)

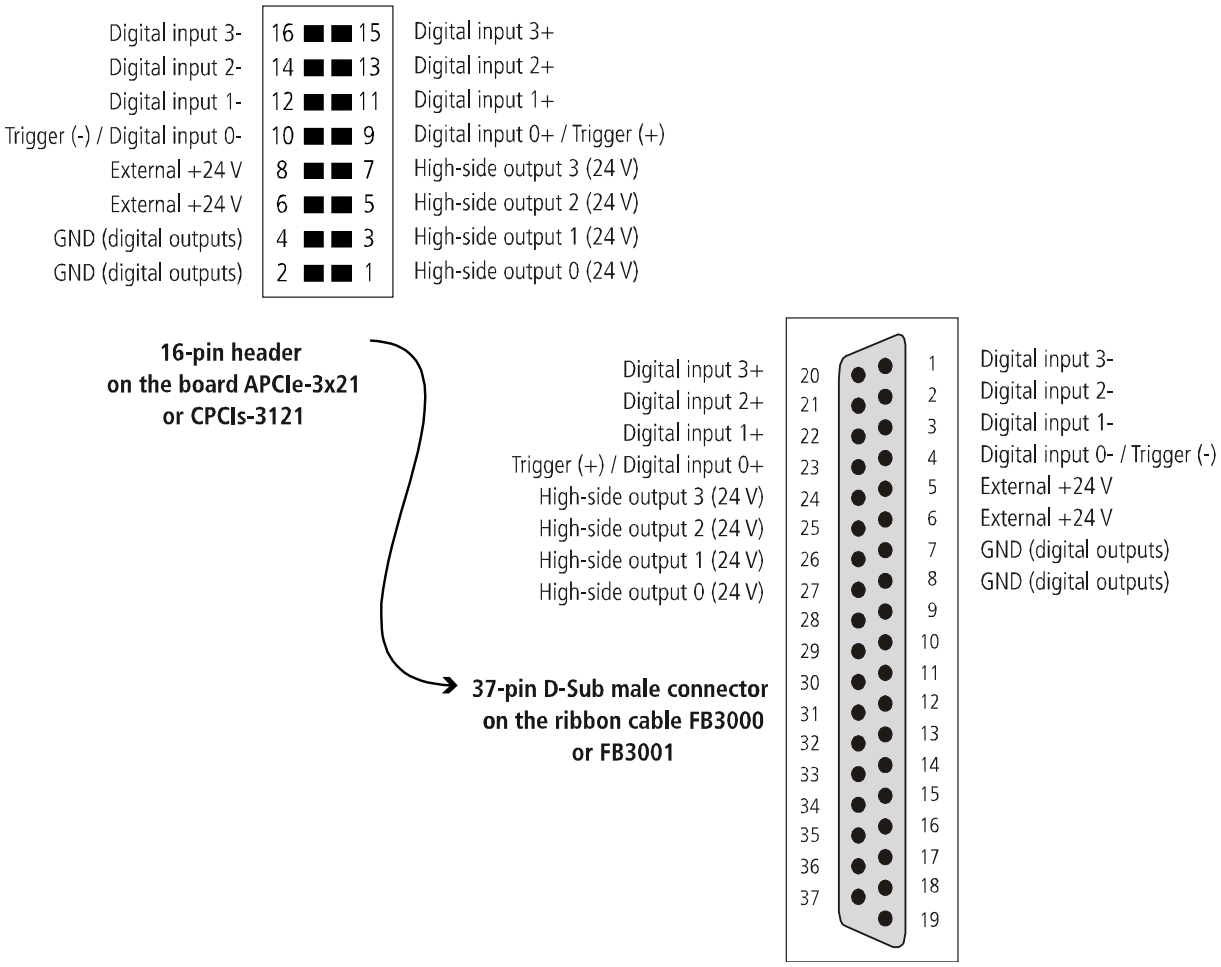


Table 3-1: Pin description (digital I/O)

Pin No. (16-pin header)	Pin No. (37-pin D-Sub male connector)	Pin function
1	27	24 V high-side output 0
2	8	Ground (digital outputs)
3	26	24 V high-side output 1
4	7	Ground (digital outputs)
5	25	24 V high-side output 2
6	6	24 V voltage supply (digital outputs)
7	24	24 V high-side output 3
8	5	24 V voltage supply (digital outputs)

Pin No. (16-pin header)	Pin No. (37-pin D-Sub male connector)	Pin function
9	23	Digital input 0+ / Trigger input (+)
10	4	Digital input 0- / Trigger input (-)
11	22	Digital input 1+
12	3	Digital input 1-
13	21	Digital input 2+
14	2	Digital input 2-
15	20	Digital input 3+
16	1	Digital input 3-

Fig. 3-11: 37-pin D-Sub male connector (option TTL I/O)

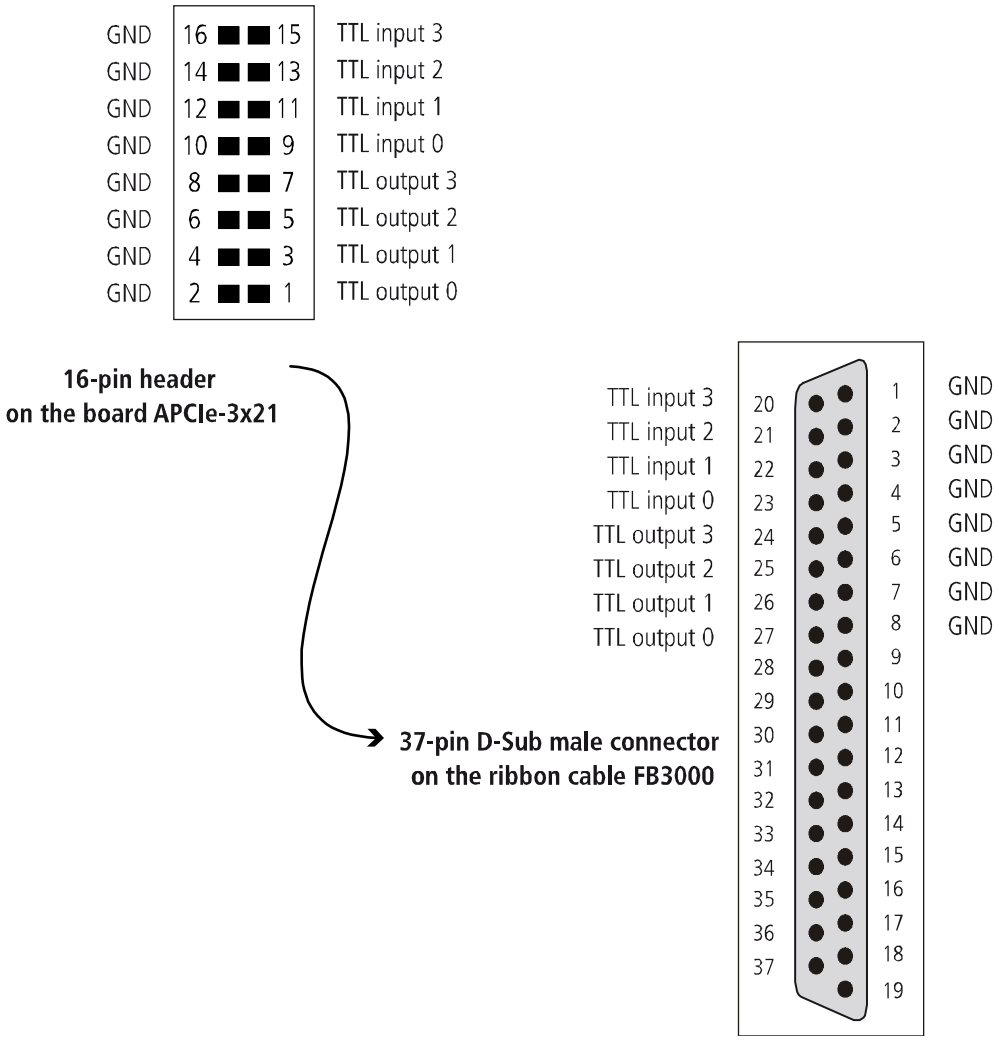
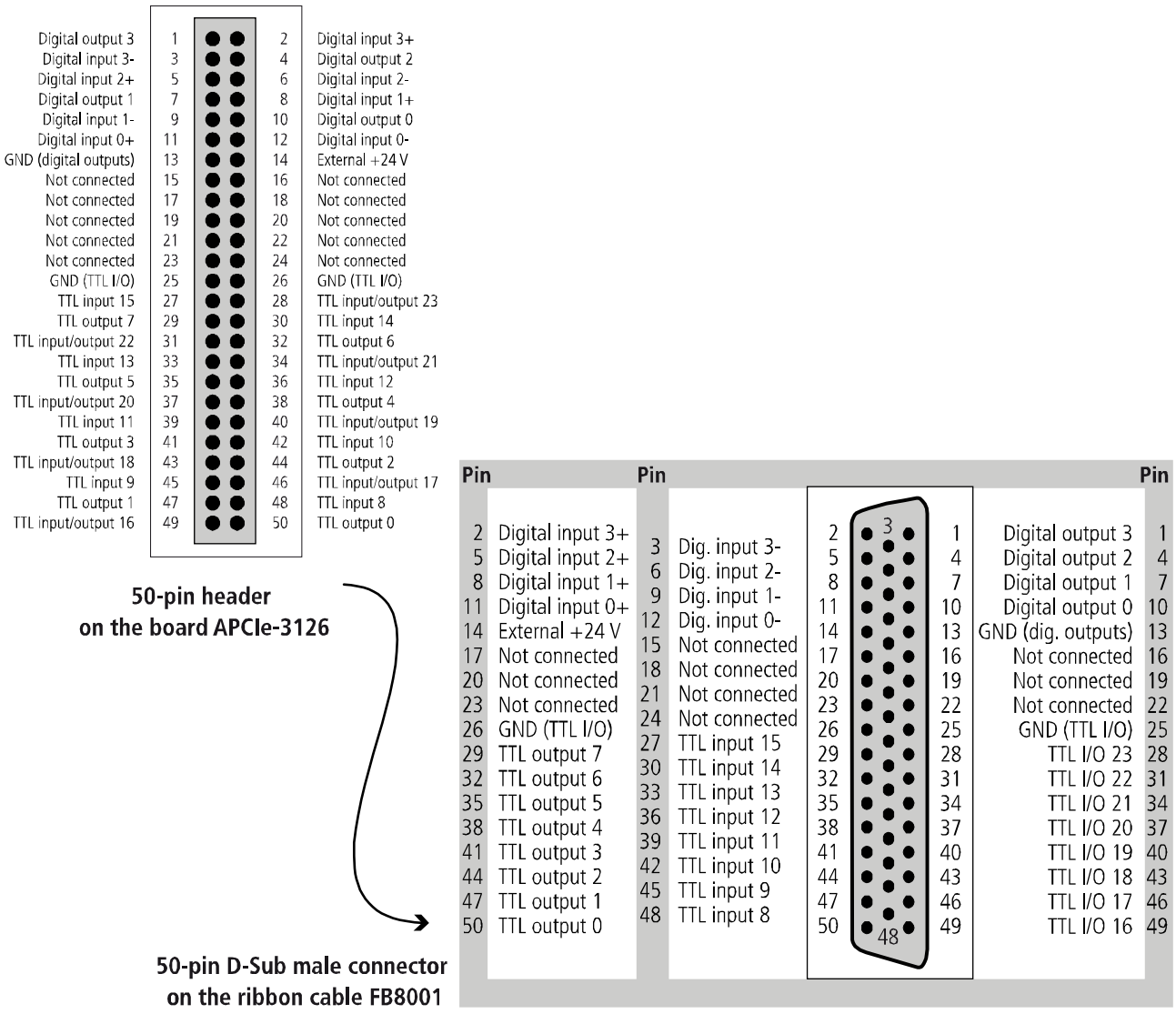


Table 3-2: Pin description (option TTL I/O)

Pin No. (16-pin header)	Pin No. (37-pin D-Sub male connector)	Pin function
1	27	TTL output 0
2	8	Ground
3	26	TTL output 1
4	7	Ground
5	25	TTL output 2
6	6	Ground
7	24	TTL output 3
8	5	Ground
9	23	TTL input 0
10	4	Ground
11	22	TTL input 1
12	3	Ground
13	21	TTL input 2
14	2	Ground
15	20	TTL input 3
16	1	Ground

Fig. 3-12: FB8001: 50-pin D-Sub male connector (digital I/O and TTL I/O)

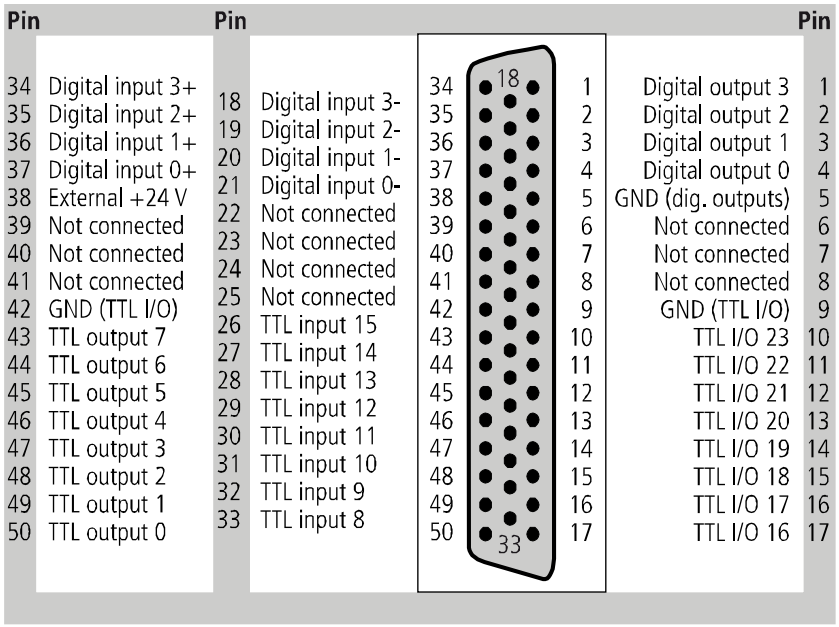


Pin 11: Digital input 0+ / Trigger input (+)
Pin 12: Digital input 0- / Trigger input (-)

NOTICE!

With the cable **ST370-16**, the 50-pin D-Sub male connector of the ribbon cable **FB8001** is adapted to a 50-pin D-Sub male connector, which can be directly used for the screw terminal panel **PX8001** (see the following pin assignment).

Fig. 3-13: ST370-16: 50-pin D-Sub male connector (digital I/O and TTL I/O)



Pin 37: Digital input 0+ / Trigger input (+)
Pin 21: Digital input 0- / Trigger input (-)

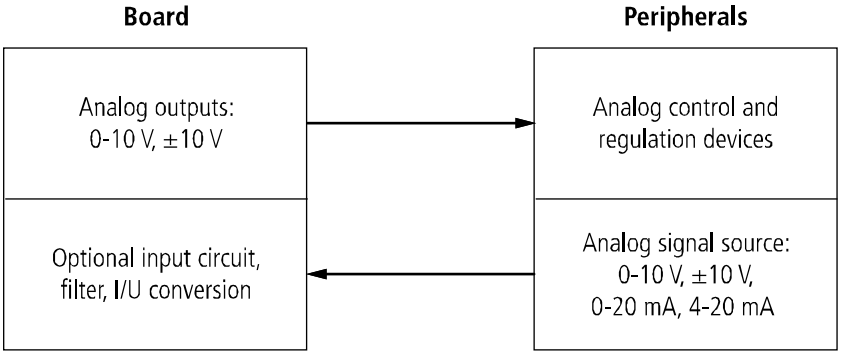
Table 3-3: Pin description (digital I/O and TTL I/O)

APCIe-3126	FB8001	ST370-16	
Pin No. (50-pin header)	**Pin No. (50-pin D-Sub male connector)**	**Pin No. (50-pin D-Sub male connector)**	**Pin function**
1		1	24 V high-side output 3
2		34	Digital input 3+
3		18	Digital input 3-
4		2	24 V high-side output 2
5		35	Digital input 2+
6		19	Digital input 2-
7		3	24 V high-side output 1
8		36	Digital input 1+
9		20	Digital input 1-
10		4	24 V high-side output 0
11		37	Digital input 0+ / Trigger input (+)
12		21	Digital input 0- / Trigger input (-)

APCIe-3126	FB8001	ST370-16	
Pin No. (50-pin header)	**Pin No. (50-pin D-Sub male connector)**	**Pin No. (50-pin D-Sub male connector)**	**Pin function**
13		5	Ground (digital outputs)
14		38	24 V voltage supply (digital outputs)
15 bis 24		22, 6, 39, 23, 7, 40, 24, 8, 41, 25	Not connected
25		9	Ground (TTL inputs/outputs)
26		42	Ground (TTL inputs/outputs)
27		26	TTL input 15
28		10	TTL input/output 23
29		43	TTL output 7
30		27	TTL input 14
31		11	TTL input/output 22
32		44	TTL output 6
33		28	TTL input 13
34		12	TTL input/output 21
35		45	TTL output 5
36		29	TTL input 12
37		13	TTL input/output 20
38		46	TTL output 4
39		30	TTL input 11
40		14	TTL input/output 19
41		47	TTL output 3
42		31	TTL input 10
43		15	TTL input/output 18
44		48	TTL output 2
45		32	TTL input 9
46		16	TTL input/output 17
47		49	TTL output 1
48		33	TTL input 8
49		17	TTL input/output 16
50		50	TTL output 0

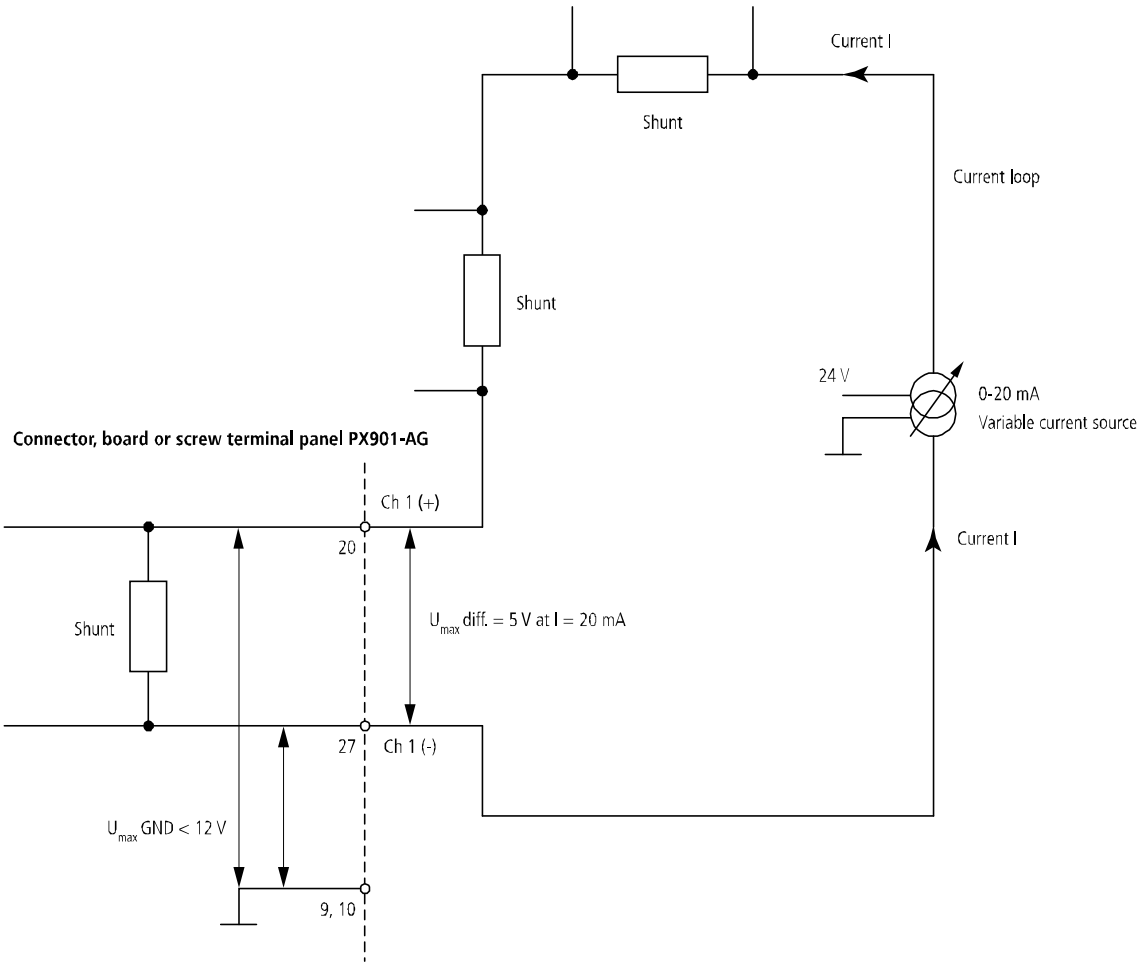
3.3.3 Connection principle

Fig. 3-14: Connection principle



With the **PC-Diff** option (see Chapter 7.4), the board has to be placed at the end of the current loop so that the voltage (U_{max} GND) at the differential input pin is 12 V max. relating to GND (see the following figure).

Fig. 3-15: Current loop for the PC-Diff option



3.3.4 Connection examples

1) Analog inputs

Fig. 3-16: Connection example (single-ended inputs

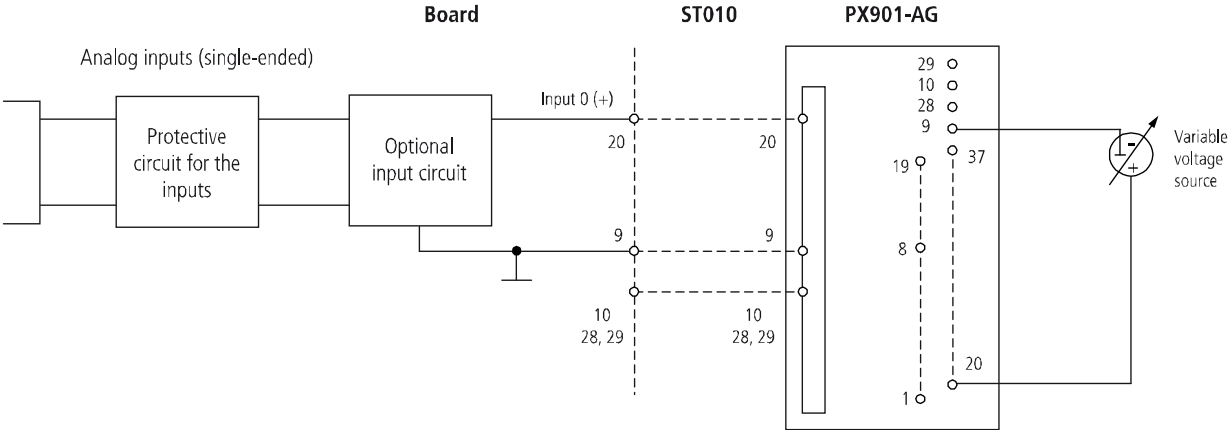
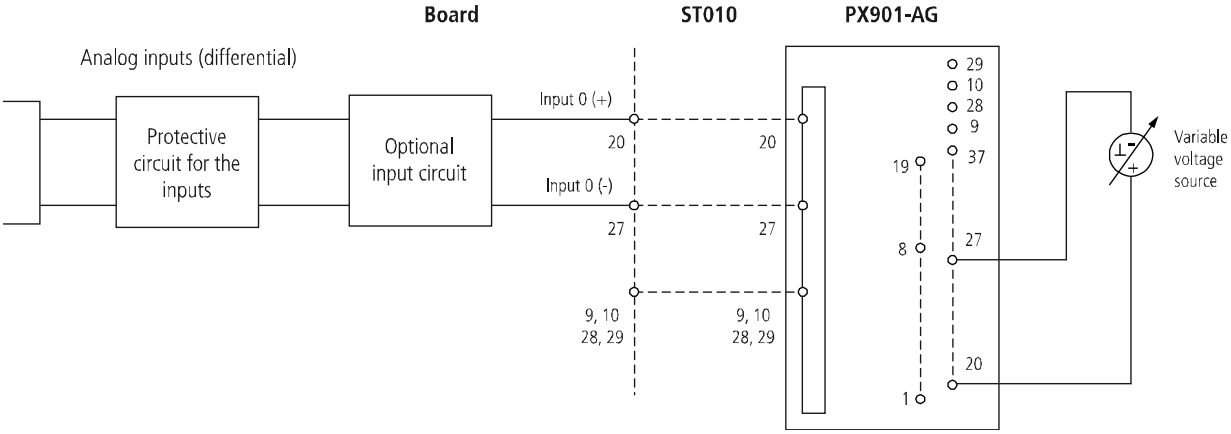


Fig. 3-17: Connection example (differential inputs)

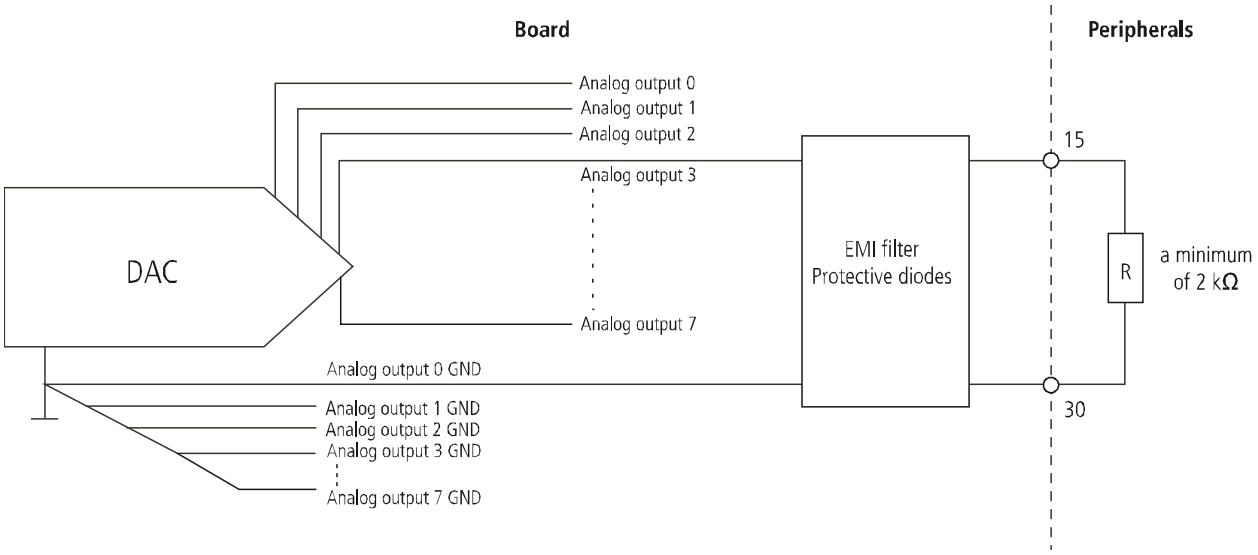


NOTICE!

Due to the very high impedance of the analog inputs, the measurement result is undefined, i.e. variable at inputs that are not connected (open). To minimise interfering factors, all the inputs that are not required should be connected with “Analog input GND” (see pin assignment).

2) Analog outputs

Fig. 3-18: Connection example (analog outputs)



3) Digital I/O (24 V)

Fig. 3-19: Connection example (digital inputs)

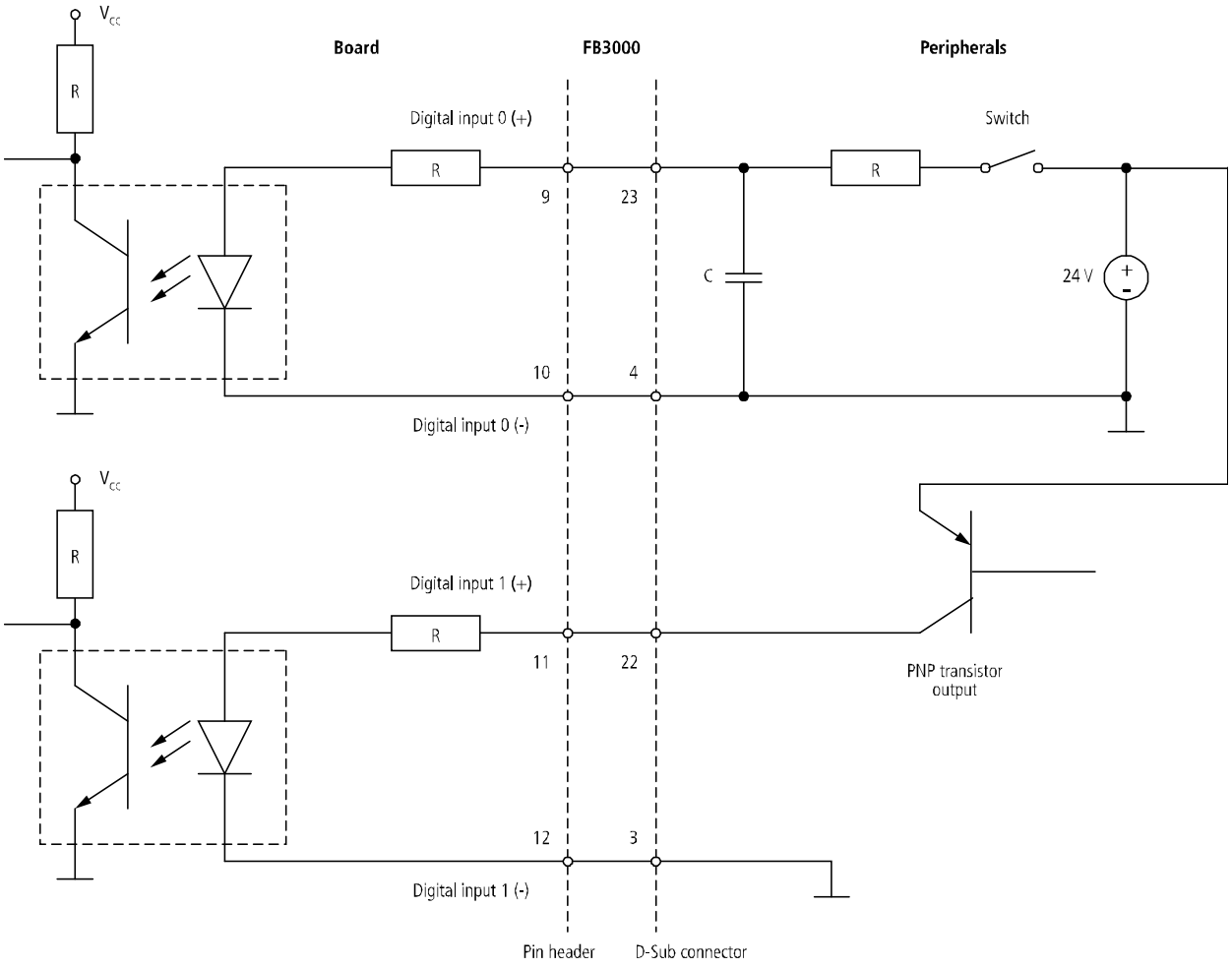
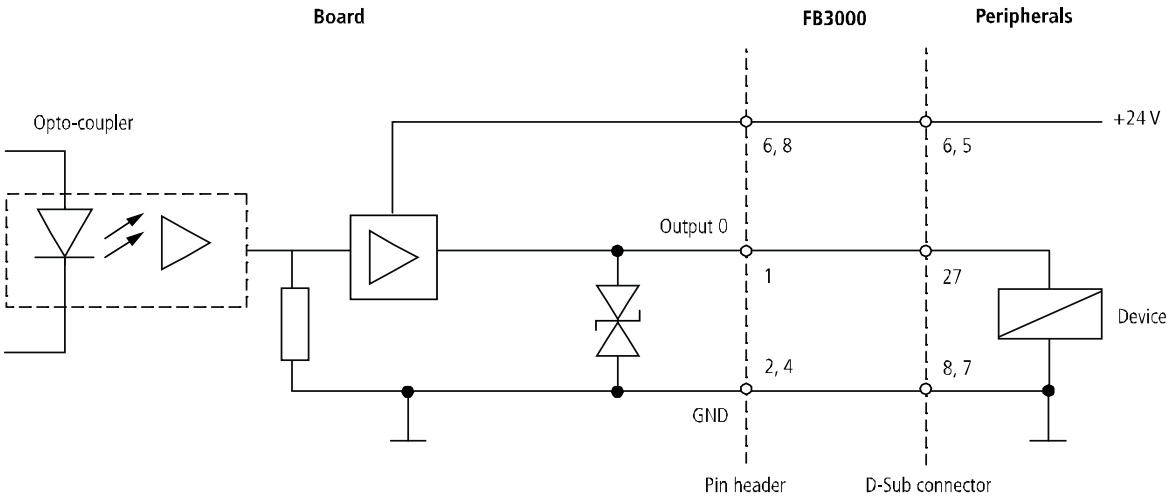


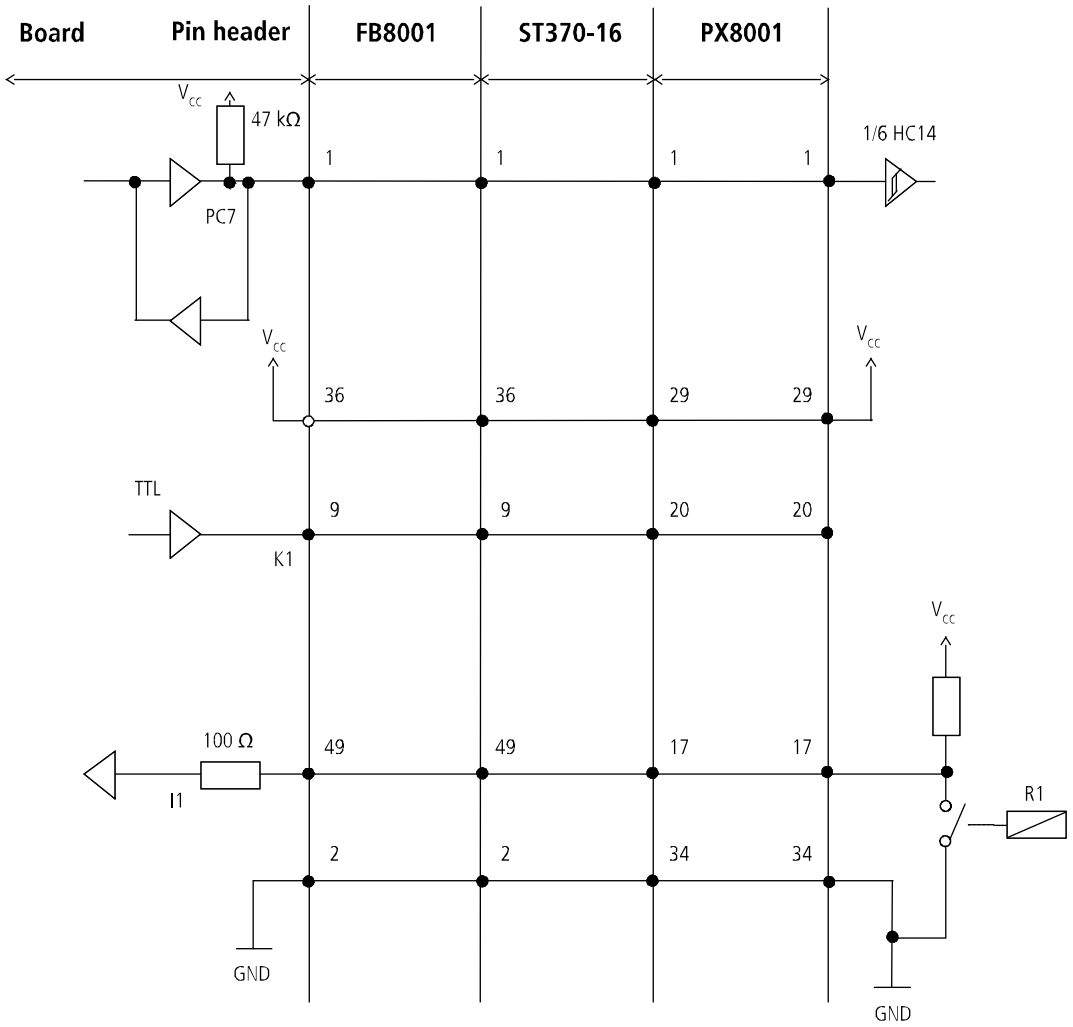
Fig. 3-20: Connection example (digital outputs)



NOTICE!
Please note that an external voltage source is required for the digital outputs (see Chapter 7.5.4).

4) TTL I/O

Fig. 3-21: Connection example (TTL I/O)



Ports 0, 1 and 2 are each set to V_{CC} via a pull-up resistor (47 kΩ).

3.4 Driver installation

Information on how to select and download the appropriate driver can be found in the document "Quick installation PC boards" (see PDF link).

The installation of drivers of the type "ADDI-DATA Multiarchitecture Device Drivers 32-/64-Bit for x86/AMD64" as well as the installation of the corresponding samples is described in the installation instructions (see PDF link).

4 Function description

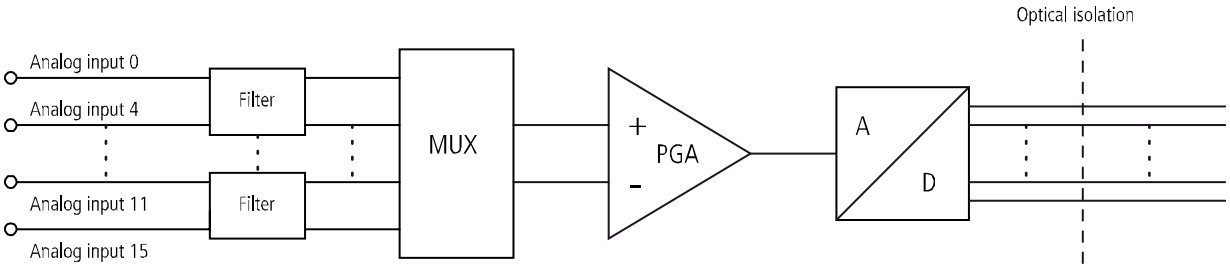
4.1 Analog inputs

Up to 16 single-ended or 8 differential signals can be connected to the boards **APCIe-3021, APCIe-3121, APCIe-3126** and **CPCIs-3121**.

4.1.1 Time-multiplexing system

The data acquisition chain of the board is based on a so-called time-multiplexing system, which comprises only one A/D converter. The measuring channels are led via an analog multiplexer to the A/D converter.

Fig. 4-1: Time-multiplexing system



The signals are led via a filter (RC circuit) to the multiplexer and then through a programmable gain amplifier to the 16-bit A/D converter.

When the multiplexer switches from one measuring channel to another, the output capacitance of the multiplexer must be reloaded to the voltage of the new channel (example: channel 0 = +9.99 V, channel 1 = -9.99 V). The current for reloading the output capacitance is supplied by the signal source (sensor). The time for reloading is called (signal) settling time. This time depends on the following parameters:

- Maximum voltage jump from one measuring channel to another
- Source impedance of the sensor system
- Filter option.

To avoid incorrect measurements, a wait time between the switching of the multiplexer and the start of the A/D conversion must be included. This time can be set in the range from 10 µs to 65,535,000 µs in steps of 1 µs using a software function (e.g. “i_PCIe3121_InitAndStartAnalogInputSequenceEx”, parameter “dw_ConvertingTime”; see Chapter 5).

4.1.2 Voltage ranges

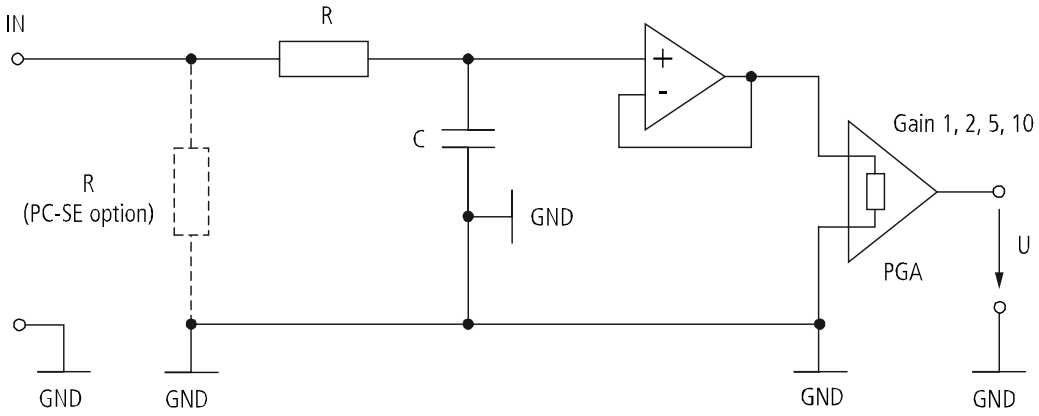
The analog input range (0-10 V, ± 10 V, 0-5 V, ±5 V, 0-2 V, ± 2 V, 0-1 V, ± 1 V or optional 0-20 mA) and the gain can be selected through software for each channel. This enables different voltages (or currents) with the channels so that the resolution of the A/D converter can be used to full capacity.

NOTICE!
Please note that a longer settling time of the measurement chain has to be reckoned with when switching the voltage range from unipolar to bipolar or vice versa.

4.1.3 Analog input circuit

1) Single-ended

Fig. 4-2: Analog input circuit (single-ended)



R (PC-SE option) = Optional equipment with current version PC-SE = 250 Ω

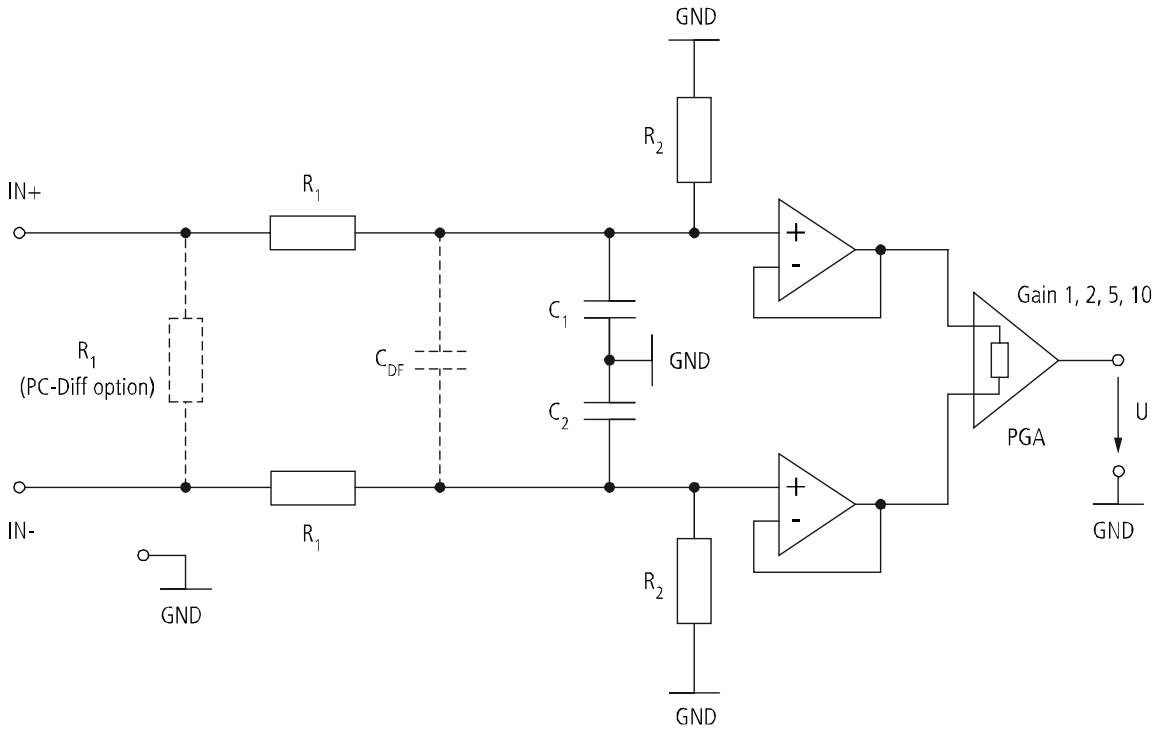
Table 4-1: Cut-off frequency calculation (single-ended)

Cut-off frequency $f_{-3dB} = 1 / (2 \pi * R * C)$

Equipment	R	C	Cut-off frequency
Standard version	100 Ω	10 nF	159 kHz
SF option (filter)	10 kΩ	470 nF	30 Hz

2) Differential

Fig. 4-3: Analog input circuit (differential)



R_1 (PC-Diff option) = Optional equipment with current version PC-Diff = 250 Ω
C_{DF} = Optional equipment with DF filter

Table 4-2: Cut-off frequency calculation (differential)

Cut-off frequency $f_{-3dB} = 1 / (2 \pi * (R_1 + R_1) * [C_{DF} + (C_1 \parallel C_2)]$

$C_{DF} = 0$ (if not fitted)

Equipment	R_1	R_2	C	Cut-off frequency
Standard version	100 Ω	1 MΩ	$C_1 = C_2 = 10$ nF	159 kHz
DF option (filter)	10 kΩ	10 MΩ	$C_{DF} = 470$ nF	30 Hz

4.1.4 Input modes of the analog inputs

For the analog input, up to 16 single-ended or 8 differential channels are available on the boards **APCIe-3021, APCIe-3121, APCIe-3126** and **CPCIs-3121**. The acquisition can be carried out in the following modes:

1) Simple mode

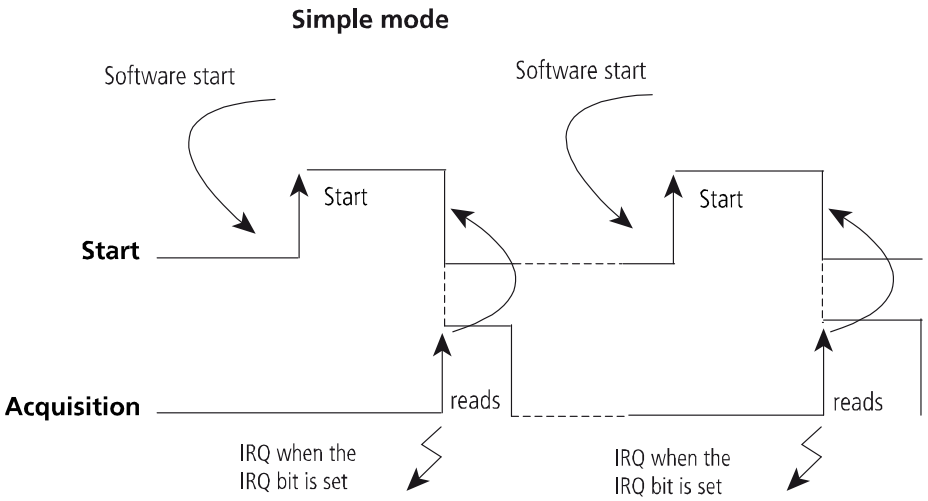
2) Scan mode

3) Sequence mode (with DMA function)

4) Auto-refresh mode

1) Simple mode

The software initialises and starts the A/D conversion. After that it reads in the digital value from one or more channels. This can be done either with or without interrupt.



2) Scan mode

There are 6 different scan modes:

a) Software-triggered single scan

b) Hardware-triggered single scan

c) Software-triggered continuous scan

d) Software-triggered continuous scan with timer delay

e) Hardware-triggered continuous scan

f) Hardware-triggered continuous scan with timer delay.

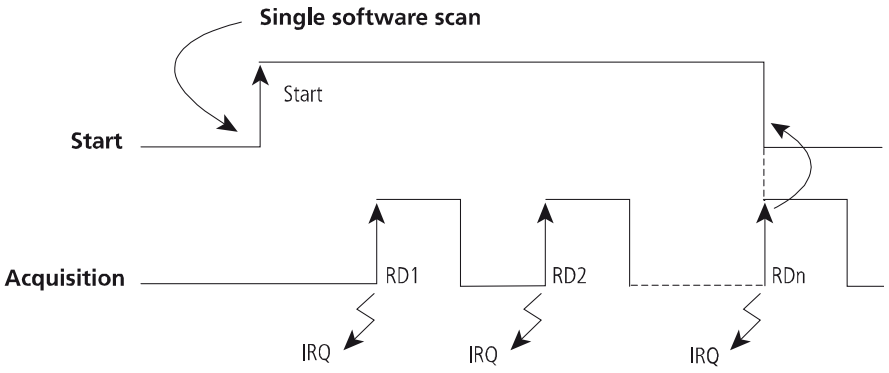
These scan modes are explained in more detail below.

a) Software-triggered single scan

The user interrupt routine is called up after the last IRQ (= ADDI-DATA driver).

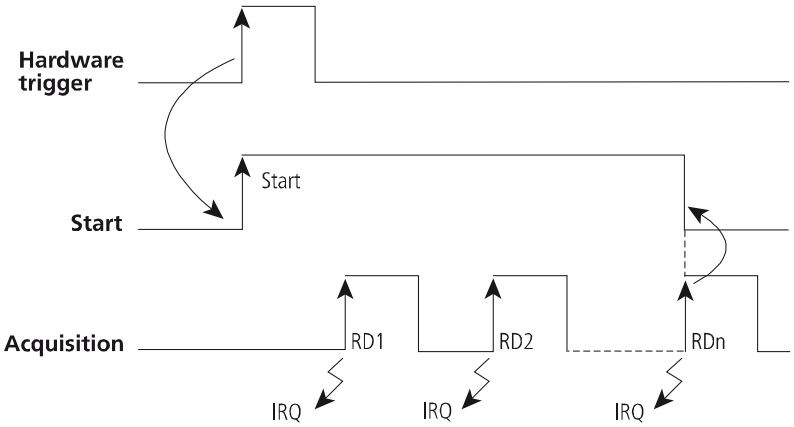
NOTICE!

Please note that the DMA function is not used in Scan mode.

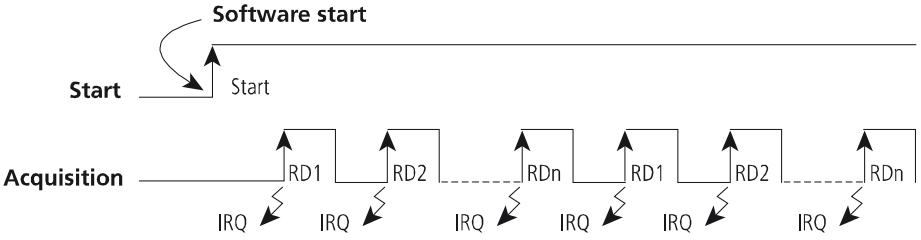


b) Hardware-triggered single scan

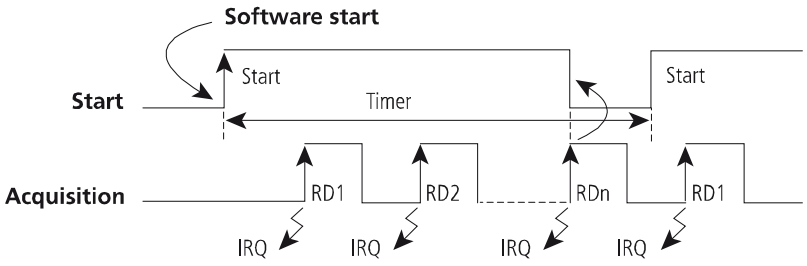
This scan can be triggered with a rising or falling edge (initialisation through software).



c) Software-triggered continuous scan

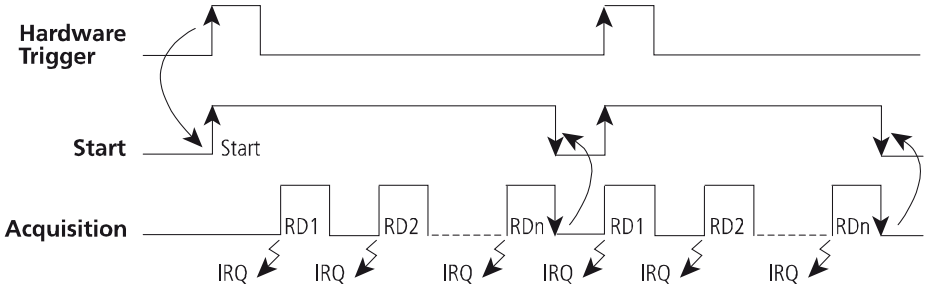


d) Software-triggered continuous scan with timer delay

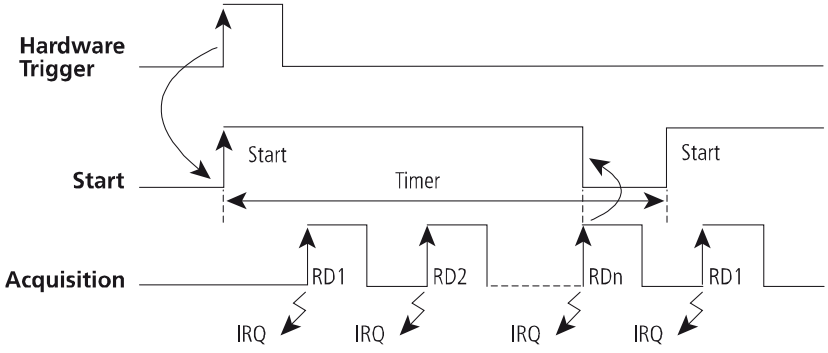


e) Hardware-triggered continuous scan

NOTICE!
Please note that in this scan mode, the external signal triggers only one scan at a time.



f) Hardware-triggered continuous scan with timer delay



3) Sequence mode (with DMA function)

Two sequence modes are available, which are described below with examples:

a) Simple sequence mode (examples 1 and 2)

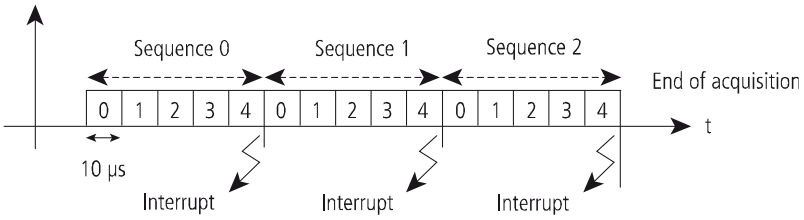
b) Sequence mode with delay.

NOTICE!
Please note that the Sequence mode always uses the DMA function (Direct Memory Access).

a) Simple sequence mode

Example 1

In this example, the interrupt is released at the end of each sequence (after 5 acquisitions at a time). The whole acquisition is completed after 3 sequences.



b_ChannelCount = 5

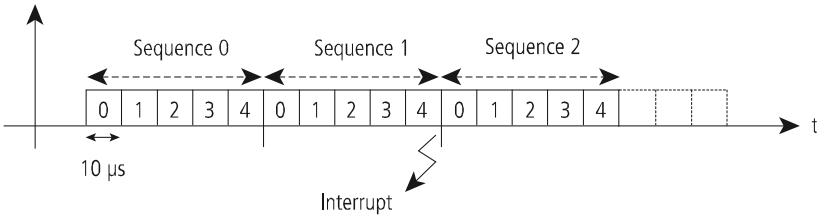
pb_Channel = 0, 1, 2, 3, 4

dw_SequenceCount = 3

dw_SequenceBeforeInterrupt = 1

Example 2

Here, the interrupt is released after 2 sequences (10 acquisitions). The entire acquisition is completed via the following function: i_PCIe3121_StopAnalogAcquisition **(APCIe-3121, APCIe-3126** and **CPCIs-3121)** or i_PCIe3021_StopAnalogAcquisition **(APCIe-3021)**



b_ChannelCount = 5

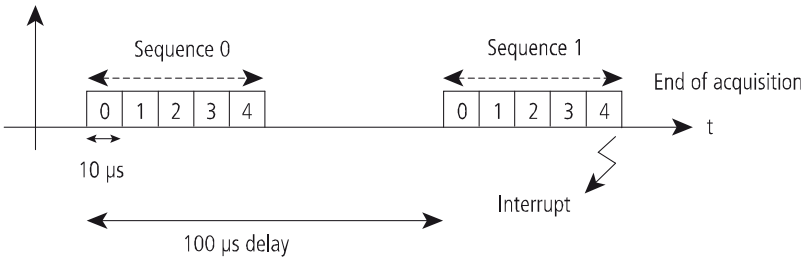
pb_Channel = 0, 1, 2, 3, 4

dw_SequenceCount = 0

dw_SequenceBeforeInterrupt = 2

b) Sequence mode with delay

The interrupt is released after 2 sequences (10 acquisitions). At the same time, the acquisition is completed. The delay between the starts of two sequences is 100 µs.



b_ChannelCount = 5

pb_Channel = 0, 1, 2, 3, 4

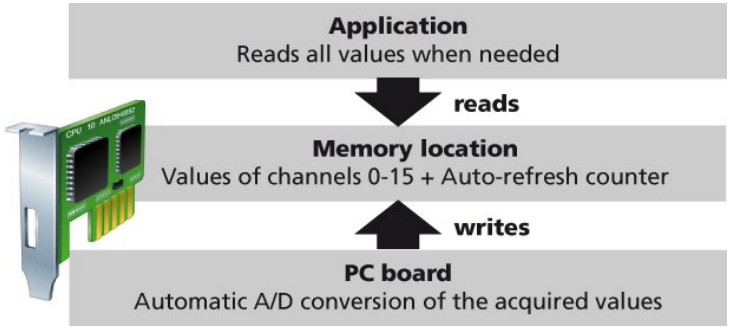
dw_DelayTime = 100

dw_SequenceCount = 2

dw_SequenceBeforeInterrupt = 2

4) Auto-refresh mode

The analog acquisition is initialised and the channel values are written in a fixed memory location on the board. The PC reads the data asynchronously to the acquisition.

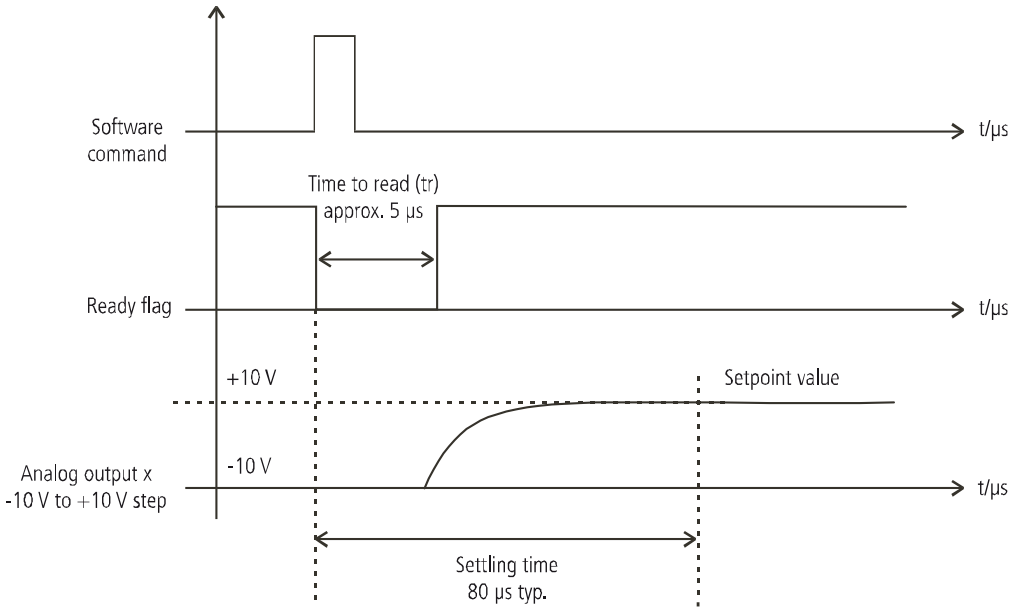


4.2 Analog outputs

There are up to 8 analog output channels with 16-bit resolution on the **APCIe-3121, APCIe-3126, APCIe-3521** and **CPCIs-3121**. The analog outputs are updated through 32-bit write operations on I/O addresses. A status bit (DAC Ready) indicates if the analog outputs are ready to be updated again.

The time between writing on the I/O addresses (DAC register) and the update of the analog outputs is 5 µs (“Time to read”). Further accesses to the DAC registers are ignored during this interval.
The time between writing the software command and reaching the setpoint value for the analog outputs is 80 µs (settling time set to 0.01% FSR).

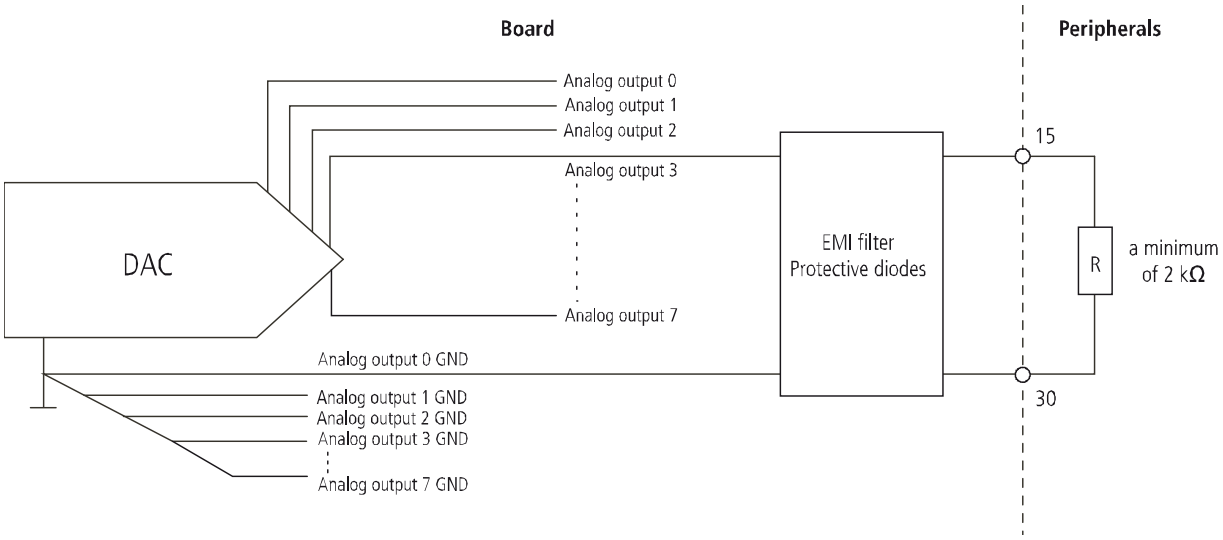
Fig. 4-4: Reaction time of the analog outputs



Optionally, analog current outputs are offered. In this case, the programmed output voltage is converted into a constant current by means of a voltage-to-current converter module (range: 0-20 mA).

When the computer is switched on, the analog outputs are temporarily in an undefined state. It is thus essential that the computer should be switched on before the connected peripherals.
After the Power ON reset of the computer, a voltage of 0 V or a current of 0 mA is applied to all analog outputs.

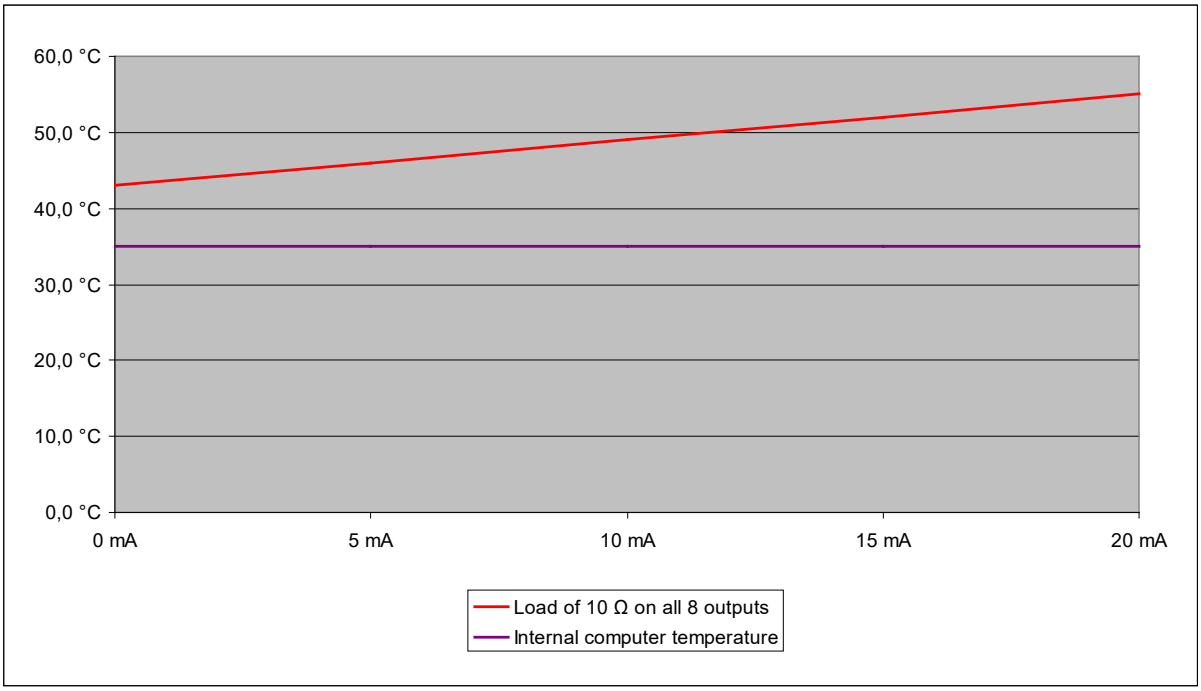
Fig. 4-5: Connection of the analog ground lines



NOTICE!
With the current outputs, sufficient cooling of the board in the PC has to be ensured. The board temperature must not exceed 60 °C!

The following diagram shows the heat development of the board with a minimum load of 10 Ω, an internal computer temperature of 35 °C and different output currents on all 8 outputs.

Fig. 4-6: Heat development of the board



4.3 Digital inputs

The digital inputs acquire external signal states. The input information is loaded as a numeric value in a memory cell of the system via the driver function. This numeric value represents the status of the input signals.

The inputs correspond to the 24 V industry standard (DIN EN IEC 61131-2):

- Logic “1” corresponds to an input voltage ≥ 19 V.
- Logic “0” corresponds to an input voltage ≤ 14 V.

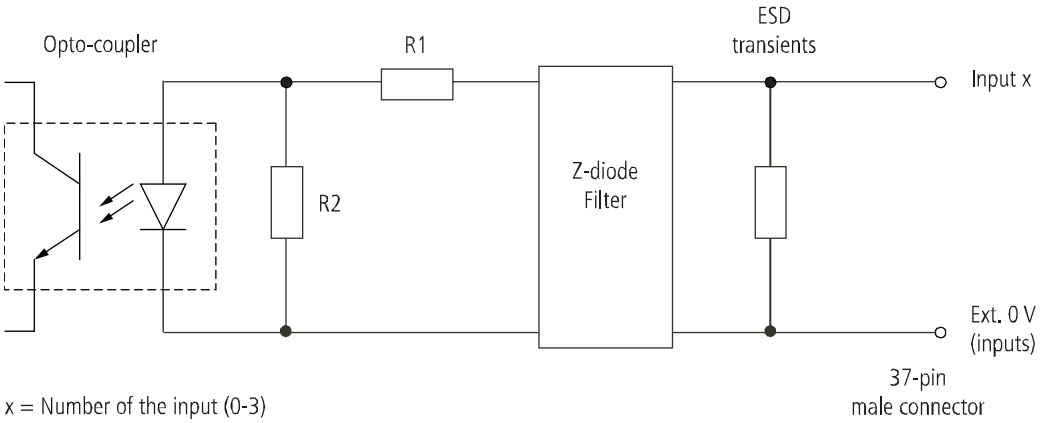
The current demand for each input is 10.5 mA at nominal voltage. The maximum input voltage is 30 V.

NOTICE!
The mains supply for the external power supply of the board must deliver at least the power that is required for your application.

The input signals are filtered by TVS diodes, Z-diodes, RC filters and opto-couplers. In this way, the effect of inductive and capacitive noise is reduced.

The board does not require initialisation to directly read the digital input information. The data is immediately available after turning on the computer.

Fig. 4-7: Input circuit



4.4 Digital outputs

For the digital outputs, positive logic is used:

- Logic “1”: Set output through software
- Logic “0”: Reset output

The maximum supply voltage is 32 V. Each output can switch a current of 65 mA. The total current of all outputs is limited to 300 mA by a polyswitch fuse element.

NOTICE!
The mains supply for the external power supply of the board must deliver at least the power that is required for your application.

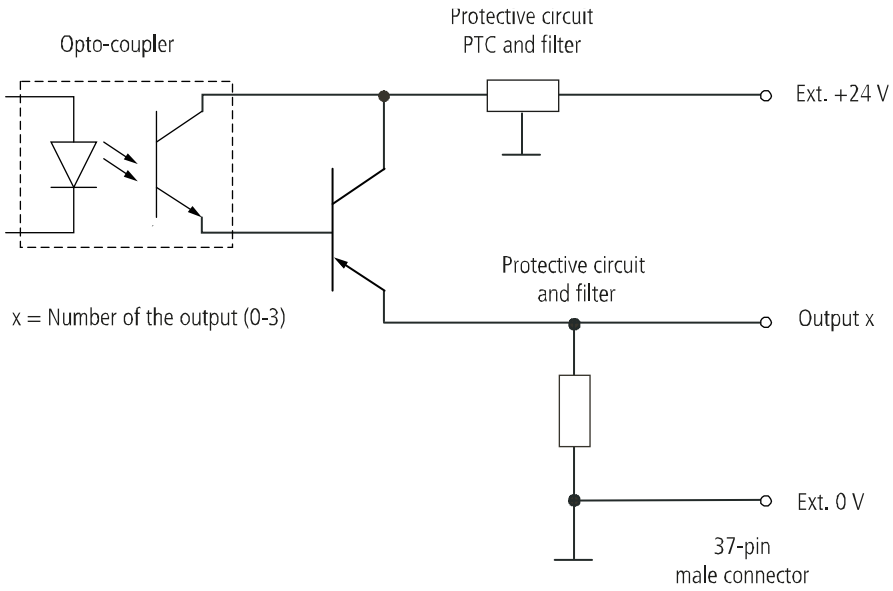
Characteristics of the 24 V outputs:

- Short-circuit protection relating to ground: The output is switched off.
- Protection against overtemperature: The output driver is switched off.

TVS diodes and opto-couplers filter noise on the peripheral side. In this way, the effect of inductive and capacitive noise on the system bus side is reduced or eliminated.

The board does not require initialisation to output the digital information. The outputs are reset to “0” after power-on (reset) and can be immediately programmed.

Fig. 4-8: Output circuit (24 V)



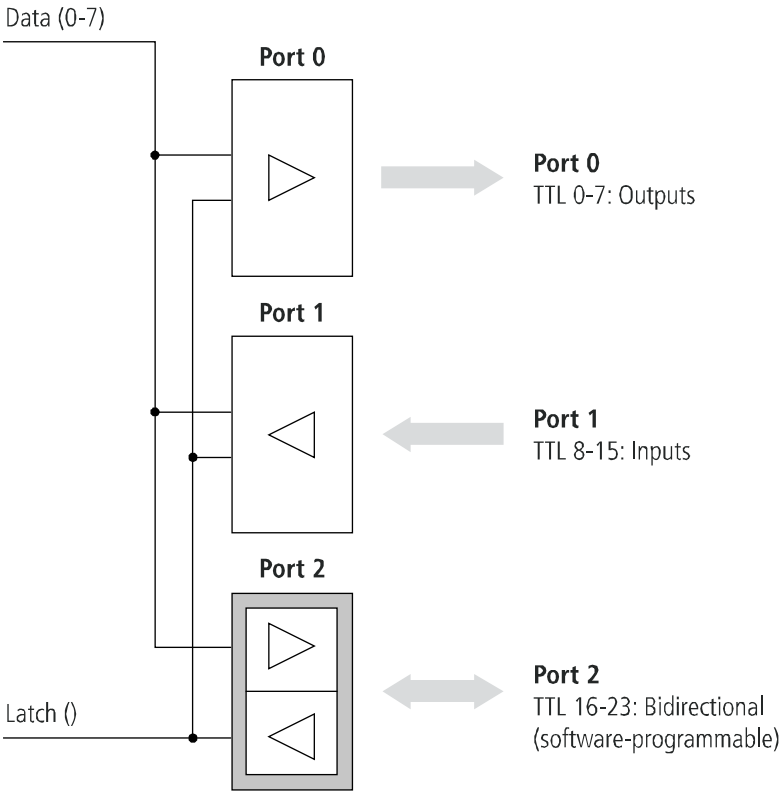
4.5 TTL I/O

The board **APCIe-3126** has 24 TTL channels, which are divided into three ports.

Table 4-3: APCIe-3126: TTL I/O ports

Port	Channel	Function
0	0 to 7	Outputs
1	8 to 15	Inputs
2	16 to 23	Inputs or outputs (software-programmable)

Fig. 4-9: APCIe-3126: Block diagram TTL I/O



4.6 Timer and watchdog

The board **APCIe-3021** is fitted with a timer. The boards **APCIe-3121, APCIe-3126, APCIe-3521** and **CPCIs-3121** each have two timers (0 and 1). One of these timers (timer 1) can also be programmed as a watchdog.

4.6.1 Timer

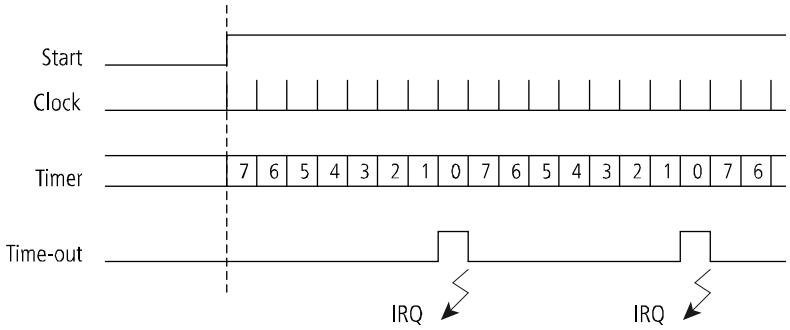
Independently from the PC clock, the timer provides a time base to synchronise operations, for example. The 16-bit timer is a downward counter which can release an interrupt after the programmed cycle time has elapsed (time-out).
The current timer value and the start value (reload value) as well as status and interrupt registers can be read back through software. The cycle time can be programmed in the range from 1 µs to 65535 s.

Example

Reload value = 7
Initialisation with a rising edge
Interrupt enabled

When the timer value is “0”, the reload value “7” will be reloaded with the next valid edge and an interrupt will be released.

Fig. 4-10: Timer (example)



4.6.2 Watchdog

The watchdog is a downward counter. It is used to monitor the analog outputs of the board.

After the start of the watchdog, the start value (reload value) is reloaded every time the analog outputs are set (triggering). Triggering can also occur directly through a software command without setting the analog outputs again. The watchdog sets the analog outputs back to 0 V after the complete cycle time has elapsed (time-out), i.e. if the watchdog has not been triggered anew.
The operating states of the watchdog can be read back. The cycle time can be programmed in the range from 1 µs to 65535 s.

4.6.3 Setting a digital output

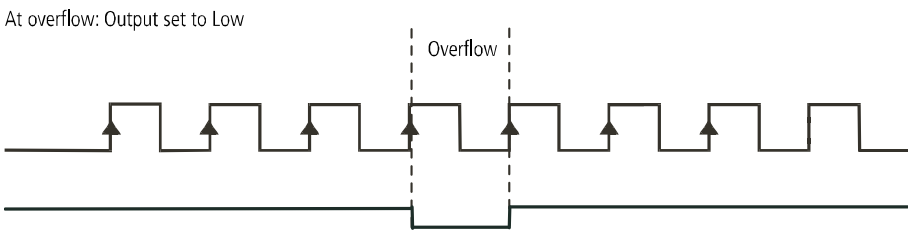
Table 4-4: Digital outputs (24 V)

Digital output	Timer/watchdog
0	Timer 0
1	Timer 1 / watchdog 0 (watchdog 0 for analog outputs)

1) Timer

When the timer has run down, a digital output (24 V) can be set. It is possible to define the output level (example: OutputAction = Set Output to Low). The output is activated for one (input) clock pulse.

Fig. 4-11: Setting a digital output (example)



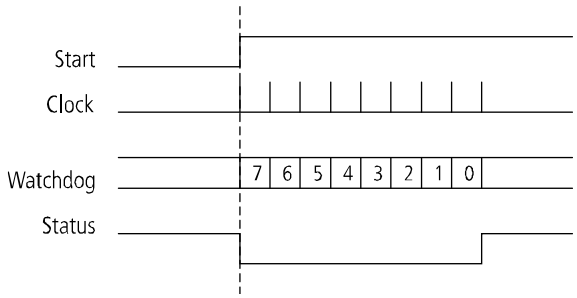
2) Watchdog

Optionally, the watchdog status can be output at the digital 24 V output 1 (output = status level).

Example

Reload value = 7
Initialisation with a rising edge
OutputAction = Set Output to High

Fig. 4-12: Watchdog (example)



5 Standard software

The API software functions supported by the board are listed in an HTML document. A description of how to access the respective file can be found in the document “Quick installation PC boards” (see PDF link), in the chapter “Standard software”.

6 Return or disposal

6.1 Return

If you need to return your board, you should read the following checklist before.

Checklist for returning the board:

- Specify the reason for returning your board (e.g. exchange, modification, repair), the serial number of the board, the contact person in your company including his/her telephone extension and e-mail address, as well as the mailing address for a potential new delivery. You do not have to indicate the RMA number.

Fig. 6-1: Serial number



- Note down the serial number of the board.
- Place the board in an ESD protective cover. Then pack it in a cardboard box so that it is well-protected for shipping. Send the packed board together with your details to:

  ADDI-DATA GmbH
  Airpark Business Center
  Airport Boulevard B210
  77836 Rheinmünster
  Germany

- If you have any questions, do not hesitate to contact us:

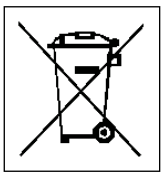
  Phone: +49 7229 1847-0
  E-mail: info@addi-data.com

6.2 Disposal of ADDI-DATA waste equipment

ADDI-DATA organises the disposal of ADDI-DATA products that were put on the German market after 13 August 2005.
If you want to return waste equipment, please e-mail your request to: info@addi-data.com.

Boards that were delivered after 13 August 2005 can be recognised by the following label:

Fig. 6-2: Disposal: Label



This symbol indicates the disposal of waste electrical and electronic equipment. It is valid in the European Union and in other European countries that have a separate collection system. Products carrying this symbol must not be treated as household waste.
For more detailed information on the recycling of these products, please contact your local citizens' office, your household waste collection service, the shop where you bought this product or the distributor you purchased this product from.

If you dispose of this product correctly, you will help to prevent damage that could be caused to the environment and to human health by inappropriate disposal. The recycling of materials will help to conserve our natural resources.

Disposal in other countries than Germany
Please dispose of the product according to the country-specific regulations.

7 Technical data and limit values

7.1 Electromagnetic compatibility (EMC)

The board **APCIe-3x2x**[1] or **CPCIs-3121** is suited for installation in personal computers (PCs) or CompactPCI Serial computers or corresponding hybrid systems which comply with the European EMC directive.

The boards **APCIe-3x2x** and **CPCIs-3121** comply with the European EMC directive. The tests were carried out by a certified EMC laboratory in accordance with the standard DIN EN IEC 61326-1.
The limit values as set out by the European EMC directive for an industrial environment are complied with.

The respective EMC test report is available on request.

7.2 Mechanical structure

Fig. 7-1: APCIe-3x2x: Dimensions

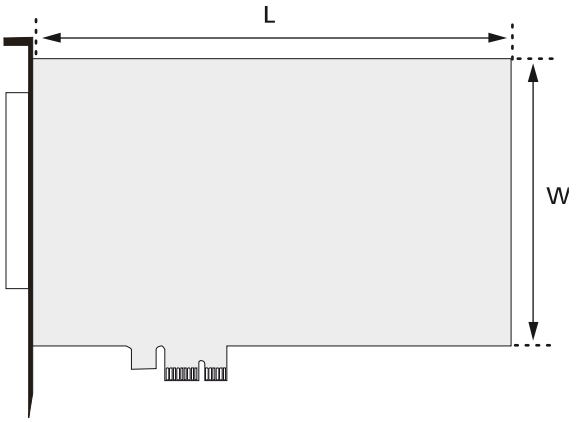


Fig. 7-2: CPCIs-3121: Dimensions



Dimensions (L x W):	**APCIe-3021, APCIe-3121, APCIe-3126, APCIe-3521:** 168 x 99 mm **CPCIs-3121:** 160 x 100 mm

[1] APCIe-3x2x = APCIe-3021, APCIe-3121, APCIe-3126 and APCIe-3521

Weight:	**APCIe-3021, APCIe-3121, APCIe-3521:** approx. 160 g **APCIe-3126:** 137 g **CPCIs-3121:** approx. 180 g
Insertion into:	**APCIe board:** PCI Express slot **CPCIs board:** CompactPCI Serial slot
Connection to peripherals:	see also Chapter 3.3
Front connector:	37-pin D-Sub male connector (analog I/O)
Additional connector:	**APCIe-3021, APCIe-3121, APCIe-3521, CPCIs-3121:** 16-pin header (digital I/O, option TTL I/O) **APCIe-3126:** 50-pin header (digital I/O, TTL I/O)
Accessories: [1]	see the following table and Chapter 3.3

Table 7-1: Accessories

	APCIe-3021, APCIe-3121, APCIe-3521	CPCIs-3121	APCIe-3126
Accessories	**Analog I/O**		
Cable	**ST010 / ST011**		
Screw terminal panel	**PX901-AG**		
	Digital I/O		
Cable	**ST010 / ST011**		**ST370-16**
	FB3000	**FB3001**	**FB8001**
Screw terminal panel	**PX901-ZG**		**PX8001**
	Option TTL I/O	**-**	**TTL I/O**
Cable	**ST010 / ST011**	**-**	**ST370-16**
	FB3000	**-**	**FB8001**
Screw terminal panel	**PX901-ZG**	**-**	**PX8001**



NOTICE!

The connection lines must be installed in such a way that they are protected against mechanical loads.

[1] Not included in standard delivery

7.3 Versions

The boards **APCIe-3x2x** and **CPCIs-3121** are available in the following versions:

Table 7-2: Versions

Version	Features
APCIe-3021-4	4 SE / 2 differential inputs
APCIe-3021-8	8 SE / 4 differential inputs
APCIe-3021-16	16 SE / 8 differential inputs
APCIe-3121-8-4	8 SE / 4 differential inputs, 4 analog voltage outputs
APCIe-3121-8-8	8 SE / 4 differential inputs, 8 analog voltage outputs
APCIe-3121-16-4	16 SE / 8 differential inputs, 4 analog voltage outputs
APCIe-3121-16-8	16 SE / 8 differential inputs, 8 analog voltage outputs
APCIe-3121-x-xC	like **APCIe-3121-x-x**, with analog current outputs
APCIe-3126-16-8	16 SE / 8 differential inputs, 8 analog voltage outputs
APCIe-3521-4	with 4 analog voltage outputs
APCIe-3521-8	with 8 analog voltage outputs
APCIe-3521-xC	like **APCIe-3521-x**, with analog current outputs
CPCIs-3121-8-4	8 SE / 4 differential inputs, 4 analog voltage outputs
CPCIs-3121-8-8	8 SE / 4 differential inputs, 8 analog voltage outputs
CPCIs-3121-16-4	16 SE / 8 differential inputs, 4 analog voltage outputs
CPCIs-3121-16-8	16 SE / 8 differential inputs, 8 analog voltage outputs

The specific version name can be found on the type label at the slot bracket or front panel of your board.

7.4 Options

Please specify the number of channels when ordering one of the following options for the boards **APCIe-3021, APCIe-3121, APCIe-3126** and **CPCIs-3121**!

Table 7-3: Options

Option	Features
SF	Precision filter for 1 single-ended channel
DF	Precision filter for 1 differential channel

Option	Features
PC-SE	Current input 0-20 mA or 4-20 mA for 1 single-ended channel
PC-Diff	Current input 0-20 mA or 4-20 mA for 1 differential channel
TTL I/O	**APCIe-3x21:** 4 TTL inputs, 4 TTL outputs

Table 7-4: PC-SE/PC-Diff option: Resolution

Measurement range	Resolution (16-bit)
0-20 mA	0 to 65535
4-20 mA	13107 to 65535

7.5 Limit values

Height:	2000 m over NN
Operating temperature:	**APCIe-3021, APCIe-3121, APCIe-3126, APCIe-3521:** 0-60 °C (with forced ventilation) **CPCIs-3121:** -40 °C to +85 °C (with forced ventilation)
Storage temperature:	**APCIe-3021, APCIe-3121, APCIe-3126, APCIe-3521:** -25 °C to +70 °C **CPCIs-3121:** -40 °C to +85 °C
Relative air humidity at indoor installation:	50 % at +40 °C 80 % at +31 °C
Minimum PC requirements:	
System bus:	**APCIe board:** 1-/4-/8-/16-lane PCI Express according to PCI Express Base Specification, Revision 1.0a (PCI Express 1.0a) **CPCIs board:** PCI Express acc. to CompactPCI Serial Specification PICMG CPCI-S.0 R1.0
Link speed	2.5 Gbit/s
Required space:	
- Analog I/O:	**APCIe board:** 1 PCI Express slot **CPCIs board:** 1 CompactPCI Serial slot
- Digital I/O:	**APCIe board:** 1 PCI Express slot (for **FB3000 / FB8001** cable) **CPCIs board:** 1 CompactPCI Serial slot (for **FB3001** cable)
- TTL I/O:	**APCIe board:** 1 PCI Express slot (for **FB8001** cable or option: for **FB3000** cable)
Operating system:	Windows 10, Windows 7, Linux
Energy demand:	
Operating voltage from the PC:	**APCIe board:** 3.3 V ± 9 % **APCIe/CPCIs board:** 12 V ± 8 %
Current consumption (typ., without load):	see the following table ± 10 %

Table 7-5: Current consumption (boards)

	APCIe-3121	APCIe-3121-x-xC	APCIe-3126	CPCIs-3121-16-8
+3.3 V from the PC	372 mA	372 mA	340 mA	-
+12 V from the PC	166 mA	167 mA	160 mA	310 mA

7.5.1 Analog inputs

Number of channels:	see Table 7-2
Resolution:	16-bit
Input range:	0-10 V (unipolar) ± 10 V (bipolar)
Throughput rate:	**APCIe-3021, APCIe-3121, APCIe-3521, CPCIs-3121:** 100 kHz **APCIe-3126:** 200 kHz
Optical isolation:	500 V (1 s tested)
Gain:	gain of 1, 2, 5 and 10
Integral nonlinearity (INL) of the A/D converter:	± 0.5 LSB typ. ± 2 LSB max.
Differential nonlinearity (DNL) of the A/D converter:	± 0.5 LSB typ. ± 1 LSB max.
Offset error (after calibration):	± 1 LSB
Gain error (after calibration):	± 1 LSB typ. ± 2.5 LSB max.
Bandwidth (-3 dB):	159 kHz (limited with low pass filter)
Overvoltage protection:	± 40 V
Input calibration:	
Unipolar offset calibration value:	5 V
Bipolar offset calibration value:	0 V
Bipolar gain calibration value:	9.9951 V
Calibration channel:	0 (single-ended)

7.5.2 Analog outputs

Output type:	voltage outputs (single-ended)
Number of channels:	see Table 7-2
Resolution:	15-bit (unipolar) 16-bit (bipolar)
Output range:	0-10 V (15-bit) ± 10 V (16-bit)
LSB:	305.176 µV
Integral nonlinearity (INL) of the D/A converter:	± 1 LSB typ. ± 4 LSB max.
Differential nonlinearity (DNL) of the D/A converter:	± 0.5 LSB typ. ± 1 LSB max.
Offset error (after calibration):	± 0.5 LSB typ. ± 2 LSB max.

Gain error (after calibration):	± 0.5 LSB typ. ± 1.5 LSB max.
Gain calibration value:	+9.9997 V
Settling time: FSR (20 V): 0.1 % FSR (20 V): 0.01 % FSR (20 V):	 30 µs typ. 55 µs typ. 80 µs typ.
Max. output current/load:	± 5 mA / 2 kΩ min. (per output)
Optical isolation:	500 V (1 s tested)
Short-circuit current:	± 35 mA max. (temporary)
Output voltage after reset:	0 V (see chapter 4.2)
Overvoltage protection:	± 15 V

Output type:	current outputs
Number of channels:	see Table 7-2
Resolution:	15-bit
Output range:	0-20 mA
LSB:	610.35 nA
Load (at 20 mA):	10 Ω (minimum) 560 Ω (maximum)
Output current after reset:	0 mA

7.5.3 Digital inputs (24 V)

Number of inputs:	4
Nominal voltage:	24 V
Filter/protective circuit:	low pass/TVS diodes
Optical isolation:	1000 V (via opto-couplers)
Input voltage:	0-30 V
Input current (at nominal voltage):	 10.5 mA typ.
Max. input frequency (at nominal voltage):	 1 MHz
Logic input levels:	UH_{max}: 30 V UH_{min}: 19 V UL_{max}: 14 V UL_{min}: 0 V

7.5.4 Digital outputs (24 V)

Number of outputs:	4
Output type:	high-side (load to ground according to DIN EN IEC 61131-2)
Nominal voltage:	24 V
Filter/protective circuit:	low pass/TVS diodes
Optical isolation:	1000 V (1 s tested)
Supply voltage:	**APCIe-3021, APCIe-3121, APCIe-3126, APCIe-3521:** 8-32 V **CPCIs-3121:** 8-28 V
Output current per output:	65 mA

Total current limit (PTC):	300 mA
Overtemperature (shutdown):	165 °C (output driver)
Temperature hysteresis:	15 °C (output driver)

7.5.5 TTL I/O



NOTICE!
The TTL inputs and outputs are not optically isolated.
Please make sure that no signal from the peripherals is connected to the inputs and outputs when the PC system is switched off or being booted up or shut down. This can be realised by means of a relay or tri-state circuit between the peripherals and the TTL inputs and outputs.
Moreover, the TTL outputs must be protected against short-circuit through the connected signals.

Number of channels:	**APCIe-3126:** 24 inputs or outputs
Number of ports:	3 ports of 8 channels each (Port 0: outputs, Port 1: inputs, Port 2: inputs/outputs)
Logic input levels:	UH_{max}: 5.5 V UH_{min}: 2 V UL_{max}: 0.8 V UL_{min} : 0 V
Logic output levels:	UH_{typ}: 5 V at -20 µA UH_{min}: 4.34 V at -6.6 mA UL_{max}: 0.33 V at 6.6 mA
Max. output load:	15 LSTTL

7.5.6 Option TTL I/O



NOTICE!
The TTL inputs and outputs are not optically isolated.
Please make sure that no signal from the peripherals is connected to the inputs and outputs when the PC system is switched off or being booted up or shut down. This can be realised by means of a relay or tri-state circuit between the peripherals and the TTL inputs and outputs.
Moreover, the TTL outputs must be protected against short-circuit through the connected signals.

Number of channels:	**APCIe-3021, APCIe-3121, APCIe-3521:** 4 inputs, 4 outputs

Logic input levels:	UH_{max}: 5.5 V UH_{min}: 2 V UL_{max}: 1.5 V UL_{min}: 0.8 V
Logic output levels:	UH_{max}: at least 4.4 V at -4 mA UH_{min}: at least 3.7 V at -20 µA UL_{max}: 0.4 V at -4 mA UL_{min}: 0.1 V at -20 µA
Max. output load:	10 LSTTL

7.5.7 Timer and watchdog

Timer (interruptible)

Number:	**APCIe-3021:** 1 (timer 0) **APCIe-3121, APCIe-3126, APCIe-3521, CPCIs-3121:** 2 (timers 0 and 1)
Resolution:	16-bit
Time base:	µs, ms, s (programmable)
Time value range:	1 to 65535
Output:	low/high (programmable)

Watchdog

Number:	**APCIe-3121, APCIe-3126, APCIe-3521, CPCIs-3121:** 1 (timer 1 as watchdog 0)
Resolution:	16-bit
Time base:	µs, ms, s (programmable)
Time value range:	1 to 65535
Tolerance:	≤ 1 µs, ms, s

8 Appendix

8.1 Glossary

Data bus
The data bus basically consists of several lines (or pins) through which the processor sends and receives data. The volume of data that can be transmitted simultaneously depends on the number of data lines. In other words: The more pins the bus has, the more efficient it is.

DMA
= Direct Memory Access

For direct memory access, i.e. direct data exchange with the PC memory, a DMA controller is used.

DNL
= Differential Nonlinearity

The differential nonlinearity is a KPI of the A/D converter or D/A converter. This value shows the difference between the measured and the ideal 1 LSB step between two neighbouring digital values.

Driver
A driver is a series of software instructions written specifically to manage particular devices.

Edge
Edges can either be rising or falling.
Logic levels are defined for processing and displaying information. In binary circuits, voltages are used for digital values. Here, the two voltage ranges “H” (high) und “L” (low) represent the information. The “H” range is closer to plus infinity; the “H” level corresponds to digital 1. “L” denotes the range closer to minus infinity; the “L” level corresponds to digital 0. The rising edge is the transition from the status “0” to “1”; the falling edge is the opposite transition.

EMC
= Electromagnetic Compatibility

According to the European EMC Directive, electromagnetic compatibility is “the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment.”

ESD
= Electrostatic Discharge

On non-conductive surfaces, an electric charge is conducted away very slowly. If the dielectric strength is overcome, there is a fast potential equalisation between the surfaces involved. The often very sudden equalisation process is referred to as electrostatic discharge (ESD). Currents of up to 20 A may occur in this process.

FSR
= Full Scale Range

FSR is the usable measurement range.

Ground line
Ground lines should not be seen as potential-free return lines. Different ground points may have small potential differences. This is always true with large currents and may cause inaccuracy in high-resolution circuits.

INL
= Integral Nonlinearity

The integral non-linearity is a KPI of the A/D converter or D/A converter. This value describes the maximum variance from a straight line that runs through the end-points of the transfer function (highest and lowest digital value). Before the measurement of the INL, the offset and the area error have to be calibrated. Calibration of the INL error alone is not possible.

Input impedance
The input impedance is the ratio of voltage to current at the input terminals when the output terminals are open.

Input level
The input level is the logarithmic ratio between two electrical values of the same type (voltage, current or power) at the signal input of any receiving unit. This unit is often configured as a logical level related to the input of the circuit. The input voltage corresponding to logic “0” is between 0 V and 15 V and the voltage corresponding to logic “1” is between 17 V and 30 V.

Interrupt
Processing of a current program is stopped or interrupted and the CPU is prompted to process another defined routine. It springs back to the interrupted program after the routine is complete.

Level
Logic levels are defined for processing and displaying information.
In binary circuits, voltages are used for digital values. Here, the two voltage ranges “H” (high) und “L” (low) represent the information.
The “H” range is closer to plus infinity; the “H” level corresponds to digital 1. “L” denotes the range closer to minus infinity; the “L” level corresponds to digital 0.

Limit value
Exceeding the limit values, even for a short time, can easily result in the destruction of the component or the (temporary) loss of functionality.

LSB
= Least Significant Bit

LSB is the lowest order bit in a digital quantity.

Operating voltage
The operating voltage is the voltage to the device in sustained operation. It must not exceed the maximum sustained voltage; and all unfavourable operating conditions, such as possible mains power surges for over a minute when the device is switched on, must be taken into account.

Optical isolation
Optical isolation means that there is no flow of electrical current between the circuit to be measured and the measuring system.

PTC
= Positive Temperature Coefficient

The best-value resistance sensors are either specified as PTC or NTC thermistors. A PTC thermistor has a positive temperature coefficient, hence, “PTC”.

Resolution
The resolution indicates how precisely a signal or value is held within the computer.

Short-circuit
A short-circuit exists between two terminals of an electric circuit if the relevant terminal voltage is zero.

Short-circuit current
A short-circuit current is the current between two short-circuited terminals.

Timer
A timer is used for adjusting time-dependent program processes between the processor and peripheral devices. It mostly contains counters that are independent of each other, and it can be programmed like a programmable I/O module via a control word register for different operating types.

Trigger
A trigger is a pulse or signal for starting or stopping a special task. Triggers are often used for controlling data acquisition.

TTL
= Transistor-Transistor Logic

TTL is a type of logic circuits that use multiple-emitter transistors. The Low signal is defined as a signal of 0.8 V or lower; the High signal as a signal of 2 V or higher.

TVS
= Transient Voltage Suppression

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9 Contact and support

Do you have any questions? Write or call us:

Address: ADDI-DATA GmbH
Airpark Business Center
Airport Boulevard B210
77836 Rheinmünster
Germany

Phone: +49 7229 1847-0
Fax: +49 7229 1847-222

E-mail: info@addi-data.com

Manual and software download from the Internet:

https://drivers.addi-data.com