DIN EN ISO9001:2000
certified

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Technical description

APCI-3200

Temperature measurement board, optically isolated

Edition: 05.05 - 03/2007

Product information

This manual contains the technical installation and important instructions for correct commissioning and usage, as well as production information according to the current status before printing.
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Declaration of Conformity

Document-Number/Month-Year: B-25121 / 06.2001

Manufacturer/Importer: ADDI-DATA GmbH
Dieselstraße 3
D-77833 OTTERSWEIER

Type: **APCI-3200**

Product description: **Board to be inserted in a PCI 32-bit/5 V slot of a PC**
Acquisition of thermocouples and Pt100
4 digital inputs and 3 digital outputs

The above named product complies with the following European directives:

Directive 72/23/EEC of 19 February 1973 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits.

Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility.

The following norms have been applied:

IEC 61010-1 2002-08

IEC 61326-2 2004

2004/10/18
Date

Legally valid signature of the manufacturer

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WARNING

In case of wrong uses and if the board is not used for the purpose it is intended:

- **people may be injured,**

- **the board, PC and peripheral may be destroyed,**

- **the environment may be polluted**

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

  If this leaflet is not with the documentation, please contact us and ask for it.

- **Observe the instructions of the manual.**

  Make sure that you do not forget or skip any step. We are not liable for damages resulting from a wrong use of the board.

- **Used symbols:**

IMPORTANT!
designates hints and other useful information.

WARNING!
It designates a possibly dangerous situation.
If the instructions are ignored the board, PC and/or peripheral may be destroyed.

Figures

Tables

1 DEFINITION OF APLICATION

1.1 Intended use

The board **APCI-3200** must be inserted in a PC with PCI 5V/32-bit slots, which is used as electrical equipment for measurement, control and laboratory pursuant to the norm IEC 61010-1.

1.2 Usage restrictions

The **APCI-3200** board must not to be used as safety related part for securing emergency stop functions.

The board must not be used in potentially explosive atmospheres.

1.3 General description of the board

Data exchange between the **APCI-3200** board and the peripheral is to occur through a shielded cable. This cable must be connected to the 50-pin SUB-D male connector of the **APCI-3200** board

The board has up to 16 output channels for processing analog signals and 4 input and 3 output channels for processing digital 24 V signals.

The use of the board **APCI-3200** in combination with external screw terminal panels or relay boards is to occur in a closed switch cabinet.

The installation is to be effected competently. **Check the shielding capacity** of the PC housing and of the cable prior to putting the device into operation.

The **PX 3200** screw terminal panel allows the connection of the analog signals to a cold junction compensation through the cable **ST3200**.

The connection with our standard cable **ST3200** complies with the following specifications:
- metallized plastic hoods
- shielded cable
- cable shield folded back and firmly screwed to the connector housing.

The use of the board according to its intended purpose includes observing all advises given in this manual and in the safety leaflet.

Uses beyond these specifications are not allowed. The manufacturer is not liable for any damages which would result from the non-observance of this clause.

The use of the board in a PC could change the PC features regarding noise emission and immunity. Increased noise emission or decreased noise immunity could result in the system not being conform anymore.

Make sure that the board remains in its protective blister pack **until it is used**.

Do not remove or alter the identification numbers of the board.
If you do, the guarantee expires.

2 USER

2.1 Qualification

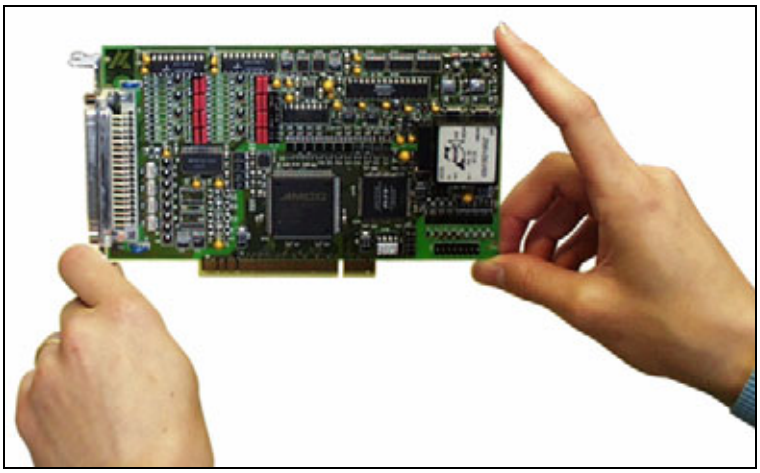
Only persons trained in electronics are entitled to perform the following works:
- installation
- use
- maintenance

2.2 Personal protection

Consider the country-specific regulations about:
- the prevention of accidents
- electrical and mechanical installations
- radio interference suppression

3 HANDLING OF THE BOARD

Fig. 3-1: Correct handling



4 TECHNICAL DATA

4.1 Electromagnetic compatibility (EMC)

The PC is to comply with the norm IEC61326 for measurement, control and laboratory use and with the specifications for EMC protection.

The board has been subjected to EMC tests in an accredited laboratory. The board complies with the limit values set by the norms IEC61326 as follows:

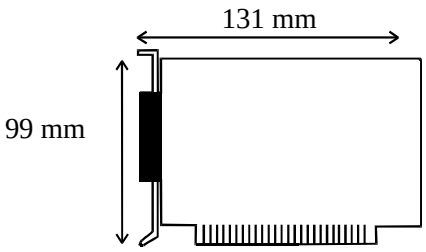
	True value	Set value
ESD (Discharge by contact/air)	4/8 kV	4/8 kV
Fields	10 V/m	10 V/m
Burst	4 kV	2 kV
Conducted radio interferences	10 V	10 V
Noise emissions	B-class	

WARNING!
The EMC tests have been carried out in a specific appliance configuration.
We guarantee these limit values **only** in this configuration.[1]

4.2 Physical set-up of the board

The board is assembled on a 4-layer printed circuit card.

Dimensions:



Weight: approx. 160 g
Installation in: ..... 32/64-bit PCI slot 5 V
Connection to the peripheral: ..... 50-pin SUB-D male connector
16-pin male connector for connecting the dig I/O

Accessories[2]:
Standard cable: **ST3200**
Ribbon cable: ..... **FB3000** for the digital I/O
Screw terminal panel: **PX3200**, **PX901-ZG**

WARNING!
The supply lines must be installed safely against mechanical loads.

[1] We transmit our appliance configuration on request.
[2] Not included in the standard delivery.

4.3 Versions

The board **APCI-3200** is available in the following versions:

Version	Number of connected thermocouples (S.E. inputs)	Number of connected RTD (differential inputs)
APCI-3200-4	4	2
APCI-3200-8	8	4
APCI-3200-16	16	8

4.4 Limit values

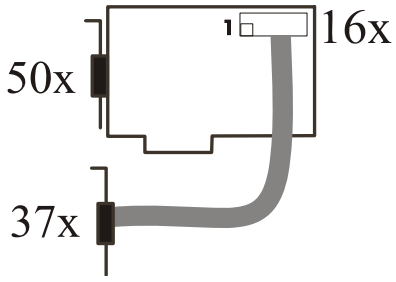
Max. altitude: ..... 2000 m
Operating temperature: ..... 0 to 60°C
Storage temperature: ..... -25 to 70°C
Relative humidity at indoor installation
50% at +40 °C
80% at +31 °C

Minimum PC requirements:
PCI BIOS from Version 1.0
Bus speed: ..... < 33 MHz
Operating system: ..... Windows NT, 98, 2000, XP, Linux
Data access: 32-bit
Decoding: ..... in the 64 K I/O range of the PC
"Target Only" Operating

Resources
4 I/O ranges: ..... 64 Bytes
256 Bytes
4 Bytes
4 Bytes
IRQs: ..... INTA of the PCI bus

Number of slot required ..... 1 slot +
1 slot opening for connecting the dig. I/O to the peripheral

Fig. 4-1: Number of slots required


1
16x
50x
37x

Optical isolation
Creeping distance: ..... 3.2 mm
Testing voltage: ..... 1000 VAC

Current sources
Number of current sources: ..... 2 to 8
+ 1 for the cold junction compensation
Output current (25 °C): ..... 200 µA ± 0.5 µA typ.
Drift: ..... ± 25 ppm/°C

Energy requirements:
- Operating voltage of the PC: ..... 5 V ± 5%
- Current consumption (without load): ..... typ. see table ± 10%

	APCI-3200-4	APCI-3200-8	APCI-3200-16
+ 5 V from PC	550 mA	570 mA	600 mA

Analog input channels
Resolution: ..... 18-bit unipolar
Number of voltage inputs: ..... 4 to 16
Overvoltage protection: ..... ± 30 V
Input voltage range: ..... Unipolar: 0 to 2.5V/PGA
Bipolar: ± 2.5 V/PGA
Input impedance: ..... S.E.: 5.6 MΩ
Diff.: 25 MΩ
Input capacity: ..... 530 pF
Input current: ..... 10 nA
Input amplifier (PGA): 1, 2, 4, 8, 16, 32, 64, 128
Data transfer: ..... The board is located in the I/O address space of the PC.
The values are written on the board through 32-bit accesses.
Digital coding: ..... Unipolar: Straight binary coding
Bipolar: Offset binary coding

Voltage range: -100 mV < V < +100 mV
Precision: 16-bit
Integral non-linearity (INL): .....± 0.0015 % of FSR[3] over the temperature range
Monotony: 16-bit
Offset error: ..... ± 0.0015 % of FSR
(Bipolar Offset Error)

[3] FSR: Full Scale Range

Voltage range: -2.5 V < V < - 100 mV and 100 mV < V < +2.5 V
Precision: 14-bit
Integral non-linearity (INL): ..... ± 0.0060 % of FSR[4] over the temperature range
Monotony: 14-bit
Offset error: ..... ± 0.0060 % of FSR (Bipolar Offset Error)
Gain error:
for gain 1, 2, 4, 8, 16, 32, 64: ..... ± 2 % of FSR
for gain 128 ..... ± 3 % of FSR

Table 4-1: Possible acquisition times

Acquisition times (Hz) 1 channel, offset, reference	Sample period (ms)
20	50
40	25
80	12.5
160	6.25

Digital input channels:
Number: 4
Input current at 24 V: ..... 2 mA typ.
Input voltage range: ..... 0-30 V
Optical isolation: ..... 1000 VAC
Logic "0" level: ..... 0-5 V
Logic "1" level: ..... 12-30 V

Digital output channels:
Number: 3
Max. switch current: ..... 125 mA typ.
Voltage range: ..... 8-30 V
Optical isolation: ..... 1000 VAC
Type: ..... Open Collector

Table 4-2: Short-circuit and line-break diagnostic

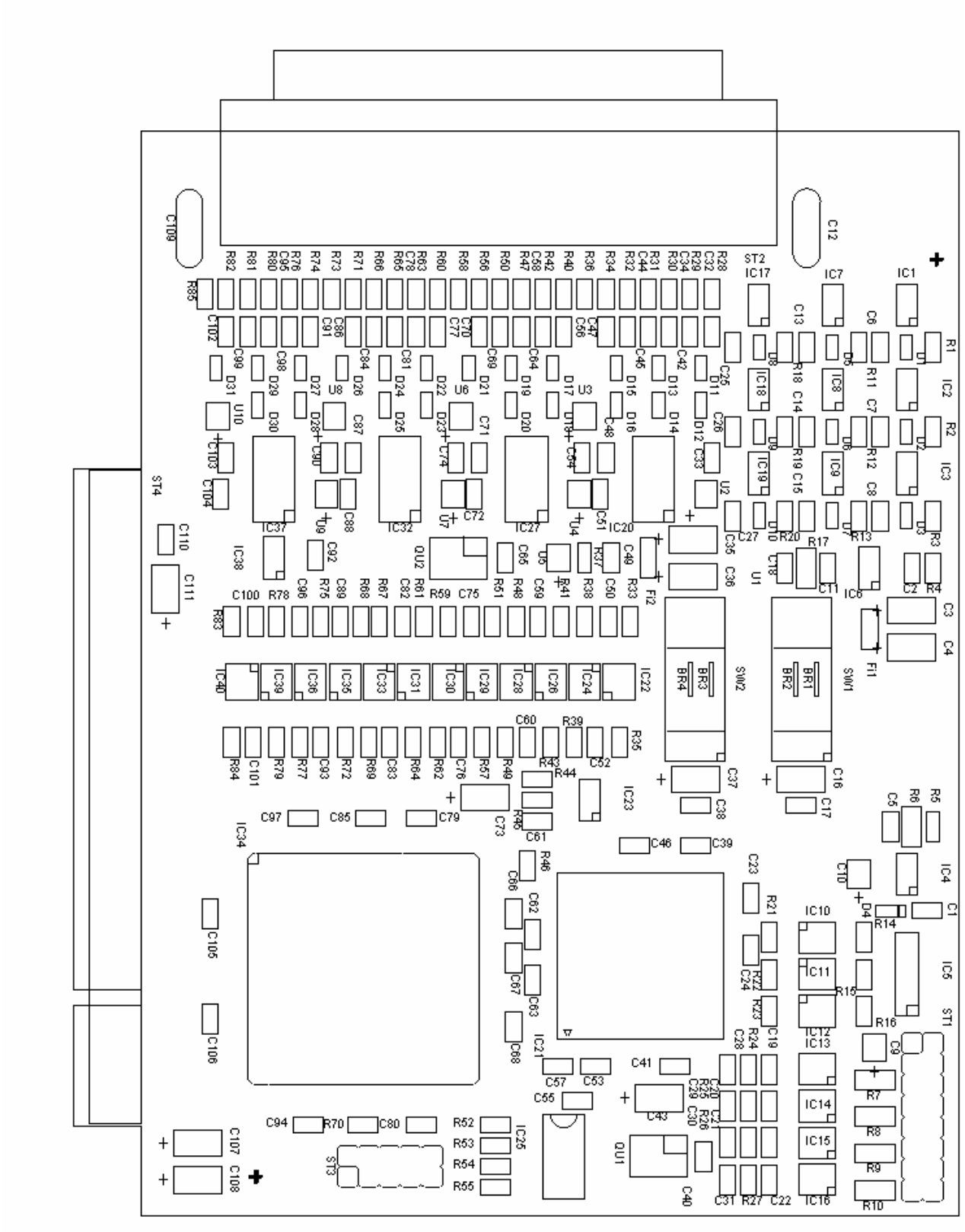
	Short-circuit		Line break	
Type of the connected sensor	Diagnostic function	Measured voltage at short-circuit	Diagnostic function	Measured voltage at line break
Thermocouple (Single-Ended)	not possible	-	possible	>2V
Resistance thermometer (Differential)	possible	< 1 mV *	possible	>2.5V
Potentiometer (Differential)	possible	< 1 mV*	possible	>2.5V

* If no sensor is connected to the board, the voltage measured at the input is also < 1 mV. In this case an additional line-break test must confirm the short-circuit diagnostic: the measured voltage must be > 2.5 V (open line).

[4] FSR: Full Scale Range

4.5 Component scheme

Fig. 4-2: Component scheme of the APCI-3200



5 INSTALLATION OF THE BOARD

IMPORTANT!
Do observe the safety precautions (yellow leaflet)!

5.1 Opening the PC

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

5.2 Selecting a free slot

Insert the board in a free PCI-5V slot (32-bit).

Fig. 5-1: PCI-5V slot (32-bit)

32 bits

Remove the back cover of the selected slot according to the instructions of the PC manufacturer. Keep the back cover. You will need it if you remove the board

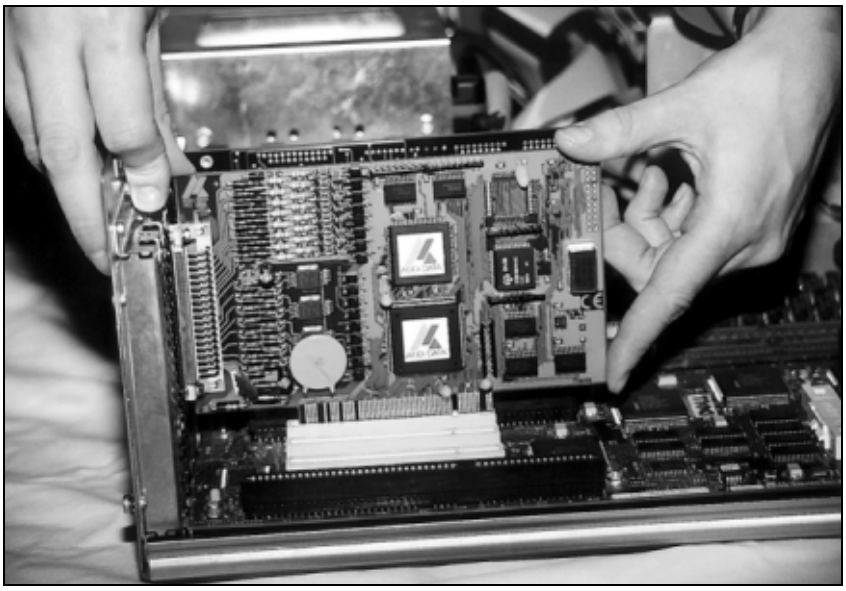
Discharge yourself from electrostatic charges.

Take the board out of its protective pack.

5.3 Plugging the board into the slot

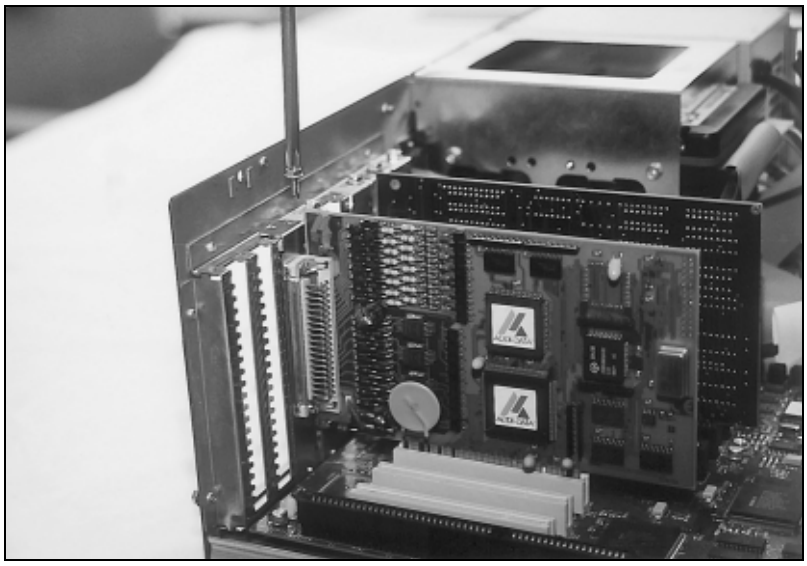
♦ Insert the board **vertically into the chosen slot.**

Fig. 5-2: Inserting the board



♦ Fasten the board **to the rear of the PC housing with the screw which was fixed on the back cover.**

Fig. 5-3: Fastening the board at the back cover



♦ **Tighten all the loosen screws.**

5.4 Closing the PC

♦ **Close your PC as described in the manual of the PC manufacturer.**

6 SOFTWARE

In this chapter you will find a description of the delivered software and its possible applications.

IMPORTANT!
Further information for installing and uninstalling the different drivers is to be found in the delivered description **"Installation instructions for the PCI and ISA bus".**

A link to the corresponding PDF file is available in the navigation pane (Bookmarks) of Acrobat Reader.

IMPORTANT!
The supported software functions for the APCI-3200 are listed in chapter 9.

The board is supplied with a CD-ROM containing the ADDIPACK software package for Windows NT 4.0 and Windows XP/2000/98.

ADDIPACK is composed of following programs:

- **ADDIREG:** The ADDIREG registration program is a 32-bit program for Windows NT 4.0 and Windows XP/2000/98. The user can register all hardware information necessary to operate the ADDI-DATA PC boards.

- **ADDIDRIVER** contains API functions to operate the ADDI-DATA boards in 32 bits.

- **ADDevice Manager** configures the resources of the ADDI-DATA virtual board (See below).

- **ADDI-DATA virtual board:**
  ADDI-DATA software is based on the principle of a **virtual board:** it transposes the different functions (e.g. digital inputs, analog outputs, timer, ...) of all inserted ADDI-DATA boards as the functions of a single (virtual) board. The virtual board features a pool of functions, the functionality of which can be called up without calling a specific board.

- **ADDEVICE MAPPER** was specifically developed for the ADDIPACK boards to facilitate the management of the virtual board. With this program you can optimally adapt the virtual board to your application requirements.

  IMPORTANT!
  For some functions of the **ADDEVICE MAPPER** program the browser Internet Explorer 6 or higher has to be installed on your PC.

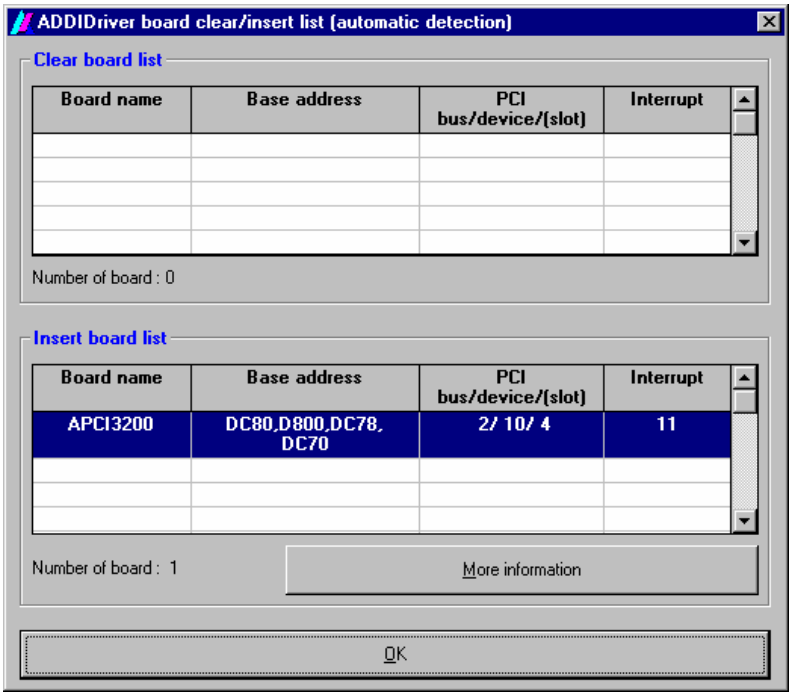
6.1 Board registration

When starting the set-up of ADDIREG, the APCI-3200 is automatically recognised and registered.

6.1.1 Installation of a new board

If a new board is recognised, the following windows is displayed:

Fig. 6-1: New inserted board



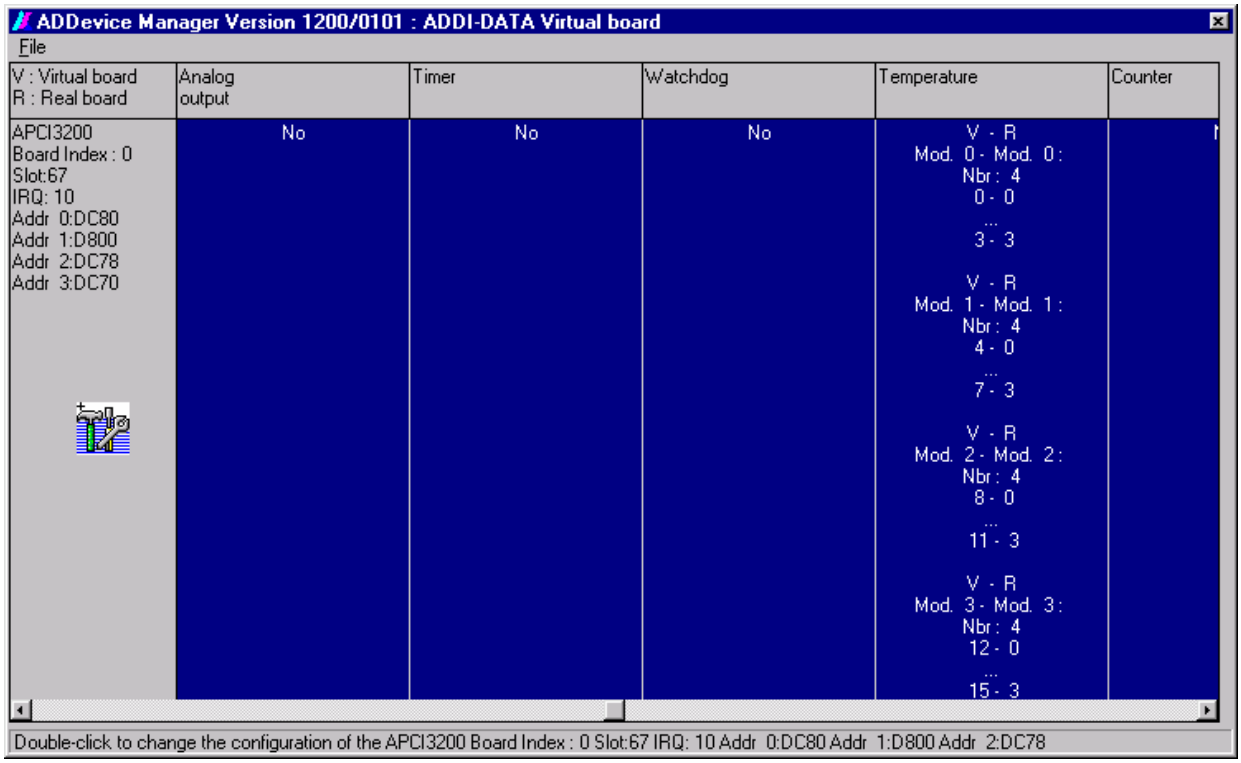
The boards which have been removed from the PC since the last ADDIREG start are listed in the upper table

The new inserted boards are listed in the lower table.

In case further information is required for the operation of the board, click on "More Information". ADDevice Manager is started.

ADDevice Manager

Fig. 6-2: ADDevice Manager



The following parameters are displayed for every inserted board:

First column:

- Board name
- Board index: Number allocated to the board when it is registered in ADDIREG.
- Slot number
- IRQ line
- Different addresses which are automatically allocated to the board by the BIOS.

Other columns:

The program distinguishes between the resources (Analog/digital input/output, watchdog, ...) of the virtual board (**V,** software) and the real board (**R,** board).

The following parameters are listed

- Module number,
- Number of resources
- Index: The first index line represents the number of the first resource (left: virtual resource - right: real board) The second index line represents the number of the last resource (left: virtual resource - right: real board).
- Type (24 V/5 V, voltage/current, HS/OC - High-Side/Open collector).
- IRQ: if the input channels are interruptible, the program displays the number of the first and of the last input channel

By clicking twice within a column, the connection principle and the technical data of the resource are displayed. This function is only possible if a question mark appears with the cursor.

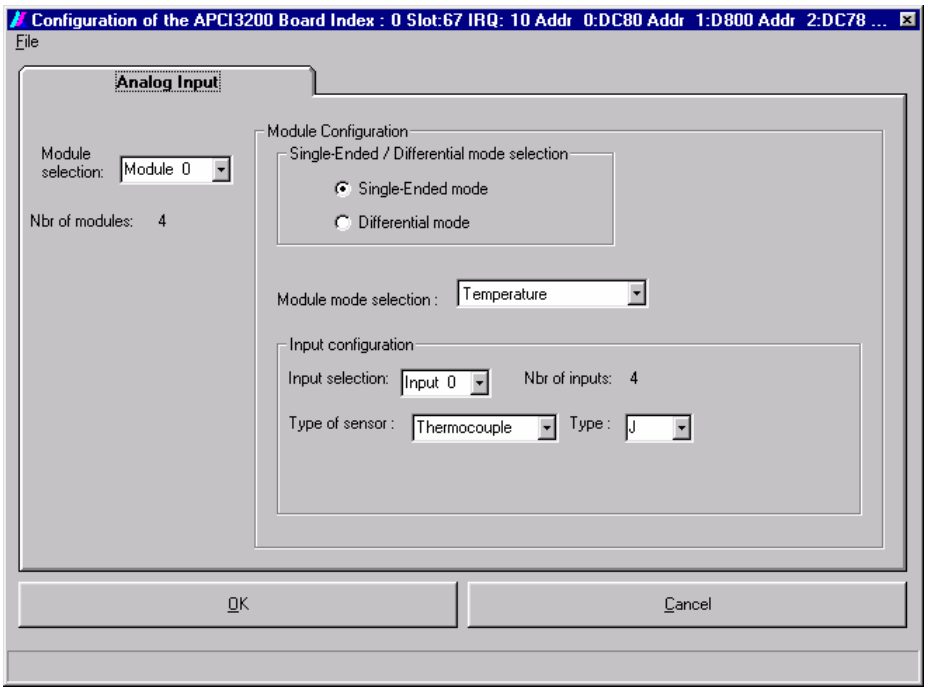
You can export the set configuration as a text file. Click on "file" and store the configuration as a .txt file with "Export information to file...". You can then print the configuration or use it for other APCI-3200 boards.

APCI-3200 configuration

If a tool icon appears together with the cursor in the first column of the ADDevice Manager, you can modify the board configuration (click twice), else not.

The input channels of the **APCI-3200** for example may have different functions.

Fig. 6-3: Configuration of the inputs for the APCI-3200



You can configure each module (4 inputs) independently from the others.

Module configuration:
Select the input mode: Single-ended or differential

Module mode selection:
According to the selected input mode (set in "Module configuration") you can select between different acquisisiton possibilities:

- temperature
- resistance
- analog

In "S.E. mode" 4 channels are available for each module. You can select between temperature and analog.
In "differential mode" 2 channels are available for each module. You can select between temperature, analog and resistance.

Input configuration:
You can select one different sensor type for each channel.
If you have selected temperature in single-ended mode, you can connect thermocouples.
If you have selected temperature in differential mode, you can connect RTD's.

After configuring the board as required, you come back to the former window with OK.

You can save the current set configuration for other boards. Click on "file" and save the configuration as .cdf file with "Save file in". You can then reload the cdf file for another board APCI-3200 by clicking ""File", "Load from File".

Once you have controlled the registration, you can quit the window of ADDevice Manager. The board is ready to operate.

6.1.2 Changing the registration of a board

You can change the current board configuration with ADDIREG.

Description of the ADDIREG program

The program is automatically installed with ADDIPACK.
Start ADDIREG under Start/Programme/ADDIPACK/ADDIREG.

IMPORTANT!
First quit all the applications (programs) which use the board before starting the ADDIREG program.

In the main window of ADDIREG the fields "Insert" and "Clear" are not available for the board.

Fig. 6-4: ADDIREG registration program (example)

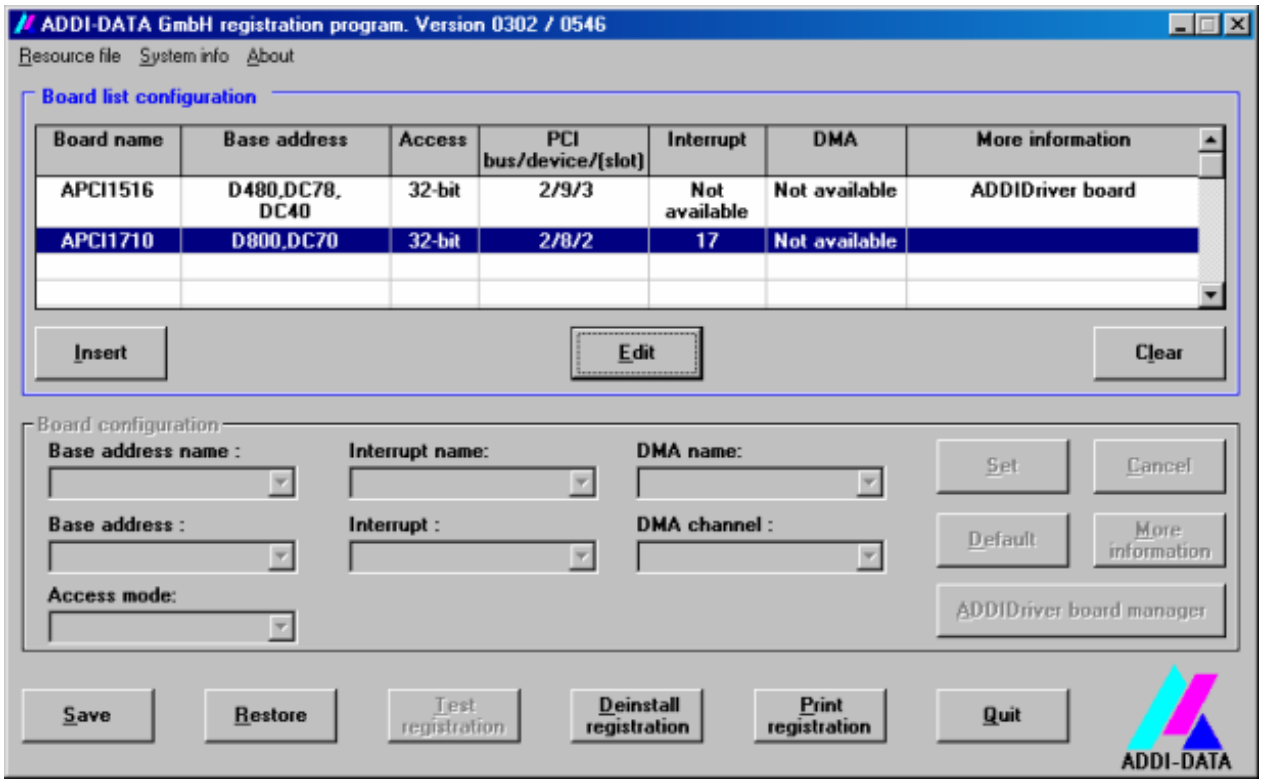


Table:

Board name:
Names of the different registered boards (e.g.: APCI-3200).

Base address:
Selected base address of the board. For PCI boards the base address is allocated through BIOS.

Access:
Selection of the access mode for the ADDI-DATA digital boards.
Access in 8-bit or 16-bit or 32-bit mode.

PCI bus/device/(slot):
Number of the used PCI bus, slot, and device. If the board is no PCI board, the message "NO" is displayed.

Interrupt:
Used interrupt of the board. If the board supports no interrupt, the message "Not available" is displayed.

DMA:
Indicates the selected DMA channel or "Not available" if the board uses no DMA or if the board is no ISA board.

More information:
Additional information like the identifier string or the installed COM interfaces. It also displays whether the board is programmed with ADDIDRIVER.

Text boxes:

Base address name:
Description of the used base addresses for the board. Select a name through the pull-down menu. The corresponding address range is displayed in the field below (Base address).

Interrupt name:
Description of the used IRQ lines for the board. Select a name through the pull-down menu. The corresponding interrupt line is displayed in the field below (Interrupt).

DMA name (for ISA boards only):
When the board supports 2 DMA channels, you can select which DMA channel is to be changed.

DMA channel (for ISA boards only):
Selection of the used DMA channel.

Buttons:

Edit:
Selection of the highlighted board with the different parameters set in the text boxes.

Set:
Sets the parametered board configuration. The configuration should be set before you save it.

Cancel:
Reactivates the former parameters of the saved configuration.

Default:
Sets the standard parameters of the board.

More information (not available for the boards with ADDIPACK)
You can change the board specific parameters like the identifier string, the COM number, the operating mode of a communication board, etc...
If your board does not support these information, you cannot activate this button.

ADDIDriver Board Manager:
Under Edit/ADDIDriver Board Manager you can check or change the current settings of the board set through the ADDEVICE Manager.
ADDevice Manager starts and displays a list of all resources available for the virtual board.

Test registration:
Controls if there is a conflict between the board and other devices installed in the PC. A message indicates the parameter which has generated the conflict. If no conflict has occurred, "Test of device registration OK" is displayed.

Deinstall registration:
Deinstalls the registrations of all boards listed in the table and deletes the entries of the boards in the Windows Registry.

Print registration:
Prints the registration parameter on your standard printer.

Quit:
Quits the ADDIREG program.

Registration test

Under "Test registration" you can test if the registration is "OK".
This test controls if the registration is right and if the board is present. If the test has been successfully completed you can quit the ADDIREG program. The board is initialised with the set parameters and can now be operated.

In case the registration data is to be modified, it is necessary to boot your PC again. A message asks you to do so. When it is not necessary you can quit the ADDIREG program and directly begin with your application.

6.2 Questions and software downloads on the web

Do not hesitate to e-mail us your questions.
per e-mail: info@addi-data.de or
hotline@addi-data.de

Free downloads of standard software

You can download the latest version of the software for the **APCI-3200**

http://www.addi-data.com

IMPORTANT!
Before using the board or in case of malfunction during operation, check if there is an update of the product (technical description, driver). The current version can be found on the internet or contact us directly.

7 CONNECTING THE PERIPHERAL

7.1 Connector pin assignment

Fig. 7-1: 50-pin SUB-D male connector

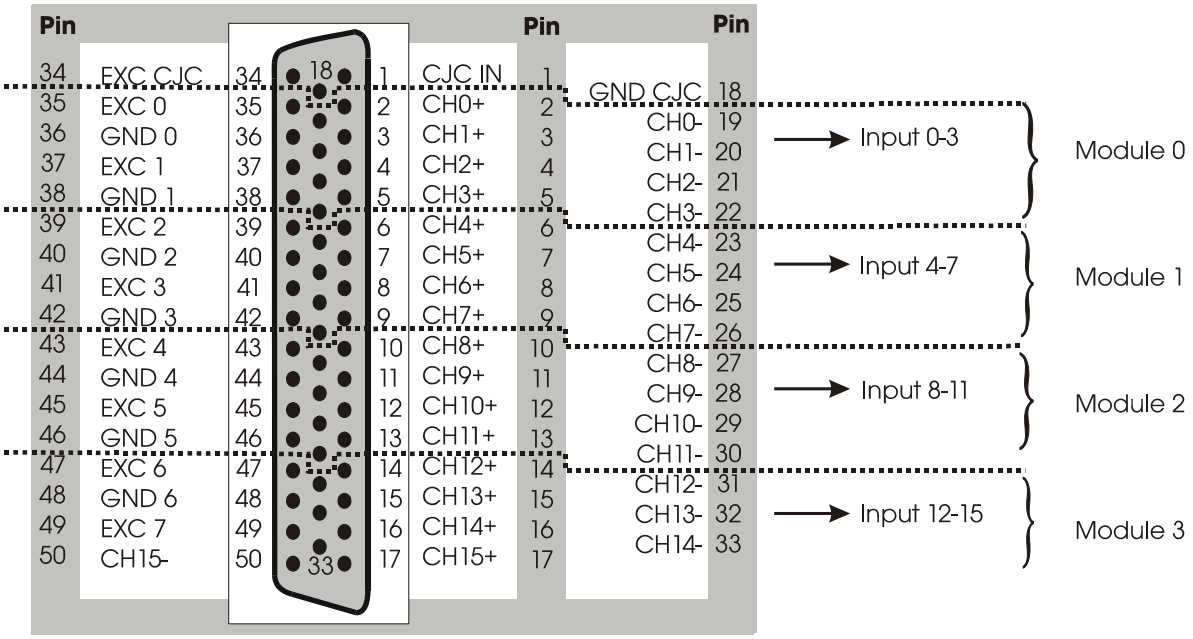
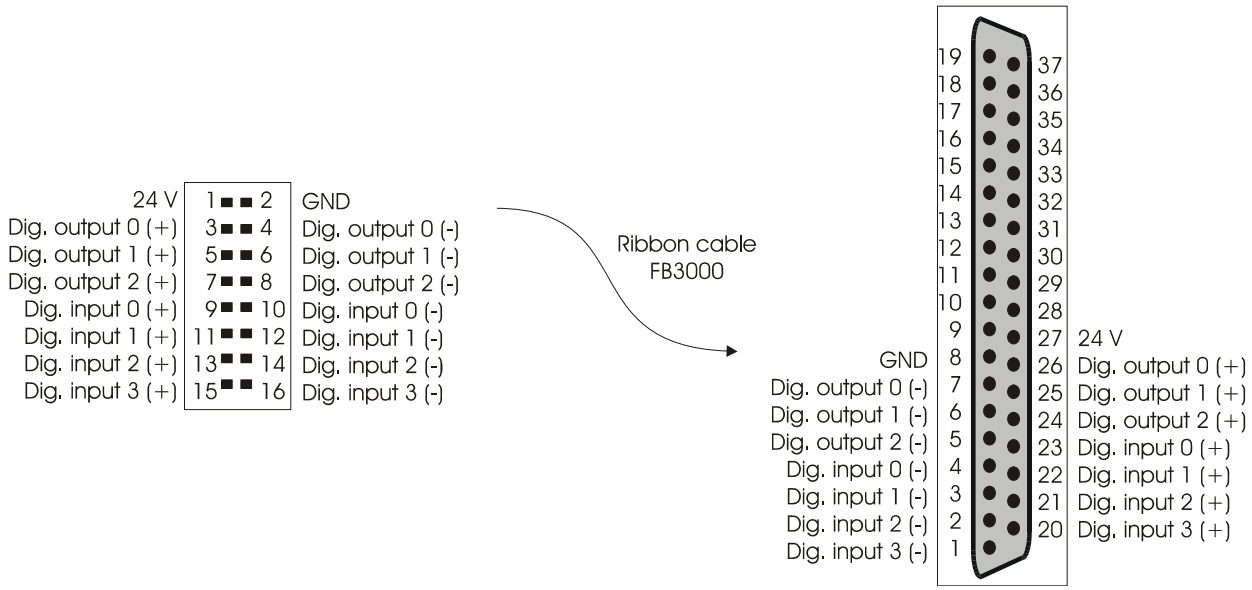


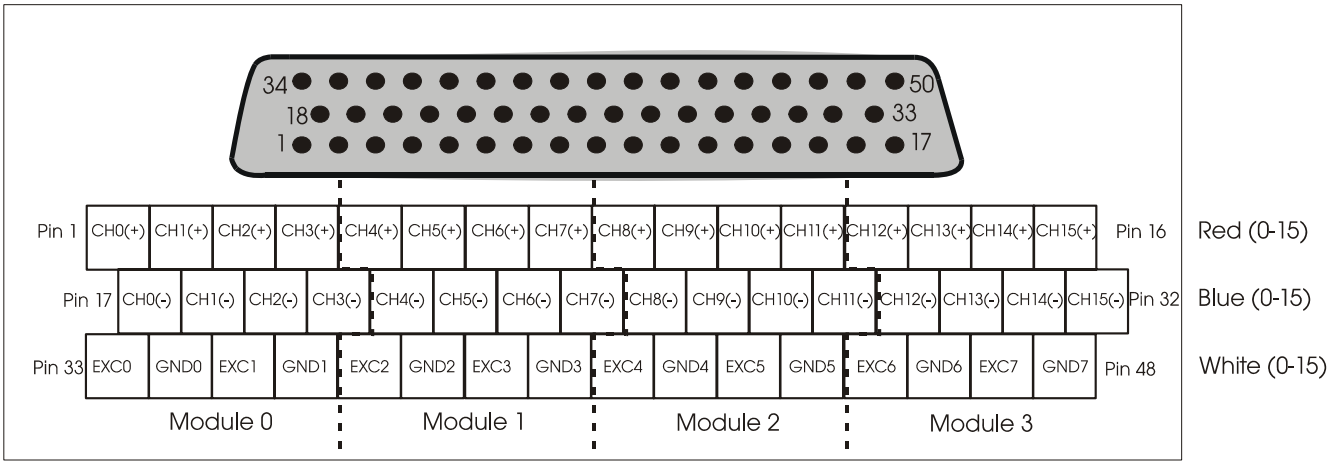
Fig. 7-2: 16-pin connector to 37-pin SUB-D connector



IMPORTANT!
Insert the FB3000 on the connector with the red cable lead on the side of the pin 1. See page 34 "Connection to the screw terminal panels".

7.2 Screw pin assignment of the PX 3200

Fig. 7-3: 48-pin screw terminal panel PX 3200



EXC: excitation; current source
Pin x : Number corresponding to the pin on the PX3200 connector

7.3 Connection principle

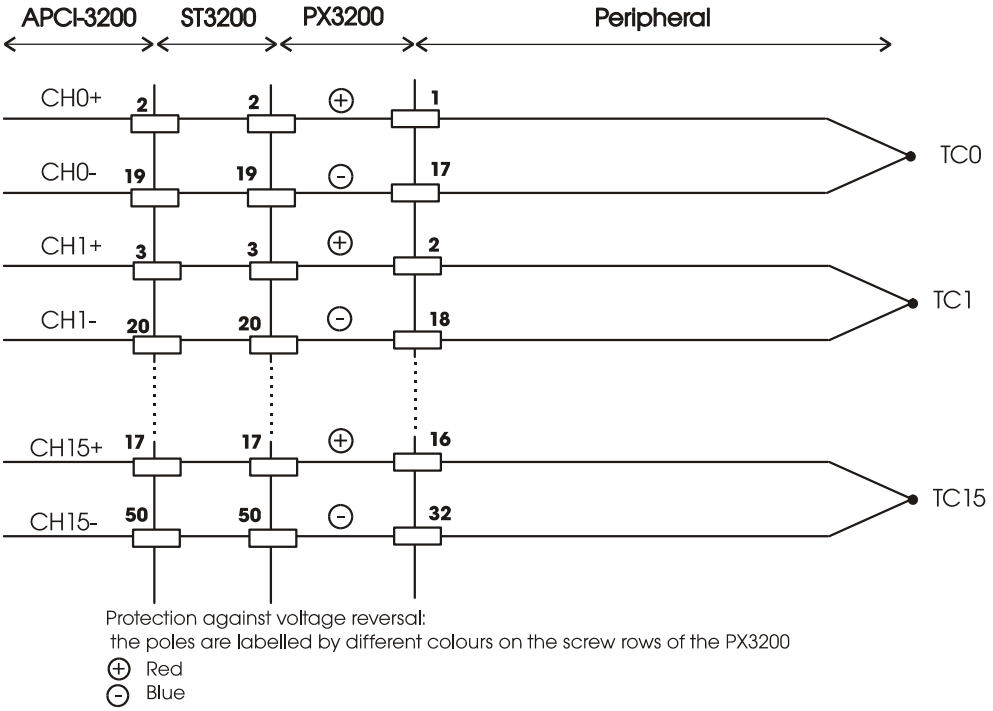
The number of connected thermocouples or RTD's depends on the version of the board.

Table 7-1: Possible connections

Version	Max. number of connected thermocouples (S.E. inputs)	Max. number of connected RTD's (Diff. inputs)		
		2-wire connection	3-wire connection	4-wire connection
APCI-3200-4	4	2	1	2
APCI-3200-8	8	4	2	4
APCI-3200-16	16	8	4	8

7.3.1 Connection of the thermocouples through the PX 3200

Fig. 7-4: Connection of the thermocouples through the PX 3200



7.3.2 Connection of RTD through the PX 3200

Fig. 7-5: Connection of RTD with 2-wire connection

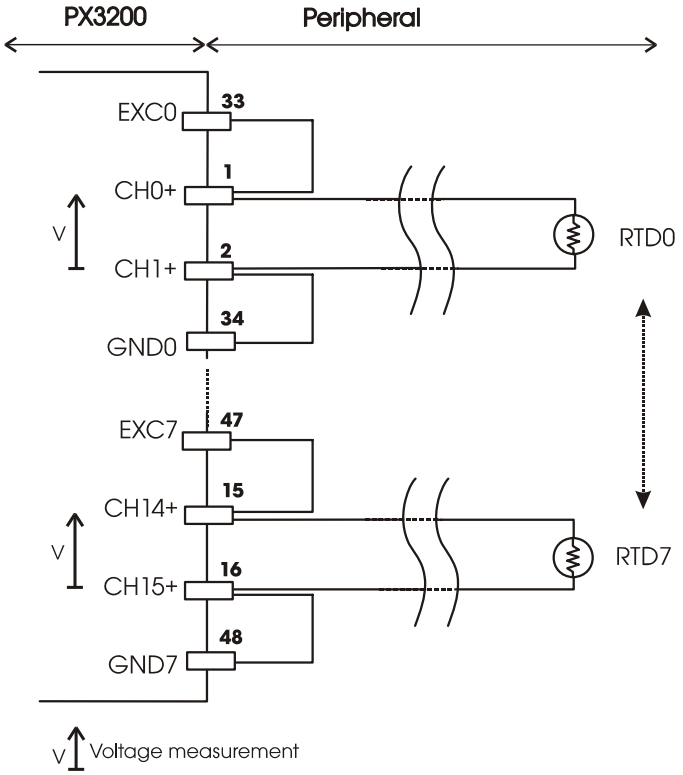


Fig. 7-6: Connection of RTD with 3-wire connection

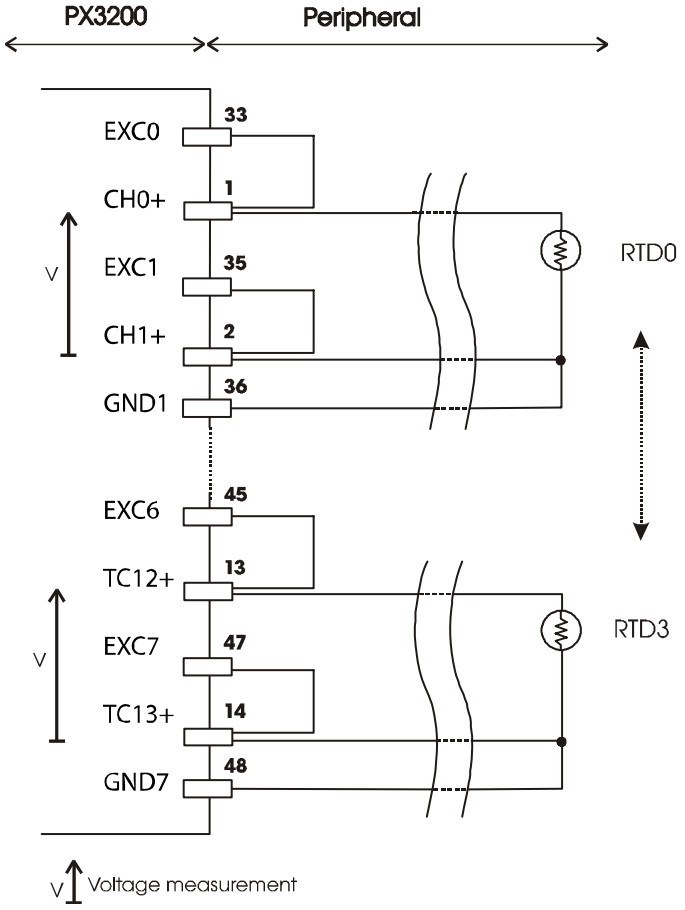
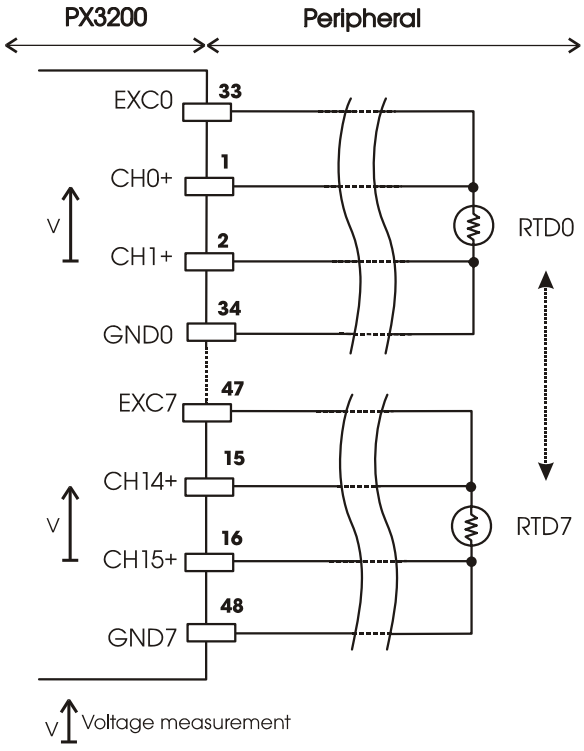
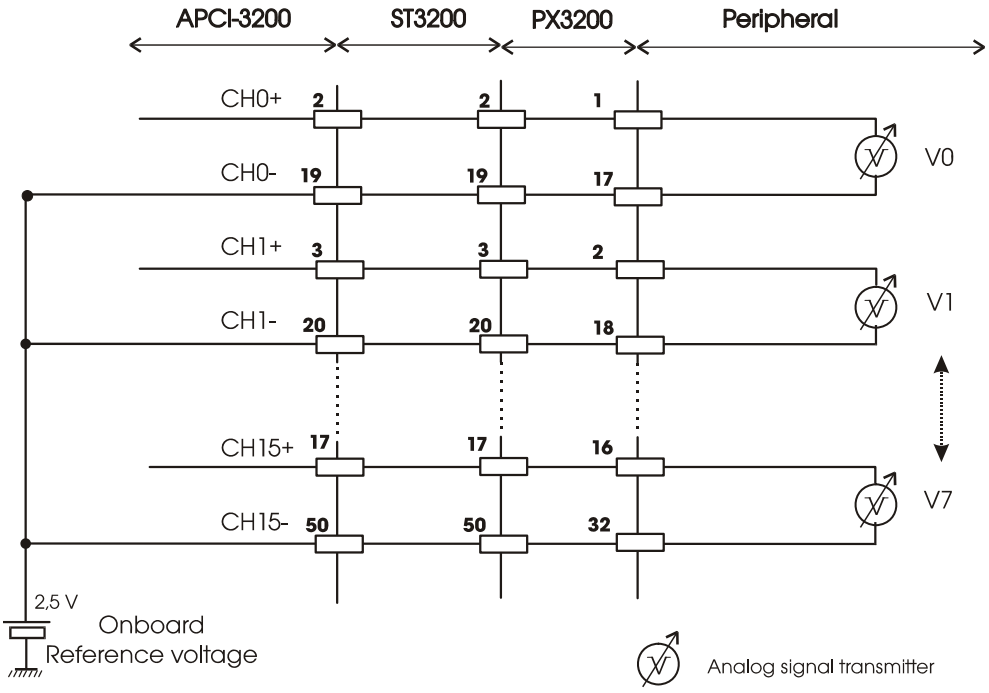


Fig. 7-7: Connection of RTD with 4-wire connection



7.3.3 Connection of the inputs as voltage input channels

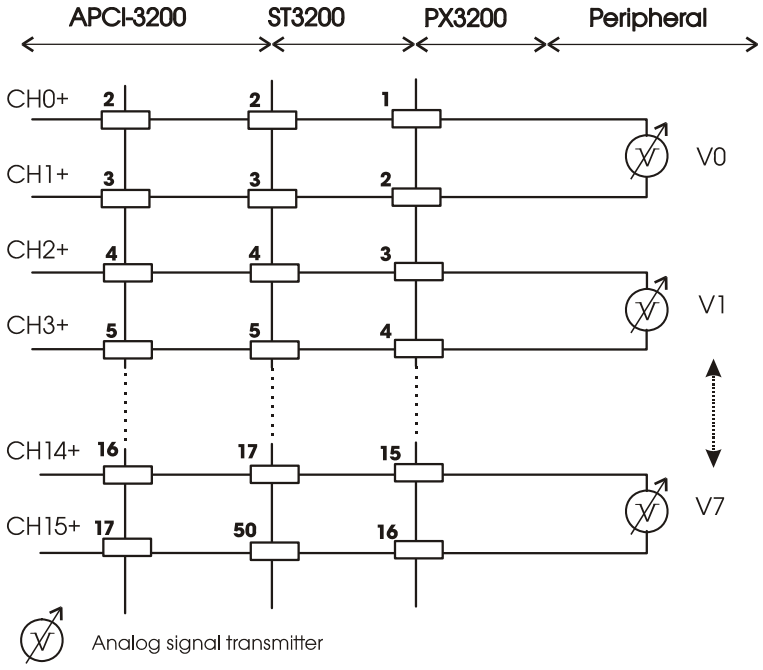
Fig. 7-8: Voltage inputs (single-ended)



WARNING!
If you operate the input channels in single-ended mode, the negative inputs 0(-) to 15(-) are connected onboard to a reference voltage of 2.5 V.
Do not connect them to the ground!

Otherwise a short circuit would occur and destroy the board.

Fig. 7-9: Voltage inputs (differential)



7.3.4 Digital input and output channels

Fig. 7-10: Digital outputs

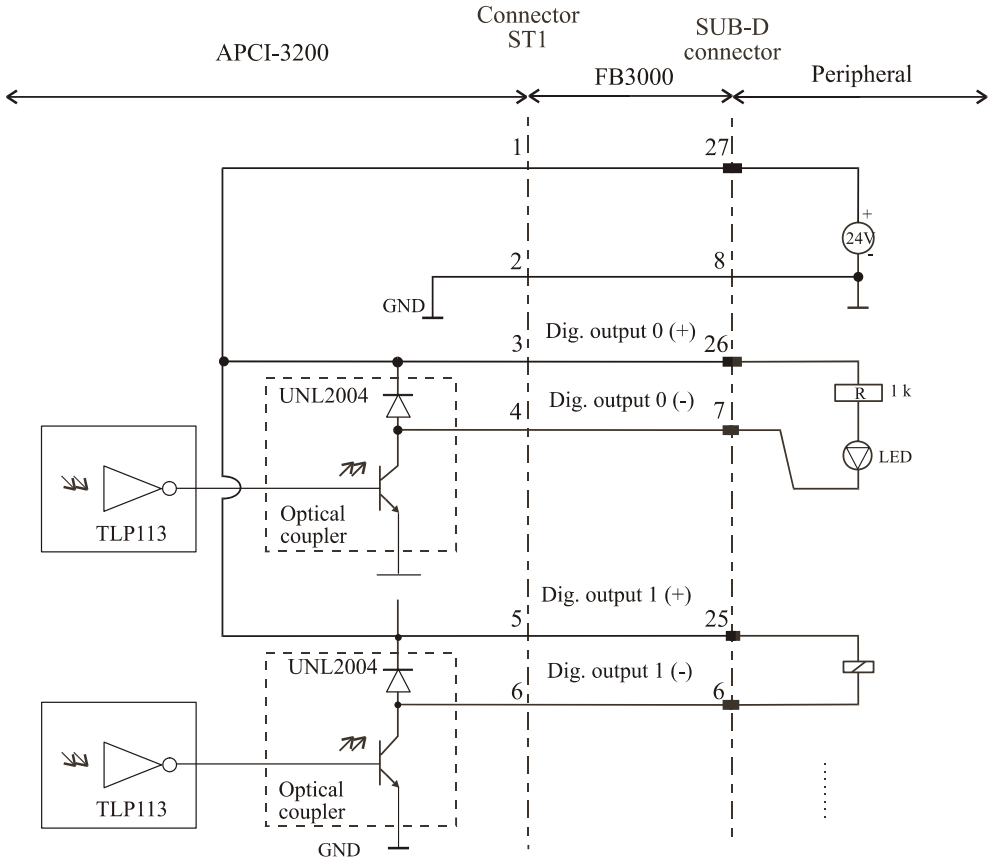
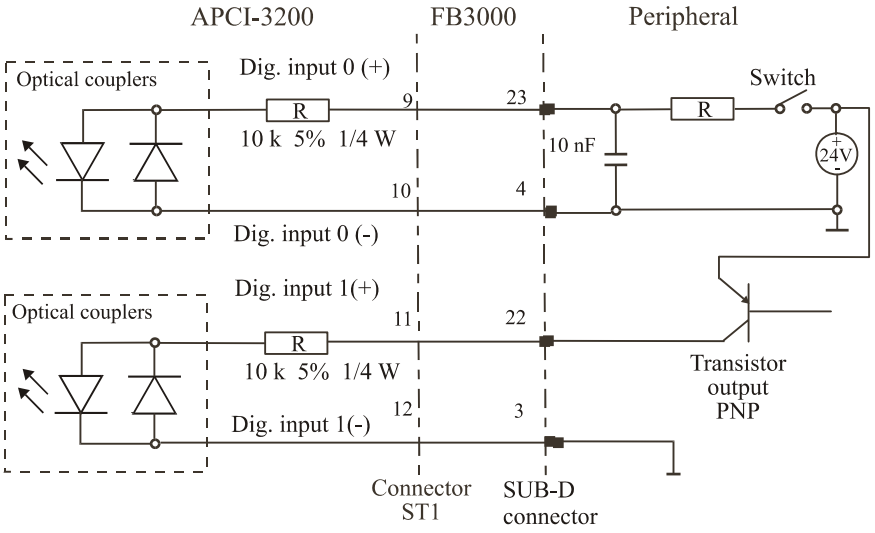
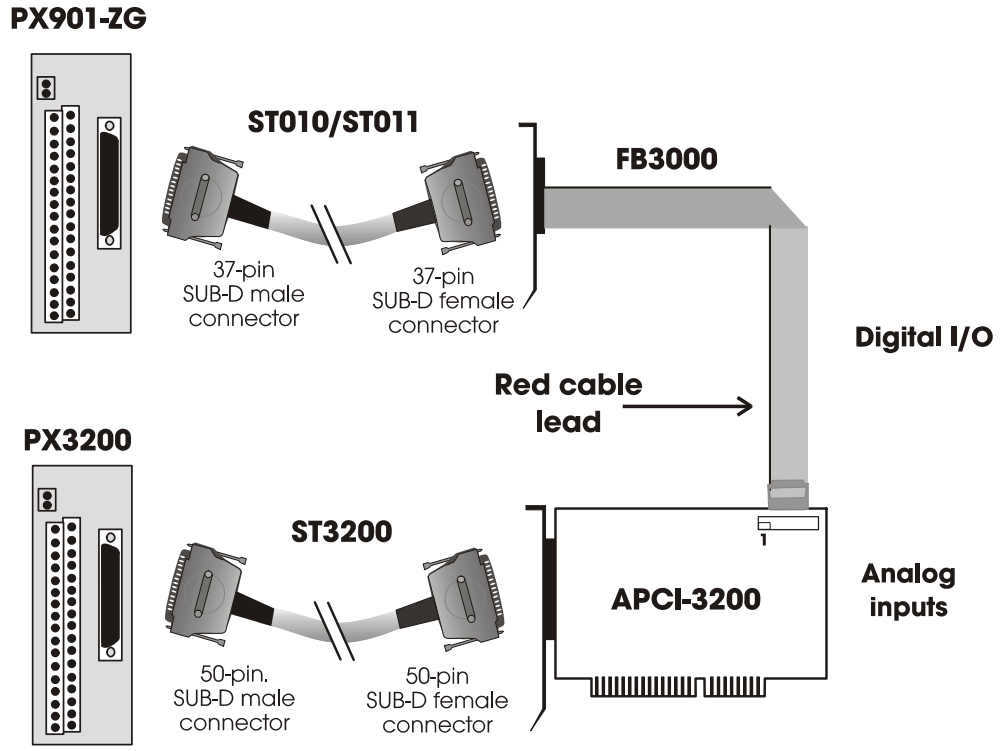


Fig. 7-11: Digital inputs



7.3.5 Connection to the screw terminal panels

Fig. 7-12: Connection to the screw terminal panels

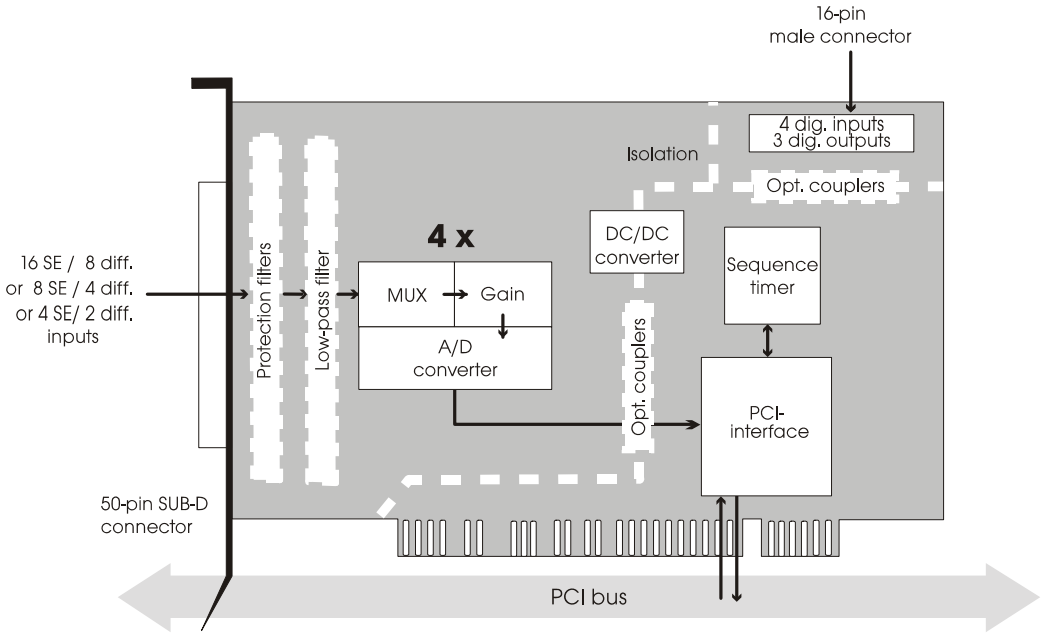


IMPORTANT!
Insert the FB3000 on the connector with the red cable lead on the side of the pin 1.

8 FUNCTIONS OF THE BOARD

8.1 Block diagram

Fig. 8-1: Block diagram of the APCI-3200



8.2 Analog inputs

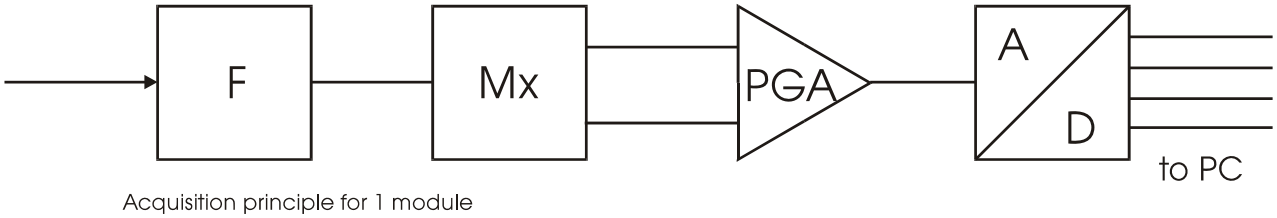
The board has max. 16 analog input channels. These are organised in 4 different modules. An 18-bit A/D converter is allocated to each module.

A converter can acquire 4 inputs:
- independently from each other or sequentially,
- once or in cycles through timer. (Scan, Single or Continuous Mode).

The APCI-3200 allows 3 different types of application:
- Acquisition of 16 SE or 8 differential analog **voltage inputs** with 18-bit resolution in a ± 2.5 V range,
- **Temperature acquisition** with thermocouples or resistance thermometer,
- **Resistance measurement.**

For the acquisition of the input signals, the following parameters are to be configured by software:
- gain
- polarity
- input mode: single-ended or differential.

Fig. 8-2: Acquisition principle of the analog inputs



Acquisition principle for 1 module

Module 0 corresponds to the inputs 0 to 3.
Module 1 corresponds to the inputs 4 to 7.
Module 2 corresponds to the inputs 8 to 11.
Module 3 corresponds to the inputs 12 to 15.

The conversion of module x is started by single start, single scan, continuous scan with or without timer, through software trigger or external hardware trigger via a digital input channel:

- Digital input 0 for module 0.
- Digital input 1 for module 1.
- Digital input 2 for module 2.
- Digital input 3 for module 3.

Once the conversion is completed, an interrupt is generated (EOC: end of conversion). The measured value can be read back at any time with the corresponding driver function.

8.2.1 Acquisition functions

Each channel can be independently acquired (software start; See Figure 8-3).

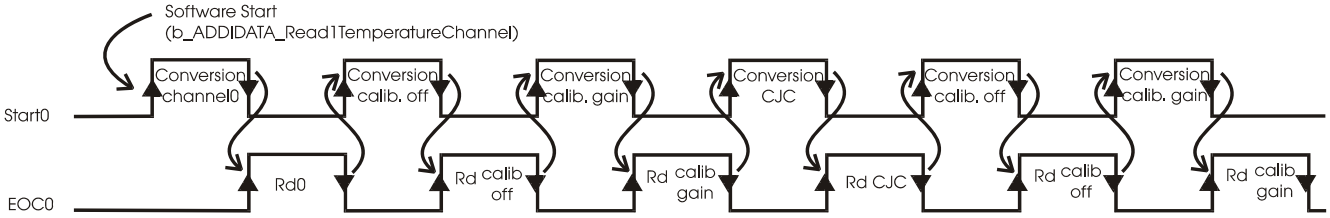
Each module (4 channels) can be independently acquired (one channel after the other):

- once through software trigger (single software scan; See figure 8-4)
- once through external trigger (single hardware scan)
- cyclically through software trigger (continuous software scan)
- cyclically through software trigger with timer (continuous software scan with Timer)
- cyclically through external trigger (continuous hardware scan)
- cyclically through external trigger with timer (continuous hardware scan with Timer; See figure 8-5)

All functions can be configured through software.

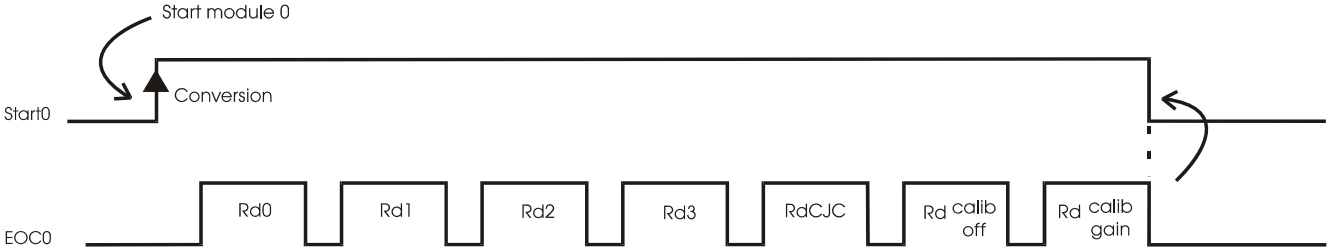
Fig. 8-3: Acquisition example - Software start

Rdx:	Read Channel x
CJC:	Cold junction compensation
calib. off:	Offset calibration
calib. gain:	Gain calibration
EOC0:	End of Conversion for the module 0
Start0:	Start of module 0



After software-start, the channel x, the offset value and the gain value are read and a 16-bit value is returned. If the module is set as a "thermocouple input", the value of the cold junction compensation is also read before returning the measured value.

Fig. 8-4: Acquisition example - Single software scan



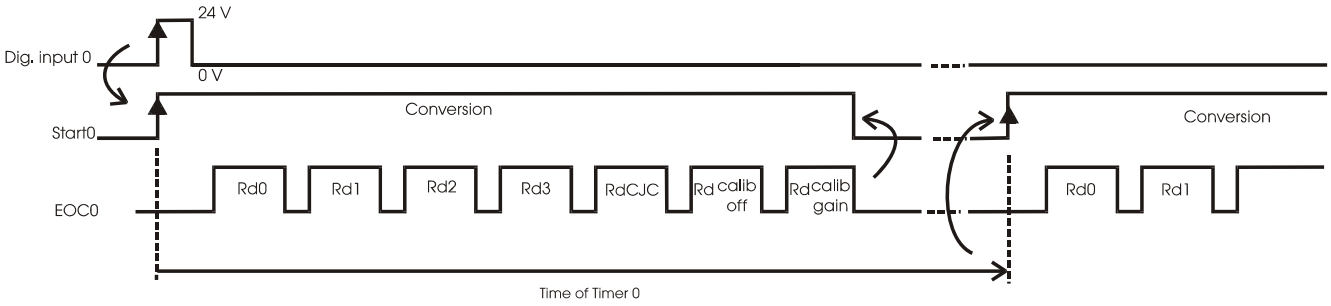
Single software scan in single-ended mode:

After a single software scan the channels 0, 1, 2, 3, the cold junction compensation, the offset value and the gain value are read. The conversion is made once (single scan) and stopped.

Single software scan in differential mode:

After a single software scan the channels 0, 1, the cold junction compensation, the offset value and the gain value are read. The conversion is made once (single scan) and stopped.

Fig. 8-5: Acquisition example - Continuous hardware scan with Timer (rising edge)



The conversion is identical to the conversion in single software scan. The only difference is that the conversion is started by one of the 4 digital inputs (external trigger). A delay time between 2 scan starts can be set through one 10-bit timer. The conversion is stopped by software.

Acquisition times

Table 8-1: Acquisition times

Acquisition times (Hz) 1 channel, offset, reference	Sample period (ms)
20	50
40	25
80	12.5
160	6.25

8.2.2 Interrupt

For each module, an "End of Conversion" (EOC) is automatically generated after each measurement. This function can generate an interrupt.

8.2.3 Timer

Through the 4 x 10-bit timers, delays can be determined between 2 starts of SCAN. Each timer can be independently configured in 3 different time bases.

Table 8-2: Timer time delays

Time unit	Range of the delay for this time unit	Corresponds to
1ms	0< t < 1023 ms	0 < t < 1.023 s
1s	0< t < 1023 s	0 < t < 17.067 min

After the delay has run down, a new SCAN cycle is started.

8.2.4 Software calibration

Each channel can be independently configured through software. For each measuring process, a software calibration of the A/D converter is completed through internal comparison with the reference voltage. The offset and gain error can then be corrected in order to measure the voltage with a precision of 16 bits.

8.2.5 Diagnostic

A diagnostic function is integrated on the board. Depending on the sensor type used, this function can detect short-circuit and line break between the board and the peripheral.

Table 8-3: Short-circuit and line-break diagnostic

	Short-circuit		Line break	
Type of the connected sensor	Diagnostic function	Measured voltage at short-circuit	Diagnostic function	Measured voltage at line break
Thermocouple (Single-Ended)	not possible	-	possible	>2V
Resistance thermometer (Differential)	possible	< 1 mV *	possible	>2.5V
Potentiometer (Differential)	possible	< 1 mV*	possible	>2.5V

* If no sensor is connected to the board, the voltage measured at the input is also 1 mV. In this case an additional line-break test must confirm the short-circuit diagnostic: the measured voltage must be > 2.5 V (open line).

8.3 Voltage acquisition

Table 8-4: Voltage accuracy

Mode	Range	Accuracy (Gain = 1)
Bipolar	-100 mV < V < + 100 mV	± 38 µV
	- 2.5 < V < - 100 mV 100 mV < V < + 2.5 V	± 152 µV
Unipolar	0 < V < 100 mV	± 19 µV
	100 mV < V < + 2.5 V	± 76 µV

8.3.1 Single-ended mode

WARNING!
If you operate the input channels in single-ended mode, the negative inputs 0(-) to 15(-) are connected onboard to a reference voltage of 2.5 V.
Do not connect them to the ground!

Otherwise a short circuit would occur and destroy the board.

8.3.2 Differential mode

This mode is recommended if the board is to be operated in rough industrial environment with many disturbance sources.

8.4 Temperature principle

IMPORTANT!
For the temperature acquisition, please consider the tolerance of each sensor (thermocouple, resistance thermometer, ...) according to the measuring range.

Please read the corresponding technical features of the sensors in the data sheet of your supplier.

Linearisation

An automatic linearisation of the connected thermocouples or RTD's is defined in software in accordance with the standard tables. The intermediate values which are not included in the tables are calculated through linear interpolation:
if the measured voltage is not included in the temperature/resistance table (for the RTD's) or the temperature/voltage table (for the thermocouples), 2 close values surrounding the required value are extracted to obtain the intermediate temperature.

The temperature is given in Celsius °C and can be then converted in Fahrenheit °F or in Kelvin °K through software.

Please use the following software functions:
- b_ADDIDATA_ConvertDegreeToFahrenheit oder
- b_ADDIDATA_ConvertDegreeToKelvin

8.5 Temperature acquisition

8.5.1 Temperature acquisition through thermocouples

Cold junction compensation

A cold junction compensation is integrated on the screw terminal panel **PX3200**. Through a RTD (Pt1000) the voltage is measured at the cold junction (V_{CJC}[5]) and used as a reference voltage to measure the temperature of the thermocouples connected to the screw terminal panel.

The cold junction compensation is calculated for each channel after each acquisition and updated through software.

Precision of the cold junction compensation

Table 8-5: Precision of the cold junction compensation

Type	Range	Precision (Unipolar, gain=1)
Pt1000 on board **PX3200**	0°C +60°C	± (0.30°C+0.0050|t°C|)

IMPORTANT!
The absolute precision of the measured temperature is to be calculated as follows:

Temperature precision =
Precision of the CJC
+ precision of the A/D converter
+ precision of the thermocouple[6].

[5] CJC: Cold Junction Compensation
[6] Consider the data sheet of the sensor manufacturer

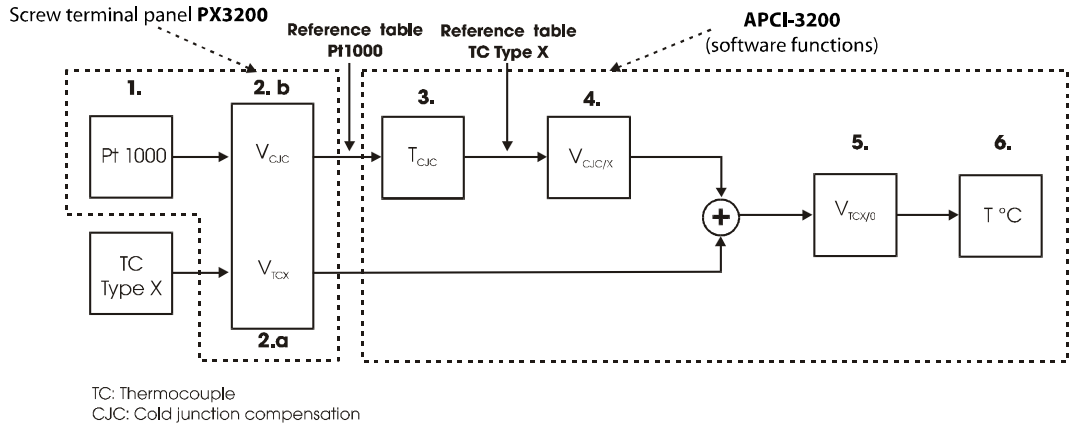
Type and precision of the thermocouples

Table 8-6: Type and precision of the A/D converter (acquisition of thermocouples)

Type	Range		Precision (Bipolar, gain=1)
Type J	-200.0°C	-0.1°C	±0.6°C
	0.0°C	+599.9°C	±0.2°C
	+600.0°C	+1200.0°C	±0.6°C
Type T	-200.0°C	-80.0°C	±0.7°C
	-79.9°C	+400.0°C	±0.3°C
Type K	-200.0°C	-0.1°C	±0.8°C
	0.0°C	+999.9°C	±0.4°C
	+1000.0°C	+1300.0°C	±0.6°C
Type E	-200.0°C	+1000.0°C	±0.5°C
Type N	-200.0°C	-0.1°C	±1.0°C
	0.0°C	+799.9°C	±0.2°C
	+800.0°C	+1300.0°C	±0.5°C
Type S	0.0°C	+399.9°C	±1.6°C
	+400°C	1768.0°C	±0.7°C
Type R	0.0°C	+399.9°C	±1.6°C
	+400.0°C	+1768.0°C	±0.6°C
Type B	+400.0°C	799.9°C	±2.0°C
	+800.0°C	+1820.0°C	±1.0°C

Temperature acquisition

Fig. 8-6: Temperature acquisition for the cold junction compensation



IMPORTANT!
The numbers in the figure above correspond to the numbers of the following list.

1. The cold junction compensation is completed through a Pt1000 which is integrated on the screw terminal panel **PX3200**.

2. Through the APCI-3200:

2.a) the voltage of the thermocouple of type X connected on the circuit board (V_{TCX})
and
2.b) the CJC voltage (V_{CJC})
are returned through software calibration (See paragraph 8.2.4).

3. The CJC voltage V_{CJC} is converted in a CJC temperature (T_{CJC}) according to **the reference table of the Pt1000**.

4. This CJC temperature (T_{CJC}) is converted in a CJC voltage ($V_{CJC/X}$) according to **the reference table of the thermocouple of type X**.

5. The voltage of the thermocouple V_{TCX} (see 2.a) and the converted voltage $V_{CJC/X}$ are added to give the thermocouple voltage ($V_{TCX/0}$) referring to 0°C.
$V_{TCX/0} = V_{TCX} + V_{CJC/X}$

6. The temperature T is calculated from the voltage referring to 0°C ($V_{TCX/0}$) in the corresponding standard table.

The temperature is given in °C and can be converted in °F or °K through software.

8.5.2 Temperature acquisition through RTD

Table 8-7: Type and precision of the A/D converter (acquisition of RTD's)

Type	Range		Precision 3-wire or 4-wire connection (Unipolar, gain=1)
Pt100	-200.0°C	+850.0°C	±0.4°C
Pt200	-200.0°C	+850.0°C	±0.4°C
Pt500	-200.0°C	+850.0°C	±0.3°C
Pt1000	-200.0°C	+499.9°C	±0.2°C
	+500.0°C	+850.0°C	±1.0°C
Ni100	-60.0°C	+250.0°C	±0.3°C

IMPORTANT!
The absolute precision of the measured temperature is to be calculated as follows:

Temperautre precision =
precision of the A/D converter (See table above)
+ precision of the RTD[7].

The RTD (resistance temperature detector) is a temperature-dependent resistance. The higher the resistance is, the higher the temperature is.

The constant measuring current flows through the RTD and causes a voltage drop. This voltage drop is measured to calculate the temperature of the RTD.

2-wire connection

See paragraph 7.3.2, Fig. 7-5: Connection of RTD with 2-wire connection.

If the RTD experiences a resistance, a voltage drop occurs on the connected pins (in the figure pins 1 and 2). The voltage measured at these pins corresponds to the voltage present on the RTD.

Yet this solution can cause a precision loss for rather long lines because the voltage drop of the constant current increases the measured value.

The board interprets this measured value as an increased temperature which results in a temperature error of the measured value.

[7] Consider the data sheet of the sensor manufacturer

3-wire connection

See paragraph 7.3.2, Fig. 7-6: Connection of RTD with 3-wire connection.

In comparison to the 2-wire connection, an additional line is driven to one of the contact of the resistance thermometer. 2 excitation lines are connected to the circuitry. As both line resistances neutralise themselves, they do not affect the voltage measurement.

The measurement accuracy at the RTD is then higher, provided the electric lines have identical properties (Length and material).

4-wire connection

See paragraph 7.3.2, Fig. 7-7: Connection of RTD with 4-wire connection.

The 4-wire connection theoretically represents the optimal solution. The current and ground lines are driven to the resistance independently from the voltage line. The line resistances and the temperature variation do not affect the result of the measurement. In addition up to 8 RTD's can be connected with the highest accuracy compared to the 4 RTD's which can be connected when using the 3-wire connection.

8.6 Resistance measurement

Table 8-8: Type and accuracy of the resistances

Type	Range		Accuracy 3-wire or 4-wire connection (Unipolar, Gain=1)
Resistance	10.0Ω	399.9Ω	±0.2Ω
	400.0Ω	999.9Ω	±0.3Ω
	1000.0Ω	1999.9Ω	±0.7Ω
	2000.0Ω	4000.0Ω	±4.0Ω

The connection and the acquisition functions of the resistances are the same as the ones of RTD's. But the resistance does not vary with the temperature.

8.7 Possible set-up

We recommend programming the following set-up in software according to the required measurement sensor. The following parameters are to be set in the corresponding software functions.

Table 8-9: Set-up suggestion

	Temperature measurement		Resistance measurement	Voltage measurement	
	Thermocouple	RTD		Single-Ended	Differential
GAIN	1	1	1	1	1
U/B#	0 (bipolar)	1 (unipolar)	1	0	0
D/S#	0 (S.E.)	1 (diff.)	1	0	1

9 STANDARD SOFTWARE

9.1 Software functions

ADDIPACK supports the following functions for the **APCI-3200**

Table 9-1: Supported software functions

Functionality	Function name
Common functions	i_ADDIDATA_OpenWin32Driver
	i_ADDIDATA_GetCurrentDriverHandle
	i_ADDIDATA_GetDriverVersion
	i_ADDIDATA_GetLocalisation
	b_ADDIDATA_CloseWin32Driver
Interrupt	b_ADDIDATA_SetFunctionalityIntRoutineWin32
	b_ADDIDATA_TestInterrupt
	b_ADDIDATA_ResetFunctionalityIntRoutine
Error	i_ADDIDATA_GetLastError
	i_ADDIDATA_GetLastErrorAndSource
	b_ADDIDATA_EnableErrorMessage
	b_ADDIDATA_DisableErrorMessage
	b_ADDIDATA_FormatErrorMessage
Temperature	b_ADDIDATA_GetNumberOfTemperatureChannels
	b_ADDIDATA_GetNumberOfTemperatureModules
	b_ADDIDATA_GetNumberOfTemperatureChannelsForTheModule
	b_ADDIDATA_GetTemperatureChannelInformation
	b_ADDIDATA_InitTemperatureChannel
	b_ADDIDATA_Read1TemperatureChannel
	b_ADDIDATA_ReadMoreTemperatureChannels
	b_ADDIDATA_ConvertDigitalToRealTemperatureValueWithCorrectionParameters
	b_ADDIDATA_ConvertMoreDigitalToRealTemperatureValues
	b_ADDIDATA_InitTemperatureChannelSCAN
	b_ADDIDATA_StartTemperatureChannelSCAN
	b_ADDIDATA_GetTemperatureChannelSCANStatus
	b_ADDIDATA_ConvertDigitalToRealTemperatureValueSCAN
	b_ADDIDATA_StopTemperatureChannelSCAN

Functionality	Function name
Temperature	b_ADDIDATA_CloseTemperatureChannelSCAN
	b_ADDIDATA_ReleaseTemperatureChannel
	b_ADDIDATA_ConvertDegreeToFahrenheit
	b_ADDIDATA_ConvertDegreeToKelvin
	b_ADDIDATA_TestTemperatureChannelShortCircuit*
	b_ADDIDATA_TestTemperatureChannelConnection*
Analog inputs	b_ADDIDATA_GetNumberOfAnalogInputs
	b_ADDIDATA_GetNumberOfAnalogInputModules
	b_ADDIDATA_GetNumberOfAnalogInputsForTheModule
	b_ADDIDATA_GetAnalogInputInformation
	b_ADDIDATA_InitAnalogInput
	b_ADDIDATA_Read1AnalogInput
	b_ADDIDATA_ReadMoreAnalogInputs
	b_ADDIDATA_ConvertMoreDigitalToRealAnalogValues
	b_ADDIDATA_InitAnalogInputSCAN
	b_ADDIDATA_StartAnalogInputSCAN
	b_ADDIDATA_GetAnalogInputSCANStatus
	b_ADDIDATA_ConvertDigitalToRealAnalogInputValueSCAN
	b_ADDIDATA_StopAnalogInputSCAN
	b_ADDIDATA_CloseAnalogInputSCAN
	b_ADDIDATA_ReleaseAnalogInput
Resistance	b_ADDIDATA_GetNumberOfResistanceChannels
	b_ADDIDATA_GetNumberOfResistanceModules
	b_ADDIDATA_GetNumberOfResistanceChannelsForTheModule
	b_ADDIDATA_GetResistanceChannelInformation
	b_ADDIDATA_InitResistanceChannel
	b_ADDIDATA_Read1ResistanceChannel
	b_ADDIDATA_ReadMoreResistanceChannels
	b_ADDIDATA_ConvertMoreDigitalToRealResistanceValues
	b_ADDIDATA_InitResistanceChannelSCAN
	b_ADDIDATA_StartResistanceChannelSCAN
	b_ADDIDATA_GetResistanceChannelSCANStatus
	b_ADDIDATA_ConvertDigitalToRealResistanceValueSCAN

Functionality	Function name
Resistance	b_ADDIDATA_StopResistanceChannelSCAN
	b_ADDIDATA_CloseResistanceChannelSCAN
	b_ADDIDATA_ReleaseResistanceChannel
	b_ADDIDATA_TestResistanceChannelShortCircuit*
	b_ADDIDATA_TestResistanceChannelConnection*
Digital inputs	b_ADDIDATA_GetNumberOfDigitalInputs
	b_ADDIDATA_GetDigitalInputInformation
	b_ADDIDATA_Read1DigitalInput
	b_ADDIDATA_Read2DigitalInputs
	b_ADDIDATA_Read4DigitalInputs
Digital outputs	b_ADDIDATA_GetNumberOfDigitalOutputs
	b_ADDIDATA_GetDigitalOutputInformation
	b_ADDIDATA_SetDigitalOutputMemoryOn
	b_ADDIDATA_SetDigitalOutputMemoryOff
	b_ADDIDATA_Set1DigitalOutputOn
	b_ADDIDATA_Set1DigitalOutputsOff
	b_ADDIDATA_Set2DigitalOutputsOn
	b_ADDIDATA_Set2DigitalOutputsOff
	b_ADDIDATA_Set4DigitalOutputOn
	b_ADDIDATA_Set4DigitalOutputOff
	b_ADDIDATA_Get1DigitalOutputStatus
	b_ADDIDATA_Get2DigitalOutputStatus
	b_ADDIDATA_Get4DigitalOutputStatus

* IMPORTANT: According to the configuration of the board, some functions are not available. See Table 4-2: Short-circuit and line-break diagnostic

9.2 Software samples

Table 9-2: Supported software samples

Functionality	Sample number	Description
Analog inputs	SAMPLE00	Display information of 1 analog input
	SAMPLE01	Read 1 analog input channel without interrupt.
	SAMPLE02	Read 1 analog input channel with interrupt.
	SAMPLE03	Read several analog input channels without interrupt.
	SAMPLE04	Read several analog input channels with interrupt.
	SAMPLE05	Test the sequence acquisition with interrupt.
	SAMPLE07	Initialise SCAN with interrupt.
Temperature	SAMPLE00	Display information of 1 temperature channel
	SAMPLE01	Read 1 temperature channel without interrupt.
	SAMPLE02	Read 1 temperature channel with interrupt.
	SAMPLE03	Read several temperature channels without interrupt.
	SAMPLE04	Read several temperature channels with interrupt.
	SAMPLE16	Initialise a single SCAN with interrupt.
	SAMPLE18	Initialise a continuous SCAN with interrupt.
Resistance	SAMPLE00	Display information of 1 resistance channel
	SAMPLE01	Read 1 resistance channel without interrupt.
	SAMPLE02	Read 1 resistance channel with interrupt.
	SAMPLE03	Read several resistance channels without interrupt.
	SAMPLE04	Read several resistance channels with interrupt.
	SAMPLE16	Initialise a single SCAN with interrupt.
	SAMPLE18	Initialise a continuous SCAN with interrupt.
Digital inputs	SAMPLE01	Read 1 digital input
	SAMPLE02	Read 2 digital inputs
	SAMPLE03	Read 4 digital inputs
Digital outputs	SAMPLE01	Test 1 digital output with/without output memory
	SAMPLE02	Test 2 digital outputs with/without output memory
	SAMPLE03	Test 4 digital outputs with/without output memory

10 GLOSSARY

Table 10-1: Glossary

Term	Description
A/D converter	= *ADC* An electronic device that produces a digital output directly proportional to an analog signal output.
Acquisition	The process by which data is gathered by the computer for analysis or storage.
Analog	Continuous real time phenomena
Clock	A circuit that generates time and clock pulses for the synchronisation of the conversion
Cold junction compensation	A method of compensating for inaccuracies in thermocouple circuits
D/A converter	= *DAC* A device that converts digital information into a corresponding analog voltage or current.
DC voltage	= *Direct current voltage* DC voltage means that the voltage is constant respecting the time. It will always fluctuate slightly. Especially at switching on and switching off the transition behaviour is of high significance.
Differential inputs (DIFF)	An analog input with two input terminals, neither of which is grounded, whose value is the difference between the two terminals.
Disturb signal	Interferences that occur during the transfer caused by reduced bandwidth, attenuation, gain, noise, delay time etc.
Driver	A part of the software that is used to control a specific hardware device such as a data acquisition board or a printer.
Edge	Logic levels are defined in order to process or show information. In binary circuits voltages are used for digital units. Only two voltage ranges represent information. These ranges are defined with H (High) and L (Low). H represents the range that is closer to Plus infinite; the H level is the digital 1. L represents the range that is closer to Minus infinite; the L level is the digital 0. The rising edge is the transition from the 0-state to the 1-state and the falling edge is the transition from the 1-state to the 0-state.
Gain	The factor by which an incoming signal is multiplied.
Ground	A common reference point for an electrical system.
Impedance	The reciprocal of admittance. Admittance is the complex ratio of the voltage across divided by the current flowing through a device, circuit element, or network.
Inductive loads	The voltage over the inductor is U=L.(dI/dt), whereas L is the inductivity and I is the current. If the current is switched on fast, the voltage over the load can become very highly for a short time.

Input impedance	The measured resistance and capacitance between the high and low inputs of a circuit.
Input level	The input level is the logarithmic relation of two electric units of the same type (voltage, current or power) at the signal input of any receive device. The receive device is often a logic level that refers to the input of the switch. The input voltage that corresponds with logic “0” is here between 0 and 15 V, and the one that corresponds with logic “1” is between 17 and 30 V.
Interrupt	A signal to the CPU indicating that the board detected the occurrence of a specified condition or event.
Level	Logic levels are defined in order to process or show information. In binary circuits voltages are used for digital units. Only two voltage ranges represent information. These ranges are defined with H (High) and L (Low). H represents the range that is closer to Plus infinite; the H level is the digital 1. L represents the range that is closer to Minus infinite; the L level is the digital 0. The rising edge is the transition from the 0-state to the 1-state and the falling edge is the transition from the 1-state to the 0-state.
Limit value	Exceeding the limit values, even for just a short time, can lead to the destruction or to a loss of functionality.
Low-pass filter	Transmitting all frequencies below a certain value
MUX	= *Multiplexer* An array of semiconductor or electromechanical switches with a common output used for selecting one of a number of input signals.
Noise immunity	Noise immunity is the ability of a device to work during an electromagnetic interference without reduced functions.
Noise suppression	The suppression of undesirable electrical interferences to a signal. Sources of noise include the ac power line, motors, generators, transformers, fluorescent lights, CRT displays, computers, electrical storms, welders, radio transmitters, and others.
Operating voltage	The operating voltage is the voltage that occurs during the continuous operation of the device. It may not exceed the continuous limit voltage. Furthermore, any negative operation situations, such as net overvoltages over one minute at switching on the device must be taken in consideration.
Optical isolation	The technique of using an optoelectric transmitter and receiver to transfer data without electrical continuity, to eliminate high-potential differences and transients.
Opto-coupler	A device containing light-emitting and light-sensitive components used to couple isolated circuits
Output voltage	The nominal voltage output reading when shaft is rotated to full range, expressed in volts DC /Vo DC)
Parameter	The parameters of a control comprise all fort he control process required numeric values, e.g. for limit values and technological number.
PCI bus	PCI bus is a fast local bus with a clock rate up to 33 MHz. This

	bus is used for processing a great number of data. The PCI bus is not limited like the ISA and EISA systems.
Protective circuitry	A protective circuitry of the active part is done in order to protect the control electronic. The simplest protective circuitry is the parallel switching of a resistance.
Protective diode	At the input of the integrated MOS (Metal Oxide Semi-Conductor)-circuits used diodes, which operates at the permitted input voltages in the reverse range, but at overvoltage in the transition range and therefore protects the circuits against damage.
Resistance	The degree to which a substance or device opposes the passage of an electric current, causing energy dissipation. Be Ohm's law resistance (measured in ohms) is equal to the voltage divided by the current.
Resolution	The smallest significant number to which a measurement can be determined. For example a converter with 12-bit resolution can resolve 1 part in 4096.
RTD	*= Resistance temperature detector* An electrical circuit element characterized by a positive coefficient for resistivity
Sensor	A device that responds to physical stimuli (heat, light, sound, pressure, motion, etc.) and produces a corresponding electrical output.
Settling time	The time required, after application of a step input signal, for the output voltage to settle and remain within a specified error band around the final value. The settling time of a system includes that of all of the components of the system.
Short circuit	A short circuit of two clamps of an electric switch is when the concerning clamp voltage is zero.
Short circuit current	Short circuit current is the current between tow short-circuited clamps.
Signal delay	The change of a signal affects the following circuitries with finite velocity; the signal will be delayed. Besides the signal delay times that are not wanted, the signal delay can be extended by time switches and delay lines.
Single Ended inputs (SE)	An analog input with one input terminal whose value is measured with respect to a common ground
Synchronous	In hardware, it is an event that occurs in a fixed time relationship to another event. In software, it refers to a function that begins an operation and returns to the calling program only when the operation is complete.
Thermocouple	A thermoelectric device for measuring temperature, consisting of two wires of different metals connected at two points, a voltage being developed between the two junctions in proportion to the temperature difference
Timer	The timer allows the adaptation of program processes between processor and peripheral devices. It usually contains from each other independent counters and can be programmed for several operation types over a control word register.

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