ALLDAQ
Competence in Measurement

# Manual

Rev. 0.94 EN


# ADQ-412 cPCI

## Isolated 2 channel current measurement board

# Imprint

Manual ADQ-410 series
Rev. 0.94
Date: 02/24/2017

## Manufacturer and Support

ALLNET® and ALLDAQ® are registered trademarks of the ALLNET® GmbH Computersysteme. For questions, problems and product information please contact the manufacturer directly:

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All information contained in this manual has been reviewed with great care. Nevertheless errors cannot be eliminated completely. Specifications and the content of this manual are subject to change without notice.

We are appreciated for notification of possible errors.

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# Table of Content

# 1. Introduction

Please check the box and the content for damages and completeness before taking the device into operation. If any fault should be detected please inform us immediately.

- Shows the packing some evidence to damaging during transport?
- Any traces of use to be recognized at the device?

The device may not be taken into operation if it is damaged. In case of doubt please contact our technical service department.

**Please read – before installing the device – this manual watchfully!**

## 1.1 Scope of delivery

- ALLDAQ ADQ-412 as CompactPCI version (8 HP)
- Two 2-pin mating plugs for Phoenix type clamps
- Two adapters from RP-SMA male connector to BNC female connector
- Driver software and documentation under: http://www.alldaq.com/en/downloads

## 1.2 Safety instructions

**Necessarily note the following advices:**

- Necessarily avoid touching of cables and connectors inside the PC with the board.
- Ensure sufficient air circulation in the CompactPCI rack.
- Never expose the device to direct solar radiation during operation.
- Never run the device near heat sources.
- Protect the device before humidity, dust, liquids and fumes.
- Don´t use the device in damp rooms and never in explosive areas.
- A repair may only be done by trained and authorized persons.

- Please note before initial operation of the device especially when using voltages greater 42 V the installation rules and all relevant standards (including VDE standards).
- We recommend to tie all unused inputs basically to the corresponding reference ground to avoid cross talk between the input lines.
- Before connecting or removing cables with your board always disconnect your field wiring from the power supply.

- Ensure that no static discharge can occur passing the board when handling it. Follow the standard ESD safety precautions (see also chapter2.1 on page 9).
- Never connect devices with voltage-carrying parts, especially not with mains voltage.

- The user must take appropriate precautions to avoid unforseeable misuse.

For damages caused by improper use and subsequent damages any liability by ALLNET® GmbH Computersysteme is excluded.

## 1.3 Location of installation and mounting

The PC boards of the ADQ-410 series are current measurement boards for industrial use. The model ADQ-412 is for installation into a free CompactPCI slot of 8 HP width. CompactPCI boards may not be taken into operation outside of an appropriate CompactPCI system. For the order of operation on installing the device please read the chapter „Initial operation" in this manual and the documentation of your PC.

The ADQ-410 series may only be used in dry rooms. CompactPCI boards are not for use with tough environment conditions (e.g. outside). Ensure a very good ventilation in the CompactPCI rack. Take care for proper fitting of the connection cables. Installation has to be done in a way that the cables (PC connection and field wiring) are not in tension else they could release itself.

## 1.4 Short description

The **ALLDAQ ADQ-412** is a CompactPCI board for dynamical current measurement from a few micro-ampere up to 50 A via shunt. Typical applications are the analysis of current spikes on the one hand and measuring on the other hand, e. g. in quality assurance or for measuring the current curve of pulse width modulated controls.

The ADQ-412 provides 2 isolated analog input channels which are electrically isolated up to 700 V between each other and towards PC ground. The relay controlled change-over between the both current measurement ranges ±25 mA and ±50 A is handled independently for each channel by the application without interrupting the measuring circuit. Both channels are assembled with a 18 bit ADC which can sample synchronously with up to 1,6 MS/s. This empowers the ADQ-412 with an unusual high bandwidth of up to 20 kHz (rectangular) with an excellent accuracy. The values can be acquired discretely or timer-controlled. On demand the measurement can be started or stopped by two external TTL trigger inputs (RP-SMA female connectors).

Each channel of the ADQ-412 generates an interrupt event on exceeding resp. undercutting the 25 mA threshold, which can be used for the range change-over on application level. Independent from this a hardware comparator automatically switches into the 50 A range as soon as the 25 mA range is over-loaded by more than 12.5%. This protection mechanism works independently ofoperation system and d application.

The current path is guided via Phoenix type clamps, which are specified for wire gauges from AWG 20 to AWG 6. A slot with 8 HP width are required in the CompactPCI rack for the ADQ-412.

# 1.5 System requirements

## 1.5.1 Hardware

- PC system with a current Intel® or compatible processor based on the x86(-64) architecture
- CompactPCI slot with 8 HP width

## 1.5.2 Software

### System Driver

- Windows Vista (SP2) (32 and 64 bit)
- Windows 7 (32 and 64 bit)
- Windows 8/8.1 (32 and 64 bit)
- Windows 10 (32 and 64 bit)

### ALLDAQ Manager

By the ALLDAQ-Manager you have central access to the software developer kit (SDK), several utility programs and help files. The ALLDAQ-Manager can be found in the info area of the taskbar (usually at the bottom right corner of the desktop) or by the Windows Start menu. See also chapter 2.4 on page 10.

### Software Developer Kit (SDK)

A function library (API) with example code for high-level language programming is included Please note the corresponding help file included with the SDK.

### LabVIEW Support

A library with virtual instruments (VIs) for easy access to the ALLDAQ hardware is included with the ALLDAQ SDK.

### MATLAB Support

An adapted MATLAB® interface for the ALLDAQ hardware with examples and a help file is included with the ALLDAQ SDK.

# 2. Initial operation

## 2.1 Installing the board

Please read the manual of your computer prior installing the board regarding the installation of additional hardware components.

Handling the board should be done with care to ensure that the device will not be damaged by electrostatic discharge (ESD), mechanical stress or current surges. Ensure to take all safety precautions to avoid an electric shock and follow the standard ESD safety precautions.

**Follow this order of operation:**

- Unplug the mains plug of your PC system.
- Open the housing as described in the manual of your PC system.

- Make sure that electrostatic discharge cannot occur via the board when you plug it in. At least one hand should be grounded in order to dissipate any static charge.
- Push the plug-in board carefully and with only a little force into the appropriate slot. Check that the board is not cant and fully plugged in.
- Screw the front panel.
- Close the housing as described in the manual of your PC system

## 2.2 Software installation

### 2.2.1 Installation under Windows

Run the file *ALLDAQDriverSetup32.exe* for 32 bit systems resp. *ALLDAQDriverSetup64.exe* for 64 bit systems in the target directory of your download. After successful installation the ALLDAQ-Manager can be found in the info area of the taskbar (usually at the bottom right corner) and in the Windows Start menu. By the ALLDAQ-Manager you have access to the software developer kit (SDK), several utility programs and help files.

## 2.3 Test programm

Simple test programs can be found in the ALLDAQ-SDK. For each programming language a subdirectory „Applications" can be found with test programs for your ALLDAQ hardware.

With the ALLDAQ-Manager you can retrieve several information of the installed ADQ hardware.

## 2.4 ALLDAQ Manager

The ALLDAQ-Manager under Windows gives you a quick overview of the parameters of the ADQ driver system and offers a central access to software tools and help files. You can find the ALLDAQ-Manager in the info area of the taskbar (as a rule at the bottom right) or via the Windows start menue.

**ALLDAQ-Manager in overview:**

- Information on the installed ALLDAQ hardware in overview
- XML export of the driver configuration for archiving and support
- Tool for interactive illustration of the pin-assignment with the possibility to generate a PDF
- Tool for user adjustment
- Convenient access to the software developer kit (SDK) for high-level language programming with examples and simple test programs
- Quick access to the help files (*.chm)

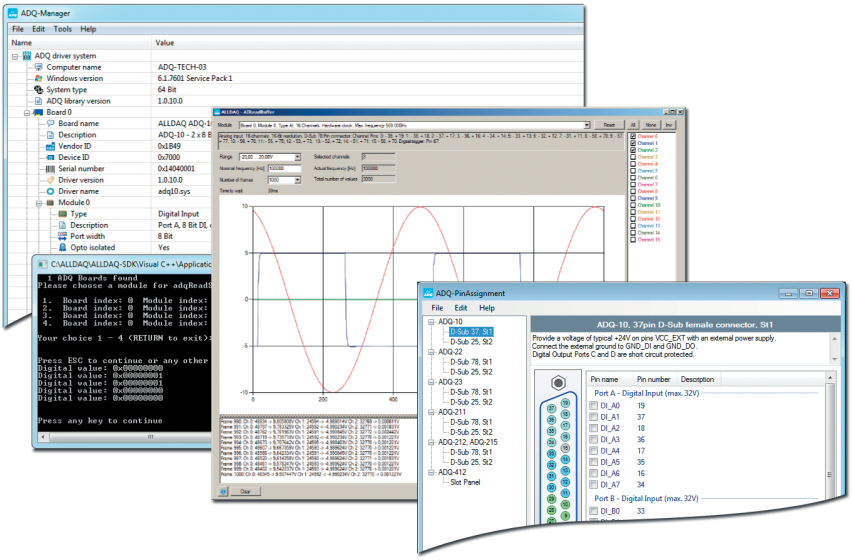


Figure 1: ALLDAQ-Manager and SDK programs

## 2.5 Adjustment/Calibration

By the ALLDAQ-Manager you can select which adjustment data record (factory or user adjustment) should be activated when booting the computer. You can change the setting at any time using the ALLDAQ-Manager.

### 2.5.1 Factory adjustment

The ADQ-412 will be adjusted before delivery. The adjustment data will be stored into an EEPROM. If a re-adjustment should be neccessary please contact our service department. For contact details see chapter 4.4 on page 23.

### 2.5.2 User adjustment

The measurement of very small current is covered by multiple error factors, e. g. line capacities, contact resistance and thermal effects. Therefore you have the possibility to perform a adjustment yourself and storing these application-specific adjustment data beside the factory adjustment data into the EEPROM.

Please follow the procedure below:

1. Power-on the system with the ADQ-412.
2. Connect the part of the field wiring you want to include into the adjustment.
3. Apply a constant current and monitor it by a high-precision ampere meter (e. g. multimeter). Make sure, that the ampere meter has a higher accuracy than the accuracy of your board.
4. Run the adjustment tool in the ALLDAQ-Manager and follow the procedure in the appropriate help file. See also chapter 2.4 on page 10.

**Note**: Repeat the adjustment for each channel separately.

**TIP:** To achieve the best accuracy, we recommend to set that sample rate which one you want to use in your measurement later.

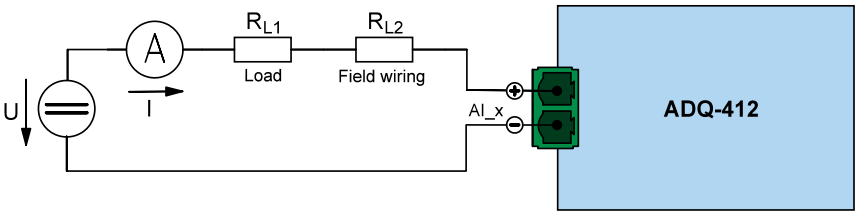


Figure 2: Wiring for adjustment

### 2.5.3 DAkkS calibration

We collaborate with independent test laboratories accredited by the Deutsche Akkreditierungsstelle GmbH (DAkkS). On-demand please contact our service department. For contact details see chapter 4.4 on page 23.

# 3. Functional groups

## 3.1 Block diagrams

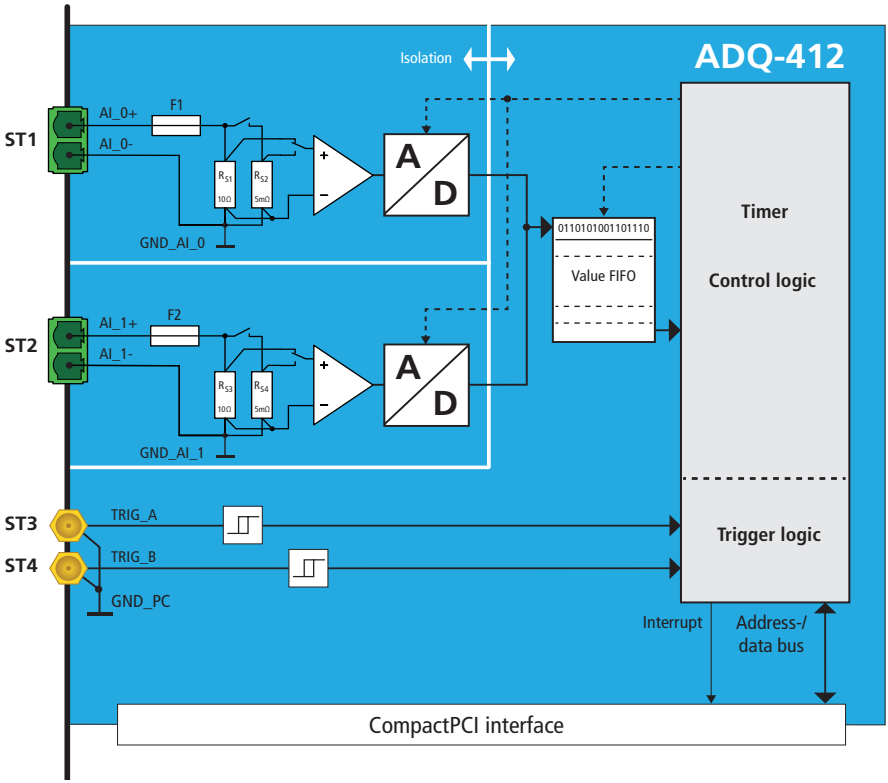


Figure 3: Block diagram ADQ-412

- 2 isolated current measurement channels
- 2 external digital trigger inputs

## 3.2 Analog acquisition

**Nyquist´s sampling theorem (Oversampling)**

Nyquist´s sampling theorem tells us, that the sample rate for a periodic signal, whose maximum frequency component should be $f_{Pmax}$, must be at least twice as high, i. e. 2 • $f_{Pmax}$ or higher. In practice we recommend to choose a sampling rate by the factor 5 or 10 higher than $f_{Pmax}$ to replicate the signal form truely. This issue is also called "oversampling".

**Example:**

The max. frequency component $f_{Pmax.}$ ($1/t_P$) of the signal frequency should be 10 kHz. The sample rate $f_S$ ($1/t_S$) should be at least 5 • 10 kHz = 50 kHz.

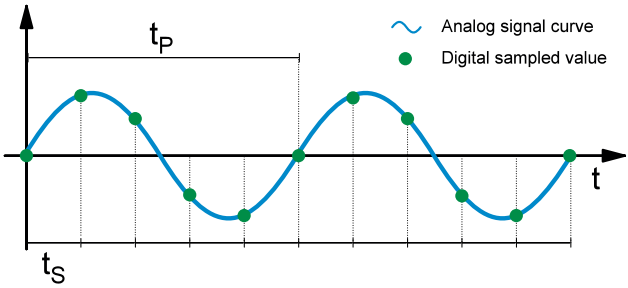


Figure 4: Nyquist-Shannon sampling theorem

### 3.2.1 Current inputs

The ADQ-412 provides 2 current measuring channels with electrical isolation of up to 700 $V_{PP}$ between each other and towards PC ground. Both channels are assembled with a 18 bit ADC and can sample with up to 1.6 MS/s synchronously.

The differential input channels are optimized for high precision current measurement from a few µA up to 50 A via shunt. The change-over of the shunts is done without interrupt of the measurement circuit. Due to the separately isolated inputs each channel has its own reference ground (GND_AI_*x*). The max. voltage potential U at the input may not exceed $U_{ISO}$.

Each channel of the ADQ-412 generates an appropriate interrupt event on under-cutting the -25 mA resp. exceeding the +25 mA threshold, which can be evaluated for the range selection on application level. Independent from this a hardware comparator automatically switches into the 50 A range as soon as the 25 mA range will be over-loaded by more than 12.5%. This protection mechanism works independently of operating system and application software.

The 50 A measurement range is secured by a 60 A cartridge fuse. Please note the characteristic dependency of current, pulse duration and ambient temperature, see .

### 3.2.1.1 Wiring

For proper signed measuring we recommend to connect the line with the positive potential to the clamp AI_*x*+ and the line with the negative potential to the clamp AI_*x*–.

Note, that the maximum voltage potential U at the differential inputs may not exceed the isolation voltage of $U_{ISO}$ = 700 $V_{RMS}$. Else the board can be be damaged irreversible. In this context we want to look at the wiring of the device under test (DUT).

- **DUT in the positive path (recommended):**
  ...it´s valid: $U = U_{DUT+} + U_S \Rightarrow$ The potential difference between GND_AI_x and GND_PC is very small because of the major part of the voltage drops at $U_{DUT+}$. This means it is not critical regarding $U_{ISO}$.

- **DUT in the negative path:**
  ...it´s valid: $U = U_S + U_{DUT-} \Rightarrow$ The potential difference between GND_AI_x and GND_PC maybe relatively big depending on U, because of the major part of the voltage drops at $U_{DUT-}$ whereas the voltage drop $U_S$ at the shunt can be neglected in practice. This means that the condition $U < U_{ISO}$ (700 $V_{RMS}$) must be followed necessarily.

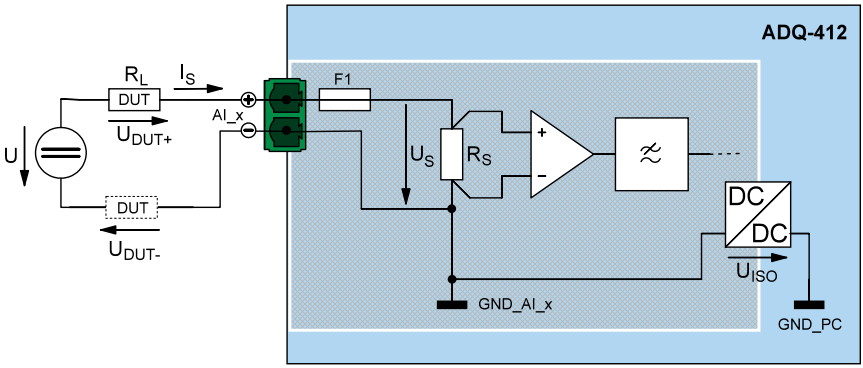


Figure 5: Wiring the current measurement channels

Ensure sufficient wire gauge of your field wiring depending on the maximum current to be measured and the length of your cable. The mating plugs are specified for wire gauges from AWG 20 to AWG 6.

### 3.2.1.2 External trigger A/D section

The ADQ-412 provides two external digital trigger inputs. By this you can feed two different trigger sources to the common control logic of the both channels. Depending on configuration the conversion can be started or stopped by a rising, a falling or any of both edges.

The digital trigger inputs (TRIG_A and TRIG_B) are designed for a TTL high-level of +5V. The trigger signal require a reference to PC ground (GND_PC).

The connection is done by coaxial connectors of type RP-SMA (Reverse Polarity SMA) which are named as female connectors although they have a pin in the center. Two adapters to BNC female connectors are included.

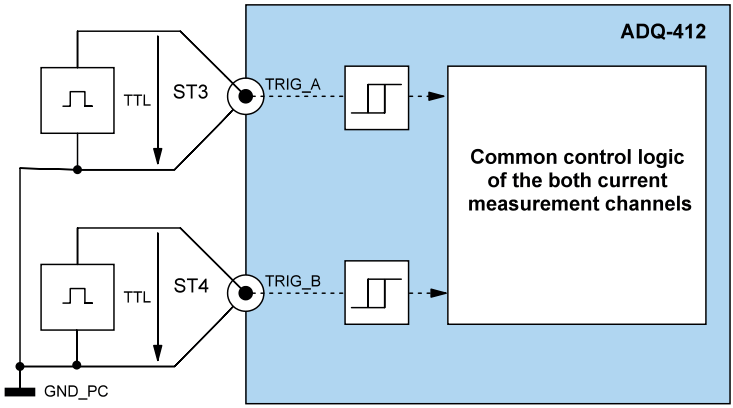


Figure 6: Wiring of the external trigger inputs

## 3.2.2 Programming

For programming the analog acquisition there is a differentiation between the so-called "Single value acquisition" and the "Timer-controlled acquisition". On demand the measurement can be started or stopped by two external TTL trigger inputs.

**Note:**

Each channel of the ADQ-412 generates an appropriate interrupt event on exceeding resp. undercutting the 25 mA threshold, which can be used for an automatic range selection on application level. Independent from this a hardware comparator automatically switches into the 50 A range as soon as the 25 mA range is exceeded by more than 12.5%. This protection mechanism works independently of operation system and application.

If a range overflow has occured a timer-controlled acquisition will be cancelled with an error because of the measurement values cannot be clearly assigned to a measurement range. On range overflow during a single read operation an error will be returned. After an error occured the measurement must be re-configured to achieve correct measurement values.

An auto-range function can only be realized if you have enough time to re-configure the measurement as soon as an interrupt occured. This is only the case on slow single value measurements. A continuous measurement with changing the measurement range in between is not possible.

### 3.2.2.1 Single value acquisition

This operation mode is for acquiring single values without fixed time reference.

Depending on configuration the conversion can be started by software or by a rising and/or falling edge at the two external trigger inputs (TRIG_*x*).

Please note the order of operation as described in the online help.

### 3.2.2.2 Timer-controlled acquisition

With the timer-controlled acquisition you can sample signals in defined time intervals and acquire them continuously. You can acquire a pre-defined number of frames or continuously. The so-called A/D value FIFO is a fast buffer memory which enables a continuous data transfer of both channels at maximum speed (1.6 MS/s per channel) to the PC.

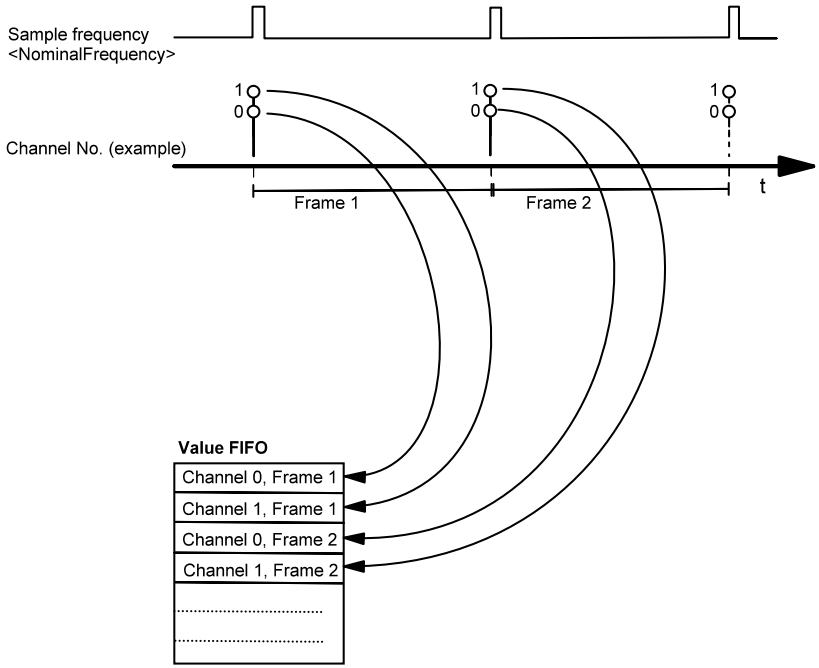


Figure 7: Timer-controlled acquisition

Please note the order of operation as described in the online help.

# 4. Appendix

## 4.1 Specifications

Conditions: $T_A$ = 23°C if not otherwise specified; warm-up time: 30 minutes.

### Current measurement channels

| Element | Condition | Specification |
|---|---|---|
| **Channels** | | 2 differential current measurement channels |
| **Sample rate** | | 1.6 MHz (synchronous) |
| **Resolution** | | 18 bit |
| **Bandwidth (-3 dB)** | Rectangular | 20 kHz |
| **Signal noise ratio (SNR)** | ±25 mA range, f = 2 kHz, $I_{ss}$ = 7.89 mA | < -100 dB |
| **Shunt type** | ±25 mA range | 10 Ω precision shunt from Isabellenhütte |
| | ±50 A range | 5 mΩ precision shunt from Isabellenhütte |
| **Current measuring ranges** | $R_S$ = 10 Ω | -25 mA..(+25 mA - 1 LSB); (1 LSB = 190 nA) |
| | $R_S$ = 5 mΩ | -50 A..(+50 A - 1 LSB); (1 LSB = 381 µA) |
| **Current load (see Figure 8)** | Continuous load | 37 A at $T_A$ = 23°C; 31 A at $T_A$ = 70°C |
| | max. 7 s after min. 10 s pause | 50 A |
| **Isolation voltage** | Channel to PC ground | 700 VDC / 700 $VAC_{RMS}$ (60 Hz) |
| | Channel to channel | 700 VDC / 700 $VAC_{RMS}$ (60 Hz) |
| **Total accurracy** | ±25 mA range | typ. 0.002%, max. 0.1% at full-scale |
| | ±50 A range | typ. 0.004%, max. 0.1% at full-scale |
| **Temperature drift** | | 20 ppm/°C |
| **Input impedance** | ±25 mA range | 10 Ω |
| | ±50 A range | 5 mΩ |
| **Value FIFO** | | 8192 values |
| **Channel list** | Channel selection | 2 entries |
| **Sample time range** | | 0.625 µs up to ~65 s (in steps of $15.\overline{15}$ ns) |
| **Trigger modes** | Start | Software, ext. trigger inputs |
| | Stop | Software, ext. trigger inputs |
| **Ext. trigger** | TRIG_A, TRIG_B | 2 digital trigger inputs (see chapter trigger inputs) |
| **Ground reference** | | floating channels |

**Dependency of the current rating from the pulse duration:**

Pulse duration maximum 7 s after a minimum pause of 10 s at 50 A (diagram is valid for a 60 A Littelfuse 495 JCASE fuse, ambient temperature: 40 °C and 100.000 pulse cycles)

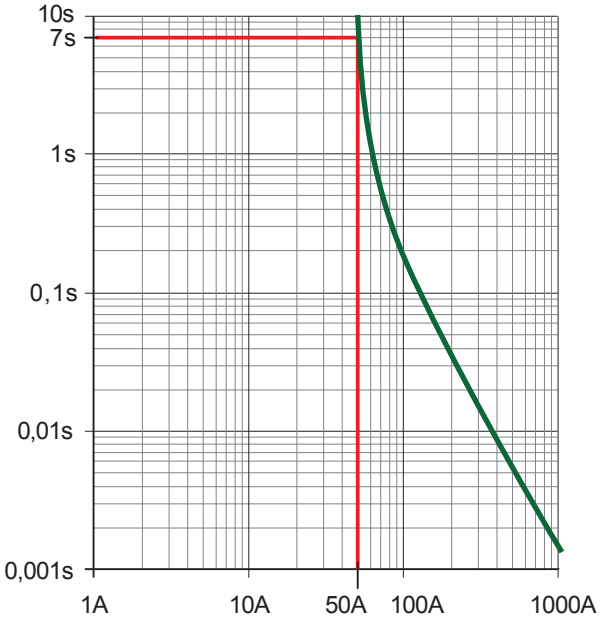


Figure 8: Characteristic of the fuse

### Trigger inputs (TTL)

| Element | Condition | Specification |
|---|---|---|
| **Number** | | 2 external trigger inputs (TRIG_A, TRIG_B) via RP-SMA female connectors (ST3, ST4) |
| **Function** | | Trigger of the common control logic for the current measurement channels |
| **Level** | | +5V TTL with Schmitt trigger characteristic (different input level on request) |
| **$U_{IH}$** | VCC = 5V | min. 2.0 V |
| **$U_{IH}$** | VCC = 5V | max. 0.8 V |
| **$I_I$** | | typ. ±1 µA |
| **Trigger clock** | Symmetrical rectangular signal | max. 1.6 MHz |
| **Trigger edges** | | rising, falling, any |
| **Ground reference** | | PC ground (GND_PC) |

### General

| Element | Condition | Specification |
|---|---|---|
| **PC interface** | | CompactPCI bus (32 bit, 33 MHz) Rev. 2.2 |
| **Power consumption of the board** | +3,3 V | typ. 125 mA |
| | +12 V | max. 625 mA |
| **Temperature range** | Operation | 0..70 °C (standard), extended temperature range on request |
| | Storage | -40..100°C |
| **Humidity** | Operation | 20%..55% (not condensing) |
| | Storage | 5%..90% (not condensing) |
| **Physical size** | (without mounting bracket and connectors) | 3 HE CompactPCI board, 8 HP width |
| **Connectors** | ST1, ST2 | 2-pin Phoenix type clamp, type: PC 6-16/2-G-10,16;<br>Mating plugs, type: PC 16/2-ST-10,16;<br>Connection according to EN-VDE for wire gauges from AWG 20 to AWG 6 |
| | ST3, ST4 | Coaxial female connectors of type: RP-SMA (Reverse Polarity SMA) |
| **Fuses** | F1, F2 | Cartridge fuse of type Littelfuse 495 JCASE<br>Current rating: 60 A (yellow),<br>Voltage drop: typical 87 mV,<br>Cold resistance: 0,76 Ω,<br>Energy value $I^2t$: 19500 $A^2s$ |
| **Certifications** | | EMC directive 2004/108/EG,<br>Emission EN 55022,<br>Noise immunity EN 50082-2,<br>RoHS |
| **Manufacturer warranty** | | 36 months |

## 4.2 Pinouts

### 4.2.1 ADQ-412

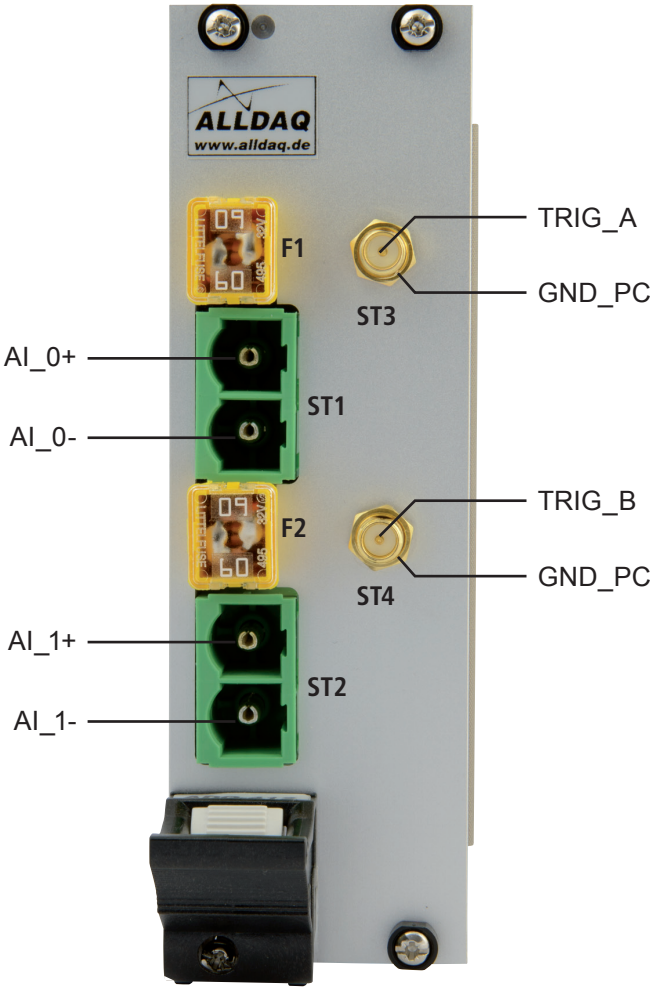


Figure 9: Connectors of the ADQ-412

The external trigger signals are connected by coaxial connectors of type RP-SMA (Reverse Polarity SMA) which are named as female connectors although they have a pin in the center.

## 4.3 Accessories

**ADQ-AP-RP-SMAM-BNCF (Art. No. 118731)**

Adapter from RP-SMA male to BNC female connector (2 pieces included)

## 4.4 Manufacturer and support

ALLNET® and ALLDAQ® are registered trademarks of the ALLNET® GmbH Computersysteme. For questions, problems and product information please contact the manufacturer directly:

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Fax: +49 (0)89 894 222 33
Internet: www.alldaq.com

# 4.5 Important notes

## 4.5.1 Packaging ordinance

Basically manufacturer and distributors are committed to take care, that sales packaging are withdrawn after use from the end user and applied to a new disposal or to a material recycling as a matter of principle (translated according to § 4 sentence 1 of VerpackVO). If you have problems as customer on disposal of packaging and shipping material please write an email to info@allnet.de.

## 4.5.2 Recycling note and RoHS compliance

Please note, that parts of products of ALLNET® GmbH should be disposed in recycling centers resp. may not be disposed via the household waste (printed circuit boards, power adapters and so on).


ALLNET® products are manufactured in accordance with RoHS (RoHS = Restriction of the use of certain hazardous substances).

## 4.5.3 CE certification

The ADQ-410 series is CE certified.

This device is compliant to the EU directive: 2004/108/EG regarding the electromagnetic compatibility (EMC) and the cross approval of their conformity. The conformity with the directive as stated above is confirmed by the CE sign on the device.

## 4.5.4 Warranty

Within the warranty time we eliminate manufacturing and material defects free of charge. The warranty terms valid for your country can be found on the homepage of your distributor. If you have questions or problems applying the warranty you can contact us during our normal opening hours under the following phone number +49 (0)89 894 222 474 or by email: support@alldaq.com.

# 5. Index

ALLDAQ

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