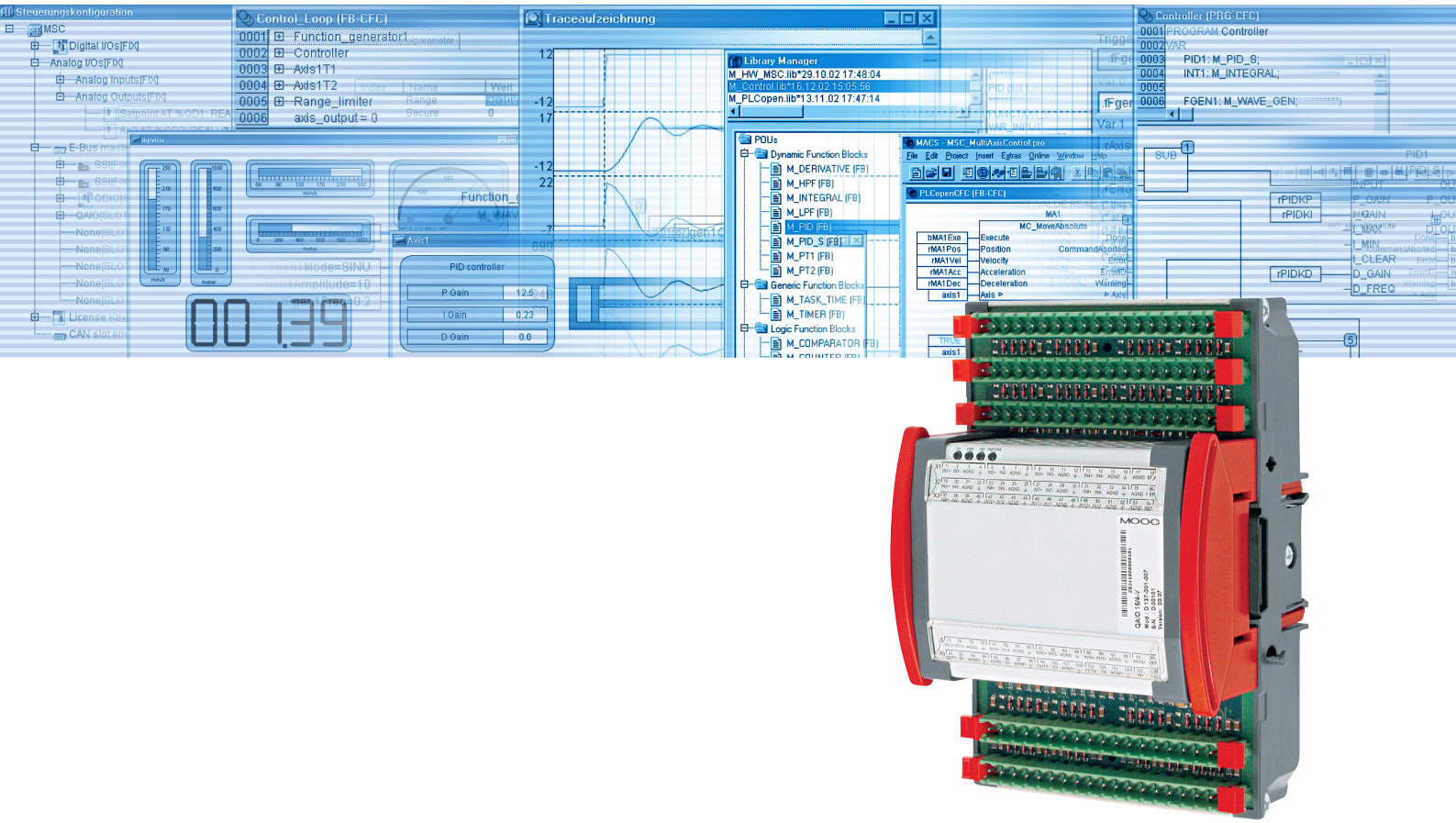
# User Manual

# M3000® Control System

# QAIO 16/4
Analog I/O Extension Module



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## DIN EN ISO 9001

Our quality standard is according to DIN EN ISO 9001.

# QAIO 16/4-V
# QAIO 16/4-A

**Analog I/O expansion modules**

**V.1.1**

**User Handbook**

A u t o m a t i o n  S y s t e m

CANtrol®

**Disclaimer**

The content of this publication was checked for compliance with the hardware and software described. However, discrepancies may arise, therefore no liability is assumed regarding complete compliance. The information in this document will be checked regularly and all necessary corrections will be included in subsequent editions. Suggestions for improvements are always welcome.

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**General Information on this Manual**

Content:
This manual describes the CANtrol module QAIO 16/4-V and QAIO 16/4-A and its modifications. The product-related information contained herein was up to date at the time of publication of this manual.

Completeness:
This manual is complete only in conjunction with the user manual entitled

'Introduction
to CANtrol Automation System'

and the product-related hardware or software user manuals required for the particular application.

Standards:
The CANtrol automation system, its components and its use are based on International Standard IEC 61131 Parts 1 to 4 (EN 61131 Parts 1 to 3 and Supplementary Sheet 1).
Supplementary Sheet 1 of EN 61131 (IEC 61131-4) entitled 'User Guidelines' is of particular importance for the user.

Order numbers:
Please see the relevant product overview in the 'Introduction to CANtrol Automation System' manual for a list of available products and their order numbers.

Ident. No.: 2801720

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# Update

| Version | Date | Subject |
|---|---|---|
| 1.0 | 5-00 | First version |
| 1.1 | 01.04.02 | Formal updates, company name and product name removed. |
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# 1. General Instructions

## 1.1. Hazard Categories and Indications

The indications described below are used in connection with safety instructions you will need to observe for your own personal safety and the avoidance of damage to property.

These instructions are emphasised by bordering and/or shading and a bold-printed indication, their meaning being as follows:


**DANGER !** means that death, severe physical injury or substantial damage to property will occur on failure to take the appropriate precautions.

**Warning !** means that death, severe physical injury or substantial damage to property may occur on failure to take the appropriate precautions.

**Caution** means that minor physical injury or damage to property may occur on failure to take the appropriate precautions.

**Note:**
provides important information on the product or refers to a section of the documentation which is to be particularly noted.

## 1.2. Qualified users

Qualified users within the meaning of the safety instructions in this documentation are trained specialists who are authorised to commission, earth and mark equipment, systems and circuits in accordance with safety engineering standards and who as project planners and designers are familiar with the safety concepts of automation engineering.

## 1.3. Use as Prescribed

This is a modular automation system based on the CANbus, intended for industrial control applications within the medium to high performance range.

The automation system is designed for use within Overvoltage Category I (IEC 364-4-443) for the controlling and regulating of machinery and industrial processes in low-voltage installations in which the rated supply voltage does not exceed 1,000 VAC (50/60 Hz) or 1,500 VDC.

Qualified project planning and design, proper transport, storage, installation, use and careful maintenance are essential to the flawless and safe operation of the automation system.

The automation system may only be used within the scope of the data and applications specified in the present documentation and associated user manuals.

**The automation system is to be used only as follows:**

- as prescribed,
- in technically flawless condition,
- without arbitrary or unauthorised changes and
- exclusively by qualified users

The regulations of the German professional and trade associations, the German technical supervisory board (TÜV), the VDE (Association of German electricians) or other corresponding national bodies are to be observed.

**Safety-oriented (fail-safe) systems**

Particular measures are required in connection with the use of SPC in safety-oriented systems. If an SPC is to be used in a safety-oriented system, the user ought to seek the full advice of the SPC manufacturer in addition to observing any standards or guidelines on safety installations which may be available.

**Warning !** As with any electronic control system, the failure of particular components may result in uncontrolled and/or unpredictable operation. All types of failure and the associated fuse systems are to be taken into account at system level. The advice of the SPC manufacturer should be sought if necessary

# 2. Analog I/O expansion module

## 2.1. Overview

**Order number**

For replacement parts, the order/item no. can be found on the module's nameplate.

**Function**

The module is used to expand the analog I/O level of Cell Controllers.
The modules are connected by direct E-bus coupling and is available with voltage or current inputs.

**Features**

Common characteristics

- 4 analog output channels
  in the form of voltage outputs, +/-10 V (GND sensing)
  resolution 11 bit + sign
- 1 reference voltage output +10 V
- Low space requirements and low mounting depth.

The modules with voltage or current inputs also have the following features:

Module with voltage inputs:

- 16 analog voltage input channels,
  suitable for connecting active and passive resistors.
  voltage rating, differential +/-10 V
  measured value resolution 11 bit + sign

Module with current inputs:

- 16 analog current input channels,
  current rating, 0... 20 mA
  measured value resolution 11 bit + sign

**Lieferumfang**

Supplied with the module package is:

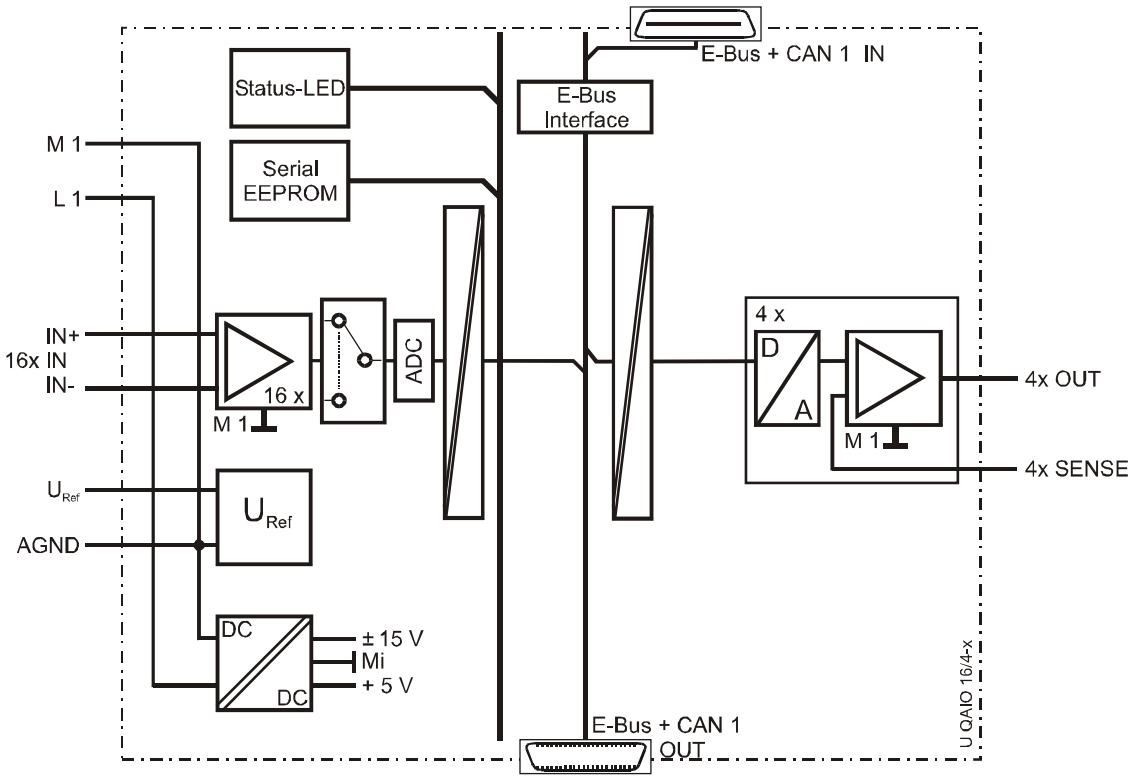
- An analog I/O expansion module with voltage or current inputs.

## 2.2. Technical data

| **Module data** | | |
|---|---|---|
| Analog I/O expansion module | voltage or current inputs | |
| Dimensions w x h x d [mm] | 124 x 170 x 85.5 (modular dimension: B = 113/118.5) | |
| Weight | approx. 550 g | |
| Mounting | Mounting rail NS 35/7,5 EN 50022 | |
| Working temperature | 5°C to 50°C (no moisture condensation) | |
| Operation and display | 4 status LED's | |
| **EMC, class of protection, insulation testing, degree of protection** | | |
| EMC (EN 50081-2 / EN 50082-2) | To achieve the precision specified, the user is required to implement shielding measures. | |
| Emitted interference | EN 50081-2, industrial sector | |
| Noise immunity | EN 50082-2, industrial sector | |
| Class of protection | EN 61131-2 | |
| Insulation resistance | EN 61131-2; 500 VDC (test voltage) | |
| Degree of protection | IP 20 | |
| **Supply voltage, power consumption** | | |
| Module electronics power supply (supply voltage) | SELV DC +24 V max. 0.3 A (EN 61131-2) on AGND earth | |
| Power consumption | at $U_e$ = DC +24 V idling max. 300 mA | |
| Electrical isolation | yes, optodecoupled from E bus; no isolation between power supply and analog channels | |
| Reverse voltage protection | yes | |
| Connections | vertical front wiring push-on terminal strips for screw, crimp or pinch connection | |
| **Reference voltage source** | | |
| Reference voltage | DC +10 V permanent short-circuit protection; $I_{Kmax}$ 25 mA | |
| Load current | max. 5 mA | |
| Precision | 0.1% | |
| **Various characteristics** | | |
| Data format in application program | Integer 16 bit | |
| Monotonicity | yes | |
| Cross talk between channels<br>- direct current<br>- 50 Hz<br>- 60 Hz | <br>>70 dB<br>>70 dB<br>>70 dB | |
| Non-linearity | < 1 LSB | |
| Repeat accuracy at certain temperature after 1 hour stabilising time | < 1 LSB | |
| **Analog inputs** | | |
| ***Static characteristics::*** | ***voltage inputs*** | ***current inputs*** |
| Number<br>Type | 16<br>voltage ± 10 V, differential | 16<br>current, ± 20 mA |
| Input impedance in signal range | 10 M Ohm | 50 Ohm |
| Analog input error of measurement<br>- greatest error at 25°C<br>- temperature coefficient | <br>±0.1% of maximum scale value<br>±0.01% of maximum scale value/°K | <br>±0.2% of maximum scale value<br>±0.02% of maximum scale value/°K |
| Greatest error over full temperature range | ± 0,2 % of maximum scale value | ± 0,3 % of maximum scale value |
| LSB value | 4.883 mV | 9.766 µA |
| Max. permissible continuous overload (exceeding this causes damage) | ± 30 V | 50 mA |

| | |
|---|---|
| Digital resolution | 11 bit + sign |
| Data format | 16 bit, integer |
| Digital value output under overload<br>Exceeding permissible measuring range:<br>Falling below permissible measuring range: | <br>+ 32752 (+9,995 V)<br>- 32768 (-10,000 V) |
| Common mode characteristics:<br>- common mode rejection | <br>≥ 70 dB |
| ***Dynamic characteristics:*** | |
| Max. system input transfer time per channel (TAID+TAIT) | <1ms<br>see documentation on function blocks CP1131 or CPC++ |
| Sampling interval per channel | 1 µs |
| Sampling repetition time per channel | >1 ms<br>see documentation on function blocks CP1131 or CPC++ |
| Input filter characteristic<br>- order<br>- transfer frequency | <br>1st order<br>approx. 10 kHz |
| ***General characteristics:*** | |
| Conversion method | successive approximation; no error codes |
| Protection devices | diodes |
| Insulation test voltage between analog converter and E bus | DC 500 V |
| **Analog outputs** | |
| ***Static characteristics:*** | |
| Output type | 4 x voltage (U), floating; ±10 V |
| Output impedance in signal range | < 0.5 Ohm |
| Analog output error:<br>- greatest error at 25°C<br>- temperature coefficient | <br>±0.15% of maximum scale value<br>±0.01% of maximum scale value/°K |
| Greatest error over full temperature range | ±0.3% of maximum scale value |
| Digital resolution | 11 bit + sign |
| Value of least significant bit (LSB) | 4.883 mV |
| ***Dynamic characteristics*** | |
| Overall system output transfer time per channel (TAQD + TAQT) | <1 ms |
| Transient time when alternating over the full range | <1 ms |
| Overshoot | typically 0.5%, load-dependent |
| ***General characteristics*** | |
| Type of protection devices | permanently short-circuit proof; $I_{Kmax}$ = 25 mA,<br>supply polarity-reversal-protected |
| Insulation test voltage between analog converter and E bus | DC 500 V |
| Permissible load types | R, (C) |
| Permissible capacitive load | <1000 pF |
| Output response for power supply connecting/disconnecting processes.. | typical spike: U = 0.1 V; τ <10 ms<br>Behaviour is strongly dependent on the connected load |
| ***Various characteristics*** | |
| Output ripple | < 1 LSB |
| Output current | max. 5 mA |
| Common mode range | +/- 2 V |

## 2.3. Block circuit diagram

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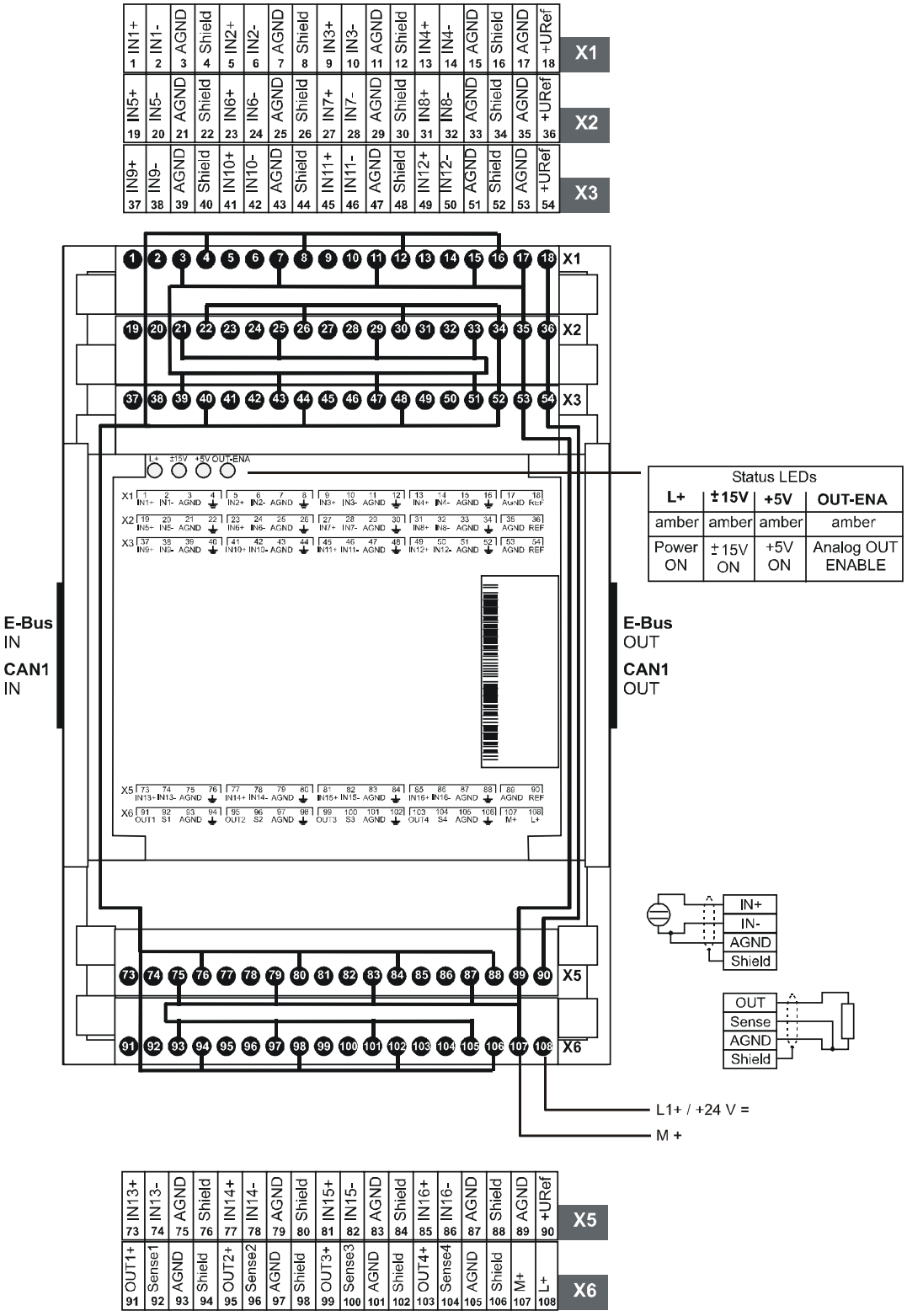
## 2.4. Module diagram and connection assignment

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## 2.5. Indicators, diagnostics

**Operational status**

The current state of voltage supplies and module functions is indicated by 4 status LEDs located on the module cover.

| LED- status | | Function |
|---|---|---|
| L+ | ON | Module electronics supply working correctly (supply voltage) |
| ± 15 V | ON | Analog unit supply working correctly |
| + 5 V OUT | ON | Module is connected to Cell Controller (E bus on voltage). |
| OUT_ENA | ON | 'ENABLE' analog outputs |

**I/O assignment**

The print on the module covers shows the assignment of the analog I/O channels, reference outputs and incoming supply to the connection terminals.

## 2.6. Shielding and measurement cabling

Reliable operation of higher-precision analog components with fast conversion times can only be achieved in an industrial environment with the help of corresponding shielding measures and the correct metrological cabling. The user must, in this regard, observe the interaction of all the analog components and their auxiliary power supplies throughout the entire system.

**Mounting the module**

The module must always be mounted in shielding (metal) switch cabinets/casings. Adequate isolation of interfering components and their cabling must be ensured within the casing by means of appropriate constructive measures (e.g. separate wiring, spatial separation of components).

**Low-frequency interference voltages**

Low-frequency interference voltages, such as the omnipresent 50 Hz network crosstalk, are cancelled out by the module's differential measuring system in conjunction with high common-mode rejection.

**High-frequency interference voltages**

High-frequency and pulse interferences have to be kept away from the signal lines by means of suitable shielding measures.
For this purpose, the line shields in the field (outside the casing) must be connected on both sides. The best results are always achieved when the cable shields are laid flat at the points where they enter the casing.

**Note:**
Experience shows that the environmental conditions within systems and equipment can change sporadically and unexpectedly.
Even if seemingly good results can be attained in a number of cases using open wiring, we advise strongly against it.
Failure to implement the measures referred to can result in lengthy error diagnostic processes and high consequential costs.

Users that implement the recommendations set out in this manual in a consistent manner will not encounter problems regarding current EMC directives.

**CE mark**

When designing the module, we attached great importance to its electromagnetic compatibility. Nonetheless, a considerable proportion of the action that must be taken in order to ensure reliable operation are outside our sphere of influence.
For this reason, we have opted not to affix the CE mark to this automation component. In this regard we would like to draw users' attention to their overall responsibility when incorporating the module into their applications.

## 2.7. Operation of the module

**Warning !** Do not insert, apply, detach or touch connections when in operation!
Destruction or malfunctioning may otherwise occur. Disconnect all incoming supplies before working on modules, including those of connected peripherals such as externally supplied sensors, programming devices, etc.

The module is designed for measuring and control functions located on a common potential island.
Items of equipment on differing potential levels can be connected via suitable isolation devices (insulating amplifier etc.).

**Note:**
The module electronics power supply (connection voltage +24$V_{DC}$) is **not** electrically isolated from the analog connections on the module. The negative connection point for the incoming supply (M1) is physically connected to the analog earth connection (AGND).
We recommend that all sensors/actuators be operated on this supply together with the module.

*Consciously arranging analog wiring with a common earth is good practice.*
*The module is designed to cope reliably and effectively with the small differences of potential unavoidably occurring when sensors and actuators are supplied jointly through appropriate SENSE lines.*

**Caution** The module's analog channels may be connected to different earths only within the permissible common mode range.
More extensive electrical isolation is not permissible for design reasons.

Non-compliance with the above will cause incorrect measurements, even on uninvolved channels, and can result in transient currents which will cause permanent damage to the module.

### 2.7.1. Fault currents

A large number of the conceivable incorrect assignments of analog connections can be resolved by means of circuit organisation.
Nonetheless, it is not economically possible with the components available today to guarantee absolute protection against all fault currents that can be implanted from outside.

| | |
|---|---|
| **Caution** | Faulty wiring, incorrect power supply or high potential differences in the measuring circuits can cause serious damage to the module or permanently impair measuring accuracy. |

### 2.7.2. Commissioning

All connections should be re-checked for correct wiring and polarity the supply voltage is applied.

The handling of the module depends on the software environment used. For this reason, you should consult the information in the programming manuals for the CP1131 or CPC++, as appropriate.

### 2.7.3. Initialisation and module identification

The analog expansion module is identified and initialised by the operating system of the upstream Cell Controllers. The identification characteristics stored in the module are evaluated by the Cell Controller for this purpose.

No dip switch settings are required. In the case of failure of the +24 V power supply or interruption of the E bus transmission, the analog outputs are reset to 0 V (LED “OUT_ENA”).

## 2.7.4. Measuring

The measurements and transfer of the data from the module to the CAN node are carried out in a cyclic manner, controlled via the API (Application Process Interface) in the operating system. No start signals have to be output for AD conversion. Execution of the measuring process depends on the software environment used. For this reason, you should consult the relevant information contained in the programming manuals for CP1131 or CPC++.

**Note:**:
The following formula applies for converting the measured data into voltage values:

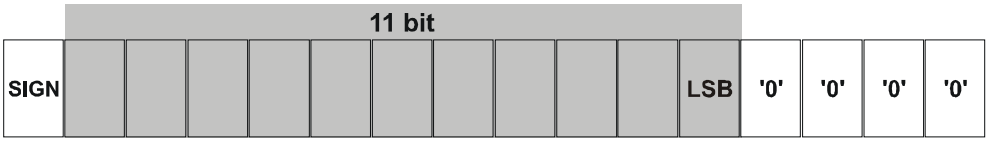
$$U = 10\ V \frac{AD}{2^{15}} \qquad I = 20\ mA \frac{AD}{2^{15}}$$

Comment: **AD** = the value supplied by the analog channel *(in_value)*

When leaving the permissible measuring range, the following values are reported:

| | | |
|---|---|---|
| Exceeding the permissible measuring range (+) | + 32752 | + 9,995 V |
| Falling short of the permissible measuring range (-) | - 32768 | - 10,000 V |

**Representation of the 11-bit measured value with sign in a 16-bit variable:**

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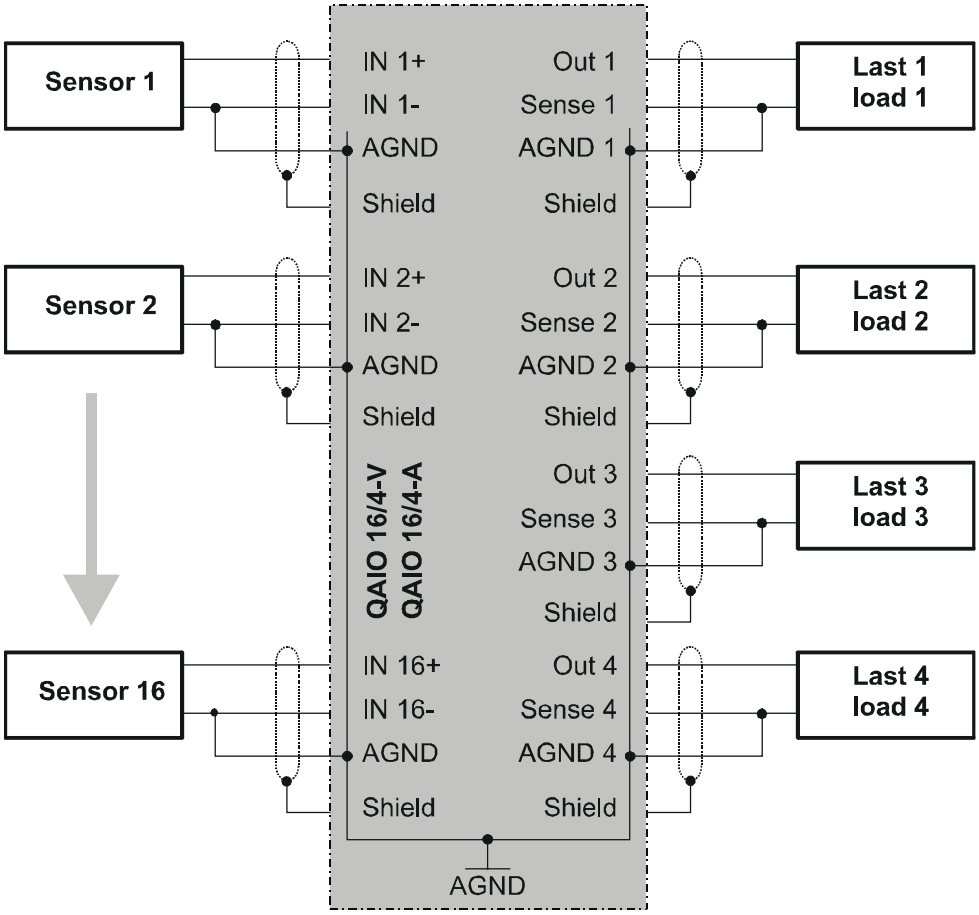
## 2.7.5. Sensor failure

In the case of sensor failure, the corresponding channel reports the value for +9.995 V to the cell controller.

## 2.7.6. Connection of sensors/actuators

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**Note:**
This interface connection is ideal for floating sensors/actuators. In the case of sensors/actuators with auxiliary power, it must be ensured that the energy supply currents do not flow via the AGND lines *(see sector 'Analog I/O channels by 'Sensor connection, examples')*.

# 2.8. Analog I/O channels

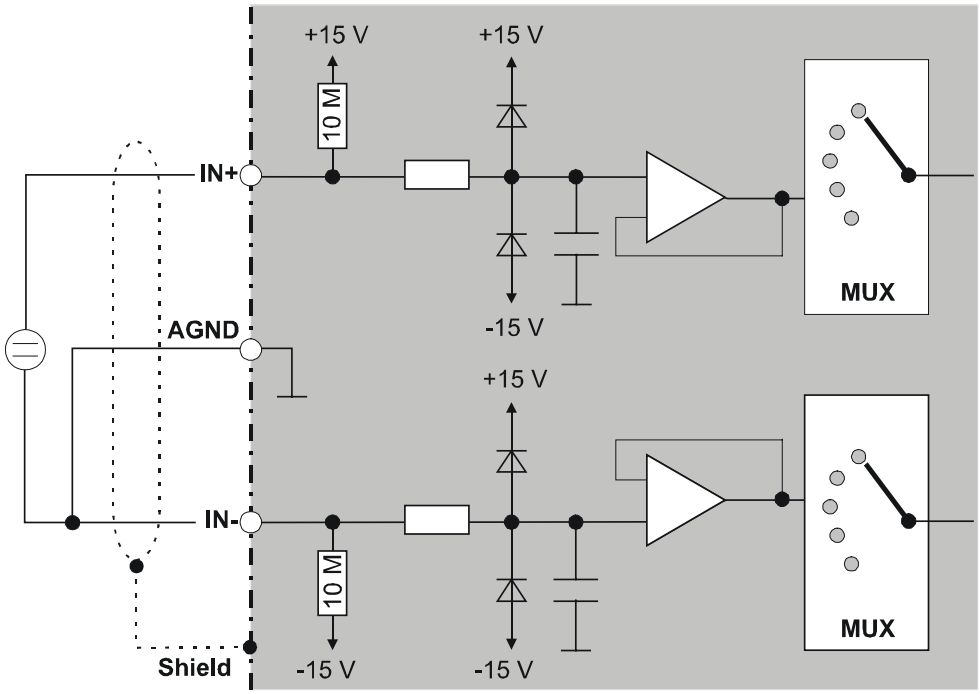
## 2.8.1. Analog input channels

The analog expansion module has 16 analog, multiplexed voltage inputs. These inputs are protected by protective diodes. The input current may not, even in the case of error, exceed the value of 10 mA per channel.

**Input channel data**

| | |
|---|---|
| Input voltage/current, rated value | +/- 10 V, differential<br>+/- 20 mA |
| Input voltage, maximum rating | +/- 12 V, |
| Input current, maximum rating | 10 mA je Kanal |
| Common mode rejection | ≥ 70 dB / DC |
| Diff. input resistance | 20 MOhm |
| Common mode input resistance | 10 MOhm, typ. |
| Input filter, 1st degree | τ = 70 µs |
| Conversion method | successive approximation,<br>no error codes |
| Resolution voltage<br>current | 11 bit + sign; 1 LSB = 4,883 mV<br>11 bit + sign; 1 LSB = 9,766 µA |
| Precision in temp. range 0-50°C<br>voltage<br>current | <br>+/- 1 LSB; +/- 0,2 %<br>+/- 1 LSB; +/- 0,3 % |

### *Voltage input (basic circuit diagram)*

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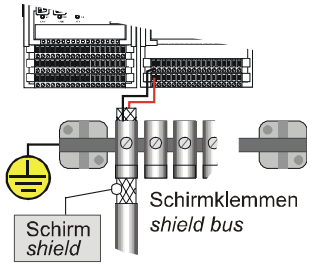
## 2.8.2. Sensor connection, examples

**Note:**
The measuring line shield can, where required, be connected to SHIELD.

Where better HF contact of the shields is possible at another point in the casing, there should be no additional connection to SHIELD on the module.

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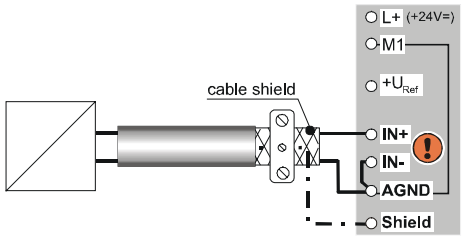
### *Floating sensors*

Connection via 2-pole, shielded cable (IN+/AGND). In the case of floating sensors, at least one of the measuring inputs (IN -) must be bridged to AGND

The cancellation of electrical isolation brought about by the bridge is absolutely necessary as capacitive signal couplings with impermissibly high common mode voltages are already built up because of the very high impedance inputs. This leads to sporadic incorrect measurements which are difficult to detect in most cases.

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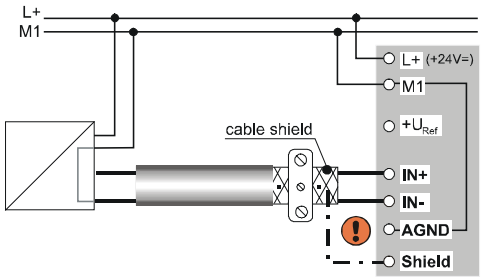
### *Potential-afflicted sensors with auxiliary power connection*

Connection via 2-pole, shielded cable (IN+/IN-). Sensors with auxiliary power supply but without electrical isolation should be operated from the same power supply source as the module. The sensor is connected to the two measuring inputs IN+ and IN- in the required polarity. The AGND connection of the module remains open.

It is to be ensured that the potential equalisation via the common supply and sensors actually occurs.

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### *Sensor connection using internal module reference voltage*

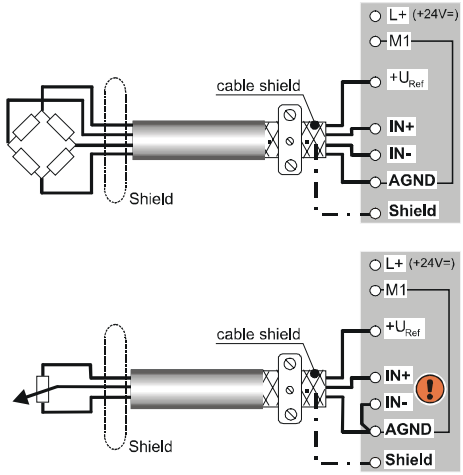
Connection via 3 or 4-pole shielded cable (IN+/IN-/$U_{Ref}$/AGND).

Radiometric sensors (potentiometer, bridge circuits) are treated as potential-afflicted sensors.

The auxiliary power is also carried in the measuring line.

If only one measuring input is needed, as in the case of the potentiometer connection, the free input must be bridged to AGND.

It must be ensured that the reference voltage is not overloaded and that the current taken from the reference source can flow back again via the AGND connections.

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## 2.8.3. Analog output channels

The analog expansion module QAIO 16/4-V has 4 analog voltage outputs. The outputs are permanently protected against short-circuiting, at a maximum short-circuit current of 25 mA.

For each output, the connection points are also provided for the analog ground (AGND) and the common earth (REF) besides the signal connections (OUT). This means that earth shifts can be compensated for as long as the condition $|U_{REF}| < 2$ V is complied with for each output.

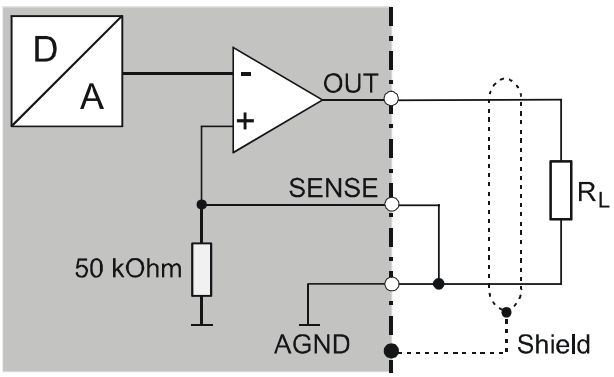
The SENSE connectors are connected directly to the earth of the associated actuator.

**Note:**
The SENSE line cannot be used alone as the feedback.

**Output channel data**

| | |
|---|---|
| Output voltage, rated value | +/- 10 V, floating |
| Output current | max. 5 mA |
| Short-circuit protection | permanent short-circuit protection $I_{Kmax}$ 25 mA |
| Transient time of DA converter | < 10 µs |
| Slew rate | > 8 V / µs |
| Resolution | 11 bit + sign,<br>1 LSB = 4,883 mV, monotone |
| Precision in temp. range | +/- 1 LSB; +/- 0,3 % |
| Load resistance | min 2 kOhm |
| Capacitive load | <1000 pF |

### *Voltage output (basic circuit diagram)*




2VF100065DG00.cdr

## 2.9. Reference voltage source

**Caution** Incoming supply of an interference voltage can cause severe damage to the reference voltage source.

The expansion module has a reference voltage source with 4 connection points ($U_{Ref}$/AGND) on the terminal level.

**Data:**

| | |
|---|---|
| Reference voltage | + 10 V |
| Precision | +/- 10 mV |
| Load current | 5 mA max. |
| Permanent short-circuit protection | short-circuit current max. 25 mA |

Leerseite

# 3. Annex

## 3.1. Environmental Protection

### 3.1.1. Emission

When used correctly, our modules do not produce any harmful emissions.

### 3.1.2. Disposal

At the end of their service life, modules may be returned to the manufacturer against payment of an all-inclusive charge to cover costs. The manufacturer will then arrange for the modules to be recycled.

## 3.2. Maintenance/Upkeep

**Warning !** Do not insert, apply, detach or touch connections while in operation – risk of destruction or malfunction.
Disconnect all incoming power supplies before working on our modules; this also applies to connected peripheral equipment such as externally powered sensors, programming devices, etc.
All ventilation openings must always be kept free of any obstruction.

The modules are maintenance-free when used correctly.
Clean only with a dry, non-fluffing cloth.
Do not use detergents.

## 3.3. Repairs/Service

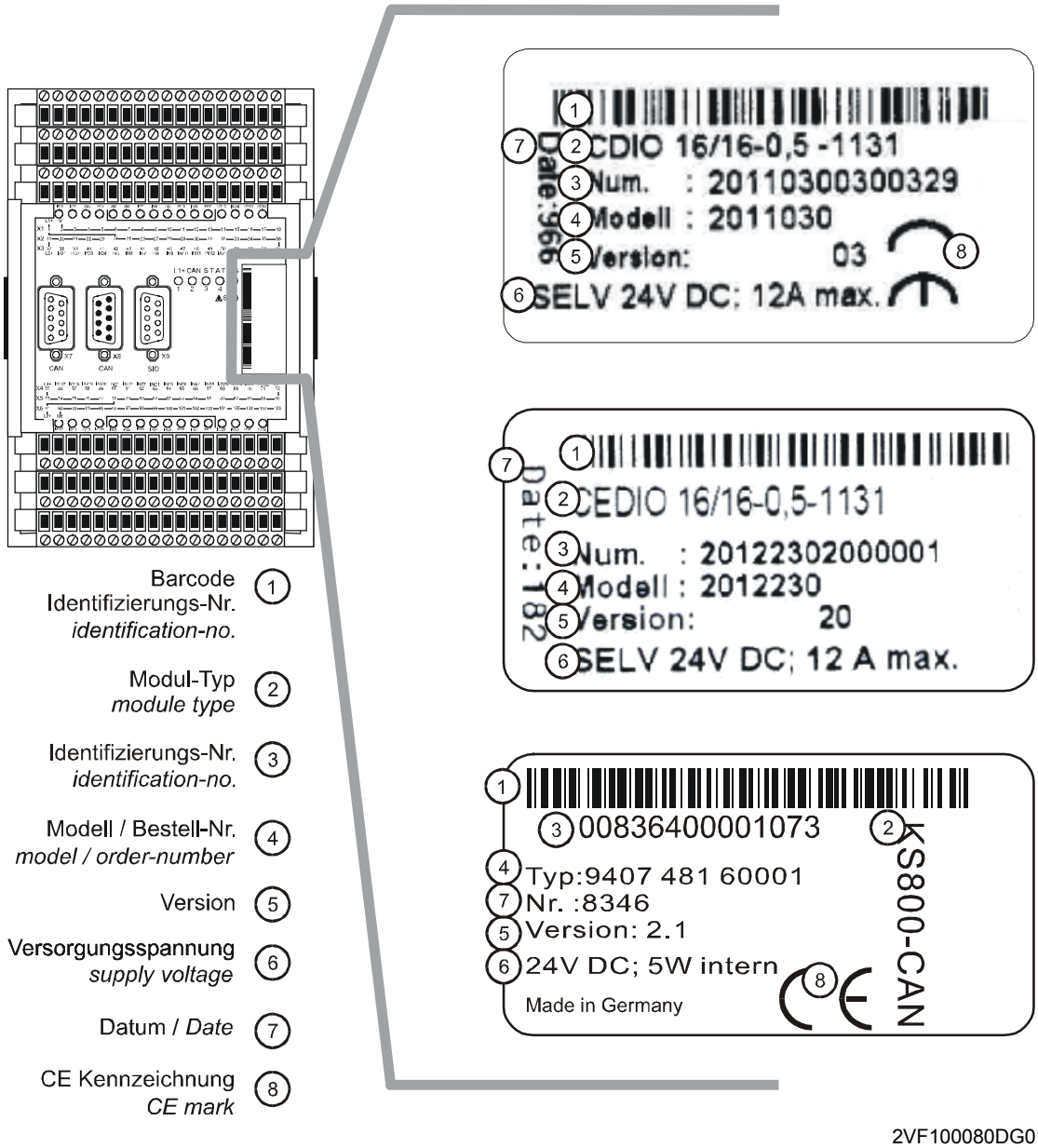
**Warning !** Repair work may only be carried out by the manufacturer or its authorised service engineers.

### 3.3.1. Warranty

Sold under statutory warranty conditions. Warranty lapses in the event of unauthorised attempts to repair the equipment and/or product, or in the event of any other form of intervention.

## 3.4. Nameplate

**Erklärungen zu den Typenschildern (Beispiel)**
*nameplate descriptions (example)*




1 Barcode
Identifizierungs-Nr.
*identification-no.*

2 Modul-Typ
*module type*

3 Identifizierungs-Nr.
*identification-no.*

4 Modell / Bestell-Nr.
*model / order-number*

5 Version

6 Versorgungsspannung
*supply voltage*

7 Datum / *Date*

8 CE Kennzeichnung
*CE mark*

2VF100080DG01.cdr

1. **Barcode**
   same as identification number.

2. **Module type**
   plain-text name of module.

3. **Identification no.**
   module's identification number.

4. **Model/order no.**
   You only need to give this number when ordering a module. The module will be supplied in its current hardware and software version.

5. **Version**
   defines the design-level of the module as supplied ex-works.

6. **Supply voltage**

7. **Date**
   internal code.

8. **CE mark**

**Note:**
The ‘Version’ (supply version) panel specifies the design-level of the module as supplied ex-works. When replacing a module, users, with the CNW (Cantrol Node Wizard) tool, can read off the current software version of the newly supplied module, and then reload their 'own' software version for a particular project if necessary.
With the latter in mind, before the download you should always keep a record of the existing software levels in your project documentation (software version, node IDs, baud rate, etc.)

## 3.5. Addresses and Bibliography

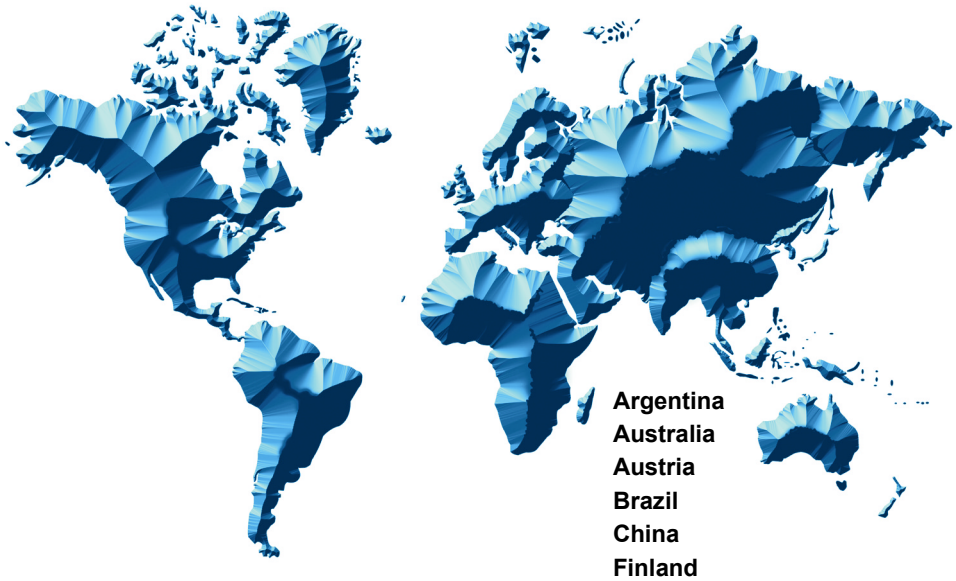
### 3.5.1. Addresses

| | | | |
|---|---|---|---|
| **CiA** | 'CAN in Automation', international manufacturers and users organisation for CAN users in the field of automation:<br><br>CiA - CAN in Automation e.V.<br>Am Weichselgarten 26<br>D-91058 Erlangen /Germany<br>e-mail: headquarters@can-cia.de<br>http://www.can-cia.de | | |
| **DIN-EN Standards** | Beuth Verlag GmbH<br>10772 Berlin | or | VDE-Verlag GmbH<br>10625 Berlin |
| **IEC Standards** | VDE Verlag GmbH<br>10625 Berlin | or | Internet search<br>http://www.iec.ch/ |

### 3.5.2. Standards/Bibliography

| | |
|---|---|
| **IEC61131-1/EN61131-1** | Programmable controllers Part 1: General information |
| **IEC61131-2/EN61131-2** | Programmable controllers Part 2: Equipment requirements and tests |
| **IEC61131-3/EN61131-3** | Programmable controllers Part 3: Programming languages |
| **IEC61131-4/EN61131Bl1** | Programmable logic controllers<br>Supplementary Sheet 1: User guidelines |
| **EN 50081 Parts 1+2** | German EMC Act: Emitted interference |
| **EN 50082 Parts 1+2** | German EMC Act: Noise immunity |
| **ISO/DIS 11898** | Draft International Standard: Road vehicles - Interchange of digital information - **C**ontroller **A**rea **N**etwork (CAN) for high-speed communication |
| **EN 954-1** | Safety of machinery: Safety-related parts of control systems (Part 1) |
| **Bibliography** | A variety of specialist publications on the CANbus is available from specialist bookshops, or can be obtained through the CiA users' organisation. |

**Note:**
Our Technical Support team will be glad to provide other literature references on request.



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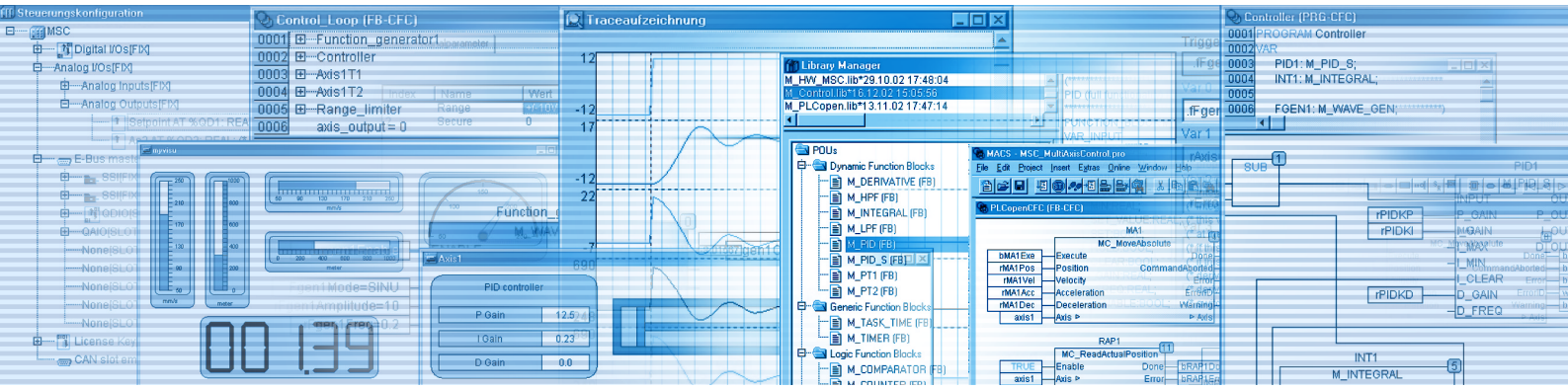


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