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b maXX Systems

I/O-Terminals for b maXX controller PLC Application Manual

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Title	Application Manual
Product	**I/O-Terminals for b maXX controller PLC** (BMC-M-xxyyyy)
Last Revision:	July 19, 2007
Art.-no.	377574
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1

INTRODUCTION

This Application Manual is an important component of your b maXX system; this means that you must thoroughly read this document, not least to ensure your own safety.

In this chapter, we will describe the first steps that you should carry out after getting this unit. We will define terms that are used in this documentation on a consistent basis and will inform you about the responsibilities you must consider when using this system.

1.1 First Steps

The Bus Terminal System

Currently, the input/output signals are wired locally at fieldbus devices and centrally at programmable control devices. The manufacturer-specific fieldbus devices with fixed input/output configuration and design that are currently available often make it necessary to install an entire group of devices with similar functionality.

This costly method of signal acquisition gives rise to high material, installation, planning and documentation costs as well as high costs for subsequent modification or expansion. Inventory management and service staff are put under unnecessary strain.

Flexible and stable

The Baumüller Bus Terminal is an open and fieldbus-neutral periphery concept consisting of electronic terminal blocks. The head of an electronic terminal block is the Bus Coupler with the interface to the fieldbus.

1.2 Terms Used

In this documentation, we will also refer to Baumüller's "**I/O-Terminals for b maXX controller PLC**" product as „bus terminals", or "plug-in module".

For a list of the abbreviations that are used, refer to ▷Appendix A Abbreviations◁ from page 207 onward.

1.2 Terms Used

2

Basic Safety Instructions

We have designed and manufactured each Baumüller module in accordance with the strictest safety regulations. Despite this, working with the module can be dangerous for you.

In this chapter, we will describe the risks that can occur when working with a Baumüller module. Risks are illustrated by icons. All the symbols that are used in this documentation are listed and explained.

In this chapter, we cannot explain how you can protect yourself from specific risks in individual cases. This chapter contains only general protective measures. We will go into concrete protective measures in subsequent chapters directly after information about the individual risk.

2.1 Hazard information and instructions

Hazard information will show you the dangers, that can lead to injuries or even to death.

Always follow the hazard information given in this document.

Hazards are always divided into three danger classifications. Each danger classification is identified by one of the following words:

DANGER

- Considerable damage to property
- Serious personal injury
- Death **will** occur

WARNING

- Considerable damage to property
- Serious personal injury
- Death **can** occur

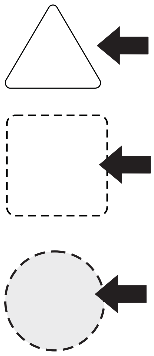
CAUTION

- Damage to property
- Slight to medium personal injury **can** occur

2.1 Hazard information and instructions

2.1.1 Structure of hazard information

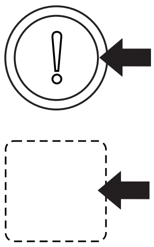
The following two examples show how hazard information is structured in principle. A triangle is used to warn you about danger to living things. If there is no triangle, the hazard information refers exclusively to damage to property.



A triangle indicates that there is danger to living things.
The color of the border shows how severe the hazard is: the darker the color, the more severe the hazard is.

The icon in the rectangle represents the hazard.
The color of the border shows how severe the hazard is: the darker the color, the more severe the hazard is.

The icon in the circle represents an instruction. Users must follow this instruction.
(The circle is shown dashed, since an instruction is not available as an icon for each hazard advisory).



The circle shows that there is a risk of damage to property.

The icon in the rectangle represents the hazard.
The color of the border shows how severe the hazard is: the darker the color, the more severe the hazard is. (The rectangle is shown dashed, since the danger is not represented as an icon with every hazard advisory)

The text next to the icons is structured as follows:

THE SIGNAL WORD IS HERE THAT SHOWS THE DEGREE OF RISK

Here we indicate whether one or more of the results below occurs if you do not observe this warning.

- Here, we describe the possible results. The worst result is always at the extreme right.

Here, we describe the hazard.

Here, we describe what you can do to avoid the hazard.

2.1.2 Hazard advisories that are used

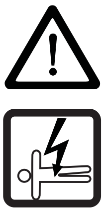
If a signal word is preceded by one of the following danger signs: ⚠ or ⚠ or ⚠, the safety information refers to injury to people.

If a signal word is preceded by a round danger sign: ⓘ, the safety information refers to damage to property.

2.1.2.1 Hazard advisories about injuries to people

To be able to differentiate visually, we use a separate border for each class of hazard information with the triangular and rectangular pictograms.

For danger classification **DANGER,** we use the ⚠ danger sign. The following hazard information of this danger classification is used in this documentation.



DANGER

The following **will occur**, if you do not observe this danger information:

- serious personal injury
- death

*Danger from: **electricity.** The hazard may be described in more detail here.*

Here, we describe what you can do to avoid the hazard.

DANGER

The following **will occur**, if you do not observe this danger information:

- serious personal injury
- death

*Danger from: **mechanical effects.** The hazard may be described in more detail here.*

Here, we describe what you can do to avoid the hazard.

For danger classification **WARNING,** we use the ⚠ danger sign. The following hazard information of this danger classification is used in this documentation.

WARNING

The following **may occur**, if you do not observe this warning information:

- serious personal injury
- death

*Danger from: **electricity.**The hazard may be described in more detail here.*

Here, we describe what you can do to avoid the hazard.

For danger classification **CAUTION,** we use the ⚠ danger sign. The following hazard information of this danger classification is used in this documentation.

CAUTION

The following **may occur**, if you do not observe this caution information:

- minor to medium personal injury.

Danger from: ***sharp edges.*** *The hazard may be described in more detail here.*

Here, we describe what you can do to avoid the hazard.

CAUTION

The following **may occur**, if you do not observe this danger information:

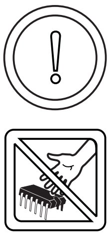
- environmental pollution.

Danger from: ***incorrect disposal.*** *The hazard may be described in more detail here.*

Here, we describe what you can do to avoid the hazard.

2.1.2.2 Hazard advisories about damage to property

If a signal word is preceded by a round danger sign: (!), the safety information refers to damage to property.



CAUTION

The following **may occur**, if you do not observe this caution information:

- property damage.

Danger from: ***electrostatic discharge.*** *The hazard may be described in more detail here.*

Here, we describe what you can do to avoid the hazard.

2.1.2.3 Instruction signs that are used

wear safety gloves

wear safety shoes

2.2 Information signs

NOTE

This indicates particularly important information.

2.3 Legal information

This documentation is intended for technically qualified personnel that has been specially trained and is completely familiar with all warnings and maintenance measures.

The equipment is manufactured to the state of the art and is safe in operation. It can be put into operation and function without problems if you ensure that the information in the documentation is complied with.

Operators are responsible for carrying out servicing and commissioning in accordance with the safety regulations, applicable standards and any and all other relevant national or local regulations with regard to cable rating and protection, grounding, isolators, overcurrent protection, etc.

Operators are legally responsible for any damage that occurs during assembly or connection.

2.4 Appropriate Use

You must always use the module appropriately. Some important information is listed below. The information below should give you an idea of what is meant by appropriate use of the module. The information below has no claim to being complete; always observe all the information that is given in these operating instructions.

- You must only add on the module to a power supply unit for b maXX controller PLC.
- Configure the application such that the module is always operating within its specifications.
- Ensure that only qualified personnel works with this module.
- Mount the module only on a power supply unit for b maXX controller PLC.
- Install the module as specified in this documentation.
- Ensure that connections always comply with the stipulated specifications.
- Operate the module only when it is in technically perfect condition.
- Always operate the module in an environment that is specified in the technical data.
- Always operate the module in a standard condition.
  For safety reasons, you must not make any changes to the module.
- Observe all the information on this topic if you intend to store the module.

You will be using the module in an appropriate way if you observe all the comments and information in these operating instructions.

2.5 Inappropriate Use

Below, we will list some examples of inappropriate use. The information below should give you an idea of what is meant by inappropriate use of the module. We cannot, however, list all possible cases of inappropriate use here. Any and all applications in which you ignore the information in this documentation are inappropriate; particularly, in the following cases:

- You added the module on an other unit/module as the power supply unit for b maXX controller PLC.
- You ignored information in these operating instructions.
- You did not use the module as intended.
- You handled the module as follows
  - you mounted it incorrectly,
  - you connected it incorrectly,
  - you commissioned it incorrectly,
  - you operated it incorrectly,
  - you allowed non-qualified or insufficiently qualified personnel to mount the module, commission it and operate it,
  - you overloaded it,
  - You operated the module
    - with defective safety devices,
    - with incorrectly mounted guards or without guards at all,
    - with non-functional safety devices and guards
    - outside the specified environmental operating conditions
- You modified the module without written permission from Baumüller Nürnberg GmbH.
- You ignored the maintenance instructions in the component descriptions.
- You incorrectly combined the module with third-party products.
- You combined the b maXX system with faulty and/or incorrectly documented third-party products.
- Your self-written PLC software contains programming errors that lead to a malfunction.

Version 1.1 of Baumüller Nürnberg GmbH's General Conditions of Sale and Conditions of Delivery dated 2/15/02 or the respective latest version applies in all cases. These will have been available to you since the conclusion of the contract at the latest.

2.6 Protective equipment

In transit, the modules are protected by their packaging. Do not remove the module from its packaging until just before you intend to mount it.

The housing of the module provides IP20 protection to the modules from dirt and damage due to static discharges from contact. This means that you never use a module with damaged housing.

2.7 Personnel training

WARNING

The following **may occur**, if you do not observe this warning information:

- serious personal injury
- death

Only qualified personnel are allowed to mount, install, operate and maintain equipment made by Baumüller Baumüller Nürnberg GmbH.

Qualified personnel (specialists) are defined as follows:

Qualified Personnel

Electrical engineers and electricians of the customer or of third parties who are authorized by Baumüller Nürnberg GmbH and who have been trained in installing and commissioning Baumüller b maXX systems and who are authorized to commission, ground and mark circuits and equipment in accordance with recognized safety standards.

Qualified personnel has been trained or instructed in accordance with recognized safety standards in the care and use of appropriate safety equipment.

Requirements of the operating staff

The b maXX system may only be operated by persons who have been trained and are authorized.

Only trained personnel are allowed to eliminate disturbances, carry out preventive maintenance, cleaning, maintenance and to replace parts. These persons must be familiar with the Operating Instructions and act in accordance with them.

Commissioning and instruction must only be carried out by qualified personnel.

2.8 Safety measures in normal operation

- At the b maXX systems' place of installation, observe the applicable safety regulations for the plant in which this unit is installed.
- Provide the b maXX system with additional monitoring and protective equipment if the safety regulations demand this.
- Observe the safety measures for the unit in which the module is installed.

2.9 Responsibility and liability

To be able to work with this module in accordance with the safety requirements, you must be familiar with and observe the hazard information and safety instructions in this documentation.

2.9.1 Observing the hazard information and safety instructions

In these operating instructions, we use visually consistent safety instructions that are intended to prevent injury to people or damage to property.

WARNING

The following **may occur**, if you do not observe this warning information:

- serious personal injury
- death

Any and all persons who work on and with Series b maXX units must always have available these Operating Instructions and must observe the instructions and information they contain – this applies in particular to the safety instructions.

Apart from this, any and all persons who work on this unit must be familiar with and observe all the rules and regulations that apply at the place of use.

2.9.2 Danger arising from using this module

The b maXX controller PLC has been developed and manufactured to the state of the art and complies with applicable guidelines and standards. It is still possible that hazards can arise during use. For an overview of possible hazards, refer to the chapter entitled ▷Basic Safety Instructions◁ from page 11 onward.
We will also warn you of acute hazards at the appropriate locations in this documentation.

2.9.3 Warranty and Liability

All the information in this documentation is non-binding customer information; it is subject to ongoing further development and is updated on a continuous basis by our permanent change management system.

Warranty and liability claims against Baumüller Nürnberg GmbH are excluded; this applies in particular if one or more of the causes listed in ▷Inappropriate Use◁ from page 16 onward or below caused the fault:

- Disaster due to the influence of foreign bodies or force majeure.

3

DESCRIPTION OF THE TERMINALS

In this chapter, we will describe the terminals and explain the type code on the I/O terminals.

3.1 General

The device line of the terminals consists of the following types:

- DI2000 2-channel digital input terminal
- DI4000 4-channel digital input terminal
- DI8000 8-channel digital input terminal
- DO2000 2-channel digital output terminal
- DO4000 4-channel digital output terminal
- DO8000 8-channel digital output terminal
- AI1010 1-channel analog input terminal 0 ... 10 V
- AI2010 2-channel analog input terminal 0 ... 10 V
- AI4010 4-channel analog input terminal 0 ... 10 V
- AI2±10 2-channel analog input terminal -10 V ... +10 V
- AI4±10 4-channel analog input terminal -10 V ... +10 V
- AI2420 2-channel loop-powered input terminal 4 - 20 mA
- AI4420 4-channel analog input terminal 4 - 20 mA
- AO2010 2-channel analog output terminal 0...10 V
- AO4010 4-channel analog output terminal 0...10 V
- AO2±10 2-channel analog output terminal -10 V ... +10 V
- AO4±10 4-channel analog output terminal -10 V ... +10 V
- AO2420 2-channel analog output terminal 4 - 20 mA
- AO4420 4-channel analog output terminal 4 - 20 mA
- EK0000 Bus end terminal
- ES0000 Feed terminal 24 V DC
- KVE000 Terminal bus extension, end terminal
- KVK000 Terminal bus extension, coupler terminal
- ZK0000 Incremental encoder interface

3.2 Short description and top view

3.2.1 DI2000 2-channel digital input terminal

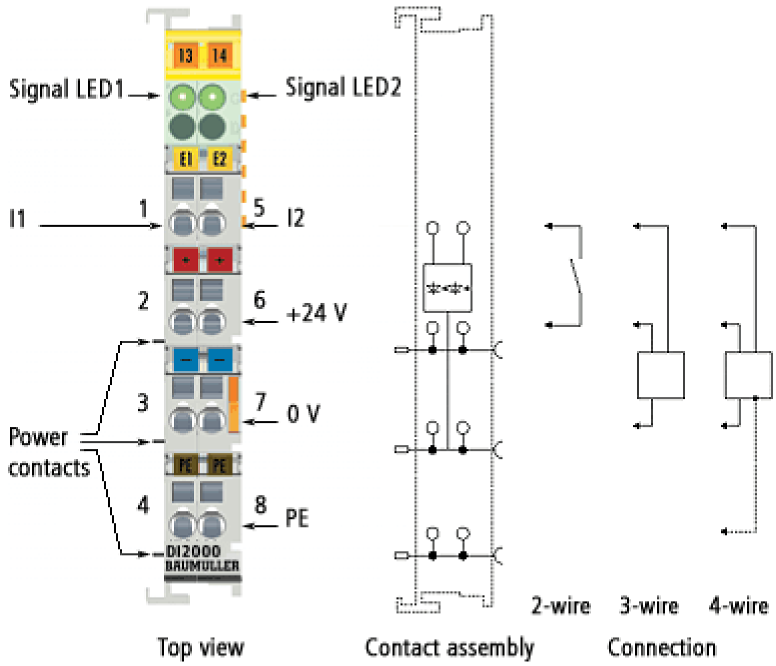


Figure 1: Top view terminal DI2000

The DI2000 digital input terminal acquires the binary control signals from the process level and transmits them, in an electrically isolated form, to the higher-level automation unit. The DI2000 version has input filters of different speeds. The Bus Terminal contains two channels that indicate their signal state by means of light emitting diodes.

3.2.2 DI4000 4-channel digital input terminal

The DI4000 digital input terminal acquires the binary control signals from the process level and transmits them, in an electrically isolated form, to the higher-level automation unit. The Bus Terminals contain four channels that indicate their signal state by means of light emitting diodes. The DI4000 is particularly useful for space-saving use in control cabinets.

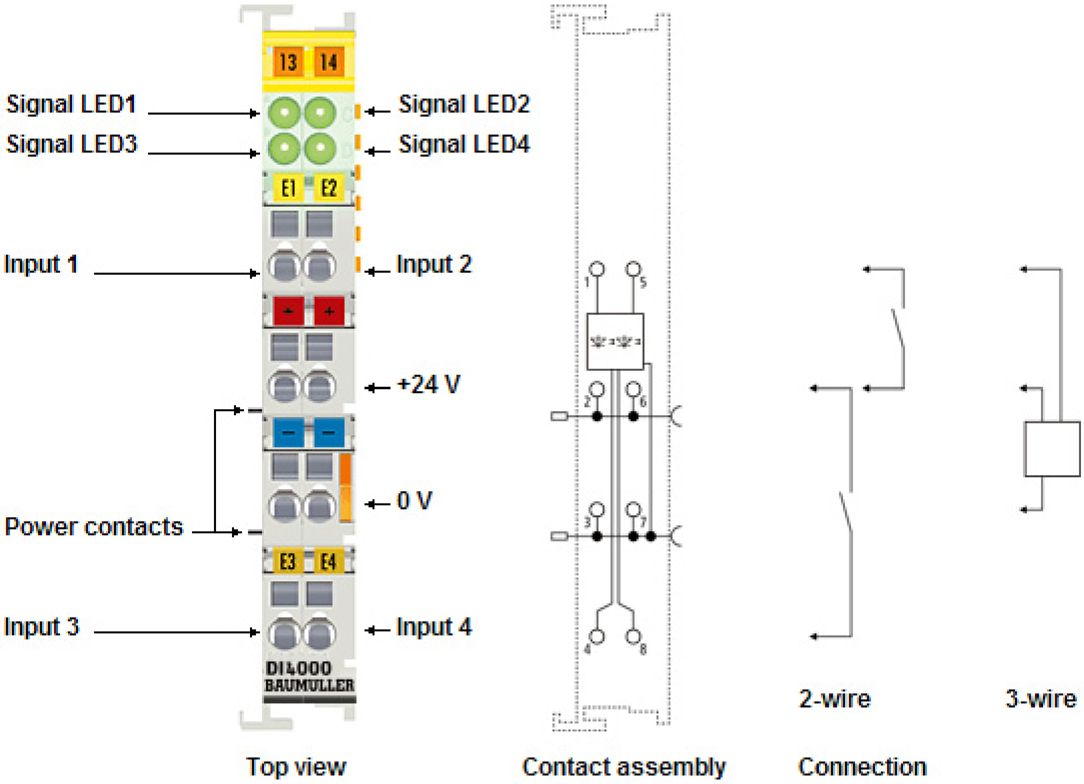


Figure2: Top view terminal DI4000

3.2.3 DI8000 8-channel digital input terminal

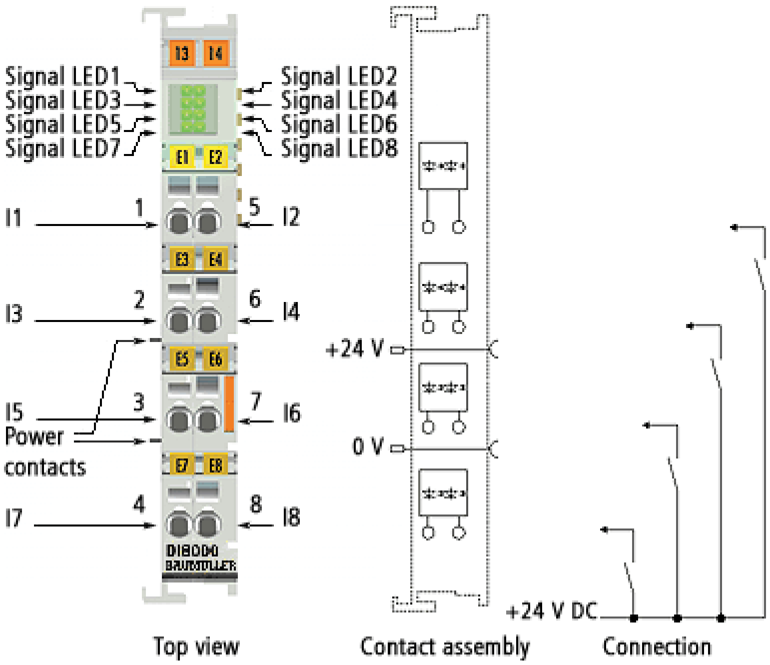


Figure 3: Top view terminal DI8000

The DI8000 digital input terminal acquires the binary control signals from the process level and transmits them, in an electrically isolated form, to the higher-level automation unit. The Bus Terminal contains eight channels which indicate their signal state by means of light emitting diodes. The terminal is particularly suitable for space-saving use in the control cabinets. By using the single-ended connection technique a multi-channel sensor can be connected in the smallest space with a minimum amount of wiring. The power contacts are looped through. The reference ground for all inputs is the 0 V power contact.

3.2.4 DO2000 2-channel digital output terminal

The DO2000 digital output terminal connects the binary control signals from the automation unit on to the actuators at the process level with electrical isolation. The DO2000 handles different load currents, and their output is protected against overload and short circuit. The Bus Terminal contains two channels that indicate their signal state by means of light emitting diodes.

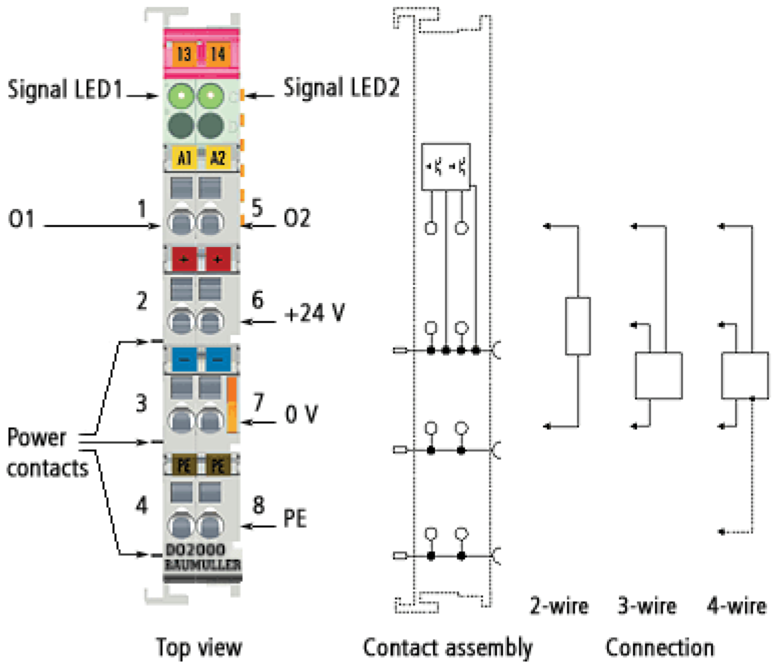


Figure 4: Top view terminal DO2000

3.2.5 DO4000 and DO4002 4-channel digital output terminal

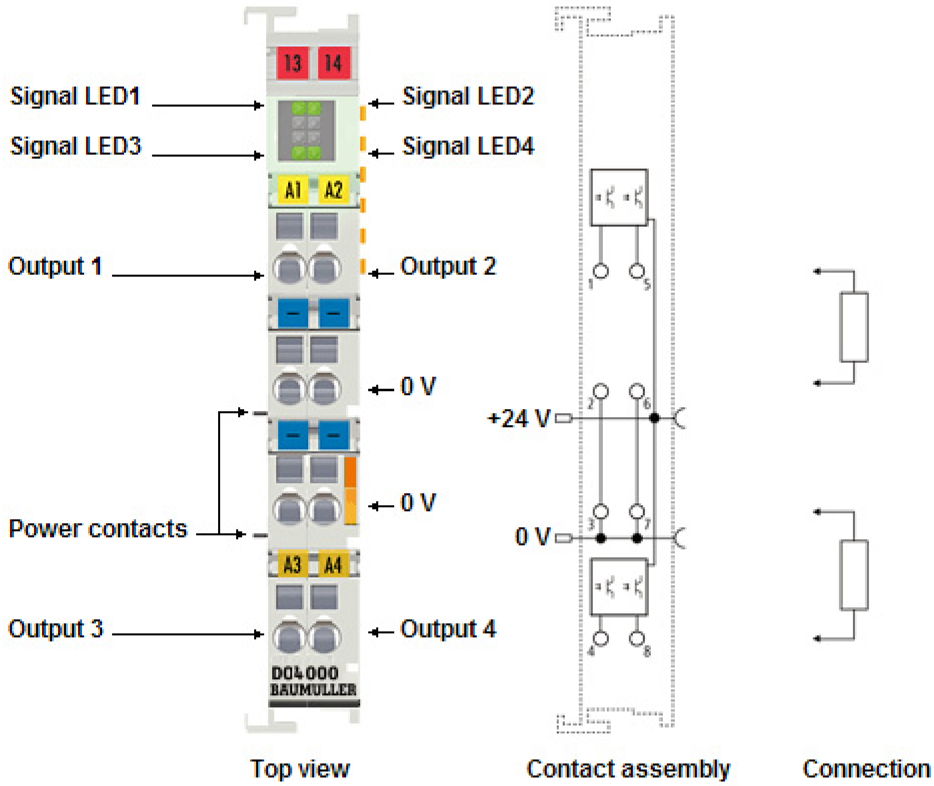


Figure 5: Top view terminal DO4000

The DO4000 digital output terminal connects the binary 24 V control signals electrically isolated with the actuators. The Bus Terminals contain four channels that indicate their signal state by means of LEDs. The 4-channel Bus Terminals enable the direct connection of four 2-wire sensors. Four ground connection points are provided.

3.2 Short description and top view

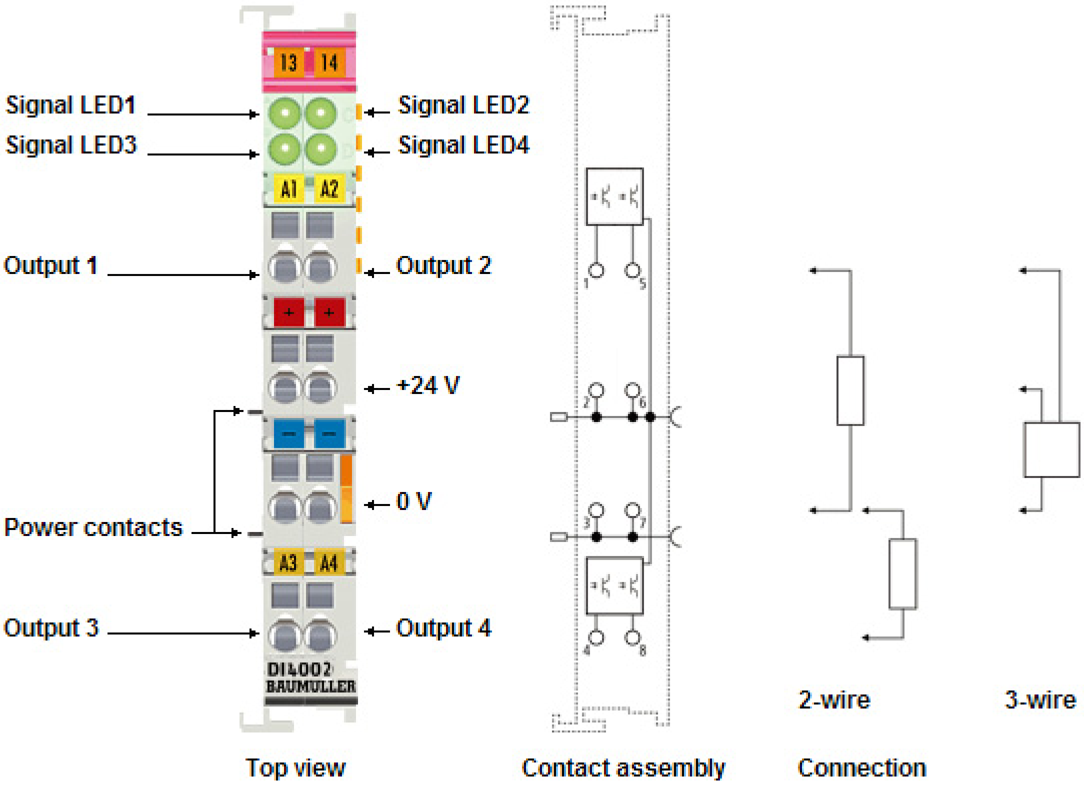


Figure6: Top view terminal DO4002

The DO4002 digital output terminal connects the binary control signals from the automation unit on to the actuators at the process level with electrical isolation. The load current output of the DO4002 version is protected against overload and short circuit. The Bus Terminal contains four channels that indicate their signal state by means of light emitting diodes.

3.2.6 DO8000 8-channel digital output terminal

The DO8000 digital output terminal connects the binary control signals from the automation unit on to the actuators at the process level with electrical isolation. The outputs of the DO8000 are protected against overload and short circuit. The DO8000 Bus Terminal is protected against reverse polarity connection. The Bus Terminal contains eight channels which indicate their signal state by means of light emitting diodes. The DO8000 is particularly suitable for space-saving use in the control cabinets. The connection technology is particularly suitable for single-ended inputs. It is a prerequisite that all components operate with the same reference ground as the DO8000. The power contacts are looped through. The 24 V power contact feeds the outputs.

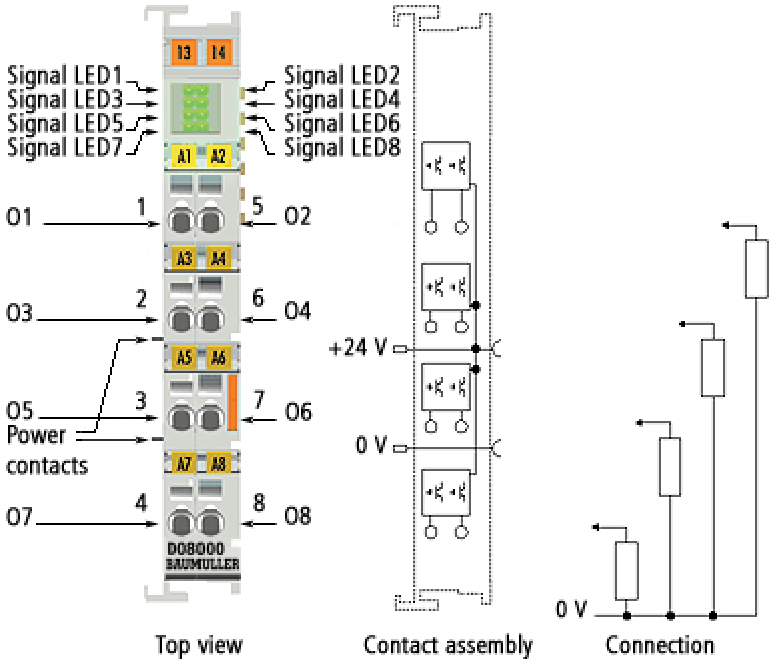


Figure 7: Top view terminal DO8000

3.2.7 AI1010 1-channel analog input terminal 0 ... 10 V

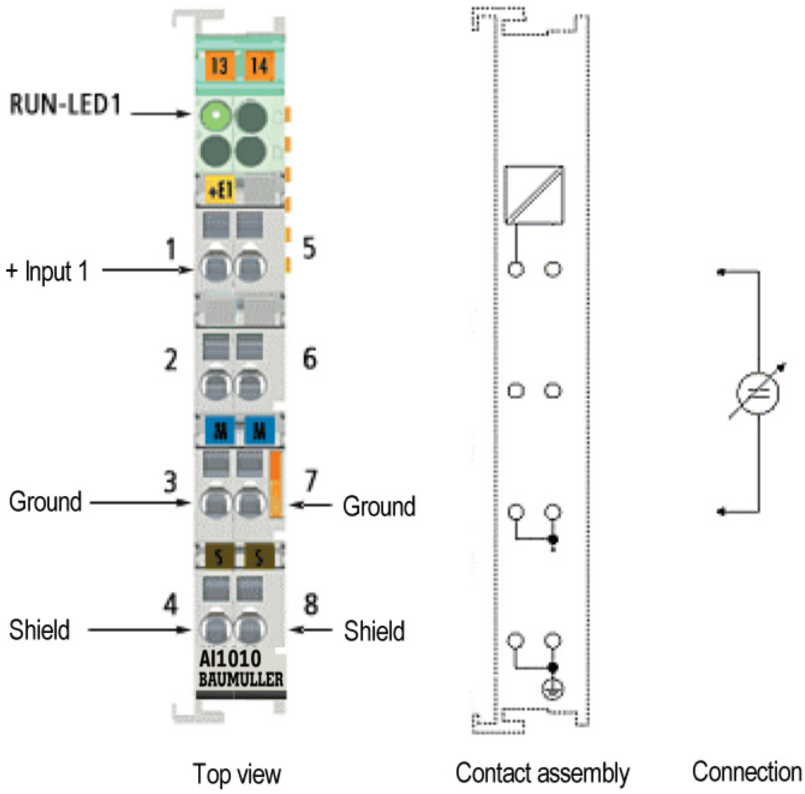


Figure 8: Top view terminal AI1010

The AI1010 analog input terminal handles signals in the range from 0 V to 10 V. The voltage is digitised to a resolution of 12 bits, and is transmitted, electrically isolated, to the higher-level automation device. The input channels of a Bus Terminal have a common ground potential, the reference ground. The AI1010 is the single-channel variant and is characterised by its fine granularity and electrical isolation. The run LED gives an indication of the data exchange with the Bus Coupler.

3.2.8 AI2010 2-channel analog input terminal 0 ... 10 V

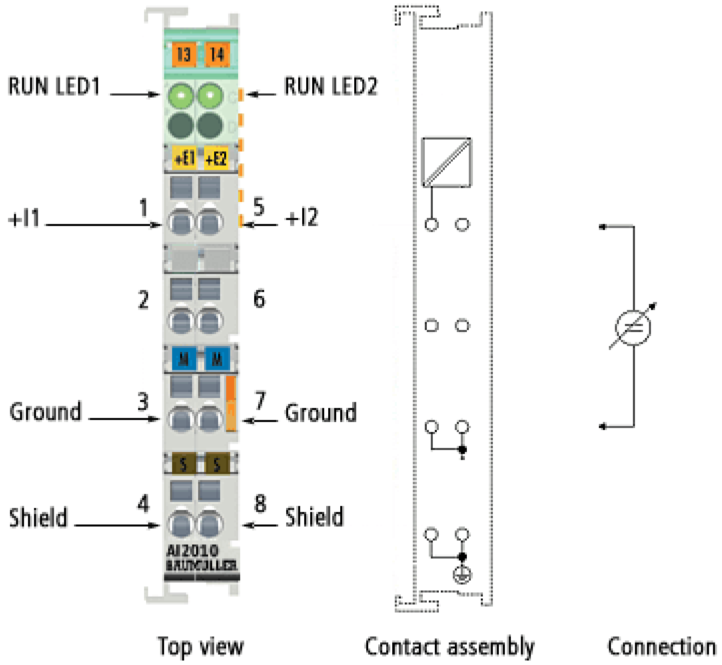


Figure 9: Top view terminal AI2010

The AI2010 analog input terminal handles signals in the range from 0 V to 10 V. The voltage is digitised to a resolution of 12 bits, and is transmitted, electrically isolated, to the higher-level automation device. The input channels of a Bus Terminal have a common ground potential, the reference ground. The AI2010 version combines 2 channels in one housing. The RUN LEDs give an indication of the data exchange with the Bus Coupler.

3.2.9 AI4010 4-channel analog input terminal 0 ... 10 V

The AI4010 analog input terminal handles signals in the range from 0 V to 10 V. The voltage is digitised to a resolution of 12 bits, and is transmitted, electrically isolated, to the higher-level automation device. The input channels of a Bus Terminal have a common ground potential. The AI4010 version combines 4 channels in one housing. The RUN LEDs give an indication of the data exchange with the Bus Coupler.

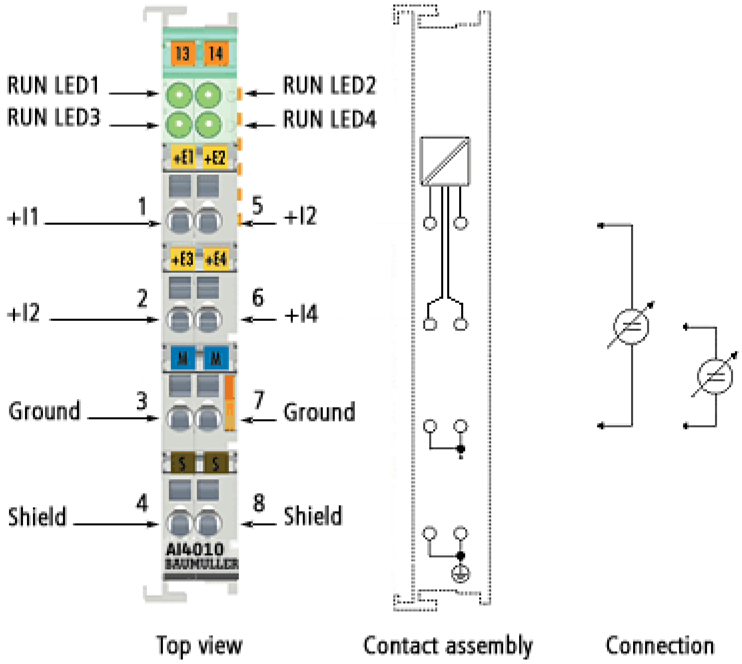


Figure 10: Top view terminal AI4010

3.2.10 AI2±10 2-channel analog input terminal -10 V ... +10 V

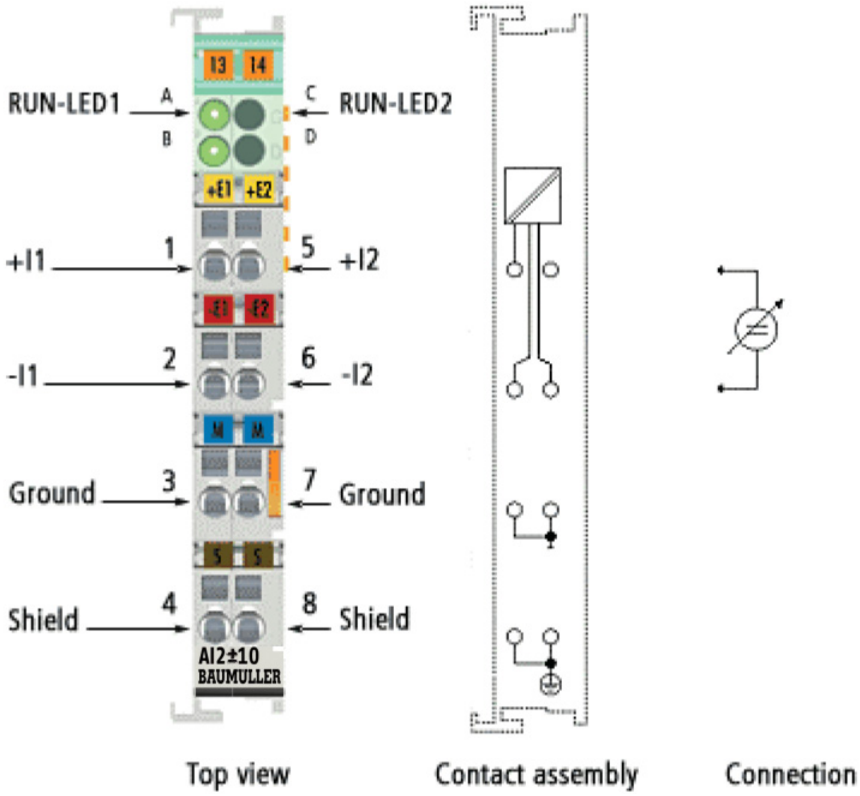


Figure 11: Top view terminal AI2±10

The AI2±10 analog input terminal handles signals in the range from -10 V to +10 V. The voltage is digitised to a resolution of 12 bits, and is transmitted, electrically isolated, to the higher-level automation device. The input channels of the Bus Terminal have differential inputs and possess a common, internal ground potential. The AI2±10 version combines two channels in one housing. The light emitting diodes give an indication of the data exchange with the Bus Coupler.

3.2.11 AI4±10 4-channel analog input terminal -10 V ... +10 V

The analog input terminal AI4±10 processes signals in the range between -10 V and +10 V. The voltage is digitised to a resolution of 12 bits, and is transmitted, electrically isolated, to the higher-level automation device. In the AI4±10 Bus Terminal, the four inputs are 2-wire versions and have a common ground potential. The reference ground of the inputs is the internal ground. The LEDs indicate the data exchange with the Bus Coupler.

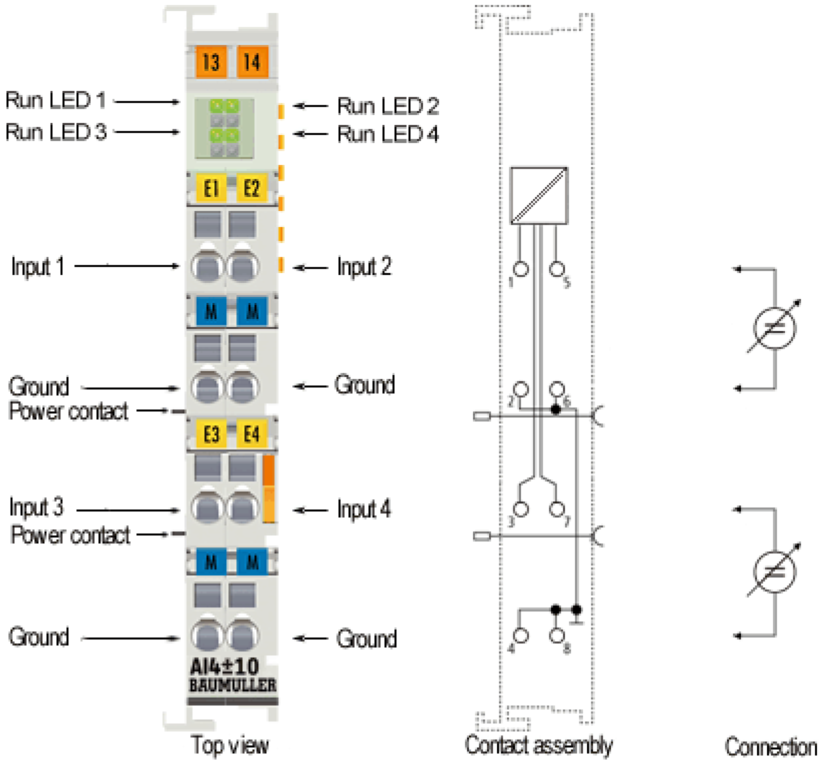


Figure 12: Top view terminal AI4±10

3.2.12 AI2420 2-channel loop-powered input terminal 4 - 20 mA

The job of the AI2420 analog input terminal is to supply power to measuring transducers located in the field, and to transmit analog measurement signals with electrical isolation to the automation device. The voltage for the sensors is supplied to the terminals via the power contacts. The power contacts can optionally be supplied with operating voltage in the standard way or via a power feed terminal (EK0000 or ES0000) with electrical isolation. The input electronics is independent of the supply voltage of the power contacts. The "0 V rail" is the reference potential for the inputs. The RUN LEDs give an indication of the data exchange with the Bus Coupler. The error LEDs indicate an overload condition and a broken wire.

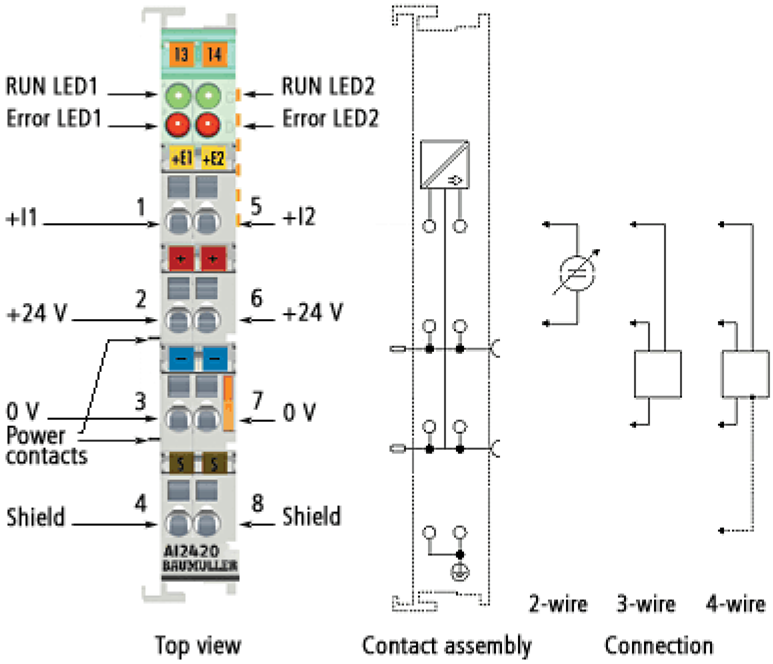


Figure 13: Top view terminal AI2420

3.2.13 AI4420 4-channel analog input terminal 4 - 20 mA

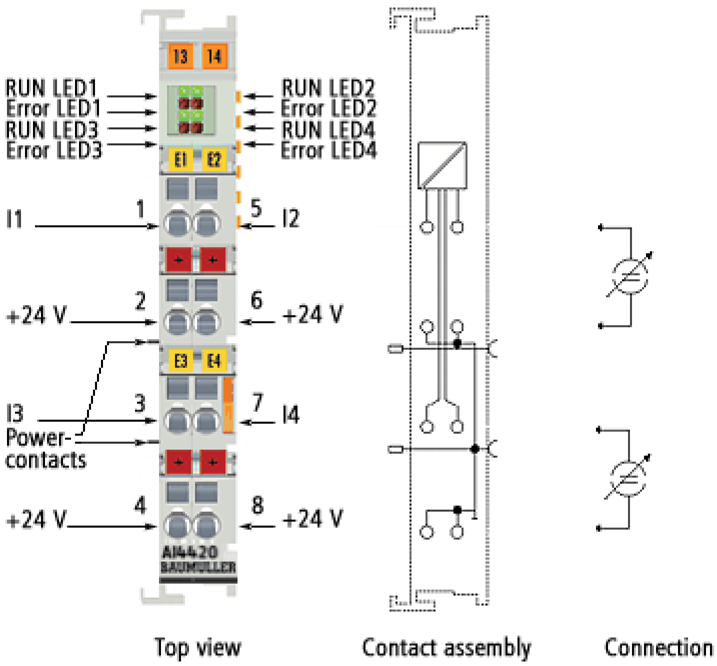


Figure 14: Top view terminal AI4420

The AI4420 analog input terminal process signals in the range between 4 and 20 mA. The current is digitised to a resolution of 12 bits, and is transmitted, in an electrically isolated form, to the higher-level automation device. In the AI4420 Bus Terminal, the four inputs are 2-wire versions and have a common ground potential. The 24 V power contact is connected to the terminals, in order to enable the connection of 2-wire sensors without external supply. The power contacts are connected through. The reference ground for all inputs is the 0 V power contact. Overload is detected in all three variants, and the terminal status is relayed to the controller via the I/O-bus. The LEDs indicate the data exchange with the Bus Coupler, as well as overload or wire breakage.

3.2.14 AO2010 2-channel analog output terminal 0...10 V

The AO2010 analog output terminal generates signals in the range from 0 V and 10 V. The voltage is supplied to the process level with a resolution of 12 bits, and is electrically isolated. The output channels of a Bus Terminal have a common ground potential. The RUN LEDs give an indication of the data exchange with the Bus Coupler.

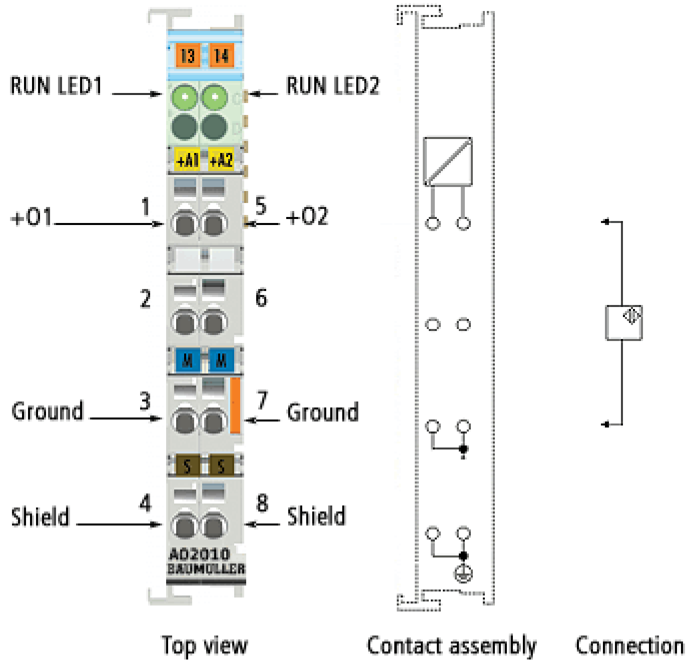


Figure 15: Top view terminal AO2010

3.2.15 AO4010 4-channel analog output terminal 0...10 V

The AO4010 analog output terminal generates signals in the range between 0 V to 10 V. The voltage is supplied to the process level with a resolution of 12 bits, and is electrically isolated. In the AO4010 Bus Terminal, the four outputs are 2-wire versions. The Bus Terminal has a common ground potential. The power contacts are connected through. The reference ground of the outputs is the 0 V power contact. The LEDs indicate the data exchange with the Bus Coupler.

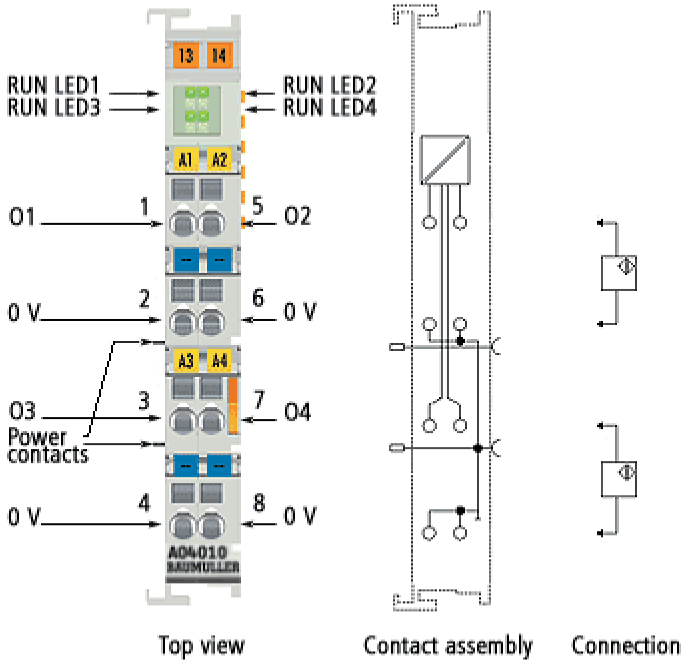


Figure 16: Top view terminal AO4010

3.2.16 AO2±10 2-channel analog output terminal -10 V ... +10 V

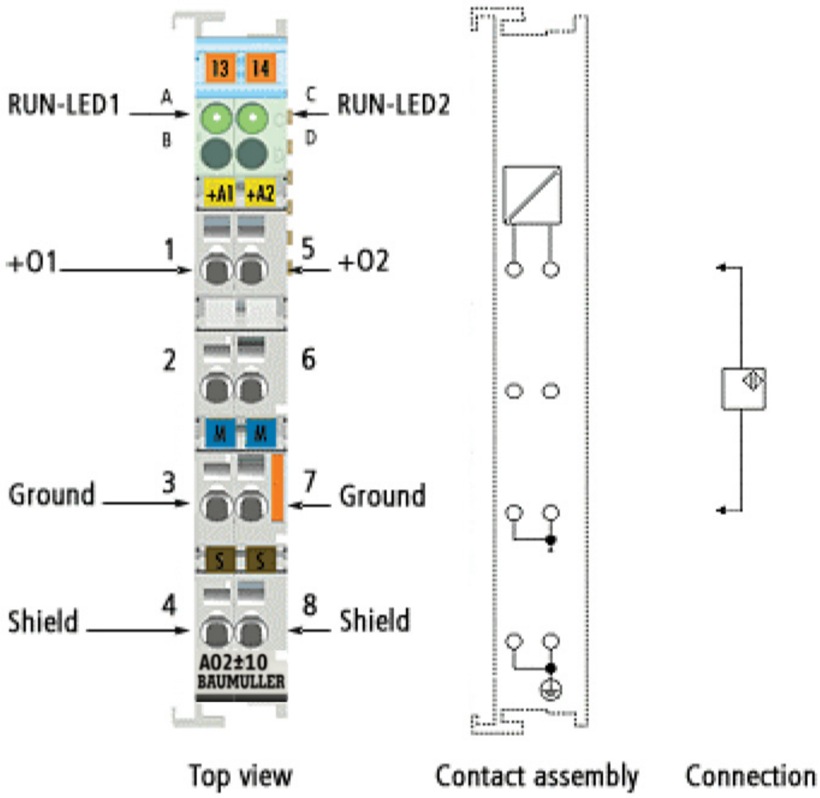


Figure 17: Top view terminal AO2±10

The AO2±10 analog output terminal generates signals in the range from -10 V and +10 V. The voltage is supplied to the process level with a resolution of 12 bits, and is electrically isolated. The output channels of a Bus Terminal have a common ground potential. The AO2±10 version combines 2 channels in one housing. The run LEDs give an indication of the data exchange with the Bus Coupler.

3.2.17 AO4±10 4-channel analog output terminal -10 V ... +10 V

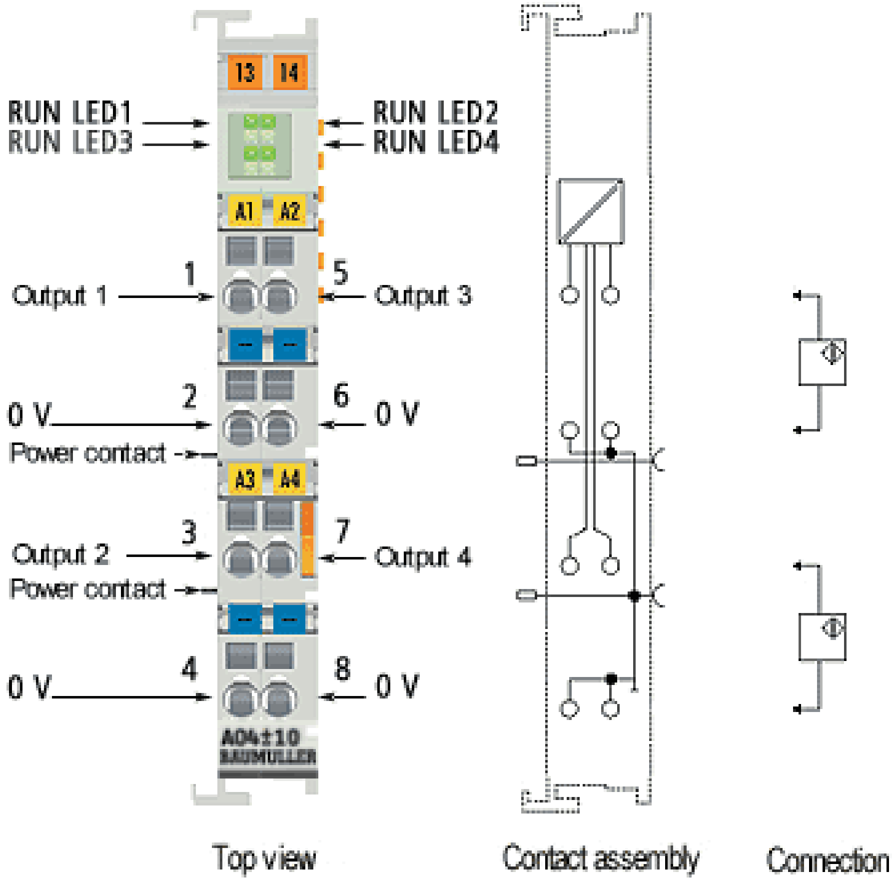


Figure 18: Top view terminal AO4±10

The AO4±10 analog output terminal generates signals in the range between -10 V to +10 V. The voltage is supplied to the process level with a resolution of 12 bits, and is electrically isolated. In the AO4±10 Bus Terminal, the four outputs are 2-wire versions. The Bus Terminals have a common ground potential. The power contacts are connected through. The reference ground of the outputs is the 0 V power contact. The LEDs indicate the data exchange with the Bus Coupler.

3.2.18 AO2420 2-channel analog output terminal 4 - 20 mA

The AO2420 analog output terminal generates analog output signals in the range from 4 to 20 mA. The power is supplied to the process level with a resolution of 12 bits, and is electrically isolated. Ground potential for the output channels of a Bus Terminal is common with the 24 V DC supply. The output stages are powered by the 24 V supply. The

AO2420 version combines 2 channels in one housing. The RUN LEDs give an indication of the data exchange with the Bus Coupler.

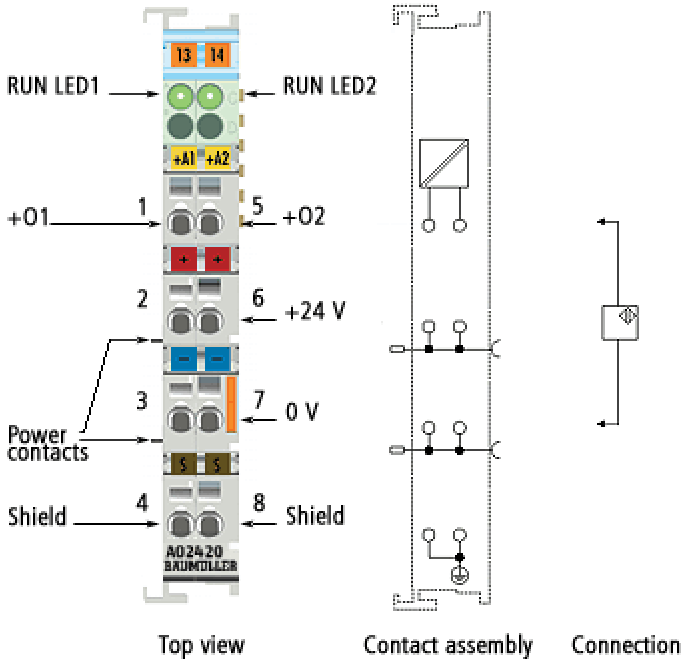


Figure 19: Top view terminal AO2420

3.2.19 AO4420 4-channel analog output terminal 4 - 20 mA

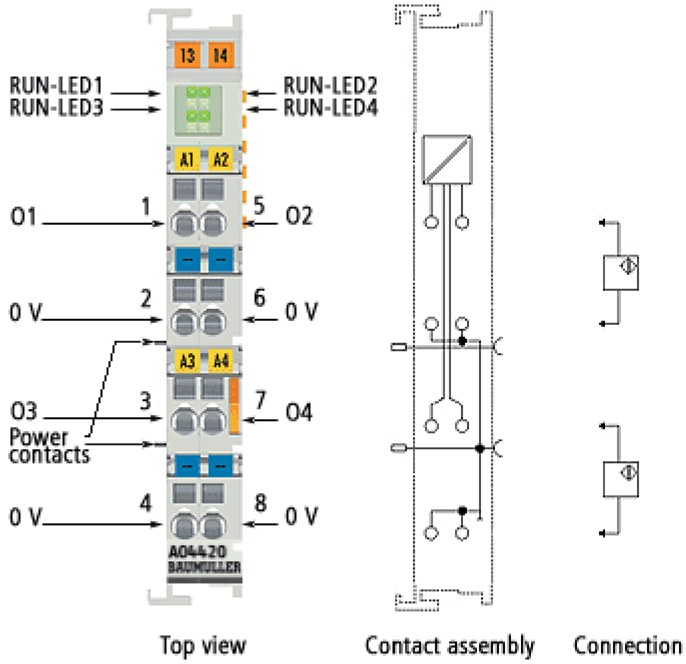


Figure 20: Top view terminal AO4420

The AO4420 analog output terminal generates signals in the range 4 ... 20 mA. The power is supplied to the process level with a resolution of 12 bits, and is electrically isolated. The output stage is powered by the 24 V supply. In the AO4420 Bus Terminal, the four outputs are 2-wire versions. The Bus Terminals have a common ground potential.

The power contacts are connected through. The reference ground of the outputs is the 0 V power contact. The LEDs indicate the data exchange with the Bus Coupler.

3.2.20 EK0000 bus end terminal

The EK0000 bus end terminals are necessary for data exchange between the Bus Coupler and the Bus Terminals. Each assembly must be terminated at the right hand end with a EK0000 bus end terminal. The bus end terminal does not have any other function or connection facility.

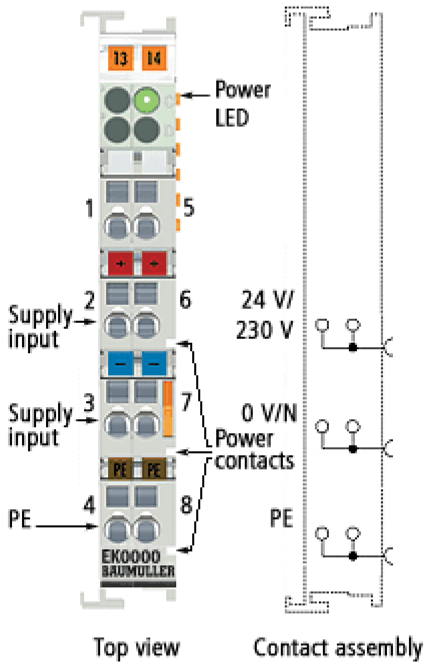


Figure 21: Top view terminal EK0000

3.2.21 ES0000 feed terminal 24 V DC

The feed terminal can be inserted anywhere between the input and output terminals in order to construct a further potential group, or in order to supply the terminals that follow to the right with additional current. The feed terminal can be used for standard voltage of 24 V DC.

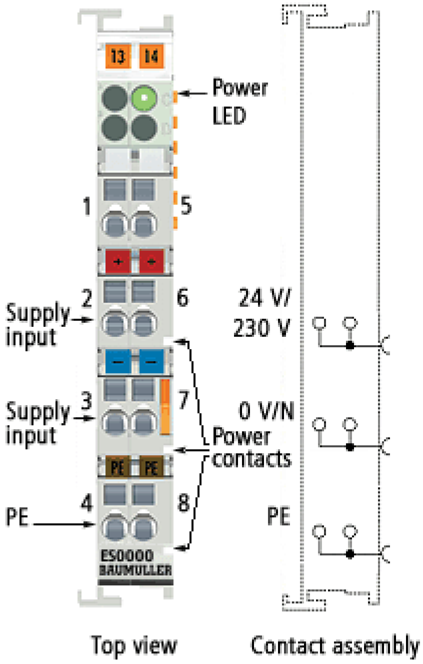


Figure 22: Top view terminal ES0000

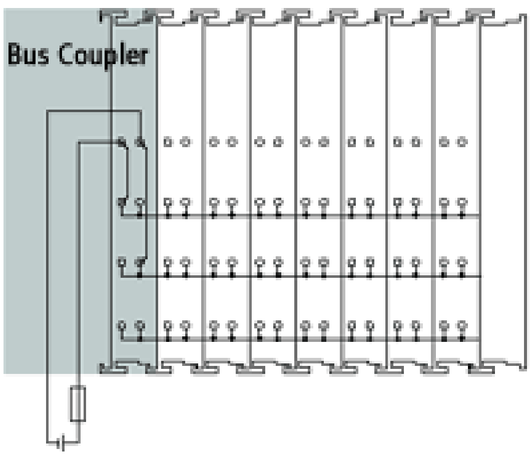


Figure 23: Infeed via Bus Coupler only, one potential group

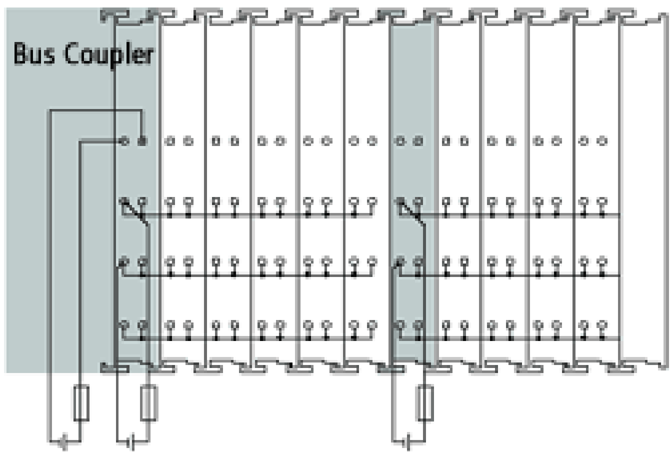


Figure 24: Infeed via Bus Coupler and incoming feeder terminal, three potential groups

3.2.22 KVE000 Terminal bus extension, end terminal

The KVE000 is attached to the end of the Bus Terminal block in the same way as the standard terminal EK0000. The block is terminated with the KVE000 and enables you to connect an Ethernet cable with a RJ45 plug. The I/O-bus signals are converted to RS485 in the KVE000.

Power to the KVE000 electronics is supplied via the I/O-bus. The KVE000 forms a properly working unit together with at least one KVK000. Apart from a supply voltage of 24 V and the insertion of the Ethernet cable, there is no further parameterisation or configuration work necessary. The Bus Coupler carries out all diagnosis and commissioning tasks.

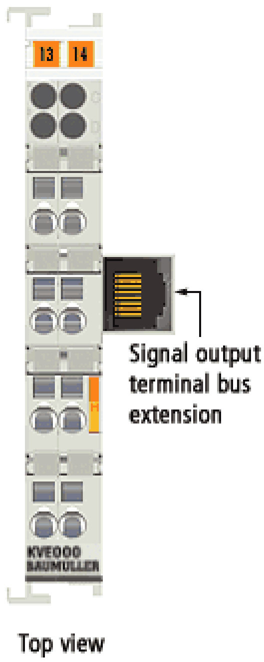


Figure 25: Top view terminal KVE000

3.2.23 KVK000 Terminal bus extension, coupler terminal

The KVK000 coupler terminal replaces the Bus Coupler on a Bus Terminal block. The KVK000 is the counterpart to the KVE000. The S(F)TP cable is plugged into the upper socket, providing the logical connection to the Bus Coupler. The extension is fully transparent for the Bus Coupler. All Bus Terminal system functions remain unchanged. The second RJ45 socket allows the system to be extended further. A new KVK000 can be connected to the first coupler terminal. The whole system can thereby be extended by 31 stations. The supply voltage for the field level and the internal electronics can be input separately. Both levels are thereby electrically isolated from one another. In the KVK000 a 400 mA I/O-bus power supply unit supplies the added Bus Terminals. The internal electronics and the field level can be supplied together from a single voltage source. Three diagnostic LEDs give information about the supply voltage for each Bus Terminal block, internal and field level.

The KVK000 can be used as the last coupler terminal in the system or as a bridge between two Bus Terminal blocks. You can switch between these two functions with a selector switch. The switch must be correctly positioned for the system to operate.

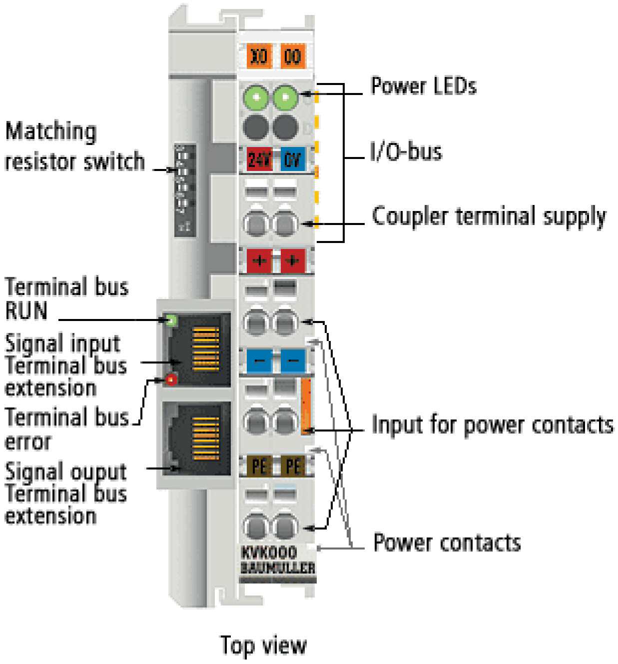


Figure 26: Top view terminal KVK000

3.2.24 ZK0000 Incremental encoder interface

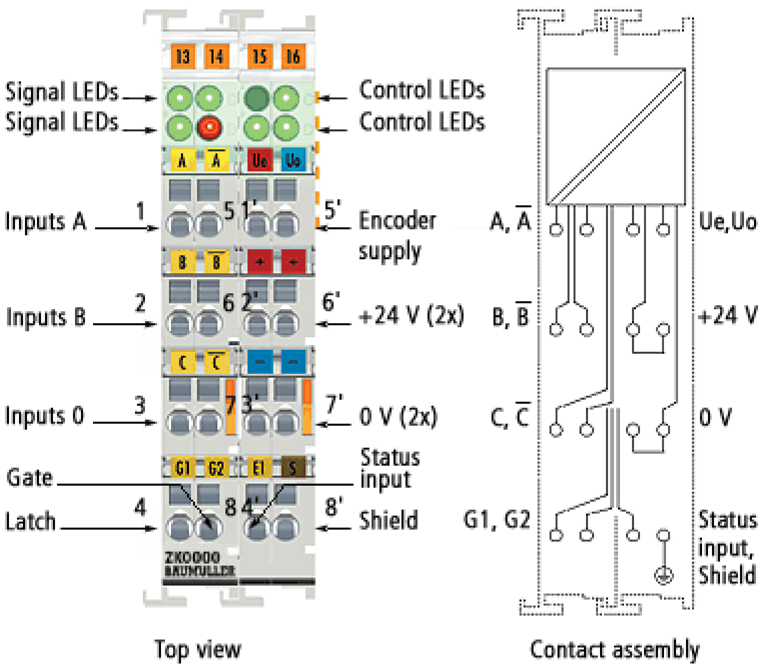


Figure 27: Top view terminal ZK0000

The ZK0000 terminal is an interface for the direct connection of incremental encoders with difference signal (RS485) or with single inputs. A 16 bit counter with a quadrature decoder and a 16 bit latch for the zero pulse can be read, set or enabled. The inputs of

ZK0000 can optionally be used as complementary or as single inputs. Incremental encoders with alarm outputs can be connected at the interface‘s status input. Interval measurement with a resolution of 200 ns is possible. The G2 input allows the counter to be halted (high = stop), and the value is read with a rising edge at G1.

3.3 Labeling of the terminals - type code

On the front panel, you will find the type code of the terminals.

NOTE

This type code applies only to terminal of the b maXX system series.

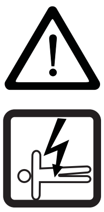
<u>xx</u>yyyy	Terminal type DI: Digital input DO: Digital output AI: Analog input AO: Analog output EK: Bus end terminal ES: Feed terminal KV: Terminal bus extension ZK Counter terminal
xx<u>yyyy</u>	Type designation

This type code is located on the respective terminal. The type code contains the terminal’s basic data. For a list of all technical data, refer to ▹Appendix D - Technical Data◃ from page 215 onward.

4

Assembly and Installation

4.1 Installation of Bus Terminals on C mounting rails



DANGER

The following **will occur**, if you do not observe this danger information:

- serious personal injury
- death

*Danger from: **electricity.** The Bus Terminals and the vicinity of the control cabinet may carry dangerous voltages.*

Bring the bus system into a safe, powered down state before starting installation, disassembly or wiring of the Bus Terminals!

Dimension drawing of a Bus Terminal:

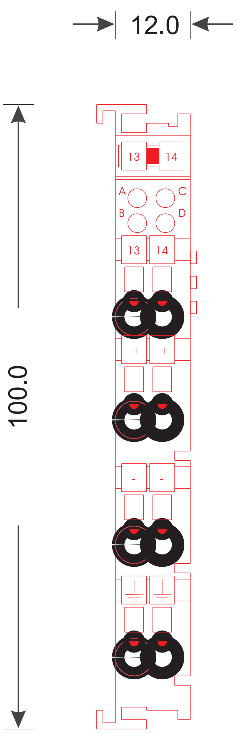


Figure28: Dimension drawing of a Bus Terminal

4.2 Assembly

The Bus Coupler and Bus Terminals are attached to commercially available 35 mm C mounting rails (EN 50022) by applying slight pressure:

1 First attach the Fieldbus Coupler to the mounting rail.

2 The Bus Terminals are now attached on the right-hand side of the Fieldbus Coupler. Join the components with tongue and groove and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.
If the Terminals are clipped onto the mounting rail first and then pushed together without tongue and groove, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

During the installation of the Bus Terminals, the locking mechanism of the terminals must not come into conflict with the fixing bolts of the mounting rail.

4.3 Connections within a bus terminal block

The electric connections between the Bus Coupler and the Bus Terminals are automatically realised by joining the components:

- The six spring contacts of the I/O-Bus deal with the transfer of the data and the supply of the Bus Terminal electronics.
- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the bus terminal block. The power contacts are supplied via terminals on the Bus Coupler.

NOTE

During the design of a bus terminal block, the pin assignment of the individual Bus Terminals must be taken account of, since some types (e.g. analog Bus Terminals or digital 4-channel Bus Terminals) do not or not fully loop through the power contacts.

Power Feed Terminals (ES0000) interrupt the power contacts and thus represent the start of a new supply rail.

4.4 PE power contact

The power contact labeled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

CAUTION

The following **may occur**, if you do not observe this caution information:

- property damage.

*Danger from: **Damage of the Terminal.** Disruptive discharge to the PE line during insulation testing of a consumer with a nominal voltage of 230 V.*

Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation testing of a consumer with a nominal voltage of 230 V).

For insulation testing, disconnect the PE supply line at the Bus Coupler or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10 mm from the group of terminals.

The PE power contact must not be used for other potentials!

4.5 Wiring

Up to eight connections enable the connection of solid or finely stranded cables to the Bus Terminals. The terminals are implemented in spring force technology. Connect the cables as follows:

1 Open a spring-loaded terminal by slightly pushing with a screwdriver or a rod into the square opening above the terminal.

2 The wire can now be inserted into the round terminal opening without any force.

3 The terminal closes automatically when the pressure is released, holding the wire securely and permanently.

4.6 Power supply

The supply connections V_k for the module electronics (I/O-Bus) and supply connections for the field devices (power contacts) of a terminal block are galvanically separated from each other and can be supplied via separate 24 V_{DC} voltage sources. If no electrical isolation is required between I/O-Bus and field devices, the module electronics and the field devices can be supplied from a single voltage source.

NOTE

For the trouble-free operation of a I/O-Bus extension system, the ground connection of the I/O-Bus power supplies (V_k 0 V) of all terminal blocks must be connected with each other via a low-impedance connection (see Figure). This also includes the ground connection of the I/O-Bus power supply of the higher-level Fieldbus Coupler!

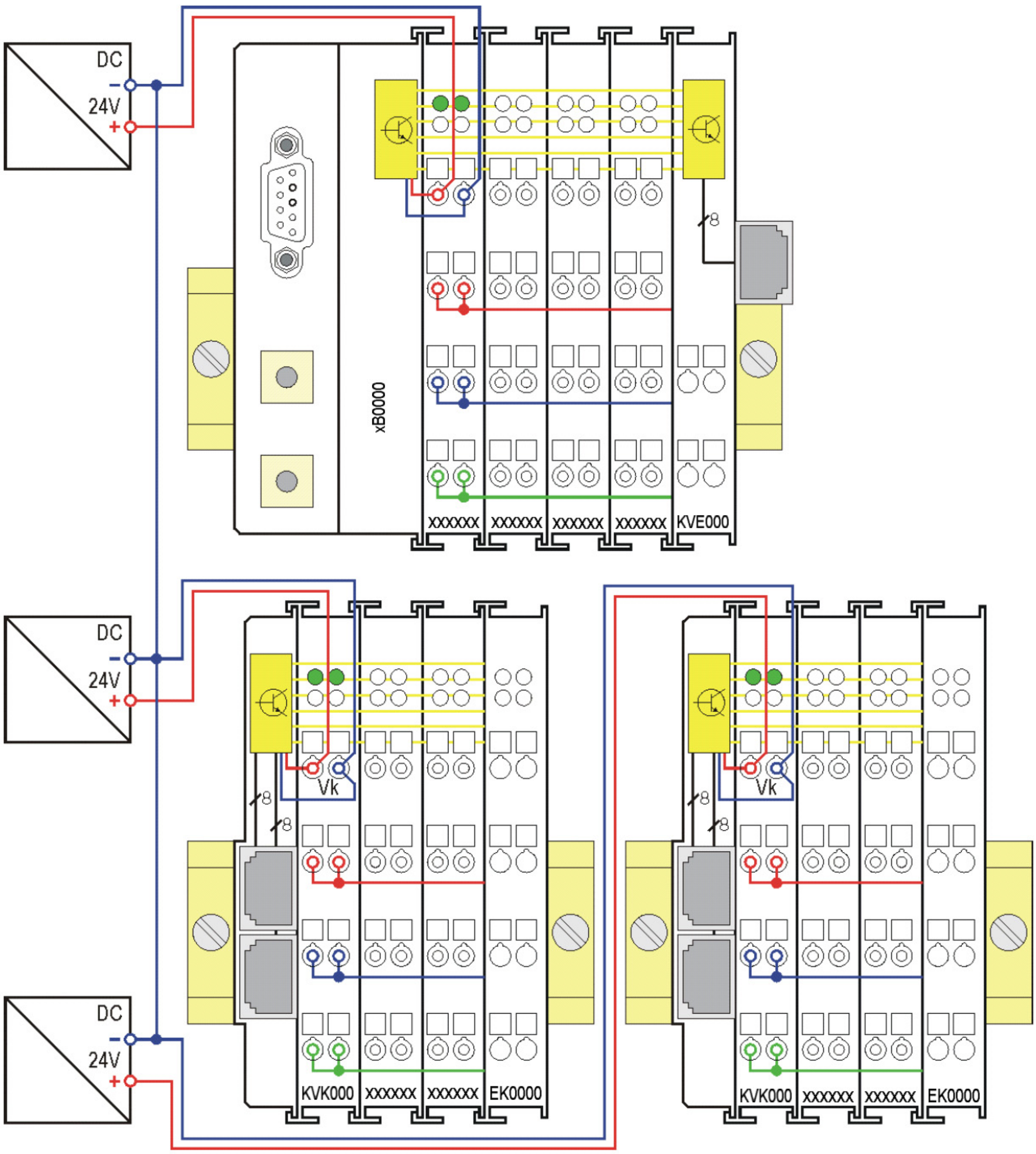


Figure29: Power supply of the terminal blocks

5

AI1010 Single- and AI2010 Dual-Channel Analog Input Terminals 0...10 V

5.1 Functional description

The analog input terminals AI1010 and AI2010 process signals in the range between 0 V and +10 V with a resolution of 12 bits (4095 increments). The inputs of the AI1010 and AI2010 are single-ended inputs with common ground potential.

Process data output format

In the delivery state the process data are shown in two's complement form (integer -1 corresponds to 0xFFFF). Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Decimal output	Hexadecimal output
0V	0	0x0000
5V	16383	0x3FFF
10V	32767	0x7FFF

LED display

The LEDs indicate the operating state of the associated terminal channels.
Green LED: RUN

- On: normal operation
- Off: Watchdog-timer overflow has occurred. If no process data are transmitted by the Bus Coupler for 100 ms, the green LEDs go out.

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X_adc: Output values of the A/D converter

Y_aus: Process data to PLC

B_a, A_a: Manufacturer gain and offset compensation (R17, R18)

B_h, A_h: Manufacturer scaling (R19, R20)

B_w, A_w: User scaling (R33, R34)

a) Neither user nor manufacturer scaling are active:

Y_a = (B_a + X_adc) * A_a (1.0)

Y_aus = Y_a

b) Manufacturer scaling active: (Default setting)

Y_1 = B_h + A_h * Y_a (1.1)

Y_aus = Y_1

c) User scaling active:

Y_2 = B_w + A_w * Y_a (1.2)

Y_aus = Y_2

d) Manufacturer and user scaling active:

Y_1 = B_h + A_h * Y_a (1.3)

Y_2 = B_w + A_w * Y_1 (1.4)

Y_aus = Y_2

The equations of the straight line are activated via register R32.

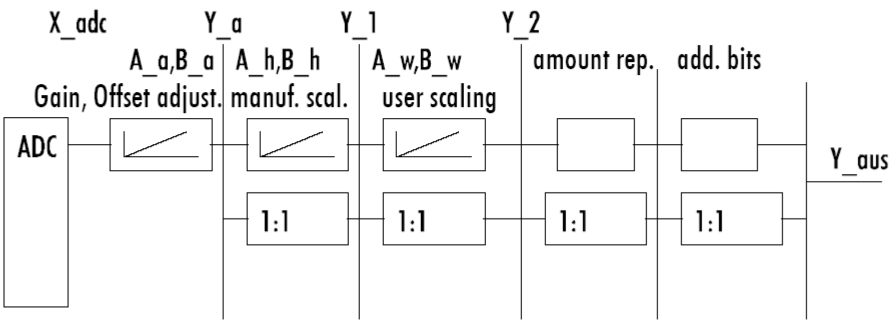


Figure 30:

5.2 Terminal configuration AI1010 and AI2010

The terminal can be configured and parameterised via the internal register structure. Each terminal channel is mapped in the Bus Coupler. Depending on the type of the Bus Coupler and the mapping configuration (e.g. Motorola/Intel format, word alignment etc.) the terminal data are mapped in different ways to the Bus Coupler memory. For parameterising a terminal, the control and status byte also has to be mapped.

PK0000 Profibus coupler

For the PK0000 Profibus coupler, the master configuration should specify for which terminal channels the control and status byte is to be inserted. If the control and status byte are not evaluated, the terminals occupy 2 bytes per channel: 4 bytes of input data

Example for AI2010:

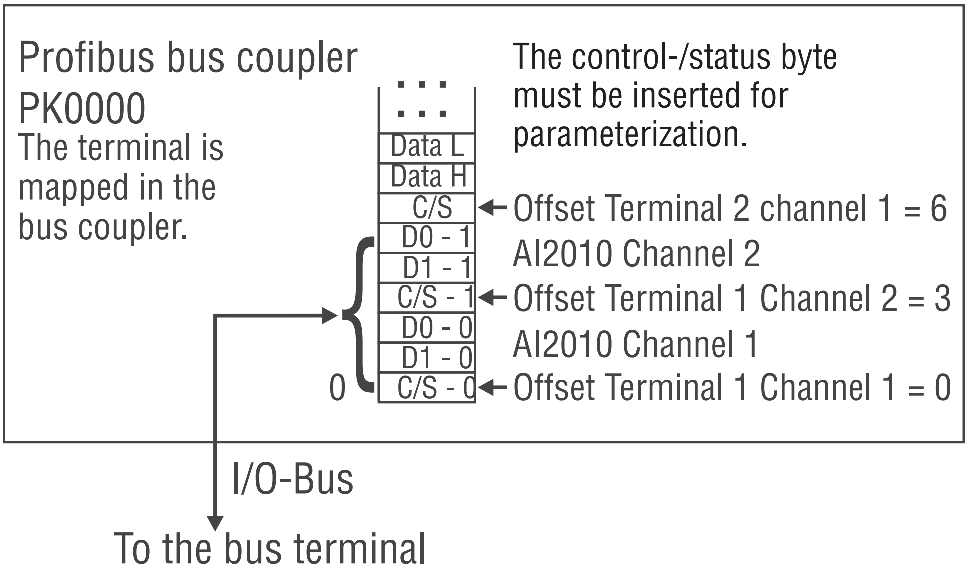


Figure 31:

Other Bus Couplers and further information

Further information about the mapping configuration of Bus Couplers (e.g. CANopen CK000x) can be found in the Appendix of the respective Bus Coupler manual under „Master configuration“.

NOTE

The Appendix contains an overview of possible mapping configurations depending on the parameters that can be set.

Parameterisation with software

The parameterisations can be carried out independently of the fieldbus system with the Baumüller configuration software ProPLC via the serial configuration interface in the Bus Coupler.

5.3 Register Description AI1010 and AI2010

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals.

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the „Register Communication“ section.

5.3.1 General Description of Registers

Complex terminals that possess a processor are able to exchange data bidirectionally with the higher-level controller. These terminals are referred to below as intelligent Bus Terminals. These include analog inputs, analog outputs, counter terminals and all other parameterisable terminals.

The main features of the internal data structure are the same for all the intelligent terminals. This data area is organised as words and comprises 64 registers. The important data and parameters of the terminal can be read and set through this structure. It is also possible for functions to be called by means of corresponding parameters. Each logical channel in an intelligent terminal has such a structure (4-channel analog terminals therefore have 4 sets of registers).

This structure is divided into the following areas:
(A detailed list of all registers can be found in ▹Register table ◃ from page 55 onward.

Application	Register
Process variables	0-7
Type register	8-15
Manufacturer parameters	16-30
User parameters	31-47
Extended user area	48-63

Process variables

R0 to R7 Registers in the terminal's internal RAM:
The process variables can be used in addition to the actual process image. Their function is specific to the terminal.

R0 to R5: Terminal-specific registers:
The function of these registers depends on the respective terminal type (see terminal-specific register description).

R6: Diagnostic register
The diagnostic register can contain additional diagnostic information. Parity errors, for instance, that occur in serial interface terminals during data transmission are indicated here.

R7: Command register
High-Byte_Write = function parameter
Low-Byte_Write = function number
High-Byte_Read = function result
Low-Byte_Read = function number

Type register

R8 to R15: Registers in the internal ROM of the terminal:

The type and system parameters are hard programmed by the manufacturer, and the user can read them but cannot change them.

R8: Terminal type:
The terminal type in register R8 is needed to identify the terminal.

R9: Software version X.y
The software version can be read as a string of ASCII characters.

R10: Data length
R10 contains the number of multiplexed shift registers and their length in bits. The Bus Coupler sees this structure.

R11: Signal channels
Related to R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length
The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data type register

Data type register	
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure 1 byte n bytes
0x03	Word array
0x04	Structure 1 byte n words
0x05	Double word array
0x06	Structure 1 byte n double words
0x07	Structure 1 byte 1 double word
0x08	Structure 1 byte 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure 1 byte n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure 1 byte n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure 1 byte n double words with variable logical channel length

R14: reserved

R15: Alignment bits (RAM)
The alignment bits are used to place the analog terminal in the Bus Coupler on a byte boundary.

Manufacturer parameters

R16 to R30: Manufacturer parameter area (SEEROM)
The manufacturer parameters are specific for each type of terminal. They are programmed by the manufacturer, but can also be modified by the controller. The manufacturer parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out.

These registers can only be altered after a code-word has been set in R31.

User parameters

R31-R47 User parameter area (SEEROM)
The user parameters are specific for each type of terminal. They can be modified by the programmer. The user parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out. The user area is write-protected by a code-word.

NOTE

R31: Code-word register in RAM
The code-word **0x1235** must be entered here so that parameters in the user area can be modified. If any other value is entered into this register, the write-protection is active. When write protection is not active, the code word is returned when the register is read. If the write protection is active, the register contains a zero value.

R32: Feature register
This register specifies the terminal's operating modes. Thus, for instance, a user-specific scaling can be activated for the analog I/Os.

R33 to R47 Terminal-specific registers
The function of these registers depends on the respective terminal type (see terminal-specific register description).

Extended application region

R47-R63
Extended registers with additional functions.

5.3.2 Terminal-specific register description

Process variables

R0: Raw ADC value X_R
This register contains the raw ADC value with gain and offset error.

R1 to R5: reserved

R6: Diagnostic register
High byte: reserved
Low byte: status byte

Manufacturer parameters

R17: Hardware compensation - offset B_a
16 bit signed integer
This register is used for offset compensation of the terminal (Eq. 1.1).
Register value approx. 0xFFXX

R18: Hardware compensation - gain A_a
16 bit * 2^{-12}
This register is used for gain compensation of the terminal (Eq. 1.1).
1 corresponds to 0x1000.
Register value approx. 0x11XX

R19: Manufacturer scaling - offset B_h
16 bit signed integer [0x0000]
This register contains the offset of the manufacturer's equation of the straight line (1.3). The straight-line equation is activated via register R32.

R20: Manufacturer scaling - gain A_h
16 bit signed integer * 2^{-10} [0x2002]
This register contains the scale factor of the manufacturer's equation of the straight line (1.3). The straight-line equation is activated via register R32.
1 corresponds to register value 0x0400.

R21: Over range limit: OVRL
16 bit signed integer in Y_a (Eq. 1.0) [0x0FFF]

This limit value limits the maximum measuring range of the input terminal.
If it is exceeded, the associated status bit is set, and the maximum value is displayed.

R22: Under range limit: UNRL
16 bit signed integer in Y_a (Eq.1.0) [0x0000]
If the actual value falls below this limit, the associated status bit is set, and the minimum value is displayed.

R23: ADC hardware preset
[0x1000]
Initialisation of the ADC offset register.

User parameters

R32: Feature register:
[0x1106]
The feature register specifies the operating modes of the terminal.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (R33, R44) active [0]
Bit 1	1	Manufacturer scaling (R19, R20) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on.
Bit 3	1	Sign / amount representation [0] Sign / amount representation is active instead of two's-complement representation. (-1 = 0x8001)
Bit 4	1	Siemens output format [0] This bit is used for inserting status information on the lowest 3 bits (see below).
Bit 7-5	-	reserved, do not change
Bit 8	1	Over range Protection [1] If values exceed or fall below the limits of the registers OVRL (R21) and UNRL (R22), the status bits are set and the measuring range is restricted accordingly.
Bit 9	1	Limit value 1 active [0] The process data are compared with limit value 1 (R35), and appropriate status bits are set.
Bit 10	1	Limit value 2 active [0] The process data are compared with limit value 1 (R36), and appropriate status bits are set.
Bit 11	1	Filter 1 active [0] For filter characteristics see R37
Bit 15-12	-	reserved, do not change

If the Siemens output format is selected, the lowest three bits are used for status evaluation. The process data is represented in bits 15 to 3, with bit 15 representing the sign bit. Scaling of the measurement reading according to the Siemens standard has to be done via user scaling (R33, R34).

Measured value	Bit 15...3	Bit 2 X	Bit 1 ERROR	Bit 0 Overflow
>10 V		0	0	1
<10 V	Process data	0	0	0

R33: User scaling - offset (B_w)
16 bit signed integer
This register contains the offset of the user straight-line equation (1.4). The straight-line equation is activated via register R32.

R34: User scaling - gain (A_w)
16 bit signed integer * 2^{-8}
This register contains the scale factor of the user straight-line equation (1.4). The straight-line equation is activated via register R32.

R35: Limit value 1 (Y_2)
If the process data are outside this limit value, the appropriate bits are set in the status byte.

R36: Limit value 2 (Y_2)
If the process data are outside this limit value, the appropriate bits are set in the status byte.

R37: Filter constant
[0x0000]

HINWEIS

This documentation applies to all terminals from software version 3x. The version number can be found within the serial number on the right-hand side face of the terminal: xxxx3xxx

Example: 52983A2A ⇒ The firmware version is **3A**.

If the internal filter is activated via R37.11, the following filter constants can be selected in R37. In the standard setting, the corresponding conversion time is 2.5 ms:

R37	Explanation	
0x0000	2nd order FIR filter.	default value
0x0100	1st order IIR filter, cut-off frequency f_g approx.1 kHz	The implemented IIR filters do not have any notch behaviour, i.e., they do not explicitly suppress any frequency.
0x0200	1st order IIR filter, cut-off frequency f_g approx. 100 Hz	
0x0300	1st order IIR filter, cut-off frequency f_g approx. 50 Hz	
0x0400	1st order IIR filter, cut-off frequency f_g approx. 20 Hz	
0x0500	1st order IIR filter, cut-off frequency f_g approx. 10 Hz	
0x0600	1st order IIR filter, cut-off frequency f_g approx. 5 Hz	
0x0700	1st order IIR filter, cut-off frequency f_g approx. 1 Hz	

R37	Explanation	
0x1000	50 Hz FIR filter Averaging over 16 values and first notch 25 Hz	In contrast to the IIR filters, FIR filter have notch behaviour. The timer settings of the notch filters are set via channel 0 of the terminal. This means that the 50 Hz filter on channel 0 and the 60 Hz filter on channel 1 cannot be active simultaneously.
0x2000	60 Hz FIR filter Averaging over 16 values and first notch 20 Hz	
Other values	No filter active	

5.3.3 Control and Status byte

Control byte for process data exchange
Gain and offset compensation

The control byte is transmitted from the controller to the terminal. It can be used

- in register mode (REG = 1_{bin}) or
- during process data exchange (REG = 0_{bin}).

The control byte can be used to carry out gain and offset compensation for the terminal (process data exchange). This requires the code word to be entered in R31. The gain and offset of the terminal can then be compensated.

The parameter will only be saved permanently once the code word is reset!

Control byte:

Bit 7 = 0_{bin}

Bit 6 = 1_{bin} Terminal compensation function is activated

Bit 4 = 1_{bin} Gain compensation

Bit 3 = 1_{bin} Offset compensation

Bit 2 = 0_{bin} Slower cycle = 1000ms
1_{bin} Fast cycle = 50ms

Bit 1 = 1_{bin} up

Bit 0 = 1_{bin} down

Status byte for process data exchange

The status byte is transmitted from the terminal to the controller. The status byte contains various status bits for the analog input channel:

Status byte:

Bit 7 = 0_{bin}

Bit 6 = 1_{bin}: ERROR - general error bit

Bit 5 | Bit 4
0_{bin} | 0_{bin} Limit value 2 not activated
0_{bin} | 1_{bin} Process data less than limit value 2
1_{bin} | 0_{bin} Process data greater than limit value 2
1_{bin} | 1_{bin} Process data equal limit value 2

Bit 3 | Bit 2
0_{bin} | 0_{bin} Limit value 1 not activated

0_{bin} | 1_{bin} Process data less than limit value 1
1_{bin} | 0_{bin} Process data greater than limit value 1
1_{bin} | 1_{bin} Process data equal limit value 1

Bit 1 = 1_{bin}: Over range
Bit 0 = 1_{bin}: Under range

5.3.4 Register communication AI1010 and AI2010

Register access via process data exchange
Bit 7 = 1_{bin}: Register mode

If bit 7 of the control byte is set, then the first two bytes of the user data are not used for exchanging process data, but are written into or read from the terminal's register set.

Bit 6=0_{bin}: read
Bit 6=1_{bin}: write

Bit 6 of the control byte specifies whether a register should be read or written. If bit 6 is not set, then a register is read out without modifying it. The value can then be taken from the input process image.

If bit 6 is set, then the user data is written into a register. As soon as the status byte has supplied an acknowledgement in the input process image, the procedure is completed (see example).

Bit 0 to 5: Address

The address of the register that is to be addressed is entered into bits 0 to 5 of the control byte.

Control byte in register mode

MSB

REG=1	W/R	A5	A4	A3	A2	A1	A0

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

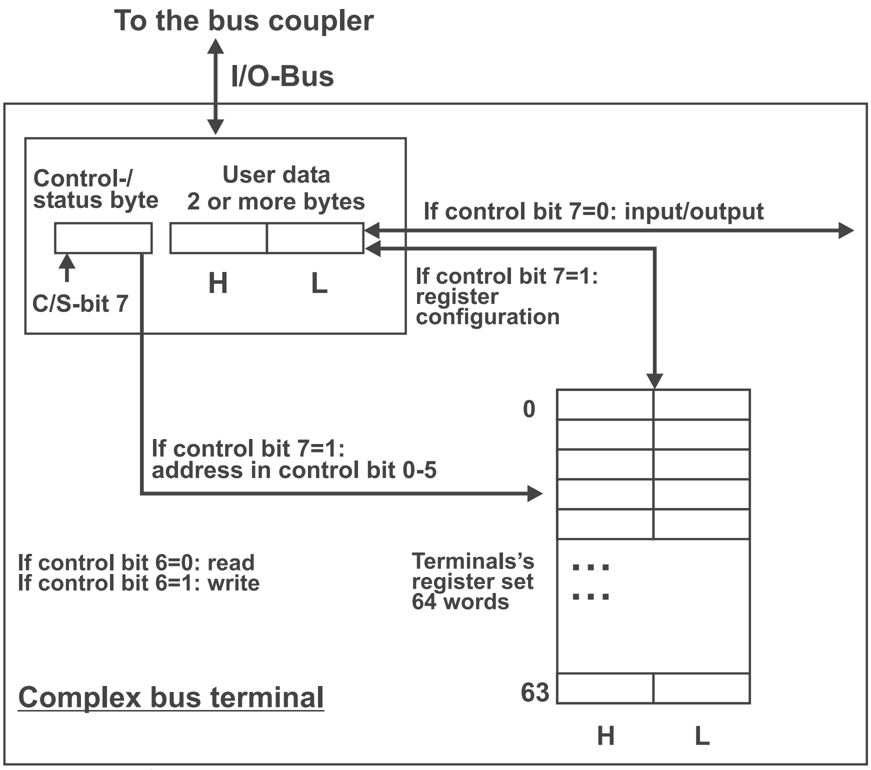


Figure 32: Complex bus terminal

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

5.4 Appendix

5.4.1 Mapping in the Bus Coupler

As already described in the Terminal Configuration section, each Bus Terminal is mapped in the Bus Coupler. In the delivery state, this mapping occurs with the default settings of the Bus Coupler for this terminal. The default setting can be changed with the Baumüller configuration software ProPLC.

If the terminals are fully evaluated, they occupy memory space in the input and output process image.

The following tables provide information about the terminal mapping, depending on the conditions set in the Bus Coupler.

AI1010:

Default mapping for: CANopen

Conditions		Word offset	High byte	Low byte
Complete evaluation:	no	0	Ch1 D1	Ch1 D0
Motorola format:	no	1	-	-
Word alignment:	any	2	-	-
		3	-	-

Default mapping for: Profibus

Conditions		Word offset	High byte	Low byte
Complete evaluation:	no	0	Ch1 D0	Ch1 D1
Motorola format:	yes	1	-	-
Word alignment:	any	2	-	-
		3	-	-

Conditions		Word offset	High byte	Low byte
Complete evaluation:	yes	0	Ch1 D0	Ch1 CB/SB
Motorola format:	no	1	-	Ch1 D1
Word alignment:	no	2	-	-
		3	-	-

Conditions		Word offset	High byte	Low byte
Complete evaluation:	yes	0	Ch1 D1	Ch1 CB/SB
Motorola format:	yes	1	-	Ch1 D0
Word alignment:	no	2	-	-
		3	-	-

AI2010:

Default mapping for: CANopen

Conditions		Word offset	High byte	Low byte
Complete evaluation:	no	0	Ch0 D1	Ch0 D0
Motorola format:	no	1	Ch1 D1	Ch1 D0
Word alignment:	any	2	-	-
		3	-	-

Default mapping for: Profibus

Conditions	Word offset	High byte	Low byte
Complete evaluation: no Motorola format: yes Word alignment: any	0	Ch0 D0	Ch0 D1
	1	Ch1 D0	Ch1 D1
	2	-	-
	3	-	-

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch0 D0	Ch0 CB/SB
	1	Ch1 CB/SB	Ch0 D1
	2	Ch1 D1	Ch1 D0
	3	-	-

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch0 D1	Ch0 CB/SB
	1	Ch1 CB/SB	Ch0 D0
	2	Ch1 D0	Ch1 D1
	3	-	-

Legend

Complete evaluation: The terminal is mapped with control and status byte.

Motorola format: Motorola or Intel format can be set.

Word alignment: The terminal is at word limit in the Bus Coupler.

Ch n SB: status byte for channel n (appears in the input process image).
Ch n CB: control byte for channel n (appears in the output process image).

Ch n D0: channel n, data byte 0 (byte with the lowest value)
Ch n D1: channel n, data byte 1 (byte with the highest value)

"-": This byte is not used or occupied by the terminal.

5.4.2 Register table

These registers exist once for each channel.

Address	Denomination	Default value	R/W	Storage medium
R0	Raw ADC value	variable	R	RAM
R1	reserved	0x0000	R	
R2	reserved	0x0000	R	
R3	reserved	0x0000	R	
R4	reserved	0x0000	R	
R5	reserved	0x0000	R	
R6	Diagnostic register	variabel	R	RAM
R7	Command register not used	0x0000	R	
R8	Terminal type	e.g. 3062	R	ROM
R9	Software version number	0x????	R	ROM

Address	Denomination	Default value	R/W	Storage medium
R10	Multiplex shift register	0x0218/0130	R	ROM
R11	Signal channels	0x0218	R	ROM
R12	Minimum data length	0x0098	R	ROM
R13	Data structure	0x0000	R	ROM
R14	not used	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	Hardware compensation: Offset	specific	R/W	SEEROM
R18	Hardware compensation: Gain	specific	R/W	SEEROM
R19	Manufacturer scaling: Offset	0x0000	R/W	SEEROM
R20	Manufacturer scaling: Gain	0x2002	R/W	SEEROM
R21	Over range limit	0x0FFF	R/W	SEEROM
R22	Under range limit	0x0000	R/W	SEEROM
R23	ADC hardware preset	0x1000	R/W	SEEROM
R24	reserved	0x0000	R/W	SEEROM
R25	reserved	0x0000	R/W	SEEROM
R26	reserved	0x0000	R/W	SEEROM
R27	reserved	0x0000	R/W	SEEROM
R28	reserved	0x0000	R/W	SEEROM
R29	reserved	0x0000	R/W	SEEROM
R30	reserved	0x0000	R/W	SEEROM
R31	Code word register	variable	R/W	RAM
R32	Feature register	0x1106	R/W	SEEROM
R33	User scaling: Offset	0x0000	R/W	SEEROM
R34	User scaling: Gain	0x0100	R/W	SEEROM
R35	Limit value 1	0x0000	R/W	SEEROM
R36	Limit value 2	0x0000	R/W	SEEROM
R37	reserved	0x0000	R/W	SEEROM
...	...	...	...	...
R63	reserved	0x0000	R/W	SEEROM

6

AI4010 4-CHANNEL ANALOG INPUT TERMINAL 0...10 V

6.1 Functional description

The Analog Input Terminal AI4010 processes signals in the range between 0 V and +10 V with a resolution of 12 bits (4095 steps). The terminal inputs are differential inputs with common ground. Due to the differential inputs, the terminals are particularly suitable for measuring earth free voltage drops.

Process data output format

In the delivery state the process data are shown in two's complement form ($-1_{integer}$ corresponds to 0xFFFF). Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Output decimal	Output hexadecimal
0V	0	0x0000
+5V	16383	0x3FFF
+10V	32767	0x7FFF

Diagnostic LEDs

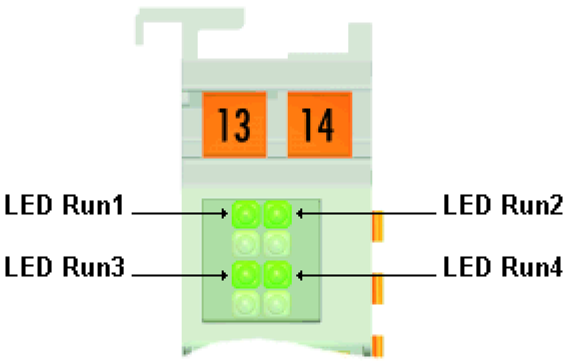


Figure 33: RUN LEDs

Meaning of LED displays

LED	Color	Chan-nel	Status	
			on	off
Run1	green	1	regular operation	A Watchdog-Timer overflow has occurred. If no process data is transmitted between control system and Bus Coupler for 100 ms, the green LEDs extinguish.
Run2		2		
Run3		3		
Run4		4		

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X_{adc}: Output values of the A/D converter

Y_{out}: Process data to PLC

B_a, A_a: Manufacturer gain and offset compensation (R17,R18)

B_h, A_h: Manufacturer scaling (R19,R20)

B_w, A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling is active:

$Y_a = (B_a + X_{adc}) * A_a$ (1.0)

$Y_{out} = Y_a$

b) Manufacturer scaling active (default setting):

$Y_1 = B_h + A_h * Y_a$ (1.1)

$Y_{out} = Y_1$

c) User scaling active:

$Y_2 = B_w + A_w * Y_a$ (1.2)

$Y_{out} = Y_2$

d) Manufacturer and user scaling active:

$Y_1 = B_h + A_h * Y_a$ (1.3)

$Y_2 = B_w + A_w * Y_1$ (1.4)

$Y_{out} = Y_2$

The equations of the straight line are activated via register R32.

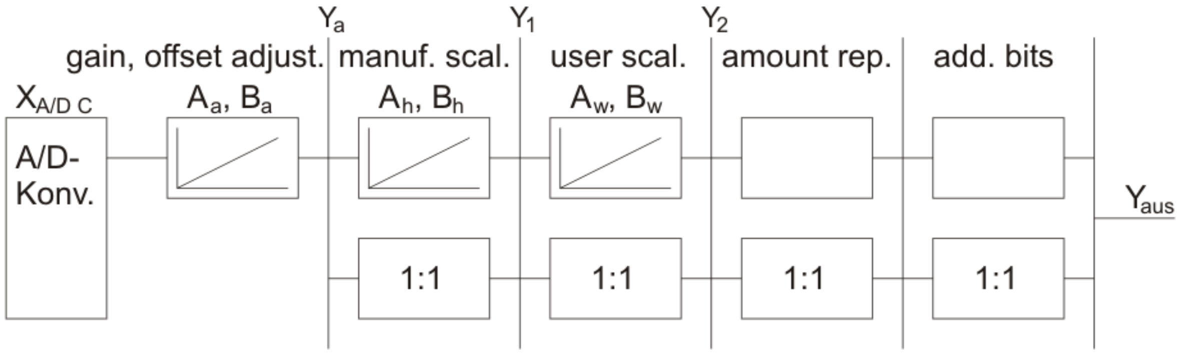


Figure34: Scaling

6.2 Access from the user program

6.2.1 Process Image

In the process image AI4010 and AI4420 are shown with up to 12 byte input and 12 byte output data.

Format	Input data	Output data
Byte	SB1	CB1
Word	DataIN1	DataOUT1
Byte	SB2	CB2
Word	DataIN2	DataOUT2
Byte	SB3	CB3
Word	DataIN3	DataOUT3
Byte	SB4	CB4
Word	DataIN4	DataOUT4

Legende

SB n: Status byte for channel n
CB n: Control byte for channel n

DataIN n: Input data word of channel n
DataOUT n:Output data word of channel n

- The mapping of the bytes and words to the addresses of the controlling system can be found on the mapping page.
- The meaning of control und status bytes can be found on the page *control and status bytes*.
- In process data mode the analog values are transmitted within the input data words DataIN1 to DataIN4 and the output data words DataOUT1 to DataOUT4 are not used.

6.2.2 Mapping

The Bus Terminals occupy addresses within the process image of the controller. The assignment of process data (input and output data) and parameterization data (control and status bytes) to the control addresses is called mapping. The type of mapping depends on:

- the fieldbus system used
- the terminal type
- the parameterization of the bus coupler (conditions) such as
  - compact or full evaluation
  - Intel or Motorola format
  - word alignment switched on or off

The Bus Couplers (CK000x) are supplied with certain default settings. The default setting can be changed with the Baumüller configuration software ProPLC.

The following tables show the mapping depending on different conditions. For information about the contents of the individual bytes please refer to the pages *Process image and Control and status byte*.

6.2.3 Compact evaluation

For compact evaluation, the analog input terminals only occupy addresses in the input process image. Control and status bytes cannot be accessed.

Compact evaluation in Intel format

Default mapping for CANopen coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: no Word alignment: any	0	Ch1 D1	Ch1 D0	-	-
	1	Ch2 D1	Ch2 D0	-	-
	2	Ch3 D1	Ch3 D0	-	-
	3	Ch4 D1	Ch4 D0	-	-

Compact evaluation in Motorola format

Default mapping for Profibus coupler

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: yes Word alignment: any	0	Ch1 D0	Ch1 D1	-	-
	1	Ch2 D0	Ch2 D1	-	-
	2	Ch3 D0	Ch3 D1	-	-
	3	Ch4 D0	Ch4 D1	-	-

6.2.4 Complete evaluation

For complete evaluation, the analog input terminals occupy addresses in the input and output process image. Control and status bytes can be accessed.

Complete evaluation in Intel format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	SB1	Ch1 D0	CB0
	1	SB2	Ch1 D1	CB1	Ch1 D1
	2	Ch2 D1	Ch2 D0	Ch2 D1	Ch2 D0
	3	Ch3 D0	SB3	Ch3 D0	CB2
	4	SB4	Ch3 D1	CB3	Ch3 D1
	5	Ch4 D1	Ch4 D0	Ch4 D1	Ch4 D0

Complete evaluation in Motorola format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	SB1	Ch1 D1	CB0
	1	SB2	Ch1 D0	CB1	Ch1 D0
	2	Ch2 D0	Ch2 D1	Ch2 D0	Ch2 D1
	3	Ch3 D1	SB3	Ch3 D1	CB2
	4	SB4	Ch3 D0	CB3	Ch3 D0
	5	Ch4 D0	Ch4 D1	Ch4 D0	Ch4 D1

Key

Complete evaluation: In addition to the process data, the control and status bytes are also mapped in the address space.

Motorola format:	Motorola or Intel format can be set.
Word alignment:	In order for the channel address range to commence at a word boundary, empty bytes are inserted into the process image as appropriate.

SB n: status byte for channel n (appears in the input process image).
CB n: control byte for channel n (appears in the output process image).

Ch n D0: channel n, lower-value data byte
Ch n D1: channel n, higher-value data byte

reserved: This byte occupies process data memory, although it has no function.

"-": This byte is not assigned or used by the terminal/module.

6.2.5 Control and Status bytes

6.2.5.1 Channel 1

Process data mode

Control byte 1 in process data mode

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal. In process data mode it has no function.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
CB1.7	RegAccess	0_{bin}	Register communication off (process data mode)
CB1.6 - CB1.0	-	0_{bin}	reserved

Status byte 1 in process data mode

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	Error	LimitValue 2 State		LimitValue 1 State		Overrange	Underrange

Legend

Bit	Name	Description	
SB1.7	RegAccess	0_{bin}	Acknowledgement for process data mode
SB1.6	Error	1_{bin}	general error bit
SB1.5 - SB1.4	LimitValue 2 State	00_{bin}	Limit value 2 not activated
		01_{bin}	Process data less than limit value 2
		10_{bin}	Process data greater than limit value 2
		11_{bin}	Process data equal limit value 2
SB1.3 - SB1.2	LimitValue 1 State	00_{bin}	Limit value 1 not activated
		01_{bin}	Process data less than limit value 1
		10_{bin}	Process data greater than limit value 1
		11_{bin}	Process data equal limit value 1
SB1.1	Overrange	1_{bin}	Permissible measuring range exceeded
SB1.0	Underrange	1_{bin}	Lower measuring range limit violated

6.2.6 Register communication

Control byte 1 in register communication

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	R/W	Reg. no.					

Legend

Bit	Name	Description	
CB1.7	RegAccess	1_{bin}	Register communication switched on
CB1.6	R/W	0_{bin}	Read access
		1_{bin}	Write access
CB1.5 bis CB1.0	Reg. no.	Register number: Enter the number of the register that you ○ want to read with input data word DataIN1 or ○ want to write with output data word DataOUT1.	

Status byte 1 in register communication

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	R/W	Reg. no.					

Legend

Bit	Name	Description	
SB1.7	RegAccess	1_{bin}	Acknowledgement for register access
SB1.6	R	0_{bin}	Read access
SB1.5 bis SB1.0	Reg. no.	Number of the register that was read or written.	

6.2.6.1 Channel 2, Channel 3 und Channel 4

The control and status bytes of channels 2, 3 and 4 are structured like the control and status byte of channel 1.

6.2.7 Register overview

The following registers are used to parameterize the AI4010. They exist once for each channel of a terminal and can be read or written by register communication using control-, status- und data bytes.

Register no.	Comment	Default value		R/W	Memory
R0	Raw value of A/D converter (X_R)	-	-	R	RAM
R1	reserved	-		-	-
...	...	...	...	...	...
R5	reserved	-	-	-	-
R6	Diagnostic register	-	-	R	RAM
R7	Command register	0x0000	0_{dez}	R/W	RAM
R8	Terminal type	0x0D88	3464_{dez}	R	ROM
R9	Firmware revision level	z.B. 0x3141	z.B. $1A_{ASCI}$	R	ROM
R10	Data length (Multiplex shift register)	0x0230	560_{dez}	R	ROM
R11	Signal channels	0x0418	1048_{dez}	R	ROM
R12	minimum data length	0x0098	152_{dez}	R	ROM
R13	Data structure (Data type register)	0x0004	4_{dez}	R	ROM
R14	reserved	-	-	-	-
R15	Alignment register	z.B. 0x7F80	z.B. 32640_{dez}	R/W	RAM
R16	Hardware revision number	z.B. 0x0000	z.B. 0_{dez}	R/W	SEEPROM
R17	Hardware compensation: Offset (B_a)	0x0000	0_{dez}	R/W	SEEPROM
R18	Hardware compensation: Gain (A_a)	ca. 0x13A6	ca. 5030_{dez}	R/W	SEEPROM

R19	manufacturer scaling: Offset (B_h)	0x0000	0_{dez}	R/W	SEEPROM
R20	manufacturer scaling: Gain (A_h)	typ. 0x2000	typ. 8192_{dez}	R/W	SEEPROM
R21	Over range limit	0x0FFF	4095_{dez}	R/W	SEEPROM
R22	Under range limit	0x0000	0_{dez}	R/W	SEEPROM
R23	reserved	-	-	-	-
...	...	...	...	...	...
R30	reserved	-	-	-	-
R31	Code word register	0x0000	0_{dez}	R/W	RAM
R32	Feature register	0x0106	262_{dez}	R/W	SEEPROM
R33	User scaling: Offset (B_w)	0x0000	0_{dez}	R/W	SEEPROM
R34	User scaling: Gain (A_w)	0x0400	1024_{dez}	R/W	SEEPROM
R35	Threshold 1 in (Y_2)	0x0000	0_{dez}	R/W	SEEPROM
R36	Threshold 2 in (Y_2)	0x0000	0_{dez}	R/W	SEEPROM
R37	reserved	-	-	-	-
...		...	...	...	...
R63	reserved	-	-	-	-

6.2.8 Register Description

All registers can be read or written via register communication.

R0: Raw value A/D C

Raw value of the A/D converter (X_R)

R6: Diagnostic register

The status byte is mapped to the lower-value byte (bit 7 to bit 0) of register R6.

The higher-value byte (bit 15 to bit 8) of register R6 is reserved.

R7: Command register

The command register of AI4010 is currently not used.

R8: Terminal description

Register R8 contains the terminal identifier. e.g.: AI4010: 0x0D88 (3464_{dez})

R9: Firmware revision level

Register R9 contains the ASCII coding of the terminal's firmware revision level, e.g. **0x3141 (1A$_{ASCII}$)**. **'0x31'** corresponds to the ASCII character **'1'** and **'0x41'** to the ASCII character **'A'**. This value can not be changed.

R10: Data length (multiplex shift register)

R10 contains the number of multiplexed shift registers and their length in bits.

R11: Signal channels

Unlike R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length

The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data structure (data type register)

Data type register	Meaning
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure: 1 byte, n bytes
0x03	Word array
0x04	Structure: 1 byte, n words
0x05	Double word array
0x06	Structure: 1 byte, n double words
0x07	Structure: 1 byte, 1 double word
0x08	Structure: 1 byte, 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure: 1 byte, n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure: 1 byte, n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure: 1 byte, n double words with variable logical channel length

R15: Alignment register

Via the alignment register bits, the Bus Coupler arranges the address range of an analog terminal such that it starts at a byte boundary.

R16: Hardware version number

Register R16 contains the hardware revision level of the terminal; this value can not be changed.

R17: Hardware compensation - offset (B_a)

This register is used for the offset compensation of the terminal (see equation 1.1). Register value (16 bit signed integer): 0x0000 (0_{dec})

R18: Hardware compensation - gain (A_a)

This register is used for the gain compensation of the terminal (see equation 1.1). Register value (16 bit signed integer x 2^{-12}):

- AI4010: approx. 0x13A6 (5030_{dec})

R19: Manufacturer scaling - offset (B_h)

This register contains the offset for the manufacturer scaling (see equation 1.3). Register value (16 bit signed integer): 0x0000 (0_{dec})
Manufacturer scaling can be activated via bit R32.1 of the feature register.

R20: Manufacturer scaling - gain (A_h)

This register contains the gain for manufacturer scaling (see equation 1.3). Register value (16 bit signed integer x 2^{-10}): typically 0x2000 (8192_{dec})
Manufacturer scaling can be activated via bit R32.1 of the feature register.

R21 Over-range limit - OvRL (Y_a)

This limit value limits the maximum measuring range of the input terminal (see equation 1.0). If it is exceeded, the associated status bit is set, and the maximum value is displayed. Register value (16 bit signed integer)

- AI4010: 0x0FFF (4095_{dec})

R22 Under-range limit - UnRL (Y_a)

If the value falls below this limit, the associated status bit is set, and the minimum value is displayed (see equation 1.0). Register value (16 bit signed integer)

- AI4010: 0x0000 (0_{dec})

R31: Code word register

- If you write into the user registers without first entering the user code word (0x1235) into the code word register, the terminal will not accept the supplied data.
- If you write values into the user registers and have previously entered the user code word (0x1235) in the code word register, these values are stored in the RAM registers and in the SEEPROM registers and are therefore retained if the terminal is restarted.

The code word is reset with each restart of the terminal.

R32: Feature register

The feature register specifies the terminal's configuration. Default: 0x0106 (262_{dec})

Bit	R32.15	R32.14	R32.13	R32.12	R32.11	R32.10	R32.9	R32.8
Name	-	-	-	-	-	enLimit2	enLimit1	enOvRP

Bit	R32.7	R32.6	R32.5	R32.4	R32.3	R32.2	R32.1	R32.0
Name	-	-	-	enSiemens	enSignRepr	enWdTimer	enManScal	enUsrScal

Legend

Bit	Name	Description		default
R32.15	-	reserved		0_{bin}
...	...	...		...
R32.11	-	reserved		0_{bin}
R32.10	enLimit2	0_{bin}	Threshold 2 is not active	0_{bin}
		1_{bin}	Threshold 2 is active	
R32.9	enLimit1	0_{bin}	Threshold 1 is not active	0_{bin}
		1_{bin}	Threshold 1 is active	
R32.8	enOvRP	0_{bin}	Over-range protection is not active	1_{bin}
		1_{bin}	Over-range protection is active: If the limit values of registers OvRL (R21) and UnRL (R22) are exceeded, the associated status bits are set and the measuring range is restricted accordingly.	
R32.7	-	reserved		0_{bin}
R32.6	-	reserved		0_{bin}
R32.5	-	reserved		0_{bin}
R32.4	enSiemens	0_{bin}	Standard output format	0
		1_{bin}	Siemens output format The three bits with the lowest value are used for displaying status information (see below).	
R32.3	enSignRepr	0_{bin}	Two's complement representation is active	0_{bin}
		1_{bin}	The arithmetic sign of numerical quantities is active (-1_{dec} = 0x8001)	
R32.2	enWdTimer	0_{bin}	Watchdog timer is not active	1_{bin}
		1_{bin}	Watchdog timer is active (the watchdog is triggered if no process data are received for 100 ms)	

Bit	Name	Description		default
R32.1	enManScal	0_{bin}	Manufacturer scaling is active	1_{bin}
		1_{bin}	Manufacturer scaling is not active	
R32.0	enUsrScal	0_{bin}	User scaling is not active	0_{bin}
		1_{bin}	User scaling is active	

Siemens output format

If the Siemens output format is selected, the lowest three bits are used for status evaluation. The process data is represented in bits 15 to 3, with bit 15 representing the sign bit. Scaling of the measurement reading according to the Siemens standard has to be done via user scaling (R33, R34).

AI4010

Measured value	Bit 15 ... 3	Bit 2 X	Bit 1 Error	Bit 0 Overflow
Measured value < -10 V		0	0	1
-10 V < Measured value < 10 V	Process data	0	0	0
Measured value > +10 V		0	0	1

R33: User scaling - offset (B_w)

This register contains the offset of the user scaling.
User scaling can be activated through bit R32.0 in the feature register.

R34: User scaling - gain (A_w)

This register contains the user scaling gain; 0x0400 (1024_{dec}) corresponds to 1.
User scaling can be activated through bit R32.0 in the feature register.

R35: Threshold 1 in Y_2

If the process data are outside this threshold, the appropriate bits are set in the status byte.

R36: Threshold 2 in Y_2

If the process data are outside this threshold, the appropriate bits are set in the status byte.

6.2.9 Examples of Register Communication

In the examples, the numbering of the bytes is according to the description without Word-Alignment.

6.2.9.1 Example 1: Reading the Firmware Issue Status from Register 9 of a Terminal

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0x89 (1000 1001_{bin})	0xXX	0xXX

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 not set indicates reading the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1001_{bin} the register number 9.
- The output data word (Byte 1 and Byte 2) has no function at the reading access. If you want to change a register, you have to write the desired value into the output data word.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x89	0x33	0x41

Explanation:

- The terminal returns the value of the Control Byte in the Status Byte, as an acknowledgement.
- The terminal returns the Firmware Issue Status 0x3341 in ASCII code, in the input data word (Byte 1 and Byte 2). This has to be interpreted as ASCII code:
  - ASCII code 0x33 stands for the cipher 3
  - ASCII code 0x41 stands for the letter A

Therefore the firmware version is 3A.

6.2.9.2 Example 2: Writing to an user registers

NOTE

At normal operation all user registers other than register 31are write protected.

In order to deactivate write protection, you have to write the password (0x1235) into register 31. Write protection is activated again by writing any value other than 0x1235

Note that some of the settings that can be made in registers only become active after the next power restart (power-off/power-on) of the terminal.

I. Writing the code word (0x1235) to Register 31

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0xDF (1101 1111_{bin})	0x12	0x35

Explanation:

- Bit 0.7 set indicates: register communication active.
- Bit 0.6 set indicates: writing to the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1111_{bin} the register number 31.
- The output data word (Byte 1 und Byte 2) contains the code word (0x1235) to deactivate the write protection.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x9F (1001 1111_{bin})	0xXX	0xXX

Explanation:

- In the Status Byte, the terminal returns a value, that differs only at bit 0.6 from the value of the of the Control Byte.
- The input data word (Byte 1 and Byte 2) has no function after the the writing access. Values that might be shown are not valid!

II. Reading Register 31 (verifying the set code word)

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0x9F (1001 1111_{bin})	0xXX	0xXX

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 not set indicates reading the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1111_{bin} the register number 31.
- The output data word (Byte 1 and Byte 2) has no function at the reading access.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x9F (1001 1111_{bin})	0x12	0x35

Explanation:

- The terminal returns the value of the Control Byte in the Status Byte, as an acknowledgement.
- The terminal returns the current value of the code word register in the input data word (Byte 1 and Byte 2).

III. Writing into Register 32 (changing the content of the feature register)

Output data

Byte 0: Control byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0xE0 (1110 0000_{bin})	0x00	0x02

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 set indicates: writing to the register
- Bit 0.5 to Bit 0.0 indicates with 10 0000_{bin} the register number 32.
- The output data word (Byte 1 and Byte 2) contains the new value for the feature register.

NOTE

The given value 0x0002 is only an example!
The bits of the feature register change the properties of the terminal und and have different meanings, depending on the terminal type. Please check the description of the feature register of your terminal type (chapter register description) about the meanings of the bits in detail, before changing the values!

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0xA0 (1010 0000_{bin})	0xXX	0xXX

Explanation:

- In the Status Byte, the terminal returns a value, that differs only at bit 0.6 from the value of the of the Control Byte.
- The input data word (Byte 1 and Byte 2) has no function after the the writing access. Values that might be shown are not valid!

IV. Reading Register 32 (verifying the changed feature register)

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0xA0 (1010 0000_{bin})	0xXX	0xXX

Explanation:
- Bit 0.7 set indicates register communication active.
- Bit 0.6 not set indicates reading the register.
- Bit 0.5 to Bit 0.0 indicates with 10 0000_{bin} the register number 32.
- The output data word (Byte 1 and Byte 2) has no function at the reading access.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0xA0 (1010 0000_{bin})	0x00	0x02

Explanation:
- The terminal returns the value of the Control Byte in the Status Byte, as an acknowledgement.
- The terminal returns the current value of the feature register in the input data word (Byte 1 and Byte 2).

V. Writing to Register 31 (setting the code word back)

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0xDF (1101 1111_{bin})	0x00	0x00

Explanation:
- Bit 0.7 set indicates register communication active.
- Bit 0.6 set indicates: writing to the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1111_{bin} the register number 31.
- The output data word (Byte 1 und Byte 2) contains 0x0000 to activate the write protection again.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x9F (1001 1111_{bin})	0xXX	0xXX

Explanation:
- In the Status Byte, the terminal returns a value, that differs only at bit 0.6 from the value of the of the Control Byte.
- The input data word (Byte 1 and Byte 2) has no function after the the writing access. Values that might be shown are not valid!

7

AI2±10 DUAL-CHANNEL ANALOG INPUT TERMINAL -10 V ... +10 V

7.1 Functional description

The analog input terminal AI2±10 process signals in the range between -10 V and +10 V with a resolution of 12 bits (4095 increments). The terminal inputs are differential inputs with common ground. Due to the differential inputs, the terminals are particularly suitable for measuring earth free voltage drops. Cross-currents caused by voltage differences at the input terminals do not lead to any appreciable measurement distortion up to a difference in potential of 35 V (UCM = 35 V).

Process data output format

In the delivery state the process data are shown in two's complement form (integer -1 corresponds to 0xFFFF). Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Decimal output	Hexadecimal output
-10 V	-32768	0x8000
-5 V	-16383	0xC001
0 V	0	0x0000
5 V	16383	0x3FFF
10 V	32767	0x7FFF

LED display

The LEDs indicate the operating state of the associated terminal channels.
Green LED: RUN

- On: normal operation
- Off: Watchdog-timer overflow has occurred. If no process data are transmitted by the Bus Coupler for 100 ms, the green LEDs go out.

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X_adc: Output values of the A/D converter
Y_aus: Process data to PLC
B_a, A_a: Manufacturer gain and offset compensation (R17, R18)

B_h, A_h: Manufacturer scaling (R19, R20)
B_w, A_w: User scaling (R33, R34)

a) Neither user nor manufacturer scaling are active:
$Y\_a = (B\_a + X\_adc) * A\_a$ (1.0)
$Y\_aus = Y\_a$

b) Manufacturer scaling active: (Default setting)
$Y\_1 = B\_h + A\_h * Y\_a$ (1.1)
$Y\_aus = Y\_1$

c) User scaling active:
$Y\_2 = B\_w + A\_w * Y\_a$ (1.2)
$Y\_aus = Y\_2$

d) Manufacturer and user scaling active:
$Y\_1 = B\_h + A\_h * Y\_a$ (1.3)
$Y\_2 = B\_w + A\_w * Y\_1$ (1.4)
$Y\_aus = Y\_2$

The equations of the straight line are activated via register R32.

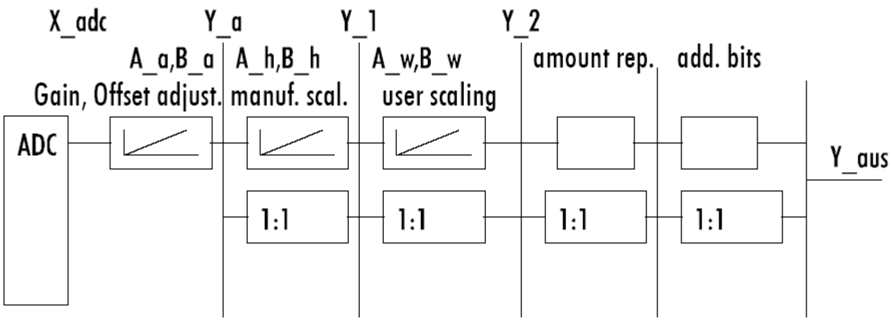


Figure 35:

7.2 Terminal configuration AI2±10

The terminal can be configured and parameterised via the internal register structure. Each terminal channel is mapped in the Bus Coupler. Depending on the type of the Bus Coupler and the mapping configuration (e.g. Motorola/Intel format, word alignment etc.) the terminal data are mapped in different ways to the Bus Coupler memory. For parameterising a terminal, the control and status byte also has to be mapped.

PK0000 Profibus coupler

For the PK0000 Profibus coupler, the master configuration should specify for which terminal channels the control and status byte is to be inserted. If the control and status byte are not evaluated, the terminals occupy 2 bytes per channel: 4 bytes of input data

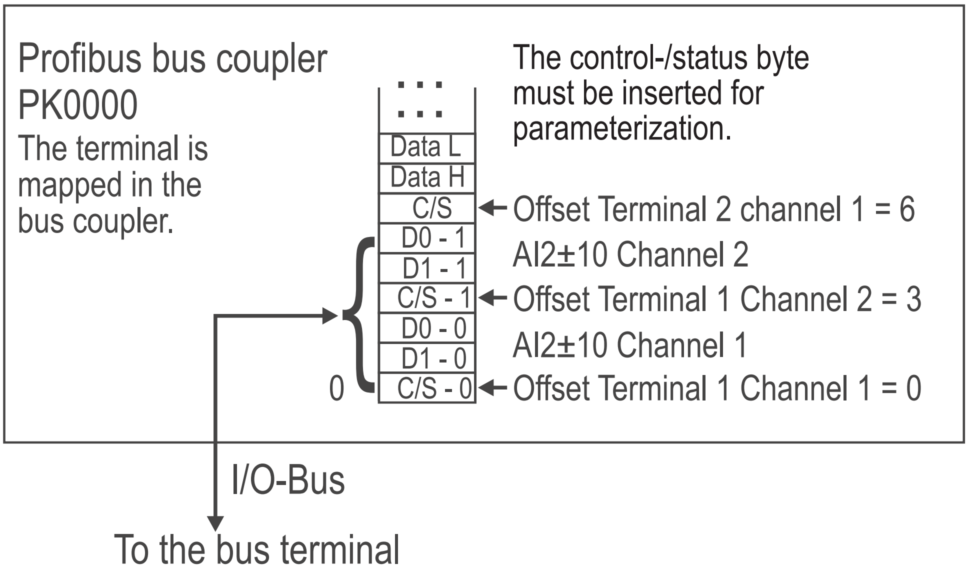


Figure 36:

Other Bus Couplers and further information

Further information about the mapping configuration of Bus Couplers (e.g. CANopen CK000x) can be found in the Appendix of the respective Bus Coupler manual under „Master configuration“.

NOTE

The Appendix contains an overview of possible mapping configurations depending on the parameters that can be set.

Parameterisation with software

The parameterisations can be carried out independently of the fieldbus system with the Baumüller configuration software ProPLC via the serial configuration interface in the Bus Coupler.

7.3 Register Description AI2±10

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals.

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the „Register Communication“ section.

7.3.1 General Description of Registers

Complex terminals that possess a processor are able to exchange data bidirectionally with the higher-level controller. These terminals are referred to below as intelligent Bus Terminals. These include analog inputs, analog outputs, counter terminals and all other parameterisable terminals.

Register Description AI2±10

The main features of the internal data structure are the same for all the intelligent terminals. This data area is organised as words and comprises 64 registers. The important data and parameters of the terminal can be read and set through this structure. It is also possible for functions to be called by means of corresponding parameters. Each logical channel in an intelligent terminal has such a structure (4-channel analog terminals therefore have 4 sets of registers).

This structure is divided into the following areas:
(A detailed list of all registers can be found in ▹Register table ◃ from page 86 onward.

Application	Register
Process variables	0-7
Type register	8-15
Manufacturer parameters	16-30
User parameters	31-47
Extended user area	48-63

Process variables

R0 to R7 Registers in the terminal's internal RAM:
The process variables can be used in addition to the actual process image. Their function is specific to the terminal.

R0 to R5: Terminal-specific registers:
The function of these registers depends on the respective terminal type (see terminal-specific register description).

R6: Diagnostic register
The diagnostic register can contain additional diagnostic information. Parity errors, for instance, that occur in serial interface terminals during data transmission are indicated here.

R7: Command register
High-Byte_Write = function parameter
Low-Byte_Write = function number
High-Byte_Read = function result
Low-Byte_Read = function number

Type register

R8 to R15: Registers in the internal ROM of the terminal:

The type and system parameters are hard programmed by the manufacturer, and the user can read them but cannot change them.

R8: Terminal type:
The terminal type in register R8 is needed to identify the terminal.

R9: Software version X.y
The software version can be read as a string of ASCII characters.

R10: Data length
R10 contains the number of multiplexed shift registers and their length in bits. The Bus Coupler sees this structure.

R11: Signal channels
Related to R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length
The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data type register

Data type register	
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure 1 byte n bytes
0x03	Word array
0x04	Structure 1 byte n words
0x05	Double word array
0x06	Structure 1 byte n double words
0x07	Structure 1 byte 1 double word
0x08	Structure 1 byte 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure 1 byte n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure 1 byte n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure 1 byte n double words with variable logical channel length

R14: reserved

R15: Alignment bits (RAM)
The alignment bits are used to place the analog terminal in the Bus Coupler on a byte boundary.

Manufacturer parameters

R16 to R30: Manufacturer parameter area (SEEROM)
The manufacturer parameters are specific for each type of terminal. They are programmed by the manufacturer, but can also be modified by the controller. The manufacturer parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out.

These registers can only be altered after a code-word has been set in R31.

User parameters

R31-R47 User parameter area (SEEROM)
The user parameters are specific for each type of terminal. They can be modified by the programmer. The user parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out. The user area is write-protected by a code-word.

NOTE

R31: Code-word register in RAM
The code-word **0x1235** must be entered here so that parameters in the user area can be modified. If any other value is entered into this register, the write-protection is active. When write protection is not active, the code word is returned when the register is read. If the write protection is active, the register contains a zero value.

R32: Feature register
This register specifies the terminal's operating modes. Thus, for instance, a user-specific scaling can be activated for the analog I/Os.

R33 to R47 Terminal-specific registers
The function of these registers depends on the respective terminal type (see terminal-specific register description).

Extended application region

R47-R63
Extended registers with additional functions.

7.3.2 Terminal-specific register description

Process variables

R0: Raw ADC value X_R
This register contains the raw ADC value with gain and offset error.

R1 to R5: reserved

R6: Diagnostic register
High byte: reserved
Low byte: status byte

Manufacturer parameters

R17: Hardware compensation - offset B_a
16 bit signed integer
This register is used for offset compensation of the terminal (Eq. 1.1).
Register value approx. 0xF0XX

R18: Hardware compensation - gain A_a
16 bit * 2^{-12}
This register is used for gain compensation of the terminal (Eq. 1.1).
1 corresponds to 0x1000.
Register value approx. 0xECXX

R19: Manufacturer scaling - offset B_h
16 bit signed integer [0x8000]
This register contains the offset of the manufacturer's equation of the straight line (1.3). The straight-line equation is activated via register R32.

R20: Manufacturer scaling - gain A_h
16 bit signed integer * 2^{-10} [0x4004]
This register contains the scale factor of the manufacturer's equation of the straight line (1.3). The straight-line equation is activated via register R32.
1 corresponds to register value 0x0400.

R21: Over range limit: OVRL
16 bit signed integer in Y_a (Eq. 1.0) [0x0FFF]

This limit value limits the maximum measuring range of the input terminal.
If it is exceeded, the associated status bit is set, and the maximum value is displayed.

R22: Under range limit: UNRL
16 bit signed integer in Y_a (Eq.1.0) [0x0000]
If the actual value falls below this limit, the associated status bit is set, and the minimum value is displayed.

R23: ADC hardware preset
[0x1000]
Initialisation of the ADC offset register.

User parameters

R32: Feature register:
[0x1106]
The feature register specifies the operating modes of the terminal.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (R33, R44) active [0]
Bit 1	1	Manufacturer scaling (R19, R20) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on.
Bit 3	1	Sign / amount representation [0] Sign / amount representation is active instead of two's-complement representation. (-1 = 0x8001)
Bit 4	1	Siemens output format [0] This bit is used for inserting status information on the lowest 3 bits (see below).
Bit 7-5	-	reserved, do not change
Bit 8	1	Over range Protection [1] If values exceed or fall below the limits of the registers OVRL (R21) and UNRL (R22), the status bits are set and the measuring range is restricted accordingly.
Bit 9	1	Limit value 1 active [0] The process data are compared with limit value 1 (R35), and appropriate status bits are set.
Bit 10	1	Limit value 2 active [0] The process data are compared with limit value 1 (R36), and appropriate status bits are set.
Bit 11	1	Filter 1 active [0] For filter characteristics see R37
Bit 15-12	-	reserved, do not change

If the Siemens output format is selected, the lowest three bits are used for status evaluation. The process data is represented in bits 15 to 3, with bit 15 representing the sign bit. Scaling of the measurement reading according to the Siemens standard has to be done via user scaling (R33, R34).

Measured value	Bit 15...3	Bit 2 X	Bit 1 ERROR	Bit 0 Overflow
Measured value >10 V		0	0	1
-10 V < measured value < 10 V	Process data	0	0	0
Measured value < -10 V		0	0	1

R33: User scaling - offset (B_w)
16 bit signed integer
This register contains the offset of the user straight-line equation (1.4). The straight-line equation is activated via register R32.

R34: User scaling - gain (A_w)
16 bit signed integer * 2^{-8}
This register contains the scale factor of the user straight-line equation (1.4). The straight-line equation is activated via register R32.

R35: Limit value 1 (Y_2)
If the process data are outside this limit value, the appropriate bits are set in the status byte.

R36: Limit value 2 (Y_2)
If the process data are outside this limit value, the appropriate bits are set in the status byte.

R37: Filter constant
[0x0000]

NOTE

This documentation applies to all terminals from software version 3x. The version number can be found within the serial number on the right-hand side face of the terminal: xxxx3xxx

Example: 52983A2A ⇒ The firmware version is **3A**.

If the internal filter is activated via R37.11, the following filter constants can be selected in R37. In the standard setting, the corresponding conversion time is 2.5 ms:

R37	Explanation	
0x0000	2nd order FIR filter.	default value
0x0100	1st order IIR filter, cut-off frequency f_g approx.1 kHz	The implemented IIR filters do not have any notch behaviour, i.e., they do not explicitly suppress any frequency.
0x0200	1st order IIR filter, cut-off frequency f_g approx. 100 Hz	
0x0300	1st order IIR filter, cut-off frequency f_g approx. 50 Hz	
0x0400	1st order IIR filter, cut-off frequency f_g approx. 20 Hz	
0x0500	1st order IIR filter, cut-off frequency f_g approx. 10 Hz	
0x0600	1st order IIR filter, cut-off frequency f_g approx. 5 Hz	
0x0700	1st order IIR filter, cut-off frequency f_g approx. 1 Hz	

R37	Explanation	
0x1000	50 Hz FIR filter Averaging over 16 values and first notch 25 Hz	In contrast to the IIR filters, FIR filter have notch behaviour. The timer settings of the notch filters are set via channel 0 of the terminal. This means that the 50 Hz filter on channel 0 and the 60 Hz filter on channel 1 cannot be active simultaneously.
0x2000	60 Hz FIR filter Averaging over 16 values and first notch 20 Hz	
Other values	No filter active	

7.3.3 Control and Status byte

Control byte for process data exchange
Gain and offset compensation

The control byte is transmitted from the controller to the terminal. It can be used

- in register mode (REG = 1_{bin}) or
- during process data exchange (REG = 0_{bin}).

The control byte can be used to carry out gain and offset compensation for the terminal (process data exchange). This requires the code word to be entered in R31. The gain and offset of the terminal can then be compensated.

The parameter will only be saved permanently once the code word is reset!

Control byte:

Bit 7 = 0_{bin}

Bit 6 = 1_{bin} Terminal compensation function is activated

Bit 4 = 1_{bin} Gain compensation

Bit 3 = 1_{bin} Offset compensation

Bit 2 = 0_{bin} Slower cycle = 1000ms
1_{bin} Fast cycle = 50ms

Bit 1 = 1_{bin} up

Bit 0 = 1_{bin} down

Status byte for process data exchange

The status byte is transmitted from the terminal to the controller. The status byte contains various status bits for the analog input channel:

Status byte:

Bit 7 = 0_{bin}

Bit 6 = 1_{bin}: ERROR - general error bit

Bit 5 | Bit 4
0_{bin} | 0_{bin} Limit value 2 not activated
0_{bin} | 1_{bin} Process data less than limit value 2
1_{bin} | 0_{bin} Process data greater than limit value 2
1_{bin} | 1_{bin} Process data equal limit value 2

Bit 3 | Bit 2
0_{bin} | 0_{bin} Limit value 1 not activated

0_{bin} | 1_{bin} Process data less than limit value 1
1_{bin} | 0_{bin} Process data greater than limit value 1
1_{bin} | 1_{bin} Process data equal limit value 1

Bit 1 = 1_{bin}: Over range
Bit 0 = 1_{bin}: Under range

7.3.4 Register communication AI1010 and AI2010

Register access via process data exchange
Bit 7 = 1_{bin}: Register mode

If bit 7 of the control byte is set, then the first two bytes of the user data are not used for exchanging process data, but are written into or read from the terminal's register set.

Bit 6=0_{bin}: read
Bit 6=1_{bin}: write

Bit 6 of the control byte specifies whether a register should be read or written. If bit 6 is not set, then a register is read out without modifying it. The value can then be taken from the input process image.

If bit 6 is set, then the user data is written into a register. As soon as the status byte has supplied an acknowledgement in the input process image, the procedure is completed (see example).

Bit 0 to 5: Address

The address of the register that is to be addressed is entered into bits 0 to 5 of the control byte.

Control byte in register mode

MSB

REG=1	**W/R**	**A5**	**A4**	**A3**	**A2**	**A1**	**A0**

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

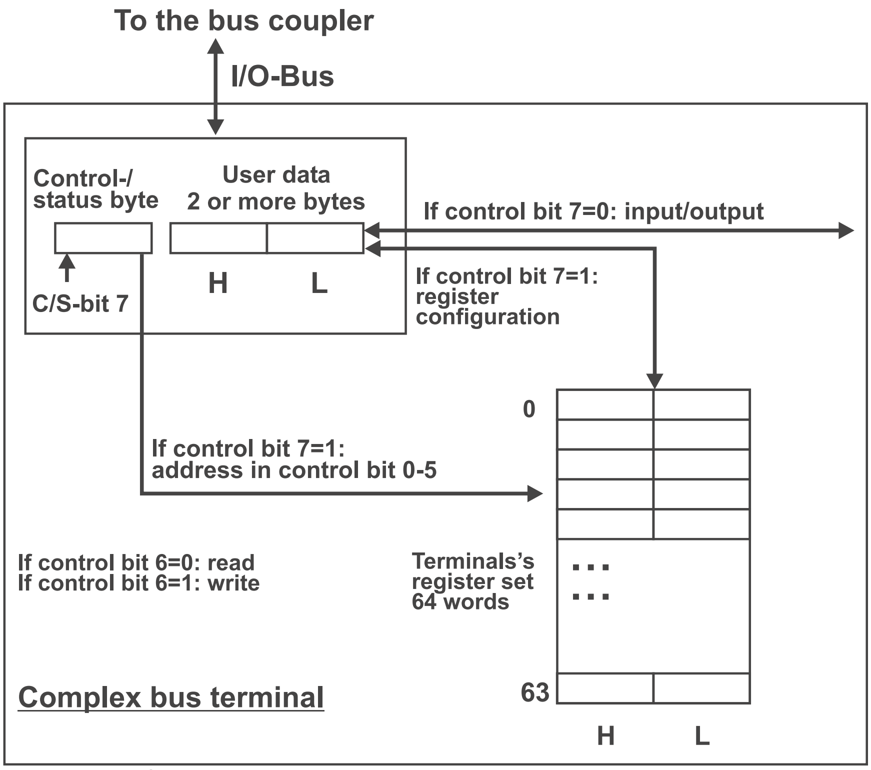


Figure 37: Complex bus terminal

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

7.4 Appendix

7.4.1 Mapping in the Bus Coupler

As already described in the Terminal Configuration section, each Bus Terminal is mapped in the Bus Coupler. In the delivery state, this mapping occurs with the default settings of the Bus Coupler for this terminal. The default setting can be changed with the Baumüller configuration software ProPLC.

If the terminals are fully evaluated, they occupy memory space in the input and output process image.

The following tables provide information about the terminal mapping, depending on the conditions set in the Bus Coupler.

Default mapping for: CANopen

Conditions	Word offset	High byte	Low byte
Complete evaluation: no Motorola format: no Word alignment: any	0	Ch1 D1	Ch1 D0
	1	Ch2 D1	Ch2 D0
	2	-	-
	3	-	-

Default mapping for: Profibus

Conditions	Word offset	High byte	Low byte
Complete evaluation: no Motorola format: yes Word alignment: any	0	Ch1 D0	Ch1 D1
	1	Ch2 D0	Ch2 D1
	2	-	-
	3	-	-

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	Ch1 CB/SB
	1	Ch2 CB/SB	Ch1 D1
	2	Ch2 D1	Ch2 D0
	3	-	-

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	Ch1 CB/SB
	1	Ch2 CB/SB	Ch1 D0
	2	Ch2 D0	Ch2 D1
	3	-	-

Legend

Complete evaluation: The terminal is mapped with control and status byte.

Motorola format: Motorola or Intel format can be set.

Word alignment: The terminal is at word limit in the Bus Coupler.

Ch n SB: status byte for channel n (appears in the input process image).
Ch n CB: control byte for channel n (appears in the output process image).

Ch n D0: channel n, data byte 0 (byte with the lowest value)
Ch n D1: channel n, data byte 1 (byte with the highest value)

"-": This byte is not used or occupied by the terminal.

7.4.2 Register table

These registers exist once for each channel.

Address	Denomination	Default value	R/W	Storage medium
R0	Raw ADC value	variable	R	RAM
R1	reserved	0x0000	R	
R2	reserved	0x0000	R	
R3	reserved	0x0000	R	
R4	reserved	0x0000	R	
R5	reserved	0x0000	R	
R6	Diagnostic register	variabel	R	RAM
R7	Command register not used	0x0000	R	
R8	Terminal type	e.g. 3002	R	ROM
R9	Software version number	0x????	R	ROM

Address	Denomination	Default value	R/W	Storage medium
R10	Multiplex shift register	0x0130	R	ROM
R11	Signal channels	0x0218	R	ROM
R12	Minimum data length	0x0098	R	ROM
R13	Data structure	0x0000	R	ROM
R14	not used	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	Hardware compensation: Offset	specific	R/W	SEEROM
R18	Hardware compensation: Gain	specific	R/W	SEEROM
R19	Manufacturer scaling: Offset	0x8000	R/W	SEEROM
R20	Manufacturer scaling: Gain	0x4004	R/W	SEEROM
R21	Over range limit	0x0FFF	R/W	SEEROM
R22	Under range limit	0x0000	R/W	SEEROM
R23	ADC hardware preset	0x1000	R/W	SEEROM
R24	reserved	0x0000	R/W	SEEROM
R25	reserved	0x0000	R/W	SEEROM
R26	reserved	0x0000	R/W	SEEROM
R27	reserved	0x0000	R/W	SEEROM
R28	reserved	0x0000	R/W	SEEROM
R29	reserved	0x0000	R/W	SEEROM
R30	reserved	0x0000	R/W	SEEROM
R31	Code word register	variable	R/W	RAM
R32	Feature register	0x1106	R/W	SEEROM
R33	User scaling: Offset	0x0000	R/W	SEEROM
R34	User scaling: Gain	0x0100	R/W	SEEROM
R35	Limit value 1	0x0000	R/W	SEEROM
R36	Limit value 2	0x0000	R/W	SEEROM
R37	reserved	0x0000	R/W	SEEROM
...	...	...	...	...
R63	reserved	0x0000	R/W	SEEROM

8

AI4±10 4-CHANNEL ANALOG INPUT TERMINAL -10 V ... +10 V

8.1 Functional description

The Analog Input Terminal AI4±10 processes signals in the range between -10 V and +10 V with a resolution of 12 bits (4095 steps). The terminals inputs are single-ended inputs with common ground potential.

Process data output format

In the delivery state the process data are shown in two's complement form ($-1_{integer}$ corresponds to 0xFFFF). Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Output decimal	Output hexadecimal
-10 V	-32768	0x8000
-5 V	-16383	0xC001
0 V	0	0x0000
+5 V	16383	0x3FFF
+10 V	32767	0x7FFF

Diagnostic LEDs

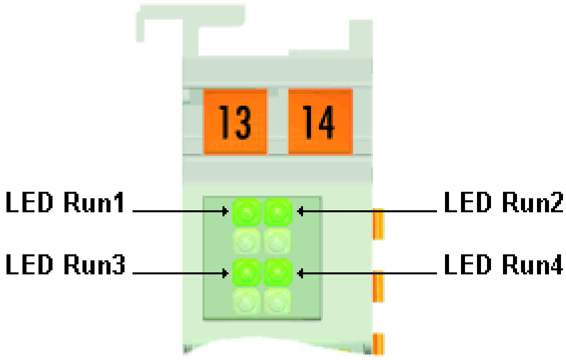


Figure 38: RUN LEDs

Meaning of LED displays

LED	**Color**	**Chan-nel**	**Status**	
			on	**off**
Run1	green	1	regular operation	A Watchdog-Timer overflow has occurred. If no process data is transmitted between control system and Bus Coupler for 100 ms, the green LEDs extinguish.
Run2		2		
Run3		3		
Run4		4		

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X_adc: Output values of the A/D converter

Y_out: Process data to PLC

B_a,A_a: Manufacturer gain and offset compensation (R17,R18)

B_h,A_h: Manufacturer scaling (R19,R20)

B_w,A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling is active:

Y_a = (B_a+X_adc) * A_a (1.0)

Y_out = Y_a

b) Manufacturer scaling active (default setting):

Y_1 = B_h + A_h * Y_a (1.1)

Y_out = Y_1

c) User scaling active:

Y_2 = B_w + A_w * Y_a (1.2)

Y_out = Y_2

d) Manufacturer and user scaling active:

$Y\_1 = B\_h + A\_h * Y\_a$ (1.3)

$Y\_2 = B\_w + A\_w * Y\_1$ (1.4)

$Y\_out = Y\_2$

The equations of the straight line are activated via register R32.

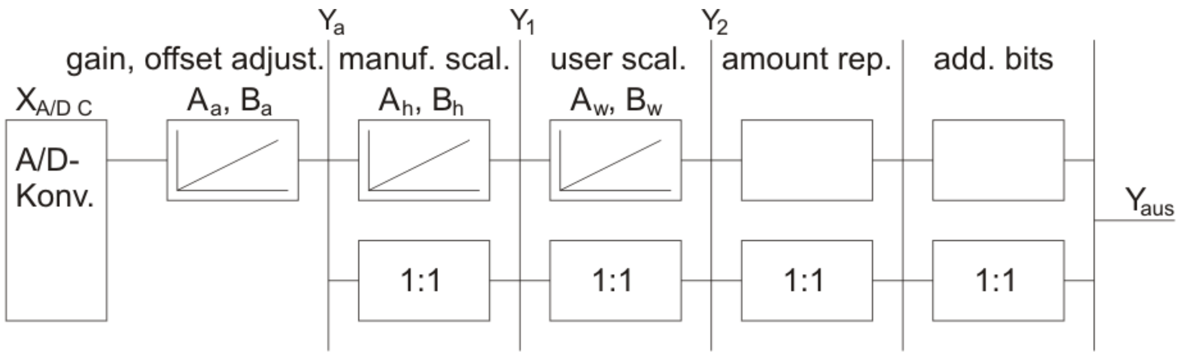


Figure39: Scaling

8.2 Access from the user program

8.2.1 Process Image

In the process image AI4±10 and AI4010 are shown with up to 12 byte input and 12 byte output data.

Format	Input data	Output data
Byte	SB1	CB1
Word	DataIN1	DataOUT1
Byte	SB2	CB2
Word	DataIN2	DataOUT2
Byte	SB3	CB3
Word	DataIN3	DataOUT3
Byte	SB4	CB4
Word	DataIN4	DataOUT4

Legende

SB n: Status byte for channel n
CB n: Control byte for channel n

DataIN n: Input data word of channel n
DataOUT n:Output data word of channel n

- The mapping of the bytes and words to the addresses of the controlling system can be found on the mapping page.
- The meaning of control und status bytes can be found on the page *control and status bytes*.
- In process data mode the analog values are transmitted within the input data words DataIN1 to DataIN4 and the output data words DataOUT1 to DataOUT4 are not used.

8.2.2 Mapping

The Bus Terminals occupy addresses within the process image of the controller. The assignment of process data (input and output data) and parameterization data (control and status bytes) to the control addresses is called mapping. The type of mapping depends on:

- the fieldbus system used
- the terminal type
- the parameterization of the bus coupler (conditions) such as
  - compact or full evaluation
  - Intel or Motorola format
  - word alignment switched on or off

The Bus Couplers (CK000x) are supplied with certain default settings. The default setting can be changed with the Baumüller configuration software ProPLC.

The following tables show the mapping depending on different conditions. For information about the contents of the individual bytes please refer to the pages *Process image and Control and status byte*.

8.2.3 Compact evaluation

For compact evaluation, the analog input terminals only occupy addresses in the input process image. Control and status bytes cannot be accessed.

Compact evaluation in Intel format

Default mapping for CANopen coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: no Word alignment: any	0	Ch1 D1	Ch1 D0	-	-
	1	Ch2 D1	Ch2 D0	-	-
	2	Ch3 D1	Ch3 D0	-	-
	3	Ch4 D1	Ch4 D0	-	-

Compact evaluation in Motorola format

Default mapping for Profibus coupler

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: yes Word alignment: any	0	Ch1 D0	Ch1 D1	-	-
	1	Ch2 D0	Ch2 D1	-	-
	2	Ch3 D0	Ch3 D1	-	-
	3	Ch4 D0	Ch4 D1	-	-

8.2.4 Complete evaluation

For complete evaluation, the analog input terminals occupy addresses in the input and output process image. Control and status bytes can be accessed.

Complete evaluation in Intel format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	SB1	Ch1 D0	CB1
	1	SB2	Ch1 D1	CB2	Ch1 D1
	2	Ch2 D1	Ch2 D0	Ch2 D1	Ch2 D0
	3	Ch3 D0	SB3	Ch3 D0	CB3
	4	SB4	Ch3 D1	CB4	Ch3 D1
	5	Ch4 D1	Ch4 D0	Ch4 D1	Ch4 D0

Complete evaluation in Motorola format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	SB1	Ch1 D1	CB1
	1	SB2	Ch1 D0	CB2	Ch1 D0
	2	Ch2 D0	Ch2 D1	Ch2 D0	Ch2 D1
	3	Ch3 D1	SB3	Ch3 D1	CB3
	4	SB4	Ch3 D0	CB4	Ch3 D0
	5	Ch4 D0	Ch4 D1	Ch4 D0	Ch4 D1

Key Complete evaluation: In addition to the process data, the control and status bytes are also mapped in the address space.

Motorola format: Motorola or Intel format can be set.

Word alignment: In order for the channel address range to commence at a word boundary, empty bytes are inserted into the process image as appropriate.

SB n: status byte for channel n (appears in the input process image).
CB n: control byte for channel n (appears in the output process image).

Ch n D0: channel n, lower-value data byte
Ch n D1: channel n, higher-value data byte

"-": This byte is not assigned or used by the terminal/module.

8.2.5 Control and Status bytes

8.2.5.1 Channel 1

Process data mode

Control byte 1 in process data mode

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal. In process data mode it has no function.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
CB1.7	RegAccess	0_{bin}	Register communication off (process data mode)
CB1.6 - CB1.0	-	0_{bin}	reserved

Status byte 1 in process data mode

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	Error	LimitValue 2 State		LimitValue 1 State		Overrange	Underrange

Legend

Bit	**Name**	**Description**	
SB1.7	RegAccess	0_{bin}	Acknowledgement for process data mode
SB1.6	Error	1_{bin}	general error bit

Bit	Name	Description	
SB1.5 - SB1.4	LimitValue 2 State	00_{bin}	Limit value 2 not activated
		01_{bin}	Process data less than limit value 2
		10_{bin}	Process data greater than limit value 2
		11_{bin}	Process data equal limit value 2
SB1.3 - SB1.2	LimitValue 1 State	00_{bin}	Limit value 1 not activated
		01_{bin}	Process data less than limit value 1
		10_{bin}	Process data greater than limit value 1
		11_{bin}	Process data equal limit value 1
SB1.1	Overrange	1_{bin}	Permissible measuring range exceeded
SB1.0	Underrange	1_{bin}	Lower measuring range limit violated

8.2.6 Register communication

Control byte 1 in register communication

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	R/W	Reg. no.					

Legend

Bit	Name	Description	
CB1.7	RegAccess	1_{bin}	Register communication switched on
CB1.6	R/W	0_{bin}	Read access
		1_{bin}	Write access
CB1.5 bis CB1.0	Reg. no.	Register number: Enter the number of the register that you ○ want to read with input data word DataIN1 or ○ want to write with output data word DataOUT1.	

Status byte 1 in register communication

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	R/W	Reg. no.					

Legend

Bit	Name	Description	
SB1.7	RegAccess	1_{bin}	Acknowledgement for register access
SB1.6	R	0_{bin}	Read access
SB1.5 bis SB1.0	Reg. no.	Number of the register that was read or written.	

8.2.6.1 Channel 2, Channel 3 und Channel 4

The control and status bytes of channels 2, 3 and 4 are structured like the control and status byte of channel 1.

8.2.7 Register overview

The following registers are used to parameterize the AI4±10. They exist once for each channel of a terminal and can be read or written by register communication using control-, status- und data bytes.

Register no.	Comment	Default value		R/W	Memory
R0	Raw value of A/D converter (X_R)	-	-	R	RAM
R1	reserved	-		-	-
...	...	...	...	...	...
R5	reserved	-	-	-	-
R6	Diagnostic register	-	-	R	RAM
R7	Command register	0x0000	0_{dec}	R/W	RAM
R8	Terminal type	0x0D4C	3404_{dec}	R	ROM
R9	Firmware revision level	e.g. 0x3141	e.g. $1A_{ASCI}$	R	ROM
R10	Data length (Multiplex shift register)	0x0230	560_{dec}	R	ROM
R11	Signal channels	0x0418	1048_{dec}	R	ROM
R12	minimum data length	0x0098	152_{dec}	R	ROM
R13	Data structure (Data type register)	0x0004	4_{dec}	R	ROM
R14	reserved	-	-	-	-
R15	Alignment register	e.g. 0x7F80	e.g. 32640_{dec}	R/W	RAM
R16	Hardware revision number	e.g. 0x0000	e.g. 0_{dec}	R/W	SEEPROM
R17	Hardware compensation: Offset (B_a)	0x0000	0_{dez}	R/W	SEEPROM
R18	Hardware compensation: Gain (A_a)	app. 0x135A	app. 4954_{dec}	R/W	SEEPROM
R19	manufacturer scaling: Offset (B_h)	0x0000	0_{dec}	R/W	SEEPROM
R20	manufacturer scaling: Gain (A_h)	typ. 0x2000	typ. 8192_{dec}	R/W	SEEPROM
R21	Over range limit	0x07FF	2047_{dec}	R/W	SEEPROM
R22	Under range limit	0xF800	63488_{dec}	R/W	SEEPROM
R23	reserved	-	-	-	-

Register no.	Comment	Default value		R/W	Memory
...	...	...	...	...	...
R30	reserved	-	-	-	-
R31	Code word register	0x0000	0_{dec}	R/W	RAM
R32	Feature register	0x0906	2310_{dec}	R/W	SEEPROM
R33	User scaling: Offset (B_w)	0x0000	0_{dec}	R/W	SEEPROM
R34	User scaling: Gain (A_w)	0x0400	1024_{dec}	R/W	SEEPROM
R35	Threshold 1 in (Y_2)	0x0000	0_{dec}	R/W	SEEPROM
R36	Threshold 2 in (Y_2)	0x0000	0_{dec}	R/W	SEEPROM
R37	Cut-off frequency of digital IIR filter	0x0100	256_{dec}	R/W	SEEPROM
R38	reserved	-	-	-	-
...		...	...	...	...
R63	reserved	-	-	-	-

8.2.8 Register Description

All registers can be read or written via register communication.

R0: Raw value A/D C

Raw value of the A/D converter (X_R)

R6: Diagnostic register

The status byte is mapped to the lower-value byte (bit 7 to bit 0) of register R6.
The higher-value byte (bit 15 to bit 8) of register R6 is reserved.

R7: Command register

The command register of AI4±10 is currently not used.

R8: Terminal description

Register R8 contains the terminal identifier. e.g.: AI4±10: 0x0D4C (3404_{dec})

R9: Firmware revision level

Register R9 contains the ASCII coding of the terminal's firmware revision level, e.g. **0x3141 (1A$_{ASCII}$)**. **'0x31'** corresponds to the ASCII character **'1'** and **'0x41'** to the ASCII character **'A'**. This value can not be changed.

R10: Data length (multiplex shift register)

R10 contains the number of multiplexed shift registers and their length in bits.

R11: Signal channels

Unlike R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length

The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data structure (data type register)

Data type register	Meaning
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure: 1 byte, n bytes
0x03	Word array
0x04	Structure: 1 byte, n words
0x05	Double word array
0x06	Structure: 1 byte, n double words
0x07	Structure: 1 byte, 1 double word
0x08	Structure: 1 byte, 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure: 1 byte, n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure: 1 byte, n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure: 1 byte, n double words with variable logical channel length

R15: Alignment register

Via the alignment register bits, the Bus Coupler arranges the address range of an analog terminal such that it starts at a byte boundary.

R16: Hardware version number

Register R16 contains the hardware revision level of the terminal; this value can not be changed.

R17: Hardware compensation - offset (B_a)

This register is used for the offset compensation of the terminal (see equation 1.1). Register value (16 bit signed integer): 0x0000 (0_{dec})

R18: Hardware compensation - gain (A_a)

This register is used for the gain compensation of the terminal (see equation 1.1). Register value (16 bit signed integer x 2^{-12}):

- AI4±10: approx. 0x135A (4954_{dec})

R19: Manufacturer scaling - offset (B_h)

This register contains the offset for the manufacturer scaling (see equation 1.3). Register value (16 bit signed integer): 0x0000 (0_{dec})
Manufacturer scaling can be activated via bit R32.1 of the feature register.

R20: Manufacturer scaling - gain (A_h)

This register contains the gain for manufacturer scaling (see equation 1.3). Register value (16 bit signed integer x 2^{-10}): typically 0x2000 (8192_{dec})
Manufacturer scaling can be activated via bit R32.1 of the feature register.

R21 Over-range limit - OvRL (Y_a)

This limit value limits the maximum measuring range of the input terminal (see equation 1.0). If it is exceeded, the associated status bit is set, and the maximum value is displayed. Register value (16 bit signed integer)

- AI4±10: 0x07FF (2047_{dec})

R22 Under-range limit - UnRL (Y_a)

If the value falls below this limit, the associated status bit is set, and the minimum value is displayed (see equation 1.0). Register value (16 bit signed integer)

- AI4±10: 0xF800 (63488_{dec})

R31: Code word register

- If you write into the user registers without first entering the user code word (0x1235) into the code word register, the terminal will not accept the supplied data.
- If you write values into the user registers and have previously entered the user code word (0x1235) in the code word register, these values are stored in the RAM registers and in the SEEPROM registers and are therefore retained if the terminal is restarted.

The code word is reset with each restart of the terminal.

R32: Feature register

The feature register specifies the terminal's configuration. Default: 0x0106 (262_{dec})

Bit	R32.15	R32.14	R32.13	R32.12	R32.11	R32.10	R32.9	R32.8
Name	-	-	-	-	enIIR	enLimit2	enLimit1	enOvRP

Bit	R32.7	R32.6	R32.5	R32.4	R32.3	R32.2	R32.1	R32.0
Name	-	-	-	enSiemens	enSignRepr	enWdTimer	enManScal	enUsrScal

Legend

Bit	Name	Description		default
R32.15	-	reserved		0_{bin}
...	...	...		...
R32.12	-	reserved		0_{bin}
R32.11	enIIR	0_{bin}	digital IIR Filter not active	1_{bin}
		1_{bin}	digital IIR Filter active	
R32.10	enLimit2	0_{bin}	Threshold 2 is not active	0_{bin}
		1_{bin}	Threshold 2 is active	
R32.9	enLimit1	0_{bin}	Threshold 1 is not active	0_{bin}
		1_{bin}	Threshold 1 is active	
R32.8	enOvRP	0_{bin}	Over-range protection is not active	1_{bin}
		1_{bin}	Over-range protection is active: If the limit values of registers OvRL (R21) and UnRL (R22) are exceeded, the associated status bits are set and the measuring range is restricted accordingly.	
R32.7	-	reserved		0_{bin}
R32.6	-	reserved		0_{bin}
R32.5	-	reserved		0_{bin}
R32.4	enSiemens	0_{bin}	Standard output format	0
		1_{bin}	Siemens output format The three bits with the lowest value are used for displaying status information (see below).	
R32.3	enSignRepr	0_{bin}	Two's complement representation is active	0_{bin}
		1_{bin}	The arithmetic sign of numerical quantities is active (-1_{dec} = 0x8001)	

Bit	Name	Description		default
R32.2	enWdTimer	0_{bin}	Watchdog timer is not active	1_{bin}
		1_{bin}	Watchdog timer is active (the watchdog is triggered if no process data are received for 100 ms)	
R32.1	enManScal	0_{bin}	Manufacturer scaling is active	1_{bin}
		1_{bin}	Manufacturer scaling is not active	
R32.0	enUsrScal	0_{bin}	User scaling is not active	0_{bin}
		1_{bin}	User scaling is active	

Siemens output format

If the Siemens output format is selected, the lowest three bits are used for status evaluation. The process data is represented in bits 15 to 3, with bit 15 representing the sign bit. Scaling of the measurement reading according to the Siemens standard has to be done via user scaling (R33, R34).

AI4±10

Measured value	Bit 15 ... 3	Bit 2 X	Bit 1 Error	Bit 0 Overflow
Measured value < -10 V		0	0	1
-10 V < Measured value < 10 V	Process data	0	0	0
Measured value > +10 V		0	0	1

R33: User scaling - offset (B_w)

This register contains the offset of the user scaling.
User scaling can be activated through bit R32.0 in the feature register.

R34: User scaling - gain (A_w)

This register contains the user scaling gain; 0x0400 (1024_{dec}) corresponds to 1.
User scaling can be activated through bit R32.0 in the feature register.

R35: Threshold 1 in Y_2

If the process data are outside this threshold, the appropriate bits are set in the status byte.

R36: Threshold 2 in Y_2

If the process data are outside this threshold, the appropriate bits are set in the status byte.

R37: Cut-off frequency of digital IIR filter

This register specifies the digital IIR filter's (first order) cut-off frequency. The IIR filter can be deactivated by bit R32.11 of the feature register.

Value	Cut-off frequency
0x0100	app. 200 Hz
0x0200	app. 100 Hz
0x0300	app. 50 Hz
0x0400	app. 20 Hz
other	no Filter active

8.2.9 Examples of Register Communication

In the examples, the numbering of the bytes is according to the description without Word-Alignment.

8.2.9.1 Example 1: Reading the Firmware Issue Status from Register 9 of a Terminal

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0x89 (1000 1001_{bin})	0xXX	0xXX

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 not set indicates reading the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1001_{bin} the register number 9.
- The output data word (Byte 1 and Byte 2) has no function at the reading access. If you want to change a register, you have to write the desired value into the output data word.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x89	0x33	0x41

Explanation:

- The terminal returns the value of the Control Byte in the Status Byte, as an acknowledgement.
- The terminal returns the Firmware Issue Status 0x3341 in ASCII code, in the input data word (Byte 1 and Byte 2). This has to be interpreted as ASCII code:
  - ASCII code 0x33 stands for the cipher 3
  - ASCII code 0x41 stands for the letter A

Therefore the firmware version is 3A.

8.2.9.2 Example 2: Writing to an user registers

NOTE

At normal operation all user registers other than register 31are write protected.

In order to deactivate write protection, you have to write the password (0x1235) into register 31. Write protection is activated again by writing any value other than 0x1235

Note that some of the settings that can be made in registers only become active after the next power restart (power-off/power-on) of the terminal.

I. Writing the code word (0x1235) to Register 31

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0xDF (1101 1111_{bin})	0x12	0x35

Explanation:

- Bit 0.7 set indicates: register communication active.
- Bit 0.6 set indicates: writing to the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1111_{bin} the register number 31.
- The output data word (Byte 1 und Byte 2) contains the code word (0x1235) to deactivate the write protection.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x9F (1001 1111_{bin})	0xXX	0xXX

Explanation:

- In the Status Byte, the terminal returns a value, that differs only at bit 0.6 from the value of the of the Control Byte.
- The input data word (Byte 1 and Byte 2) has no function after the the writing access. Values that might be shown are not valid!

II. Reading Register 31 (verifying the set code word)

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0x9F (1001 1111_{bin})	0xXX	0xXX

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 not set indicates reading the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1111_{bin} the register number 31.
- The output data word (Byte 1 and Byte 2) has no function at the reading access.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x9F (1001 1111_{bin})	0x12	0x35

Explanation:

- The terminal returns the value of the Control Byte in the Status Byte, as an acknowledgement.
- The terminal returns the current value of the code word register in the input data word (Byte 1 and Byte 2).

III. Writing into Register 32 (changing the content of the feature register)

Output data

Byte 0: Control byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0xE0 (1110 0000_{bin})	0x00	0x02

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 set indicates: writing to the register
- Bit 0.5 to Bit 0.0 indicates with 10 0000_{bin} the register number 32.
- The output data word (Byte 1 and Byte 2) contains the new value for the feature register.

NOTE

The given value 0x0002 is only an example!
The bits of the feature register change the properties of the terminal und and have different meanings, depending on the terminal type. Please check the description of the feature register of your terminal type (chapter register description) about the meanings of the bits in detail, before changing the values!

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0xA0 (1010 0000_{bin})	0xXX	0xXX

Explanation:

- In the Status Byte, the terminal returns a value, that differs only at bit 0.6 from the value of the of the Control Byte.
- The input data word (Byte 1 and Byte 2) has no function after the the writing access. Values that might be shown are not valid!

IV. Reading Register 32 (verifying the changed feature register)

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0xA0 (1010 0000_{bin})	0xXX	0xXX

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 not set indicates reading the register.
- Bit 0.5 to Bit 0.0 indicates with 10 0000_{bin} the register number 32.
- The output data word (Byte 1 and Byte 2) has no function at the reading access.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0xA0 (1010 0000_{bin})	0x00	0x02

Explanation:

- The terminal returns the value of the Control Byte in the Status Byte, as an acknowledgement.
- The terminal returns the current value of the feature register in the input data word (Byte 1 and Byte 2).

V. Writing to Register 31 (setting the code word back)

Output data

Byte 0: Control byte	Byte 1: DataOUT1, high byte	Byte 2: DataOUT1, low byte
0xDF (1101 1111_{bin})	0x00	0x00

Explanation:

- Bit 0.7 set indicates register communication active.
- Bit 0.6 set indicates: writing to the register.
- Bit 0.5 to Bit 0.0 indicates with 00 1111_{bin} the register number 31.
- The output data word (Byte 1 und Byte 2) contains 0x0000 to activate the write protection again.

Input Data (answer of the bus terminal)

Byte 0: Status byte	Byte 1: DataIN1, high byte	Byte 2: DataIN1, low byte
0x9F (1001 1111_{bin})	0xXX	0xXX

Explanation:

- In the Status Byte, the terminal returns a value, that differs only at bit 0.6 from the value of the of the Control Byte.
- The input data word (Byte 1 and Byte 2) has no function after the the writing access. Values that might be shown are not valid!

9

AI2420 Two-Channel Analog Input Terminal 4 - 20 mA

9.1 Functional description

The analog input terminals AI2420 process signals in the range between 4 and 20 mA with a resolution of 12 bits (4095 increments). They can supply the sensors from voltage fed in via the power contacts. The power contacts can optionally be supplied via the standard supply or via a feed terminal with electrical isolation.

Process data output format

In the delivery state the process data are shown in two's complement form (integer -1 corresponds to 0xFFFF). Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Output decimal	Output hexadecimal
4mA	0	0x0000
12mA	16383	0x3FFF
20mA	32767	0x7FFF

LED display

The LEDs indicate the operating state of the associated terminal channels.

Green LED: RUN

- On: normal operation
- Off: Watchdog-timer overflow has occurred. If no process data is transmitted to the bus coupler for 100 ms, the green LEDs go out.

Red LED: ERROR

- On: The limit stop of the A/D converter has been reached. The current is greater than 21.5 mA.
- Off: normal operation

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X_adc: Output values of the A/D converter
Y_aus: Process data to PLC
B_a,A_a: Manufacturer gain and offset compensation (R17,R18)

B_h,A_h: Manufacturer scaling (R19,R20)
B_w,A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling are active:
Y_a = (B_a+X_adc)* A_a (1.0)
Y_aus = Y_a

b) Manufacturer scaling active (factory setting)
Y_1 = B_h + A_h * Y_a (1.1)
Y_aus = Y_1

c) User scaling active:
Y_2 = B_w + A_w * Y_a (1.2)
Y_aus = Y_2

d) Manufacturer and user scaling active:
Y_1 = B_h + A_h * Y_a (1.3)
Y_2 = B_w + A_w * Y_1 (1.4)
Y_aus = Y_2

The equations of the straight line are activated via register R32.

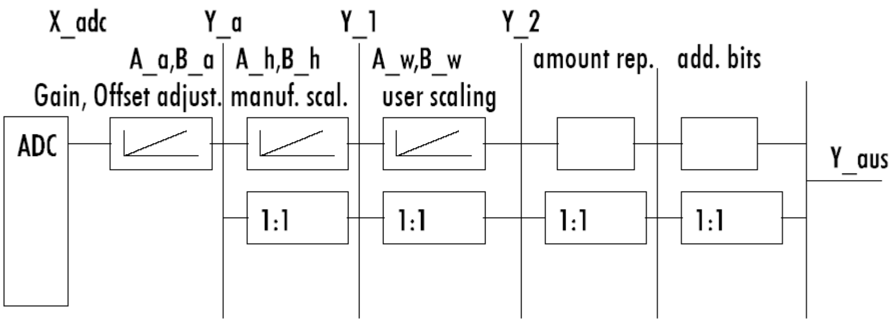


Figure 40:

9.2 Terminal configuration AI2420

The terminal can be configured and parameterised via the internal register structure. (see ▹Terminal configuration AI1010 and AI2010 ◃ from page 44 onward).

9.3 Register Description

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals (see ▹General Description of Registers ◃ from page 45 onward).

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the Register Communication section.

9.3.1 Terminal-specific register description

Process variables

R0: Raw ADC value X_R
This register contains the raw ADC value with gain and offset error.

R1-R5: Reserved

R6: Diagnostic register
High byte: reserved
Low byte: Status byte

Manufacturer parameters

R17: Hardware compensation - offset B_a
16 bit signed integer
This register is used for offset compensation of the terminal (Eq. 1.1).
Register value approx. 0xFFXX

R18: Hardware compensation - gain A_a
16 Bit * 2^{-12}
This register is used for gain compensation of the terminal (Eq. 1.1).
1 corresponds to 0x1000.
Register value approx. 0x11XX

R19: Manufacturer scaling - offset B_h
16 Bit signed integer [0x0000]
This register contains the offset of the manufacturer's equation of the straight line (1.3). The straight-line equation is activated via register R32.

R20: Manufacturer scaling - gain A_h
16 Bit signed integer * 2^{-10} [0x2002]
This register contains the scale factor of the manufacturer's equation of the straight line (1.3). The straight-line equation is activated via register R32.
1 corresponds to register value 0x0400.

R21: Over range limit: OVRL
16 bits signed integer in Y_a Eq. 1.0 [0x0FFF]
This limit value limits the maximum measuring range of the input terminal.
If it is exceeded, the associated status bit is set, and the maximum value is displayed.

R22: Under range limit: UNRL
16 bits signed integer in Y_a Eq.1.0 [0x0000]
If the actual value falls below this limit, the associated status bit is set, and the minimum value is displayed.

R23: ADC hardware preset
[0x0000]
Initialisation of the ADC offset register.

User parameters

R32: Feature register:
[0x1106]
The feature register specifies the operating modes of the terminal.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (R33, R44) active [0]
Bit 1	1	Manufacturer scaling (R19, R20) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on.

Feature bit no.		Description of the operating mode
Bit 3	1	Sign / amount representation [0] Sign / amount representation is active instead of two's-complement representation. (-1 = 0x8001)
Bit 4	1	Siemens output format [0] This bit is used for inserting status information on the lowest 3 bits (see below).
Bit 7-5	-	reserved, do not change
Bit 8	1	Over range Protection [1] If values exceed or fall below the limits of the registers OVRL (R21) and UNRL (R22), the status bits are set and the measuring range is restricted accordingly.
Bit 9	1	Limit value 1 active [0] The process data are compared with limit value 1 (R35), and appropriate status bits are set.
Bit 10	1	Limit value 2 active [0] The process data are compared with limit value 1 (R36), and appropriate status bits are set.
Bit 11	1	Filter 1 active [0], filter characteristics see R37
Bit 12	1	Break active [1], do not change
Bit 15-13	-	reserved, do not change

If the Siemens output format is selected, the lowest three bits are used for status evaluation. The process data is represented in bits 3 to 15, with bit 15 representing the sign bit. Scaling of the measurement reading according to the Siemens standard has to be done via user scaling (R33, R34).

Measured value	Bit 3-15	Bit 2 X	Bit 1 Wire breakage	Bit 0 Overflow/ Underflow
Measured value > 20 mA		0	0	1
4 mA < measured value < 20 mA	Process data	0	0	0
Measured value < 4 mA	Process data	0	1	1

R33: User scaling - offset B_w
16 bit signed integer
This register contains the offset of the user straight-line equation (1.4). The straight-line equation is activated via register R32.

R34: User scaling - gain A_w
16 Bit signed integer * 2^{-8}
This register contains the scale factor of the user straight-line equation (1.4). The straight-line equation is activated via register R32.

R35: Limit value 1 in Y_2
If the process data are outside this limit value, the appropriate bits are set in the status byte.

R36: Limit value 2 in Y_2
If the process data are outside this limit value, the appropriate bits are set in the status byte.

R37: Filter constant
[0x0000]

NOTE

This documentation applies to all terminals from software version 3x. The version number can be found within the serial number on the right-hand side face of the terminal: xxxx3xxx
Example: 52983A2A ⇒ The firmware version is **3A**.

If the internal filter is activated via R37.11, the following filter constants can be selected in R37. In the standard setting, the corresponding conversion time is 2.5 ms:

<table>
<tr><th>R37</th><th>Explanation</th><th></th></tr>
<tr><td>0x0000</td><td>2nd order FIR filter.</td><td>default value</td></tr>
<tr><td>0x0100</td><td>1st order IIR filter, cut-off frequency f_g approx.1 kHz</td><td rowspan="7">The implemented IIR filters do not have any notch behaviour, i.e., they do not explicitly suppress any frequency.</td></tr>
<tr><td>0x0200</td><td>1st order IIR filter, cut-off frequency f_g approx. 100 Hz</td></tr>
<tr><td>0x0300</td><td>1st order IIR filter, cut-off frequency f_g approx. 50 Hz</td></tr>
<tr><td>0x0400</td><td>1st order IIR filter, cut-off frequency f_g approx. 20 Hz</td></tr>
<tr><td>0x0500</td><td>1st order IIR filter, cut-off frequency f_g approx. 10 Hz</td></tr>
<tr><td>0x0600</td><td>1st order IIR filter, cut-off frequency f_g approx. 5 Hz</td></tr>
<tr><td>0x0700</td><td>1st order IIR filter, cut-off frequency f_g approx. 1 Hz</td></tr>
<tr><td>0x1000</td><td>50 Hz FIR filter
Averaging over 16 values and first notch 25 Hz</td><td rowspan="2">In contrast to the IIR filters, FIR filter have notch behaviour. The timer settings of the notch filters are set via channel 0 of the terminal. This means that the 50 Hz filter on channel 0 and the 60 Hz filter on channel 1 cannot be active simultaneously.</td></tr>
<tr><td>0x2000</td><td>60 Hz FIR filter
Averaging over 16 values and first notch 20 Hz</td></tr>
<tr><td>Other values</td><td>No filter active</td><td></td></tr>
</table>

9.3.2 Control and Status byte

Control byte for process data exchange
Gain and offset compensation

The control byte is transmitted from the controller to the terminal. It can be used

- in register mode (REG = 1bin) or
- during process data exchange (REG = 0bin).

The control byte can be used to carry out gain and offset compensation for the terminal (process data exchange). This requires the code word to be entered in R31. The gain and offset of the terminal can then be compensated.

The parameter will only be saved permanently once the code word is reset!

Control byte:

Bit 7 = 0_{bin}	
Bit 6 = 1_{bin}	Terminal compensation function is activated
Bit 4 = 1_{bin}	Gain compensation
Bit 3 = 1_{bin}	Offset compensation
Bit 2 = 0_{bin}	Slower cycle = 1000ms
1_{bin}	Fast cycle = 50ms
Bit 1 = 1_{bin}	up
Bit 0 = 1_{bin}	down

Status byte for process data exchange

The status byte is transmitted from the terminal to the controller. The status byte contains various status bits for the analog input channel:

Status byte:

Bit 7 = 0_{bin}

Bit 6 = 1_{bin}: ERROR - general error bit

Bit 5 | Bit 4	
0_{bin} | 0_{bin}	Limit value 2 not activated
0_{bin} | 1_{bin}	Process data less than limit value 2
1_{bin} | 0_{bin}	Process data greater than limit value 2
1_{bin} | 1_{bin}	Process data equal limit value 2
Bit 3 | Bit 2	
0_{bin} | 0_{bin}	Limit value 1 not activated
0_{bin} | 1_{bin}	Process data less than limit value 1
1_{bin} | 0_{bin}	Process data greater than limit value 1
1_{bin} | 1_{bin}	Process data equal limit value 1

Bit 1 = 1_{bin}: Over range
Bit 0 = 1_{bin}: Under range

9.3.3 Register communication AI2420

Register access via process data exchange
Bit 7=1_{bin}: Register mode

If bit 7 of the control byte is set, then the first two bytes of the user data are not used for exchanging process data, but are written into or read from the terminal's register set.

Bit 6=0_{bin}: read
Bit 6=1_{bin}: write

Bit 6 of the control byte specifies whether a register should be read or written. If bit 6 is not set, then a register is read out without modifying it. The value can then be taken from the input process image.

If bit 6 is set, then the user data is written into a register. As soon as the status byte has supplied an acknowledgement in the input process image, the procedure is completed (see example).

Bit 0 to 5: Address

The address of the register that is to be addressed is entered into bits 0 to 5 of the control byte.

Control byte in register modus

MSB

REG=1	W/R	A5	A4	A3	A2	A1	A0

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

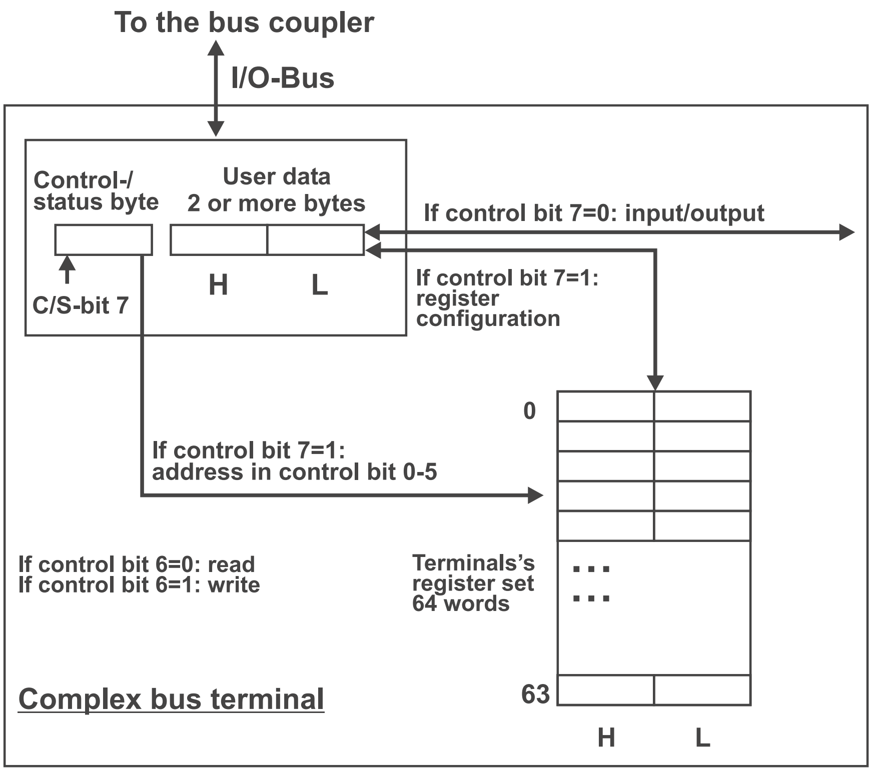


Figure 41: Complex bus terminal

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

9.4 Appendix

See ▹Appendix ◃ from page 53 onward.

Register table see ▹Register table ◃ from page 55 onward.

10

AI4420 Two-Channel Analog Input Terminal 4 - 20 mA

10.1 Functional description

The analog input terminals AI4420 process signals in the range between 4 and 20 mA with a resolution of 12 bits (4095 increments). They can supply the sensors from voltage fed in via the power contacts. The power contacts can optionally be supplied via the standard supply or via a feed terminal with electrical isolation.

Process data output format

In the delivery state the process data are shown in two's complement form (integer -1 corresponds to 0xFFFF). Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Output decimal	Output hexadecimal
4mA	0	0x0000
12mA	16383	0x3FFF
20mA	32767	0x7FFF

LED display

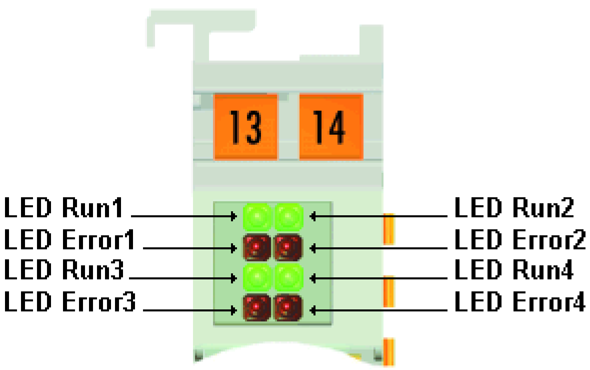


Figure 42: Run and Error LEDs

Operation status of the channels is shown by four green Run LEDs and four red Error LEDs.

LED	Color	Channel	Status	
			On	Off
Run1	green	1	regular operation	A watchdog-timer overflow has occurred. If no process data is transmitted between control system and bus coupler for 100 ms, the green LEDs extinguish.
Run2		2		
Run3		3		
Run4		4		
Error1	red	1	Current consumption of the channel higher than 20.8 mA	regular operation
Error2		2		
Error3		3		
Error4		4		

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X_{adc}: Output values of the A/D converter
Y_{aus}: Process data to PLC
B_a, A_a: Manufacturer gain and offset compensation (R17,R18)
B_h, A_h: Manufacturer scaling (R19,R20)
B_w, A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling are active:
$Y_a = (B_a + X_{adc}) * A_a$ (1.0)
$Y_{aus} = Y_a$

b) Manufacturer scaling active (factory setting)
$Y_1 = B_h + A_h * Y_a$ (1.1)
$Y_{aus} = Y_1$

c) User scaling active:
$Y_2 = B_w + A_w * Y_a$ (1.2)
$Y_{aus} = Y_2$

d) Manufacturer and user scaling active:
$Y_1 = B_h + A_h * Y_a$ (1.3)
$Y_2 = B_w + A_w * Y_1$ (1.4)
$Y_{aus} = Y_2$

The equations of the straight line are activated via register R32.

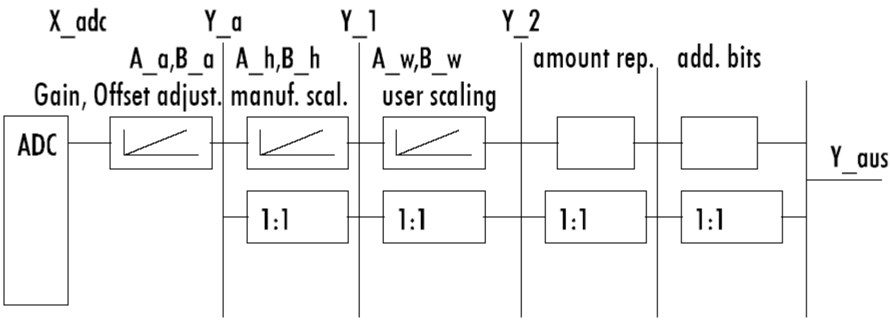


Figure 43:

10.2 Access from the user program

10.2.1 Process Image

In the process image AI4010 and AI4420 are shown with up to 12 byte input and 12 byte output data.

Format	Input data	Output data
Byte	SB1	CB1
Word	DataIN1	DataOUT1
Byte	SB2	CB2
Word	DataIN2	DataOUT2
Byte	SB3	CB3
Word	DataIN3	DataOUT3
Byte	SB4	CB4
Word	DataIN4	DataOUT4

Legende

SB n: Status byte for channel n
CB n: Control byte for channel n

DataIN n: Input data word of channel n
DataOUT n:Output data word of channel n

- The mapping of the bytes and words to the addresses of the controlling system can be found on the mapping page.
- The meaning of control und status bytes can be found on the page *control and status bytes*.
- In process data mode the analog values are transmitted within the input data words DataIN1 to DataIN4 and the output data words DataOUT1 to DataOUT4 are not used.

10.2.2 Mapping

The Bus Terminals occupy addresses within the process image of the controller. The assignment of process data (input and output data) and parameterization data (control and status bytes) to the control addresses is called mapping. The type of mapping depends on:

- the fieldbus system used
- the terminal type
- the parameterization of the bus coupler (conditions) such as
  - compact or full evaluation
  - Intel or Motorola format
  - word alignment switched on or off

The Bus Couplers (CK000x) are supplied with certain default settings. The default setting can be changed with the Baumüller configuration software ProPLC.

The following tables show the mapping depending on different conditions. For information about the contents of the individual bytes please refer to the pages *Process image and Control and status byte*.

10.2.3 Compact evaluation

For compact evaluation, the analog input terminals only occupy addresses in the input process image. Control and status bytes cannot be accessed.

Compact evaluation in Intel format

Default mapping for CANopen coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: no Word alignment: any	0	Ch1 D1	Ch1 D0	-	-
	1	Ch2 D1	Ch2 D0	-	-
	2	Ch3 D1	Ch3 D0	-	-
	3	Ch4 D1	Ch4 D0	-	-

Compact evaluation in Motorola format

Default mapping for Profibus coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: yes Word alignment: any	0	Ch1 D0	Ch1 D1	-	-
	1	Ch2 D0	Ch2 D1	-	-
	2	Ch3 D0	Ch3 D1	-	-
	3	Ch4 D0	Ch4 D1	-	-

10.2.4 Complete evaluation

For complete evaluation, the analog input terminals occupy addresses in the input and output process image. Control and status bytes can be accessed.

Complete evaluation in Intel format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	SB1	Ch1 D0	CB0
	1	SB2	Ch1 D1	CB1	Ch1 D1
	2	Ch2 D1	Ch2 D0	Ch2 D1	Ch2 D0
	3	Ch3 D0	SB3	Ch3 D0	CB2
	4	SB4	Ch3 D1	CB3	Ch3 D1
	5	Ch4 D1	Ch4 D0	Ch4 D1	Ch4 D0

Complete evaluation in Motorola format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	SB1	Ch1 D1	CB0
	1	SB2	Ch1 D0	CB1	Ch1 D0
	2	Ch2 D0	Ch2 D1	Ch2 D0	Ch2 D1
	3	Ch3 D1	SB3	Ch3 D1	CB2
	4	SB4	Ch3 D0	CB3	Ch3 D0
	5	Ch4 D0	Ch4 D1	Ch4 D0	Ch4 D1

Key

Complete evaluation: In addition to the process data, the control and status bytes are also mapped in the address space.

Motorola format: Motorola or Intel format can be set.

Word alignment: In order for the channel address range to commence at a word boundary, empty bytes are inserted into the process image as appropriate.

SB n: status byte for channel n (appears in the input process image).
CB n: control byte for channel n (appears in the output process image).

Ch n D0: channel n, lower-value data byte
Ch n D1: channel n, higher-value data byte

reserved: This byte occupies process data memory, although it has no function.

"-": This byte is not assigned or used by the terminal/module.

10.2.5 Control and Status bytes

10.2.5.1 Channel 1

Process data mode

Control byte 1 in process data mode

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal. In process data mode it has no function.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legende

Bit	**Name**	**Description**	
CB1.7	RegAccess	0_{bin}	Register communication off (process data mode)
CB1.6 - CB1.0	-	0_{bin}	reserved

Status byte 1 in process data mode

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	Error	LimitValue 2 State		LimitValue 1 State		Overrange	Underrange

Legende

Bit	**Name**	**Description**	
SB1.7	RegAccess	0_{bin}	Acknowledgement for process data mode
SB1.6	Error	1_{bin}	general error bit
SB1.5 - SB1.4	LimitValue 2 State	00_{bin}	Limit value 2 not activated
		01_{bin}	Process data less than limit value 2
		10_{bin}	Process data greater than limit value 2
		11_{bin}	Process data equal limit value 2
SB1.3 - SB1.2	LimitValue 1 State	00_{bin}	Limit value 1 not activated
		01_{bin}	Process data less than limit value 1
		10_{bin}	Process data greater than limit value 1
		11_{bin}	Process data equal limit value 1
SB1.1	Overrange	1_{bin}	Permissible measuring range exceeded
SB1.0	Underrange	1_{bin}	Lower measuring range limit violated

10.2.6 Register communication

Control byte 1 in register communication

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	R/W	Reg. no.					

Legende

Bit	**Name**	**Description**	
CB1.7	RegAccess	1_{bin}	Register communication switched on
CB1.6	R/W	0_{bin}	Read access
		1_{bin}	Write access
CB1.5 bis CB1.0	Reg. no.	Register number: Enter the number of the register that you ○ want to read with input data word DataIN1 or ○ want to write with output data word DataOUT1.	

Status byte 1 in register communication

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	R/W	Reg. no.					

Legend

Bit	**Name**	**Description**	
SB1.7	RegAccess	1_{bin}	Acknowledgement for register access
SB1.6	R	0_{bin}	Read access
SB1.5 bis SB1.0	Reg. no.	Number of the register that was read or written.	

10.2.6.1 Channel 2, Channel 3 und Channel 4

The control and status bytes of channels 2, 3 and 4 are structured like the control and status byte of channel 1.

10.2.7 Register overview

The following registers are used to parameterize the AI4010. They exist once for each channel of a terminal and can be read or written by register communication using control-, status- und data bytes.

Register no.	Comment	Default value		R/W	Memory
R0	Raw value of A/D converter (X_R)	-	-	R	RAM
R1	reserved	-		-	-
...	...	...	...	...	...
R5	reserved	-	-	-	-
R6	Diagnostic register	-	-	R	RAM
R7	Command register	0x0000	0_{dez}	R/W	RAM
R8	Terminal type	0x0D88	3464_{dez}	R	ROM
R9	Firmware revision level	z.B. 0x3141	z.B. $1A_{ASCI}$	R	ROM
R10	Data length (Multiplex shift register)	0x0230	560_{dez}	R	ROM
R11	Signal channels	0x0418	1048_{dez}	R	ROM
R12	minimum data length	0x0098	152_{dez}	R	ROM
R13	Data structure (Data type register)	0x0004	4_{dez}	R	ROM
R14	reserved	-	-	-	-
R15	Alignment register	z.B. 0x7F80	z.B. 32640_{dez}	R/W	RAM
R16	Hardware revision number	z.B. 0x0000	z.B. 0_{dez}	R/W	SEEPROM
R17	Hardware compensation: Offset (B_a)	0x0000	0_{dez}	R/W	SEEPROM
R18	Hardware compensation: Gain (A_a)	ca. 0x13A6	ca. 5030_{dez}	R/W	SEEPROM
R19	manufacturer scaling: Offset (B_h)	0x0000	0_{dez}	R/W	SEEPROM
R20	manufacturer scaling: Gain (A_h)	typ. 0x2000	typ. 8192_{dez}	R/W	SEEPROM
R21	Over range limit	0x0FFF	4095_{dez}	R/W	SEEPROM
R22	Under range limit	0x0000	0_{dez}	R/W	SEEPROM
R23	reserved	-	-	-	-
...	...	...	...	...	...
R30	reserved	-	-	-	-
R31	Code word register	0x0000	0_{dez}	R/W	RAM
R32	Feature register	0x0106	262_{dez}	R/W	SEEPROM
R33	User scaling: Offset (B_w)	0x0000	0_{dez}	R/W	SEEPROM
R34	User scaling: Gain (A_w)	0x0400	1024_{dez}	R/W	SEEPROM
R35	Threshold 1 in (Y_2)	0x0000	0_{dez}	R/W	SEEPROM
R36	Threshold 2 in (Y_2)	0x0000	0_{dez}	R/W	SEEPROM
R37	reserved	-	-	-	-
...		...	...	...	...
R63	reserved	-	-	-	-

10.2.8 Register Description

All registers can be read or written via register communication.

R0: Raw value A/D C

Raw value of the A/D converter (X_R)

R6: Diagnostic register

The status byte is mapped to the lower-value byte (bit 7 to bit 0) of register R6.

The higher-value byte (bit 15 to bit 8) of register R6 is reserved.

R7: Command register

The command register of AI4010 is currently not used.

R8: Terminal description

Register R8 contains the terminal identifier. e.g.: AI4010: 0x0D88 (3464_{dez})

R9: Firmware revision level

Register R9 contains the ASCII coding of the terminal's firmware revision level, e.g. **0x3141 (1A$_{ASCII}$)**. **'0x31'** corresponds to the ASCII character **'1'** and **'0x41'** to the ASCII character **'A'**. This value can not be changed.

R10: Data length (multiplex shift register)

R10 contains the number of multiplexed shift registers and their length in bits.

R11: Signal channels

Unlike R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length

The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data structure (data type register)

Data type register	Meaning
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure: 1 byte, n bytes

Data type register	Meaning
0x03	Word array
0x04	Structure: 1 byte, n words
0x05	Double word array
0x06	Structure: 1 byte, n double words
0x07	Structure: 1 byte, 1 double word
0x08	Structure: 1 byte, 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure: 1 byte, n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure: 1 byte, n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure: 1 byte, n double words with variable logical channel length

R15: Alignment register

Via the alignment register bits, the Bus Coupler arranges the address range of an analog terminal such that it starts at a byte boundary.

R16: Hardware version number

Register R16 contains the hardware revision level of the terminal; this value can not be changed.

R17: Hardware compensation - offset (B_a)

This register is used for the offset compensation of the terminal (see equation 1.1). Register value (16 bit signed integer): 0x0000 (0_{dec})

R18: Hardware compensation - gain (A_a)

This register is used for the gain compensation of the terminal (see equation 1.1). Register value (16 bit signed integer x 2^{-12}):

- AI4010: approx. 0x13A6 (5030_{dec})

R19: Manufacturer scaling - offset (B_h)

This register contains the offset for the manufacturer scaling (see equation 1.3). Register value (16 bit signed integer): 0x0000 (0_{dec})
Manufacturer scaling can be activated via bit R32.1 of the feature register.

R20: Manufacturer scaling - gain (A_h)

This register contains the gain for manufacturer scaling (see equation 1.3). Register value (16 bit signed integer x 2^{-10}): typically 0x2000 (8192_{dec})
Manufacturer scaling can be activated via bit R32.1 of the feature register.

R21 Over-range limit - OvRL (Y_a)

This limit value limits the maximum measuring range of the input terminal (see equation 1.0). If it is exceeded, the associated status bit is set, and the maximum value is displayed. Register value (16 bit signed integer)

- AI4010: 0x0FFF (4095_{dec})

R22 Under-range limit - UnRL (Y_a)

If the value falls below this limit, the associated status bit is set, and the minimum value is displayed (see equation 1.0). Register value (16 bit signed integer)

- AI4010: 0x0000 (0_{dec})

R31: Code word register

- If you write into the user registers without first entering the user code word (0x1235) into the code word register, the terminal will not accept the supplied data.
- If you write values into the user registers and have previously entered the user code word (0x1235) in the code word register, these values are stored in the RAM registers and in the SEEPROM registers and are therefore retained if the terminal is restarted.

The code word is reset with each restart of the terminal.

R32: Feature register

The feature register specifies the terminal's configuration. Default: 0x0106 (262_{dec})

Bit	R32.15	R32.14	R32.13	R32.12	R32.11	R32.10	R32.9	R32.8
Name	-	-	-	-	-	enLimit2	enLimit1	enOvRP

Bit	R32.7	R32.6	R32.5	R32.4	R32.3	R32.2	R32.1	R32.0
Name	-	-	-	enSiemens	enSignRepr	enWdTimer	enManScal	enUsrScal

Legend

Bit	Name	Description		default
R32.15	-	reserved		0_{bin}
...	...	...		...
R32.11	-	reserved		0_{bin}
R32.10	enLimit2	0_{bin}	Threshold 2 is not active	0_{bin}
		1_{bin}	Threshold 2 is active	
R32.9	enLimit1	0_{bin}	Threshold 1 is not active	0_{bin}
		1_{bin}	Threshold 1 is active	
R32.8	enOvRP	0_{bin}	Over-range protection is not active	1_{bin}
		1_{bin}	Over-range protection is active: If the limit values of registers OvRL (R21) and UnRL (R22) are exceeded, the associated status bits are set and the measuring range is restricted accordingly.	
R32.7	-	reserved		0_{bin}
R32.6	-	reserved		0_{bin}
R32.5	-	reserved		0_{bin}
R32.4	enSiemens	0_{bin}	Standard output format	0
		1_{bin}	Siemens output format The three bits with the lowest value are used for displaying status information (see below).	
R32.3	enSignRepr	0_{bin}	Two's complement representation is active	0_{bin}
		1_{bin}	The arithmetic sign of numerical quantities is active (-1_{dec} = 0x8001)	
R32.2	enWdTimer	0_{bin}	Watchdog timer is not active	1_{bin}
		1_{bin}	Watchdog timer is active (the watchdog is triggered if no process data are received for 100 ms)	
R32.1	enManScal	0_{bin}	Manufacturer scaling is active	1_{bin}
		1_{bin}	Manufacturer scaling is not active	
R32.0	enUsrScal	0_{bin}	User scaling is not active	0_{bin}
		1_{bin}	User scaling is active	

Siemens output format

If the Siemens output format is selected, the lowest three bits are used for status evaluation. The process data is represented in bits 15 to 3, with bit 15 representing the sign bit. Scaling of the measurement reading according to the Siemens standard has to be done via user scaling (R33, R34).

AI4010

Measured value	Bit 15 ... 3	Bit 2 X	Bit 1 Error	Bit 0 Overflow
Measured value < -10 V		0	0	1
-10 V < Measured value < 10 V	Process data	0	0	0
Measured value > +10 V		0	0	1

R33: User scaling - offset (B_w)

This register contains the offset of the user scaling.
User scaling can be activated through bit R32.0 in the feature register.

R34: User scaling - gain (A_w)

This register contains the user scaling gain; 0x0400 (1024_{dec}) corresponds to 1.
User scaling can be activated through bit R32.0 in the feature register.

R35: Threshold 1 in Y_2

If the process data are outside this threshold, the appropriate bits are set in the status byte.

R36: Threshold 2 in Y_2

If the process data are outside this threshold, the appropriate bits are set in the status byte.

Examples See ▷Examples of Register Communication ◁ from page 70 onward.

11

AO2010 Two-Channel Analog Output Terminal 0...10 V

11.1 Functional description

The analog output terminal AO2010 generates signals in the range between 0 V and 10 V with a resolution of 12 bits (4095 increments). The output voltage is electrically isolated from the I/O-Bus.

Process data input format

In the delivery state, the process data are entered in two's complement form (integer -1 corresponds to 0xFFFF). Other formats may be selected via the feature register.

hexadecimal	Process data decimal	Output voltage
0x0000	0	0 V
0x3FFF	16383	5 V
0x7FFF	32767	10 V

LED display

The RUN LEDs indicate the operating state of the associated terminal channels.

Green LED: RUN

- On: normal operation
- Off: Watchdog-timer overflow has occurred. If no process data are transmitted by the Bus Coupler for 100 ms, the green LEDs go out. A user-specified voltage will be applied to the output (see feature register).

Process data

The process data arriving from the Bus Coupler are output to the process:

X: PLC process data
B_h,A_h: Manufacturer scaling (R19,R20)
B_w, A_w: User scaling (R33,R34)
Y_dac: output value to the D/A converter

a) Neither user nor manufacturer scaling are active:
Y_dac = X (1.0)

b) Manufacturer scaling active:
Y_1 = B_h + A_h * X (1.1)
Y_dac = Y_1

c) User scaling active:
Y_2 = B_w + A_w * X (1.2)
Y_dac = Y_2

d) Manufacturer and user scaling active:
Y_1 = B_h + A_h * X (1.3)
Y_dac = B_w + A_w * Y_1 (1.4)

The equations of the straight line are activated via register R32.

11.2 Terminal configuration

The terminal can be configured and parameterised via the internal register structure (see ▹Terminal configuration AI1010 and AI2010 ◃ from page 44 onward).

11.3 Register description

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals (see ▹General Description of Registers ◃ from page 45 onward).

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the Register Communication section.

11.3.1 Terminal-specific register description

Process variables

R0-R4: reserved

R5: Raw DAC value Y_dac
The 12-bit value transferred to the D/A converter is called raw DAC value. It is calculated from the process data via the manufacturer and user scaling.

R6-R7: reserved

Manufacturer parameters

R17: Hardware compensation - offset
This register is used for hardware offset compensation (8-bit digital potentiometer) of the terminal. The register is transferred to the hardware after each processor reset or with each write access to R17. Note that the transferred offset does not correspond to the DAC values.
High byte: reserved
Low byte: Offset value (0 to 255)

R18: Hardware compensation - gain
This register is used for hardware gain compensation (8-bit digital potentiometer) of the terminal. The register is transferred to the hardware after each processor reset or with each write access to R17.
High byte: reserved
Low byte: Gain value (0 to 255)

R19: Manufacturer scaling - offset B_h
16 bit signed integer [0x0000]
This register contains the offset of the manufacturer's equation of the straight line (1.1). The straight-line equation is activated via register R32.

R20: Manufacturer scaling - gain A_h
16 bits signed integer *2^{-8} [0x0020]
This register contains the scale factor of the manufacturer's equation of the straight line (1.1). The straight-line equation is activated via register R32.
1 corresponds to register value 0x0100.

R21: Manufacturer's switch-on value
[0V], 12 bits unsigned integer in X [0x000]
The manufacturer switch-on value is applied to the terminal output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms).

The manufacturer switch-on value is activated via register R32.

User parameters

R32: Feature register:
[0x0006]
The feature register specifies the operating modes of the terminal.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (1.2) active [0]
Bit 1	1	Manufacturer scaling (1.1) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on. In the event of a watchdog overflow, either the manufacturer or the user switch-on value is applied to the terminal output.
Bit3	1	Sign / amount representation [0]
Bit4	-	reserved
Bit5	1	Calculation of absolute value [0] 0x7FFF ⇒ 10 V 0x8000 ⇒ 10 V
Bit 6 -7	-	reserved, do not change
Bit 8	0/1	0_{bin}: Manufacturer switch-on value [0] 1_{bin}: User's switch-on value
Bit 9 - 15	-	reserved, do not change

R33: User scaling - offset B_w
16 bit signed integer [0x0000]
This register contains the offset of the user straight-line equation (4.1). The straight-line equation is activated via register R32.

R34: User scaling - gain A_w
16 bits signed integer * 2^{-8} [0x0100]
This register contains the scale factor of the user straight-line equation (4.1). The straight-line equation is activated via register R32.

R35: User's switch-on value Y_2
16 bit signed integer [0x0000]
If the user switch-on value is activated in register R32, this value is applied to the terminal output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms).

11.3.2 Control and Status byte

Control byte for process data exchange
Gain and offset compensation

The control byte is transmitted from the controller to the terminal. It can be used

- in register mode (REG = 1_{bin}) or
- during process data exchange (REG = 0_{bin}).

The control byte can be used to carry out gain and offset compensation for the terminal (process data exchange). This requires the code word to be entered in R31. The gain and offset of the terminal can then be compensated.

The parameter will only be saved permanently once the code word is reset!

Control byte:

Bit7 = 0_{bin}
Bit6 = 1_{bin} Terminal compensation function is activated
Bit4 = 1_{bin} Gain compensation
Bit3 = 1_{bin} Offset compensation
Bit2 = 0_{bin} Slower cycle = 1000ms
1_{bin} Fast cycle = 50ms
Bit1 = 1_{bin} up
Bit0 = 1_{bin} down

Status byte for process data exchange

The status byte is transmitted from the terminal to the controller. For model AO2010, the status byte in the process data exchange is not used.

11.3.3 Register communication AO2010

Register access via process data exchange
Bit 7=1_{bin}: Register mode

If bit 7 of the control byte is set, then the first two bytes of the user data are not used for exchanging process data, but are written into or read from the terminal's register set.

Bit 6=0_{bin}: read
Bit 6=1_{bin}: write

Bit 6 of the control byte specifies whether a register should be read or written. If bit 6 is not set, then a register is read out without modifying it. The value can then be taken from the input process image.

If bit 6 is set, then the user data is written into a register. As soon as the status byte has supplied an acknowledgement in the input process image, the procedure is completed (see example).

Bit 0 to 5: Address

The address of the register that is to be addressed is entered into bits 0 to 5 of the control byte.

Control byte in register modus

MSB

REG=1	W/R	A5	A4	A3	A2	A1	A0

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

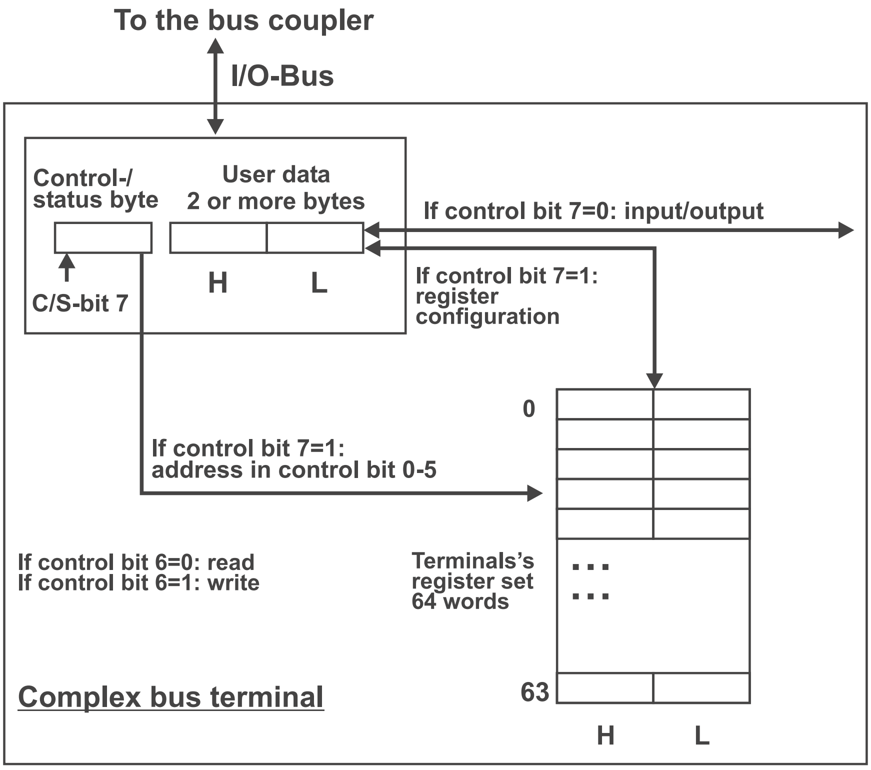


Figure 44:

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

11.4 Appendix

11.4.1 Mapping in the Bus Coupler

See ▷Appendix◁ from page 53 onward.

11.4.2 Register table

These registers exist once for each channel.

Address	Denomination	Default value	R/W	Storage medium
R0	reserved	0x0000	R	
R1	reserved	0x0000	R	
R2	reserved	0x0000	R	
R3	reserved	0x0000	R	
R4	reserved	0x0000	R	
R5	Raw DAC value	variable	R	RAM
R6	Diagnostic register not used	0x0000	R	RAM

Address	Denomination	Default value	R/W	Storage medium
R7	Command register not used	0x0000	R	
R8	Terminal type	e.g. 4002	R	ROM
R9	Software version number	0x????	R	ROM
R10	Multiplex shift register	0x0218	R	ROM
R11	Signal channels	0x0218	R	ROM
R12	Minimum data length	0x9800	R	ROM
R13	Data structure	0x0000	R	ROM
R14	reserved	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	Hardware compensation: Offset	specific	R/W	SEEROM
R18	Hardware compensation: Gain	specific	R/W	SEEROM
R19	Manufacturer scaling: Offset	0x0000	R/W	SEEROM
R20	Manufacturer scaling: Gain	0x0020	R/W	SEEROM
R21	Manufacturer scaling	0x0000	R/W	SEEROM
R22	reserved	0x0000	R/W	SEEROM
R23	reserved	0x0000	R/W	SEEROM
R24	reserved	0x0000	R/W	SEEROM
R25	reserved	0x0000	R/W	SEEROM
R26	reserved	0x0000	R/W	SEEROM
R27	reserved	0x0000	R/W	SEEROM
R28	reserved	0x0000	R/W	SEEROM
R29	reserved	0x0000	R/W	SEEROM
R30	reserved	0x0000	R/W	SEEROM
R31	Code word register	variabel	R/W	RAM
R32	Feature register	0x0006	R/W	SEEROM
R33	User scaling: Offset	0x0000	R/W	SEEROM
R34	User scaling: Gain	0x0100	R/W	SEEROM
R35	User switch-on value	0x0000	R/W	SEEROM
R36	reserved	0x0000	R/W	SEEROM
...	...	...	...	...
R63	reserved	0x0000	R/W	SEEROM

12

AO4010 FOUR CHANNEL ANALOG OUTPUT TERMINAL 0...10 V

12.1 Functional description

The analog output terminal AO4010 generates signals in the range between 0 V and 10 V with a resolution of 12 bits (4095 increments). The terminal outputs are single ended outputs with common ground.

Process data input format

In the delivery state, the process data are entered in two's complement form (integer -1 corresponds to 0xFFFF). Other formats may be selected via the feature register (e.g. sign/amount representation, Siemens format).

hexadecimal	Process data decimal	Output voltage
0x0000	0	0 V
0x3FFF	16383	5 V
0x7FFF	32767	10 V

LED display

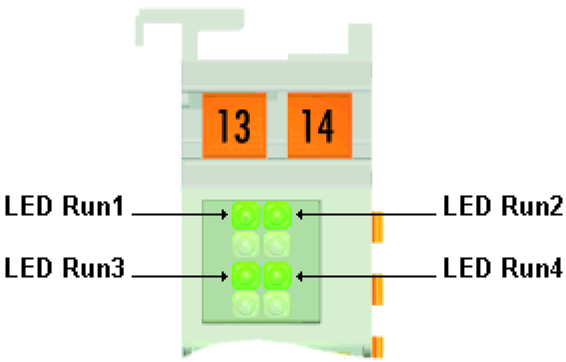


Figure 45: RUN-LEDs

Operation status of the channels is shown by four green Run LEDs.

LED	Color	Channel	Status	
			On	**Off**
Run1	green	1	regular operation	A Watchdog-Timer overflow has occurred. If no process data is transmitted between control system and Bus Coupler for 100 ms, the green LEDs extinguish.
Run2		2		
Run3		3		
Run4		4		

Process data equitation

The process data that are transferred to the Bus Terminal are calculated using the following equations:

X: PLC Process data

Y_dac: Process data to D/A converter

B_a,A_a: Manufacturer gain and offset compensation (R17,R18)

B_h,A_h: Manufacturer scaling (R19,R20)

B_w,A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling is active:

Y_dac = X x A_a + B_a (1.0)

b) Manufacturer scaling active (default setting):

Y_1 = B_h + A_h * X (1.1)

Y_dac = Y_1 * A_a + B_a

c) User scaling active:

Y_2 = B_w + A_w * X (1.2)

Y_dac = Y_2 * A_a + B_a

d) Manufacturer and user scaling active:

Y_1 = B_h + A_h * X (1.3)

Y_2 = B_w + A_w * Y_1 (1.4)

Y_dac = Y_2 * A_a + B_a

The equations of the straight line are activated via register R32.

12.2 Access from the User Program

12.2.1 Process image

In the process image AO4010 as well as AO4420 are shown with up to 12 byte input and 12 byte output data.

Format	Input data	Output data
Byte	SB1	CB1
Word	DataIN1	DataOUT1
Byte	SB2	CB2
Word	DataIN2	DataOUT2
Byte	SB3	CB3
Word	DataIN3	DataOUT3
Byte	SB4	CB4
Word	DataIN4	DataOUT4

Legend

SB n: Status byte for channel n
CB n: Control byte for channel n

DataIN n: Input data word of channel n
DataOUT n:Output data word of channel n

- The mapping of the bytes and words to the addresses of the controlling system can be found on the mapping page.
- The meaning of control und status bytes can be found on the page *control and status bytes*.
- In process data mode the analog values are transmitted within the input data words DataIN1 to DataIN4 and the output data words DataOUT1 to DataOUT4 are not used.

12.2.2 Mapping

The Bus Terminals occupy addresses within the process image of the controller. The assignment of process data (input and output data) and parameterization data (control and status bytes) to the control addresses is called mapping. The type of mapping depends on:

- the fieldbus system used
- the terminal type
- the parameterization of the bus coupler (conditions) such as
  - compact or full evaluation
  - Intel or Motorola format
  - word alignment switched on or off

The Bus Couplers (CK000x) are supplied with certain default settings. The default setting can be changed with the Baumüller configuration software ProPLC.

The following tables show the mapping depending on different conditions. For information about the contents of the individual bytes please refer to the pages *Process image and Control and status byte*.

12.2.3 Compact evaluation

For compact evaluation, the analog output terminals only occupy addresses in the output process image. Control and status bytes cannot be accessed.

Compact evaluation in Intel format

Default mapping for CANopen coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: no Word alignment: any	0	-	-	Ch1 D1	Ch1 D0
	1	-	-	Ch2 D1	Ch2 D0
	2	-	-	Ch3 D1	Ch3 D0
	3	-	-	Ch4 D1	Ch4 D0

Compact evaluation in Motorola format

Default mapping for Profibus coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: yes Word alignment: any	0	-	-	Ch1 D0	Ch1 D1
	1	-	-	Ch2 D0	Ch2 D1
	2	-	-	Ch3 D0	Ch3 D1
	3	-	-	Ch4 D0	Ch4 D1

12.2.4 Complete evaluation

For complete evaluation, the analog output terminals occupy addresses in the input and output process image. Control and status bytes can be accessed.

Complete evaluation in Intel format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	SB1	Ch1 D0	CB1
	1	SB2	Ch1 D1	CB2	Ch1 D1
	2	Ch2 D1	Ch2 D0	Ch2 D1	Ch2 D0
	3	Ch3 D0	SB3	Ch3 D0	CB3
	4	SB4	Ch3 D1	CB4	Ch3 D1
	5	Ch4 D1	Ch4 D0	Ch4 D1	Ch4 D0

Complete evaluation in Motorola format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	SB1	Ch1 D1	CB1
	1	SB2	Ch1 D0	CB2	Ch1 D0
	2	Ch2 D0	Ch2 D1	Ch2 D0	Ch2 D1
	3	Ch3 D1	SB3	Ch3 D1	CB3
	4	SB4	Ch3 D0	CB4	Ch3 D0
	5	Ch4 D0	Ch4 D1	Ch4 D0	Ch4 D1

Key

Complete evaluation: In addition to the process data, the control and status bytes are also mapped in the address space.

Motorola format: Motorola or Intel format can be set.

Word alignment: In order for the channel address range to commence at a word boundary, empty bytes are inserted into the process image as appropriate.

SB n: status byte for channel n (appears in the input process image).
CB n: control byte for channel n (appears in the output process image).

Ch n D0: channel n, lower-value data byte
Ch n D1: channel n, higher-value data byte

reserved: This byte occupies process data memory, although it has no function.

"-": This byte is not assigned or used by the terminal/module.

12.2.5 Control and Status bytes

12.2.5.1 Channel 1

Process data mode

Control byte 1 in process data mode

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal. In process data mode it has no function.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
CB1.7	RegAccess	0_{bin}	Register communication off (process data mode)
CB1.6 - CB1.0	-	0_{bin}	reserved

Status byte 1 in process data mode

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller. In process data mode it has no function.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
SB1.7	RegAccess	0_{bin}	Acknowledgement for process data mode
SB1.6 - SB1.0	-	0_{bin}	reserved

12.2.5.2 Register communication

Control byte 1 in register communication

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	R/W	Reg-Nr.					

Legend

Bit	Name	Description	
CB1.7	RegAccess	1_{bin}	Register communication switched on
CB1.6	R/W	0_{bin}	Read access
		1_{bin}	Write access
CB1.5 to CB1.0	Reg-Nr.	Register number: Enter the number of the register that you ○ want to read with input data word DataIN1 or ○ want to write with output data word DataOUT1.	

Status byte 1 in register communication

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	R/W	Reg-Nr.					

Legend

Bit	Name	Description	
SB1.7	RegAccess	1_{bin}	Acknowledgement for register access
SB1.6	R	0_{bin}	Read access
SB1.5 to SB1.0	Reg-Nr.	Number of the register that was read or written.	

12.2.5.3 Channel 2, channel 3 und channel 4

The control and status bytes of channels 2, 3 and 4 are structured like the control and status byte of channel 1.

12.2.6 Register overview

The following registers are used to parameterize the AO4010. They exist once for each channel of a terminal and can be read or written by register communication using control-, status- und data bytes.

Address	Denomination	Default value		R/W	Storage medium
R0	Process data for D/A C	-	-	R	RAM
R1	reserved	-		-	-
...	...	...	...	...	...
R5	reserved	-	-	-	-
R6	Diagnostic register (not used)	-	-	R	RAM
R7	Command register (not used)	0x0000	0_{dec}	R/W	RAM
R8	Terminal type	0x1134	4404_{dec}	R	ROM

Address	Denomination	Default value		R/W	Storage medium
R9	Firmware revision level	e.g. 0x3141	e.g. $1A_{ASCI}$	R	ROM
R10	Data length (Multiplex shift register)	0x0230	560_{dec}	R	ROM
R11	Signal channels	0x0418	1048_{dec}	R	ROM
R12	Minimum data length	0x9800	38912_{dec}	R	ROM
R13	Data structure (Data type register)	0x0004	4_{dec}	R	ROM
R14	reserved	-	-	-	-
R15	Alignment register	e.g. 0x7F80	e.g. 32640_{dec}	R/W	RAM
R16	Hardware revision number	e.g. 0x0000	e.g. 0_{dec}	R/W	SEEPROM
R17	Hardware compensation: offset (B_a)	0x0001	1_{dec}	R/W	SEEPROM
R18	Hardware compensation: gain (A_a)	typ. 0x0E99	typ. 3737_{dec}	R/W	SEEPROM
R19	Manufacturer scaling: offset (B_h)	0x0000	0_{dec}	R/W	SEEPROM
R20	Manufacturer scaling: gain (A_h)	typ. 0x0020	typ. 32_{dec}	R/W	SEEPROM
R21	Manufacturer switch-on value	0x0000	0_{dec}	R/W	SEEPROM
R22	reserved	-	-	-	-
R23	reserved	-	-	-	-
...	...	...	...	...	...
R30	reserved	-	-	-	-
R31	Code word register	0x0000	0_{dec}	R/W	RAM
R32	Feature register	0x0006	6_{dec}	R/W	SEEPROM
R33	User scaling: offset (B_w)	0x0000	0_{dec}	R/W	SEEPROM
R34	User scaling: gain (A_w)	0x0100	256_{dec}	R/W	SEEPROM
R35	User switch-on value (Y_2)	0x0000	0_{dec}	R/W	SEEPROM
R36	reserved	-	-	-	-
...	reserved	...	...	...	...
R63	reserved	-	-	-	-

12.2.7 Register Description

All registers can be read or written via register communication.

R0: Raw value A/D C

Process data, delivered to the the D/A converter

R6: Diagnostic register

The diagnostic register of AO4010 is currently not used.

R7: Command register

The command register of AO4010 is currently not used.

R8: Terminal description

Register R8 contains the terminal identifier. e.g.: AO4010: 0x1134 (4404_{dec})

R9: Firmware revision level

Register R9 contains the ASCII coding of the terminal's firmware revision level, e.g. **0x3141** ($1A_{ASCII}$). **'0x31'** corresponds to the ASCII character **'1'** and **'0x41'** to the ASCII character **'A'**. This value can not be changed.

R10: Data length (multiplex shift register)

R10 contains the number of multiplexed shift registers and their length in bits.

R11: Signal channels

Unlike R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length

The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data structure (data type register)

Data type register	Meaning
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure: 1 byte, n bytes
0x03	Word array
0x04	Structure: 1 byte, n words
0x05	Double word array
0x06	Structure: 1 byte, n double words
0x07	Structure: 1 byte, 1 double word
0x08	Structure: 1 byte, 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure: 1 byte, n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length

0x14	Structure: 1 byte, n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure: 1 byte, n double words with variable logical channel length

R15: Alignment register

Via the alignment register bits, the Bus Coupler arranges the address range of an analog terminal such that it starts at a byte boundary.

R16: Hardware version number

Register R16 contains the hardware revision level of the terminal; this value can not be changed.

R17: Hardware compensation - offset (B_a)

This register is used for the offset compensation of the terminal (see equation 1.1). Register value (16 bit signed integer). Default: 0x0001 (1_{dec})

R18: Hardware compensation - gain (A_a)

This register is used for the gain compensation of the terminal (see equation 1.1). Register value (16 bit unsigned integer x 2^{-12}). Default: typically 0x0E99 (3737_{dec})

R19: Manufacturer scaling - offset (B_h)

This register contains the offset for the manufacturer scaling (see equation 1.3). Register value (16 bit signed integer). Default: 0x0000 (0_{dec})

Manufacturer scaling can be activated via bit R32.1 of the feature register.

R20: Manufacturer scaling - gain (A_h)

This register contains the gain for manufacturer scaling (see equation 1.3). Register value (16 bit unsigned integer x 2^{-8}). Default: typically 0x2000 (8192_{dec})

Manufacturer scaling can be activated via bit R32.1 of the feature register.

R21 Manufacturer activation value

The terminal applies the manufacturer activation value to its output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms) has occurred. Register value (16 Bit signed Integer).

R31: Kodewort-Register

- If you write into the user registers without first entering the user code word (0x1235) into the code word register, the terminal will not accept the supplied data.

- If you write values into the user registers and have previously entered the user code word (0x1235) in the code word register, these values are stored in the RAM registers and in the SEEPROM registers and are therefore retained if the terminal is restarted.

The code word is reset with each restart of the terminal.

R32: Feature register

The feature register specifies the terminal's configuration. Default: 0x0006 (6_{dec})

Bit	R32.15	R32.14	R32.13	R32.12	R32.11	R32.10	R32.9	R32.8
Name	-	-	-	-	-	-	-	enUserActValue

Bit	R32.7	R32.6	R32.5	R32.4	R32.3	R32.2	R32.1	R32.0
Name	-	-	enSignRepr	-	enSignAmRepr	enWdTimer	enManScal	enUsrScal

Legend

Bit	**Name**	**Description**		**default**
R32.15	-	reserved		0_{bin}
...	...	...		...
R32.9	-	reserved		0_{bin}
R32.8	enUserActValue	0_{bin}	Manufacturer activation value active	0_{bin}
		1_{bin}	User activation value active:	
R32.7	-	reserved		0_{bin}
R32.6	-	reserved		0_{bin}
R32.5	enSignRepr	0_{bin}	Signed representation is not active	0_{bin}
		1_{bin}	Signed representation is active	
R32.4	-	reserved		0_{bin}
R32.3	enSignAmRepr	0_{bin}	Two's complement representation is active	0_{bin}
		1_{bin}	The arithmetic sign of numerical quantities is active (-1_{dec} = 0x8001)	
R32.2	enWdTimer	0_{bin}	Watchdog timer is not active	1_{bin}
		1_{bin}	Watchdog timer is active (the watchdog is triggered if no process data are received for 100 ms)	
R32.1	enManScal	0_{bin}	Manufacturer scaling is active	1_{bin}
		1_{bin}	Manufacturer scaling is not active	
R32.0	enUsrScal	0_{bin}	User scaling is not active	0_{bin}
		1_{bin}	User scaling is active	

R33: User scaling - offset (B_w)

This register contains the offset of the user scaling.
User scaling can be activated through bit R32.0 in the feature register.

R34: User scaling - gain (A_w)

This register contains the user scaling gain. Default: 0x0100 (256_{dec}).
User scaling can be activated through bit R32.0 in the feature register.

R35: User activation value

If the user activation value has been activated by bit R32.8 of the feature register, the terminal applies the user activation value instead of the manufacturer activation value to its output if a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms) happens.

Examples

See ▷Examples of Register Communication ◁ from page 70 onward.

13

AO2±10 Two-Channel Analog Output Terminal -10 V ... +10 V

13.1 Functional description

The analog output terminal AO2±10 generates signals in the range between -10 V and +10 V with a resolution of 12 bits (4095 increments). The output voltage is electrically isolated from the I/O-Bus.

Process data input format

In the delivery state, the process data are entered in two's complement form (integer -1 corresponds to 0xFFFF). Other formats may be selected via the feature register.

Process data		
hexadecimal	**decimal**	**Output voltage**
0x8001	-32767	-10 V
0xC001	-16383	-5 V
0x0000	0	0 V
0x3FFF	16383	5 V
0x7FFF	32767	10 V

LED display

Both RUN LEDs indicate the operating state of the associated terminal channels.

Green LED: RUN

- On: normal operation
- Off: Watchdog-timer overflow has occurred. If no process data are transmitted by the Bus Coupler for 100 ms, the green LEDs go out. A user-specified voltage will be applied to the output (see feature register).

Process data

The process data arriving from the Bus Coupler are output to the process:

X: PLC process data
B_h,A_h: Manufacturer scaling (R19,R20)
B_w, A_w: User scaling (R33,R34)
Y_dac: output value to the D/A converter

a) Neither user nor manufacturer scaling are active:
Y_dac = X (1.0)

b) Manufacturer scaling active:
Y_1 = B_h + A_h * X (1.1)
Y_dac = Y_1

c) User scaling active:
Y_2 = B_w + A_w * X (1.2)
Y_dac = Y_2

d) Manufacturer and user scaling active:
Y_1 = B_h + A_h * X (1.3)
Y_dac = B_w + A_w * Y_1 (1.4)

The equations of the straight line are activated via register R32.

13.2 Terminal configuration

The terminal can be configured and parameterised via the internal register structure. Each terminal channel is mapped in the Bus Coupler. Depending on the type of the Bus Coupler and the mapping configuration (e.g. Motorola/Intel format, word alignment etc.) the terminal data are mapped in different ways to the Bus Coupler memory. For parameterising a terminal, the control and status byte also has to be mapped.

PK0000 Profibus coupler

For the PK0000 Profibus coupler, the master configuration should specify for which terminal channels the control and status byte is to be inserted. If the control and status byte are not evaluated, the terminals occupy 2 bytes per channel: 4 bytes of input data

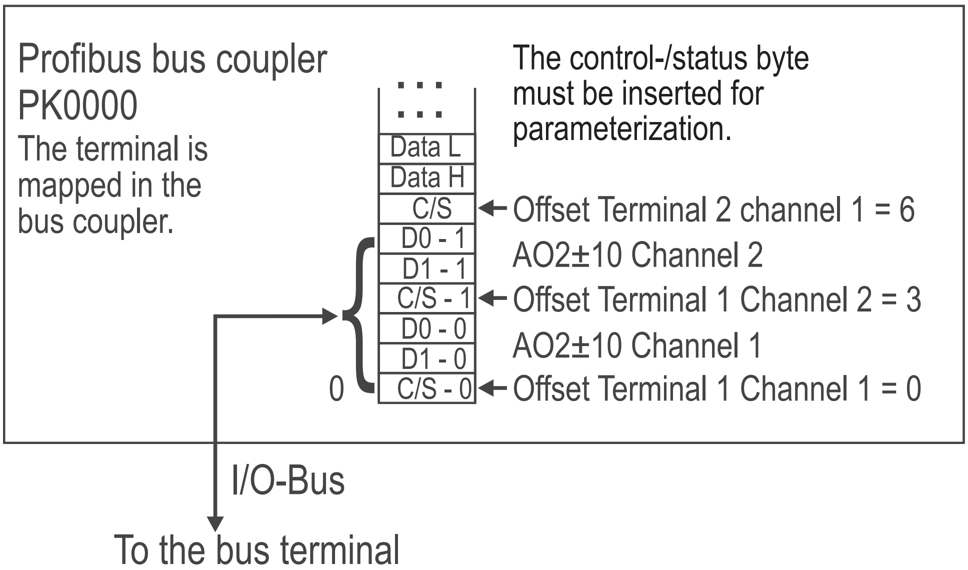


Figure 46:

Other Bus Couplers and further information

Further information about the mapping configuration of Bus Couplers (e.g. CANopen CK000x) can be found in the Appendix of the respective Bus Coupler manual under „Master configuration“.

NOTE

The Appendix contains an overview of possible mapping configurations depending on the parameters that can be set.

Parameterisation with software

The parameterisations can be carried out independently of the fieldbus system with the Baumüller configuration software ProPLC via the serial configuration interface in the Bus Coupler.

13.3 Register description

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals (see ▷General Description of Registers ◁ from page 45 onward).

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the Register Communication section.

13.3.1 Terminal-specific register description

Process variables

R0-R4: reserved

R5: Raw DAC value Y_dac
The 12-bit value transferred to the D/A converter is called raw DAC value. It is calculated from the process data via the manufacturer and user scaling.

R6-R7: reserved

Manufacturer parameters

R17: Hardware compensation - offset
This register is used for hardware offset compensation (8-bit digital potentiometer) of the terminal. The register is transferred to the hardware after each processor reset or with each write access to R17. Note that the transferred offset does not correspond to the DAC values.
High byte: reserved
Low byte: Offset value (0 to 255)

R18: Hardware compensation - gain
This register is used for hardware gain compensation (8-bit digital potentiometer) of the terminal. The register is transferred to the hardware after each processor reset or with each write access to R17.
High byte: reserved
Low byte: Gain value (0 to 255)

R19: Manufacturer scaling - offset B_h
16 bit signed integer [0x0000]
This register contains the offset of the manufacturer's equation of the straight line (1.1). The straight-line equation is activated via register R32.

R20: Manufacturer scaling - gain A_h
16 bits signed integer $*2^{-8}$ [0x0020]
This register contains the scale factor of the manufacturer's equation of the straight line

(1.1). The straight-line equation is activated via register R32.
1 corresponds to register value 0x0100.

R21: Manufacturer's switch-on value
[0V], 12 bits unsigned integer in X [0x000]
The manufacturer switch-on value is applied to the terminal output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms).

The manufacturer switch-on value is activated via register R32.

User parameters

R32: Feature register:
[0x0006]
The feature register specifies the operating modes of the terminal.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (1.2) active [0]
Bit 1	1	Manufacturer scaling (1.1) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on. In the event of a watchdog overflow, either the manufacturer or the user switch-on value is applied to the terminal output.
Bit3	1	Sign / amount representation [0]
Bit 4 -7	-	reserved, do not change
Bit 8	0/1	0_{bin}: Manufacturer switch-on value [0] 1_{bin}: User's switch-on value
Bit 9 - 15	-	reserved, do not change

R33: User scaling - offset B_w
16 bit signed integer [0x0000]
This register contains the offset of the user straight-line equation (4.1). The straight-line equation is activated via register R32.

R34: User scaling - gain A_w
16 bits signed integer * 2^{-8} [0x0100]
This register contains the scale factor of the user straight-line equation (4.1). The straight-line equation is activated via register R32.

R35: User's switch-on value Y_2
16 bit signed integer [0x0000]
If the user switch-on value is activated in register R32, this value is applied to the terminal output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms).

13.3.2 Control and Status byte

Control byte for process data exchange Gain and offset compensation

The control byte is transmitted from the controller to the terminal. It can be used

- in register mode (REG = 1_{bin}) or
- during process data exchange (REG = 0_{bin}).

The control byte can be used to carry out gain and offset compensation for the terminal (process data exchange). This requires the code word to be entered in R31. The gain and offset of the terminal can then be compensated.

The parameter will only be saved permanently once the code word is reset!

Control byte:

Bit7 = 0_{bin}
Bit6 = 1_{bin} Terminal compensation function is activated
Bit4 = 1_{bin} Gain compensation
Bit3 = 1_{bin} Offset compensation
Bit2 = 0_{bin} Slower cycle = 1000ms
1_{bin} Fast cycle = 50ms
Bit1 = 1_{bin} up
Bit0 = 1_{bin} down

Status byte for process data exchange The status byte is transmitted from the terminal to the controller. For model AO2±10, the status byte in the process data exchange is not used.

13.3.3 Register communication AO2±10

Register access via process data exchange Bit 7=1_{bin}: Register mode If bit 7 of the control byte is set, then the first two bytes of the user data are not used for exchanging process data, but are written into or read from the terminal's register set.

Bit 6=0_{bin}: read Bit 6=1_{bin}: write Bit 6 of the control byte specifies whether a register should be read or written. If bit 6 is not set, then a register is read out without modifying it. The value can then be taken from the input process image.

If bit 6 is set, then the user data is written into a register. As soon as the status byte has supplied an acknowledgement in the input process image, the procedure is completed (see example).

Bit 0 to 5: Address The address of the register that is to be addressed is entered into bits 0 to 5 of the control byte.

Control byte in register modus

MSB

REG=1	**W/R**	**A5**	**A4**	**A3**	**A2**	**A1**	**A0**

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

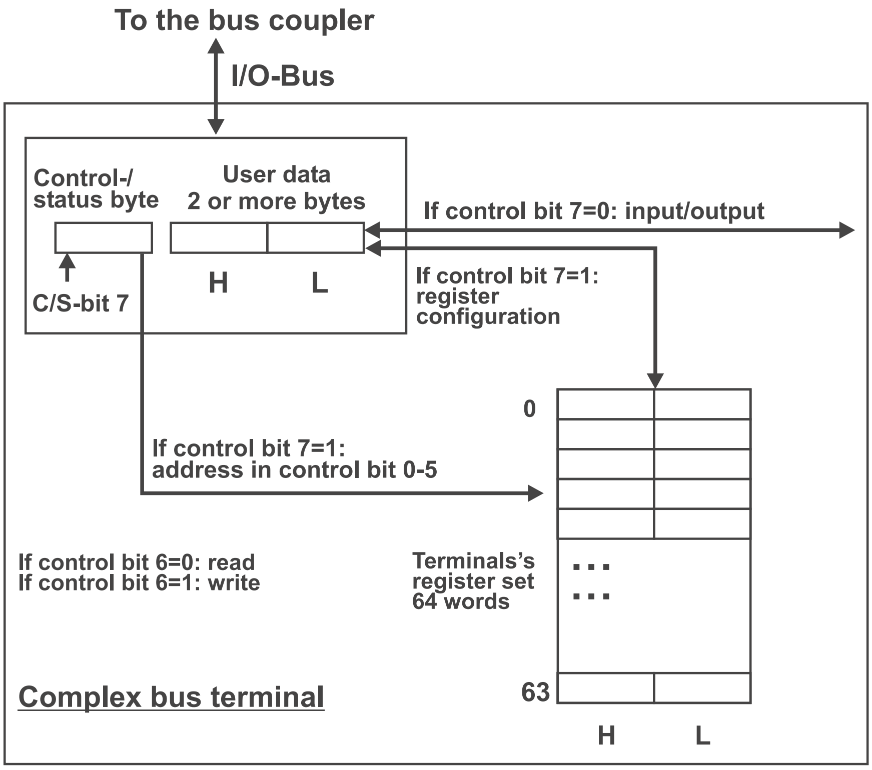


Figure 47:

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

13.4 Appendix

13.4.1 Mapping in the Bus Coupler

As already described in the Terminal Configuration section, each Bus Terminal is mapped in the Bus Coupler. In the delivery state, this mapping occurs with the default settings of the Bus Coupler for this terminal. The default setting can be changed with the Baumüller configuration software ProPLC.

If the terminals are fully evaluated, they occupy memory space in the input and output process image.

The following tables provide information about the terminal mapping, depending on the conditions set in the Bus Coupler.

Default mapping for: CANopen

Conditions		Word offset	High byte	Low byte
Complete evaluation: Motorola format: Word alignment:	no no any	0	Ch0 D1	Ch0 D0
		1	Ch1 D1	Ch1 D0
		2	-	-
		3	-	-

Default mapping for: Profibus

Conditions	Word offset	High byte	Low byte
Complete evaluation: no Motorola format: yes Word alignment: any	0	Ch0 D0	Ch0 D1
	1	Ch1 D0	Ch1 D1
	2	-	-
	3	-	-

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch0 D0	Ch0 CB/SB
	1	Ch1 CB/SB	Ch0 D1
	2	Ch1 D1	Ch1 D0
	3	-	-

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch0 D1	Ch0 CB/SB
	1	Ch1 CB/SB	Ch0 D0
	2	Ch1 D0	Ch1 D1
	3	-	-

Legend

Complete evaluation: The terminal is mapped with control and status byte.

Motorola format: Motorola or Intel format can be set.

Word alignment: The terminal is at word limit in the Bus Coupler.

Ch n SB: status byte for channel n (appears in the input process image).
Ch n CB: control byte for channel n (appears in the output process image).

Ch n D0: channel n, data byte 0 (byte with the lowest value)
Ch n D1: channel n, data byte 1 (byte with the highest value)

"-": This byte is not used or occupied by the terminal.

13.4.2 Register table

These registers exist once for each channel.

Address	Denomination	Default value	R/W	Storage medium
R0	reserved	0x0000	R	
R1	reserved	0x0000	R	
R2	reserved	0x0000	R	
R3	reserved	0x0000	R	
R4	reserved	0x0000	R	
R5	Raw DAC value	variable	R	RAM
R6	Diagnostic register not used	0x0000	R	RAM
R7	Command register not used	0x0000	R	

Address	Denomination	Default value	R/W	Storage medium
R8	Terminal type	e.g. 4032	R	ROM
R9	Software version number	0x????	R	ROM
R10	Multiplex shift register	0x0218/ 130	R	ROM
R11	Signal channels	0x0218	R	ROM
R12	Minimum data length	0x9800	R	ROM
R13	Data structure	0x0000	R	ROM
R14	reseved	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	Hardware compensation: Offset	specific	R/W	SEEROM
R18	Hardware compensation: Gain	specific	R/W	SEEROM
R19	Manufacturer scaling: Offset	0x0800	R/W	SEEROM
R20	Manufacturer scaling: Gain	0x0010	R/W	SEEROM
R21	Manufacturer scaling	0x0800	R/W	SEEROM
R22	reserved	0x0000	R/W	SEEROM
R23	reserved	0x0000	R/W	SEEROM
R24	reserved	0x0000	R/W	SEEROM
R25	reserved	0x0000	R/W	SEEROM
R26	reserved	0x0000	R/W	SEEROM
R27	reserved	0x0000	R/W	SEEROM
R28	reserved	0x0000	R/W	SEEROM
R29	reserved	0x0000	R/W	SEEROM
R30	reserved	0x0000	R/W	SEEROM
R31	Code word register	variabel	R/W	RAM
R32	Feature register	0x0006	R/W	SEEROM
R33	User scaling: Offset	0x0000	R/W	SEEROM
R34	User scaling: Gain	0x0100	R/W	SEEROM
R35	User switch-on value	0x0000	R/W	SEEROM
R36	reserved	0x0000	R/W	SEEROM
...	...	...	...	...
R63	reserved	0x0000	R/W	SEEROM

14

AO4±10 FOUR CHANNEL ANALOG OUTPUT TERMINAL -10 V ... +10 V

14.1 Functional description

The analog output terminal AO4±10 generates signals in the range between -10 V and +10 V with a resolution of 12 bits (4095 increments). The terminal outputs are single ended outputs with common ground.

Process data input format

In the delivery state, the process data are entered in two's complement form (integer -1 corresponds to 0xFFFF). Other formats may be selected via the feature register (e.g. sign/amount representation, Siemens format).

Output value		
hexadecimal	**decimal**	**Output voltage**
0x8000	-32768	-10 V
0xC001	-16383	-5 V
0x0000	0	0 V
0x3FFF	16383	+5 V
0x7FFF	32767	+10 V

LED display

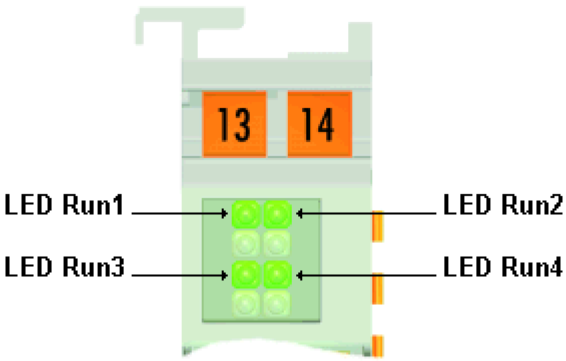


Figure 48: RUN-LEDs

Operation status of the channels is shown by four green Run LEDs.

LED	Color	Channel	Status	
			On	**Off**
Run1	green	1	regular operation	A Watchdog-Timer overflow has occurred. If no process data is transmitted between control system and Bus Coupler for 100 ms, the green LEDs extinguish.
Run2		2		
Run3		3		
Run4		4		

Process data equitation

The process data that are transferred to the Bus Terminal are calculated using the following equations:

X: PLC Process data

Y_dac: Process data to D/A converter

B_a, A_a: Manufacturer gain and offset compensation (R17,R18)

B_h, A_h: Manufacturer scaling (R19,R20)

B_w, A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling is active:

Y_dac = X x A_a + B_a (1.0)

b) Manufacturer scaling active (default setting):

Y_1 = B_h + A_h * X (1.1)

Y_dac = Y_1 * A_a + B_a

c) User scaling active:

Y_2 = B_w + A_w * X (1.2)

Y_dac = Y_2 * A_a + B_a

d) Manufacturer and user scaling active:

Y_1 = B_h + A_h * X (1.3)

Y_2 = B_w + A_w * Y_1 (1.4)

Y_dac = Y_2 * A_a + B_a

The equations of the straight line are activated via register R32.

14.2 Access from the User Program

14.2.1 Process image

In the process image AO4010 as well as AO4+10 are shown with up to 12 byte input and 12 byte output data.

Format	Input data	Output data
Byte	SB1	CB1
Word	DataIN1	DataOUT1
Byte	SB2	CB2
Word	DataIN2	DataOUT2
Byte	SB3	CB3
Word	DataIN3	DataOUT3
Byte	SB4	CB4
Word	DataIN4	DataOUT4

Legend: SB n: Status byte for channel n
CB n: Control byte for channel n

DataIN n: Input data word of channel n
DataOUT n: Output data word of channel n

- The mapping of the bytes and words to the addresses of the controlling system can be found on the mapping page.
- The meaning of control und status bytes can be found on the page *control and status bytes*.
- In process data mode the analog values are transmitted within the input data words DataIN1 to DataIN4 and the output data words DataOUT1 to DataOUT4 are not used.

14.2.2 Mapping

The Bus Terminals occupy addresses within the process image of the controller. The assignment of process data (input and output data) and parameterization data (control and status bytes) to the control addresses is called mapping. The type of mapping depends on:

- the fieldbus system used
- the terminal type
- the parameterization of the bus coupler (conditions) such as
  - compact or full evaluation
  - Intel or Motorola format
  - word alignment switched on or off

The Bus Couplers (CK000x) are supplied with certain default settings. The default setting can be changed with the Baumüller configuration software ProPLC.

The following tables show the mapping depending on different conditions. For information about the contents of the individual bytes please refer to the pages *Process image and Control and status byte*.

14.2.3 Compact evaluation

For compact evaluation, the analog output terminals only occupy addresses in the output process image. Control and status bytes cannot be accessed.

Compact evaluation in Intel format

Default mapping for CANopen coupler

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: no Word alignment: any	0	-	-	Ch1 D1	Ch1 D0
	1	-	-	Ch2 D1	Ch2 D0
	2	-	-	Ch3 D1	Ch3 D0
	3	-	-	Ch4 D1	Ch4 D0

Compact evaluation in Motorola format

Default mapping for Profibus coupler

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: yes Word alignment: any	0	-	-	Ch1 D0	Ch1 D1
	1	-	-	Ch2 D0	Ch2 D1
	2	-	-	Ch3 D0	Ch3 D1
	3	-	-	Ch4 D0	Ch4 D1

14.2.4 Complete evaluation

For complete evaluation, the analog output terminals occupy addresses in the input and output process image. Control and status bytes can be accessed.

Complete evaluation in Intel format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	SB1	Ch1 D0	CB1
	1	SB2	Ch1 D1	CB2	Ch1 D1
	2	Ch2 D1	Ch2 D0	Ch2 D1	Ch2 D0
	3	Ch3 D0	SB3	Ch3 D0	CB3
	4	SB4	Ch3 D1	CB4	Ch3 D1
	5	Ch4 D1	Ch4 D0	Ch4 D1	Ch4 D0

Complete evaluation in Motorola format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	SB1	Ch1 D1	CB1
	1	SB2	Ch1 D0	CB2	Ch1 D0
	2	Ch2 D0	Ch2 D1	Ch2 D0	Ch2 D1
	3	Ch3 D1	SB3	Ch3 D1	CB3
	4	SB4	Ch3 D0	CB4	Ch3 D0
	5	Ch4 D0	Ch4 D1	Ch4 D0	Ch4 D1

Key

Complete evaluation: In addition to the process data, the control and status bytes are also mapped in the address space.

Motorola format: Motorola or Intel format can be set.

Word alignment: In order for the channel address range to commence at a word boundary, empty bytes are inserted into the process image as appropriate.

SB n: status byte for channel n (appears in the input process image).
CB n: control byte for channel n (appears in the output process image).

Ch n D0: channel n, lower-value data byte
Ch n D1: channel n, higher-value data byte

reserved: This byte occupies process data memory, although it has no function.

"-": This byte is not assigned or used by the terminal/module.

14.2.5 Control and Status bytes

14.2.5.1 Channel 1

Process data mode

Control byte 1 in process data mode

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal. In process data mode it has no function.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
CB1.7	RegAccess	0_{bin}	Register communication off (process data mode)
CB1.6 - CB1.0	-	0_{bin}	reserved

Status byte 1 in process data mode

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller. In process data mode it has no function.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
SB1.7	RegAccess	0_{bin}	Acknowledgement for process data mode
SB1.6 - SB1.0	-	0_{bin}	reserved

14.2.5.2 Register communication

Control byte 1 in register communication

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	R/W	Reg-Nr.					

Legend

Bit	Name	Description	
CB1.7	RegAccess	1_{bin}	Register communication switched on
CB1.6	R/W	0_{bin}	Read access
		1_{bin}	Write access
CB1.5 to CB1.0	Reg-Nr.	Register number: Enter the number of the register that you ○ want to read with input data word DataIN1 or ○ want to write with output data word DataOUT1.	

Status byte 1 in register communication

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	R/W	Reg-Nr.					

Legend

Bit	Name	Description	
SB1.7	RegAccess	1_{bin}	Acknowledgement for register access
SB1.6	R	0_{bin}	Read access
SB1.5 to SB1.0	Reg-Nr.	Number of the register that was read or written.	

14.2.5.3 Channel 2, channel 3 und channel 4

The control and status bytes of channels 2, 3 and 4 are structured like the control and status byte of channel 1.

14.2.6 Register overview

The following registers are used to parameterize the AO4010. They exist once for each channel of a terminal and can be read or written by register communication using control-, status- und data bytes.

Address	Denomination	Default value		R/W	Storage medium
R0	Process data for D/A C	-	-	R	RAM
R1	reserved	-		-	-
...	...	...	...	...	...
R5	reserved	-	-	-	-
R6	Diagnostic register (not used)	-	-	R	RAM
R7	Command register (not used)	0x0000	0_{dec}	R/W	RAM

Address	Denomination	Default value		R/W	Storage medium
R8	Terminal type	0x1152	4434_{dec}	R	ROM
R9	Firmware revision level	e.g. 0x3141	e.g. $1A_{ASCI}$	R	ROM
R10	Data length (Multiplex shift register)	0x0230	560_{dec}	R	ROM
R11	Signal channels	0x0418	1048_{dec}	R	ROM
R12	Minimum data length	0x9800	38912_{dec}	R	ROM
R13	Data structure (Data type register)	0x0004	4_{dec}	R	ROM
R14	reserved	-	-	-	-
R15	Alignment register	e.g. 0x7F80	e.g. 32640_{dec}	R/W	RAM
R16	Hardware revision number	e.g. 0x0000	e.g. 0_{dec}	R/W	SEEPROM
R17	Hardware compensation: offset (B_a)	0x0000	0_{dec}	R/W	SEEPROM
R18	Hardware compensation: gain (A_a)	typ. 0x0E99	typ. 3737_{dec}	R/W	SEEPROM
R19	Manufacturer scaling: offset (B_h)	0x0001	1_{dec}	R/W	SEEPROM
R20	Manufacturer scaling: gain (A_h)	typ. 0x0020	typ. 32_{dec}	R/W	SEEPROM
R21	Manufacturer switch-on value	0x07FF	2047_{dec}	R/W	SEEPROM
R22	Hardware compensation: gain (Aa) for negative values	0x0E99	3737_{dec}	R/W	SEEPROM
R23	reserved	-	-	-	-
...	...	...	...	...	...
R30	reserved	-	-	-	-
R31	Code word register	0x0000	0_{dec}	R/W	RAM
R32	Feature register	0x0006	6_{dec}	R/W	SEEPROM
R33	User scaling: offset (B_w)	0x0000	0_{dec}	R/W	SEEPROM
R34	User scaling: gain (A_w)	0x0100	256_{dec}	R/W	SEEPROM
R35	User switch-on value (Y_2)	0x0000	0_{dec}	R/W	SEEPROM
R36	reserved	-	-	-	-
...	reserved	...	...	...	...
R63	reserved	-	-	-	-

14.2.7 Register Description

All registers can be read or written via register communication.

R0: Raw value A/D C

Process data, delivered to the the D/A converter

R6: Diagnostic register

The diagnostic register of AO4±10 is currently not used.

R7: Command register

The command register of AO4±10 is currently not used.

R8: Terminal description

Register R8 contains the terminal identifier. e.g.: AO4±10: 0x1152 (4434_{dec})

R9: Firmware revision level

Register R9 contains the ASCII coding of the terminal's firmware revision level, e.g. **0x3141** ($1A_{ASCII}$). **'0x31'** corresponds to the ASCII character **'1'** and **'0x41'** to the ASCII character **'A'**. This value can not be changed.

R10: Data length (multiplex shift register)

R10 contains the number of multiplexed shift registers and their length in bits.

R11: Signal channels

Unlike R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length

The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data structure (data type register)

Data type register	Meaning
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure: 1 byte, n bytes
0x03	Word array
0x04	Structure: 1 byte, n words
0x05	Double word array
0x06	Structure: 1 byte, n double words
0x07	Structure: 1 byte, 1 double word
0x08	Structure: 1 byte, 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure: 1 byte, n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length
0x14	Structure: 1 byte, n words with variable logical channel length

Data type register	Meaning
0x15	Double word array with variable logical channel length
0x16	Structure: 1 byte, n double words with variable logical channel length

R15: Alignment register

Via the alignment register bits, the Bus Coupler arranges the address range of an analog terminal such that it starts at a byte boundary.

R16: Hardware version number

Register R16 contains the hardware revision level of the terminal; this value can not be changed.

R17: Hardware compensation - offset (B_a)

This register is used for the offset compensation of the terminal (see equation 1.1). Register value (16 bit signed integer). Default: 0x0001 (1_{dec})

R18: Hardware compensation - gain (A_a)

This register is used for the gain compensation of the terminal (see equation 1.1). Register value (16 bit unsigned integer x 2^{-12}). Default: typically 0x0E99 (3737_{dec})

R19: Manufacturer scaling - offset (B_h)

This register contains the offset for the manufacturer scaling (see equation 1.3). Register value (16 bit signed integer). Default: 0x0000 (0_{dec})

Manufacturer scaling can be activated via bit R32.1 of the feature register.

R20: Manufacturer scaling - gain (A_h)

This register contains the gain for manufacturer scaling (see equation 1.3). Register value (16 bit unsigned integer x 2^{-8}). Default: typically 0x2000 (8192_{dec})

Manufacturer scaling can be activated via bit R32.1 of the feature register.

R21 Manufacturer activation value

The terminal applies the manufacturer activation value to its output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms) has occurred. Register value (16 Bit signed Integer).

R22: Hardware compensation - gain (Aa) for negative values

This register is used for the gain compensation of the terminal for negative values. Default: typically 0x0E99 (3737_{dec})

R31: Kodewort-Register

- If you write into the user registers without first entering the user code word (0x1235) into the code word register, the terminal will not accept the supplied data.
- If you write values into the user registers and have previously entered the user code word (0x1235) in the code word register, these values are stored in the RAM registers and in the SEEPROM registers and are therefore retained if the terminal is restarted.

The code word is reset with each restart of the terminal.

R32: Feature register

The feature register specifies the terminal's configuration. Default: 0x0006 (6_{dec})

Bit	R32.15	R32.14	R32.13	R32.12	R32.11	R32.10	R32.9	R32.8
Name	-	-	-	-	-	-	-	enUserActValue

Bit	R32.7	R32.6	R32.5	R32.4	R32.3	R32.2	R32.1	R32.0
Name	-	-	enSignRepr	-	enSignAmRepr	enWdTimer	enManScal	enUsrScal

Legend

Bit	**Name**	**Description**		**default**
R32.15	-	reserved		0_{bin}
...	...	...		...
R32.9	-	reserved		0_{bin}
R32.8	enUserActValue	0_{bin}	Manufacturer activation value active	0_{bin}
		1_{bin}	User activation value active:	
R32.7	-	reserved		0_{bin}
R32.6	-	reserved		0_{bin}
R32.5	enSignRepr	0_{bin}	Signed representation is not active	0_{bin}
		1_{bin}	Signed representation is active	
R32.4	-	reserved		0_{bin}
R32.3	enSignAmRepr	0_{bin}	Two's complement representation is active	0_{bin}
		1_{bin}	The arithmetic sign of numerical quantities is active (-1_{dec} = 0x8001)	
R32.2	enWdTimer	0_{bin}	Watchdog timer is not active	1_{bin}
		1_{bin}	Watchdog timer is active (the watchdog is triggered if no process data are received for 100 ms)	

Bit	Name	Description		default
R32.1	enManScal	0_{bin}	Manufacturer scaling is active	1_{bin}
		1_{bin}	Manufacturer scaling is not active	
R32.0	enUsrScal	0_{bin}	User scaling is not active	0_{bin}
		1_{bin}	User scaling is active	

R33: User scaling - offset (B_w)

This register contains the offset of the user scaling.
User scaling can be activated through bit R32.0 in the feature register.

R34: User scaling - gain (A_w)

This register contains the user scaling gain. Default: 0x0100 (256_{dec}).
User scaling can be activated through bit R32.0 in the feature register.

R35: User activation value

If the user activation value has been activated by bit R32.8 of the feature register, the terminal applies the user activation value instead of the manufacturer activation value to its output if a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms) happens.

Examples See ▹Examples of Register Communication◃ from page 70 onward.

15

AO2420 Two-Channel Analog Output Terminal 4 - 20 mA

15.1 Functional description

The analog output terminal AO2420 generates signals in the range between 4 and 20 mA with a resolution of 12 bits (4095 increments). The output current is electrically isolated from the I/O-Bus.

The supply voltage fed in via the power contacts is used for generating the output current.

Process data input format

In the delivery state, the process data are entered in two's complement form (integer -1 corresponds to 0xFFFF). Other formats may be selected via the feature register.

Process data hexadecimal	Process data decimal	Output current
0x0000	0	4 mA
0x3FFF	16383	12 mA
0x7FFF	32767	20 mA

LED display

Both RUN LEDs indicate the operating state of the associated terminal channels.

Green LED: RUN

- On: normal operation
- Off: Watchdog-timer overflow has occurred. If no process data are transmitted by the Bus Coupler for 100 ms, the green LEDs go out. A user-specified voltage will be applied to the output (see feature register).

Process data

The process data arriving from the Bus Coupler are output to the process:

X: PLC process data
B_h, A_h: Manufacturer scaling (R19,R20)
B_w,A_w: User scaling (R33,R34)
Y_dac: output value to the D/A converter

a) Neither user nor manufacturer scaling are active:
Y_dac = X (1.0)

b) Manufacturer scaling active:
Y_1 = B_h + A_h * X (1.1)
Y_dac = Y_1

c) User scaling active:
Y_2 = B_w + A_w * X (1.2)
Y_dac = Y_2

d) Manufacturer and user scaling active:
Y_1 = B_h + A_h * X (1.3)
Y_dac = B_w + A_w * Y_1 (1.4)

The equations of the straight line are activated via register R32.

15.2 Terminal configuration

The terminal can be configured and parameterised via the internal register structure (see ▹Terminal configuration AI1010 and AI2010 ◃ from page 44 onward).

15.3 Register description

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals (see ▹General Description of Registers ◃ from page 45 onward).

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the Register Communication section.

15.3.1 Terminal-specific register description

Process variables

R0 to R4: reserved

R5: Raw DAC value Y_dac
The 12-bit value transferred to the D/A converter is called raw DAC value. It is calculated from the process data via the manufacturer and user scaling.

R6 to R7: reserved

Manufacturer parameters

R17: Hardware compensation - offset
This register is used for hardware offset compensation (8-bit digital potentiometer) of the terminal. The register is transferred to the hardware after each processor reset or with each write access to R17. Note that the transferred offset does not correspond to the DAC values.
High byte: reserved
Low byte: Offset value (0 to 255)

R18: Hardware compensation - gain
This register is used for hardware gain compensation (8-bit digital potentiometer) of the terminal. The register is transferred to the hardware after each processor reset or with each write access to R17.
High byte: reserved
Low byte: Gain value (0 to 255)

R19: Manufacturer scaling - offset B_h
16 bit signed integer [0x0000]
This register contains the offset of the manufacturer's equation of the straight line (1.1). The straight-line equation is activated via register R32.

R20: Manufacturer scaling - gain A_h
16 bits signed integer *2^{-8} [0x0020]
This register contains the scale factor of the manufacturer's equation of the straight line (1.1). The straight-line equation is activated via register R32.
1 corresponds to register value 0x0100.

R21: Manufacturer's switch-on value
[0V], 12 bits unsigned integer in X [0x000]
The manufacturer switch-on value is applied to the terminal output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms).

The manufacturer switch-on value is activated via register R32.

User parameters

R32: Feature register:
[0x0006]
The feature register specifies the operating modes of the terminal.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (1.2) active [0]
Bit 1	1	Manufacturer scaling (1.1) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on. In the event of a watchdog overflow, either the manufacturer or the user switch-on value is applied to the terminal output.
Bit3	1	Sign / amount representation [0]
Bit 4 -7	-	reserved, do not change
Bit 8	0/1	0_{bin}: Manufacturer switch-on value [0] 1_{bin}: User's switch-on value
Bit 9 - 15	-	reserved, do not change

R33: User scaling - offset B_w
16 bit signed integer [0x0000]
This register contains the offset of the user straight-line equation (4.1). The straight-line equation is activated via register R32.

R34: User scaling - gain A_w
16 bits signed integer * 2^{-8} [0x0100]
This register contains the scale factor of the user straight-line equation (4.1). The straight-line equation is activated via register R32.

R35: User's switch-on value Y_2
16 bit signed integer [0x0000]
If the user switch-on value is activated in register R32, this value is applied to the terminal output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms).

15.3.2 Control and Status byte

Control byte for process data exchange
Gain and offset compensation

The control byte is transmitted from the controller to the terminal. It can be used

- in register mode (REG = 1_{bin}) or
- during process data exchange (REG = 0_{bin}).

The control byte can be used to carry out gain and offset compensation for the terminal (process data exchange). This requires the code word to be entered in R31. The gain and offset of the terminal can then be compensated.

The parameter will only be saved permanently once the code word is reset!

Control byte:

Bit7 = 0_{bin}
Bit6 = 1_{bin} Terminal compensation function is activated
Bit4 = 1_{bin} Gain compensation
Bit3 = 1_{bin} Offset compensation
Bit2 = 0_{bin} Slower cycle = 1000ms
1_{bin} Fast cycle = 50ms
Bit1 = 1_{bin} up
Bit0 = 1_{bin} down

Status byte for process data exchange

The status byte is transmitted from the terminal to the controller. For model AO2010, the status byte in the process data exchange is not used.

15.3.3 Register communication AO2420

Register access via process data exchange
Bit 7=1_{bin}: Register mode

If bit 7 of the control byte is set, then the first two bytes of the user data are not used for exchanging process data, but are written into or read from the terminal's register set.

Bit 6=0_{bin}: read
Bit 6=1_{bin}: write

Bit 6 of the control byte specifies whether a register should be read or written. If bit 6 is not set, then a register is read out without modifying it. The value can then be taken from the input process image.

If bit 6 is set, then the user data is written into a register. As soon as the status byte has supplied an acknowledgement in the input process image, the procedure is completed (see example).

Bit 0 to 5: Address

The address of the register that is to be addressed is entered into bits 0 to 5 of the control byte.

Control byte in register modus

MSB

REG=1	**W/R**	**A5**	**A4**	**A3**	**A2**	**A1**	**A0**

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

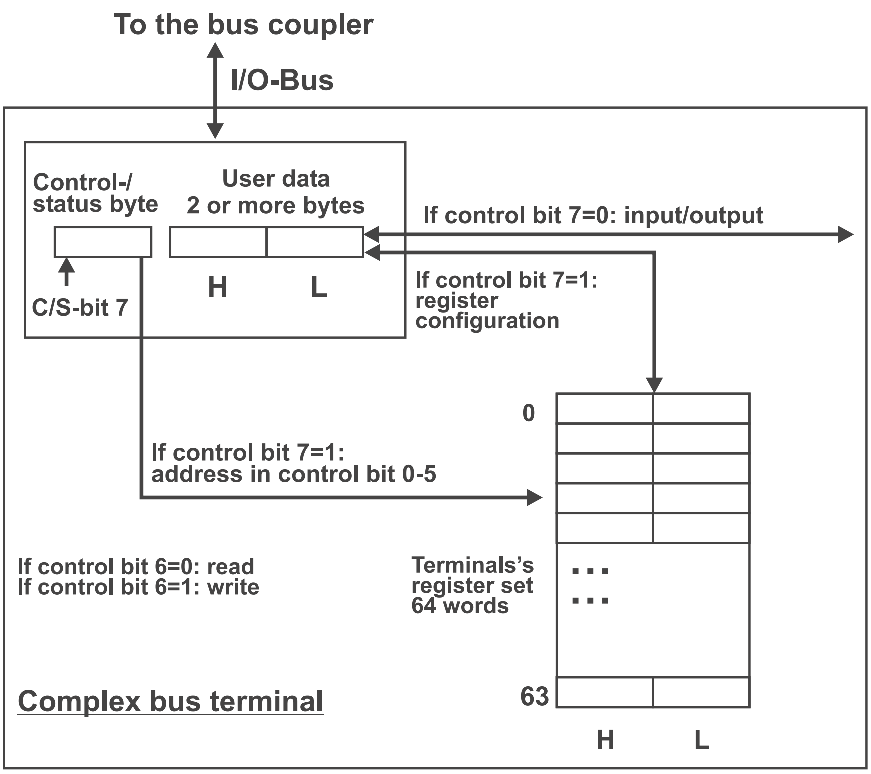


Figure 49:

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

15.4 Appendix

15.4.1 Mapping in the Bus Coupler

See ▷Appendix ◁ from page 53 onward.

Register table see ▷Register table ◁ from page 133 onward.

16

AO4420 Four-Channel Analog Output Terminal 4 - 20 mA

16.1 Functional description

The analog input terminal AO4420 generates signals in the range between 4 and 20 mA with a resolution of 12 bits (4095 increments). The actuators are supplied from the voltage fed via the power contacts. The power contacts can optionally be supplied via the standard supply or via a feed terminal with electrical isolation.

Format of the output values

In the delivery state the process data are shown in two's complement form (integer -1 corresponds to 0xFFFF). Other data formats can be selected via the feature register R32 (e.g. sign/amount representation, Siemens format).

hexadecimal	Process data decimal	Output current
0x0000	0	4 mA
0x3FFF	16383	12 mA
0x7FFF	32767	20 mA

LED display

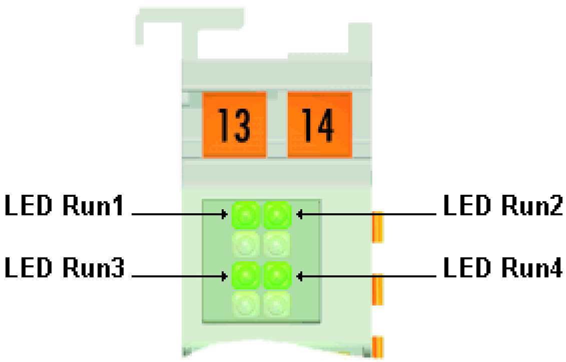


Figure 50: RUN-LEDs

Operation status of the channels is shown by four green Run LEDs.

LED	Color	Channel	Status	
			On	Off
Run1	green	1	regular operation	A Watchdog-Timer overflow has occurred. If no process data is transmitted between control system and Bus Coupler for 100 ms, the green LEDs extinguish.
Run2		2		
Run3		3		
Run4		4		

Process data

The process data that are transferred to the Bus Coupler are calculated using the following equations:

X: PLC Process data

Y_dac: Process data to D/A converter

B_a,A_a: Manufacturer gain and offset compensation (R17,R18)

B_h,A_h: Manufacturer scaling (R19,R20)

B_w,A_w: User scaling (R33,R34)

a) Neither user nor manufacturer scaling is active:

Y_dac = X x A_a + B_a (1.0)

b) Manufacturer scaling active (default setting):

Y_1 = B_h + A_h * X (1.1)

Y_dac = Y_1 * A_a + B_a

c) User scaling active:

Y_2 = B_w + A_w * X (1.2)

Y_dac = Y_2 * A_a + B_a

d) Manufacturer and user scaling active:

Y_1 = B_h + A_h * X (1.3)

Y_2 = B_w + A_w * Y_1 (1.4)

Y_dac = Y_2 * A_a + B_a

The equations of the straight line are activated via register R32.

16.2 Access from the User Program

16.2.1 Process image

In the process image AO4010 as well as AO4420 are shown with up to 12 byte input and 12 byte output data.

Format	Input data	Output data
Byte	SB1	CB1
Word	DataIN1	DataOUT1
Byte	SB2	CB2
Word	DataIN2	DataOUT2
Byte	SB3	CB3
Word	DataIN3	DataOUT3
Byte	SB4	CB4
Word	DataIN4	DataOUT4

Legend

SB n: Status byte for channel n
CB n: Control byte for channel n

DataIN n: Input data word of channel n
DataOUT n:Output data word of channel n

- The mapping of the bytes and words to the addresses of the controlling system can be found on the mapping page.
- The meaning of control und status bytes can be found on the page *control and status bytes*.
- In process data mode the analog values are transmitted within the input data words DataIN1 to DataIN4 and the output data words DataOUT1 to DataOUT4 are not used.

16.2.2 Mapping

The Bus Terminals occupy addresses within the process image of the controller. The assignment of process data (input and output data) and parameterization data (control and status bytes) to the control addresses is called mapping. The type of mapping depends on:

- the fieldbus system used
- the terminal type
- the parameterization of the bus coupler (conditions) such as
  - compact or full evaluation
  - Intel or Motorola format
  - word alignment switched on or off

The Bus Couplers (CK000x) are supplied with certain default settings. The default setting can be changed with the Baumüller configuration software ProPLC.

The following tables show the mapping depending on different conditions. For information about the contents of the individual bytes please refer to the pages *Process image and Control and status byte*.

16.2.3 Compact evaluation

For compact evaluation, the analog output terminals only occupy addresses in the output process image. Control and status bytes cannot be accessed.

Compact evaluation in Intel format

Default mapping for CANopen coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: no Word alignment: any	0	-	-	Ch1 D1	Ch1 D0
	1	-	-	Ch2 D1	Ch2 D0
	2	-	-	Ch3 D1	Ch3 D0
	3	-	-	Ch4 D1	Ch4 D0

Compact evaluation in Motorola format

Default mapping for Profibus coupler

	Address	**Input data**		**Output data**	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: no Motorola format: yes Word alignment: any	0	-	-	Ch1 D0	Ch1 D1
	1	-	-	Ch2 D0	Ch2 D1
	2	-	-	Ch3 D0	Ch3 D1
	3	-	-	Ch4 D0	Ch4 D1

16.2.4 Complete evaluation

For complete evaluation, the analog output terminals occupy addresses in the input and output process image. Control and status bytes can be accessed.

Complete evaluation in Intel format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: no Word alignment: no	0	Ch1 D0	SB1	Ch1 D0	CB1
	1	SB2	Ch1 D1	CB2	Ch1 D1
	2	Ch2 D1	Ch2 D0	Ch2 D1	Ch2 D0
	3	Ch3 D0	SB3	Ch3 D0	CB3
	4	SB4	Ch3 D1	CB4	Ch3 D1
	5	Ch4 D1	Ch4 D0	Ch4 D1	Ch4 D0

Complete evaluation in Motorola format

	Address	Input data		Output data	
Conditions	**Word offset**	**High byte**	**Low byte**	**High byte**	**Low byte**
Complete evaluation: yes Motorola format: yes Word alignment: no	0	Ch1 D1	SB1	Ch1 D1	CB1
	1	SB2	Ch1 D0	CB2	Ch1 D0
	2	Ch2 D0	Ch2 D1	Ch2 D0	Ch2 D1
	3	Ch3 D1	SB3	Ch3 D1	CB3
	4	SB4	Ch3 D0	CB4	Ch3 D0
	5	Ch4 D0	Ch4 D1	Ch4 D0	Ch4 D1

Key

Complete evaluation: In addition to the process data, the control and status bytes are also mapped in the address space.

Motorola format: Motorola or Intel format can be set.

Word alignment: In order for the channel address range to commence at a word boundary, empty bytes are inserted into the process image as appropriate.

SB n: status byte for channel n (appears in the input process image).
CB n: control byte for channel n (appears in the output process image).

Ch n D0: channel n, lower-value data byte
Ch n D1: channel n, higher-value data byte

reserved: This byte occupies process data memory, although it has no function.

"-": This byte is not assigned or used by the terminal/module.

16.2.5 Control and Status bytes

16.2.5.1 Channel 1

Process data mode

Control byte 1 in process data mode

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal. In process data mode it has no function.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
CB1.7	RegAccess	0_{bin}	Register communication off (process data mode)
CB1.6 - CB1.0	-	0_{bin}	reserved

Status byte 1 in process data mode

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller. In process data mode it has no function.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	-	-	-	-	-	-	-

Legend

Bit	**Name**	**Description**	
SB1.7	RegAccess	0_{bin}	Acknowledgement for process data mode
SB1.6 - SB1.0	-	0_{bin}	reserved

16.2.5.2 Register communication

Control byte 1 in register communication

Control byte 1 (CB1) is located in the output image, and is transmitted from the controller to the terminal.

Bit	CB1.7	CB1.6	CB1.5	CB1.4	CB1.3	CB1.2	CB1.1	CB1.0
Name	RegAccess	R/W	Reg-Nr.					

Legend

Bit	Name	Description	
CB1.7	RegAccess	1_{bin}	Register communication switched on
CB1.6	R/W	0_{bin}	Read access
		1_{bin}	Write access
CB1.5 to CB1.0	Reg-Nr.	Register number: Enter the number of the register that you ○ want to read with input data word DataIN1 or ○ want to write with output data word DataOUT1.	

Status byte 1 in register communication

The status byte 1 (SB1) is located in the input image, and is transmitted from terminal to the controller.

Bit	SB1.7	SB1.6	SB1.5	SB1.4	SB1.3	SB1.2	SB1.1	SB1.0
Name	RegAccess	R/W	Reg-Nr.					

Legend

Bit	Name	Description	
SB1.7	RegAccess	1_{bin}	Acknowledgement for register access
SB1.6	R	0_{bin}	Read access
SB1.5 to SB1.0	Reg-Nr.	Number of the register that was read or written.	

16.2.5.3 Cannel 2, channel 3 und channel 4

The control and status bytes of channels 2, 3 and 4 are structured like the control and status byte of channel 1.

16.2.6 Register over view

The following registers are used to parameterize the AO4420. They exist once for each channel of a terminal and can be read or written by register communication using control-, status- und data bytes.

Address	Denomination	Default value		R/W	Storage medium
R0	Process data for D/A C	-	-	R	RAM
R1	reserved	-		-	-
...	...	...	...	...	...
R5	reserved	-	-	-	-
R6	Diagnostic register (not used)	-	-	R	RAM
R7	Command register (not used)	0x0000	0_{dec}	R/W	RAM
R8	Terminal type	0x1148	4424_{dec}	R	ROM

Address	Denomination	Default value		R/W	Storage medium
R9	Firmware revision level	e.g. 0x3141	e.g. $1A_{ASCI}$	R	ROM
R10	Data length (Multiplex shift register)	0x0230	560_{dec}	R	ROM
R11	Signal channels	0x0418	1048_{dec}	R	ROM
R12	Minimum data length	0x9800	38912_{dec}	R	ROM
R13	Data structure (Data type register)	0x0004	4_{dec}	R	ROM
R14	reserved	-	-	-	-
R15	Alignment register	e.g. 0x7F80	e.g. 32640_{dec}	R/W	RAM
R16	Hardware revision number	e.g. 0x0000	e.g. 0_{dec}	R/W	SEEPROM
R17	Hardware compensation: offset (B_a)	0x0001	1_{dec}	R/W	SEEPROM
R18	Hardware compensation: gain (A_a)	typ. 0x0E99	typ. 3737_{dec}	R/W	SEEPROM
R19	Manufacturer scaling: offset (B_h)	0x0000	0_{dec}	R/W	SEEPROM
R20	Manufacturer scaling: gain (A_h)	typ. 0x0020	typ. 32_{dec}	R/W	SEEPROM
R21	Manufacturer switch-on value	0x0000	0_{dec}	R/W	SEEPROM
R22	reserved	-	-	-	-
R23	reserved	-	-	-	-
...	...	...	...	...	...
R30	reserved	-	-	-	-
R31	Code word register	0x0000	0_{dec}	R/W	RAM
R32	Feature register	0x0006	6_{dec}	R/W	SEEPROM
R33	User scaling: offset (B_w)	0x0000	0_{dez}	R/W	SEEPROM
R34	User scaling: gain (A_w)	0x0100	256_{dec}	R/W	SEEPROM
R35	User switch-on value (Y_2)	0x0000	0_{dec}	R/W	SEEPROM
R36	reserved	-	-	-	-
...	reserved	...	...	...	...
R63	reserved	-	-	-	-

16.2.7 Register Description

All registers can be read or written via register communication.

R0: Raw value A/D C

Process data, delivered to the the D/A converter

R6: Diagnostic register

The diagnostic register of AO4420 is currently not used.

R7: Command register

The command register of AO4420 is currently not used.

R8: Terminal description

Register R8 contains the terminal identifier. e.g.: AO4010: 0x1134 (4404_{dec})

R9: Firmware revision level

Register R9 contains the ASCII coding of the terminal's firmware revision level, e.g. **0x3141** ($1A_{ASCII}$). **'0x31'** corresponds to the ASCII character **'1'** and **'0x41'** to the ASCII character **'A'**. This value can not be changed.

R10: Data length (multiplex shift register)

R10 contains the number of multiplexed shift registers and their length in bits.

R11: Signal channels

Unlike R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

R12: Minimum data length

The particular byte contains the minimum data length for a channel that is to be transferred. If the MSB is set, the control and status byte is not necessarily required for the terminal function and is not transferred to the control, if the Bus Coupler is configured accordingly.

R13: Data structure (data type register)

Data type register	Meaning
0x00	Terminal with no valid data type
0x01	Byte array
0x02	Structure: 1 byte, n bytes
0x03	Word array
0x04	Structure: 1 byte, n words
0x05	Double word array
0x06	Structure: 1 byte, n double words
0x07	Structure: 1 byte, 1 double word
0x08	Structure: 1 byte, 1 double word
0x11	Byte array with variable logical channel length
0x12	Structure: 1 byte, n bytes with variable logical channel length (e.g. 60xx)
0x13	Word array with variable logical channel length

Data type register	Meaning
0x14	Structure: 1 byte, n words with variable logical channel length
0x15	Double word array with variable logical channel length
0x16	Structure: 1 byte, n double words with variable logical channel length

R15: Alignment register

Via the alignment register bits, the Bus Coupler arranges the address range of an analog terminal such that it starts at a byte boundary.

R16: Hardware version number

Register R16 contains the hardware revision level of the terminal; this value can not be changed.

R17: Hardware compensation - offset (B_a)

This register is used for the offset compensation of the terminal (see equation 1.1). Register value (16 bit signed integer). Default: 0x0001 (1_{dec})

R18: Hardware compensation - gain (A_a)

This register is used for the gain compensation of the terminal (see equation 1.1). Register value (16 bit unsigned integer x 2^{-12}). Default: typically 0x0E99 (3737_{dec})

R19: Manufacturer scaling - offset (B_h)

This register contains the offset for the manufacturer scaling (see equation 1.3). Register value (16 bit signed integer). Default: 0x0000 (0_{dec})

Manufacturer scaling can be activated via bit R32.1 of the feature register.

R20: Manufacturer scaling - gain (A_h)

This register contains the gain for manufacturer scaling (see equation 1.3). Register value (16 bit unsigned integer x 2^{-8}). Default: typically 0x2000 (8192_{dec})

Manufacturer scaling can be activated via bit R32.1 of the feature register.

R21 Manufacturer activation value

The terminal applies the manufacturer activation value to its output after a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms) has occurred. Register value (16 Bit signed Integer).

R31: Code word register

- If you write into the user registers without first entering the user code word (0x1235) into the code word register, the terminal will not accept the supplied data.

- If you write values into the user registers and have previously entered the user code word (0x1235) in the code word register, these values are stored in the RAM registers and in the SEEPROM registers and are therefore retained if the terminal is restarted.

The code word is reset with each restart of the terminal.

R32: Feature register

The feature register specifies the terminal's configuration. Default: 0x0006 (6_{dec})

Bit	R32.15	R32.14	R32.13	R32.12	R32.11	R32.10	R32.9	R32.8
Name	-	-	-	-	-	-	-	enUserActValue

Bit	R32.7	R32.6	R32.5	R32.4	R32.3	R32.2	R32.1	R32.0
Name	-	-	enSignRepr	-	enSignAmRepr	enWdTimer	enManScal	enUsrScal

Legend

Bit	**Name**	**Description**		**default**
R32.15	-	reserved		0_{bin}
...	...	...		...
R32.9	-	reserved		0_{bin}
R32.8	enUserActValue	0_{bin}	Manufacturer activation value active	0_{bin}
		1_{bin}	User activation value active:	
R32.7	-	reserved		0_{bin}
R32.6	-	reserved		0_{bin}
R32.5	enSignRepr	0_{bin}	Signed representation is not active	0_{bin}
		1_{bin}	Signed representation is active	
R32.4	-	reserved		0_{bin}
R32.3	enSignAmRepr	0_{bin}	Two's complement representation is active	0_{bin}
		1_{bin}	The arithmetic sign of numerical quantities is active (-1_{dec} = 0x8001)	
R32.2	enWdTimer	0_{bin}	Watchdog timer is not active	1_{bin}
		1_{bin}	Watchdog timer is active (the watchdog is triggered if no process data are received for 100 ms)	
R32.1	enManScal	0_{bin}	Manufacturer scaling is active	1_{bin}
		1_{bin}	Manufacturer scaling is not active	
R32.0	enUsrScal	0_{bin}	User scaling is not active	0_{bin}
		1_{bin}	User scaling is active	

R33: User scaling - offset (B_w)

This register contains the offset of the user scaling.
User scaling can be activated through bit R32.0 in the feature register.

R34: User scaling - gain (A_w)

This register contains the user scaling gain. Default: 0x0100 (256_{dec}).
User scaling can be activated through bit R32.0 in the feature register.

R35: User activation value

If the user activation value has been activated by bit R32.8 of the feature register, the terminal applies the user activation value instead of the manufacturer activation value to its output if a system reset or a watchdog timer overflow (terminal has not received any process data for 100 ms) happens.

Examples See ▷Examples of Register Communication ◁ from page 70 onward.

17

KVE000/KVK000 I/O-Bus Extension E/K

17.1 Functional Description

17.1.1 System expansion

Based on a bus terminal block consisting of a Bus Coupler and a maximum of 64 Bus Terminals, using the I/O-Bus Extension Terminals KVE000 and KVK000 your system can be expanded by up to 31 terminal blocks. The expansion terminal blocks can be equipped with a maximum of 64 Bus Terminals each. The maximum permissible configuration consists of 255 Bus Terminals and 1020 I/Os. The I/O-Bus Extension Terminals KVE000 and KVK000 enable a distance of 5 m max. between two terminal blocks and therefore an overall system length of 155 m.

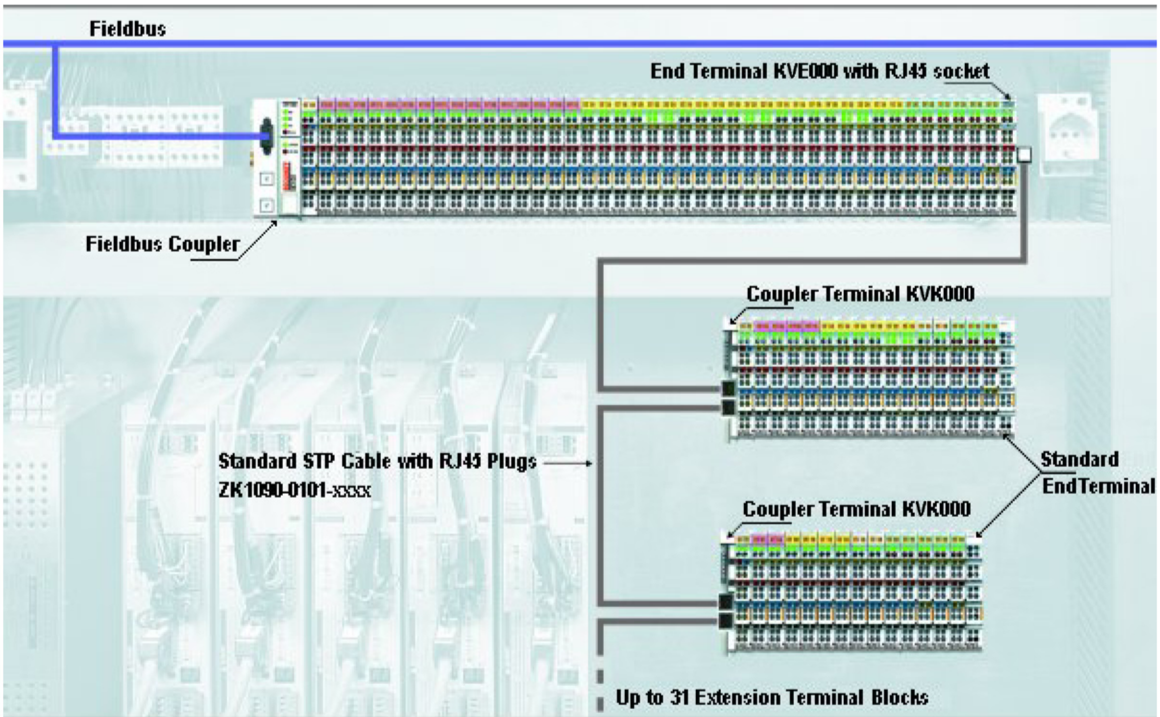


Figure 51:

The I/O-Bus Extension Terminals KVE000 and KVK000 integrate seamlessly into the Baumüller Bus Terminal system in terms of their appearance and functionality. The transparent terminal lugs used for labeling indicate their function as system terminals.

17.1.2 KVE000

The End Terminal with RJ45 socket (KVE000) is plugged into the end of the bus terminal block instead of a standard End Terminal (EK0000) and enables the connection of the I/O-Bus extension cable. The electronics of the KVE000 are supplied via the I/O-Bus from the Fieldbus Coupler.

17.1.3 KVK000

In the expansion terminal blocks, the Coupler Terminal KVK000 replaces the Fieldbus Coupler and takes over its function. Start the expansion station by installing a Coupler Terminal KVK000 on the C-mounting rail and connect its RJ45 socket (identified with IN) to the preceding bus terminal block via a I/O-Bus extension cable with a maximum length of 5 m. Connect the I/O-Bus extension cable

- of the first expansion terminal block to the End Terminal with RJ45 socket (KVE000) of the terminal block with the Fieldbus Coupler;
- of all other expansion terminal blocks to the RJ45 socket (identified with OUT) of the Coupler Terminal (KVK000) of the preceding expansion terminal block.

The power contacts and the corresponding connecting points of the Coupler Terminal are electrically isolated from the I/O-Bus.

17.1.4 I/O-Bus extension cable

Data transmission between the terminal blocks is via Ethernet cable with RJ45 plugs. Baumüller offers preassembled cables in different lengths, which can be customized with commercially available Ethernet tools.

NOTE

The I/O-Bus Extension Terminals should also work with cables from other manufacturers. However, Baumüller recommends the use of Baumüller Ethernet cables, which are tested for the specified functionality.

17.1.5 KVE000: End Terminal with RJ45 socket

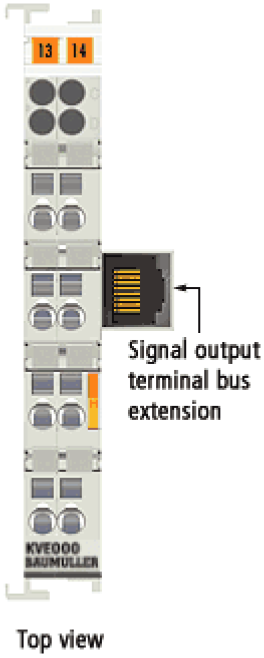


Figure 52: KVE000: End Terminal with RJ45 socket

Detail	Function
I/O-Bus extension output	RJ45 socket for the continuing I/O-Bus extension

17.1.6 KVK000: Coupler terminal

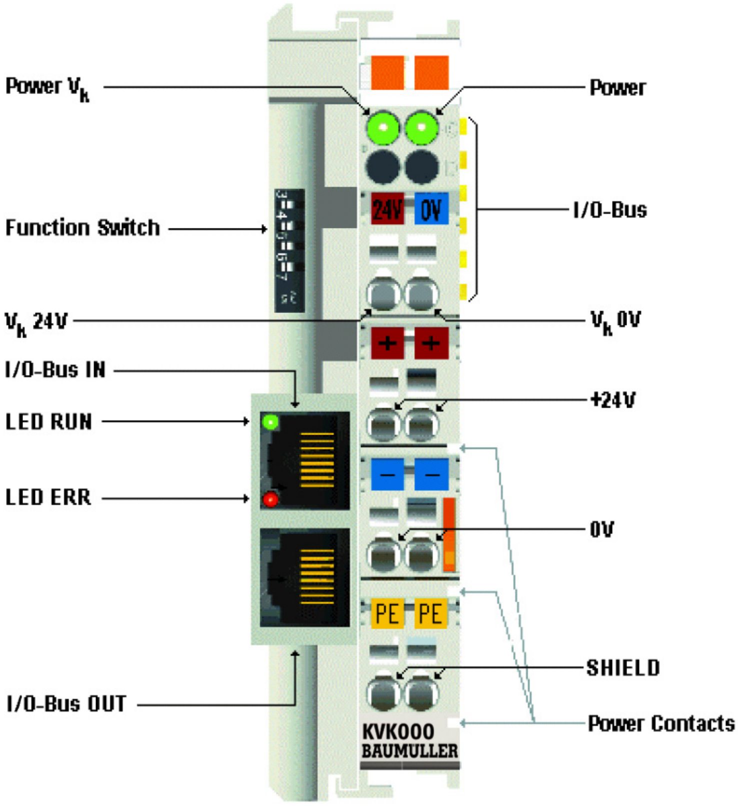


Figure 53:

Detail	Function
Power V_k	LED indicates whether the supply voltage for the electronics of the Coupler Terminal is switched on.
Power	LED indicates whether the supply voltage for the I/O terminals of the terminal block is switched on. The power supply of the terminals is via the power contacts.
Function Switch	Switch for the terminating resistor of the Coupler Terminal
I/O-Bus	Internal I/O-Bus of a bus terminal block
V_k 24V	Terminal for the feed of the +24 V power supply for the Coupler Terminal electronics
V_k 0V	Terminal for the feed of the 0 V power supply for the Coupler Terminal electronics
I/O-Bus IN	RJ45 socket for the incoming I/O-Bus extension
I/O-Bus IN, LED RUN	LED indicating that the I/O-Bus is transferring data
I/O-Bus IN, LED ERR	LED indicating a fault on the I/O-Bus

Detail	Function
I/O-Bus OUT	RJ45 socket for the continuing I/O-Bus extension
+24 V	Terminal for the feed of the +24 V power supply for the power contacts
0 V	Terminal for the feed of the 0 V power supply for the power contacts
SHIELD	Terminal for the connection of PE for the power contacts
Power Contacts	Internal power contacts of a bus terminal block

17.2 Mounting and wiring

17.2.1 Structure of an I/O-Bus extension

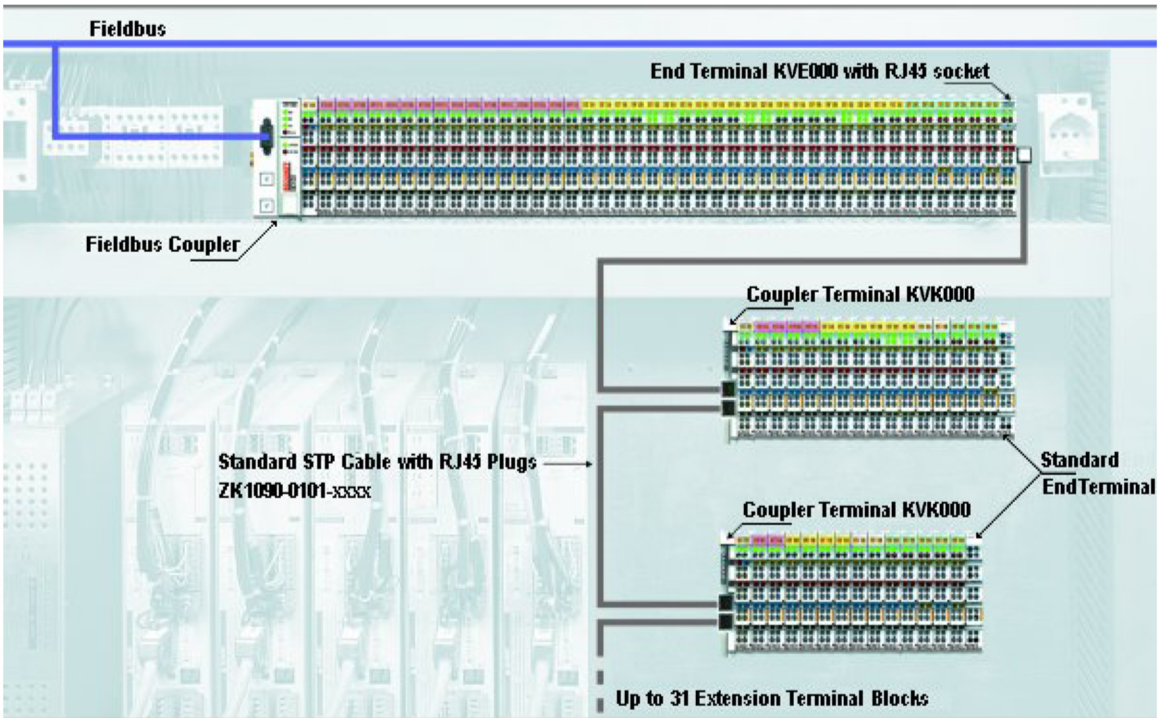


Figure 54:

17.2.2 Assembly

During installation, follow the notes in Section ▷Assembly and Installation ◁ from page 39 onward.

1 Ensure that the system is powered down and in a safe state.

2 Install the first bus terminal block, consisting of the Fieldbus Coupler and the desired Bus Terminals, on a C mounting rail.
Instead of a standard End Terminal (EK0000), install an End Terminal with RJ45 socket (KVE000) as the last terminal at the end of the first bus terminal block.

3 Install the first expansion terminal block, consisting of a Coupler Terminal (KVK000) and the desired Bus Terminals, on a C mounting rail.
Install a standard End Terminal (EK0000) as the last terminal at the end of the first expansion terminal block.

4 Connect one RJ45 plug of an Ethernet cable into the RJ45 socket of the KVE000 of the first bus terminal block until it clicks into place.
Connect the other RJ45 plug of the Ethernet cable into the RJ45 socket (labelled IN) of the expansion terminal block Coupler Terminal (KVK000) until it clicks into place.

5 Install the next expansion terminal block, consisting of a Coupler Terminal (KVK000) and the desired Bus Terminals, on a C mounting rail.
Install a standard End Terminal (EK0000) as the last terminal at the end of this expansion terminal block.

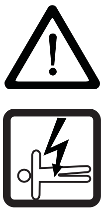
6 Connect one RJ45 plug of an Ethernet cable into the RJ45 socket (labelled OUT) of the KVE000 of the previous expansion terminal block until it clicks into place.
Connect the other RJ45 plug of the Ethernet cable into the RJ45 socket (labelled IN) of the KVK000 of the added expansion terminal block until it clicks into place.

7 Repeat steps 5 and 6 in order to connect further expansion terminal blocks. A maximum of 31 expansion terminal blocks can be connected.

8 Set the Function Switch on all Coupler Terminals (KVK000) correctly.

17.2.3 Function Switch

Activate the terminating resistor at the last expansion terminal block of your I/O-Bus extension system by switching the *Function Switch* on the last Coupler Terminal (KVK000) to the *Load* position.



DANGER

The following **will occur**, if you do not observe this danger information:

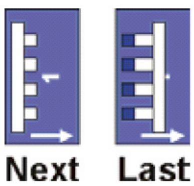
- serious personal injury
- death

The danger is: ***Electricity.***

Correct setting of the *Function Switches* of all Coupler Terminals (KVK000) within a I/O-Bus extension system must be ensured:

- The *Function Switch* of all Coupler Terminals (KVK000) to which a continuing Ethernet cable is connected must be set to position Next!
- The *Function Switch* may be set to the Load position only at the last Coupler Terminal (KVK000) of the I/O-Bus extension system!

Function Switch:



All expansion terminal blocks connected after a Coupler Terminal (KVK000), whose *Function Switch* is set to position Load, are not included correctly in the process image:

- The inputs of these terminals are not visible in the process image!
- The outputs of these terminals are not controlled by the process image!

Correct setting of the Function Switches must also be ensured if Coupler Terminals (KVK000) are replaced!

17.2.4 Disassembly

During disassembly, follow the notes in Section Installation of Bus Terminals on C mounting rails.

1 Ensure that the system is powered down and in a safe state.
2 Press the plastic lock of the RJ45 plug and pull it from the socket.
3 Carefully pull the orange-coloured lug approximately 1 cm out of the disassembled terminal, until it protrudes loosely. The lock with the C mounting rail is now released for this terminal, and the terminal can be pulled from the mounting rail without excessive force.
4 Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal away from the mounting rail.

17.3 Diagnostic

17.3.1 Diagnostic LEDs

17.3.1.1 Coupler Terminal (KVK000)

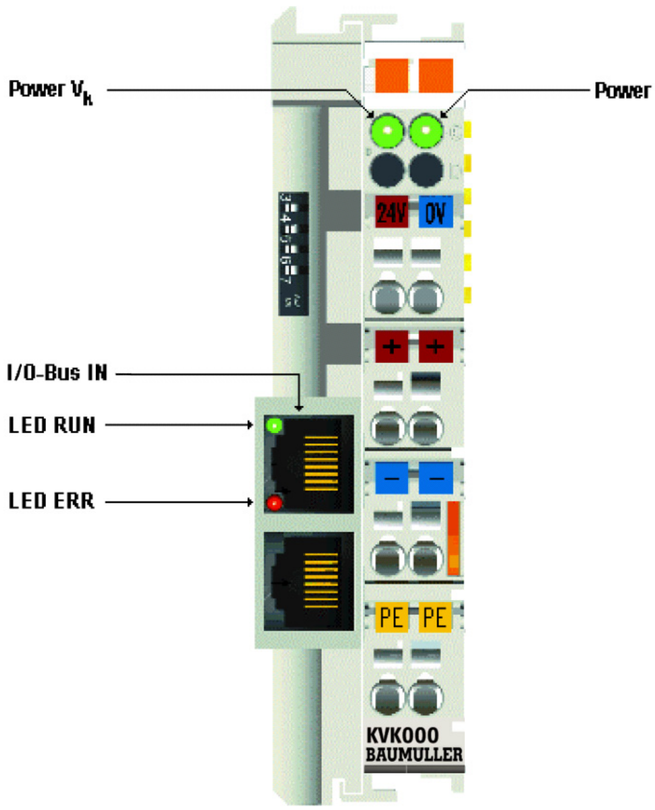


Figure 55:

Diagnostic LEDs for power supply

LED	Function	Display	Meaning
Power V_k (green)	Indicates whether the supply voltage for the electronics of the Coupler Terminal is switched on.	on	Supply voltage present
		off	Power supply has failed or is switched off
Power (green)	Indicates whether the supply voltage for the I/O terminals of the terminal block is switched on. The power supply of the terminals is via the power contacts.	on	Supply voltage present
		off	Power supply has failed or is switched off

Diagnostic LEDs on the RJ45 socket for the incoming I/O-Bus extension (I/O-Bus IN)

LED ***RUN*** (green)	LED ***ERR*** (red)	Meaning	Possible causes
on	off	Data transmission on the I/O-Bus extension is active	• Supply voltage present • Connection properly established
off	on	Data transmission on the I/O-Bus extension is interrupted	• Ethernet cable not connected • Cable fracture or short-circuit of the Ethernet cable • RJ45 plug was pulled • *Function Switch* of a KVK000 not set correctly
off	off	Data transmission on the I/O-Bus extension is interrupted	• The supply voltage for the electronics of the Coupler Terminal has failed? • Coupler Terminal faulty

17.3.1.2 End Terminal with RJ45 socket (KVE000)

The End Terminal KVE000 has no separate diagnostic LEDs. For diagnosing the I/O-Bus of your bus terminal block, the diagnostic LEDs *I/O RUN* and *I/O ERR* of the Fieldbus Coupler installed there are used.

Typical diagnostic LEDs of a Fieldbus Coupler

LED *RUN* (green)	LED *ERR* (red)	Meaning	Possible causes
on	off	Data transmission on the I/O-Bus is active	• Supply voltage present • Connection properly established
off	flashing	Data transmission on the I/O-Bus is interrupted	• Bus Terminal not properly plugged in • Configuration error • Installed Bus Terminal faulty
off	off	Data transmission on the I/O-Bus is interrupted	• The supply voltage for the electronics of the Fieldbus Coupler has failed • Fieldbus Coupler faulty

17.3.2 Behaviour in case of an error

If the communication between two or several bus terminal blocks of a I/O-Bus extension system is interrupted

- the green LEDs *RUN* on the I/O-Bus extension input sockets (I/O-Bus IN) of all KVK000 will go out;
- the red LEDs *ERR* on the I/O-Bus extension input sockets (I/O-Bus IN) of all KVK000 will go on;
- the green LED *I/O RUN* of your Fieldbus Coupler will go out;
- the red LED *I/O ERR* of the higher-level Fieldbus Coupler will flash rapidly, indicating an interruption of the communication.

Blink Code

If you now perform a reset for the Fieldbus Coupler, the Fieldbus Coupler searches for the cause of the fault and indicates it as a blink code via the LED *I/O ERR*.

A blink code is made up as follows:

- rapid flicker
- short break
- LED flashes m times for Error Code m
- short break
- LED flashes n times for error code argument n
- short break

Count the error code and the error code argument. The flash code is repeated continuously.

The error code for a I/O-Bus interruption is 4. The error code argument indicates the Bus Terminal after which communication was interrupted. Examples are shown in the Fault table for I/O-Bus interruption.

17.3.3 Fault table for I/O-Bus interruption

Examples of fault indications in the event of communication interruption on the I/O-Bus

Error	Display	Specific display	Possible cause	Remedy
no data transmission on the I/O-Bus and the I/O-Bus extension	LED *ERR* of the Coupler Terminals KVK000 are on	LED *I/O ERR* of the higherlevel Fieldbus Coupler flashes rapidly	I/O-Bus or I/O-Bus extension was interrupted	After any interruption of the data transmission on the I/O-Bus, the higher-level Fieldbus Coupler requires a reset in order to restart the data transmission or to locate the fault.
	LED *ERR* of the Coupler Terminals KVK000 are on LED *I/O ERR* of the higher-level Fieldbus Coupler flashes as follows after switching on (Blink Code): - fast - 4 times slow - n times slow		The Ethernet cable of a I/O-Bus extension is not plugged in correctly	Fault after the n-th Bus Terminal: ensure that the RJ45 plug is connected correctly.
			The *Function Switch* of the last Coupler Terminal is not in position *Load*	Set the *Function Switch* of the last Coupler Terminal to position *Load*!
			Wrong Ethernet cable	Fault after the n-th Bus Terminal: Do not use a crossed Ethernet cable for I/O-Bus extension!
		LED *Power* V_k of the affected Coupler Terminal is not on	The supply voltage of a Coupler Terminal has failed	Check the supply voltages of the bus terminal block after the n-th Bus Terminal
	LED *ERR* of the Coupler Terminals KVK000 are on	LED *I/O ERR* of the higherlevel Fieldbus Coupler flashes rapidly	Ethernet cable too long	The length of the Ethernet cable between two terminal blocks must not exceed 5 m.
				The overall length of the I/O-Bus extension must not exceed 155 m (31 x 5 m).
			Ethernet cable defective	Check the Ethernet cable.
			Wrong End Terminal installed: The End Terminal with RJ45 socket (KVE000) is only used at the bus terminal block with the Fieldbus Coupler.	All expansion terminal blocks must be terminated with standard End Terminals (EK0000)!

Please see the documentation your Fieldbus Coupler for further error codes (m≠4) and the associated error code arguments.

18

ZK0000 Inkremental Encoder Interface

18.1 Description of functions

The incremental encoder interface terminal ZK0000 enables the connection of any incremental encoders to the bus coupler or the PLC. A 16-bit counter with a quadrature decoder and a 16-bit latch can be read, set or activated. Besides the decoder imputs A, B, C, an additional latch input G1 (24 V) and a gate imput G2 (24 V) for disabling the counter are available.

The 16-bit up / down counter mode can also be selected. In this mode of operation, input B is the counting input.

1-fold, 2-fold or 4-fold evaluation of the encoder signals A, B, C in simple or complementary form can be parametrized via the field bus.

The terminal is supplied as a 4-fold quadrature decoder with complementary evaluation of the encoder signals A, B, C. For operation of the encoder interface, the operating voltage of 24 V DC must be connected to the terminal contacts in addition to the encoder inputs.

The ZK0000 has additional features:

- Incremental encoder with fault alarm outputs can be connected to the Status input of the ZK0000.
- A period measurement with a resolution of 200 ns can also be performed.

Assignments of terminal contacts

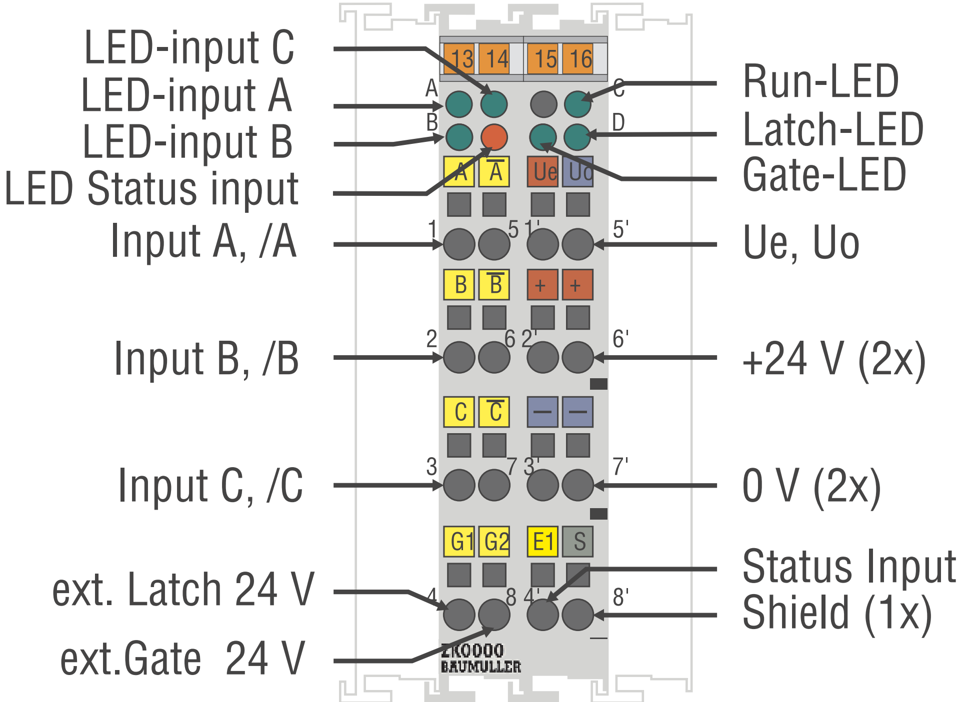


Figure 56:

Inputs A,/A:
Pulse input in the terminal's encoder and counter mode.

Inputs B,/B:
Phase-shifted pulse input in the terminal's encoder mode.

Counting direction input in the terminal's counter mode.
Counting direction:
+ 5 V (or open contact): up
0 V: down

Inputs C,/C:
Zero point pulse input for the terminal's latch register.
This input is activated via the EN_LATC bit in the terminal's control byte.

External Latch 24V
Additional latch input of the terminal.
This input is activated via the EN_LAT_EXT bit in the terminal's control byte.

The counter value is latched when this input is alerted and an edge change takes place from 0 V to 24 V.

External Gate 24 V
A high level at this contact suppresses counting by the terminal.

Status Input 5 V
Incremental encoder with fault alarm outputs can be connected to the Status input of the ZK0000.

Ue
Voltage supply for the encoder (+5 V).

Uo
Voltage supply for the encoder (0 V).

0V, 24 V
A supply of 0 V and 24 V voltage must be applied to these contacts for operation of the terminal.

Operating modes

These can be set via the feature register (default: incremental encoder):

A, B, zero pulse incremental encoder (default)

Up/down counter with:

- A = Count, the positive edges of the input pulses are counted
- B = Up/down input
  B = 0: up counting direction
  B = 1: down counting direction
- C = Gate input
  C = 0: counter enabled
  C = 1: counter disabled

Functions

- Counting
- Counter setting
- Arming the zero pulse and storing the valid value
- Determining the period between two pulses with a resolution of two 200 ns (the time between two positive edges of the input signal A is evaluated)
- Inidcation of a counter overflow or underflow.

LED display

The signal LED's indicate the status of the encoder inputs A, B, C, Status input and of the logic inputs of the gate and of the additonal external latch. The RUN LED indicates cyclic data transfer with the higher-level controller. The RUN LED goes off if no process data is exchanged for 100 ms.

Process data

The ZK0000 always occupies 6 bytes of input data and 6 bytes of output data. The control/status byte is at the least significant byte offset.

The data word D0/D1 contains the counter value (read/set) and the data word D3/D4 contains the latch word (read).

In the period measurement mode the value can be found in D2 together with D3 and D4.

18.2 Terminal configuration ZK0000

The terminal can be configured and parameterised via the internal register structure. (see ▹Terminal configuration AI1010 and AI2010 ◃ from page 44 onward).

18.3 Register Description

Different operating modes or functionalities may be set for the complex terminals. The General Description of Registers explains those register contents that are the same for all complex terminals (see ▹General Description of Registers ◃ from page 45 onward).

The terminal-specific registers are explained in the following section.

Access to the internal terminal registers is described in the Register Communication section.

18.3.1 Terminal-specific register description

Application parameters

R32: Feature register:
[0x2200]
The feature register determines the operating modes of the terminal.

Feature bit no.		Mode description
Bit 0	0	not used, don´t change
Bit 1	0/1	0: Counter inhibit with high-level at Gate input [0] 1: Counter inhibit with low-level at Gate-input
Bit 3 Bit 2	0 0	Status input (activ-low) is mapped into the status-byte.5 (ST.5) [00]
	1 0	ST.5 = Status-input, ST.6 = Status-input
	1 1	ST.5 = Status-input, ST.6 = Status-input
	0 1	reserved
Bit 6 Bit 5 Bit 4	0 0 0	External Latch function activ [000]
	0 0 1	Period measurement active
	all other combinations	reserved
Bit 7 - 9	0	not used, don´t change
Bit 11 Bit 10	0 0	4-fold evaluation of the encoder signals A,B,C, i.e. both rising and falling edges of the encoder signals A, B are counted. [00]
	0 1	1-fold evaluation of the encoder signals A, B, C, i.e. every period of the encoder signal A is counted.
	1 0	2-fold evaluation of the encoder signals A, B, C, i.e. every edge of the encoder signal A is counted.
	1 1	4-fold evaluation of the encoder signals A, B, C
Bit 14 - 12	0	not used, don´t change
Bit 15	0/1	0: Encoder interface. [0] 1: Counter mode is activated. 16-bit up/down counter Input A: Counter Input B: Counting direction (5 V or open = up, 0 V = down) Input C: Latch

18.3.2 Control and Status byte

CONTROL byte in process transfer

The control byte is transferred from the controller to the terminal. It can be used in the register mode (REG = 1) or in process data transfer (REG = 0). Various actions are triggered in the the ZK0000 with the control byte:

MSB

REG=0					**CNT_SET**	**EN_LAT_EXT / RD_PERIOD**	**EN_LATC**

Bit	Function
CNT_SET	The counter is set to the value that is specified via the process data with the rising edge of CNT_SET.
EN_LAT_EXT	The external latch input is activated. With the first external latch impulse after validity of the EN_LAT_EXT bit, the counter value in the latch register is stored. The pulses that follow have no influence on the latch register when the bit is set. Attention must be paid to ensuring that the corresponding latch valid bit (LAT_EXT_VAL) has been removed from the terminal before alerting of the zero pulse. This fuctionality is adjustable in the feature register (default).
RD_PERIOD	The periods between two positive edges of the input A are measured with a resolution of 200 ns. When the bit is set, this period is output in the databytes D2, D3, D4. This functionality is adjustable in the feature register.
EN_LATC	The zero point latch (C input) is activated. The counter value is stored in the latch register with the first external latch pulse after validity of the EN_LATC bit (this has priority over EN_LAT_EXT). The pulses that follow have no influence on the latch register when the bit is set. Attention must be paid to ensuring that the corresponding latch valid bit (LATC_VAL) has been removed from the terminal before the zero pulse is alerted (the LATC_VAL bit cannot be removed from the terminal until the C pulse has a low level).

STATUS byte in process data transfer

The status byte is transferred from the terminal to the controller. The status byte contains various status bits of the ZK0000.

MSB

REG=0		**STATUS_ INPUT**	**OVER- FLOW**	**UNDER- FLOW**	**CNTSET_ ACC**	**LAT_EXT_VAL / RD_PERIOD_Q**	**LATC_VAL**

Bit	
STATUS_ INPUT	The state of the Status input is mapped in this Bit (adjustable via feature register)
OVERFLOW	This bit is set if an overflow (65535 to 0) of the 16-bit counter occurs. It is reset when the counter exceeds a third of the measurement range (21845 to 21846) or as soon as an underflow occurs.
UNDERFLOW	This bit is set if an underflow (0 to 65535) of the 16-bit counter occurs. It is reset when the counter drops below two thirds of the measurement range (43690 to 43689) or as soon as an overflow occurs.
CNTSET_ACC	The data for setting the counter has been accepted by the terminal.
RD_PERIOD_Q	The data bytes 2, 3, 4 contain the period time
LAT_EXT_VAL	An external latch pulse has occurred. The data D2,D3 in the process image corresponds to the latched value when the bit is set. To activate the latch input again, EN_LAT_EXT must first be removed and then set again.
LATC_VAL	A zero point latch has occurred. The data D2,D3 in the process image corresponds to the latched value when the bit is set. To activate the latch input again, EN_LATC must first be removed and then set again.

18.3.3 Register communication ZK0000

Register access via process data transfer
Bit 7=1: register mode

When bit 7 of the control byte is set, the first two bytes of the user data are not used for process data transfer, but are written into or read out of the terminal's register.

Bit 6=0: read
Bit 6=1: write

In bit 6 of the control byte, you define whether a register is to be read or written. When bit 6 is not set, a register is read without modification. The value can be taken from the input process image.

When bit 6 is set, the user data is written into a register. The operation is concluded as soon as the status byte in the input process image has supplied an acknowledgement (see examples).

Bit 0 to 5: address

The address of the register to be addressed is entered in bits 0 to 5 of the control byte.

Control byte in register mode

MSB

REG=1	W/R	A5	A4	A3	A2	A1	A0

REG = 0_{bin}: Process data exchange
REG = 1_{bin}: Access to register structure
W/R = 0_{bin}: Read register
W/R = 1_{bin}: Write register
A5 to A0 = Register address
Address bits A5 to A0 can be used to address a total of 64 registers.

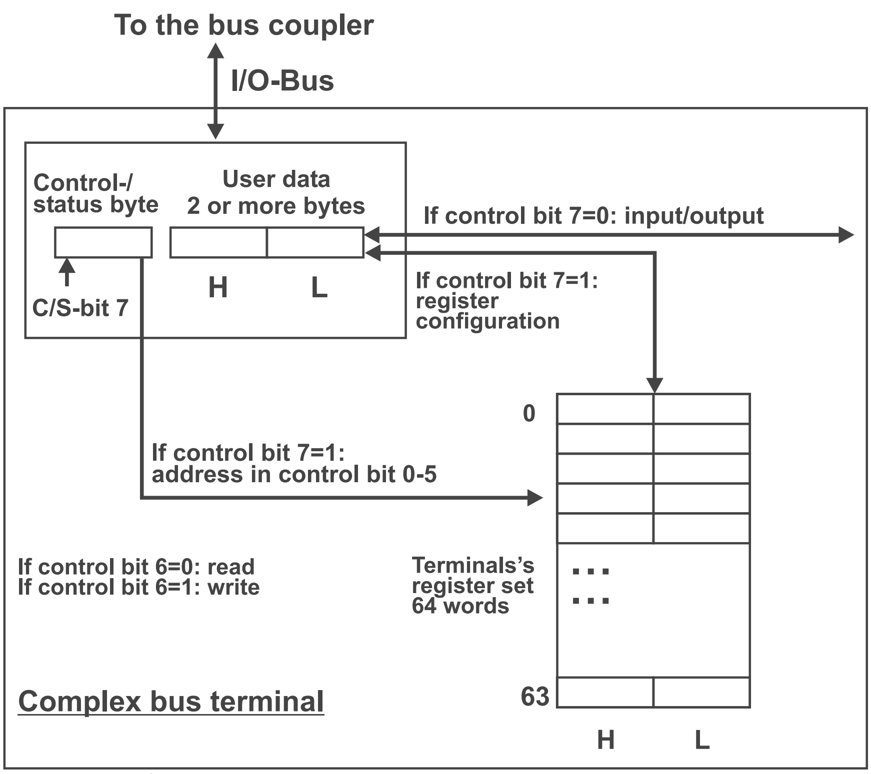


Figure 57: Complex bus terminal

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes.

18.4 Appendix

As already described in the chapter terminal configuration, each bus terminal is mapped in the bus coupler. In the standard case, this mapping is done with the default setting in the bus coupler / bus terminal. This default setting can be modified with the Baumüller configuration software ProPLC. The following tables provide information on how the ZK0000 maps itself in the bus coupler depending on the set parameters.

18.4.1 Mapping in the bus coupler

The ZK0000 is mapped in the bus coupler depending on the set parameters. The terminal is always evaluated completely, the terminal occupies memory space in the process image of the input **and** outputs.

Default: CANopen

	I/O Offset	High Byte	Low Byte
Complete evaluation = X MOTOROLA format = 0 Word alignment = 0	3		
	2	D4	D3
	1	(D2)	D1
	0	D0	CT/ST

Default: Profibus

	I/O Offset	High Byte	Low Byte
Complete evaluation = X MOTOROLA format = 1 Word alignment = 0	3		
	2	D3	D4
	1	(D2)	D0
	0	D1	CT/ST

Legend

Complete evaluation: The terminal is mapped with control / status byte.
Motorola format: The Motorola or Intel formal can be set.
Word alignment: The terminal is at a word limit in the bus coupler.

CT: Control- Byte (appears in the PI of the outputs).
ST: Status- Byte (appears in the PI of the inputs).
D0/D1: Counter word (read/set)
(D2): contains the period, together with D3/D4
D3/D4: Latch word (read)

18.4.2 Table of the register

Register set

Address	Description	Default value	R/W	Storage medium
R0	not used	0x0000	R	
R1	not used	0x0000	R	
R2	not used	0x0000	R	
R3	not used	0x0000	R	
R4	not used	0x0000	R	
R5	not used	0x0000	R	
R6	Diagnostic register – not used	0x0000	R	
R7	Command register- not used	0x0000	R	
R8	Terminal type	5101	R	ROM
R9	Software version number	0x????	R	ROM
R10	Multiplex shift register	0x0218/0130	R	ROM
R11	Signal channels	0x0130	R	ROM
R12	Minimum data length	0x3030	R	ROM
R13	Data structure	0x0000	R	ROM
R14	not used	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	not used	0x0000	R/W	SEEROM
R18	not used	0x0000	R/W	SEEROM
R19	not used	0x0000	R/W	SEEROM
R20	not used	0x0000	R/W	SEEROM
R21	not used	0x0000	R/W	SEEROM
R22	not used	0x0000	R/W	SEEROM
R23	not used	0x0000	R/W	SEEROM

Address	Description	Default value	R/W	Storage medium
R24	not used	0x0000	R/W	SEEROM
R25	not used	0x0000	R/W	SEEROM
R26	not used	0x0000	R/W	SEEROM
R27	not used	0x0000	R/W	SEEROM
R28	not used	0x0000	R/W	SEEROM
R29	not used	0x0000	R/W	SEEROM
R30	not used	0x0000	R/W	SEEROM
R31	Code word register	variable	R/W	RAM
R32	Feature register	0x2200	R/W	SEEROM
R33	not used	0x0000	R/W	SEEROM
R34	not used	0x0000	R/W	SEEROM
R35	not used	0x0000	R/W	SEEROM
R36	not used	0x0000	R/W	SEEROM
R37	not used	0x0000	R/W	SEEROM
R38	not used	0x0000	R/W	SEEROM
R39	not used	0x0000	R/W	SEEROM
R40	not used	0x0000	R/W	SEEROM
R41	not used	0x0000	R/W	SEEROM
R42	not used	0x0000	R/W	SEEROM
R43	not used	0x0000	R/W	SEEROM
R44	not used	0x0000	R/W	SEEROM
R45	not used	0x0000	R/W	SEEROM
R46	not used	0x0000	R/W	SEEROM
R47	not used	0x0000	R/W	SEEROM

19

DISMANTLING, STORAGE

In this chapter, we will describe how you decommission the terminals and store it. Observe the ▷Basic Safety Instructions ◁ from page 11 onward.

19.1 Safety regulations

Bring the bus system into a safe, powered down state before starting disassembly of the Terminals! Only specially trained personnel are allowed to dismantle the terminals. The safety regulations for commissioning apply analogously to dismantling.

19.2 Requirements of the personnel carrying out work

The personnel that carries out dismantling must have the necessary knowledge and have been trained appropriately to carry out this work. Choose these persons such that they understand and can apply the safety instructions printed on the unit and parts of it and on the connections.

19.3 Disassembly

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Carefully pull the orange-colored lug approximately 1 cm out of the disassembled terminal, until it protrudes loosely. The lock with the mounting rail is now released for this terminal, and the terminal can be pulled from the mounting rail without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal away from the mounting rail.

19.4 Storage conditions

Store the terminals in suitable packaging according to the storage conditions in ▷Anhang D - Technische Daten◁ from page 205 onward.

19.5 Recommissioning

If you want to recommission the terminals, observe the information in "Storage Conditions". Then, carry out ▷Assembly and Installation ◁ from page 39 onward again.

APPENDIX A ABBREVIATIONS

ADC Analog digital converter

CPU Central Processing Unit

EEPROM Electrically eraseable programmable read only memory

EMC Electromagnetic compatibility

EN European standard

EPROM Erasable Programmable Read Only Memory

EXT, ext Extern

I/O Input/Output, Eingang und Ausgang

I/O Bus Bus for the input and output modules (bus between b maXX controller PLC and the modules right handed of the PLC or power supply unit)

LED Light Emitting Diode

MSB most significant bit

OVRL **Ov**er **r**ange **l**imit

PA

PLC Process loop control, Speicher programmierbare Steuerung, SPS

RAM Random Access Memory

ROM Read Only Memory

SEEROM serial EEPROM

SW Software

UNRL **Un**der **r**ange **l**imit

APPENDIX B ACCESSORIES

In this appendix, you will find a list of all the accessories that are available for Baumüller Nürnberg GmbH's I/O terminals.

If you have any queries about accessories or suggestions for improvements, Baumüller's Product Management will be pleased to hear from you.

B.1 List of all accessories

At the moment there are no accessories available for the I/O terminals.

List of all accessories

C

APPENDIX C MANUFACTURER DECLARATION

In this section we provide general information about EU directives, the CE symbol and the Declaration by Manufacturer.

C.1 What is an EU directive?

EU directives specify requirements. The directives are written by the relevant bodies within the EU and are implemented by all the member countries of the EU in national law. In this way the EU directives guarantee free trade within the EU.

An EU directive only contains essential minimum requirements. You will find detailed requirements in standards, to which references are made in the directive.

C.2 What the CE symbol indicates

a) The CE marking symbolizes conformity to all the obligations incumbent on manufacturers for the product by virtue of the Community directives providing for its affixing.

…

b) The CE marking affixed to industrial products symbolizes the fact that the natural or legal person having affixed or been responsible for the affixing of the said marking has verified that the product conforms to all the Community total harmonization provisions which apply to it and has been the subject of the appropriate conformity evaluation procedures.

…

Council Decision 93/465/EEC, Annex I B. a) + c)

We affix the CE mark to the equipment and to the documentation as soon as we have established that we have satisfied the requirements of the relevant directives.

All converters and control systems supplied by the Baumüller Nürnberg GmbH satisfy the requirements of 73/23/EEC (Low Voltage Directive).
As all converters and control systems comply with the requirements of the harmonized

standards EN50178, EN 60204-1, EN 60529 and HD625.1 S1, the protection targets of 73/23/EWG are reached.

With specified application of this Baumüller equipment in your machinery, you can act on the assumption that the equipment satisfies the requirements of 98/37/EG (machinery directive). Therefore the equipment is developed and constructed in such a way, that the requirements of the harmonized standard EN 60204-1 can be met by the electrical installation.

Compliance with 89/336/EEC (EMC Directive) depends on how the equipment is installed. Since you are performing installation yourself, it is you who are responsible for complying with 89/336/EEC.
A declaration of conformity on the EMC directive therefore cannot be issued.

We will provide you with support in the form of EMC information. You will find this information in the operating manual and in “filters for main applications”. When you have complied with all the requirements we impose in this documentation, you can assume that the drive satisfies the requirements of the EMC Directive.
The limit values and requirements for variable-speed electrical drives are determined in the harmonized product standard EN61800-3. If you are erecting an installation, for which a declaration of conformity on the EMC directive must be generated, it may be necessary to specify several harmonized standards, which you have used for the compliance of the protection targets of the directive. The harmonized product standard EN 61800-3 has to be used with electrical drives.

To enable you to market your machine within the EU, you must be in possession of the following:

- Conformity mark (CE mark)
- Declaration(s) of Conformity regarding the directive(s) relevant to the machine

C.3 Definition of the term Declaration by Manufacturer

A Declaration by Manufacturer as defined by this documentation is a declaration that the machine/safety component brought into circulation conforms to all the relevant fundamental safety and health requirements.

By issuing the Declaration of Conformity in this section the Baumüller Nürnberg GmbH declares that the equipment conforms to the relevant fundamental safety and health requirements resulting from the directives and standards which are listed in the Declaration of Conformity .

The Baumüller equipment is integrated into a machine. For health and safety, of the users for example, it is important for the entire machine to conform to all the relevant fundamental safety and health requirements. For this reason the Baumüller Nürnberg GmbH draws attention in the Declaration by Manufacturer to the fact that it is prohibited to put the machine as a whole into operation before it has been declared that the machine conforms to the provisions of the Machinery Directive.

C.4 Manufacturer Declaration

EG-Herstellererklärung

Declaration by Manufacturer

gemäß EG-Richtlinie 98/37/EG (Maschinen) vom 22.06.1998
geändert durch: 98/79/EG vom 27.10.1998

in accordance with EC directive 98/37/EG (machinery) dated 22.06.1998
changed by: 98/79/EC dated 27.10.1998

b maXX I/O terminals

Das obige Gerät wurde entwickelt und konstruiert sowie anschließend gefertigt in Übereinstimmung mit o. g. EG-Richtlinie und u. g. Normen in alleiniger Verantwortung von:
The unit specified above was developed and constructed as well as manufactured in accordance with the above mentioned directive and the standards mentioned below under liability of:

Baumüller Nürnberg GmbH, Ostendstr. 80 - 90, D- 90482 Nürnberg

Berücksichtigte Normen - standards complied with:

Norm / standard	
EN 60204-1	Sicherheit von Maschinen - Elektrische Ausrüstung von Maschinen Safety of machinery - Electrical equipment of machines

Die Inbetriebnahme der Maschine, in die dieses Gerät eingebaut wird, ist untersagt bis die Konformität der Maschine mit der obengenannten Richtlinie erklärt ist.
The machinery into which this unit is to be incorporated must not be put into service until the machinery has been declared in conformity with the provisions of the directive mentioned above.

Nürnberg, 01. Juni 2006

Andreas Baumüller
Geschäftsführer
Head Division

ppa. Dr. Peter Heidrich
Entwicklungsleiter
Head of development

Seite 1 von 1 / page 1 of 1

C.4 Manufacturer Declaration

APPENDIX D - TECHNICAL DATA

In this appendix, you will find the technical data for Baumüller Nürnberg GmbH's I/O terminals.

D.1 Terminal housing

Mechanical data	
Design form	compact terminal housing with signal LED
Material	polyamide (PA 6.6)
Dimensions (w x h x d)	12 mm x 100 mm x 68 mm
Mounting	on 35 mm C mounting rail according to EN 50022 with lock
Side by side mount. by means of	double slot and key connection
Labelling	standard terminal block marking and plain language slides (8 mm x 47 mm)

Connection	
Wiring	Cage Clamp® spring-loaded system
Connection cross-section	0.08 mm² ... 2.5 mm², AWG 28-14, stranded wire, solid wire
Power contacts	up to 3 blade/spring contacts
Current load I_{MAX}	10 A (125 A short-circuit)

D.2 DI2000 and DI4000 2/4-channel digital input terminal

Technical data	DI2000	DI4000
Number of inputs	2	4
Nominal voltage	24 V DC (-15% / +20%)	
„0" signal voltage	-3 ... +5 V	
„1“ signal voltage	15 ... 30 V	
Input filter	3,0 ms	
Input current	typ. 5 mA	
Curr. consump. from I/O-bus	typ. 3 mA	
Electrical isolation	500 V_{rms} (I/O-bus/field potential)	
Bit width in the process image	2 inputs	4 inputs
Configuration	no address or configuration settings	
Weight approx.	50 g	55 g
Operating temperature	0°C ... +55°C	
Storage temperature	-25°C ... +85°C	
Relative humidity	95%, no condensation	
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29	
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)	
Installation position	variable	
Protection class	IP20	

D.3 DI8000 8-channel digital input terminal

Technical data	DI8000
Number of inputs	8
Nominal voltage	24 V DC (-15% / +20%)
„0" signal voltage	-3 ... +5 V (IEC 61131-2, type 1)
„1“ signal voltage	15 ... 30 V (IEC 61131-2, type 1)
Input filter	3,0 ms
Input current	3 mA typ.
Curr. consump. from I/O-bus	5 mA typ.
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Bit width in the process image	8 inputs
Configuration	no address or configuration settings

Technical data	DI8000
Weight approx.	55 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 50082 (ESD, burst)/EN 50018
Installation position	variable
Protection class	IP20

D.4 DO2000 2-channel digital output terminal

Technical data	DO2000
Number of outputs	2
Rated load voltage	24 V DC (-15% / +20%)
Load type	ohmsch, induktiv, Lampenlast
Max. output current (per channel)	0,5 A (short-circuit-proof)
Max. short-circuit current	0,6 ... 1,0 A
Breaking energy	< 150 mJ/channel
Reverse voltage protection	no
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Current consumption from load vol-tage	typ. 15 mA
Curr. consump. from I/O-bus	typ. 5 mA
Bit width in the process image	2 outputs
Configuration	no address or configuration settings
Weight approx.	55 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.5 DO4000 and DO4002 4-channel digital output terminal

Technical data	DO4000	DO4002
Number of outputs	4	4
Rated load voltage	24 V DC (-15% / +20%)	
Load type	ohmic, inductive, lamp load	
Max. output current (per channel)	0.5 A (short-circuit-proof), total current 3 A	
Max. short-circuit current	0,7 A ... 1,7 A	---
Current consumption from load voltage	typ. 9 mA	
Curr. consump. from I/O-bus	typ. 30 mA	
Reverse voltage protection	yes	no
Electrical isolation	500 V_{rms} (I/O-bus/field potential)	
Bit width in the process image	4 outputs	
Configuration	no address or configuration settings	
Weight approx.	70 g	70 g
Operating temperature	0°C ... +55°C	
Storage temperature	-25°C ... +85°C	
Relative humidity	95%, no condensation	
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29	
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)	
Installation position	variable	
Protection class	IP20	

D.6 DO8000 8-channel digital output terminal

Technical data	DO8000
Number of outputs	8
Rated load voltage	24 V DC (-15% / +20%)
Load type	ohmic, inductive, lamp load
Max. output current (per channel)	0.5 A (short-circuit-proof), total current 3 A
Current consumption from load voltage	typ. 18 mA
Curr. consump. from I/O-bus	typ. 60 mA
Reverse voltage protection	yes
Electrical isolation	500 V_{rms} (I/O-bus/field potential)

Technical data	DO8000
Bit width in the process image	8 outputs
Configuration	no address or configuration settings
Weight approx.	70 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.7 AI2010 2-channel analog input terminal 0 ... 10 V

Technical data	AI1010	AI2010
Number of inputs	1 (single ended)	2 (single ended)
Power supply	via the I/O-Bus	
Signal voltage	0 ... 10 V	
Internal resistance	> 130 kΩ	
Resolution	12 bit	
Conversion time	~ 1 ms	~ 2 ms
Meas. error (total meas. range)	< ± 0,3% (of the full scale value)	
Electrical isolation	500 V_{rms} (I/O-bus/field potential)	
Curr. consump. from I/O-bus	typ. 60 mA	
Bit width in the process image	input: 1 x 16 bit data (1 x 8 bit control/status optional)	input: 2 x 16 bit data (2 x 8 bit control/status optional)
Configuration	no address or configuration settings	
Weight approx.	60 g	60 g
Operating temperature	0°C ... +55°C	
Storage temperature	-25°C ... +85°C	
Relative humidity	95%, no condensation	
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29	
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)	

Technical data	AI1010	AI2010
Installation position	variable	
Protection class	IP20	

D.8 AI4010 4-channel analog input terminal 0 ... 10 V

Technical data	AI4010
Number of inputs	4 (single ended)
Power supply	via the I/O-Bus
Signal voltage	0 ... 10 V
Internal resistance	> 130 kΩ
Resolution	12 bit
Conversion time	~ 2 ms
Meas. error (total meas. range)	< ± 0,3% (of the full scale value)
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Curr. consump. from I/O-bus	typ. 65 mA
Bit width in the process image	input: 4 x 16 bit data (4 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	60 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.9 AI2±10 2-channel analog input terminal -10 V ... +10 V

Technical data	AI2±10
Number of inputs	2
Power supply	via the I/O-Bus
Signal voltage	-10 V ... +10 V
Internal resistance	> 200 kΩ

Technical data	AI2±10
Resolution	12 bit (for 0 ... 10 V range: resolution: 11 bit)
Conversion time	~ 2 ms
Meas. error (total meas. range)	< ± 0,3% (of the full scale value)
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Curr. consump. from I/O-bus	typ. 65 mA
Bit width in the process image	input: 2 x 16 bit data (2 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	70 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.10 AI4±10 4-channel analog input terminal -10 V ... +10 V

Technical data	AI4±10
Number of inputs	4
Power supply	via the I/O-Bus
Signal voltage	-10 V ... +10 V
Internal resistance	> 130 kΩ
Resolution	12 bit (for 0 ... 10 V range: resolution: 11 bit)
Conversion time	~ 2 ms
Meas. error (total meas. range)	< ± 0,3% (of the full scale value)
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Curr. consump. from I/O-bus	typ. 140 mA
Bit width in the process image	input: 4 x 16 bit data (4 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	70 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation

Technical data	AI4±10
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.11 AI2420 2-channel loop-powered input terminal 4 - 20 mA

Technical data	AI2420
Number of inputs	2
Power supply	24 V DC via the power contacts
Signal current	4 ... 20 mA
Internal resistance	typ. 80 Ω + diode voltage 0.7 V
Surge voltage resistance	35 V max.
Resolution	12 bit
Conversion time	~ 2 ms
Meas. error (total meas. range)	< ± 0,3% (of the full scale value)
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Curr. consump. from I/O-bus	typ 65 mA
Bit width in the process image	input: 2 x 16 bit data (2 x 8 bit control/status optional)
Configuration	no address or configuration settings
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.12 AI4420 4-channel analog input terminal 4 - 20 mA

Technical data	**AI4420**
Number of inputs	4
Power supply	via the I/O-bus
Signal current	4 ... 20 mA
Internal resistance	<85 Ω typ.
Common-mode voltage U_{CM}	30 V max.
Resolution	12 bit
Conversion time	~ 2 ms
Meas. error (total meas. range)	< ± 0,3% (of the full scale value)
Surge voltage resistance	30 V DC
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Curr. consump. from I/O-Bus	typ. 60 mA
Bit width in the process image	input: 4 x 16 bit data (4 x 8 bit control/status optional)
Weight approx.	55 g
Configuration	no address or configuration settings
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.13 AO2010 2-channel analog output terminal 0...10 V

Technical data	**AO2010**
Number of outputs	2
Power supply	via the I/O-bus
Signal voltage	0 ... 10 V
Load	> 5 kΩ (short-circuit-proof)
Accuracy	± 0.5 LSB linearity error, ± 0.5 LSB offset error, ± 0.1 % of full scale value
Resolution	12 bit

Technical data	AO2010
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Conversion time	~ 1,5 ms
Curr. consump. from I/O-bus	75 mA
Bit width in the process image	output: 2 x 16 bit data (2 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	85 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.14 AO4010 4-channel analog output terminal 0...10 V

Technical data	AO4010
Number of outputs	4
Signal voltage	0 ... 10 V
Load	> 5 kΩ (short-circuit-proof)
Accuracy	< ± 0.1 % (of the full scale value)
Resolution	12 bit
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Conversion time	~ 4 ms
Curr. consump. from I/O-bus	75 mA
Bit width in the process image	output: 4 x 16 bit data (4 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	85 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29

Technical data	AO4010
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.15 AO2±10 2-channel analog output terminal -10 V ... +10 V

Technical data	AO2±10
Number of outputs	2
Power supply	via the I/O-bus
Signal voltage	-10 V ... +10 V
Load	> 5 kΩ (short-circuit-proof)
Accuracy	± 0.5 LSB linearity error, ± 0.5 LSB offset error, ± 0.1 % of full scale value
Resolution	12 bit
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Conversion time	~ 1,5 ms
Curr. consump. from I/O-bus	75 mA
Bit width in the process image	output: 2 x 16 bit data (2 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	85 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.16 AO4±10 4-channel analog output terminal -10 V ... +10 V

Technical data	**AO4±10**
Number of outputs	4
Power supply	via the I/O-bus
Signal voltage	-10 V ... +10 V
Load	> 5 kΩ (short-circuit-proof)
Accuracy	± 0.5 LSB linearity error, ± 0.5 LSB offset error, ± 0.1 % of full scale value
Resolution	12 bit
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Conversion time	~ 4 ms
Curr. consump. from I/O-bus	20 mA
Bit width in the process image	output: 4 x 16 bit data (4 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	85 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.17 AO2420 2-channel analog output terminal 4 - 20 mA

Technical data	**AO2420**
Number of outputs	2
Power supply	24 V DC via the power contacts
Signal current	4 ... 20 mA
Load	< 500 Ω (short-circuit-proof)
Accuracy	± 0.5 LSB linearity error, ± 0.5 LSB offset error, ± 0.1 % of full scale value
Resolution	12 bit
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Conversion time	~ 1,5 ms

Technical data	AO2420
Curr. consump. from I/O-bus	typ. 60 mA
Bit width in the process image	output: 2 x 16 bit data (2 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	80 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.18 AO4420 4-channel analog output terminal 4 - 20 mA

Technical data	AO4420
Number of outputs	4
Power supply	24 V DC via the power contacts
Signal current	4 ... 20 mA
Load	< 350 Ω (short-circuit-proof)
Accuracy	< ± 0.1 % (of the full scale value)
Resolution	12 bit
Electrical isolation	500 V_{rms} (I/O-bus/field potential)
Conversion time	~ 4 ms
Curr. consump. from I/O-bus	typ. 60 mA
Bit width in the process image	output: 4 x 16 bit data (4 x 8 bit control/status optional)
Configuration	no address or configuration settings
Weight approx.	80 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29

Technical data	AO4420
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.19 EK0000 Bus end terminal

Technical data	EK0000
I/O-bus looped through	- / yes
Logical width in process image	0
Housing width in mm	12
Side by side mount. on Bus Terminals with power contact	yes
Side by side mount. on Bus Terminals without power contact	ja

D.20 ES0000 Feed terminal 24 V DC

Technical data	ES0000
Nominal voltage	24 V DC
Diagnostics	-
Power LED	green
Defect LED	-
Reported to I/O-bus	-
PE contact	yes
Shielding connection	-
Renewed infeed	yes
Connection facility to additional power contact	1
I/O-bus looped through	yes
Logical width in process image	0
Connection to top-hat rail	-
Electrical isolation	yes

Technical data	ES0000
Housing width in mm	12
Side by side mount. on Bus Terminals with power contact	yes
Side by side mount. on Bus Terminals without power contact	yes

D.21 KVE000 Terminal bus extension, end terminal

Technical data	KVE000
Number of coupler terminals	up to 31 KVK000
Peripheral signals	Bus Coupler dependency
Configuration possibility	none, automatic
Max. number of bytes	Bus Coupler dependency
Baud rates	automatic detection
Length between modules	max. 5 m between KVE000 and KVK000
Bus connection	1 x RJ45 socket
I/O-bus current consumption	70 mA
Power contact voltage	24 V DC max.
Power contact current load	10 A max.
Dielectric strength	500 V_{rms} (power contact/supply voltage/I/O-bus)
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.22 KVK000 Terminal bus extension, coupler terminal

Technical data	KVK000
Number of Bus Terminals	64
Type/number of peripheral signals	Bus Coupler dependency
Bus connection	2 x RJ45 socket (input + output)
Power supply	24 V DC (-15%/+20%)

Technical data	KVK000
Input current	70 mA + (total I/O-bus current)/4; 200 mA max.
Starting current	2.5 x continuous current
Length between modules	max. 5 m between KVE000 and KVK000
I/O-bus power supply	up to 400 mA
Power contact voltage	24 V DC max.
Power contact current load	10 A max.
Dielectric strength	500 V_{rms} (power contact/supply voltage/fieldbus)
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

D.23 ZK0000 Incremental encoder interface

Technical data	ZK0000
Sensor connection	A, A (inv), B, B (inv), zero, zero (inv), difference signal (RS485); status input
Sensor operating voltage	5 V DC
Sensor output current	0.5 A
Counter	16 Bit binary
Cut off frequency	1 MHz (with 4-fold evaluation)
Quadrature decoder	1, 2, or 4-fold evaluation
Zero-pulse latch	16 bit
Commands	read, set, enable
Supply voltage	24 V DC (-15%/+20%)
Current consumption of power contacts	0.1 A (without sensor load current)
Bit width in the process image	input/output: 1 x 16 bit data, 2 x 8 bit control/status
Curr. consump. from I/O-bus	25 mA
Weight approx.	85 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C

Technical data	ZK0000
Relative humidity	95%, no condensation
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27/29
EMC resistance burst/ESD	conforms to EN 61000-6-2 (EN 50082)/ EN 61000-6-4 (EN 50081)
Installation position	variable
Protection class	IP20

Index

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