Kollmorgen Automation Suite

AKT2G I/O Manual

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1 Table of Contents

2 About This Manual

This manual provides installation and operating instructions for Kollmorgen AKT2G I/O slice devices, including Safety devices.

2.1 Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.

It is essential that the following notes and explanations are followed when installing and commissioning these components.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

2.2 Origin of the document

This documentation was originally written in German. All other languages are derived from the German original.

Safety content derived from the following original files:

- EL1904.pdf, v2.2.0, 2020-07-17
- EL2904.pdf, v2.2.0, 2020-07-17

2.3 Currentness

Please check whether you are using the current and valid version of this document. The current version of the PDF can be downloaded from Kollmorgen's support website at https://www.kollmorgen.com/en-us/developer-network/downloads/. In case of doubt, please contact Technical Support.

An alternative resource is to use the KAS online help. The online help will always have the latest information in electronic form. See http://webhelp.kollmorgen.com/kas/

2.4 Product features

Only the product features specified in the current user documentation are valid.

2.5 Disclaimer

The documentation has been prepared with care. The products described are subject to cyclical revision. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. We reserve the right to revise and change the documentation at any time and without prior announcement. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

2.6 Safety Instructions

2.6.1 Delivery state

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Kollmorgen.

2.6.2 Operator's obligation to exercise diligence

The operator must ensure that

- the safety products are only used as intended (see chapter Product description);
- the safety products are only operated in sound condition and in working order.
- the safety products are operated only by suitably qualified and authorized personnel.
- the personnel is instructed regularly about relevant occupational safety and environmental protection aspects, and is familiar with the operating instructions and in particular the safety instructions contained herein.
- the operating instructions are in good condition and complete, and always available for reference at the location where the safety products are used.
- none of the safety and warning notes attached to the safety products are removed, and all notes remain legible.

2.6.3 Description of safety symbols

In these operating instructions the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

⚠ DANGER	**Serious risk of injury!** Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.
⚠ WARNING	**Risk of injury!** Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.
⚠ CAUTION	**Personal injuries!** Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.
NOTICE **Attention**	**Damage to the environment or devices** Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.
NOTE	**Tip or pointer** This symbol indicates information that contributes to better understanding.

2.7 Interference-Free EtherCAT Terminals

Use of interference-free EtherCAT Terminals in safety applications

If an EtherCAT Terminal is described as interference-free, this means that the consecutive terminal behaves passively in a safety application (e.g. in the case of the all-pole switch-off of a po- tential group).

In this case the terminals do not represent an active part of the safety controller and do not affect the Safety Integrity Level (SIL) or Performance Level (PL) attained in the safety application.

3 Mounting and Wiring of I/O Terminals

3.1 Instructions for ESD Protection

NOTE

Desctruction of the devices by electrostatic discharge possible!

The devices contain components at risk from electrostatic discharge caused by improper handling.

- Please ensure you are electrostatically discharged and avoid touching the contacts of the device directly.
- Avoid contact with highly insulating materials (synthetic fibers, plastic film, etc.).
- Surroundings (working place, packaging, and personnel) should be grounded properly when handling the devices.
- Each assembly must be terminated at the right hand end with an AKT2G-EM-000-000 bus end cap to ensure the protection class and ESD protection.

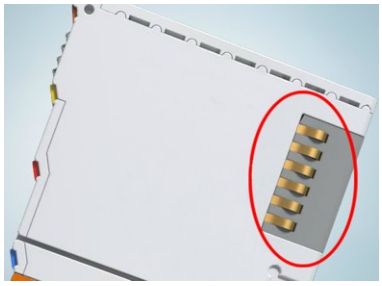


Figure 2-1: Spring contacts of the I/O components.

3.2 Installation on mounting rails

⚠WARNING

Risk of electric shock and damage of device!

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

3.2.1 Assembly

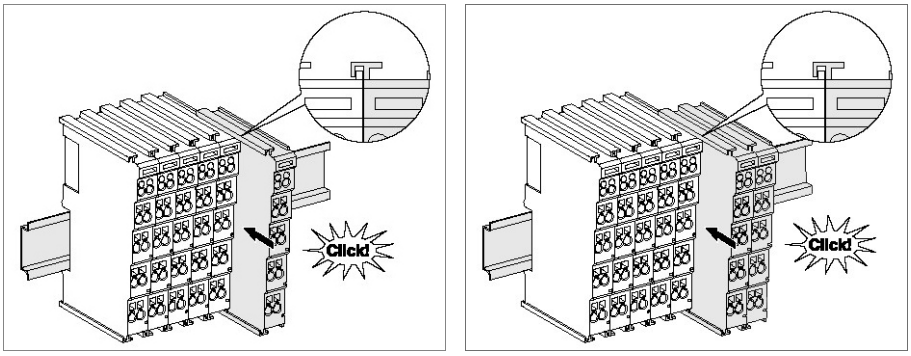


Figure 2-2: Attaching on mounting rail

The bus coupler and bus terminals are attached to commercially available 35 mm mounting rails (DIN rails according to EN 60715) 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.

TIP

Fixing of mounting rails

The locking mechanism of the terminals and couplers extends to the profile of the mounting rail. At the installation, the locking mechanism of the components must not come into conflict with the fixing bolts of the mounting rail. To mount the mounting rails with a height of 7.5 mm under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

3.2.2 Disassembly

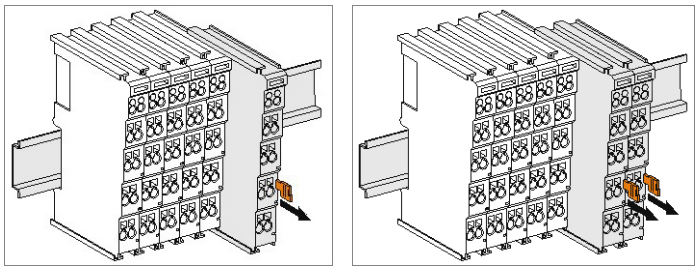


Figure 2-3: Disassembling of terminal

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Pull the terminal by its orange-colored lugs approximately 1 cm away from the mounting rail. In doing so for this terminal the mounting rail lock is released automatically and you can pull the terminal out of the bus terminal block easily 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 out of the bus terminal block.

3.2.3 Connections within a bus terminal block

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

- The six spring contacts of the E-Bus/K-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 (up to 24 V) or for higher voltages via power feed terminals.

NOTE

Power Contacts

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 (AKT2G-PSF-024-000) interrupt the power contacts and thus represent the start of a new supply rail.

3.2.4 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.

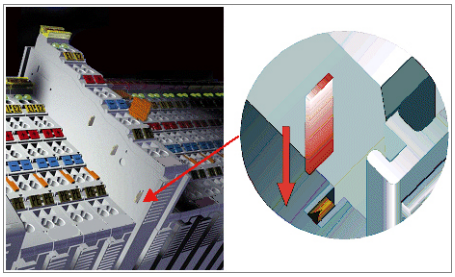


Figure 2-4: Power contact on left side

NOTE

Possible damage of the device

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.

⚠WARNING

Risk of electric shock!

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

3.3 Installation instructions for enhanced mechanical load capacity

⚠WARNING

Risk of injury through electric shock and damage to the device!

Bring the Bus Terminal system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals!

3.3.1 Additional checks

The terminals have undergone the following additional tests:

Verification	Explanation
Vibration	10 frequency runs in 3 axes
	6 Hz < f < 60 Hz displacement 0.35 mm, constant amplitude
	60.1 Hz < f < 500 Hz acceleration 5 g, constant amplitude
Shocks	1000 shocks in each direction, in 3 axes
	25 g, 6 ms

3.3.2 Additional installation instructions

For terminals with enhanced mechanical load capacity, the following additional installation instructions apply:

- The enhanced mechanical load capacity is valid for all permissible installation positions
- Use a mounting rail according to EN 60715 TH35-15
- Fix the terminal segment on both sides of the mounting rail with a mechanical fixture, e.g. an earth terminal or reinforced end clamp
- The maximum total extension of the terminal segment (without coupler) is: 64 terminals (12 mm mounting with) or 32 terminals (24 mm mounting with)
- Avoid deformation, twisting, crushing and bending of the mounting rail during edging and installation of the rail
- The mounting points of the mounting rail must be set at 5 cm intervals
- Use countersunk head screws to fasten the mounting rail
- The free length between the strain relief and the wire connection should be kept as short as possible. A distance of approx. 10 cm should be maintained to the cable duct.

3.4 Connection

3.4.1 Connection system

⚠WARNING

Risk of electric shock and damage of device!

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

3.4.1.1 Overview

The Bus Terminal system offers different connection options for optimum adaptation to the respective application:

- The terminals of AKT2G and AKT series with standard wiring include electronics and connection level in a single enclosure.

3.4.1.2 Standard wiring (AKT2G/AKT-xx)

Figure 2-5: Standard wiring

The terminals of AKT2G and AKT series have been tried and tested for years.

They feature integrated screwless spring force technology for fast and simple assembly.

3.4.2 Wiring

⚠WARNING

Risk of electric shock and damage of device!

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

3.4.2.1 Terminals for standard wiring AKT2G-xx/AKT-xx

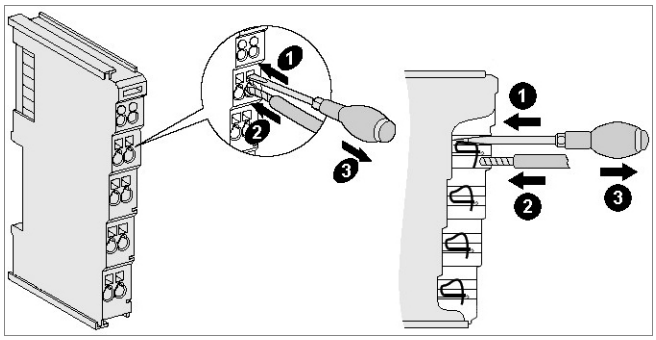


Figure 2-6: Connecting a cable on a terminal point

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

1. Open a terminal point by pushing a screwdriver straight against the stop into the square opening above the terminal point. Do not turn the screwdriver or move it alternately (don't toggle).
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal point closes automatically when the pressure is released, holding the wire securely and permanently.

   See the following table for the suitable wire size width.

Terminal Housing	AKT2G-xx, AKT-xx
Wire size width (single core wires)	0.08 ... 2.5 mm^2
Wire size width (fine-wire conductors)	0.08 ... 2.5 mm^2
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm^2
Wire stripping length	8 ... 9 mm

3.4.3 Shielding

NOTE

Shielding

Encoder, analog sensors and actors should always be connected with shielded, twisted paired wires.

⚠WARNING

Observe the special conditions for the intended use of Kollmorgen fieldbus components with extended temperature range (ET) in potentially explosive areas (directive 2014/34/EU)!

- The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60079-15! The environmental conditions during use are thereby to be taken into account!
- For dust (only the fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9): The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-0 for group IIIA or IIIB and IP6X for group IIC, taking into account the environmental conditions under which the equipment is used.
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range of -25 to 60°C for the use of Kollmorgen fieldbus components with extended temperature range (ET) in potentially explosive areas!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!
- The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The fuses of the AKT2G-PSF-024-000 power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!

3.5 Installation positions

NOTE

Constraints regarding installation position and operating temperature range

Please refer to the technical data for a terminal to ascertain whether any restrictions regarding the installation position and/or the operating temperature range have been specified. When installing high power dissipation terminals ensure that an adequate spacing is maintained between other components above and below the terminal in order to guarantee adequate ventilation!

3.5.1 Optimum installation position (standard)

The optimum installation position requires the mounting rail to be installed horizontally and the connection surfaces of the AKT2G terminals to face forward (see Figure 2-7: Recommended distances for standard installation position). The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. “From below” is relative to the acceleration of gravity.

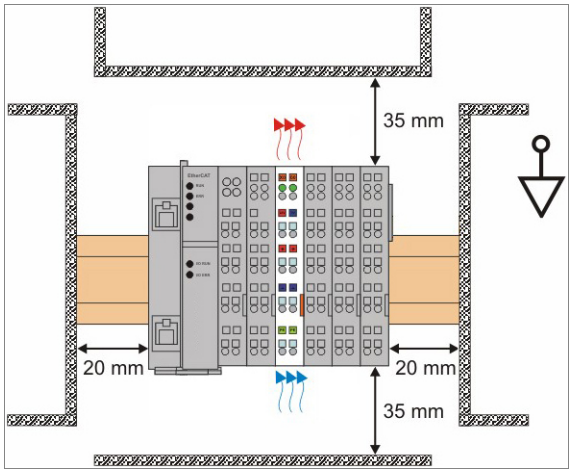


Figure 2-7: Recommended distances for standard installation position

Compliance with the distances shown in Fig. Recommended distances for standard installation position is recommended.

3.5.2 Other installation positions

All other installation positions are characterized by different spatial arrangement of the mounting rail - see Figure 2-8: Other installation positions.

The minimum distances to ambient specified above also apply to these installation positions.

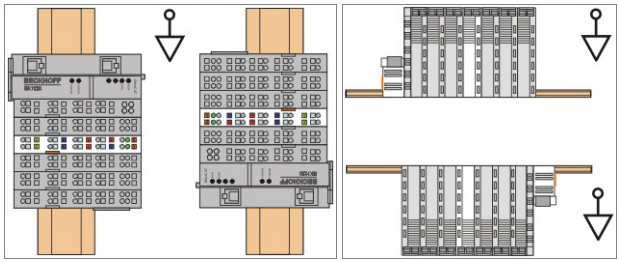


Figure 2-8: Other installation positions

3.6 Positioning of Passive Terminals

TIP

Hint for positioning of passive terminals in the bus terminal block
EtherCAT Terminals (AKT2G-xx), which do not take an active part in data transfer within the bus terminal block are so called passive terminals. The passive terminals have no current consumption out of the E-Bus.
To ensure an optimal data transfer, you must not directly string together more than two passive terminals!

3.6.1 Examples for positioning of passive terminals (highlighted)

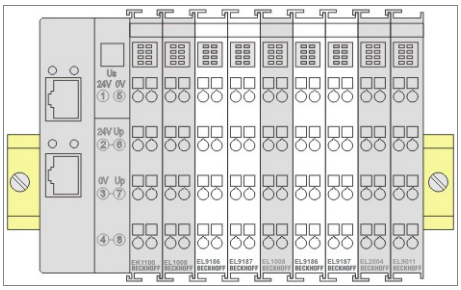


Figure 2-9: Correct positioning

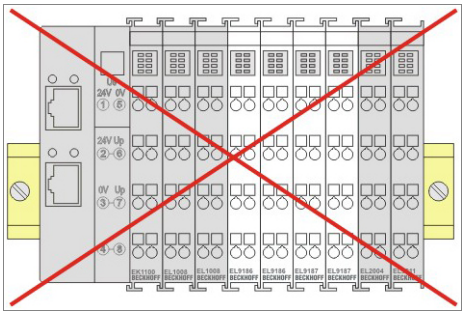


Figure 2-10: Incorrect positioning

3.7 UL Notice

Application

Kollmorgen EtherCAT modules are intended for use with Kollmorgen's UL Listed EtherCAT System only.

Examination

For cULus examination, the Kollmorgen I/O System has only been investigated for risk of fire and electrical shock (in accordance with UL508 and CSA C22.2 No. 142).

For devices with Ethernet connectors

Not for connection to telecommunication circuits.

3.7.1 Basic principles

UL certification according to UL508. Devices with this kind of certification are marked by this sign:

3.8 Continuative documentation about explosion protection

NOTE

Explosion protection for terminal systems

Pay also attention to the continuative documentation

4 Safety I/O Information

4.1 Safety Operation

4.1.1 Environmental Conditions

Please ensure that the safety components are only transported, stored and operated under the specified conditions (see technical data)!

⚠WARNING

Risk of injury!

The safety components must not be used under the following operating conditions.

- under the influence of ionizing radiation (that exceeds the level of the natural environmental radiation)
- in corrosive environments
- in an environment that leads to unacceptable soiling of the safety component

NOTICE

Electromagnetic compatibility

The safety components comply with the current standards on electromagnetic compatibility with regard to spurious radiation and immunity to interference in particular.

However, in cases where devices such as mobile phones, radio equipment, transmitters or high-frequency systems that exceed the interference emissions limits specified in the standards are operated near safety components, the function of the safety components may be impaired.

4.1.2 Safety Instructions

Before installing and commissioning the safety components please read the Safety Instructions in this documentation.

⚠WARNING

Commissioning Test

Before the AKT2G-SDI-004-000/AKT2G-SDO-004-000 can be used for the safety task, the user must carry out a commissioning test so that sensor and actuator wiring errors can be ruled out.

4.1.3 Transport / Storage

Use the original packaging in which the components were delivered for transporting and storing the safety components.

⚠CAUTION

Note the specified environmental conditions

Please ensure that the digital safety components are only transported and stored under the specified environmental conditions (see technical data).

4.1.4 Mechanical Installation

⚠DANGER

Risk of injury!

Bring the bus system into a safe, de-energized state before starting installation, disassembly or wiring of the devices!

⚠CAUTION

Use ferrules with plastic collars

When using fine-wire cables for signal connections, use ferrules with plastic collars. This leads to a higher system availability when test pulses for the corresponding channels are switched off.

4.1.4.1 Control cabinet / terminal box

The safety terminals must be installed in a control cabinet or terminal box with IP54 protection class according to IEC 60529 as a minimum.

4.1.4.2 Installation position and minimum distances

For the prescribed installation position the mounting rail is installed horizontally and the mating surfaces of the terminals point toward the front (see illustration below). The terminals are ventilated from below, which enables optimum cooling of the electronics through convection. The direction indication “down” corresponds to the direction of positive acceleration due to gravity.

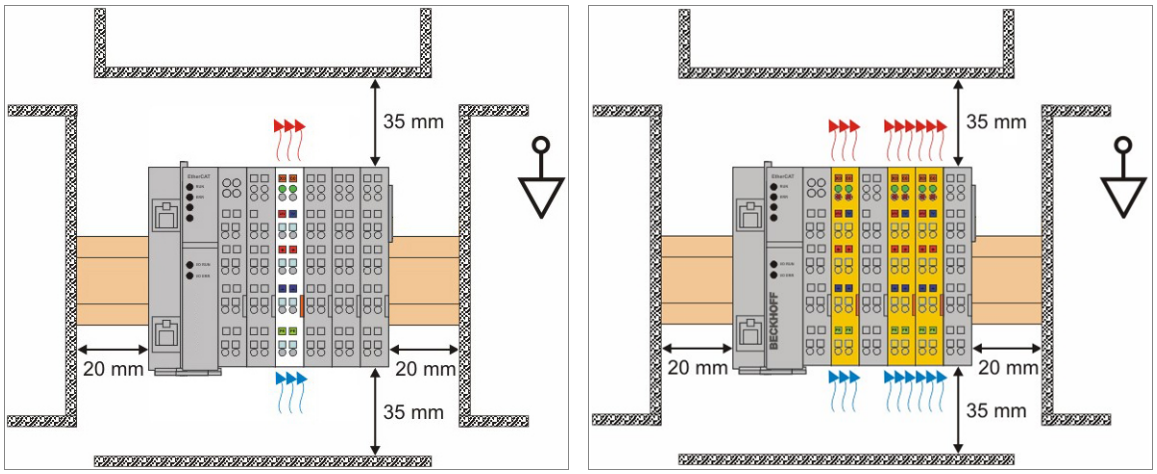


Figure 3-1: Installation position and minimum distances

In order to ensure optimum convection cooling, the distances to neighboring devices and to control cabinet walls must not be smaller than those shown in the diagram.

NOTE

External heat sources / radiant heat / impaired convection

The maximum permissible ambient temperature of 55°C was checked with the above example configuration. Impaired convection, an unfavorable location near heat sources or an unfavorable configuration of the EtherCAT Terminals may result in overheating of the terminals.

The key parameter is always the maximum permitted internally measured temperature of 95°C, above which the safety terminals switch to safe state and report an error. The internal temperature can be read from the safety components via CoE.

4.2 Safety Terminal Reaction Times

The safety terminals form a modular safety system that exchanges safety-oriented data via the Safety-over-EtherCAT protocol. This topic is intended to help you determine the system's reaction time from the change of signal at the sensor to the reaction at the actuator.

4.2.1 Typical Reaction Time

The typical reaction time is the time that is required to transmit information from the sensor to the actuator, if the overall system is working without error in normal operation.

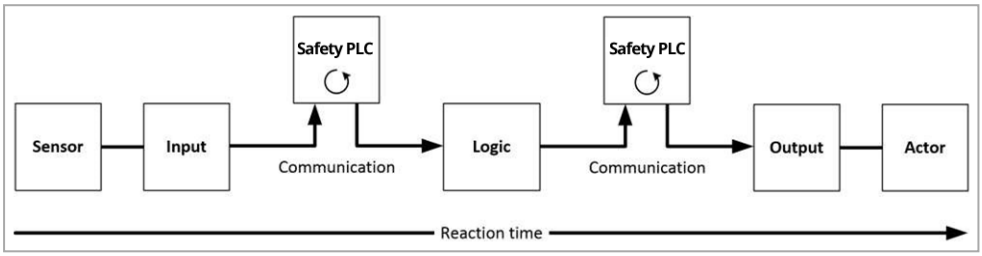


Figure 3-2: Typical reaction time

Definition	Description
RTSensor	Reaction time of the sensor until the signal is provided at the interface. Typically supplied by the sensor manufacturer.
RTInput	Reaction time of the safe input, such as AKT2G-SDI-004. This time can be found in the technical data. In the case of the AKT2G-SDI-004 it is 4 ms.
RTComm	Reaction time of the communication This is typically 3x the EtherCAT cycle time, because new data can only be sent in a new Safety-over-EtherCAT telegram. These times depend directly on the higher-level standard controller (cycle time of the PLC).
RTLogic	Reaction time of the logic terminal. This is the cycle time of the safety PLC, depending on the size of the safety project.
RTOutput	Reaction time of the output terminal. This typically lies within the range of 2 to 3 ms.
RTActor	Reaction time of the actuator. This information is typically supplied by the actuator manufacturer
WDComm	Watchdog time of the communication

This results in the following equation for the typical reaction time:

$$ReactionTime_{typ} = RT_{Sensor} + RT_{Input} + 3 * RT_{Comm} + RT_{Logic} + 3 * RT_{Comm} + RT_{output} + RT_{Actor}$$

with, for example

$$ReactionTime_{typ} = 5ms + 4ms + 3 * 1ms + 10ms + 3 * 1ms + 3ms + 20ms = 48ms$$

4.2.2 Worst-Case Reaction Time

The worst case reaction time is the maximum time required to switch off the actuator in the case of an error.

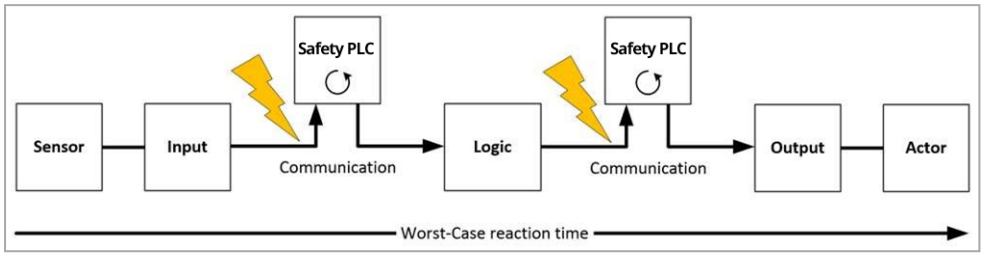


Figure 3-3: Worst-case reaction time

This assumes that a signal change occurs at the sensor and is transmitted to the input. A communication error occurs at precisely the moment when the signal is to be transferred to the communication interface. This is detected by the logic following the watchdog time of the communication link. This information should then be transferred to the output, but a further communication error occurs here. This error is detected at the output following the expiry of the watchdog time and leads to the switch-off.

This results in the following equation for the worst-case reaction:

$$ReactionTime_{max} = WD_{Comm} + WD_{Comm} + RT_{Actor}$$

with, for example

$$ReactionTime_{max} = 2 * 15ms + 20ms = 50ms$$

4.3 Safety I/O Maintenance

Maintenance

The safety components are maintenance-free!

Environmental conditions

⚠WARNING

Observe the specified environmental conditions!

Please ensure that the safety components are only stored and operated under the specified conditions (see technical data).

If the safety component is operated outside the permitted temperature range it will switch to **Global Shutdown** state.

Cleaning

Protect the safety component from unacceptable soling during operation and storage!

If the safety component was subjected to unacceptable soiling it may no longer be operated!

⚠WARNING

Have soiled terminals checked!

Cleaning of the safety component by the user is not permitted!

Please send soiled terminals to the manufacturer for inspection and cleaning!

5 Remote Input/Output Terminals

KAS remote I/Os provide a complete spectrum of bus couplers, digital and analog inputs, digital and analog outputs, stepper, counter, and thermocouple modules.

Related Documents

Please find in the table below the list of each I/O component available.

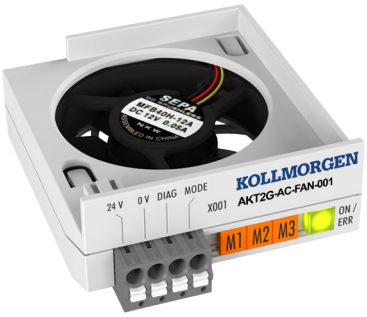
AKT2G (EtherCAT) Terminals

I/O Terminal Part Number	I/O Terminal Description
AKT2G-AC-FAN-001	Fan cartridge for EtherCAT and Bus Terminals
AKT2G-AN-240-000	2-channel input terminal PT100 (RTD) for resistance sensors, 16 bit, 2-, 3-wire system
AKT2G-AN-400-000	4-channel thermocouple input terminal, preset to type K, with wire breakage detection, 16 bit
AKT2G-AN-430-000	4-channel analog input, parameterisable, -10/0...+10 V, -20/0/+4...+20 mA, 16 bit
AKT2G-AT-410-000	4-channel analog output terminal 0...10 V, 12 bit, 1-wire system
AKT2G-AT-425-000	4-channel analog output terminal -10 V...+10 V, 12 bit, 4 x 2-wire system
AKT2G-DN-002-000	Up/down counter 24 V DC, 100 kHz, 32 bit counter depth
AKT2G-DN-008-000	8-channel digital input terminal 24 V DC, filter 3.0 ms, 1-wire system
AKT2G-DNH-008-000	8-channel digital input terminal 24 V DC, filter 10 µs, 1-wire system
AKT2G-DT-008-000	8-channel digital output terminal 24 V DC, 0.5 A, 1-wire system
AKT2G-ECT-000-000	EtherCAT Coupler for E-bus terminals
AKT2G-EM-000-000	Bus end cover for E-bus terminals, cover for power and E-bus contacts, grey
AKT2G-ENC-180-000	1-channel incremental encoder interface, 32 bit
AKT2G-ENC-190-000	Incremental encoder interface with differential input, 16/32 bit
AKT2G-PSF-024-000	Power supply terminal with fuse, 24 V DC
AKT2G-SDI-004-000	4-channel digital input terminal, Safety, 24 V DC
AKT2G-SDO-004-000	4-channel digital output terminal, Safety, 24 V DC, 0.5 A
AKT2G-SM-L15-000	Stepper motor terminal, 24 V DC, 1.5 A, vector control
AKT2G-SM-L50-000	Stepper motor terminal, 50 V DC, 5 A, vector control

Table 3-1: List of KAS I/O Terminals

5.1 AKT2G-AC-FAN-001

Fan cartridge for EtherCAT and Bus Terminals



5.1.1 Introduction

The AKT2G-AC-FAN-001 fan cartridge is used for forced ventilation within the terminal housing and ensures better heat dissipation from the housing. It extends the thermal operating range of EtherCAT Terminals (AKT2G-xxx) and K-Bus Terminals (AKT-xxx) and offers a wide range of new application options. The cartridge is installed on the underside of the terminal segment and covers a width of four standard terminals (4 x 12mm). It consists of the fan, an installation plate, a terminal strip (24 V DC, 0 V DC, diag, mode) and a bracket for fixation on different terminal housings (see Figure 3-4: Components AKT2G-AC-FAN-001).

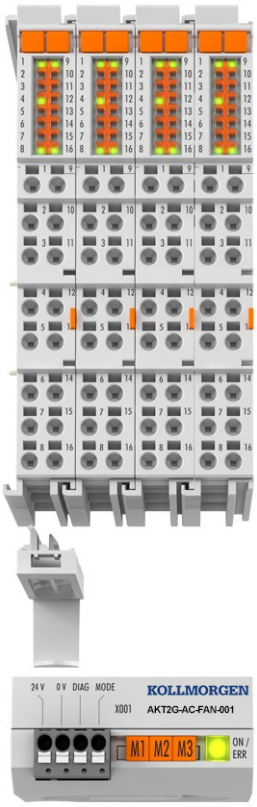


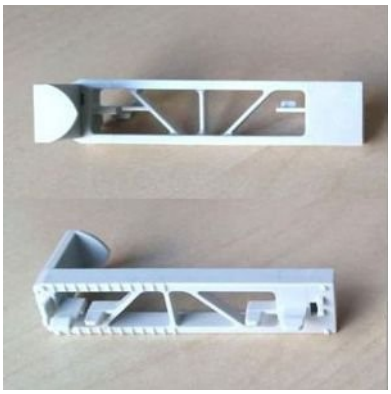
Figure 3-4: Components AKT2G-AC-FAN-001

5.1.2 Technical Data

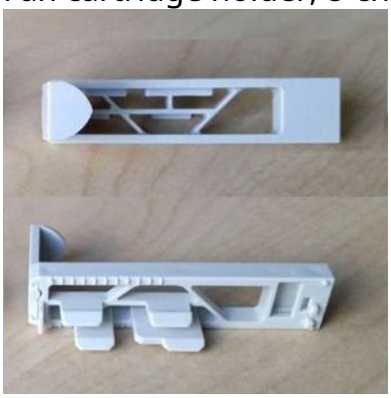
Technical data	AKT2G-AC-FAN-001
Number of channels	1 fan
Nominal voltage	24 V DC (-15 %/+20 %)
Current consumption (at 24 V operating voltage)	ca. 45 mA
Operating modes	temperature-controlled, full speed, frequency controlled
Rotational frequency fan	adjustable in 9 steps via frequency (1…9 Hz), max. ~5,500 rpm
Diagnostics, max. output current	fan fault, 15 mA
Life span	MTBF typ. = 280,000 h @ 20°C
Special features	increased performance and extended temperature range for various terminals
Dimensions (W x H x D)	47 mm x 22 mm x 55 mm
Weight	32 g (incl. bracket)
Operating / storage temperature	-25…+70°C/-40…+85°C
Relative humidity	95 %, no condensation
Vibration / shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity / emission	conforms to EN 61000-6-2/EN 61000-6-4
Protect. class / installation pos.	IP 20/see Mounting and Demounting
Approval	CE, cULus

5.1.3 Mounting and Demounting

The AKT2G-AC-FAN-001 fan cartridge is snapped onto a 48-mm wide terminal group of Kollmorgen standard or highdensity (HD) terminals using the "8-channel/16-channel fan cartridge holder" supplied as an accessory.



Fan cartridge holder, 8-channel



Fan cartridge holder, 16-channel

The width of the individual terminals may be 12mm (single width) or 24mm (double width) or a combination of both.

The mounting of the AKT2G-AC-FAN-001 is described below by way of an example.

5.1.3.1 Mounting

⚠WARNING

Risk of injury through electric shock and damage to the device!

Bring the Bus Terminals system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals.

1. Assemble the terminals to be ventilated into a group with a width of 48mm and snap the holder on the left in the lower ventilation cut-outs of the first terminal to be ventilated, as shown in Figure 3-5: Engaging the holder for the fan cartridge.

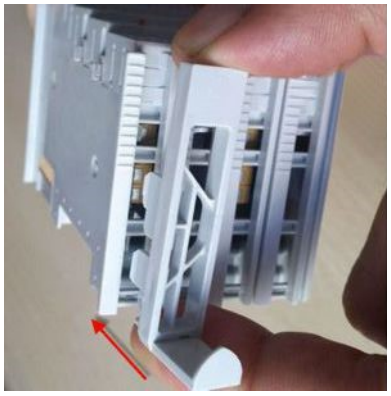


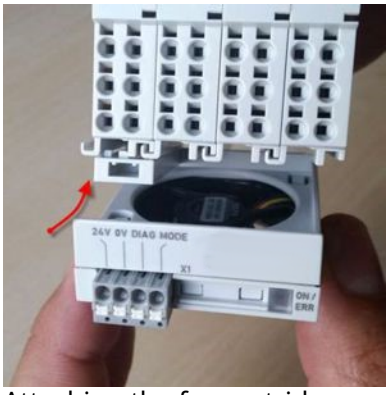
Figure 3-5: Engaging the holder for the fan cartridge

The holder is correctly engaged when a clear click sound is heard.

Correctly engaged holder, front view

Correctly engaged holder, side view

2. Push the fan cartridge onto the holder as shown in figure Attaching the fan cartridge. The holding tab and the recess (see figure Push fan cartridge with recess over holding tab) on the fan cartridge fit each other and close flush in a downward direction.



Attaching the fan cartridge

Push fan cartridge with recess over holding tab

3. Make sure that the latching tab is pushed into the groove until a click noise is heard as in 5.1 AKT2G-AC-FAN-001. The fan cartridge is now correctly attached.

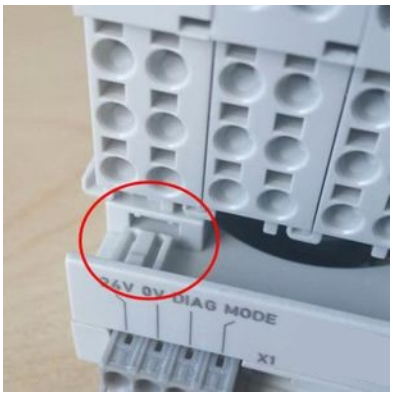
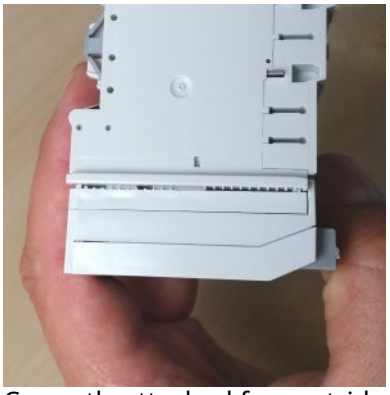


Figure 3-6: Push latching tab into groove

Correctly attached fan cartridge, front view



Correctly attached fan cartridge, side view

5.1.3.2 Removal

1. To dismantle, pull the fan cartridge off the terminal group in the direction of the arrow (see the following figure).

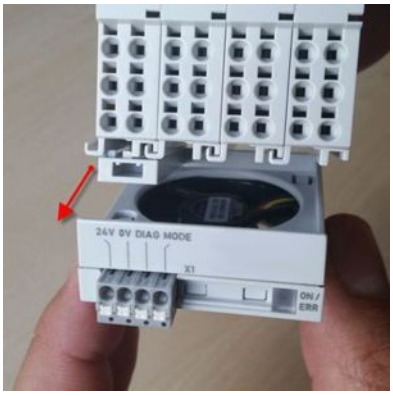


Figure 3-7: Pull the fan cartridge off towards the front

2. To detach the holder from the terminal, place a screwdriver between the terminal and holder (see the following figure) and carefully lever until the holder releases.

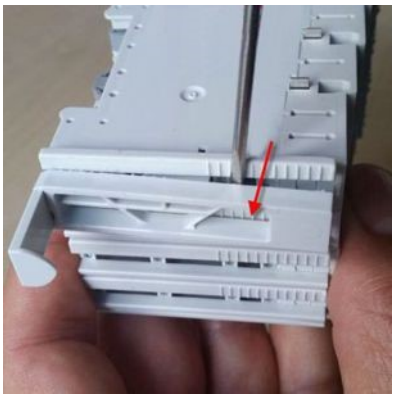


Figure 3-8: Remove the holder using a screwdriver

NOTE

Clearance of the fan cartridge module

When installing terminals with mounted fan cartridge module ensure that an adequate spacing (> 35 mm) is maintained between other components above and below the terminals (incl. fan cartridge) in order to guarantee a flawless operation of the fan cartridge and adequate ventilation of the terminals.

5.1.4 LED Display and Connection

Figure 3-9: AKT2G-AC-FAN-001 LED

5.1.4.1 Diagnosis LED

LED	Display		
On Err	off		No power supply
	green	on	supply voltage present, fan does not move, revolution temperature-controlled
		flashing	Operating display, flashing frequency depends on revolution (see table connection “Mode”)
	red		Error / fan malfunction

5.1.4.2 Connection

Designation	Meaning
24 V	+24 V power supply
0 V	0 V power supply
Mode	Input speed regulation via external voltage • 0 V, revolution temperature-controlled • 1 Hz, approx. 2700 U/min • 2 Hz, approx. 3150 U/min • 3 Hz, approx. 3600 U/min • 4 Hz, approx. 3960 U/min • 5 Hz, approx. 4290 U/min • 6 Hz, approx. 4620 U/min • 7 Hz, approx. 5010 U/min • 8 Hz, approx. 5370 U/min • 9 Hz, approx. 5500 U/min • High level (11 - 24 V): max. revolution, approx.. 5500 U/min.

Designation	Meaning
Diag	Output diagnosis (max. output current 15 mA) • Low level: Error/ fan malfunction • High level: normal operating status, no malfunction

5.1.5 Basic Function Principles and Commissioning

5.1.5.1 Area of application

The AKT2G-AC-FAN-001 fan cartridge is delivered ready to operate. No adjustments need to be made to the device.

A typical application of the fan module is extension of the performance range of the terminals through forced cooling. This enables the AKT2G-SM-L15-000 EtherCAT servo terminal to operate with higher output current so that the performance is on a par with the AKT2G-SM-L50-000 with the benefit of a 50% smaller footprint.

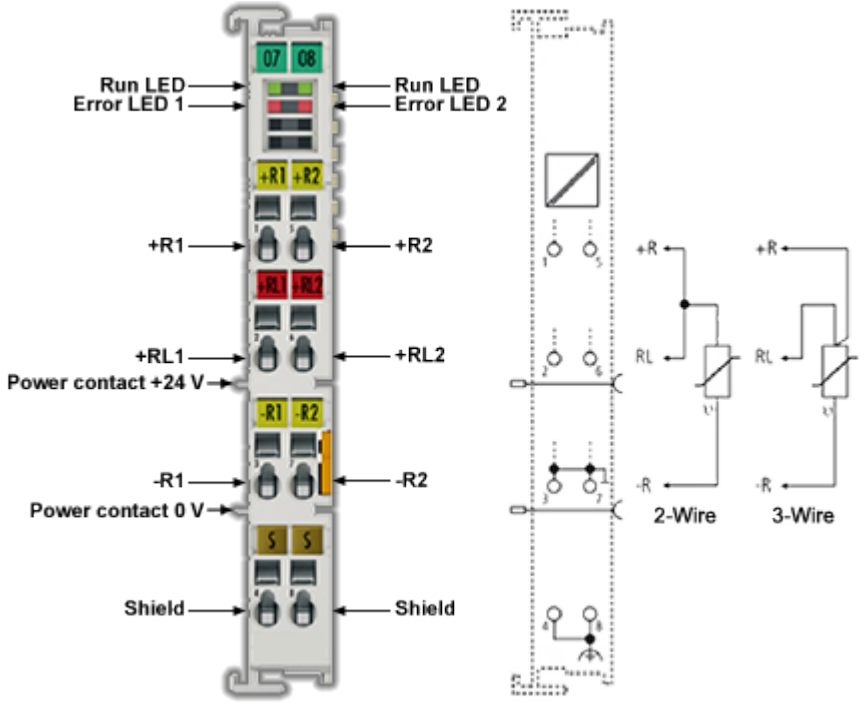
A further application is extension of the operating temperature range of the terminals. Depending on the technical specification, the fan module enables the terminals to operate at temperatures of up to 70°C. The exact terminal-specific information for this application can be found in the documentation for the respective terminals.

5.1.5.2 Commissioning

- Connect the AKT2G-AC-FAN-001 fan cartridge according to the instructions in the section LED Display and Connection.
- The fan can be operated in three different modes:
  - **Demand-based control via an integrated temperature sensor** (default, only power supply required)
    - The fan cartridge starts operating at approx. 40°C (~2.700 U/min) and increases the speed stepwise with increasing temperature
    - From approx. 55°C the fan reaches the full speed (~5.500 U/min)
    - If the temperature decreases below approx. 35°C, the fan cartridge switches off
  - **Continuous operation at full load** (in addition to the power supply a high signal is applied at the mode pin.)
  - **Frequency controlled by an externally applied frequency** (1 – 9 Hz) at the Mode pin, which is converted internally in steps from 2,700 rpm to max. ~5,500 rpm. A digital output terminal, for example, can be used as an external source. The measurement of the internal terminal temperature is used as reference for speed control of the fan via the frequency.
- In case of error there is a low signal on the "Diag" output and the LED display lights up red.

5.2 AKT2G-AN-240-000

2-channel input terminal PT100 (RTD) for resistance sensors, 16 bit, 2-, 3-wire system.



The AKT2G-AN-240 analog input terminal allows resistance sensors to be connected directly. The AN-240 circuitry can operate 2- and 3-wire sensors. Several characteristic sensor curves (Pt100, Pt1000, NI120, NI1000, KTY types and others) are supported.

The terminals from the AKT2G-AN-240 can measure the temperature at the measuring point or directly output the resistance values of the sensors. For temperature measurements the temperature value is calculated via the characteristic curves stored in the terminal.

The EtherCAT Terminals indicate their signal state by means of light emitting diodes. Sensor malfunctions such as broken wires are indicated by error LEDs.

See also: Notices on Analog Specifications for information on

- Measuring Error / Measurement Deviation
- Temperature Coefficient tK [ppm/K]
- Single-Ended / Differential Typification
- Common-mode voltage and reference ground (based on differential inputs)
- Dielectric strength
- Temporal Aspects of Analog/Digital Conversion

5.2.1 Technology RTD Measuring

5.2.1.1 Function

The AKT2G-AN-240 analog input terminals allow resistance sensors in the range 0 - 4096 Ohm to be connected directly.

Functions:

- Resistance measurement
  - Measuring range 0 to 1024 Ω: Resolution 1/64 Ohm
  - Measuring range 0 to 4096 Ω: Resolution 1/16 Ohm
  - The use of the terminal in the range from 0 to 10 Ohm is not recommended due to the relatively low measuring accuracy.
  - With the AN-240 the external bridge must be inserted between +R and +RL in 3-wire mode
- Temperature measurement

  The measured sensor resistance is converted directly into a temperature by the internal µC via the desired linearization characteristic curve
  - Standard resolution 1/10 °C (1 digit = 0.1 °C) according to a theoretically representable temperature range [- 3276.7 to 3276.8 °C]

    The physically specified temperature range for the respective sensor is to be observed!
  - Various PTC sensor characteristic curves are implemented over their complete measuring range for selection in the AN-240 series: Pt/Ni xxxx, KTY xx
  - Scaling and presentation can be changed

Additional notes:

- The resistance is determined by means of Ratiometric Voltage Measurement.
- The error state "broken wire" is detected as overrange, signaled as an error to the controller and indicated by the ERROR LED.
- The error state "short-circuit" is detected as underrange if the resistance is smaller than the smallest resistance of the measuring range, signaled as an error to the controller and indicated by the ERROR LED.
- In the delivery state, the measured value is displayed in increments of 1/10° C in two's complement format (integer).
- Other methods of display, e.g. high resolution with 1/100 °C can be selected via CoE 0x80n0:02.

  When using the high resolution a temperature range of -320 to +320 °C (-32566 to 32567) is measurable by the 2-byte PDO.

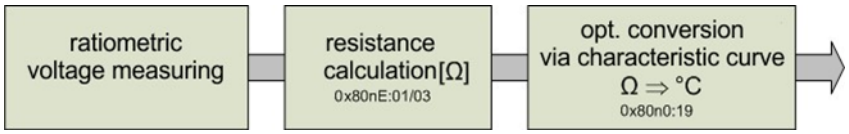


Figure 3-10: Display of the measurement and calculation of the resistance/temperature

5.2.1.2 Ratiometric Voltage Measurement

The AKT2G-AN-240 measures resistance ratiometrically by means of voltage comparison, see Figure 3-11: 3-wire connection technology:

- A constant voltage of 2.5 V is applied across a highly precise known reference resistance R_{ref} and the sensor R_t connected in series.

- 5 kOhm reference resistor

- The sensor resistance can be determined by comparing the two voltages, V1 at reference and V2 at the sensor
- The measuring current through the sensor thus depends on the sensor resistance; this must be considered in questions of sensor self-heating

  Example: at 0°C and thus 1000 Ohm internal resistance, a Pt1000 thus causes a measuring current of 0.1 mA on an AN-240.

IMPORTANT

Wiring of the input channels

Due to this measurement principle (resistive temperature sensor), a sensor may not be connected in parallel to two or more input channels!

5.2.1.3 Connection Techniques

The electrical connection of a resistance sensor to the AKT2G-AN-240 can take place using the 2-wire, or 3-wire. Since the measuring method is a resistance measurement, the sensor supply cables with their internal resistance can falsify the measurement. The following are available for this:

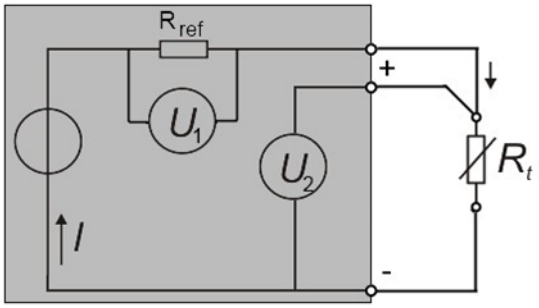


Figure 3-11: 3-wire connection technology

- 3-wire sensors: this simplified connection reduces wiring costs and compensates cable resistances to a considerable degree.
- 2-wire sensors: very simple connection, recommended only for short supply cables

  The supply line resistances can be eliminated from the calculation in 2-wire mode if they are made known to the AN-240 in the CoE object 0x80n0:1B (unit [1/32 Ω]). The determination of the supply line resistance is possible on the application side either by measurement or by comparison.

TIP

Two-wire connection

If the AN-240 is operated with a two-wire connection, the inputs +R and +RL must be bridged by the user.

5.2.1.3.1 Example of line compensation in the 2-wire mode

Example of line compensation in the 2-wire mode. The cross-sectional area of the 50 meter long copper wire connecting cable is 0.5 mm2. The specific resistance of copper is 0.0175 Ω mm2 m-1.

Determination of the total resistance of the feed cable:

$$R_{Ltot} = 0.0175\,\Omega\,mm^2m^{-1}\ \cdot\ (2\cdot\ 50\,m/0.5mm^2) = 3.5\,\Omega$$

For a resistance change of the Pt100 of ≈0.39 Ω/K, the resulting temperature deviation is:

$$3.5\Omega/(0.39\Omega/^\circ C) = 8.97^\circ C$$

if the line resistance is not taken into account. If the 3.5 Ohm are now entered as

$$3.5\,\Omega/(1/32)\,\Omega = 112_{dec}$$

in 0x8000:1B (see "80n0:1B" on page 56) this is subtracted from the measured value and the temperature is corrected accordingly.

5.2.1.4 Overview of Suitable Resistance Sensors

The following resistance sensors are suitable for temperature measurement with the AKT2G-AN-240 and can be selected via the object 0x80n0:19.

Type	Resistance range	Implemented temperature range
Pt100 (0.00385 Ω/Ω/°C, IEC60751 characteristic curve Pt385)	~ 18 ... ~390 Ohm	-200°C to 850°C
Ni100		-60°C to 250°C
Pt1000 (0.00385 Ω/Ω/°C, IEC60751 characteristic curve Pt385)	~180 ... ~3900 Ohm	-200°C to 850°C
Pt500		-200°C to 850°C
Pt200		-200°C to 1370°C
Ni1000		-60°C to 250°C
Ni1000 TK5000 100°C: 1500 ohm		-30 to 160°C
Ni120		-60°C to 320°C
KT100/110/130/210/230 KTY10/11/13/16/19	~500 ... ~2200 Ohm	-55 ...150°C
KTY81/82-110,120,150		
KTY81-121		
KTY81-122		
KTY81-151		
KTY81-152		
KTY81/82-210,220,250		
KTY81-221		
KTY81-222		
KTY81-251		
KTY81-252		

Type	Resistance range	Implemented temperature range
KTY83-110,120,150	~500 ... ~2500 Ohm	-50...175°C
KTY83-121		
KTY83-122		
KTY83-151		
KTY83-152		
KTY84-130,150	~350 ... ~2500 Ohm	-40...300°C
KTY84-151		
KTY21/23-6	~500 ... ~4000 Ohm	-50...150°C
KTY1x-5		
KTY1x-7		
KTY21/23-5		
KTY21/23-7		

5.2.2 Basic Principles of RTD Technology

Certain materials change their electrical resistance if the temperature of the material changes. Thanks to this property they can be used as sensors for the measurement of temperature. Such an RTD element (Resistance Temperature Device) or thermistor then exhibits a well-known material-dependent property, i.e. how the resistance changes in relation to the temperature – the so-called characteristic. In an initial approximation this characteristic can be taken to be a linear equation:

$$\Delta R = k\Delta T$$

The factor k can be positive or negative and must be specified by the sensor manufacturer:

- positive coefficient (PTC): resistance increases with increasing temperature, i.e. it conducts less well; the sensor is then referred to as a PTC thermistor
- negative coefficient (NTC): resistance increases with decreasing temperature, i.e. it conducts better; the sensor is then referred to as an NTC thermistor

The larger the coefficient, the higher the sensitivity of the sensor.

NOTE

Temperature measurement

This kind of temperature measurement is to be distinguished from that using thermocouple sensors:
these spontaneously generate a (small) voltage across the conductor, which is measured at the contact points.

Within a very small measuring range nearly all materials can be described by such a linear characteristic.

However, it is often necessary to measure over a large measuring range, e.g. several tens or hundreds of °K. Within such ranges the characteristic must be described for many materials by non-linear equations of a higher order or by using exponential components. Examples of such equations are

- Platinum/PT sensors (PTC thermistor) according to IEC 60751:
  - for the range -200.. 0°C:

    $$R(T) = R_0(1 + AT + BT^2 + C(T - 100°C)T^3)$$

  - for the range 0°C..850°C:

    $$R(T) = R_0(1 + AT + BT^2)$$

The coefficients A, B and C are to be specified by the sensor manufacturer or taken from the standard. The parameter R0 indicates the resistance in ohm of the platinum sensor at T = 0 °C. The sensor designations are based on these characteristics, e.g. for PT100 R_0 = 100 Ω at T=0 °C.

- Steinhart-Hart (for NTC thermistor)

  $$\frac{1}{T} = a + b\ln(R) + c\ln^3(R)$$

The coefficients a, b, c should be specified by the sensor manufacturer, or they can be determined by measuring the resistance at three known temperatures.

- B-parameter equation (for NTC thermistor)

  $$R_T = R(T) = A \cdot e^{\frac{B}{T}} = R_{T_0} \cdot e^{B\left(\frac{1}{T} - \frac{1}{T_0}\right)}$$

The coefficients R_{T0}, B, T_0 should be specified by the sensor manufacturer, or they can be determined by measuring the resistance at two known temperatures.

The B-parameter equation is a simplified version of the Steinhart-Hart equation. The B-parameter itself is only constant in a small range, e.g. between 25°C.. 50°C or 25°C.. 85°C, which is identified as follows: $B_{25/50}$ or $B_{25/85}$. The accuracy of the equation strongly depends on the B-parameter. The larger the measuring range, the lower the accuracy. If a larger measuring range required, it is preferable to use the Steinhart-Hart equation.

- and others

A typical characteristic is shown for each of the NTC and PTC families in following figure:

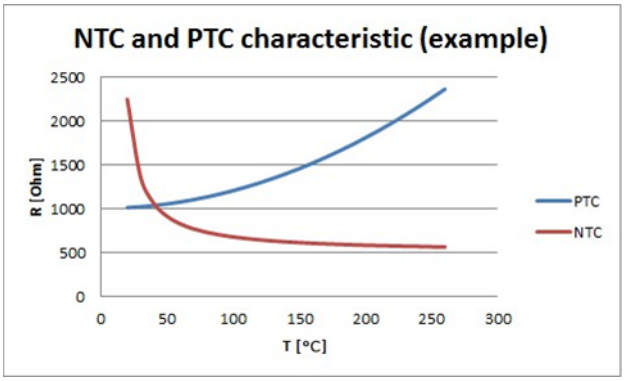


Figure 3-12: Examples for temperature-dependent resistance values

Hence, there is no such *thing* as a general NTC or PTC sensor – in fact, they are names for sensor families with a certain behavior.

For common sensors/characteristics such as PT100, these characteristics are already permanently implemented into the measuring devices. The user must check whether a sensor that he intends to use is supported by the measuring device. The following criteria apply here:

- **Temperature range:** does the sensor support the intended temperature range?
- **Measuring range:** can the sensor resistance be measured in the intended temperature range?
- **Characteristic curve:** can the measured resistance be converted accordingly into temperature? (base point, gradient/coefficient)
- **Velocity:** how often is the resistance measured?

In a quite basic way, a sensor manufacturer can of course also publish the characteristic of its sensor as a value table.

NOTE

Resistance measurement

To determine the resistance it is usual to pass a measuring current in the mA range (< 5 mA) through the sensor and to measure the resulting voltage. Three effects must be taken into consideration when doing this:

- the measuring current can lead to self-heating of the sensor. However, this usually has only a minimal effect on the measuring accuracy.

Special sensors tend to be used for cryogenic applications.

- the sensor supply lines also always have a resistance and add a (usually) constant additional resistance to the measurement. This can be compensated by
- 3-wire connection of the sensor
- manually accounting for the known wire resistance in the calculation
- using a sensor with a higher nominal resistance – the supply line effects are then of less consequence
- Insulation faults or thermovoltages can affect the measurement.

For classification there follows an overview of the NTC/PTC properties of various sensors:

NTC and PTC Properties

NTC	PTC
many semiconductors	many metals
various ceramics	various ceramics
NTC20, NTC100, etc.	Pt100, Pt1000, ..
	KTY ..
	Ni100, Ni1000, ..
	FeT

NOTE

Sensor exchange

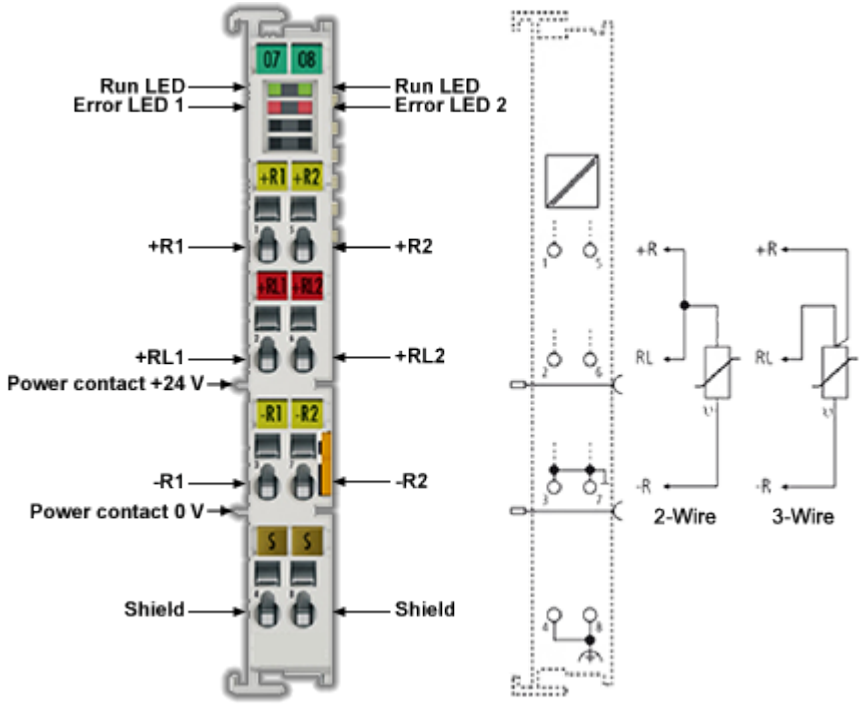
Please note that 1:1 exchangeability is not always guaranteed, especially in the case of manufacturer-specified sensors. If necessary, the new sensor must be re-calibrated in the system.

5.2.3 LEDs and Connection

NOTE

Two-Wore Connection

If the AKT2G-AN-240 is operated with a two-wire connection, the inputs +R and +RL must be bridged by the user.



AN-240 LEDs

LED	Color	Meaning	
RUN	green	This LED indicates the terminal's operating state:	
		off	State of the EtherCAT state machine: INIT = initialization of the terminal or BOOTSTRAP = function for firmware updates of the terminal
		flashing	State of the EtherCAT state machine: PREOP = function for mailbox communication and different standard-settings set
		Single flash	State of the EtherCAT state machine: SAFEOP = verification of the sync manager channels and the distributed clocks. Outputs remain in safe state
		on	State of the EtherCAT state machine: OP = normal operating state; mailbox and process data communication is possible
ERROR1, ERROR2	red	Short circuit or wire breakage. The resistance is in the invalid range of the characteristic curve	

AN-240 Pin Assignment

Terminal point	No.	Comment
+R1	1	Input +R1
+RL1	2	Input +RL1
-R1	3	Input -R1
Shield	4	Shield (internally connected to terminal point 8)
+R2	5	Input +R2
+RL2	6	Input +RL2
-R2	7	Input -R2
Shield	8	Shield (internally connected to terminal point 4)

5.2.4 Connection of Analog RTD Signal Lines

The RTD input terminals of the AN-240 measure the analog resistance of the sensor. The voltage drop at the sensor (including the line resistances, depending on the connection technology) is equivalent to the sensor resistance and therefore a measure for the sensor temperature, if the characteristic sensor curve is known. The following procedure serves for connecting analog signal cables in order to ensure error-free measurement of the analog signals.

5.2.4.1 Measures

- Sensor cable to be used
  - Tightly twisted
  - Shielded copper braid
  - Use low-impedance cable, particularly for 2-wire connection
- Keep the sensor and sensor cables free from external potential.

  On no account should the GND connections (3/7) be connected with other potentials.
- The resistor for the RTD sensor (e.g. 100 or 1000 Ω nominal) should be chosen based on the ratio between sensor resistance and line resistance, taking account of the connection type (2/3-wire).

5.2.4.2 Shielding Measures

NOTE

Shielding Measures

Due to the complexity in the "EMC" area, there is no generally applicable guideline, but only technical measures in accordance with the state of the art, which can sometimes contradict each other. These must be checked for feasibility and effectiveness, taking into account the plant specifications, and applied by the plant installer following assessment.

The following notes on shielding are to be understood as technical suggestions that have proven themselves from time to time in practical use. It must be checked in each case which measures can be applied, depending on the installation and plant. The effectiveness of each measure must be checked individually. The formal transferability of measures to other types of plant is in general not possible.

Priority is to be given to typical national or general normative specifications.

A shielding approach is described below that in many cases improves the measurement quality. The suggested measures must be checked for feasibility and effectiveness in the actual plant.

- Apply the shield with a low resistance and enveloping the cable by 360°
- at the entry point into the control cabinet, the shield should be earthed conductively
- the shield should be earthed again at the terminal
  - at the terminal connection point, if present
  - if no terminal connection point is available, earth the shield as close to the terminal as possible.
  - to avoid ground loops the shield can be undone after entry into the control cabinet. A capacitive connection to the terminal shield contact is possible.
  - avoid unshielded cable lengths of > 50 cm!

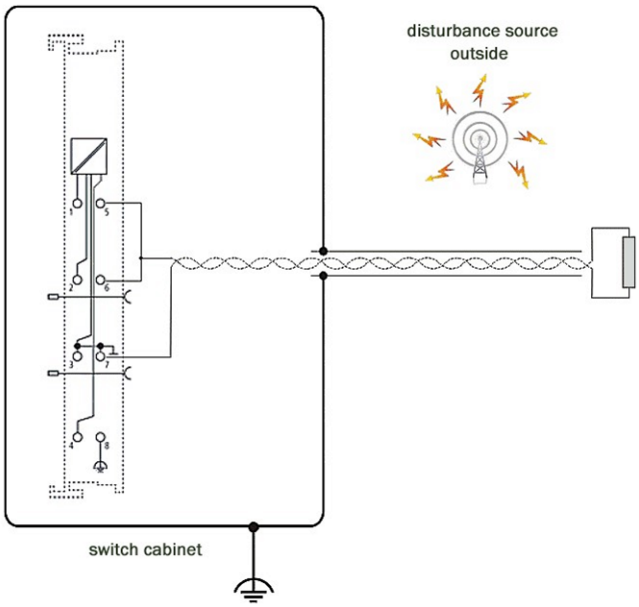


Figure 3-13: Example of AN-240 shield connection with shield contact, in the case of potential interference sources inside the control cabinet

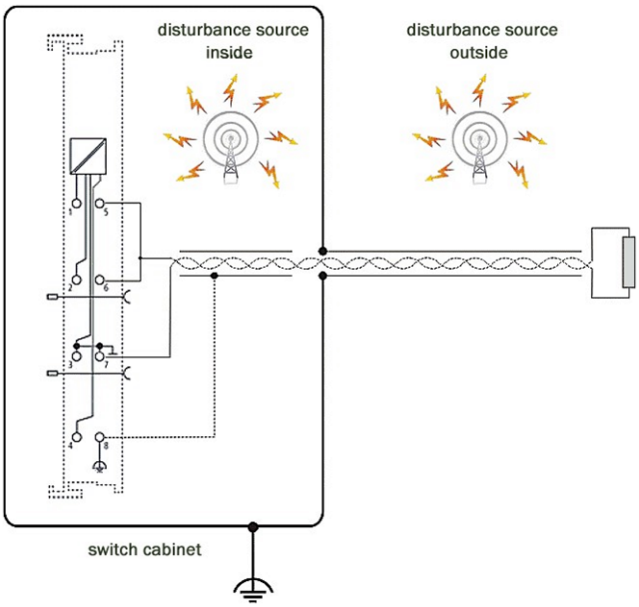


Figure 3-14: Example of AN-240 shield connection with shield contact, in the case of potential interference sources inside and outside the control cabinet

5.2.5 Settings and Application Notes for AN-240

5.2.5.1 Default setting

The AKT2G-AN-240 can be used for direct temperature or resistance measurements. The corresponding CoE settings are shown in the following table.

The relationship between temperature and resistance of a Pt100/Pt1000 sensor is shown below:

Temperature	typical resistance, approx.
850°C	Pt1000: 3.9 kΩ Pt100: 390 Ω
320°C	Pt1000: 2.2 kΩ Pt100: 220 Ω
-200°C	Pt1000: 180 Ω Pt100: 18 Ω

Characteristic sensor curves are available from the sensor manufacturers.

	AKT2G-AN-240
Default/factory setting	• 2-wire connection • Pt100 (CoE 0x80n0:19) • Presentation signed (CoE 0x80n0:02) • Limits disabled • 50 Hz filter enabled • All channels enabled
Area of application	The terminal is calibrated in the measuring range “1/16 Ω” (10 Ω to 4 kΩ) and can be used in this resistance range.

5.2.5.2 Notice regarding Resistance Measurement mode

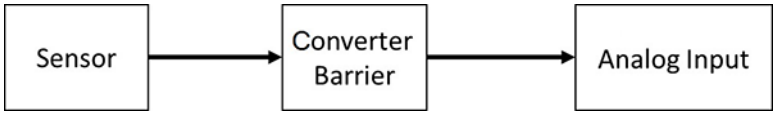
In Resistance Measurement mode the measured value is always displayed unsigned, irrespective of the Presentation setting (object 0x80n0:02), as 0..xFFFF with the respective value.

1/16 Ω -> ~62 mΩ/Digit

1/64 Ω -> ~15 mΩ/Digit

5.2.6 Basics About Signal Isolators, Barriers

Occasionally, analog signals cannot be fed directly from the sensor to the analog input module, in which case a special intermediary device must be added.

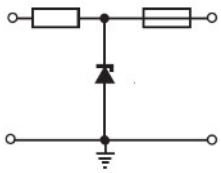


Reasons may include:

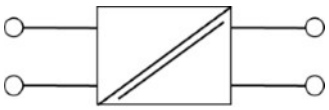
- The sensor may be installed in hazardous locations and protected according to the intrinsic safety ignition protection type (Ex i) while a module is not yet available for the desired application
- Separate electrical isolation between the sensor and the module is required
- The sensor has an electrical output signal for which does not yet offer a suitable input module.

The type of intermediate device depends on the following criteria

- Electrical signal supplied by the sensor: voltage 10 V or µV, AC or DC, 20 mA or 1 A, resistance, ...
- the sensor must be powered in some way, e.g.
  - an IEPE sensor requires 2..8 mA constant current
  - a resistor requires a measuring current
  - an electronic sensor may need a 24V supply, or it may be fed via a 20 mA loop
- What dynamic transmission quality for AC signals must the sensor provide via the intermediate device? Each intermediate device influences the analog signal, e.g. in terms of frequency-dependent attenuation, crosstalk, line resistance or bandwidth. This must be taken into account when an intermediate device is used in a metrological application.
- Is the device used for energy limitation in accordance with the intrinsic safety ignition protection type (Ex i)? In this case, a barrier with appropriate approval is required. Zener barriers are often used in such situations. They are made up of resistors, fuses and Zener diodes.

  As already mentioned, these can influence the analog signal quality with respect to the above features, e.g. by temperature-dependent change of the internal resistance. Terms: Zener barrier
- Does it have to ensure electrical isolation of the analog signal?

  Does electrical isolation of the analog signal have to be provided? Devices that electrically isolate the transmitted signal reconfigure the signal, so that in this case special attention must be paid to the signal influence. In this case the analog properties of the isolator and the analog module are interlinked. The properties of the isolator are dominant, particularly when ELM measurement modules or other high-quality analog modules are used. On the output side, they typically supply standard signals, such as 10 V or 20 mA. Compared with the use of external devices for electrical isolation, the use of Kollmorgen input modules with

channel-based electrical isolation is advantageous. Terms: signal isolator, signal converter, signal transducer, isolating amplifier, measuring amplifier, level transducer

- Are both measures, i.e. explosion protection according to ignition protection type Ex i and electrical isolation necessary? In this case, so-called isolation barriers are used, which ensure energy limitation for intrinsic safety and also electrical isolation of the signal. Please refer to the notes on analog signal influence referred to above.

From a metrological point of view, signal-influencing intermediate devices should be avoided if possible.

5.2.7 Technical Data

Technical Data	AKT2G-AN-240-000
Number of inputs	2
Sensor types	Pt100, Pt200, Pt500, Pt1000, Ni100, Ni120, Ni1000 KT/KTY from firmware 06 Resistance measurement 10 Ω to 1 kΩ or 10 Ω to 4 kΩ (e.g. for potentiometer connection)
Connection method	2-, 3-wire (Preset: 3-wire)
Temperature range	Range-dependent: -200…+850°C (Pt sensors); -60…+250°C (Ni sensors)
Resolution (default)	0.1°C per digit
Conversion time	approx. 800 ms - 2 ms (configurable), depending on configuration and filter setting approx. 85 ms, preset
Measuring current (depending on the sensor element and temperature)	typ. < 0.5 mA
Measuring error	for Pt sensors: < ±0.5 °C at ambient temperature 0°C ... +55°C < ±1.5 °C in the extended temperature range
Width in the process image	max. 8-byte input
Power supply for electronics	via the E-Bus
Current consumption from the Ebus	typ. 190 mA
Electrical isolation	500 V (E-bus/field voltage)
Weight	approx. 60 g
Permissible ambient temperature range during operation	-25°C to +60°C (extended temperature range)
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (connected width: 12 mm)
Installation	on 35 mm mounting rail according to EN 60715
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also Mounting and Wiring of I/O Terminals.
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE ATEX cULus

5.2.8 AKT2G-AN-240 CoE Object Description

NOTE

Relevant Objects

The object description refers to the analog input terminals for Pt100 (RTD) in 1 to 8 channel versions. Observe the indices with regard to the objects relevant for the respective terminal (channel dependent).

5.2.8.1 Introduction

The CoE overview contains objects for different intended applications:

- Objects required for parameterization and profile-specific objects required during commissioning
- Objects for indicating internal settings (may be fixed)

The following section first describes the objects required for normal operation, followed by a complete overview of missing objects.

5.2.8.2 Objects for Commissioning

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default value
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1dec)
1011:01	SubIndex 001	If this object is set to "0x64616F6C" in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0dec)

Index 80n0 RTD settings for 0 ≤ n ≤ 7 (Ch. 1 - 8)

Index (hex)	Name	Meaning	Data type	Flags	Default value
80n0:0	RTD Settings	Maximum subindex	UINT8	RO	0x1B (27dec)
80n0:01	Enable user scale	User scale is active.	BOOLEAN	RW	0x00 (0dec)
80n0:02	Presentation	0: Signed presentation 1: Absolute value with MSB as sign Signed amount representation 2: High resolution (1/100 C°) [default for	BIT3	RW	0x00 (0dec)
80n0:05	Siemens bits	The S5 bits are superimposed on the three low-order bits (value60n0:11) Bit 0 = 1 (“overrange” or “underrange”) Bit 1 (not used) Bit 2 (not used)	BOOLEAN	RW	0x00 (0dec)
80n0:06*	Enable filter	Enable filter, which makes PLC-cycle-synchronous data exchange unnecessary	BOOLEAN	RW	0x00 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default value
80n0:07*	Enable limit 1	The status bits are set in relation to Limit 1	BOOLEAN	RW	0x00 (0dec)
80n0:08*	Enable limit 2	The status bits are set in relation to Limit 2	BOOLEAN	RW	0x00 (0dec)
8010:09*	Enable automatic calibration	A calibration is cyclically started. (optional)	BOOLEAN	RW	0x00 (0dec)
80n0:0A	Enable user calibration	Enabling of the user calibration	BOOLEAN	RW	0x00 (0dec)
80n0:0B	Enable vendor calibration	Enabling of the vendor calibration	BOOLEAN	RW	0x01 (1dec)
80n0:11	User scale offset	User scaling offset	INT16	RW	0x0000 (0dec)
80n0:12	User scale gain	This is the user scaling gain. The gain is represented in fixed-point format, with the factor 2-16. The value 1 corresponds to 65535 (0x00010000).	INT32	RW	0x00010000 (65536dec)
80n0:13*	Limit 1	First limit value for setting the status bits (resolution 0.1 °C)	INT16	RW	0x0000 (0dec)
80n0:14*	Limit 2	Second limit value for setting the status bits (resolution 0.1 °C)	INT16	RW	0x0000 (0dec)
80n0:15	Filter settings	This object determines the digital filter settings, if it is active via Enable filter (index 0x80n0:06). The possible settings are sequentially numbered. 0. 50 Hz 1. 60 Hz 2. 100 Hz 3. 500 Hz 4. 1 kHz 5. 2 kHz 6. 3.75 kHz 7. 7.5 kHz 8. 15 kHz 9. 30 kHz 10. 5 Hz 11. 10 Hz	UINT16	RW	0x0000 (0dec)
80n0:17	User calibration offset	User offset calibration	INT16	RW	0x0000 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default value
80n0:18	User calibration gain	User gain compensation	UINT16	RW	0xFFFF (65535dec)
80n0:19	RTD element	RTD Element 0. Pt100 1. Ni100, -60°C to 250° 2. Pt1000, -200°C to 850°C 3. Pt500, -200°C to 850°C 4. Pt200, -200°C to 850°C 5. Ni1000, -60°C to 250°C 6. Ni1000, TK5000, 100°C: 1500 Ohm (-30 to 160°C) 7. Ni120, -60°C to 320°C 8. Output in Ohm Resolution 1/16 Ohm (0 to 4096 Ohm*** 9. Output in Ohm Resolution 1/64 Ohm (0 to 1024 Ohm*** 10-32: KT100/110/130/210/230 KTY10/11/13/16/19 KTY81/82-110,120,150 (-50...150°C) KTY81-121 KTY81-122 KTY81-151 KTY81-152 KTY81/82-210,220,250 KTY81-221 KTY81-222 KTY81-251 KTY81-252 KTY83-110,120,150 (-50...175°C) KTY83-121 KTY83-122 KTY83-151 KTY83-152 KTY84-130,150 (-40...300°C) KTY84-151 KTY21/23-6 (-50...150°C) KTY1x-5 KTY1x-7 KTY21/23-5 KTY21/23-7	UINT16	RW	0x0000 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default value
80n0:1A	Connection technology	Connection technology 0. Two-wire connection 1. Three-wire connection 2. Four-wire connection 3. not connected	UINT16	RW	0x0000 (0dec)
80n0:1B	Wire calibration 1/32 Ohm	Calibration of the supply lines	INT16	RW	0x0000 (0dec)

NOTE

The filter properties are set only via index 0x8000:15

The filter frequencies are set for all channels of the AN-240 terminals centrally via index 0x8000:15 (channel 1).

The corresponding indices 8010:15 of the AN-240 have no parameterization function!

5.2.8.3 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

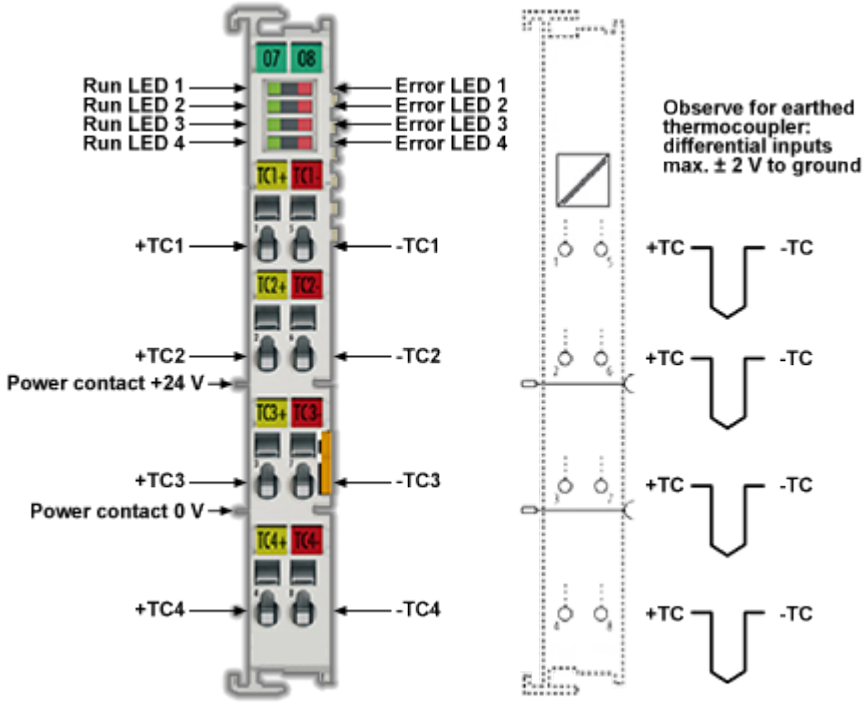
Index 60n0 RTD Inputs for $0 \leq n \leq 7$ (Ch. 1 - 8)

Index (hex)	Name	Meaning	Data type	Flags	Default value
60n0:0	RTD Inputs	Maximum subindex	UINT8	RO	0x11 (17_{dec})
60n0:01	Underrange	The measuring range is undershot.	BOOLEAN	RO	0x00 (0_{dec})
60n0:02	Overrange	The measuring range is overshot. (“open circuit” detection if “error” [index 0x60n0:07]) is set	BOOLEAN	RO	0x00 (0_{dec})
60n0:03*	Limit 1	Limit value monitoring 0. not active 1. Value is larger than the limit value 2. Value is smaller than the limit value 3. Value is equal to the limit value	BIT2	RO	0x00 (0_{dec})
60n0:05*	Limit 2	Limit value monitoring 0. not active 1. Value is larger than the limit value 2. Value is smaller than the limit value 3. Value is equal to the limit value	BIT2	RO	0x00 (0_{dec})
60n0:07	Error	The error bit is set if the data is invalid.	BOOLEAN	RO	0x00 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default value
60n0:0F	TxPDO State	Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).	BOOLEAN	RO	0x00 (0_{dec})
60n0:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated.	BOOLEAN	RO	0x00 (0_{dec})
60n0:11	Value	The analog input data	INT16	RO	0x00 (0_{dec})

5.3 AKT2G-AN-400-000

4-channel thermocouple input terminal, preset to type K, with wire breakage detection, 16 bit



See also: Notices on Analog Specifications for information on

- Measuring Error / Measurement Deviation
- Temperature Coefficient tK [ppm/K]
- Common-mode voltage and reference ground (based on differential inputs)
- Dielectric strength
- Temporal Aspects of Analog/Digital Conversion

5.3.1 Thermocouple Technology Basics

The thermocouple terminals can evaluate thermocouples of the types B, C, E, J, K, L, N, R, S, T and U. The characteristic curves are linearized and the reference temperature determined directly within the terminal.

Temperatures are output in 1/10°C, for example (device-dependent). The terminal is fully configurable via the Bus Coupler or the control system. Different output formats may be selected or own scaling activated. In addition, linearization of the characteristic curve and determination and calculation of the reference temperature (temperature at the terminal connection contacts) can be switched off.

5.3.1.1 Measuring principle of the thermocouple

Thermocouples can be classified as active transducers. They exploit the thermo-electric effect (Seebeck, Peltier, Thomson). A voltage referred to as thermovoltage occurs over the length of a cable with different temperatures at both ends. It is an unambiguous function of the temperature and the material. In a “TC element” this effect is utilized by operating two different conductor materials in parallel.

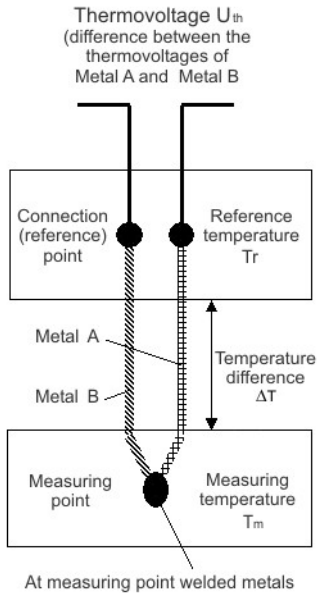


Figure 3-15: Principle of the thermocouple

Example: In the following example, the voltage U_{th} is given which is present at a type-K thermocouple at the temperature Tm.

$$U_{th} = (k_{NiCr} - k_{Ni}) \times \Delta T$$

with

$$\Delta T = T_m - T_v$$

A type-K thermocouple consists of a junction of a nickel-chrome alloy and nickel, where k_{NiCr} and k_{Ni} represent the thermoelectric coefficients of nickel-chrome and nickel respectively. By adapting the equation according to T_m, the sought-after temperature can be calculated from the voltage measured across the thermocouple. Based on the difference to the cold junction temperature, the temperature at the measurement point can be determined to an accuracy of better than one tenth of a Kelvin with the aid of the above thermocouple equation.

NOTE

Sensor Circuit

A modification of the sensor circuit with additional devices such as change over switches or multiplexer decreases the measure accuracy. We strongly advise against such modifications.

5.3.1.2 Internal conversion of the thermovoltage and the reference voltage

Since the coefficients are determined at a reference temperature of 0°C, it is necessary to compensate for the effect of the reference temperature. This is done by converting the reference temperature into a reference voltage that depends on the type of thermocouple, and adding this to the measured thermovoltage. The temperature is found from the resulting voltage and the corresponding characteristic curve.

$$U_k = U_m + U_r$$

$$T_{out} = f(U_k)$$

5.3.1.3 Overview of suitable thermocouples

The following thermocouples are suitable for temperature measurement:

Type (according to EN60584-1)	Element	Implemented temperature range	Color coding (sheath - plus pole - minus pole)
B	Pt30%Rh-Pt6Rh	600°C to 1800°C	grey - grey - white
C *	W5%Re-W25%Re	0°C to 2320°C	n.d.
E	NiCr-CuNi	-100°C to 1000°C	violet - violet - white
J	Fe-CuNi	-100°C to 1200°C	black - black - white
K	NiCr-Ni	-200°C to 1370°C	green - green - white
L **	Fe-CuNi	0°C to 900°C	blue - red - blue
N	NiCrSi-NiSi	-100°C to 1300°C	pink - pink - white
R	Pt13%Rh-Pt	0°C to 1767°C	orange - orange - white
S	Pt10%Rh-Pt	0°C to 1760°C	orange - orange - white
T	Cu-CuNi	-200°C to 400°C	brown - brown - white
U **	Cu-CuNi	0°C to 600°C	brown - red - brown

* not standardized according to EN60584-1

** according to DIN 43710

TIP

Maximum cable length to the thermocouple

Without additional protective measures, the maximum cable length from the EtherCAT Terminal to the thermocouple is 30 m. For longer cable lengths, suitable surge protection should be provided.

5.3.2 LEDs

LED	Color	Meaning	
RUN	green	This LED indicates the terminal's operating state:	
		off	State of the EtherCAT State Machine: INIT = initialization of the terminal
		flashing uniformly	State of the EtherCAT State Machine: PREOP = function for mailbox communication and different standard-settings set
		flashing slowly	State of the EtherCAT State Machine: SAFEOP = verification of the sync manager channels and the distributed clocks. Outputs remain in safe state
		on	State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible
		flashing rapidly	State of the EtherCAT State Machine: BOOTSTRAP = function for terminal firmware updates
ERROR1-4	red	Short circuit or wire breakage. The resistance is in the invalid range of the characteristic curve.	

5.3.3 Connection Instructions for Earthed/Potential-Free Thermocouples

Due to the differential inputs of the terminals, different connection types are recommended depending on the type of thermocouple used. For earthed thermocouples, ground is not connected to the shielding. If the thermocouple does not have a ground connection, the ground and shielding contacts can be connected (see 5.3 AKT2G-AN-400-000).

NOTE

Connection instructions for thermocouples

- Earthed thermocouple
  - Do not connect GND to the shielding
- Potential-free / earth-free thermocouple
  - GND can be connected to the shielding
  - or: GND can connected to any potential, **max. 35 V** to 0 V power
- Non-potential-free thermocouple
  - Do not connect GND to the shielding
  - Do not connect GND to thermocouple potential.
  - Thermocouple-potential **max. 35 V** to 0 V power
- Unused inputs
  - Unused inputs should be short-circuited (low-resistance connection of +TC, -TC)

5.3.3.1 Shielding Measures

NOTE

Shielding Measures

Due to the complexity in the "EMC" area, there is no generally applicable guideline, but only technical measures in accordance with the state of the art, which can sometimes contradict each other. These must be checked for feasibility and effectiveness, taking into account the plant specifications, and applied by the plant installer following assessment.

The following notes on shielding are to be understood as technical suggestions that have proven themselves from time to time in practical use. It must be checked in each case which measures can be applied, depending on the installation and plant. The effectiveness of each measure must be checked individually. The formal transferability of measures to other types of plant is in general not possible.

Priority is to be given to typical national or general normative specifications.

A shielding approach is described below that in many cases improves the measurement quality. The suggested measures must be checked for feasibility and effectiveness in the actual plant.

- Apply the shield with a low resistance and enveloping the cable by 360°
- at the entry point into the control cabinet, the shield should be earthed conductively
- the shield should be earthed again at the terminal
  - at the terminal connection point, if present
  - if no terminal connection point is available, earth the shield as close to the terminal as possible.
  - to avoid ground loops the shield can be undone after entry into the control cabinet. A capacitive connection to the terminal shield contact is possible.
  - avoid unshielded cable lengths of > 50 cm!

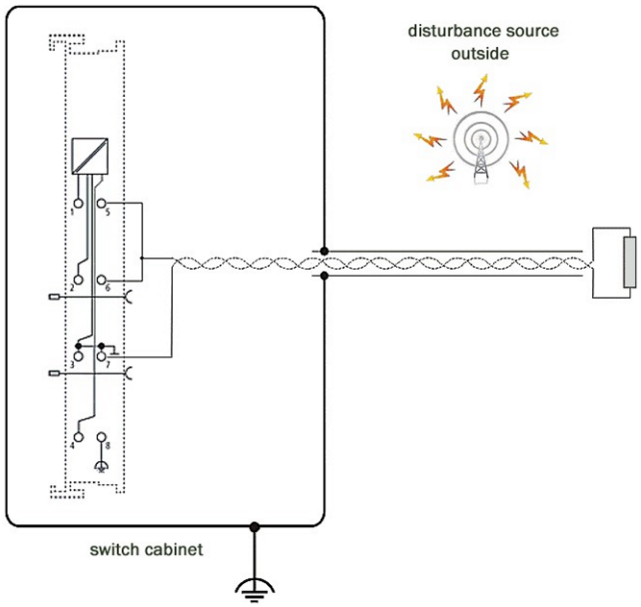


Figure 3-16: Example of AN-240 shield connection with shield contact, in the case of potential interference sources inside the control cabinet

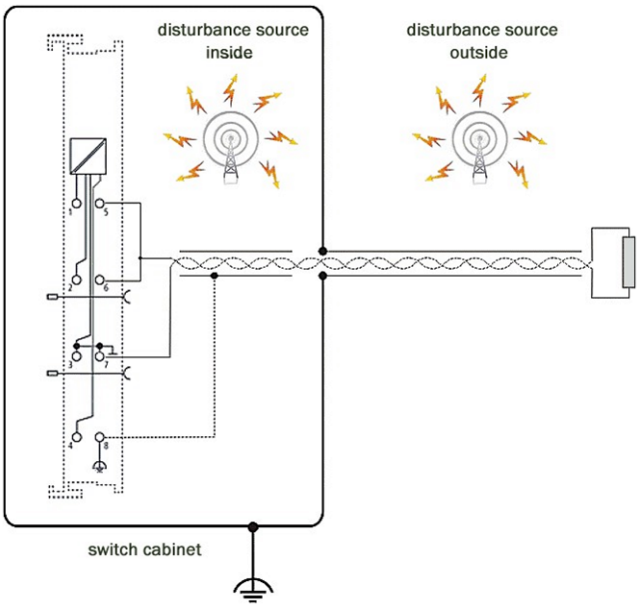
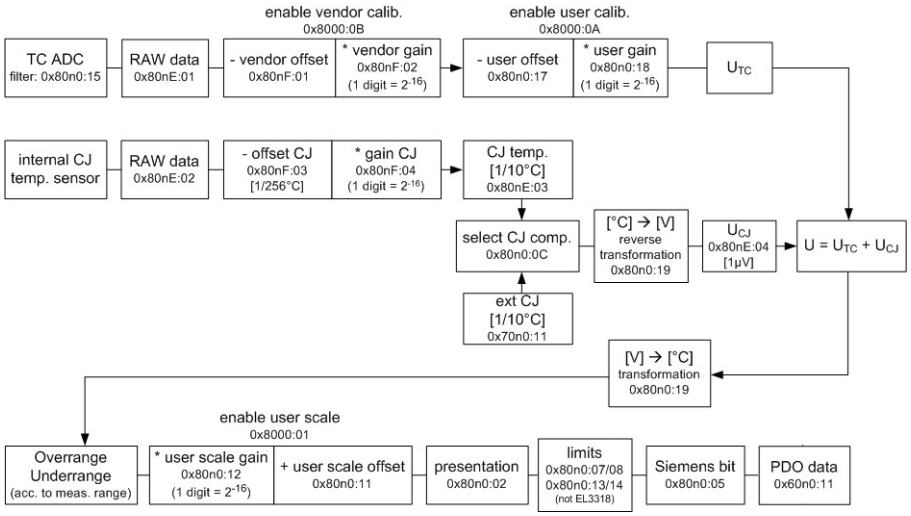


Figure 3-17: Example of AN-240 shield connection with shield contact, in the case of potential interference sources inside and outside the control cabinet

5.3.4 Data Processing - TC Temperature



5.3.5 Settings

5.3.5.1 Presentation

index 0x80n0:02

In the delivery state, the measured value is output in increments of 1/10° C in two's complement format (signed integer).

Index 0x80n0:02 offers the possibility to change the method of representation of the measured value.

Measured value	Output (hexadecimal)	Output (signed integer, decimal)
-200.0 °C	0nF830	-2000
-100.0 °C	0nFC18	-1000
-0.1 °C	0nFFFF	-1
0.0 °C	0n0000	0
0.1 °C	0n0001	1
100.0 °C	0n03E8	1000
200.0 °C	0n07D0	2000
500.0 °C	0x1388	5000
850.0 °C	0x2134	8500
1000.0 °C	0x2170	10000

Table 3-2: Output of measured value and process data

- Signed Integer:

  The measured value is presented in two’s complement format.
  Maximum presentation range for 16 bit = -32768 .. +32767

  Example:

  - 1000 0000 0000 0000bin = 0x8000hex = - 32768dec
  - 1111 1111 1111 1110bin = 0nFFFEhex = - 2dec
  - 1111 1111 1111 1111bin = 0nFFFFhex = - 1dec
  - 0000 0000 0000 0001bin = 0n0001hex = +1dec
  - 0000 0000 0000 0010bin = 0n0002hex = +2dec
  - 0111 1111 1111 1111bin = 0x7FFFhex = +32767dec

- Absolute value with MSB as sign:

  The measured value is output in magnitude-sign format.
  Maximum presentation range for 16 bit = -32767 .. +32767

  Example:

  - 1111 1111 1111 1111bin = 0nFFFFhex = - 32767dec
  - 1000 0000 0000 0010bin = 0x8002hex = - 2dec
  - 1000 0000 0000 0001bin = 0x8001hex = - 1dec
  - 0000 0000 0000 0001bin = 0n0001hex = +1dec
  - 0000 0000 0000 0010bin = 0n0002hex = +2dec
  - 0111 1111 1111 1111bin = 0x7FFFhex = +32767dec

- High resolution (1/100 C°):

  The measured value is output in 1/100 °C steps.

5.3.5.2 Siemens bits

index 0x80n0:05

If the bit in index 0x80n0:05 is set, status displays are shown for the lowest 3 bits. In the error case "overrange" or "underrange", bit 0 is set.

5.3.5.3 Underrange, Overrange

Undershoot and overshoot of the measuring range (underrange, overrange), index 0x60n0:02, 0x60n0:03

- $U_k > U_{kmax}$: Index 0x60n0:02 and index 0x60n0:07 (overrange and error bit) are set. The linearization of the characteristic curve is continued with the coefficients of the overrange limit up to the limit stop of the A/D converter or to the maximum value of 0x7FFF.
- $U_k < U_{kmax}$: Index 0x60n0:01 and index 0x60n0:07 (underrange and error bit) are set. The linearization of the characteristic curve is continued with the coefficients of the underrange limit up to the limit stop of the A/D converter or to the minimum value of 0x8000.

For overrange or underrange the red error LED is switched on.

5.3.5.4 Notch filter (conversion times)

5.3.5.4.1 Notch filter, index 0x80n0:06

The AN-400 terminals are equipped with a digital filter. The filter performs a notch filter function and determines the conversion time of the terminal. It is parameterized via the indices 0x80n0:15. The higher the filter frequency, the faster the conversion time.

TIP

Index 0x80n0:06

The filter function is always active even if the bit is not set, since this is obligatory for the measurement process!

NOTE

The filter characteristics are set via index 0x8000:15

The filter frequencies are set for all channels of the AN-400 terminals centrally via index 0x8000:15 (channel 1, see "80n0:15" on page 76). The corresponding indices 0x8010:15, 0x8020:15, 0x8030:15 have no parameterization function.

TIP

Conversion time

The conversion time is determined as follows:

No. of active channels * no. of measurements * no. of filter periods + computing time = conversion time

Example: (2 channels), 3 measurements (thermocouple, wire breakage, cold junction), filter 50 Hz

```
2 channels * 3 measurements * (1/50 Hz) + 6 ms ≈ 126 ms
```

Example: (4 channels), 3 measurements (thermocouple, wire breakage, cold junction), filter 50 Hz

```
4 channels * 3 measurements * (1/50 Hz) + 12 ms ≈ 252 ms
```

Typical conversion times with 3 measurements (thermocouple, broken wire, cold junction)

Filter frequency	AKT2G-AN-400
5 Hz	2.4 s
10 Hz	1.2 s
50 Hz	250 ms
60 Hz	210 ms
100 Hz	130 ms
500 Hz	33 ms
1000 Hz	24 ms
2000 Hz	20 ms
3750 Hz	19 ms
7500 Hz	19 ms
15000 Hz	19 ms
30000 Hz	19 ms
mV range	12 ms

Table 3-3: Conversion times in relation to the filter frequencies

5.3.5.5 Limit 1 and Limit 2

Limit 1 and limit 2, index 0x80n0:13, index 0x80n0:14

A temperature range can be set that is limited by the values in the indices 0x80n0:13 and 0x80n0:14. If the limit values are overshot, the bits in indices 0x80n0:07 and 0x80n0:08 are set.

The temperature value is entered with a resolution of 0.1 °C.

Example:

Limit 1= 30 °C

Value index 0x80n0:13 = 300

5.3.5.6 Calibration

5.3.5.6.1 User calibration

index 0x80n0:0A

User calibration is enabled via index 0x80n0:0A. Parameterization takes place via the indices

- 0x80n0:17
  Thermocouple offset (index 0x80nF:01, user calibration)
- 0x80n0:18
  Thermocouple gain (index 0x80nF:02, user calibration)

5.3.5.6.2 User scaling

index 0x80n0:01

The user scaling is enabled via index 0x80n0:01. Parameterization takes place via the indices

- 0x80n0:11
  User scaling offset

  The offset describes a vertical shift of the characteristic curve by a linear amount.

  At a resolution of 0.1°, 1 digit(dec) corresponds to an increase in measured value by 0.1° At a resolution of 0.01°, 1 digit(dec) corresponds to an increase in measured value by 0.01
- 0x80n0:12
  User scaling gain

  The default value of 65536(dec) corresponds to gain = 1.

  The new gain value for 2-point user calibration after offset calibration is determined as follows:

  Gain_new = reference temperature / measured value x 65536(dec)

5.3.5.6.3 Calculation of process data

The concept "calibration" is used here even if it has nothing to do with the deviation statements of a calibration certificate. Actually, this is a description of the vendor or customer calibration data/adjustment data used by the device during operation in order to maintain the assured measuring accuracy.

The terminal constantly records measured values and saves the raw values from its A/D converter in the ADC raw value objects 0x80nE:01, 0x80nE:02. After each recording of the analog signal, the correction calculation takes place with the vendor and user calibration data as well as the user scaling, if these are activated (see following picture).

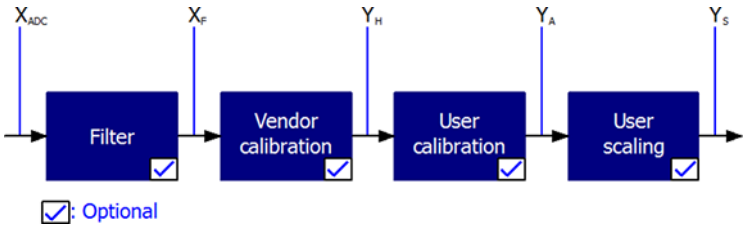


Figure 3-18: Calculation of process data

Calculation	Designation
X_{ADC}	Output of the A/D converter
X_F	Output value after the filter

Calculation	Designation
$Y_H = (X_{ADC} - B_H) \times A_H \times 2^{-14}$	Measured value after vendor calibration,
$Y_A = (Y_H - B_A) \times A_A \times 2^{-14}$	Measured value after vendor and user calibration
$Y_S = Y_A \times A_S \times 2^{-16} + B_S$	Measured value following user scaling

Legend for previous table

Name	Designation	Index
X_{ADC}	Output value of the A/D converter	0x80nE:01
X_F	Output value after the filter	-
B_H	Vendor calibration offset (not changeable)	0x80nF:01
A_H	Vendor calibration gain (not changeable)	0x80nF:02
B_A	User calibration offset (can be activated via index 0x80n0:0A)	0x80n0:17
A_A	User calibration gain (can be activated via index 0x80n0:0A)	0x80n0:18
B_S	User scaling offset (can be activated via index 0x80n0:01)	0x80n0:11
A_S	User scaling gain (can be activated via index 0x80n0:01)	0x80n0:12
Y_S	Process data for controller	-

NOTE

Measurement Result

The accuracy of the result may be reduced if the measured value is smaller than 32767 / 4 due to one or more multiplications.

5.3.5.7 Producer Codeword

NOTE

Producer Codeword

The vendor reserves the authority for the basic calibration of the terminals. The Producer codeword is therefore at present reserved.

5.3.6 Operation with an external cold junction

The AKT2G-AN-400 supports operation with an internal cold junction as standard. This means that the thermocouple is attached to the terminal points at the front of the terminal housing, so that the material transition and the cold junction are located at the front of the terminal housing. The terminal measures the cold junction temperature with its own internal temperature sensor and calculates the desired measuring point temperature value.

In special applications, operation with an external cold junction is required. The external cold junction is connected to the AN-400 with a normal copper connection cable, the material transition then takes place in the external connection point.

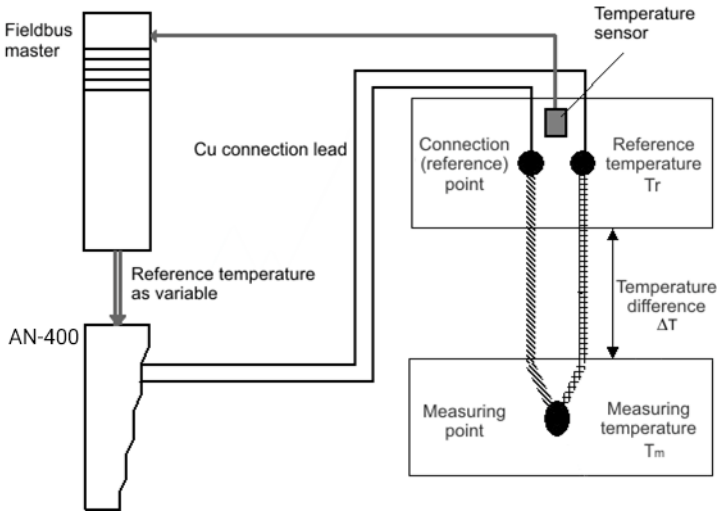


Figure 3-19: External cold junction

For this operation the following must be set

- all CJCompensation PDO of the terminal must be activated, even if the "external cold junction" function is only used on isolated channels
- In CoE 0x80n0:0C of the desired channel, the external cold junction calculation must be activated by the value "2" (external process data).

The cold junction temperature T_V must now be recorded by a separate temperature sensor at the cold junction and fed to the terminal via the fieldbus master and the fieldbus as a linked variable ("external") (see Figure 3-19: External cold junction).

The separate measurement can technically be done via another thermocouple connected to an AN-400, or any other temperature measurement whose value is known to the controller.

The AN-400 then supplies the measured value *Value*, taking into account the temperature value supplied with *CJCompensation*:

The comparison data is written to CoE 0x70n0:11.

NOTE

Alternative to cold junction measurement

As an alternative to the procedure described above, the cold junction can be maintained at a defined temperature through ice water (0° C), for example. In this case, the temperature is known without measurement of the cold junction temperature (Figure 3-19: External cold junction) and can be reported to the AN-400 via the process data.

5.3.7 Interference From Equipment

When operating the AKT2G-AN-400 analog EtherCAT terminals, high frequency superimposed signals from interfering devices (e.g. proportional valves, stepper motors or DC motor output stages) can be picked up by the terminal. In order to guarantee interference-free operation, we recommend the use of separate power supply units for the terminals and the interference-causing devices.

5.3.8 Wire Break Detection

The AKT2G-AN-400 terminals provide a wire break detection of the connected thermocouple. A periodical testing current of several µA will be given to the thermocouple for detection. No voltage measurement takes place during test.

Due to particular cases, the testing current could have a disturbing effect, the wire break detection can be disabled by CoE (object 0x80n0:0E, "Disable wire break detection") since following firmware versions:

	AKT2G-AN-400
Firmware	04
ESI / Revision	0023

5.3.9 Status Word

The status information for each channel of the AN-400 is transmitted cyclically from the terminal to the EtherCAT Master as process data (PDO). Two versions of the device description are available for the AN-400, representing the process image in individual and extended forms.

The AN-400 transmits the following process data:

- Underrange: Measurement is below range
- Overrange: Range of measurement exceeded ("Cable break" together with "Error")
- Limit 1: Limit value monitoring 0: ok, 1: Limit value overshot , 2: limit range undershot
- Limit 2: Limit value monitoring 0: ok, 1: Limit value overshot , 2: limit range undershot
- Error: The error bit is set if the process data is invalid (cable break, overrange, underrange)
- TxPDO State: Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).
- TxPDO Toggle: The TxPDO toggle is toggled by the slave when the data of the associated TxPDO isupdated. This allows the currently required conversion time to be derived.

The limit evaluation is set in the "8000" objects in the CoE directory.

5.3.10 Technical Data

Technical Data	AKT2G-AN-400-000
Number of inputs	4
Thermocouple sensor types	Types J, K, L, B, E, N, R, S, T, U, C (default setting type K), mV measurement
Input filter limit frequency	1 kHz typ.; depending on sensor length, conversion time, sensor type
Connection technology	2-wire
Maximum cable length to the thermocouple	30 m
Measuring range, FSV	in the range defined in each case for the sensor (default setting: type K; -200 … +1370°C) Voltage: ± 30 mV (1 µV resolution) up to ± 75 mV (4 µV resolution)
Resolution	Internal: 16 bit Temperature representation: 0.1/0.01 °C per digit, default 0.1°C Note: 16 bit is used for FSV calculation; so, value leaps >0.01°C will occur at resolution 0.01°C depending of which thermocouple is set; e.g. type K: approx. 0.04°C
Supports NoCoeStorage function	yes, from firmware 01
Wiring fail indication	yes
Conversion time	approx. 2.5 s to 20 ms, depending on configuration and fil ter setting, default: approx. 250 ms
Measuring error	< ±0.3 % (relative to full scale value)
Voltage supply for electronics	via the E-bus
Distributed Clocks	-
Current consumption via E-bus	typ. 200 mA
Bit width in the process data image	max. 16 byte input, max. 8 byte output
Max. potential ±TC against ground	2 V, important e.g. when operating with grounded thermocouples
Max. differential voltage between the ±TC inputs	±15 V permanent
Electrical isolation	500 V (E-bus/field voltage)
Configuration	via KAS IDE
Weight	approx. 60 g

Technical Data	AKT2G-AN-400-000
Permissible ambient temperature range during operation	-25°C ... +60°C (extended temperature range), from firmware 06
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also installation instructions for terminals with increased mechanical load capacity
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, ATEX, cULus, IECEx

5.3.11 AKT2G-AN-400 Object Description and Parameterization

NOTE

Parameterization via the CoE Init-Commands (CAN over EtherCAT)

The EtherCAT device is parameterized via the CoE Init-Commands tab . Please note the following general CoE notes when using/manipulating the CoE parameters:

- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary, existence of current XML description
- use “CoE reload” for resetting changes

The CoE overview contains objects for different intended applications:

- Objects required for parameterization during commissioning:
  - Restore Object index 0x1011
  - Configuration Data index 0x80n0
- Profile-specific objects:
  - Configuration Data (vendor-specific) index 0x80nF
  - Input Data index 0x60n0
  - Output Data index 0x70n0
  - Information and Diagnostic Data index 0x80nE, 0xF000, 0xF008, 0xF010
- AKT2G-AN-400 Object Description and Parameterization

The following section first describes the objects required for normal operation, followed by a complete overview of missing objects.

5.3.11.1 Restore Object

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to "0x64616F6C" in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0_{dec})

5.3.11.2 Configuration Data

Index 80n0 TC Settings (for Ch. 1 - 8 ($0 \leq n \leq 7$))

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:0	TC Settings	Maximum subindex	UINT8	RO	0x19 (25_{dec})
80n0:01	Enable User scaling	User scaling is active.	BOOLEAN	RW	0x00 (0_{dec})
80n0:02	Presentation	0. Signed presentation, 0.1°C/digit 1. Absolute value with MSB as sign (signed amount representation), 0.1°C/digit 2. High resolution (0.01°C/digit)	BIT3	RW	0x00 (0_{dec})
80n0:05	Siemens bits	The S5 bits are displayed in the three low-order bits	BOOLEAN	RW	0x00 (0_{dec})
80n0:06	Enable Notch filter (conversion times)	This setting generally activates the basic filters in object 0x80n0:15. These are technically realized in the ADC and can therefore not be switched off, even if they are set to "disabled" in the object.	BOOLEAN	RW	0x01 (1_{dec})
80n0:07	Enable limit 1 (see Limit 1 and Limit 2)	Limit 1 enabled	BOOLEAN	RW	0x00 (0_{dec})
80n0:08	Enable limit 2 (see Limit 1 and Limit 2)	Limit 2 enabled	BOOLEAN	RW	0x00 (0_{dec})
80n0:0A	Enable User calibration	Enabling of the user calibration	BOOLEAN	RW	0x00 (0_{dec})
80n0:0B	Enable AKT2G-AN-400-000	Enabling of the vendor calibration	BOOLEAN	RW	0x01 (1_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:0C	Coldjunction compensation (see Operation with an external cold junction)	0. internal 1. no - Cold junction compensation is not active 2. Extern process data - Cold junction compensation takes place via the process data (resolution [1/10]°C)	BIT2	RW	0x00 (0_{dec})
80n0:0E	Disable Wire Break Detection	0. Wire break detection is active 1. Wire break detection is not active	BOOLEAN	RW	0x00 (0_{dec})
80n0:11	User scaling Offset	User scaling offset	INT16	RW	0x0000 (0_{dec})
80n0:12	User scaling Gain	User scaling gain. The gain is represented in fixed-point format, with the factor 2-16. The value 1 corresponds to 65536 (0x00010000)	INT32	RW	0x00010000 (65536_{dec})
80n0:13	Limit 1 (see Limit 1 and Limit 2)	First limit value for setting the status bits (resolution 0.1 °C)	INT16	RW	0x0000 (0_{dec})
80n0:14	Limit 2 (see Limit 1 and Limit 2)	Second limit value for setting the status bits (resolution 0.1 °C)	INT16	RW	0x0000 (0_{dec})
80n0:15	Filter settings (see Notch filter (conversion times))	This object determines the basic digital filter settings. The possible settings are sequentially numbered. 0. 2.5 Hz 1. 5 Hz 2. 10 Hz 3. 16.6 Hz 4. 20 Hz 5. 50 Hz 6. 60 Hz 7. 100 Hz	UINT16	RW	0x0000 (0_{dec})
80n0:17	User calibration Offset	User calibration offset	INT16	RW	0x0000 (0_{dec})
80n0:18	User calibration Gain	User calibration gain	UINT16	RW	0xFFFF (65535_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:19	TC Element	Thermocouple Implemented temperature range 0. Type: K -200°C to 1370°C 1. Type: J -100°C to 1200°C 2. Type: L 0°C to 900°C 3. Type: E -100°C to 1000°C 4. Type: T -200°C to 400°C 5. Type: N -100°C to 1300°C 6. Type: U 0°C to 600°C 7. Type: B 600°C to 1800°C 8. Type: R 0°C to 1767°C 9. Type: S 0°C to 1760°C 10. Type: C 0°C to 2320°C 100: ± 30 mV (1 µV resolution) 101: ± 60 mV (2 µV resolution) 102: ± 75 mV (4 µV resolution)	UINT16	RW	0x0000 (0_{dec})

5.3.11.3 Profile-specific objects

5.3.11.3.1 0x6000-0xFFFF

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

5.3.11.4 Configuration Data (vendor-specific)

Index 80nF TC Vendor data (for Ch. 1 - 8 ($0 \leq n \leq 7$))

Index (hex)	Name	Meaning	Data type	Flags	Default
80nF:0	TC Vendor data	Maximum subindex	UINT8	RO	0x04 (4_{dec})
80nF:01	Calibration offset TC	Thermocouple offset (vendor calibration)	INT166	RW	0x002D (45_{dec})
80nF:02	Calibration gain TC	Thermocouple gain (vendor calibration)	UINT16	RW	0x5B9A (23450_{dec})
80nF:03	Calibration offset CJ	Cold junction offset [Pt1000] (vendor calibration)	INT16	RW	0x01B8 (440_{dec})
80nF:04	Calibration gain CJ	Cold junction gain [Pt1000] (vendor calibration)	UINT16	RW	0x39B2 (14770_{dec})

5.3.11.5 Input Data

Index 60n0 TC Inputs (for Ch. 1 - 8 ($0 \leq n \leq 7$))

Index (hex)	Name	Meaning	Data type	Flags	Default
60n0:0	TC Inputs	Maximum subindex	UINT8	RO	0x11 (17_{dec})
60n0:01	Underrange	Value below measuring range.	BOOLEAN	RO	0x00 (0_{dec})
60n0:02	Overrange	Measuring range exceeded. ("wire breakage" together with "error" [index 0x60n0:07])	BOOLEAN	RO	0x00 (0_{dec})
60n0:03	Limit 1	Limit value monitoring 0. not activated 1. limit range exceeded 2: limit range undershot	BIT2	RO	0x00 (0_{dec})
60n0:05	Limit 2	Limit value monitoring 0. not activated 1. limit range exceeded 2: limit range undershot	BIT2	RO	0x00 (0_{dec})
60n0:07	Error	The error bit is set if the value is invalid (wire breakage, overrange, underrange).	BOOLEAN	RO	0x00 (0_{dec})
60n0:0F	TxPDO State	Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).	BOOLEAN	RO	0x00 (0_{dec})
60n0:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated.	BOOLEAN	RO	0x00 (0_{dec})
60n0:11	Value	Analog input value (resolution: see Configuration Data index 0x80n0:02)	INT16	RO	0x0000 (0_{dec})

5.3.11.6 Output Data

Index 70n0 TC Outputs (for Ch. 1 - 8 ($0 \leq n \leq 7$))

Index (hex)	Name	Meaning	Data type	Flags	Default
70n0:0	TC Outputs	Maximum subindex	UINT8	RO	0x11 (17_{dec})
70n0:11	CJCompensation	Temperature of the cold junction (resolution in 1/10 °C) (index 0x80n0:0C, comparison via the process data)	INT16	RO	0x0000 (0_{dec})

5.3.11.7 Information and Diagnostic Data

Index 80nE TC Internal data (for Ch. 1 - 8 ($0 \leq n \leq 7$))

Index (hex)	Name	Meaning	Data type	Flags	Default
80nE:0	TC Internal data	Maximum subindex	UINT8	RO	0x05 (5_{dec})
80nE:01	ADC raw value TC	ADC raw value thermocouple	UINT32	RO	0x0000 (0_{dec})
80nE:02	ADC raw value PT1000	ADC raw value PT1000	UINT32	RO	0x0000 (0_{dec})
80nE:03	CJ temperature	Cold junction temperature (resolution [1/10]°C)	INT16	RO	0x0000 (0_{dec})
80nE:04	CJ voltage	Cold junction voltage (resolution 1 µV)	INT16	RO	0x0000 (0_{dec})
80nE:05	CJ resistor	Cold junction resistance (PT1000 temperature sensor) (resolution 1/10 Ohm)	UINT16	RO	0x0000 (0_{dec})

Index F000 Modular device profile

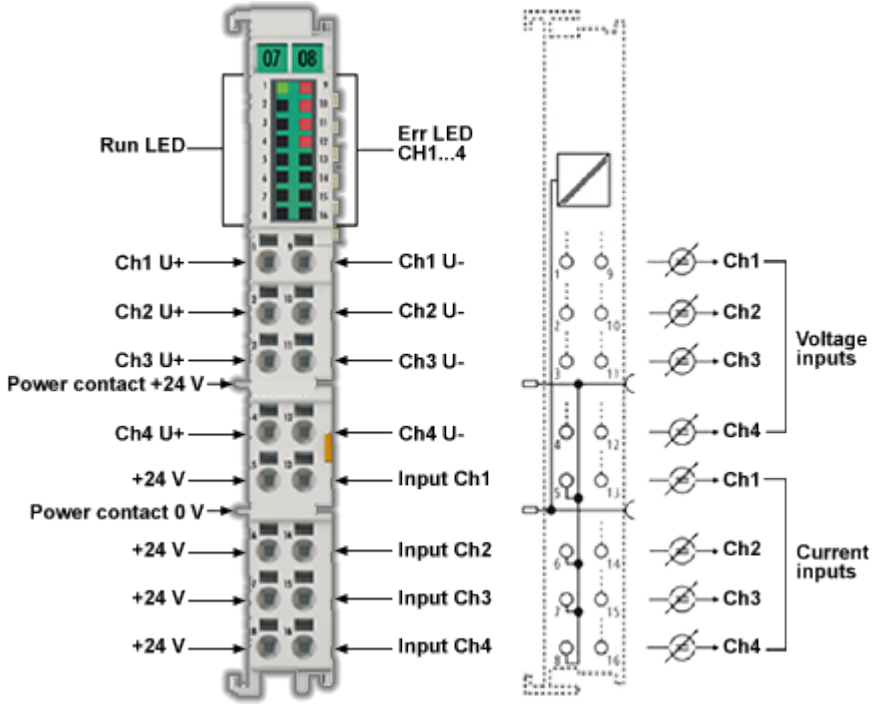
Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular device profile	General information for the modular device profile	UINT8	RO	0x02 (2_{dec})
F000:01	Module index distance	Index spacing of the objects of the individual channels	UINT16	RO	0x0010 (16_{dec})
F000:02	Maximum number of modules	Number of channels	UINT16	RO	0x0004 (4_{dec})

Index F008 Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0	Code word	currently reserved	UINT32	RW	0x0000 (0_{dec})

5.4 AKT2G-AN-430-000

4-channel analog input, parameterizable, -10/0...+10 V, -20/0/+4...+20 mA, 16 bit



See Also:

- Single-Ended / Differential Typification
- Dielectric strength
- Temporal Aspects of Analog/Digital Conversion

5.4.1 Configuration of 0/4..20 mA Differential Inputs

This section describes the 0/4..20 mA differential inputs for terminal series AKT2G-AN-430.

For the single-ended 20 mA inputs the terminal series AN-430 they only apply with regard to technical transferability and also for devices whose analog input channels have a common related ground potential (and therefore the channels are not to each other and/or not to power supply electrically isolated). Herewith an example for an electrically isolated device is the terminal AN-430.

5.4.1.1 Technical Background

The internal input electronics of the terminals referred to above have the following characteristic (see Figure 3-20: Internal connection diagram 0/4...20 mA inputs):

- Differential current measurement, i.e. concrete potential reference is primarily not required. The system limit applies is the individual terminal AN-430.
- Current measurement via a 33 Ω shunt per channel, resulting in a maximum voltage drop of 660 mV via the shunt
- Internal resistor configuration with GND point (A) central to the shunt

  The configuration of the resistors is symmetric, such that the potential of (A) is central relative to the voltage drop via the shunt.
- All channels within the terminal have this GND_{int} potential in common.

- the common GND_{int} potential (A)
  - is connected for 1 and 2 channel terminals to a terminal point and not with GND_{PC} (power contact).
  - is connected for 4 channel terminals with GND_{PC}
- The center point of the voltage drop over the 33 Ω shunt is referred to common mode point (CMP). According to the technical product data, the maximum permitted UCM voltage (common mode) refers to the potential between the CMP of a channel and the internal GND or the potential between the CMP of 2 channels within a terminal.

  It must not exceed the specified limit (typically ±10 or ±35 V).

Accordingly, for multi-channel measurements U_{CM} specifications must be followed.

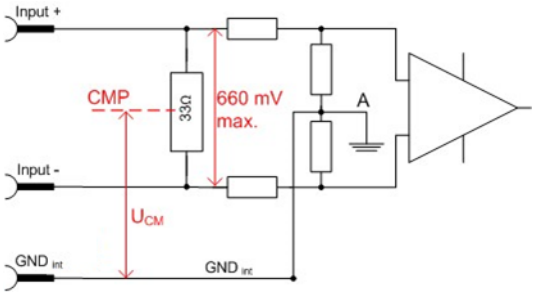


Figure 3-20: Internal connection diagram 0/4...20 mA inputs

The block diagram for a 2 channel terminal shows the linked GND points within the terminal (Internal connection diagram for 0/4..20 mA inputs of a AKT2G-AN-430):

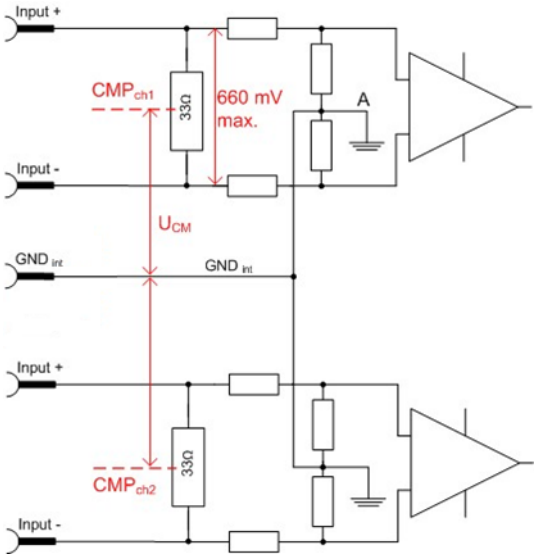


Figure 3-21: Internal connection diagram for 0/4..20 mA inputs of a AKT2G-AN-430

For all channels within the terminal U_{CM-max} must not be exceeded.

NOTE

U_{CM} for 0/4..20 mA inputs

If U_{CM} of an analog input channel is exceeded, internal equalizing currents result in erroneous measurements.

For 1 and 2 channel terminals the internal GND is therefore fed out to a terminal point, so that the U_{CM} specification can be met through application-specific configuration of this GND point, even in cases of atypical sensor configuration.

5.4.1.2 Summary

- We recommended connecting GND_{int} with a low-impedance potential, because this significantly improves the measuring accuracy of the AN-430.

  Please note the instructions relating to the U_{CM} potential reference.

- The U_{CM} potential reference must be adhered to between CMP ↔ GND_{int} and $CMP_{ch(x)}$ ↔ $CMP_{ch(y)}$.

  If this cannot be guaranteed, the single-channel version should be used.

- Terminal configuration:
  - AN-430: GND is connected with the negative power contact. The external connection should be such that condition 2 is met.

If the sensor cable is shielded, the shield should not be connected with the GND_{int} terminal point but with a dedicated low-impedance shield point.

- If terminal points of several AN-430 terminals are connected with each other, ensure that condition 2 is met.

NOTE

Connection of GND_{int}

To achieve a precise measurement result GND_{int} should be connected to a suitable external low-impedance potential, taking account the specifications for U_{CM}.

In the AN-430 terminals GND_{int} is already connected with the negative power contact. Here too the specifications for U_{CM} must be followed.

5.4.2 CoE Object Description and Parameterization

5.4.2.1 Restore Object

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to “0x64616F6C” in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0_{dec})

5.4.2.2 Configuration Data

*Index 80n0*** AI settings (for $0 \leq n \leq 3$)*

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:0	AI Settings	Maximum subindex	UINT8	RO	0x18 (24_{dec})
80n0:01	Enable user scale	User scale is active.	BOOLEAN	RW	0x00 (0_{dec})
80n0:02	Presentation	0. Signed presentation 1. Unsigned presentation 2. Absolute value with MSB as sign Signed amount representation	BIT3	RW	0x00 (0_{dec})
80n0:05	Siemens bits	The S5 bits are displayed in the three low-order bits	BOOLEAN	RW	0x00 (0_{dec})
80n0:06	Enable filter	Enable filter, which makes PLC-cycle-synchronous data exchange unnecessary	BOOLEAN	RW	0x00 (0_{dec})
80n0:07	Enable limit 1	Limit 1 enabled	BOOLEAN	RW	0x00 (0_{dec})
80n0:08	Enable limit 2	Limit 2 enabled	BOOLEAN	RW	0x00 (0_{dec})
80n0:0A	Enable user calibration	Enabling of the user calibration	BOOLEAN	RW	0x00 (0_{dec})
80n0:0B	Enable vendor calibration	Enabling of the vendor calibration	BOOLEAN	RW	0x01 (1_{dec})
80n0:0E	Swap limit bits	Changing of the Limit Bits	BOOLEAN	RW	0x00 (0_{dec})
80n0:11	User scale offset	User scaling offset	INT16	RW	0x0000 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:12	User scale gain	User scaling gain. The gain is represented in fixed-point format, with the factor 2^{-16}. The value 1 corresponds to 65536_{dec} (0x00010000) and is limited to ±0x7FFFF	INT32	RW	0x00010000 (65536_{dec})
80n0:13	Limit 1	First limit value for setting the status bits	INT16	RW	0x0000 (0_{dec})
80n0:14	Limit 2	Second limit value for setting the status bits	INT16	RW	0x0000 (0_{dec})
80n0:15	Filter settings	This object determines the digital filter settings, if it is active via Enable filter (index 0x80n0:06). The possible settings are sequentially numbered. 0. 50 Hz FIR 1. 60 Hz FIR 2. IIR 1 3. IIR 2 4. IIR 3 5. IIR 4 6. IIR 5 7. IIR 6 8. IIR 7 9. IIR 8	UINT16	RW	0x0000 (0_{dec})
80n0:17	User calibration offset	User offset compensation	INT16	RW	0x0000 (0_{dec})
80n0:18	User calibration gain	User calibration gain	INT16	RW	0x4000 (16384_{dec})

NOTE

The filter characteristics are set via index 0x8000:15 (see "80n0:15" on page 84)

The filter frequencies are set for all channels of the AN-430 terminals centrally via index 0x8000:15 (channel 1). All other corresponding indices 0x80n0:15 have no parameterization function!

Index 80nD AI Advanced settings (for $0 \leq n \leq 3$)

Index (hex)	Name	Meaning	Data type	Flags	Default
80nD:0	AI Advanced Settings	Maximum subindex	UINT8	RO	0x12 (18_{dec})

Index (hex)	Name	Meaning		Data type	Flags	Default
80nD:11	Input Type	Measurement mode, allowed values:		UINT16	RW	0x0002 (2_{dec})
		0x02	-10..+10 V			
		0x0E	0..10 V			
		0x11	-20..+20 mA			
		0x12	0..20 mA			
		0x13	4..20 mA			
		0x14	4..20 mA (NAMUR)			
80nD:12	Scaler	Scaling range, allowed values:		UINT16	RW	0x0000 (0_{dec})
		0x00	Extended Range			
		0x03	0x03 Legacy Range			
80nD:17	Low Range Error	Lower threshold for setting the error bit and error led		INT32	RW	Dependent on 80nD:11
80nD:18	High Range Error	Upper threshold for setting the error bit and error led		INT32	RW	Dependent on 80nD:11

*Index 80nE*** AI internal data (for $0 \leq n \leq 3$)*

Index (hex)	Name	Meaning	Data type	Flags	Default
80nE:0	AI internal data	Maximum subindex	UINT8	RO	0x01 (1_{dec})
80nE:01	ADC raw value	ADC raw value	UINT16	RO	-

*Index 80nF*** AI vendor data (for $0 \leq n \leq 3$)*

Index (hex)	Name	Meaning	Data type	Flags	Default
80nF:0	AI vendor data	Maximum subindex	UINT8	RO	0x02 (2_{dec})
80nF:01	Calibration offset	Offset (vendor calibration)	INT16	RW	0x0000 (0_{dec})
80nF:02	Calibration gain	Gain (vendor calibration)	INT16	RW	0x4000 (16384_{dec})

Index 80nF AI Vendor data (for $0 \leq n \leq 3$)

Index (hex)	Name	Meaning	Data type	Flags	Default
80nF:0	AI Vendor data	Maximum subindex	UINT8	RO	0x06 (6_{dec})
80nF:01	R0 offset	Offset (Vendor calibration)	INT16	RW	0x0000 (0_{dec})
80nF:02	R0 gain	Gain (Vendor calibration)	INT16	RW	0x4000 (16384_{dec})
80nF:03	R1 offset	Offset (Vendor calibration)	INT16	RW	0x0000 (0_{dec})
80nF:04	R1 gain	Gain (Vendor calibration)	INT16	RW	0x4000 (16384_{dec})
80nF:05	R2 offset	Offset (Vendor calibration)	INT16	RW	0x0000 (0_{dec})
80nF:06	R2 gain	Gain (Vendor calibration)	INT16	RW	0x4000 (16384_{dec})

5.4.2.3 Input Data

*Index 60n0*** AI inputs (for 0 ≤ n ≤ 3)*

Index (hex)	Name	Meaning	Data type	Flags	Default
60n0:0	AI inputs	Maximum subindex	INT16	RO	0x11 (17dec)
60n0:01	Underrange	Value below measuring range.	BOOLEAN	RO	0x00 (0dec)
60n0:02	Overrange	Measuring range exceeded.	BOOLEAN	RO	0x00 (0dec)
60n0:03	Limit 1	Limit value monitoring Limit 1 0. not active 1. value is smaller than limit value 1 2. value is larger than limit value 1 3. Value is equal to limit value 1	BIT2	RO	0x00 (0dec)
60n0:05	Limit 2	Limit value monitoring limit 2 0. not active 1. value is smaller than limit value 2 2. value is larger than limit value 2 3. Value is equal to limit value 2	BIT2	RO	0x00 (0dec)
60n0:07	Error	The error bit is set if the data is invalid (over-range, under-range)	BOOLEAN	RO	0x00 (0dec)
60n0:0E	Sync error	The Sync error bit is only required for DC mode. It indicates whether a synchronization error has occurred during the previous cycle. This means a SYNC signal was triggered in the AN-430, although no new process data were available (0=OK, 1=NOK).	BOOLEAN	RO	0x00 (0dec)
60n0:0F	TxPDO State	Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).	BOOLEAN	RO	0x00 (0dec)
60n0:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated.	BOOLEAN	RO	0x00 (0dec)
60n0:11	Value	Analog input date	INT16	RO	0x0000 (0dec)

5.4.3 Technical Data

Technical Data		AKT2G-AN-430-000
Analog inputs		4 (U differential, I single-ended)
Conversion type		simultaneous
ADC type		SAR
Signal voltage		-10/0…+10 V
Signal current		-20/0/+4…+20 mA
Measuring range, nominal (Full Scale Value)	Voltage measurement range	-10/0…+10 V
	Current measurement range	-20/0/+4…+20 mA
Measuring range, technical	Voltage measurement range	-10.73…+10.73 V
	Current measurement range	-21.47…+21.47 mA
Measuring error (full measuring range)		< ±0.3 % (relative to full scale value)
Distributed Clocks		yes
Distributed Clocks precision		<< 1 µs
Support NoCoeStorage		yes
Resolution		16 bit (incl. sign)
Internal resistance		Voltage measurement: > 200 kΩ | Current measurement: 85 Ω typ.
Input filter limit frequency		5 kHz
Common-mode voltage UCM		35 V max. (voltage measurement)
Minimal EtherCAT cycle time		200 µs
Overcurrent protection		50 mA typ.
Bit width of the process image		Inputs: 16 Byte
Configuration		no address or configuration settings required
MTBF (+55°C)		-

Technical Data		AKT2G-AN-430-000
Special features		U/I parameterisable, Extended Range, standard and compact process image, activatable FIR/IIR filters
Supply voltage for electronic		via the E-bus
Current consumption via E-bus		typ. 170 mA
Electrical isolation		500 V (E bus/ fieldbus voltage)
Recommended operating voltage range (ground related to GND/ 0V power contact)	Voltage measurement range	UCM 35 V max.
	Current measurement range	single ended, dielectric strength max. 30 V
Recommended signal range	Voltage measurement range	Extended Range (107%), differential
	Current measurement range	Extended Range (107%), single ended
Destruction limit (ground related to GND/ 0V power contact)	Voltage measurement range	50 V
	Current measurement range	30 V
Destruction limit (differential)	Voltage measurement range	50 V
	Current measurement range	n.a.
Weight		approx. 65 g
Permissible ambient temperature range during operation		-25…+60 °C
Permissible ambient temperature range during storage		-40…+85 °C
Permissible relative humidity		95 %, no condensation
Design		HD (High Density) housing with signal LED
Dimensions (W x H x D)		approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting		on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance		conforms to EN 60068-2-6/EN 60068-2-27

Technical Data	AKT2G-AN-430-000
EMC immunity/emission	conforms to EN 61000-6-2/EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, cULus

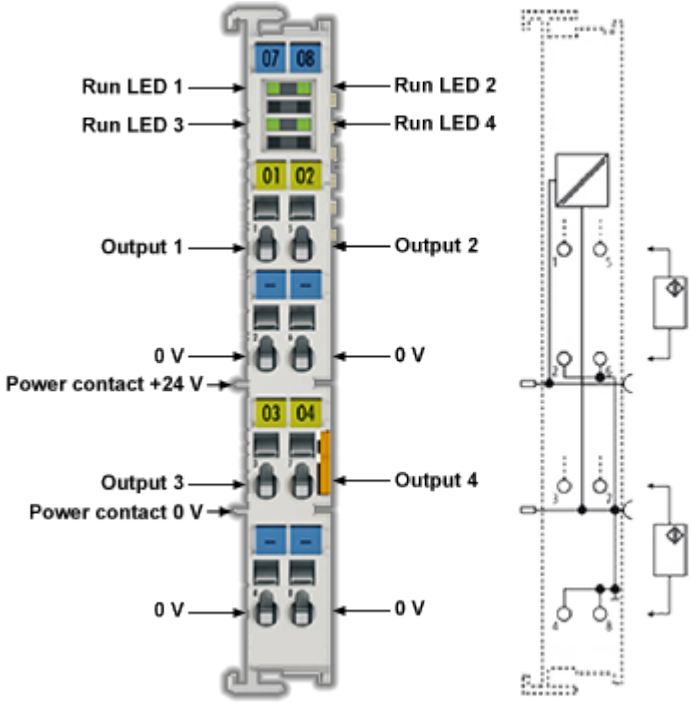
5.5 AKT2G-AT-410-000

Four-channel analog output terminals, 0..10 V, 12 bit

The AKT2G-AT-410 analog output terminal generates signals in the range between 0 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 the EtherCAT Terminal has a common ground potential. The output stages are powered by the 24 V supply. The signal state of the EtherCAT Terminals is indicated by light emitting diodes. The AT-410 supports distributed clocks, i.e. the input data can be monitored synchronously with other data that are also linked to distributed clock terminals. The accuracy across the system is < 100 ns.

See Also:

- Temporal Aspects of Analog/Digital Conversion
- Map Input and Output to Variables



5.5.1 LEDs

LED	Color	Meaning	
RUN	green	This LED indicates the terminal's operating state:	
		off	State of the EtherCAT State Machine: INIT = initialization of the terminal, state of the EtherCAT State Machine: BOOTSTRAP = function for firmware updates of the terminal
		flashing	State of the EtherCAT State Machine: PREOP = function for mailbox communication and different standard-settings set
		single flash	State of the EtherCAT State Machine: SAFEOP = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state
		on	State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible

If several RUN LEDs are present, all of them have the same function.

5.5.2 Object Description and Parameterization

5.5.2.1 Restore objects

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to “0x64616F6C” in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0_{dec})

5.5.2.2 Configuration data

Index 8pp0 AO settings Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
8pp0:0	AO settings Ch.1-8	Max. Subindex	UINT8	RO	0x16 (22_{dec})
8pp0:01	Enable user scale	User scale is active.	BOOLEAN	RW	0x00 (0_{dec})
8pp0:02	Presentation	0. Signed presentation The measured value is presented in two’s complement format. Maximum representation range for 16 bits = -32768_{dec} ... $+32767_{dec}$ 1. Unsigned presentation Maximum presentation range for 16 bit : 0 .. $+65535_{dec}$ 2. Absolute value with MSB as sign The measured value is output in magnitude-sign format. Maximum representation range for 16 bits = -32768_{dec} ... $+32767_{dec}$ 3. Absolute value Negative numbers are also output as positive numbers.	BIT3	RW	0x00 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
8pp0:05	Watchdog	0: Default watchdog value 0. The default value (8pp0:13) is active. 1. Watchdog ramp The ramp (8pp0:14) for moving to the default value is active. 2. Last output value In the event of a watchdog drop the last process data is issued.	BIT2	RW	0x00 (0_{dec})
8pp0:07	Enable user calibration	Enable user calibration	BOOLEAN	RW	0x00 (0_{dec})
8pp0:08	Enable vendor calibration	Enable vendor calibration	BOOLEAN	RW	0x01 (1_{dec})
8pp0:11	Offset	User scaling offset	INT16	RW	0x0000 (0_{dec})
8pp0:12	Gain	User scaling gain. The gain is represented in fixed-point format, with the factor 2-16. The value 1 corresponds to 65535 (0x00010000).	INT32	RW	0x00010000 (65536_{dec})
8pp0:13	Default output	default output value	INT16	RW	0x0000 (0_{dec})
8pp0:14	Default output ramp	Ramp for ramping down to the default value Value in digits/ms.	UINT16	RW	0xFFFF (65535_{dec})
8pp0:15	User calibration offset	User calibration offset	INT16	RW	0x0000 (0_{dec})
8pp0:16	User calibration gain	User calibration gain	UINT16	RW	0xFFFF (65535_{dec})

Index 8ppE AO internal data Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
8ppE:0	AO internal data Ch.1-8	Max. Subindex	UINT8	RO	0x01 (1_{dec})
8ppE:01	DAC raw value	DAC raw value	UINT16	RO	0x0000 (0_{dec})

Index 8ppF AO vendor data Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
8ppF:0	AO vendor data Ch.1-8	Max. Subindex	UINT8	RO	0x02 (2_{dec})
8ppF:01	Calibration offset	Vendor calibration offset	INT16	RW	0x0000 (0_{dec})
8ppF:02	Calibration gain	Vendor calibration gain	UINT16	RW	0x1EFA (7930_{dec})

5.5.2.3 Output Data

Index 7pp0 AO outputs Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
7pp0:0	AO outputs Ch.1-8	Max. Subindex	UINT8	RO	0x01 (1_{dec})
7pp0:01	Analog output	Analog output data	INT16	RO	0x0000 (0_{dec})

5.5.3 Technical Data

Technical Data	AKT2G-AT-410-000
Number of outputs	4
Power supply	24 V DC via the power contacts
Signal voltage	0..10 V
Load	> 5 kΩ (short-circuit-proof)
Measuring error	< ± 0.1% (at 0 °C ... +55 °C, relative to the full scale value) < ± 0.2% (when the extended temperature range is used)
Resolution	12 bit
Conversion time	~ 250 µs
Power supply for electronics	via the E-bus
Distributed Clocks	yes
Current consumption via Ebus	typ. 140 mA
Electrical isolation	500 V (E-bus/field voltage)
Bit width in process image	4 x 16-bit AO output
Configuration	via KAS IDE
Weight	approx. 60 g
Permissible ambient temperature range during operation	-25 °C ... +60 °C (extended temperature range)
Permissible ambient temperature range during storage	-40 °C ... +85 °C
Permissible relative humid- ity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also installation instructions for enhanced mechanical load capacity
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, ATEX, cULus

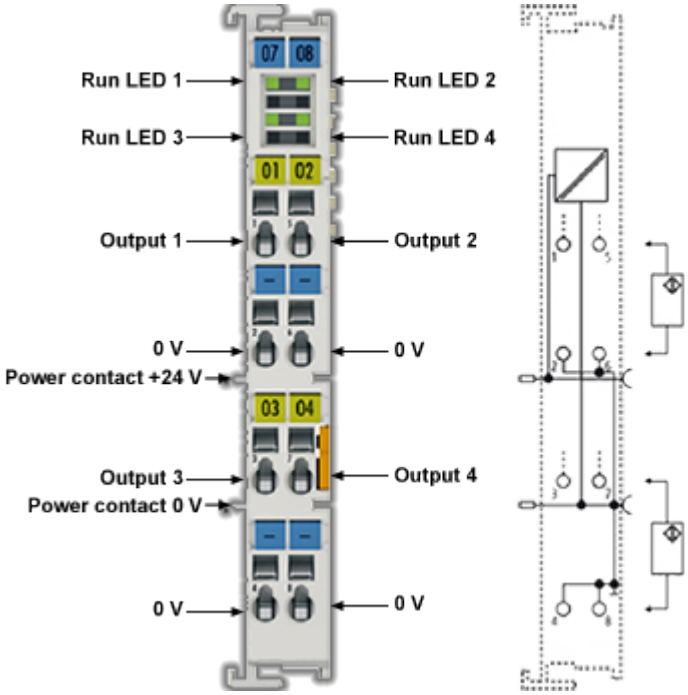
5.6 AKT2G-AT-425-000

Four-channel analog output terminals, -10..+10 V, 12 bit

The AKT2G-AT-425 Analog Output Terminal generates signals in the range from -10 V to +10 V. The voltage is supplied to the process level with a resolution of 12 bits, and is electrically isolated. The output channels of an EtherCAT Terminal have a common ground potential. The output stages are powered by the 24 V supply. The signal state of the EtherCAT Terminals is indicated by light emitting diodes. The AT-425 supports distributed clocks, i.e. the input data can be monitored synchronously with other data that are also linked to distributed clock terminals. The accuracy across the system is < 100 ns.

See Also:

- Temporal Aspects of Analog/Digital Conversion
- Map Input and Output to Variables



5.6.1 LEDs

LED	Color	Meaning	
RUN	green	This LED indicates the terminal's operating state:	
		off	State of the EtherCAT State Machine: INIT = initialization of the terminal, state of the EtherCAT State Machine: BOOTSTRAP = function for firmware updates of the terminal
		flashing	State of the EtherCAT State Machine: PREOP = function for mailbox communication and different standard-settings set
		single flash	State of the EtherCAT State Machine: SAFEOP = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state
		on	State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible

If several RUN LEDs are present, all of them have the same function.

5.6.2 Object Description and Parameterization

5.6.2.1 Restore objects

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to “0x64616F6C” in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0_{dec})

5.6.2.2 Configuration data

Index 8pp0 AO settings Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
8pp0:0	AO settings Ch.1-8	Max. Subindex	UINT8	RO	0x16 (22_{dec})
8pp0:01	Enable user scale	User scale is active.	BOOLEAN	RW	0x00 (0_{dec})
8pp0:02	Presentation	0. Signed presentation The measured value is presented in two’s complement format. Maximum representation range for 16 bits = -32768_{dec} ... $+32767_{dec}$ 1. Unsigned presentation Maximum presentation range for 16 bit : 0 .. $+65535_{dec}$ 2. Absolute value with MSB as sign The measured value is output in magnitude-sign format. Maximum representation range for 16 bits = -32768_{dec} ... $+32767_{dec}$ 3. Absolute value Negative numbers are also output as positive numbers.	BIT3	RW	0x00 (0_{dec})

Index (hex)	Name	Meaning	Data type	Flags	Default
8pp0:05	Watchdog	0: Default watchdog value 0. The default value (8pp0:13) is active. 1. Watchdog ramp The ramp (8pp0:14) for moving to the default value is active. 2. Last output value In the event of a watchdog drop the last process data is issued.	BIT2	RW	0x00 (0_{dec})
8pp0:07	Enable user calibration	Enable user calibration	BOOLEAN	RW	0x00 (0_{dec})
8pp0:08	Enable vendor calibration	Enable vendor calibration	BOOLEAN	RW	0x01 (1_{dec})
8pp0:11	Offset	User scaling offset	INT16	RW	0x0000 (0_{dec})
8pp0:12	Gain	User scaling gain. The gain is represented in fixed-point format, with the factor 2-16. The value 1 corresponds to 65535 (0x00010000).	INT32	RW	0x00010000 (65536_{dec})
8pp0:13	Default output	default output value	INT16	RW	0x0000 (0_{dec})
8pp0:14	Default output ramp	Ramp for ramping down to the default value Value in digits/ms.	UINT16	RW	0xFFFF (65535_{dec})
8pp0:15	User calibration offset	User calibration offset	INT16	RW	0x0000 (0_{dec})
8pp0:16	User calibration gain	User calibration gain	UINT16	RW	0xFFFF (65535_{dec})

Index 8ppE AO internal data Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
8ppE:0	AO internal data Ch.1-8	Max. Subindex	UINT8	RO	0x01 (1_{dec})
8ppE:01	DAC raw value	DAC raw value	UINT16	RO	0x0000 (0_{dec})

Index 8ppF AO vendor data Ch.1-8

Index (hex)	Name	Meaning	Data type	Flags	Default
8ppF:0	AO vendor data Ch.1-8	Max. Subindex	UINT8	RO	0x02 (2_{dec})
8ppF:01	Calibration offset	Vendor calibration offset	INT16	RW	0x0000 (0_{dec})
8ppF:02	Calibration gain	Vendor calibration gain	UINT16	RW	0x1EFA (7930_{dec})

5.6.2.3 Output Data

Index 7pp0 AO outputs Ch.1-8

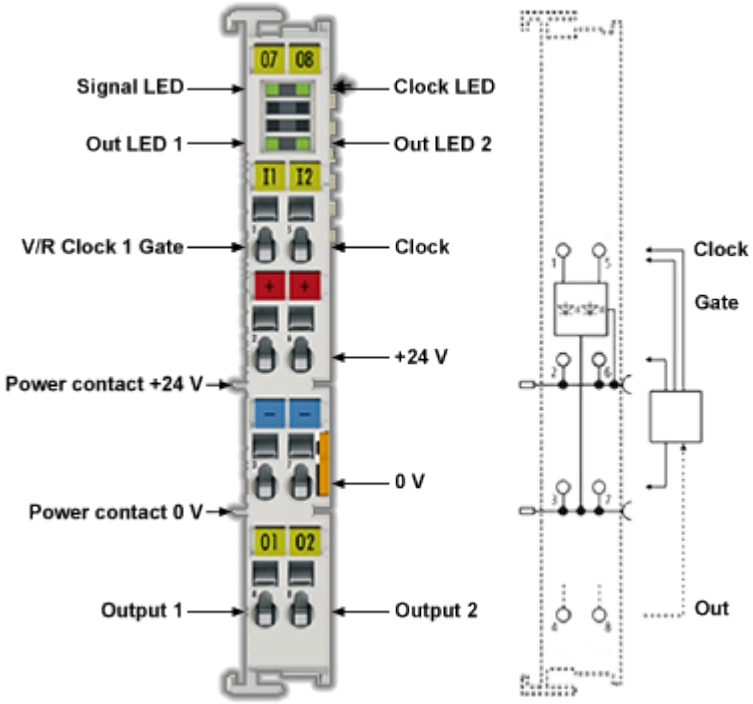
Index (hex)	Name	Meaning	Data type	Flags	Default
7pp0:0	AO outputs Ch.1-8	Max. Subindex	UINT8	RO	0x01 (1_{dec})
7pp0:01	Analog output	Analog output data	INT16	RO	0x0000 (0_{dec})

5.6.3 Technical Data

Technical Data	AKT2G-AT-425-000
Number of outputs	4
Power supply	24 V DC via the power contacts
Signal voltage	-10 ..+10 V
Load	> 5 kΩ (short-circuit-proof)
Measuring error	< ± 0.1% (at 0 °C ... +55 °C, relative to the full scale value) < ± 0.2% (when the extended temperature range is used)
Resolution	12 bit
Conversion time	~ 250 µs
Power supply for electronics	via the E-bus
Distributed Clocks	yes
Current consumption via Ebus	typ. 140 mA
Electrical isolation	500 V (E-bus/field voltage)
Bit width in process image	4 x 16-bit AO output
Configuration	via KAS IDE
Weight	approx. 60 g
Permissible ambient temperature range during operation	-25 °C ... +60 °C (extended temperature range)
Permissible ambient temperature range during storage	-40 °C ... +85 °C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also installation instructions for enhanced mechanical load capacity
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, ATEX, cULus

5.7 AKT2G-DN-002-000

Up/Down Counter 24 V_{DC}, 100 kHz, 32 bit counter depth



The up/down counter counts binary pulses, and transmits the counter state, in an electrically isolated form, to the higher-level automation device.

The AKT2G-DN-002 EtherCAT Terminal can alternatively be operated as:

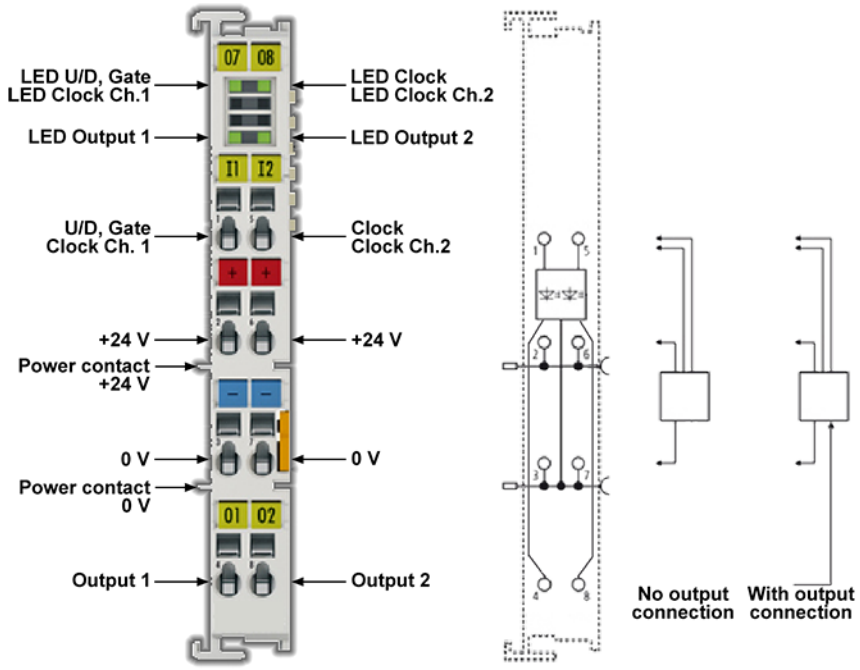
- a single-channel counter (32 bit) that can be toggled between counting up and down via the U/D input (delivery state)
- a single-channel counter (32 bit) that is controlled via the gate connection
- two separate logic counters (32 bit) that can count in one direction only with the Clock 1 and Clock 2 inputs

The signal state of the inputs and outputs is indicated by light emitting diodes.

The two outputs (Output 1 and Output 2) are switched in relation to the counter value and can thus be used as fast control signals for field devices.

The AKT2G-DN-002 supports distributed clocks, i.e. the input data can be monitored synchronously with other data that are also linked to distributed clock terminals. The accuracy across the system is < 100 ns.

5.7.1 LEDs and Connection



5.7.1.1 LEDs

LED	Color	Meaning
UP/DOWN, GATE CLOCK CH.1	green	Signal at U/D, Gate input (operating mode 32 bit up/down counter, 32 bit gated counter) Signal at the Clock input, channel 1 (operating mode 2 x 32 bit counter) see "Operating Mode Selection" on page 105
CLOCK CLOCK CH.2	green	Signal at Clock input (operating mode 32 bit up/down counter, 32 bit gated counter) Signal at the Clock input, channel 2 (operating mode 2 x 32 bit counter see "Operating Mode Selection" on page 105
OUTPUT1 OUTPUT2	green	Signal at the corresponding output

5.7.1.2 Connection

Terminal Point		Description
Name	No.	
U/D, Gate Clock Ch.1	1	Up/down input (operating mode 32 bit up/down counter), Gate input (operating mode 32 bit counter with gate function) Clock 1 input (operating mode 2 x 32 bit counter) see "Operating Mode Selection" on page 105
+24 V	2	+24 V (internally connected to terminal point 6 and positive power contact)
0 V	3	0 V (internally connected to terminal point 7 and negative power contact)
Output 1	4	Output 1
Clock Clock Ch.2	5	Clock input (operating mode 32 bit up/down counter) and (operating mode 32 bit counter with gate function) Clock 2 input (operating mode 2 x 32 bit counter) see "Operating Mode Selection" on page 105
+24 V	6	+24 V (internally connected to terminal point 2 and positive power contact)
0 V	7	0 V (internally connected to terminal point 3 and negative power contact)
Output 2	8	Output 2

5.7.2 Basic Function Principles

The AKT2G-DN-002 input terminals count binary pulses and transfer the current value to the higher-level controller.

In addition to the 32 bit up/down counter, further available operating modes are a 32 bit gated counter or two 32 bit counters. In gated counter mode, a low or high level at the Gate input inhibits the counting function of the terminal.

If two 32 bit counters are active, the U/D input (terminal point 1) is configured as the input for the first counter and the Clock 2 input (terminal point 5) as the input for the second counter.

Beyond that, two digital outputs can be set.

The maximum input frequency is limited to 100 kHz for the AKT2G-DN-002; the counters react to the rising edge of the input signal.

5.7.3 Operating Mode Selection

The following operation modes are possible.

Operation mode	Predefined PDO Assignment	Setting of the counting direction via CoE directory	Switchable outputs

1 (default)	**1Ch. +/- Counter:**
	0x1A02 – CNT Inputs
	+
	0x1602 – CNT Outputs
		Index 0x8020:05:
		0: Enable UD counter
		• UD input (terminal point 1): sets the counting direction:
		  • High level: up;
		  • Low level: Down
		• Clock input (terminal point 5): indicates the individual pulses.
			Output 1

2	**1Ch. +/- Counter:** 0x1A02 – CNT Inputs + 0x1602 – CNT Outputs	**Index 0x8020:05:** 1: Enable pos. gate • Gate is inhibited by a positive level on the gate input (terminal point 1) • Clock input (terminal point 5): indicates the individual pulses. + **Index 0x8020:04:** 0: up counter 1: down counter	Output 1
3	**1Ch. +/- Counter:** 0x1A02 – CNT Inputs + 0x1602 – CNT Outputs	**Index 0x8020:05:** 2: Enable neg. gate • Gate is inhibited by a negative level on the gate input (terminal point 1) • Clock input (terminal point 5): indicates the individual pulses. + **Index 0x8020:04:** 0: up counter 1: down counter	Output 1
4	**2Ch. Counter:** 0x1A00 – CNT Inputs Channel 1 0x1A01 – CNT Inputs Channel 2 + 0x1600 – CNT Outputs Channel 1 0x1601 – CNT Outputs Channel 2	**Index 0x8000:04 (Channel1) and Index 0x8010:04 (Channel2)** 0:up counter 1:down counter	Counter 1 → Output 1 Counter 2 → Output 2

In addition, the distributed clock function may be activated for the AKT2G-DN-002.

Single-channel up/down counter, gated counter (operating mode 1-3)

1. Selection of the PDOs for "1Ch.+/-Counter"
2. CoE Init-command to configure index 0x8020:05:
   - "Enable UD counter" – single-channel up/down counter (operating mode 1)
     If a high signal level is encountered at the up/down input of the terminal (terminal point 1), the counter counts up in the event of positive edges at the clock input (terminal point 5), with a low signal level it counts down.
   - "Enable pos. gate" – single-channel gated counter closes in the case of a high level (operating mode 2)
     The counter is inhibited if a high level is encountered at the gate input of the terminal (terminal point 1).
     The counting direction is set by index 0x8020:04 (0: up, 1: down). The clock input (terminal point 5) indicates the individual pulses.
   - "Enable neg. gate" – single-channel gated counter closes in the case of a low level (operating mode 3)
     The counter is inhibited if a low level is encountered at the gate input of the terminal (terminal point 1).The counting direction is set by index 0x8020:04 (0: up, 1: down).
     The clock input (terminal point 5) indicates the individual pulses.

Two-channel up/down counter (operating mode 4)

1. Selection of the PDOs for "2Ch. Counter"
   The terminal points 1 or 5 serve as clock input for 32 bit counter 1 or 2.
2. CoE Init-commands to configure the indices 0x8000:04 for channel 1 and 0x8010:04 for channel. Two options are available per channel:
   - 0: up counter
   - 1: down counter

5.7.4 Objects for Commissioning

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1dec)
1011:01	SubIndex 001	If this object is set to “0x64616F6C” in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0dec)

Index 8000 CNT Settings Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
8000:0	CNT Settings Ch.1	Maximum subindex	UINT8	RO	0x13 (19dec)
8000:01	Enable function to set output	Activates the function for setting Output 1	BOOLEAN	RW	0x00 (0dec)
8000:02	Enable function to reset output	Activates the function for resetting Output 1	BOOLEAN	RW	0x00 (0dec)
8000:03	Enable reload	The counter counts to the value in index 0x8000:13	BOOLEAN	RW	0x00 (0dec)
8000:04	Count down	Counting direction: • 0: Up • 1: Down	BOOLEAN	RW	0x00 (0dec)
8000:11	Switch on threshold value	Switch-on threshold value for Output 1	UINT32	RW	0x00000000 (0dec)
8000:12	Switch off threshold value	Switch-off threshold value for Output 1	UINT32	RW	0x00000000 (0dec)
8000:13	Counter reload value	The limit that can be activated via "Enable reload" (index 0x8000:03). The counter counts to this limit and, on exceeding it, begins again at zero.	UINT32	RW	0x00000001 (1dec)

Index 8010 CNT Settings Ch.2

Index (hex)	Name	Meaning	Data type	Flags	Default
8010:0	CNT Settings Ch.2	Maximum subindex	UINT8	RO	0x13 (19dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
8010:01	Enable function to set output	Activates the function for setting Output 2	BOOLEAN	RW	0x00 (0dec)
8010:02	Enable function to reset output	Activates the function for resetting Output 2	BOOLEAN	RW	0x00 (0dec)
8010:03	Enable reload	The counter counts to the value in index 0x8010:13	BOOLEAN	RW	0x00 (0dec)
8010:04	Count down	Counting direction • 0: Up • 1: Down	BOOLEAN	RW	0x00 (0dec)
8010:11	Switch on threshold value	Switch-on threshold value for Output 2	UINT32	RW	0x00000000 (0dec)
8010:12	Switch off threshold value	Switch-off threshold value for Output 2	UINT32	RW	0x00000000 (0dec)
8010:13	Counter reload value	The limit that can be activated via "Enable reload" (index 0x8010:03). The counter counts to this limit and, on exceeding it, begins again at zero.	UINT32	RW	0x00000001 (1dec)

Index 8020 CNT Settings

Index (hex)	Name	Meaning	Data type	Flags	Default
8020:0	CNT Settings	Maximum subindex	UINT8	RO	0x13 (19dec)
8020:01	Enable function to set output	Activates the function for setting Output 1	BOOLEAN	RW	0x00 (0dec)
8020:02	Enable function to reset output	Activates the function for resetting Output 1	BOOLEAN	RW	0x00 (0dec)
8020:03	Enable reload	The counter counts to the value in index 0x8020:13	BOOLEAN	RW	0x00 (0dec)
8020:04	Count down	Counting direction • 0: Up • 1: Down	BOOLEAN	RW	0x00 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
8020:05	Operating mode	Operating mode • 0: Enable UD counter U/D input (terminal point 1) specifies the counting direction: High level: up, low level: down • 1: Enable pos. gate (gate inhibits with positive level) • 2: Enable neg. gate (gate inhibits with negative level)	BIT2	RW	0x00 (0dec)
8020:11	Switch on threshold value	Switch-on threshold value for Output 1	UINT32	RW	0x00000000 (0dec)
8020:12	Switch off threshold value	Switch-off threshold value for Output 1	UINT32	RW	0x00000000 (0dec)
8020:13	Counter reload value	The limit that can be activated via "Enable reload" (index 0x8020:03). The counter counts to this limit and, on exceeding it, begins again at zero.	UINT32	RW	0x00000001 (1dec)

5.7.5 Profile-specific objects (0x6000-0xFFFF)

The profile-specific objects have the same meaning for all EtherCAT slaves that support the profile 5001.

Index 6000 CNT Inputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
6000:0	CNT Inputs Ch.1	Maximum subindex	UINT8	RO	0x11 (17dec)
6000:01	Output functions enabled	This bit indicates that the internal functions for the output have been enabled	BOOLEAN	RO	0x00 (0dec)
6000:02	Status of output	Status of the output	BOOLEAN	RO	0x00 (0dec)
6000:03	Set counter done	The counter was set	BOOLEAN	RO	0x00 (0dec)
6000:04	Counter inhibited	The counter is stopped for as long as this bit is set	BOOLEAN	RO	0x00 (0dec)
6000:06	Status of input clock	State of the Clock input (high level applied)	BOOLEAN	RO	0x00 (0dec)
6000:0E	Sync Error	Synchronization error	BOOLEAN	RO	0x00 (0dec)
6000:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated	BOOLEAN	RO	0x00 (0dec)
6000:11	Counter value	Counter value	UINT32	RO	0x00000000 (0dec)

Index 6010 CNT Inputs Ch.2

Index (hex)	Name	Meaning	Data type	Flags	Default
6010:0	CNT Inputs Ch.2	Maximum subindex	UINT8	RO	0x11 (17dec)
6010:01	Output functions enabled	This bit indicates that the internal functions for the output have been enabled	BOOLEAN	RO	0x00 (0dec)
6010:02	Status of output	Status of the output	BOOLEAN	RO	0x00 (0dec)
6010:03	Set counter done	The counter was set	BOOLEAN	RO	0x00 (0dec)
6010:04	Counter inhibited	The counter is stopped for as long as this bit is set	BOOLEAN	RO	0x00 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
6010:06	Status of input clock	State of the Clock input (high level applied)	BOOLEAN	RO	0x00 (0dec)
6010:0E	Sync Error	Synchronization error	BOOLEAN	RO	0x00 (0dec)
6010:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated	BOOLEAN	RO	0x00 (0dec)
6010:11	Counter value	Counter value	UINT32	RO	0x00000000 (0dec)

Index 6020 CNT Inputs

Index (hex)	Name	Meaning	Data type	Flags	Default
6020:0	CNT Inputs	Maximum subindex	UINT8	RO	0x11 (17dec)
6020:01	Output functions enabled	This bit indicates that the internal functions for the output have been enabled	BOOLEAN	RO	0x00 (0dec)
6020:02	Status of output	Status of the output	BOOLEAN	RO	0x00 (0dec)
6020:03	Set counter done	The counter was set.	BOOLEAN	RO	0x00 (0dec)
6020:04	Counter inhibited	The counter is stopped for as long as this bit is set	BOOLEAN	RO	0x00 (0dec)
6020:05	Status of input UD	State of the Up/Down input (high level applied)	BOOLEAN	RO	0x00 (0dec)
6020:06	Status of input clock	State of the Clock input (high level applied)	BOOLEAN	RO	0x00 (0dec)
6020:0E	Sync Error	Synchronization error	BOOLEAN	RO	0x00 (0dec)
6020:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated	BOOLEAN	RO	0x00 (0dec)
6020:11	Counter value	Counter value	UINT32	RO	0x00000000 (0dec)

Index 7000 CNT Outputs Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
7000:0	CNT Outputs Ch.1	Maximum subindex	UINT8	RO	0x11 (17dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
7000:01	Enable output functions	The internal functions for the output are enabled via this bit	BOOLEAN	RO	0x00 (0dec)
7000:02	Set output	Set output	BOOLEAN	RO	0x00 (0dec)
7000:03	Set counter	Set counter	BOOLEAN	RO	0x00 (0dec)
7000:04	Inhibit counter	The counter is stopped as long as this bit is active. The previous counter state is retained.	BOOLEAN	RO	0x00 (0dec)
7000:11	Set counter value	This is the counter value to be set via “Set counter” (index 0x7000:03).	UINT32	RO	0x00000000 (0dec)

Index 7010 CNT Outputs Ch.2

Index (hex)	Name	Meaning	Data type	Flags	Default
7010:0	CNT Outputs Ch.2	Maximum subindex	UINT8	RO	0x11 (17dec)
7010:01	Enable output functions	The internal functions for the output are enabled via this bit	BOOLEAN	RO	0x00 (0dec)
7010:02	Set output	Set output	BOOLEAN	RO	0x00 (0dec)
7010:03	Set counter	Set counter	BOOLEAN	RO	0x00 (0dec)
7010:04	Inhibit counter	The counter is stopped as long as this bit is active. The previous counter state is retained.	BOOLEAN	RO	0x00 (0dec)
7010:11	Set counter value	This is the counter value to be set via “Set counter” (index 0x7010:03).	UINT32	RO	0x00000000 (0dec)

Index 7020 CNT Outputs

Index (hex)	Name	Meaning	Data type	Flags	Default
7020:0	CNT Outputs	Maximum subindex	UINT8	RO	0x11 (17dec)
7020:01	Enable output functions	The internal functions for the output are enabled via this bit	BOOLEAN	RO	0x00 (0dec)
7020:02	Set output	Set output	BOOLEAN	RO	0x00 (0dec)
7020:03	Set counter	Set counter	BOOLEAN	RO	0x00 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
7020:04	Inhibit counter	The counter is stopped as long as this bit is active. The previous counter state is retained.	BOOLEAN	RO	0x00 (0dec)
7020:11	Set counter value	This is the counter value to be set via “Set counter” (index 0x7020:03).	UINT32	RO	0x00000000 (0dec)

Index F000 Modular device profile

Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular device profile	General information for the modular device profile	UINT8	RO	0x02 (2dec)
F000:01	Module index distance	Index spacing of the objects of the individual channels	UINT16	RO	0x0010 (16dec)
F000:02	Maximum number of modules	Number of channels	UINT16	RO	0x0003 (3dec)

Index F008 Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0*	Code word	NoCoeStorage function: The input code of the code word 0x12345678 activates the NoCoeStorage function: Changes to the CoE directory are not saved if the function is active. The function is deactivated by: 1.) changing the code word or 2.) restarting the terminal.	UINT32	RW	0x00000000 (0dec)

* Function NoCoeStorage from Firmware 03

NOTE

Code word

The vendor reserves the authority for the basic calibration of the terminals. The code word is therefore at present reserved.

Index F010 Module list

Index (hex)	Name	Meaning	Data type	Flags	Default
F010:0	Module list	Maximum subindex	UINT8	RO	0x03 (3dec)
F010:01	SubIndex 001	reserved	UINT16	RO	0x0096 (150dec)
F010:02	SubIndex 002	reserved	UINT16	RO	0x0096 (150dec)
F010:03	SubIndex 003	reserved	UINT16	RO	0x0096 (150dec)

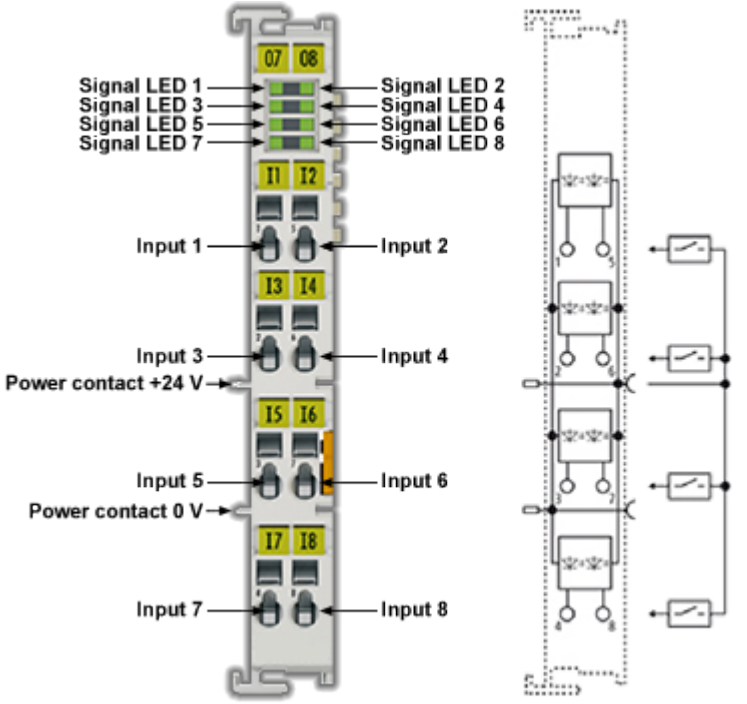
5.7.6 Technical Data

Technical Data	AKT2G-DN-002-000
Number of counters	1 or 2
Rated voltage	24 VDC (-15%/+20%)
Signal voltage “0”	-3 V ... 5 V (EN 61131-2, type 1)
Signal voltage “1”	15 V ... 30 V (EN 61131-2, type 1)
Counting frequency	100 kHz
Counter depth	32 bit
Input current	typ. 5 mA (EN 61131-2, type 1)
Output current (per channel)	max. 0.5 A (short-circuit-proof)
Distributed Clocks (DC)	yes
Current consumption power contacts	typ. 14 mA + load
Current consumption via E-bus	typ. 130 mA
Electrical isolation	500 V (E-bus/field voltage)
Supports NoCoeStorage function	yes
Weight	approx. 50 g
Permissible ambient temperature range during operation	-25°C ... +60°C (extended temperature range)
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also Mounting and Wiring of I/O Terminals
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE ATEX, cULus

5.8 AKT2G-DN-008-000

8-channel Digital Input Terminal 24 V DC, filter 3.0 ms, 1-wire system

The DN-008 digital input terminal acquires binary control signals from the process level and transmit them, in an electrically isolated form, to the higher-level automation device. The digital input terminals of the DN-008 feature an input filter (3 ms) and indicate their signal state through an LED for each channel.



5.8.1 LEDs

LED	Color	Meaning	
INPUT 1- 8	green	off	Signal voltage "0" (-3 V ... 5 V)
		on	Signal voltage "1" (11 V ... 30 V)

5.8.2 Connection

Terminal Point		Description
Name	No.	
Input 1	1	Input 1
Input 3	2	Input 3
Input 5	3	Input 5
Input 7	4	Input 7
Input 2	5	Input 2
Input 4	6	Input 4
Input 6	7	Input 6
Input 8	8	Input 8

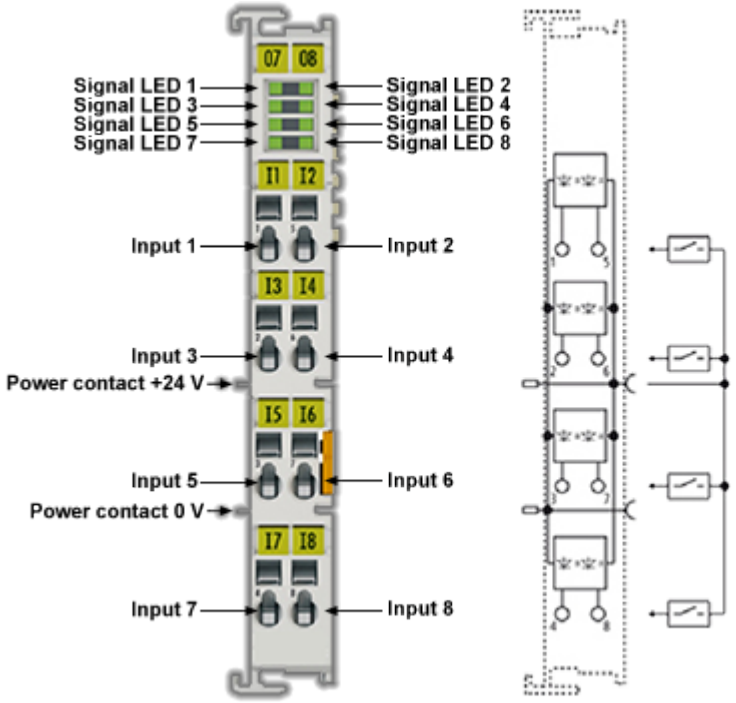
5.8.3 Technical Data

Technical Data	AKT2G-DN-008-000
Number of inputs	8
Number of simultaneously controllable in- puts, depending on the ambient temperature	8 (-25°C ... +55°C) 4 (> +55°C) (aligned in horizontal installation position)
Nominal voltage of the inputs	24 VDC (-15% / +20%)
Signal voltage "0"	-3 V ... 5 V (EN 61131-2, type 1/3)
Signal voltage "1"	11 V ... 30 V (EN 61131-2, type 1/3)
Input filter	3 ms
Input current	typically 3 mA (EN 61131-2, type 1/3)
Current consumption power contacts	typ. 2 mA + load
Current consumption via E-bus	typ. 90 mA
Electrical isolation	500 V (E-bus/field voltage)
Bit width in the process image	8 input bits
Configuration	no address setting, configuration via KAS IDE
Weight	approx. 55 g
Permissible ambient temperature range during operation	-25°C ... +60°C (extended temperature range, aligned in horizontal installation position) -25°C ... +45°C (all other installation positions)
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	according to EN 60068-2-6/EN 60068-2-27, see also Installation instructions for terminals with increased mechanical load capacity
EMC resistance burst/ESD	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	see note Constraints regarding installation position and operating temperature range
Approval	CE, cULus, ATEX, IECEx

5.9 AKT2G-DNH-008-000

8-channel Digital Input Terminal 24 V DC, filter 10 µs, 1-wire system

The DNH-008 digital input terminal acquires binary control signals from the process level and transmit them, in an electrically isolated form, to the higher-level automation device. The digital input terminals of the DNH-008 series feature an input filter (10 µs) and indicate their signal state through an LED for each channel.



5.9.1 LEDs

LED	Color	Meaning	
INPUT 1- 8	green	off	Signal voltage "0" (-3 V ... 5 V)
		on	Signal voltage "1" (11 V ... 30 V)

5.9.2 Connection

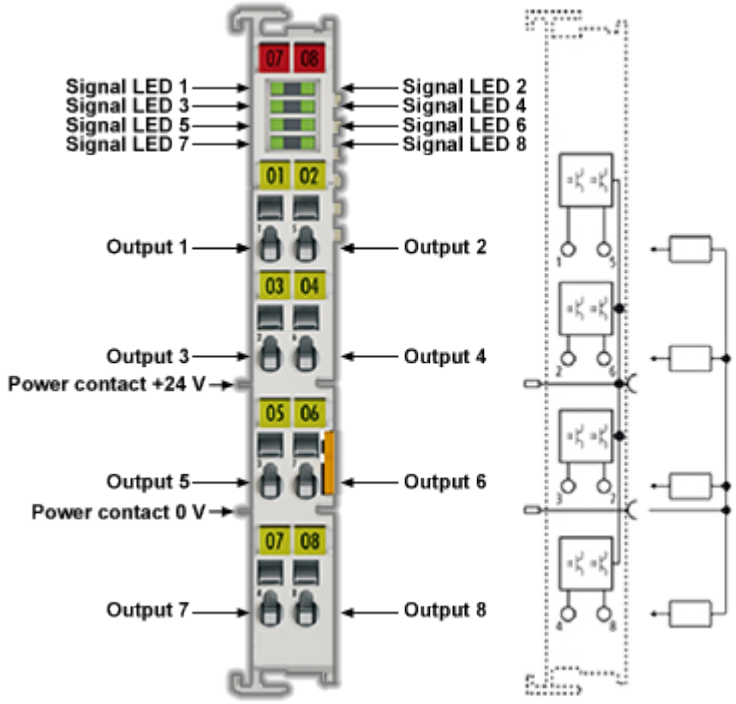
Terminal Point		Description
Name	No.	
Input 1	1	Input 1
Input 3	2	Input 3
Input 5	3	Input 5
Input 7	4	Input 7
Input 2	5	Input 2
Input 4	6	Input 4
Input 6	7	Input 6
Input 8	8	Input 8

5.9.3 Technical Data

Technical Data	AKT2G-DNH-008-000
Number of imputs	8
Number of simultaneously controllable inputs, depending on the ambient temperature	8 (-25°C ... +55°C) 4 (> +55°C) (aligned in horizontal installation position)
Nominal voltage of the inputs	24 VDC (-15% / +20%)
Signal voltage "0"	-3 V ...5 V (EN 61131-2, type 1/3)
Signal voltage "1"	11 V ... 30 V (EN 61131-2, type 1/3)
Input filter	10 µs typ. (10...50 µs)
Input current	typically 3 mA (EN 61131-2, type 1/3)
Current consumption power contacts	typ. 2 mA + load
Current consumption via E-bus	typ. 90 mA
Electrical isolation	500 V (E-bus/field voltage)
Bit width in the process image	8 input bits
Configuration	no address setting, configuration via KAS IDE
Weight	approx. 55 g
Permissible ambient temperature range during operation	-25°C ... +60°C (extended temperature range, aligned in horizontal installa tion position) -25°C ... +45°C (all other installation positions)
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	according to EN 60068-2-6/EN 60068-2-27, see also Installation instructions for terminals with increased mechanical load capacity
EMC resistance burst/ESD	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	see note Constraints regarding installation position and operating temperature range
Approval	CE, cULus, ATEX

5.10 AKT2G-DT-008-000

8-channel Digital Output Terminal 24 V DC, 0.5 A, 1-wire system



The AKT2G-DT-008 digital output terminal relays binary control signals of the automation device in an electrically isolated manner to the actuators of the process level. They are protected against reverse polarity at the power contacts. The digital output terminals of the device indicate their signal state through an LED for each channel.

5.10.1 AKT2G-DT-008 LEDs and Connection

5.10.1.1 LEDs

LED	Color	Meaning	
OUTPUT 1- 8	green	off	No output signal
		on	24 VDC output signal at the respective output

5.10.1.2 Connection

Terminal point		Description
Name	No.	
Output 1	1	Output 1
Output 3	2	Output 3
Output 5	3	Output 5
Output 7	4	Output 7
Output 2	5	Output 2
Output 4	6	Output 4

Terminal point		Description
Name	No.	
Output 6	7	Output 6
Output 8	8	Output 8

5.10.2 Technical Data

Technical Data	AKT2G-DT-008-000
Number of outputs	8
Non-reactive outputs	yes (see Interference-Free EtherCAT Terminals)
Load type	ohmic, inductive, lamp load
Nominal output voltage	24 VDC (-15% / +20%)
Switching times	TON: 60 µs typ.; TOFF: 300 µs typ.
Output current per channel	maximum 0.5 A (short-circuit proof)
Switch-off energy (inductive)	max. 150 mJ/channel
Current consumption from load voltage (power contacts)	typ. 15 mA
Supply voltage for electronic	via the E-Bus
Current consumption via E-bus	typ. 110 mA
Electrical isolation	500 V (E-bus/field voltage)
Bit width in the process image	8 output bits
Configuration	no address setting, configuration via KAS IDE
Weight	approx. 55 g
Permissible ambient temperature range during operation	Aligned in horizontal installation position: -25°C ... +60°C (extended temperature range) All other installation positions: -25°C ... +45°C
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	according to EN 60068-2-6/EN 60068-2-27, see also Installation instructions for terminals with increased mechanical load capacity
EMC resistance burst/ESD	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	see note Constraints regarding installation position and operating temperature range
Approval	CE, cULus, ATEX

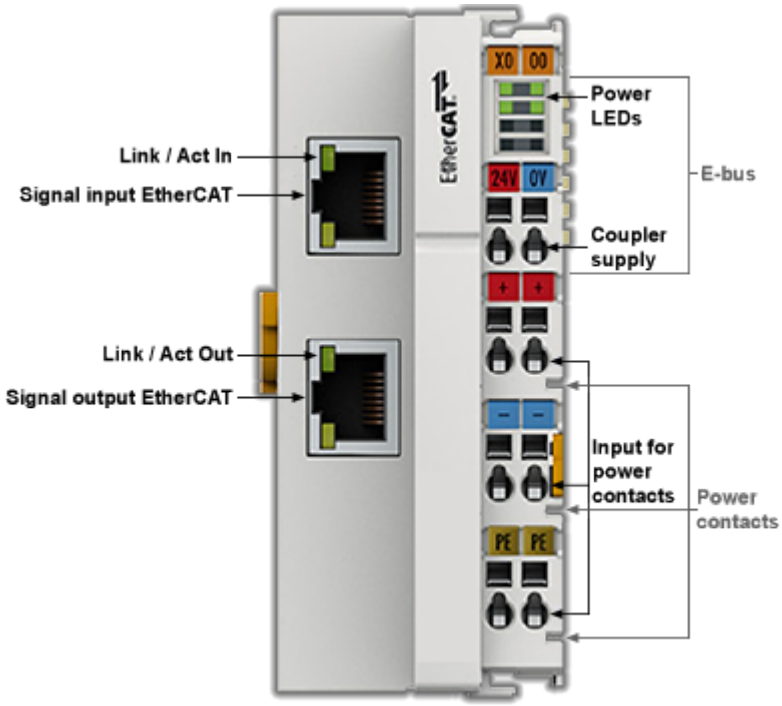
5.11 AKT2G-ECT-000-000

EtherCAT Coupler for E-bus Terminals

5.11.1 Overview of EtherCAT Couplers

An EtherCAT coupler is required in order to connect EtherCAT Terminals with E-bus-communication to an EtherCAT network. This coupler relays the communication from the higher level EtherCAT network to the terminals.

5.11.2 EtherCAT Coupler for E-bus terminals



The ECT-000 coupler connects the EtherCAT Device Protocol with the EtherCAT Terminals. One station consists of a coupler, any number of EtherCAT Terminals and a bus end terminal (AKT2G-EM-000-000).

The coupler converts the telegrams from Ethernet 100BASE-TX to E-bus signal representation in passing with minimum latency. The coupler is connected to the network via the upper Ethernet interface. The lower RJ-45 socket may be used to connect further EtherCAT devices in the same strand.

The coupler supplies the connected terminals with the necessary E-bus current for communication. The coupler can supply a maximum of 5 V/2 A. Power feed terminals (AKT2G-PSF-024-000) must be integrated if more current is required.

In the EtherCAT network, the coupler can be installed anywhere, including before, after, or in the middle of the EtherCAT servo drives. However, the coupler does not support MAC Unicast or IP addressing from a switch or a router.

5.11.3 EtherCAT Coupler Port Allocation

According to the EtherCAT specification, an ESC (EtherCAT Slave Controller, hardware processing unit of the EtherCAT protocol) can have 1 to 4 ports, which it controls itself. Via an open port it can handle outgoing and incoming Ethernet traffic.

The following figure shows the direction of data flow in a fully connected ECT-000 as an example:

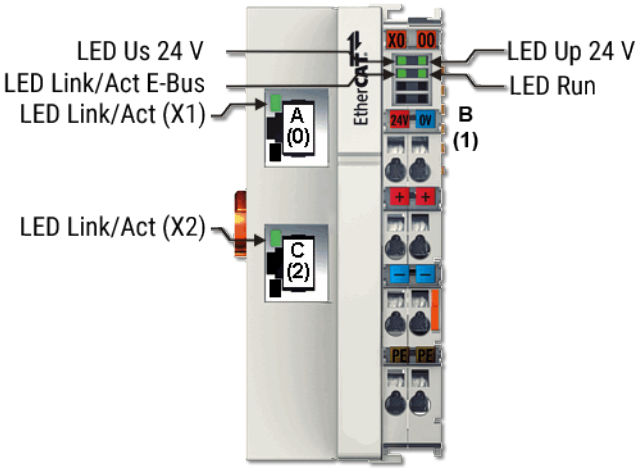


Figure 3-22: Example: AKT2G-ECT-000 EtherCAT coupler with 3 ports

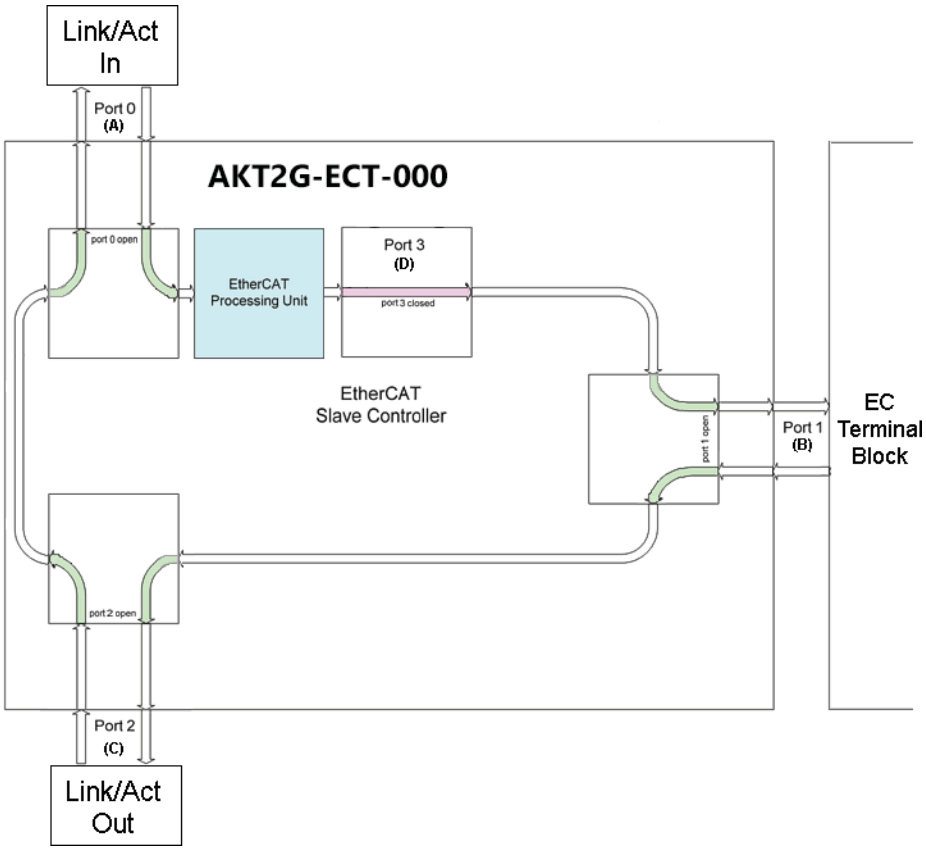


Figure 3-23: Internal and external port assignment for Bus Coupler AKT2G-ECT-000

Frame processing sequence

1. The EtherCAT frame arriving at the EtherCAT signal input is passed on by Port 0 (A) to the EtherCAT processing unit.

2. The EtherCAT frame arrives at Port 1 (B) and the data frame departs via Port 1 (B) to the following slave in the EtherCAT terminal network (if a slave is connected there and reports 'Link').
3. After the arrival of the data frame at Port 1 (B) from the terminal network, this is passed on to Port 2 (C) and leaves the coupler at the following EtherCAT output (if a slave is connected there and reports 'Link').
4. The data frame arrives at Port 2 (C). This is now forwarded to port 0 (A) and leaves the ECT-000 via the EtherCAT input.

TIP

Processing of the data

The data in the EtherCAT datagrams are processed only between Ports 0 (A) and 3 (D) in the EtherCAT processing unit. The non-implemented (internal) Port 3 (D) is considered to be closed and passes on the datagram to Port 1 (B).

5.11.4 Power Supply, Potential Groups

5.11.4.1 Bus Coupler power supply

The Bus Coupler requires a 24 VDC supply for its operation. The connection is made by means of the upper spring-loaded terminals labeled 24 V and 0 V. The supply voltage is used by the Bus Coupler electronics and for direct voltage generation for the E-bus. The voltage generation for the E-bus takes place in a DC/DC converter without electrical isolation.

The ECT-000 units supply the E-bus with max. 2,000 mA E-bus current. Power feed terminals are to be inserted if the added terminals require more current.

5.11.4.2 Input for power contacts

The bottom six connections with spring-loaded terminals can be used to feed the supply for the peripherals. The spring-loaded terminals are joined in pairs to a power contact. The feed for the power contacts has no connection to the voltage supply for the Bus Coupler. The design of the feed permits voltages of up to 24 V. The assignment in pairs and the electrical connection between feed terminal contacts allows the connection wires to be looped through to various terminal points. The current load via the power contacts may not permanently exceed 10 A; the supply line must therefore be protected by a 10 A fuse (slow-blow).

5.11.4.3 Power contacts

On the right hand face of the Bus Coupler there are three spring contacts for the power contact connections. The spring contacts are hidden in slots so that they can not be accidentally touched. By attaching a Bus Terminal the blade contacts on the left hand side of the Bus Terminal are connected to the spring contacts. The tongue and groove guides on the top and bottom of the Bus Coupler and of the Bus Terminals guarantees that the power contacts mate securely.

The current load of the power contacts may not permanently exceed 10 A.

5.11.4.4 Electrical isolation

The bus couplers operate by means of three independent potential groups. The supply voltage feeds the E- bus electronics in the bus coupler and the E-bus itself, which are electrically isolated. The supply voltage is also used to generate the operating voltage for the fieldbus.

NOTE

All the Bus Terminals are electrically isolated from the E-bus. The E-bus is thus electrically isolated from everything else.

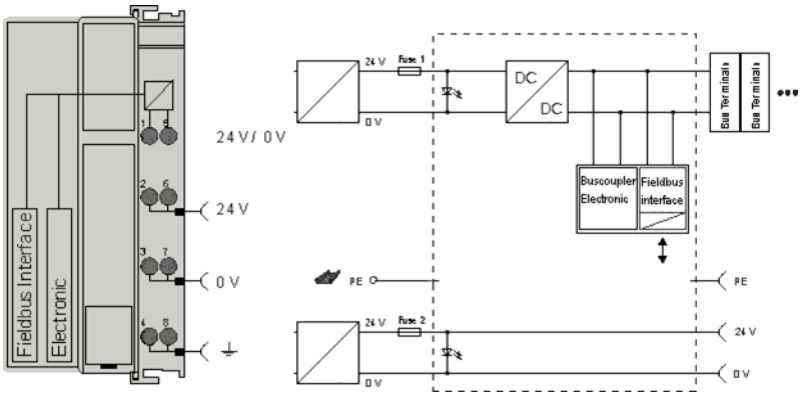


Figure 3-24: Potential diagram ECT-000

5.11.4.5 GND concept

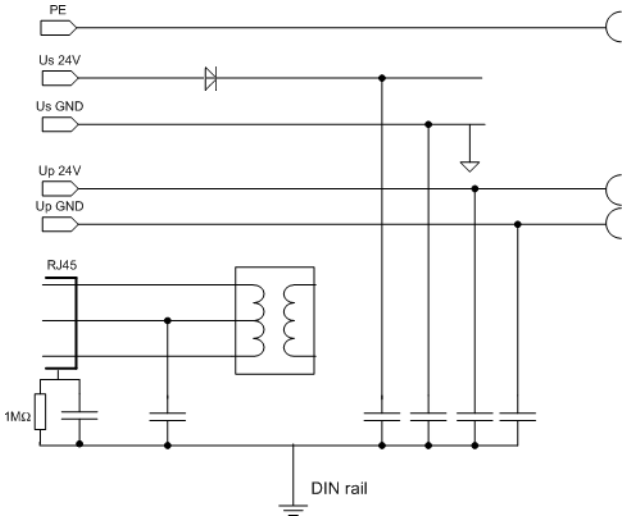


Figure 3-25: GND concept ECT-000

5.11.4.6 Fuse protection

Coupler supply, fuse 1	Depending on the required current consumption and hence the configured terminals typical max. 1 A
Power contacts, fuse 2	Permitted max. 10 A (slow-blow)

The coupler electronics and the power contacts can be supplied together from the same source. In this case the fuse should be dimensioned for 10 A max.

5.11.5 ECT-000 Diagnostic LEDs

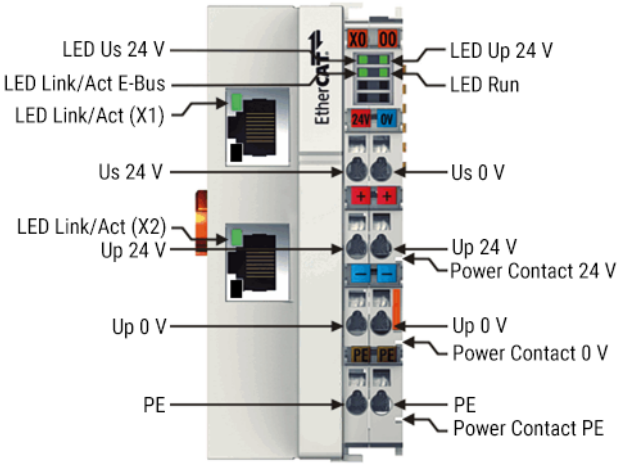


Figure 3-26: Diagnostic LEDs EK1100, EK1100-0008

5.11.5.1 LEDs for Power Supply Diagnostics

LED		Display	State	Description
Us	green	off	-	No operating voltage present at the Bus Coupler
		on	-	24 VDC operating voltage present at the Bus Coupler
Up	green	off	-	No power supply present at the power contacts
		on	-	24 VDC power supply present at the power contacts

5.11.5.2 Diagnostic LEDs for the EtherCAT State Machine/PLC

LED		Display	State	Description
RUN	green	off	Init	The Bus Coupler is in initialization state
		flashing	Pre-Operational	The Bus Coupler is in pre-operational state
		single flash	Safe-Operational	The Bus Coupler is in safe-operational state
		on	Operational	The Bus Coupler is in operational state
		flickers	Bootstrap	Firmware is being loaded.

5.11.5.3 LEDs for Fieldbus Diagnosis

LED		Display	State	Description
LINK/ACT (X1 IN)	green	off	-	No connection on the incoming EtherCAT strand
		on	linked	Preceding EtherCAT device connected
		flashing	active	Communication with preceding EtherCAT device
LINK/ACT (X2 OUT)	green	off	-	No connection on the outgoing EtherCAT strand
		on	linked	Following EtherCAT device connected
		flashing	active	Communication with following EtherCAT device

LED		Display	State	Description
LINK / ACT E-bus	green	off	-	No connection to internal E-bus
		on	linked	Connection to internal E-bus
		flashing	active	Connection/communication internal E-bus

5.11.6 Technical Data

Characteristic	AKT2G-ECT-000-000
Protection class	IP20
Higher level network technology	100 MBit FastEthernet (100BASE-TX)
Higher level network - max. connection length	100 m
Higher level network connection technology	RJ45
higher-level network protocol	EtherCAT Device Protocol
supports HotConnect with address setting on the device	yes, Fast-Hot-Connect

Technical Data	AKT2G-ECT-000-000
Task in the EtherCAT system	Coupling of EtherCAT Terminals (ECT-xxx) to 100BASE-TX EtherCAT networks
Number of EtherCAT Terminals	up to 65535 in the overall system
Number of peripheral signals	max. 4.2 GB addressable IO points
Data transfer medium	Ethernet 100BASE-TX (at least Ethernet CAT5 cable)
Cable length between 2 Bus Couplers	max. 100 m (100BASE-TX)
Protocol / Baud rate	EtherCAT Device Protocol / 100 MBaud
HotConnect	no
Delay	1 µs typ.
Bus connection	2 x RJ45
Power supply	24 VDC (-15%/+20%)
Current consumption	70 mA + (∑ E-bus current/4)
E-bus power supply (5 V)	max. 2 A (-25 °C ... +55 °C)
	max. 1 A (> +55 °C)
Power contacts	max. 24 VDC, max. 10 A
Electrical isolation	500 V (power contact/supply voltage/EtherCAT)
Dimensions (W x H x D)	approx. 44 mm x 100 mm x 68 mm
Weight	approx. 105 g
Permissible ambient temperature range during operation	-25°C ... +60°C (extended temperature range)
Permissible ambient temperature range during storage	-40°C ... + 85°C
Permissible relative air humidity	95%, no condensation
Mounting	on 35 mm mounting rail according to EN 60715

Technical Data	AKT2G-ECT-000-000
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also Installation instructions] for enhanced mechanical load capacity
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, ATEX, cULus, IECEx

5.12 AKT2G-EM-000-000

EtherCAT Bus End Cover for E-bus terminals, power, and E-bus contacts

Bus end cover for E-bus terminals, cover for power and E-bus contacts. This item has no electrical signals, it simply provides a barrier to the side bus connections.

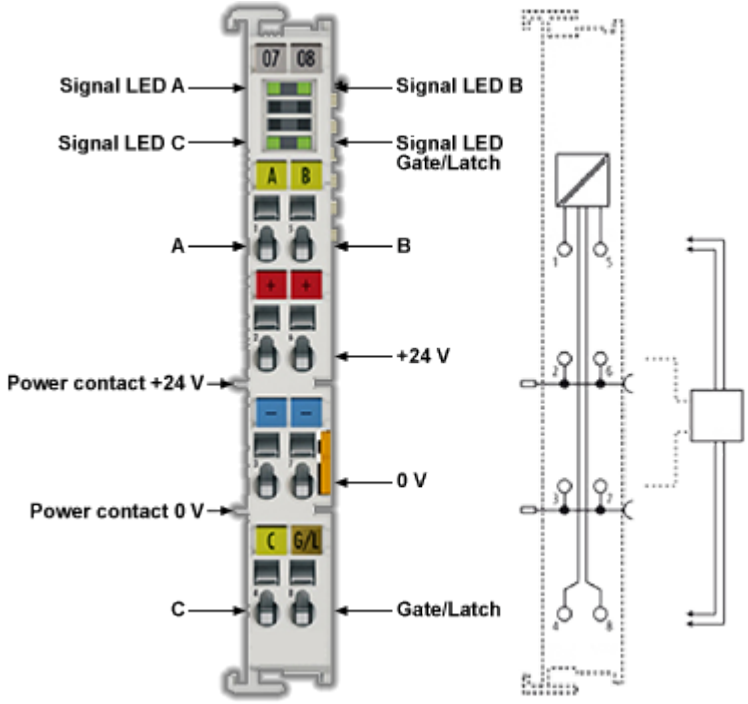
Each EtherCAT terminal block must be terminated at the right hand end with a AKT2G-EM-000-000 bus end cap due to mechanical and electrical protection.

Technical Data	AKT2G-EM-000-000
Electrical isolation	-
Bit width in the process image	0
Configuration	no address or configuration settings
Diagnosis	-
PE contact	no
Renewed infeed	-
Connection facility to additional power contact	-
Side by side mounting on Bus Terminals with power contact	yes
Side by side mounting on Bus Terminals without power contact	yes
Electrical connection to mounting rail	no
Weight	approx. 8 g
Permissible ambient temperature	-25°C ... +60°C (extended temperature range)

Technical Data	AKT2G-EM-000-000
Permissible ambient temperature range (during storage)	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 8 mm x 100 mm x 34 mm (width aligned: 5 mm)
Mounting	aligned to the last terminal in the terminal block
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC resistance burst/ESD	conforms to EN 61000-6-2/EN 61000-6-4
Protection class	IP 20
Installation position	variable
Approval	CE, ATEX, cULus

5.13 AKT2G-ENC-180-000

1-channel incremental encoder interface, 32 bit



5.13.1 Incremental Encoder Interface AKT2G-ENC-180

The AKT2G-ENC-180 EtherCAT Terminal is an interface with 24 V inputs for the direct connection of incremental encoders. A 32 bit counter with a quadrature decoder and a 32 bit latch for the zero pulse can be read, set or enabled.

The measurement of period and frequency is possible. The gate input allows the locking of the counter, selectively with a high or low level. The latch input is similarly configurable and evaluates high or low levels.

The AKT2G-ENC-180 supports distributed clocks, i.e. the input data can be synchronously acquired with other data that are similarly connected, distributed to distributed clock terminals. The universal system accuracy is around < 100 ns.

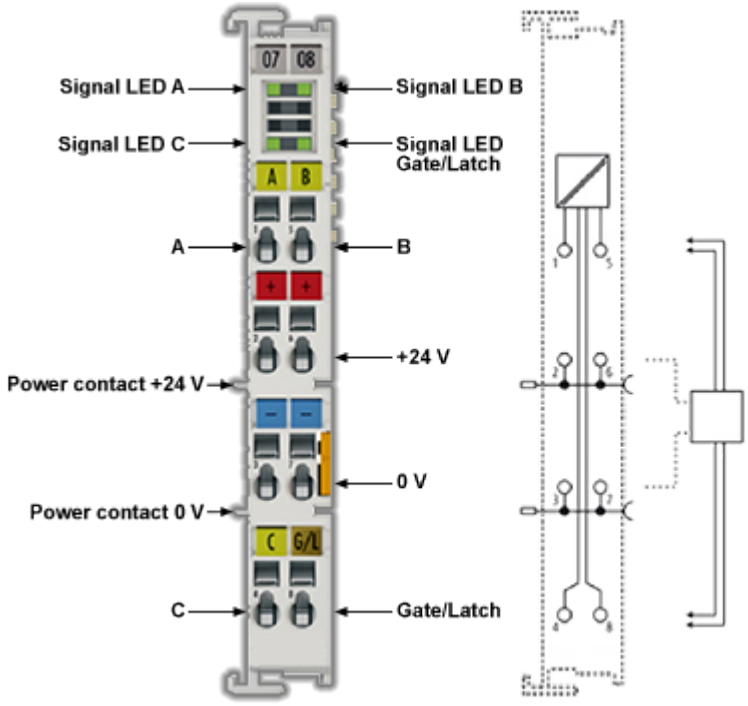
With a moving axis, the micro-increment functionality offers 256 times higher axis position resolution than physically provided by the encoder.

The AKT2G-ENC-180 can also be used as a single-channel 32/16 bit counter on channel A, in which case the signal level on channel B defines the count direction.

5.13.2 AKT2G-ENC-180 Technical Data

Technical Data	AKT2G-ENC-180-000
Sensor inputs	1
Encoder connection	A, B, C, gate/latch input, 24 V
Encoder operating voltage	24 V
Signal voltage "0" (inputs A, B, C, gate/latch)	0 V .. 5 V (EN 61131-2, type 1)
Signal voltage "1" (inputs A, B, C, gate/latch)	15 V .. 30 V (EN 61131-2, type 1)
Counter	1 x 32/16-bit binary, switchable
Limit frequency	max. 400,000 increments/s with 4-fold evaluation), corresponds to 100 kHz
Quadrature decoder	4-fold evaluation
Timestamp resolution	1 ns
Timestamp accuracy	100 ns
Commands	Read, set, latch, gate function
Power supply for electronic	via the E-Bus
Distributed Clocks	yes
Supply voltage	24 V_{DC} (-15 %/+20 %)
Current consumption from the E-bus	typ. 130 mA
Current consumption from the power contacts	0.1 A (excluding sensor load current)
Electrical isolation	500 V (E-bus/field voltage)
Supports NoCoeStorage function	yes
Weight	approx. 50 g
Permissible ambient temperature range during operation	-25 °C ... +60 °C (extended temperature range)
Permissible ambient temperature range during storage	-40 °C ... +85 °C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	according to EN 60068-2-6/EN 60068-2-27, see also Installation instructions for terminals with increased mechanical load capacity
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, ATEX, cULus

5.13.3 AKT2G-ENC-180-000 LEDs and Pin Assignment



AKT2G-ENC-180-000 LEDs

LED	Color	Meaning
A, B, C	green	flashes when pulses are present at the inputs
Gate, Latch	green	lights up when a signal is present at the gate/latch input

AKT2G-ENC-180-000 Pin Assignment

Terminal Point	No.	Comment
A	1	Encoder input A
+24 V	2	+24 V (internally connected to terminal point 6 and positive power contact)
0 V	3	0 V (internally connected to terminal point 7 and negative power contact)
C	4	Encoder input C
C	5	Encoder input B
+24 V	6	+24 V (internally connected to terminal point 2 and positive power contact)
0 V	7	0 V (internally connected to terminal point 3 and negative power contact)
Gate / Latch 24 V	8	Gate / Latch input

5.13.4 Commissioning AKT2G-ENC-180-000

5.13.4.1 Basic function principles

The terminal acquires the 90° phase-shifted digital output signal of an incremental encoder on channels A and B. The zero pulse is acquired on channel C. These signals are converted into a position value with quadruple evaluation with the aid of the quadrature encoder and the 32-bit counter. The latch and reset functions enable the exact referencing and saving of the counter value, irrespective of the speed.

Incremental encoders divide a 360° rotation of the encoder axis into individual steps (increments) and mark a full revolution by means of a special mark (zero pulse).

The phase angle between the signals on channels A and B sets the counting direction.

Up: signal on channel A leads signal on channel B by 90°

Down: signal on channel A lags signal on channel B by 90°

In case of single evaluation, the positive edges on channel A are counted.

In case of quadruple evaluation, the positive and negative edges on channel A and channel B are counted.

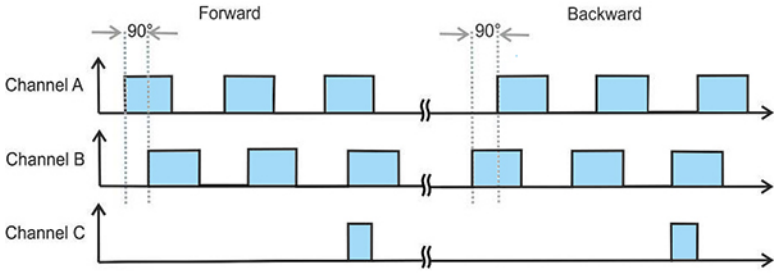


Figure 3-27: Quadrature decoder

Whereas absolute value encoders deliver an absolute and unambiguous position value over the complete travel path directly after switching on, it is necessary with incremental encoders to perform a reference run homing after switching on in order to be able to determine an unambiguous position.

Referencing can be carried out, for example, with the aid of reference cams or using the zero pulse of the encoder.

5.13.4.2 Operating modes and settings

5.13.4.2.1 General

The AKT2G-ENC-180 incremental encoder interface terminal enables connection of incremental encoders with the Bus Coupler or the PLC. A 32-bit counter with quadrature decoder as well as a 32-bit latch can be read, set or activated (switchable to 16-bit). In addition to the encoder inputs A, B and C, a gate/latch input (24 V) is also available on the AKT2G-ENC-180 for latching/saving the counter value. The gate/latch input is parameterizable via the CoE directory. no function, or disabling the counter at HIGH or LOW signal level.

The AKT2G-ENC-180 can also be used as a single-channel 32/16 bit counter on channel A, in which case the signal level on channel B defines the count direction. The changeover to this mode takes place via the CoE directory.

The Counter Value input value represents a 32-bit “position counter”. At the period input the period between two positive edges of channel A is measured with a resolution of 100 ns (default setting, decimal value x 100 ns). Depending on the setting (index 0x8000:14, index 0x8000:16), the period length may be up to 1.6 s or 3.2 s.

5.13.4.2.2 Operating modes

Permissible operating modes for the AKT2G-ENC-180

The following modes are available for the AKT2G-ENC-180. They apply both for the encoder analysis and counter terminal mode.

The combinations of DC, PDO and CoE settings listed below are permissible per mode. Other settings can lead to irregular process data and error messages in the Safety PLC System Manager Logger window.

Mode	DC	Pain PDO	Optional PDO 1	Optional PDO 2	Features CoE
1	FreeRun	Predefined PDO Assignment: Standard 32-bit (MDP 511): 0x1A00 + 0x1600 + 0x1A02			CoE combinations 0x8000:nn
		0x1A00 Inputs: 16 Bit Status, 32 Bit Counter Value, 32 Bit Latch Value + 0x1600 Outputs: 16 Bit Control, 32 Bit Set Counter Value	0x1A02 32 Bit Period or 0x1A03 32 Bit Frequency	--	
2	FreeRun	Predefined PDO Assignment: Standard 16-bit (MDP 511): 0x1A01 + 0x1601 + 0x1A02			CoE combinations 0x8000:nn
		0x1A01 Inputs: 16 Bit Status, 16 Bit Counter Value, 16 Bit Latch Value + 0x1601 Outputs: 16 Bit Control 16 Bit Set Counter Value	0x1A02 32 Bit Period or 0x1A03 32 Bit Frequency	--	
3	DC/DCi	Predefined PDO Assignment: Standard 32 Bit with 64 Bit Timestamp (MDP 511): 0x1A00 + 0x1600 + 0x1A02 + 0x1A04			CoE combinations 0x8000:nn
		0x1A00 Inputs: 16 Bit Status, 32 Bit Counter Value, 32 Bit Latch Value + 0x1600 Outputs: 16 Bit Control, 32 Bit Set Counter Value	0x1A02 32 Bit Period or 0x1A03 32 Bit Frequency	0x1A04 64 Bit Timestamp or 0x1A05 32 Bit Timestamp (compact)	

<table>
<tr><th>Mode</th><th>DC</th><th>Pain PDO</th><th>Optional PDO 1</th><th>Optional PDO 2</th><th>Features CoE</th></tr>
<tr><td rowspan="2">4</td><td rowspan="2">DC/DCi</td><td colspan="3">Predefined PDO Assignment:
Standard 16 Bit with 32 Bit Timestamp (MDP 511):
0x1A01 + 0x1601 + 0x1A02 + 0x1A05</td><td rowspan="2">CoE combinations
0x8000:nn</td></tr>
<tr><td>0x1A01 Inputs:
16 Bit Status,
16 Bit Counter Value,
16 Bit Latch Value
+
0x1601 Outputs:
16 Bit Control,
16 Bit Set Counter Value</td><td>0x1A02
32 Bit Period
or
0x1A03
32 Bit Frequency</td><td>0x1A04
64 Bit Timestamp
or
0x1A05
32 Bit Timestamp (compact)</td></tr>
</table>

5.13.4.2.3 Explanatory notes for parameters and modes

5.13.4.2.3.1 Frequency

- The timeframe for the frequency calculation as well as the resolution can be parameterized in the CoE objects Frequency window (index: 0x80n0:11), Frequency scaling (index: 0x80n0:13), Frequency resolution (index: 0x80n0:15) and Frequency wait time (index: 0x80n0:17). • The positive edges of track A are counted in the specified timeframe (see Frequency modes) and the next subsequent edge including the time until it arrives is counted. The waiting time for the edge can be set in the CoE object Frequency Wait Time (index: 0x80n0:17) (unit: ms) and is set as standard to 1.6 seconds. This is also the maximum value.
- The frequency is always specified as a positive number, irrespective of the sense of rotation.
- The size of the timeframe is 10 ms (default), but at the least the basic unit Frequency window base (index: 0x80n0:0F).
- This calculation is carried out in the terminal in free-running mode without reference to the distributed clocks system. It is therefore independent of the DC mode.
- AKT2G-ENC-180: No frequency measurement is possible if the counter is blocked by the gate. In this case the period can be measured regardless.
- AKT2G-ENC-180: A C or external reset restarts the frequency measurement. The last frequency value remains unchanged until a new frequency value is determined.
- The object Frequency window base (index: 0x80n0:0F) is used for switching the basic unit for the Frequency window between 1 µs and 1 ms, in order to adjust the time window for the measurement. The following maximum measuring windows are therefore possible:

Basic unit	Max. timeframe
1 µs	65.5 ms
1 ms	65 s

- on expiry of the measuring window Frequency window (index: 0x80n0:11), the subsequent positive edge on track A is awaited, but at the longest for 1.6 s or the time from Frequency wait time (index: 0x80n0:17).
- The frequency is measured with different accuracies depending on the selected basic unit Frequency window base (index 0x80n0:0F) and the window size.

5.13.4.2.3.2 Frequency mode A

The measurement is automatically performed in frequency mode A if the window size is smaller than or equal to 600 ms.

- Basic unit 1 µs: all window sizes
- Basic unit 1 ms: up to 600 ms window size

5.13.4.2.3.3 Measurement sequence

- The measurement starts with a positive edge at track A. The current counter value and time (resolution: 100 ns) are stored.
- On expiry of the measuring window Frequency window (index: 0x80n0:11), the subsequent rising edge on track A is awaited, but at the longest for 1.6 s or the time from Frequency wait time (index: 0x80n0:17).
- The frequency is calculated from the edge difference and the actual elapsed time.

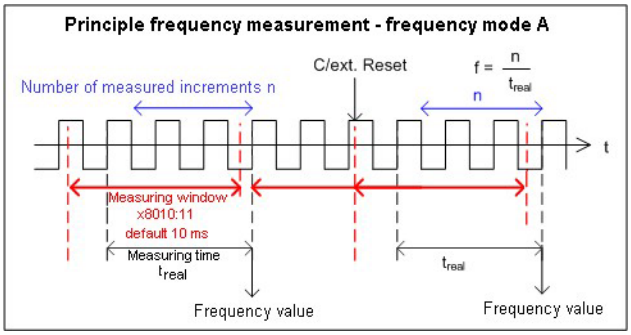


Figure 3-28: Frequency measurement principle - frequency mode A

5.13.4.2.3.4 Frequency mode B

The measurement is automatically performed in frequency mode B if the window size is greater than 600 ms.

- Basic unit 1 ms: from 601 ms window size

Measurement sequence

- At the start of the measurement the time and the current position are stored with a resolution of 100 ns, irrespective of the current signal position.
- After the measurement the current position is stored irrespective of the current signal position.
- The frequency is calculated from the number of increments and the actual elapsed time.
- The frequency measurement therefore takes place with reduced accuracy.
- The larger the measuring window in relation to the basic unit, the more precise the frequency calculation.

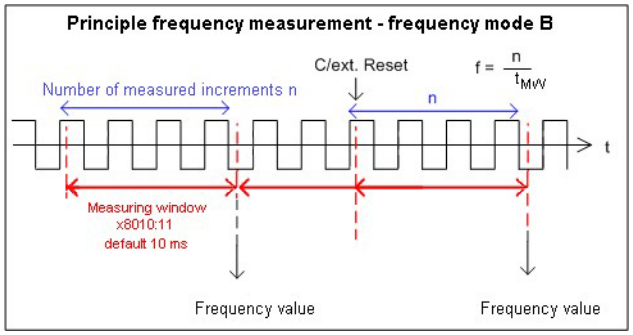


Figure 3-29: Frequency measurement principle - frequency mode B

5.13.4.2.3.5 Period calculation

- This calculation is carried out free-running in the slave without reference to the distributed clocks system. It is therefore independent of the DC mode.
- During each cycle the interval between two positive edges of input A is counted.
- Depending on the setting, periods of up to 1.6 s or 3.2 s in length are measurable.
- If no edge change occurs for approx. 1.6 s, any period specification is cancelled.

5.13.4.2.3.6 Gate function

The counter can be latched with the aid of the gate function. The Gate polarity object (index: 0x8000:04) provides three different options:

0: The gate function is inactive.

1: The counter value is latched by a HIGH level at the gate input. The counter value does not change as long as the HIGH level is applied. Signals on channels A and B have no effect on the counter value.

2: The counter value is locked by a LOW level at the gate input. The counter value does not change as long as the LOW level is applied. Signals on channels A and B have no effect on the counter value.

In the case of a simultaneous activation of the gate function (latch on HIGH level / latch on LOW level) and Enable extern reset (reset on positive edge / reset on negative edge), the counter value is first reset to zero. Latching subsequently takes place.

5.13.4.2.3.7 Latch

Activating the latch C input (“C”) and latching the counter value

- The counter value is saved in Latch value (index: 0x6000:12) upon the first latch pulse (positive edge on input “C”) after setting the bit (TRUE) in Enable latch C (index: 0x7000:01) (takes priority over Enable latch extern on positive / negative edge index: 0x7000:02 / 0x7000:04). If the bit is set, the subsequent pulses on the other inputs have no effect on the latch value in Latch value (index: 0x6000:12).
- After re-activation of Enable latch C (index: 0x7000:01), the next counter value at the latch input can be written only if the value of the Latch C valid bit (index 0x6000:01 FALSE) has been reset.

Activation of the external latch input and saving (“latching”) of the counter value (index 0x7000:02, 0x7000:04)

- The counter value at the latch input Latch value (index 0x6000:12) will be saved upon the first external latch pulse with a positive edge if the bit (TRUE) is set in Enable extern latch on positive edge (index: 0x7000: 02). The subsequent pulses have no influence on the latch value in Latch value (index: 0x6000:12).
- The counter value at the latch input Latch value (index: 0x6000:12) will be saved upon the first external latch pulse with a negative edge if the bit (TRUE) is set in Enable extern latch on negative edge (index: 0x7000: 04). The subsequent pulses have no influence on the latch value in Latch value (index: 0x6000:12).
- After re-activation, a new counter value on the latch input can be written only if the value of the Latch extern valid bit (index: 0x6000:02) has been reset.

5.13.4.2.3.8 Reset

The counter can be reset via Enable C reset (index: 0x8000:01) or via Enable extern reset (index: 0x8000:02). Extern reset polarity (index: 0x8000:10) defines whether the reset takes place on a positive or negative edge at the external latch input.

“Enable C reset” (index: 0x8000:01)

- For activation the bit in Enable C reset (index: 0x8000:01) is set to TRUE.

  The counter value is reset to zero if the zero pulse is present on channel C.

“Enable extern reset” (index: 0x8000:02),

- For activation the bit in Enable extern reset (index: 0x8000:02) is set to TRUE.
- “Extern reset polarity” (index: 0x8000:10)
  - Bit not set: the counter is set to zero with a negative edge at the external latch input.
  - Bit set: the counter is set to zero with a positive edge at the external latch input.

  The simultaneous activation of the functions Enable C reset (index: 0x8000:01) und Enable extern reset (index: 0x8000:02) is not possible.

5.13.4.2.3.9 Up/down counter

- The operating mode (encoder or up/down counter) is selected via the CoE object Enable up/down counter (index: 0x80n0:03).

  On the CoE - Online tab, click on the row of the index to be parameterized, enter the corresponding value in the SetValue dialog and confirm with OK.

  - 0: the up/down counter is not active.
  - 1: the up/down counter is active. • In the case of the AKT2G-ENC-180 the counter value can be locked via the object Gate polarity (index:

  0x8000:04) (s. Gate function).

- The counting direction (up/down) is specified via the signal level at channel B. • An additional option for reversing the direction of rotation is to set the Reversion of rotation bit (index: 0x80n0:0E).
- Connection:

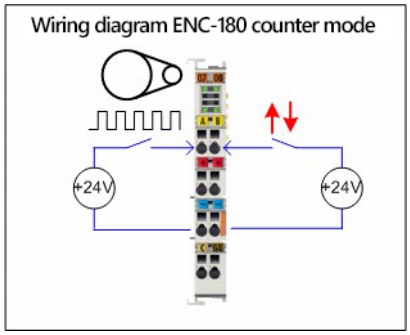


Figure 3-30: Counter connection principle

5.13.4.2.3.10 Micro-increments

- Works with and without distributed clocks, but in the AKT2G-ENC-180 this is only meaningful in conjunction with one of the DC modes
- By setting the counter value only the integer component can be modified.
- The principle:

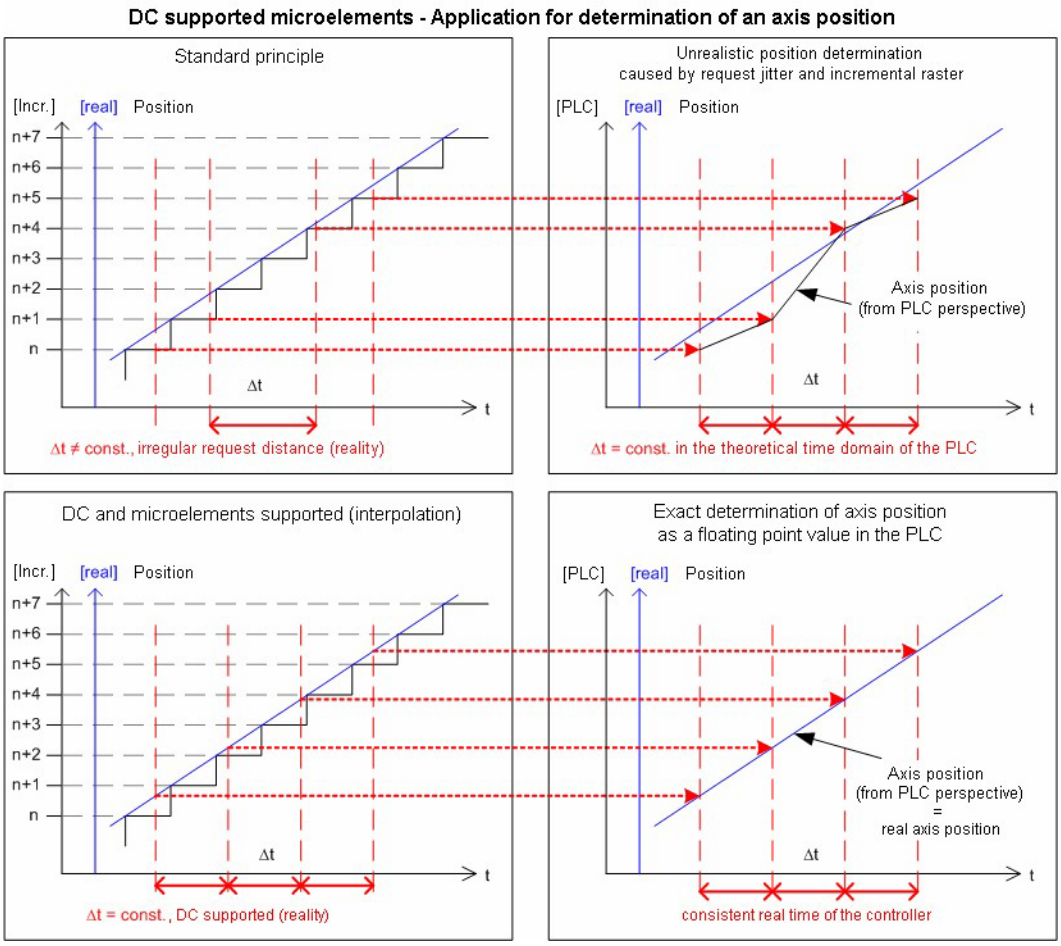


Figure 3-31: Principle of frequency measurement

The highly constant query cycles (accuracy: 100 ns) of the distributed clocks system permits the AKT2G-ENC-180 to interpolate interpolated axis positions between the counted encoder increments above a certain speed. The interpolation resolution is 8 bit, corresponding to 256 values. A standard encoder with 1,024 bars with 4-way evaluation and micro-increments thus becomes a high-resolution axis encoder with 4096 * 256 = 1,048,567 bars.

If the speed falls below the minimum speed, this is displayed by the object Extrapolation stall (index: 0x60n0:08) in the process data.

5.13.4.2.3.11 Digital filter

The AKT2G-ENC-180 has a digital filter on encoder channels A and B that can be switched off (object Disable Filter, index: 0x80n0:08). This acts as a diffuse low-pass filter at about 100 KHz (equals 400,000 increments/second with 4-fold evaluation), i.e. the permissible limit frequency.

In each application it is advisable to check whether it would be advantageous to deactivate the filter - the detection of fast axis movements may be improved as a result.

5.14 AKT2G-ENC-190-000

Incremental encoder interface with differential input, 16/32 bit

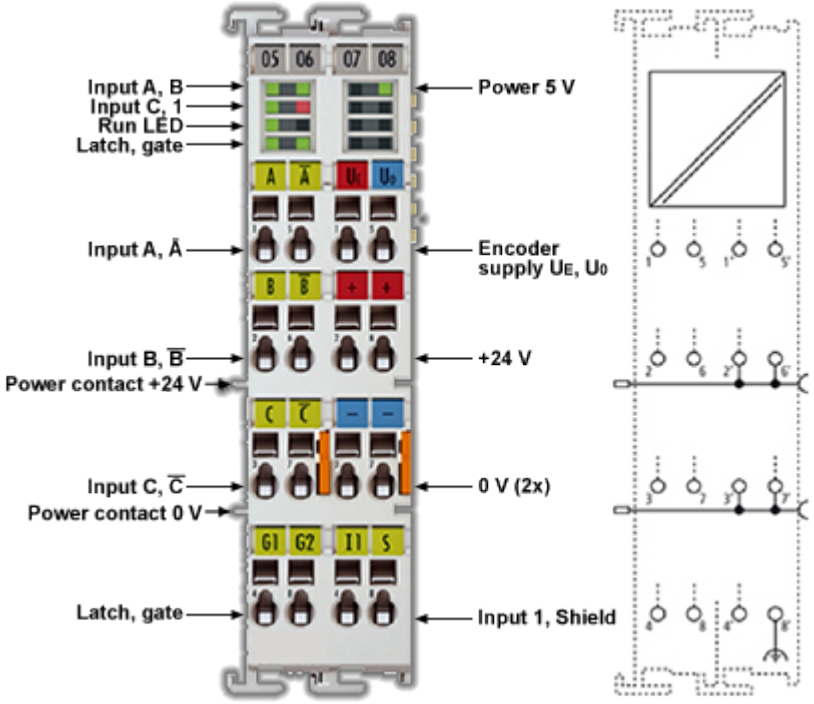


Figure 3-32: AKT2G-ENC-190-000

The AKT2G-ENC-190-000 EtherCAT Terminal is an interface for direct connection of incremental encoders with differential inputs (RS422). A 16-bit counter (in normal operating mode) or a switchable 16/32-bit counter (in enhanced operating mode) with a quadrature decoder and a 16-bit latch (in normal operating mode) or 32-bit latch (in enhanced operating mode) for the zero pulse can be read, set or enabled. Incremental encoders with alarm output can be connected at the negative switching status input of the interface. The measurement of period and frequency is possible. The gate input allows the locking of the counter, alternatively with a high or low level. The latch input is similarly configurable and evaluates high or low levels. The AKT2G-ENC-190-000 can also be used as bidirectional counter on channel A; channel B specifies the count direction.

5.14.1 Technology

The AKT2G-ENC-190-000 incremental encoder interface terminal enables connection of incremental encoders with

A/B/C track to the Bus Coupler and the PLC. A 16-bit counter (in normal operating mode) or a switchable 16/32-bit counter (in enhanced operating mode) with a quadrature decoder and a 16-bit latch (in normal operating mode) or 32-bit latch (in enhanced operating mode) can be read, set or enabled. Differential signals based on RS422 are provided as encoder connection. From hardware 09 single-ended 5 V signals are possible for the AKT2G-ENC-190-000 based on pull-up resistors.

In addition to the encoder inputs A, B and C, an additional latch input G1 (24 V) and a gate input G2 (24 V) for locking the counter during operation are available.

The terminal is supplied as a 4-fold quadrature decoder with complementary analysis of the sensor signals A, B, C. If the incremental encoder has an alarm output it can be connected to the INPUT 1 status input of the AKT2G-ENC-190-000. The AKT2G-ENC-190-000 can optionally be operated as a bidirectional counter terminal on channel A.

5.14.1.1 AKT2G-ENC-190-000 input impedance

The signal source must be able to operate the input impedance of the AKT2G-ENC-190-000 (typically 220 Ω, subject to modification) with adequate voltage levels according to RS422.

5.14.1.2 Gate/latch input

For gate and latch inputs (24 V) a max. input frequency of 1 MHz is permitted. Subject to modification.

5.14.1.3 Level on interface

In differential mode the AKT2G-ENC-190-000 expects the signal levels after RS422. The data are transferred without ground reference as voltage difference between two cables (signal A and inverted signal /A). The terminal analyses signal levels in the range -200 mV < Vid < +200 mV as valid signals. The differential signal must be in the common mode range (<+13.2 V and >-10 V, with respect to GND) (cf. diagram). Signal levels outside this range can lead to destruction.

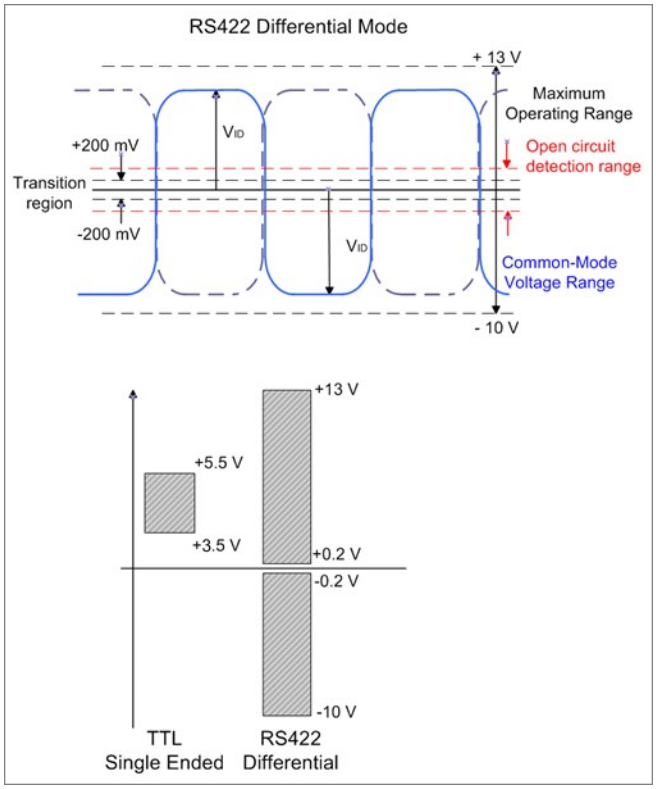


Figure 3-33: Level interface

In differential mode only the voltage difference is evaluated, so that common-mode interference on the transmission link does not lead to corruption of the wanted signal, since any interference affects both cables simultaneously.

If the AKT2G-ENC-190-000 is only operated in single-ended mode, a nominal level voltage between 3.5 V and 5.5 V is expected.

5.14.2 Technical Data

Technical Data	AKT2G-ENC-190-000
Sensor connection	A, ¬A, B, ¬B, C, ¬C (RS422 differential inputs) also single-ended connection (5 V ±20%) possible
Additional inputs	gate, latch (24 VDC, both max. 1 MHz permitted), status input (max. 5 VDC, potential-free, switching to negative potential)
Encoder operating voltage / Encoder supply	5 VDC (generated from the 24 V DC power contacts)
Sensor output current	0.5 A
Counter	16 bit, 16/32 bit switchable
Zero pulse latch	16 bit, 16/32 bit switchable
Limit frequency	1 MHz (equals 4 million increments with 4-fold evaluation)
Quadrature decoder	4-fold evaluation
Distributed Clocks	in enhanced operating mode
Broken wire detection to sensor	in enhanced operating mode
Commands	read, set, enable
Cycle time	min. 100 µs
Current consumption via Ebus	typ. 130 mA
Current consumption from the power contacts	0.1 A (excluding sensor load current)
Electrical isolation	500 V (E-bus/field voltage)
Bit width in process image	up to 6 bytes outputs, 22 bytes inputs, depends on parametrization
MTBF (+55°C)	-
Weight	approx. 100 g
Permissible ambient temperature range during operation	-25°C ... +60°C (extended temperature range)
Permissible ambient temperature range during storage	-40°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 27 mm x 10 mm x 70 mm (width aligned: 24 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also installation instructions for enhanced mechanical load capacity
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE ATEX cULus

5.14.3 AKT2G-ENC-190-000 LEDs and Connection

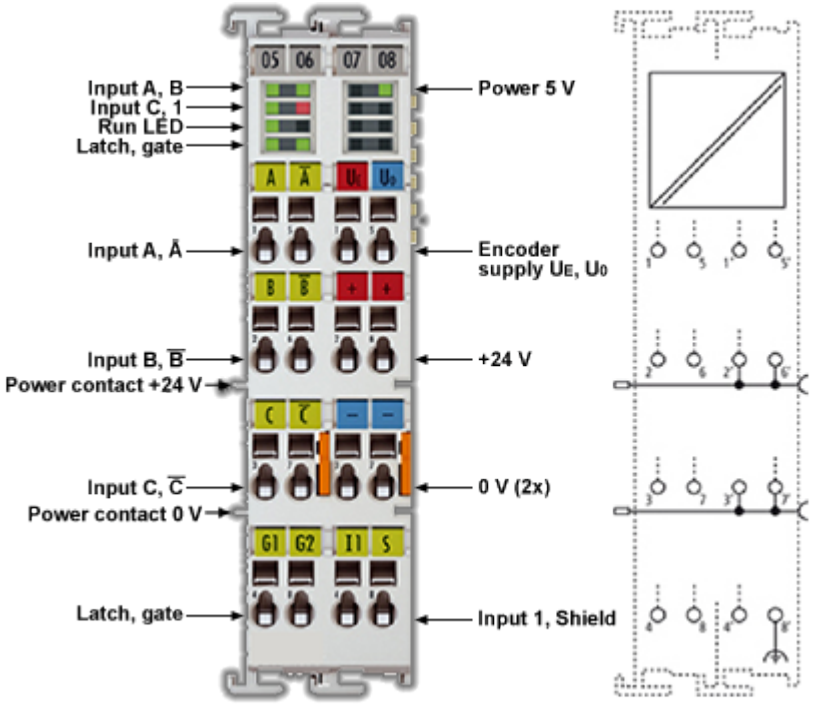


Figure 3-34: AKT2G-ENC-190-000

5.14.3.1 Connection

NOTE

Encoder supply via the terminal

The encoder supply voltage (5 V), can be taken from the terminal point 1'.

Terminal Point	No.	Comment
A	1	Encoder input A
B	2	Encoder input B
C	3	Encoder input C
Latch 24 V	4	Latch input
¬A	5	Encoder input A
¬B	6	Encoder input B
¬C	7	Encoder input C
Gate 24 V	8	Gate input
Ue = +5 V	1'	+5 V encoder supply
+24 V	2'	+24 V (internally connected to terminal point 6' and positive power contact)
0 V	3'	0 V (internally connected to terminal point 7' and negative power contact)
Input 1	4'	Status input 1 Alarm input from rotary encoder. Internally connected to 5 V via pull-up. Switching to negative potential, i.e. connection to GND leads to error bit and LED display. If externally supplied (not recommended) 5 V max. against GND is permitted.

Terminal Point	No.	Comment
Uo = 0 V	5'	0 V encoder supply
+24 V	6'	+24 V (internally connected to terminal point 2' and positive power contact)
0 V	7'	0 V (internally connected to terminal point 3' and negative power contact)
Shield	8'	Screen

5.14.3.2 LEDs

LED	Color	Meaning
LED	Color	Meaning
INPUT A, B, C	green	indicates TRUE level
INPUT 1	red	is lit, if INPUT 1 is connected to GND [INPUT 1 is connected to an internal 5 V HIGH level though internal pull-up (default)]
LATCH	green	is lit, if a signal (+24 V) is connected to the latch input
GATE	green	is lit, if a signal (+24 V) is connected to the gate input
RUN	green	This LED indicates the terminal's operating state: off: State of the EtherCAT State Machine: INIT = initialization of the terminal or BOOTSTRAP = function for firmware updates of the terminal flashing: State of the EtherCAT State Machine: PREOP = function for mailbox communication and different standard-settings set single flash: State of the EtherCAT State Machine: SAFEOP = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state on: State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible
POWER 5 V	green	Operating voltage display for incremental encoder power supply

5.14.4 Commissioning AKT2G-ENC-190-000

5.14.4.1 Normal Operation Mode

5.14.4.1.1 Process data and modes - Normal Operation Mode

In AKT2G-ENC-190-000 “normal operation mode” the following modes are available:

Mode	Distributed Clock	Main PDO	Comment	Optional PDO 1	Comment	Features CoE	Comment
1	Operational	0x1A00 + 0x1600	16 bit Value/Latch Byte-Alignment	0x1A02	Frequency: 32 bit Period: 16 bit Window: 16 bit CoE object 0x8001:02	0x8000:01 + 0x8001:02	Register reload + Reload Value
2	Operational	"	"	"	"	0x8000:02	Index Reset
3	Operational	"	"	"	"	0x8000:03, :04, :05	FWD Cnt + pos/ neg Gate
4	Operational	0x1A01 + 0x1601	16 bit Value/Latch Word Alignment	0x1A02	Frequency: 32 bit Period: 16 bit Window: 16 bit CoE object 0x8001:02	0x8000:01 + 0x8001:02	Register reload + Reload Value
5	Operational	"	"	"	"	0x8000:02	Index Reset
6	Operational	"	"	"	"	0x8000:03, :04, :05	FWD Cnt + pos/ neg Gate

NOTE

Frequency

- The timeframe for the frequency calculation is set to 10 ms (see Fig. “Process data” tab); in addition a variably configurable measuring window is available (parameterization via object 0x8001:01, output frequency value in object 0x6000:06).
- Only the increment edges in the specified time window are counted.
- If no edge change occurs for approx. 1.6 s, any frequency specification is cancelled.
- This calculation is carried out in the slave without reference to the distributed clocks system. It is therefore independent of the DC mode.
- No frequency measurement is possible if the counter is blocked by the gate. In this case the period can be measured regardless.
- If an encoder signal is only present at input A/A and the frequency/period is to be measured, the terminal must be set to “Enable FWD count” in CoE 0x8000:03.
- A C or external reset restarts the frequency measurement. The last frequency value remains unchanged until a new frequency value is determined.

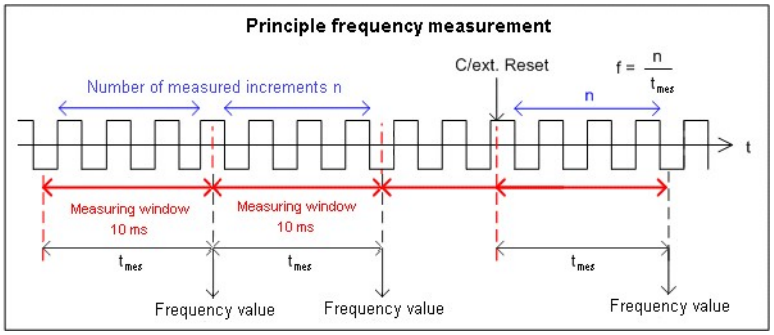


Figure 3-35: Frequency measurement principle in normal operation mode

Period calculation

- This calculation is carried out in the slave without reference to the distributed clocks system. It is therefore independent of the DC mode.
- In each cycle the interval between 2 positive edges of input A is counted with a resolution of 100 ns.
- If no edge change occurs for approx. 1.6 s, any period specification is canceled.
- **NOTE**

  Frequency and period measurement

  From the explanatory notes above it is apparent that the frequency measurement can measure the current axis status (velocity) significantly more accurately than the period measurement. Frequency measurement is therefore preferable, if possible.

Register Reload

- If Register Reload is enabled in CoE object 0x8000:01, the counter value is set to zero in the event of overflow over the value in CoE object 0x8001:02 and to the value in CoE object 0x8001:02 in the event of underflow below 0.

Index Reset

- If Index Reset is enabled in CoE object 0x8000:02, input C resets the counter to 0.

  NOTE

  "Register Reload" and "Index Reset"

  "Register Reload" and "Index Reset" cannot be operated simultaneously.

FWD Cnt

- If FwdCnt is activated in CoE object 0x8000:03, the AKT2G-ENC-190-000 operates as counter on channel A. Channel B indicates the counting direction: B=TRUE forward, B=FALSE backward. The counter can be locked via the gate input (24 V).
  - CoE object 0x8000:04 (TRUE): Locking of the counter at the gate input with positive edge (0 V -> + 24 V).
  - CoE object 0x8000:05 (TRUE): Locking of the counter at the gate input with negative edge (+ 24 V -> + 0 V).

5.14.4.1.2 Object Description and Parameterization - Normal Operation Mode

5.14.4.1.2.1 Restore object

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore the default settings	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to “0x64616F6C” in the set value dialog, all backup objects are reset to their delivery state. Note: Some FW versions also accept the following input: "0x6C6F6164".	UINT32	RW	0x00000000 (0_{dec})

5.14.4.1.2.2 Configuration data

Index 8000 Non-Volatile Settings 0

Index (hex)	Name	Meaning	Data type	Flags	Default
8000:0	Non-Volatile Settings 0	Maximum subindex	UINT8	RO	0x05 (5_{dec})
8000:01	Enable register reload	The counter counts up to the “Counter reload value”, or the “Counter reload value” (0x8001:02) is loaded in the event of an underflow Example 360° encoder with set bit: Moves in positive direction via Counter reload value: Reset counter value to 0. Moves in negative direction less than 0: Reset counter value to Counter reload value	BOOLEAN	RW	0x00 (0_{dec})
8000:02	Enable index reset	Activates input “C” for resetting the counter. Example 360° encoder with set bit: Moves in positive direction (signal at input “C”): Reset counter value to 0 Moves in negative direction (signal at input “C”): underflow with FFFF, FFFE etc.)	BOOLEAN	RW	0x00 (0_{dec})
8000:03	Enable FWD count	FALSE The terminal operates in quadrature decoder mode TRUE The terminal operates as counter, count direction to input B	BOOLEAN	RW	0x00 (0_{dec})
8000:04	Enable pos. gate	Gate input responds to positive edge and locks the counter	BOOLEAN	RW	0x01 (1_{dec})
8000:05	Enable neg. gate	Gate input responds to negative edge and locks the counter	BOOLEAN	RW	0x00 (0_{dec})

Index 8001 Non-Volatile Settings 1

Index (hex)	Name	Meaning	Data type	Flags	Default
8001:0	Non-Volatile Settings 1	Maximum subindex	UINT8	RO	0x02 (2_{dec})
8001:01	Frequency window	The value specifies the size of the time window for the “Window” variable. resolution: 16µs; e.g. default value: 16 µs x 100_{dec} = 1.6 ms	UINT16	RW	0x0064 (100_{dec})
8001:02	Counter reload value	If “Enable register reload” = TRUE, the counter counts up to this value and is loaded with this value in the event of an underflow	UINT16	RW	0xFFFF (65535 $_{dec}$)

5.14.4.1.2.3 Input data

Index 6000 Inputs

Index (hex)	Name	Meaning	Data type	Flags	Default
6000:0	Inputs	Length of this object	UINT8	RO	0x06 (6_{dec})
6000:01	Status	Status byte	UINT8	RO	0x00 (0_{dec})
6000:02	Value	meter reading	UINT16	RO	0x0000 (0_{dec})
6000:03	Latch	Latch value	UINT16	RO	0x0000 (0_{dec})
6000:04	Frequency	Frequency value (resolution: 0.01 Hz / digit) [fixed 10 ms measuring window]	UINT32	RO	0x00000000 (0_{dec})
6000:05	Period	Period (resolution 500 ns / digit)	UINT16	RO	0x0000 (0_{dec})
6000:06	Window	Measured value of the variable timeframe (“Frequency window” (0x8001:01)	UINT16	RO	0x0000 (0_{dec})

5.14.4.1.2.4 Output data

Index 7000 Outputs

Index (hex)	Name	Meaning	Data type	Flags	Default
7000:0	Outputs	Length of this object	UINT8	RO	0x02 (2_{dec})
7000:01	Ctrl	Control byte	UINT8	RO	0x00 (0_{dec})
7000:02	Value	The counter value to be set via CNT_SET (CB.02).	UINT16	RO	0x0000 (0_{dec})

5.14.4.1.3 Control and status byte

5.14.4.1.4 Control byte

The control byte (CB) is located in the output process image, and is transmitted from the controller to the terminal.

Bit	CB.7	CB.6	CB.5	CB.4	CB.3	CB.2	CB.1	CB.0
Name	-	-	-	-	EN_LATCH_ EXTN	CNT_ SET	EN_LATCH_ EXTP	EN_ LATC

Control Byte Legend

Bit	Name	Description	
CB.3	EN_ LATCH_ EXTN	1_{bin}	With a valid EN_LATCH_EXTN bit the counter value is stored in latch input (index 0x6000:03) when the first external latch pulse with falling edge is encountered. Subsequent pulses have no influence on the latch value. Please note: A new counter value can only be written to the latch input when the Latch Valid bit (LAT_EXT_VAL) in the status byte has a low signal level.
CB.2	CNT_SET	rise	The counter is set with rising edge of CNT_SET to the value specified via the process data (index 0x7000:02).
CB.1	EN_ LATCH_ EXTP	1_{bin}	With a valid EN_LATCH_EXTP bit the counter value is stored in latch input (index 0x6000:03) when the first external latch pulse with rising edge is encountered. Subsequent pulses have no influence on the latch value. Please note: A new counter value can only be written to the latch input when the Latch Valid bit (LAT_EXT_VAL) in the status byte has a low signal level.
CB.0	EN_LATC	1_{bin}	The null point latch (C input) is activated. The counter value is saved when the first external latch pulse after a valid EN_LATC bit encountered (this has priority over EN_LAT_EXTN / EN_LAT_EXTP). If the bit is set subsequent pulses have no influence on the latch value. Please note: A new counter value can only be written to the latch input when the Latch Valid bit (LATC_VAL) in the status byte has a low signal level (the LATC_ VAL bit (SB.0) is only cleared by the terminal when the C pulse = LOW).

5.14.4.1.5 Status byte

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

Bit	SB.7	SB.6	SB.5	SB.4	SB.3	SB.2	SB.1	SB.0
Name	-	-	STATUS_ INPUT	OVERFLOW	UNDERFLOW	CNTSET_ ACC	LAT_ EXT_ VAL	LATC_ VAL

Status Byte Legend

Bit	Name	Description	
SB.5	STATUS_ INPUT	$0_{bin}/1_{bin}$	Indicates the status of INPUT 1
SB.4	OVERFLOW	1_{bin}	This bit is set if the 16-bit counter overflows (65535 to 0). It is reset when the counter exceeds one third of its measuring range (21845 to 21846) or immediately an underflow occurs.

Bit	Name	Description	
SB.3	UNDERFLOW	1_{bin}	This bit is set if the 16-bit counter underflows (0 to 65535). It is reset when the counter drops below two thirds of its measuring range (43690 to 43689) or immediately an overflow occurs.
SB.2	CNTSET_ACC	1_{bin}	The data for setting the counter (index 0x7000:02) is accepted from the terminal.
SB.1	LAT_EXT_VAL	1_{bin}	An external latch pulse has occurred. The data with index 0x6000:03 match the latched value when the bit is set. To reactivate the latch input EN_LAT_EXTN or EN_LATCH_EXTP (CB.3 or CB.1) has first to be cleared and then to be set once more.
SB.0	LATC_VAL	1_{bin}	A zero point latch has occurred. The data with index 0x6000:03 match the latched value when the bit is set. In order to reactivate the latch input, it is necessary for EN_LATC (CB.0) first be cleared and then to be set once more.

5.14.4.1.6 Single-Ended Connection for TTL Encoder

In addition to encoders with differential RS422 interface, single-ended encoders with TTL interface are also supported. Please note the following:

- Operating mode selection encoder "0x8000:03 Enable FWD count = FALSE".
- The differential inputs (/A, /B, /C) must remain open and must not be connected to ground

5.14.4.2 Enhanced Operation Mode

5.14.4.2.1 Process data and modes - Enhanced operation mode

In AKT2G-ENC-190-000 “enhanced operation mode” the following modes are available:

Mode	DC	Main PDO	Comment	Optional PDO 1	Comment	Optional PDO 2	Comment	Features CoE	Comment
7	FreeRun	0x1A04 + 0x1603	Count/Latch in 32 bit	0x1A05 or 0x1A06	Frequency (32 bit) or Period (32bit)	--		0x80n0:nn	CoE combinations 0x80n0:nn
8	"	0x1A03 + 0x1602	compact: Count/Latch in 16 bit	"	"	--		"	"
9	DC/DCi	0x1A04 + 0x1603	Count/Latch in 32 bit	"	"	0x1A07 or 0x1A08	Timestamp 64 bit Timestamp 32 bit (compact)	"	"
10	"	0x1A03 + 0x1602	compact: Count/Latch in 16 bit	"	"	"	"	"	"

5.14.4.2.1.1 Frequency

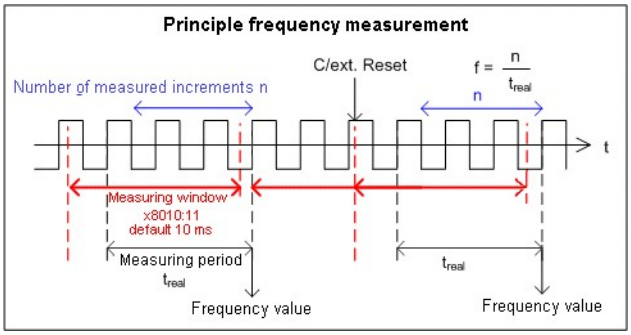
- The time window for the frequency calculation and the resolution can be parameterized in CoE objects 0x80n0:11, 0x80n0:13, 0x80n0:15, 0x80n0:17.
- The positive edges of track A are counted within the specified timeframe and the next edge including the time up to it are counted. The waiting time can be set in CoE object 0x80n0:17 “Frequency Wait Time” (unit: ms). The default value is 1.6 sec. This is also the maximum value.
- The time window is 10 ms (default), min. 1 µs. With the default setting it is possible to measure frequencies up to approx. 800 kHz. At higher frequencies a smaller value must be selected for the timeframe.
- The time is measured with a resolution of 100 ns.
- This calculation is carried out in the slave without reference to the distributed clocks system. It is therefore independent of the DC mode.
- No frequency measurement is possible if the counter is blocked by the gate. In this case the period can be measured regardless.
- If an encoder signal only is only present at input A/A and the frequency/period is to be measured, the terminal must be set to “Up/Down Counter” in CoE 0x8010:03.
- A C or external reset restarts the frequency measurement. The last frequency value remains unchanged until a new frequency value is determined.

5.14.4.2.1.2 Frequency measurement

- Basic unit 1 µs: all window sizes

5.14.4.2.1.3 Measurement sequence

- The measurement starts with a positive edge at track A. The current counter value and time (resolution: 100 ns) are stored.
- After the measuring window time has elapsed (index 0x80n0:11), the system waits for the following rising edge at track A or a maximum of 1.6 sec or the time from 0x80n0:17
- The frequency is calculated from the edge difference and the actual elapsed time.



5.14.4.2.1.4 Period calculation

- This calculation is carried out in the slave without reference to the distributed clocks system. It is therefore independent of the DC mode.
- In each cycle the interval between 2 positive edges of input A is counted with a resolution of 100 ns.
- If no edge change occurs for approx. 1.6 s, any period specification is cancelled.

NOTE

Frequency and period measurement

From the explanatory notes above it is apparent that the frequency measurement can measure the current axis status (velocity) significantly more accurately than the period measurement. Frequency measurement is therefore preferable, if possible.

5.14.4.2.1.5 Latch

Activation of latch C input (“C”) and saving (“latching”) of the counter value (index 0x70n0:01)

- The counter value is saved at the first external latch pulse (positive edge at input “C”) after the bit has been set (“TRUE”) in index 0x70n0:01 (has priority before 0x70n0:02 / 0x70n0:04). The subsequent pulses at the other inputs have no influence on the latch value in index 0x60n0:12 if the bit is set.
- Note for “Latch C valid” bit: A new counter value at the latch input can only be written once the value of the “Latch C valid” bit (index 0x60n0:01) is “FALSE”.

Activation of the external latch input (“gate/latch”) and latching of the counter value (index 0x70n0:02, 0x70n0:04)

- The counter value at the latch input (Index 0x70n0:02) will be saved upon the first external latch pulse with a rising edge if the bit (“TRUE”) is set in index 0x60n0:12. The subsequent pulses have no influence on the latch value in index 0x60n0:12.
- The counter value at the latch input (Index 0x60n0:12) will be saved upon the first external latch pulse with a falling edge if the bit (“TRUE”) is set in index 0x70n0:04. The subsequent pulses have no influence on the latch value in index 0x60n0:12.
- Note for "Latch extern valid" bit: A new counter value at the latch input can only be written once the value of the “Latch extern valid” bit (index 0x60n0:02) is “FALSE”.

5.14.4.2.1.6 Reset

- Counter reset (index 0x80n0:01, 0x80n0:02, 0x80n0:10): For a counter reset via input C set the bit in index 0x80n0:01, for a reset via the external latch input set the bit in index 0x80n0:02.
- The functions “Enable C reset” (0x80n0:01) and “Enable extern reset” (0x80n0:02) cannot be activated simultaneously.
- Note for “Extern reset polarity”, index 0x80n0:10: The edge for setting the counter to zero can be selected via index 0x80n0:10.

  Bit not set: counter is set to zero with falling edge.

  Bit set: counter is set to zero with rising edge.

5.14.4.2.1.7 Up/down counter

- The mode (encoder or up/down counter) is set via the CoE objects (profile-specific objects, tab CoE Online, index 0x80n0:03 “Enable up/down counter”). Click on the corresponding row of the index to be parameterized, enter 1 in the SetValue dialog and confirm with OK.
- Set the gate polarity accordingly via object 0x80n0:04.
- An additional option for reversing the rotation direction is available by setting the bit in index 0x80n0:0E.

5.14.4.2.1.8 Overflow/underflow

- Overflow/underflow control is inactive in combination with an activated reset function (C/external).
- The underflow bit (0x60n0:04) is set if an underflow ...00 → ...FF occurs. It is reset if 2/3 of the counter range are underrun.
- The overflow bit (0x60n0:05) is set if an overflow FF...→ 00... occurs. It is reset if 1/3 of the counter range is exceeded.

5.14.4.2.1.9 Open circuit detection

- A separate open circuit detection can be activated for each of the channels A, B and C (index 0x80n0:0B, 0x80n0:0C, 0x80n0:0D).
- Open circuit detection is activated for channels A and B by default.
- A differential voltage of typically -1.5 V >Vid > +1.5 V is detected as an open circuit.
- If an open circuit is detected, it is indicated as process data open circuit = TRUE. The bit in object 0x60n0:07 is set. An open circuit is indicated separately in indices 0xA0n0:01 (track A), 0xA0n0:02 (track B) and 0xA0n0:03 (track C).
- TxPDO state also becomes TRUE if an open circuit is detected, since invalid data have to be assumed.

NOTE

Open circuit detection vs. single-ended lines (TTL interface)

The open circuit detection does principally not work with single-ended lines (TTL interface).

5.14.4.2.1.10 Micro-increments

- Works with and without distributed clocks, but this is only meaningful in conjunction with one of the DC modes
- By setting the counter value only the integer component can be modified.
- The principle:

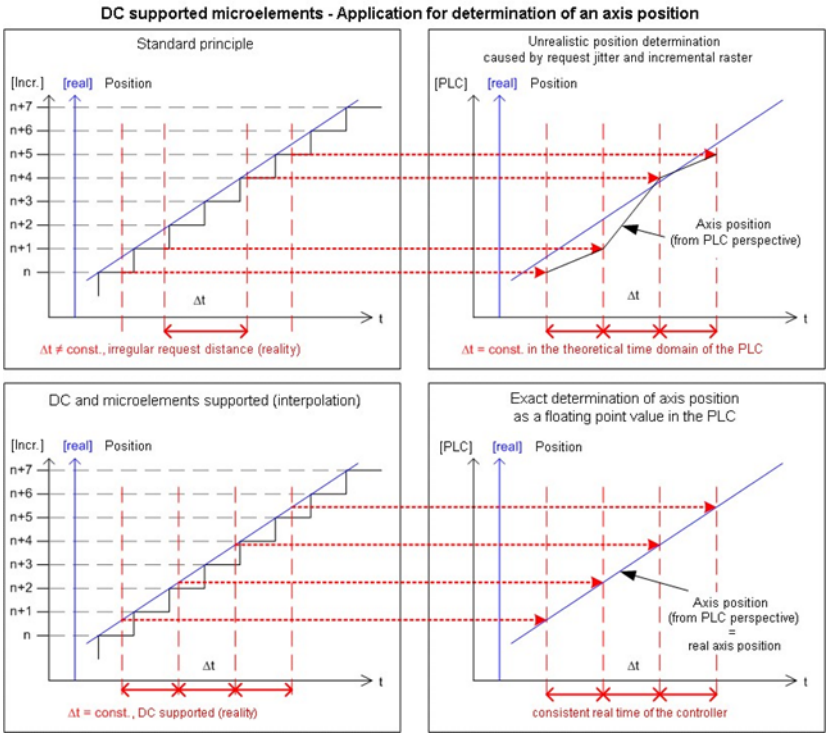


Figure 3-36: Frequency measurement principle in enhanced operation mode

The highly constant query cycles (accuracy: 100 ns) of the distributed clocks systems enable the AKT2G-ENC-190 to interpolate axis positions between the counted encoder increments from a certain speed. The interpolation resolution is 8 bit, corresponding to 256 values. A standard encoder with 1,024 bars with 4way evaluation and micro-increments thus becomes a high-resolution axis encoder with 4096 * 256 = 1,048,567 bars.

Underrunning of the minimum velocity is indicated by the object 0x60n0:08 (extrapolation stall) in the process data.

5.14.4.2.1.11 Configuration Data

Index 8010 ENC Settings

Index (hex)	Name	Meaning	Data type	Flags	Default
8010:0	ENC Settings	Maximum subindex	UINT8	RO	0x17 (32dec)
8010:01	Enable C reset	The counter is reset via the C input.	BOOLEAN	RW	0x00 (0dec)
8010:02	Enable extern reset	A counter reset is triggered via the external latch input (24 V)	BOOLEAN	RW	0x00 (0dec)
8010:03	Enable up/down counter	Enablement of the up/down counter in place of the encoder with the bit set. Increments are counted at input A. Input B specifies the counting direction.	BOOLEAN	RW	0x00 (0dec)
8010:04	Gate polarity	0: Disable gate 1: Enable pos. gate (gate locks with “HIGH” level) 2: Enable neg. gate (gate locks with “LOW” level)	BIT2	RW	0x01 (1dec)
8010:08	Disable filter	0: Activates the input filter (inputs A, /A, B, /B, C, /C only) 1: Deactivates the input filter If a filter is activated a signal edge must be present for at least 2.4 µs in order to be counted as an increment.	BOOLEAN	RW	0x01 (1dec)
8010:0A	Enable micro increments	If DC mode is activated, the AKT2G-ENC-190 interpolates micro-increments between the integer encoder increments. The lower 8 bits of the counter value are used in each case for the display. A 32-bit counter thus becomes a 24+8-bit counter, a 16-bit counter becomes an 8+8-bit counter.	BOOLEAN	RW	0x00 (0dec)
8010:0B	Open circuit detection A	An open circuit on track A is indicated in index 0x6010:07 and as process data. Diagnosis is only possible if the corresponding input is wired differentially. A differential voltage < 3.5 V (typical, subject to change) is detected as a broken wire.	BOOLEAN	RW	0x01 (1dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
8010:0C	Open circuit detection B	An open circuit on track B is indicated in index 0x6010:07 and as process data. Diagnosis is only possible if the corresponding input is wired differentially. A differential voltage < 3.5 V (typical, subject to change) is detected as a broken wire.	BOOLEAN	RW	0x01 (1dec)
8010:0D	Open circuit detection C	An open circuit on track C is indicated in index 0x6010:07 and as process data. Diagnosis is only possible if the corresponding input is wired differentially. A differential voltage < 3.5 V (typical, subject to change) is detected as a broken wire.	BOOLEAN	RW	0x00 (0dec)
8010:0E	Reversion of rotation	Activates reversion of rotation	BOOLEAN	RW	0x00 (0dec)
8010:10	Extern reset polarity	0: Fall (the counter is set to zero with a falling edge) 1: Rise (the counter is set to zero with a rising edge)	BIT1	RW	0x01 (1dec)
8010:11	Frequency window	This is the minimum time over which the frequency is determined. Default 10 ms [resolution: 1 µs] The number of pulses in the time window + the following is measured. The maximum waiting time is specified in the "Frequency Wait Time" parameter. The number of pulses is divided by the actual time window size. The determined frequency is output in index 0x6010:13 and as a process data. The frequency calculation is carried out locally without distributed clocks function.	UINT16	RW	0x2710 (10000dec)
8010:13	Frequency scaling	Scaling of the frequency measurement (must be divided by this value to obtain the unit in Hz): 100: “0.01 Hz”	UINT16	RW	0x0064 (100dec)
8010:14	Period scaling	Resolution of the period in the process data: 100: “100 ns” period value is a multiple of 100 ns 500: “500 ns” period value is a multiple of 500 ns	UINT16	RW	0x0064 (100dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
8010:15	Frequency resolution	Resolution of the frequency measurement: 100: “0.01 Hz”	UINT16	RW	0x0064 (100dec)
8010:16	Period resolution	Internal resolution of the period measurement: 100: “100 ns” period value is a multiple of 100 ns The period is calculated internally with a resolution of 100 ns. The max. measurable period can then be approx. 1.6 seconds. 500: “500 ns” period value is a multiple of 500 ns Internally the period is calculated with 500 ns resolution. The maximum measurable period is approx. 32.7 ms. The resolution of process data continues to be the value according to index 0x8010:14 (e.g. 100 ns [default]).	UINT16	RW	0x01F4 (500dec)
8010:17	Frequency Wait Time	Waiting time [ms] for frequency measurement Once the time specified in the frequency window has elapsed, the system waits for the next positive edge from track A. This enables the update speed for the Frequency process data to be optimized, depending on the expected frequencies. At least double the period of the minimum frequency to be measured should be entered here. t >= 2* (1 / fmin)	UINT16	RW	0x0640 (1600dec)

Index 6010 ENC Inputs

Index (hex)	Name	Meaning	Data type	Flags	Default
6010:0	ENC Inputs	Maximum subindex	UINT8	RO	0x16 (22dec)
6010:01	Latch C valid	The counter value was locked with the “C” input. The data with index 0x6010:12 match the latched value when the bit is set. To reactivate the latch input, index 0x7010:01 must be cancelled and then reset.	BOOLEAN	RO	0x00 (0dec)
6010:02	Latch extern valid	The counter value was locked via the external latch. The data with index 0x6010:12 match the latched value when the bit is set. To reactivate the latch input, index 0x7000:02 or object index 0x7000:04 must be cancelled and then reset.	BOOLEAN	RO	0x00 (0dec)
6010:03	Set counter done	The counter was set.	BOOLEAN	RO	0x00 (0dec)
6010:04	Counter underflow	Counter underflow. Overflow/underflow control is inactive in combination with a reset function (C/external).	BOOLEAN	RO	0x00 (0dec)
6010:05	Counter overflow	Counter overflow. Overflow/underflow control is inactive in combination with a reset function (C/external).	BOOLEAN	RO	0x00 (0dec)
6010:06	Status of input status	State of the status input (alarm “input 1”)	BOOLEAN	RO	0x00 (0dec)
6010:07	Open circuit	Indicates an open circuit. Configuration via index 0x8010:0A, 0x8010:0B, 0x8010:0C	BOOLEAN	RO	0x00 (0dec)
6010:08	Extrapolation stall	The extrapolated part of the counter is invalid	BOOLEAN	RO	0x00 (0dec)
6010:09	Status of input A	Status of input A	BOOLEAN	RO	0x00 (0dec)
6010:0A	Status of input B	Status of input B	BOOLEAN	RO	0x00 (0dec)
6010:0B	Status of input C	Status of input C	BOOLEAN	RO	0x00 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
6010:0C	Status of input gate	The state of the gate input	BOOLEAN	RO	0x00 (0dec)
6010:0D	Status of extern latch	Status of the extern latch input	BOOLEAN	RO	0x00 (0dec)
6010:0E	Sync Error	The Sync error bit is only required for DC mode. It indicates whether a synchronization error has occurred during the previous cycle. This means a SYNC signal was triggered in the AKT2G-ENC-190, although no new process data were available (0=OK, 1=NOK).	BOOLEAN	RO	0x00 (0dec)
6010:0F	TxPDO State	Validity of the data of the associated TxPDO (0 = valid, 1 = invalid).	BOOLEAN	RO	0x00 (0dec)
6010:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated.	BOOLEAN	RO	0x00 (0dec)
6010:11	Counter value	Counter value	UINT32	RO	0x00000000 (0dec)
6010:12	Latch value	Latch value	UINT32	RO	0x00000000 (0dec)
6010:13	Frequency value	The frequency (setting of the scaling and resolution in index 0x8010:13 and 0x8010:15)	UINT32	RO	0x00000000 (0dec)
6010:14	Period value	The period (setting of the scaling and resolution in index 0x8010:14 and 0x8010:16)	UINT32	RO	0x00000000 (0dec)
6010:16	Timestamp	Timestamp of the last counter change	UINT64	RO	

Index 7010 ENC Outputs

Index (hex)	Name	Meaning	Data type	Flags	Default
7010:0	ENC Outputs	Maximum subindex	UINT8	RO	0x11 (17dec)
7010:01	Enable latch C	Activate latching via input “C”.	BOOLEAN	RO	0x00 (0dec)
7010:02	Enable latch extern on positive edge	Activate external latch with positive edge.	BOOLEAN	RO	0x00 (0dec)
7010:03	Set counter	Set counter	BOOLEAN	RO	0x00 (0dec)

Index (hex)	Name	Meaning	Data type	Flags	Default
7010:04	Enable latch extern on negative edge	Activate external latch with negative edge.	BOOLEAN	RO	0x00 (0dec)
7010:11	Set counter value	The counter value to be set via “Set counter” (index 0x7010:03).	UINT32	RO	0x00000000 (0dec)

5.14.4.2.1.12 Information / Diagnostic Data (Channel Specific)

Index A010 ENC Diag data

Index (hex)	Name	Meaning	Data type	Flags	Default
A010:0	ENC Diag data	Maximum subindex	UINT8	RO	0x03 (3dec)
A010:01	Open circuit A	Open circuit on track A	BOOLEAN	RO	0x00 (0dec)
A010:02	Open circuit B	Open circuit on track B	BOOLEAN	RO	0x00 (0dec)
A010:03	Open circuit C	Open circuit on track C	BOOLEAN	RO	0x00 (0dec)

5.14.4.2.2 Single-ended connection for TTL encoder

In addition to encoders with differential RS422 interface, single-ended encoders with TTL interface are also supported. Please note the following:

- Operating mode selection encoder "0x80n0:03 Enable up/down counter = FALSE".
- The differential inputs (/A, /B, /C) must remain open and must not be connected to ground
- The option to reverse the direction of rotation is given by setting the bit in index 0x80n0:0E "reversion of rotation =TRUE".
- The open circuit detection does not work in principle conditionally with single-ended connection

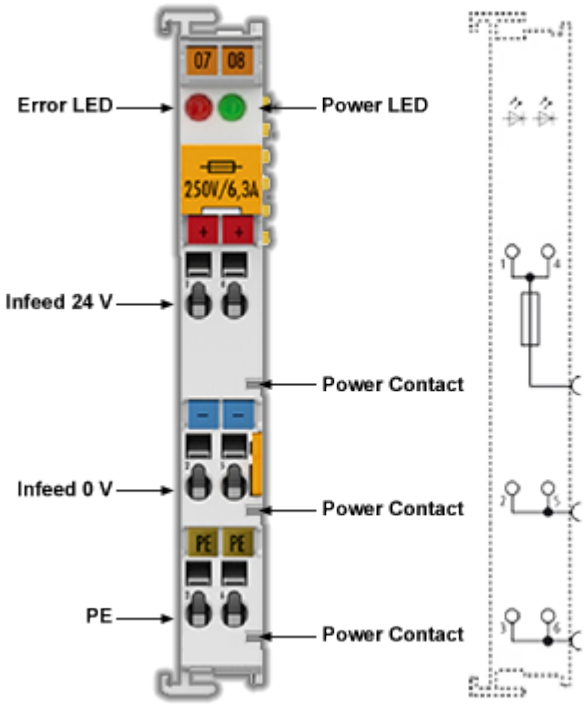
5.15 AKT2G-PSF-024-000

Power Supply Terminal with fuse, 24 V DC

The AKT2G-PSF-024 feed terminal can be positioned at any location between the input and output terminals for establishing a further potential group or for supplying the terminals following on the right in applications with high current load. The E-Bus is looped through.

See Also:

- Positioning of Passive Terminals



5.15.1 Connections

Terminal Point		Description
Indication	Number	
+24 V	1	Supply input + 24 V (connected internally with terminal 4 and positive power contact)
0 V	2	0 V for supply input (connected internally with terminal 5 and negative power contact)
PE	3	PE (connected internally with terminal 6 and PE power contact)
+24 V	4	Supply input + 24 V (connected internally with terminal 1 and positive power contact)
0 V	5	0 V for supply input (connected internally with terminal 2 and negative power contact)
PE	6	PE (connected internally with terminal 3 and PE power contact)

5.15.2 LEDs

LED	Color	Meaning	
Power LED	green	off	No input voltage at supply input
		on	24 VDC at supply input
Error LED	red	off	Fuse OK
		on	Fuse error

5.15.3 Technical Data

Technical Data	AKT2G-PSF-024-000
Nominal voltage	24 VDC
Power contact current load	max. 10 A
Electrical isolation	500 V (E-bus/field potential)
Integrated fine-wire fuse	yes; 6.3 A
Current consumption from E-Bus	-
Bit width in the process image	-
Configuration	no address or configuration settings
Power LED	yes
Diagnosis (fuse)	yes, Error LED
Electrical connection to mounting rail	no
PE contact	yes
Renewed infeed	yes
Connection facility to additional power contact	1
Side by side mounting on Bus Terminals with power contact	yes
Side by side mounting on Bus Terminals without power contact	yes
Weight	approx. 55 g
Permissible ambient temperature range (during operation)	0°C ... +55°C
Permissible ambient temperature range (during storage)	-25°C ... +85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting	on 35 mm mounting rail conforms to EN 60715
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC resistance burst/ESD	conforms to EN 61000-6-2/EN 61000-6-4
Protection class	IP 20
Installation position	variable, see Positioning of Passive Terminals
Approval	CE, ATEX, cULus

⚠CAUTION

Hazard to individuals and devices!

When designing a Bus Terminal block with different potentials on the power contacts (e.g. 230 V AC and 24 V DC), please note that it is mandatory to use potential separation terminals!
Bring the bus system into a safe, powered down state before starting installation, disassembly or wiring of the Bus Terminals!

5.16 AKT2G-SDI-004-000

5.16.1 Safety terminal with 4 digital fail-safe inputs

The AKT2G-SDI-004 is a digital input terminal with floating contacts for 24 V DC. The Bus Terminal has 4 fail-safe inputs.

With two-channel connection, the AKT2G-SDI-004 meets the requirements of IEC 61508:2010 SIL 3, DIN EN ISO 13849-1:2015 (Cat 4, PL e), UL508, UL1998 and UL991.

The safety terminal has the typical design of an EtherCAT terminal.

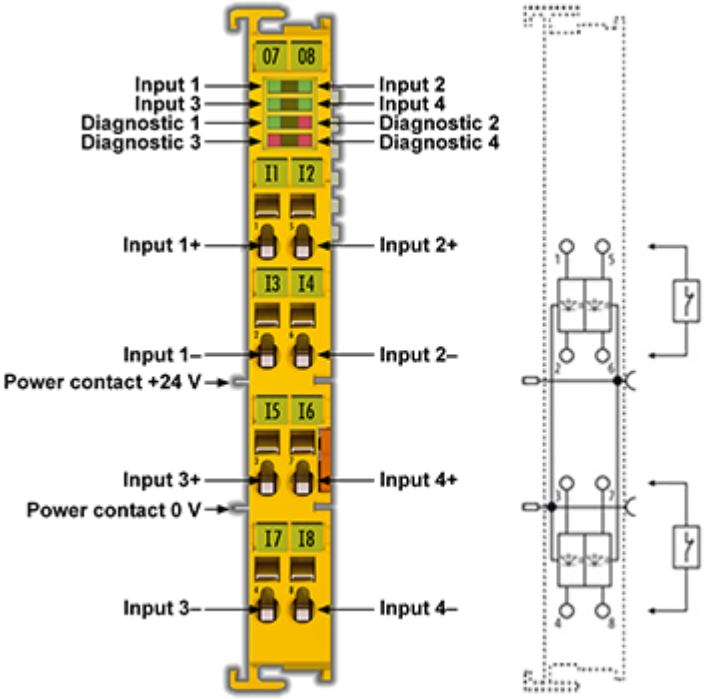


Figure 3-37: AKT2G-SDI-004 – safety terminal with 4 digital fail-safe inputs

TIP

Be sure to review

- Safety Instructions
- Safety Operation
- Safety Terminal Reaction Times
- Safety I/O Maintenance

5.16.2 Intended use

⚠WARNING

Caution - Risk of injury!

Safety components may only be used for the purposes described below!

The safety terminals expand the application range of the E-Bus terminal system with functions that enable them to be used for machine safety applications. The safety terminals are designed for machine safety functions and directly associated industrial automation tasks. They are therefore only approved for applications with a defined fail-safe state. This safe state is the wattless state. Fail-safety according to the relevant standards is required.

The safety terminals enable connection of:

- 24 VDC sensors (AKT2G-SDI-004) such as emergency off pushbutton switches, pull cord switches, position switches, two-hand switches, safety mats, light curtains, light barriers, laser scanner, etc.
- 24 VDC actuators (AKT2G-SDO-004) such as contactors, protection door switches with tumbler, signal lamps, servo drives, etc.

NOTE

Test pulses

When selecting actuators please ensure that the AKT2G-SDO-004 test pulses do not lead to actuator switching or diagnostic message from the AKT2G-SDO-004.

The following safety components have been developed for these tasks:

- The AKT2G-SDI-004 is an EtherCAT Terminal with 4 digital fail-safe inputs.
- The AKT2G-SDO-004 is an EtherCAT Terminal with 4 digital fail-safe outputs.

These safety components are suitable for operation on the

- Kollmorgen AKT2G-ECT-000-000 series Bus Couplers

⚠WARNING

Power supply from SELV/PELV power supply unit!

The safety components must be supplied with 24 VDC by an SELV/PELV power supply unit with an output voltage limit Umax of 36 VDC. Failure to observe this can result in a loss of safety.

⚠CAUTION

Follow the machinery directive!

The safety components may only be used in machines as defined in the machinery directive.

⚠CAUTION

Ensure traceability!

The buyer has to ensure the traceability of the device via the serial number.

5.16.3 Technical Data

Product designation	AKT2G-SDI-004
Number of inputs	4
Status display	4 (one green LED per input)
Reaction time (read input/write to E-bus)	typically: 4 ms, maximum: see error reaction time
Error reaction time	≤ watchdog time
Cable length between sensor and terminal	unshielded max. 100 m (0.75 or 1 mm²) shielded max. 100 m (0.75 or 1 mm²)
Output current of the clock outputs	typically 10 mA, max. 15 mA
Input process image	6 bytes
Output process image	6 bytes
AKT2G-SDI-004 supply voltage (PELV)	24 VDC (–15% / +20%)
Signal voltage "0" inputs	-3 V to 5 V (EN 61131-2, type 3) see section Characteristic curve of the inputs
Signal voltage "1" inputs	11 V to 30 V (EN 61131-2, type 3) see section Characteristic curve of the inputs
Current consumption of the modular electronics at 24 V (without current consumption of sensors)	4 channels occupied: typically 12 mA 0 channels occupied: typically 1.4 mA
Current consumption via E-bus	4 channels occupied: approx. 200 mA
Power dissipation of the terminal	typically 1 W
Electrical isolation (between the channels)	no
Electrical isolation (between the channels and the E-bus)	yes
Insulation voltage (between the channels and the E-bus, under common operating conditions)	insulation tested with 500 VDC
Dimensions (W x H x D)	12mm x 100mm x 68mm
Weight	approx. 50 g
Permissible ambient temperature (operation) up to SW 05	0 °C to +55 °C (see note in Installation position and minimum distances)
Permissible ambient temperature (operation) from SW 06 (week 02/2014)	-25°C to +55 °C (see note in Installation position and minimum distances)
Permissible ambient temperature (transport/storage)	-40°C to +70°C

Product designation	AKT2G-SDI-004
Permissible air humidity	5% to 95%, non-condensing
Permissible air pressure (operation/storage/transport)	750 hPa to 1100 hPa (this corresponds to a height of approx. -690 m to 2450 m over sea level assuming an international standard atmosphere)
Climate category according to EN 60721-3-3	3K3 (the deviation from 3K3 is possible only with optimal environmental conditions and also applies only to the technical data which are specified differently in this documentation)
Permissible level of contamination according to EN 60664-1	level of contamination 2 (comply with the section Safety I/O Maintenance
Impermissible operating conditions	Safety terminals must not be used under the following operating conditions: • under the influence of ionizing radiation (that exceeds the level of the natural environmental radiation) • in corrosive environments • in an environment that leads to unacceptable soiling of the Bus Terminal
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
Shocks	15 g with pulse duration 11 ms in all three axes
Protection class	IP20
Permitted operating environment	In the control cabinet or terminal box, with minimum protection class IP54 according to IEC 60529
Permissible installation position	see section Installation position and minimum distances
Approvals	CE, cULus

5.16.4 Safety Parameters

Key Figures	AKT2G-SDI-004
Lifetime [a]	20
Prooftest Interval [a]	not required [1]
PFHD	1.11E-09
%SIL3	1.11%
PFD	8.29E-05
%SIL3	8.29 %
MTTFd	high
DC	high
Performance level	PL e
Category	4
HFT	1
Element classification [2]	Type B

1. Special proof tests are not required during the entire service life of the AKT2G-SDI-004 EtherCAT terminal.
2. Classification according to IEC 61508-2:2010 (chapter 7.4.4.1.2 and 7.4.4.1.3)

The AKT2G-SDI-004 EtherCAT Terminal can be used for safety-related applications within the meaning of IEC 61508:2010 up to SIL3 and EN ISO 13849-1 up to PL e (Cat4).

For the calculation or estimation of the MTTFd value from the PFHD value, further information can be found in ISO 13849-1:2015 Table K.1.

5.16.5 Characteristic curve of the inputs

The characteristic curve of the inputs is similar to type 3 according to EN 61131-2.

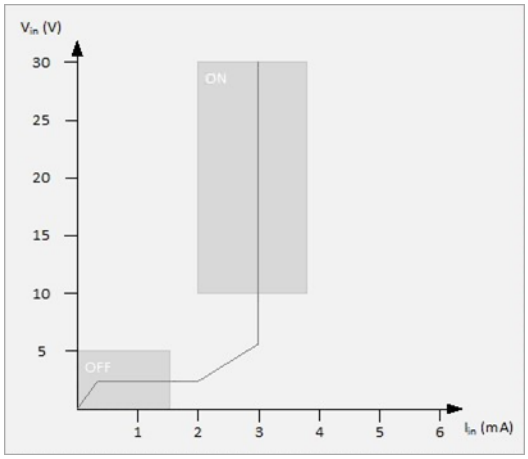
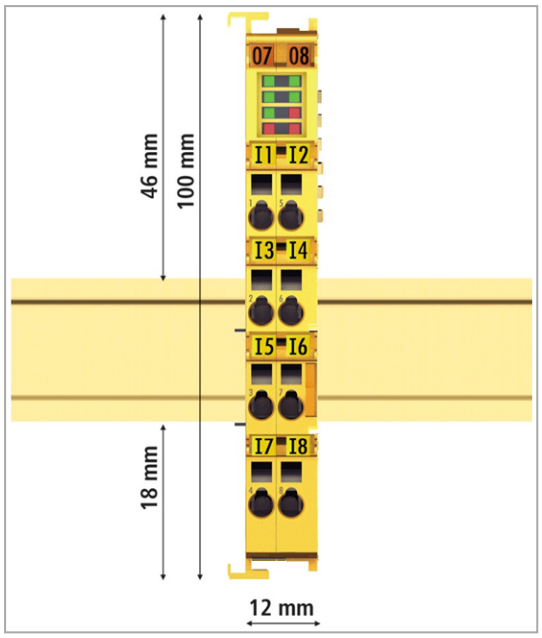


Figure 3-38: Characteristic curve of the inputs

5.16.6 Dimensions



Width	12 mm (side-by-side installation)
Height	100 mm
Depth	68 mm

Figure 3-39: Dimensions of the AKT2G-SDI-004.

5.16.7 Block Diagram of the AKT2G-SDI-004

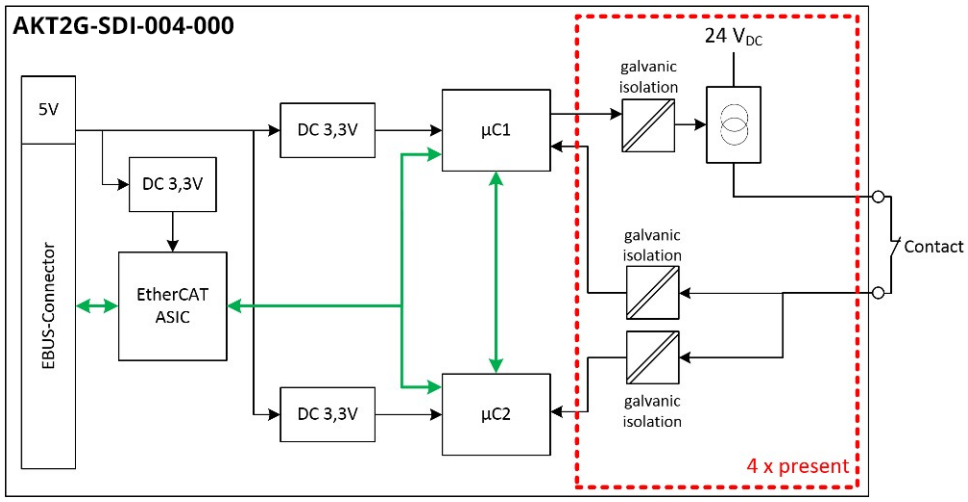


Figure 3-40: Block diagram of the AKT2G-SDI-004

The block diagram shows the basic configuration of a channel in the AKT2G-SDI-004. The part with a red border is present four times in the terminal.

5.16.8 AKT2G-SDI-004 Pin Assignment

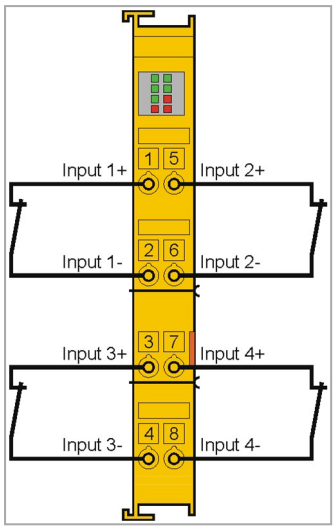


Figure 3-41: AKT2G-SDI-004 pin assignment

Terminal point	Input	Signal
1	1	Input 1+
2		Input 1-
3	3	Input 3+
4		Input 3-
5	2	Input 2+
6		Input 2-
7	4	Input 4+
8		Input 4-

NOTE

Configurable inputs

The inputs 1 to 4 can be occupied as you want with normally closed contacts or normally open contacts. The corresponding analysis is carried out in the safety PLC.

5.16.9 Signal Cables

5.16.9.1 Permitted cable length

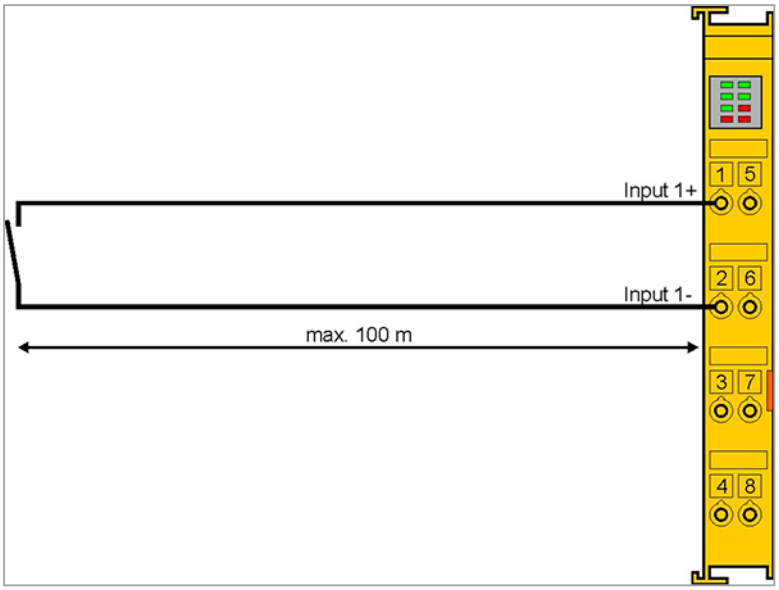


Figure 3-42: Permitted cable length

When connecting a single switching contact via its own continuous cabling (or via a non-metallic sheathed cable), the maximum permitted cable length is 100 m.

The use of contact points, connectors or additional switching contacts in the cabling reduces the maximum propagation.

5.16.9.2 Cable routing

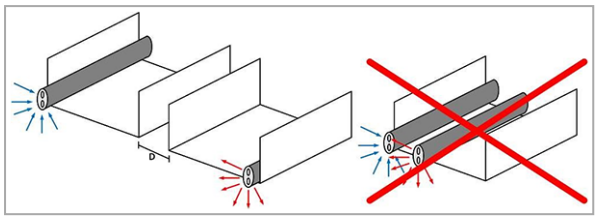


Figure 3-43: Cable routing

NOTICE

Route the signal cable separately

The signal cable must be routed separately from potential sources of interference, such as motor supply cables, 230 VAC power cables etc.!

Interference caused by cables routed in parallel can influence the signal form of the test pulses and thus cause diagnostic messages (e.g. sensor errors or OpenLoad errors).

- D: Distance between the cable ducts should be as large as possible
- blue arrows: signal line
- red arrows: potential source of interference

The common routing of signals together with other clocked signals in a common cable also reduces the maximum propagation, since crosstalk of the signals can occur over long cable lengths and cause diagnostic messages.

The test pulses can be switched off (sensor test parameter) if the connection of a common cable is unavoidable. However, this then leads to a reduction in the degree of diagnostic cover when calculating the performance level.

5.16.9.3 Test pulses

The typical length of a test pulse (switching from 24 V to 0 V and back to 24 V) is 350 µs and takes place approx. 250 times per second.

The test pulses at the outputs Input 1+ to Input 4+ are generated separately for each channel in order to be able to detect cross-circuits between the individual channels of a terminal and also between channels of different terminals. In order to generate test pulses as shown in the diagram, the sensor test active safety parameter must be set to true for the respective channels. The test cycle for all four channels is typically 4 ms. The times between the test pulses of different channels vary, thus allowing better diagnostic detection.

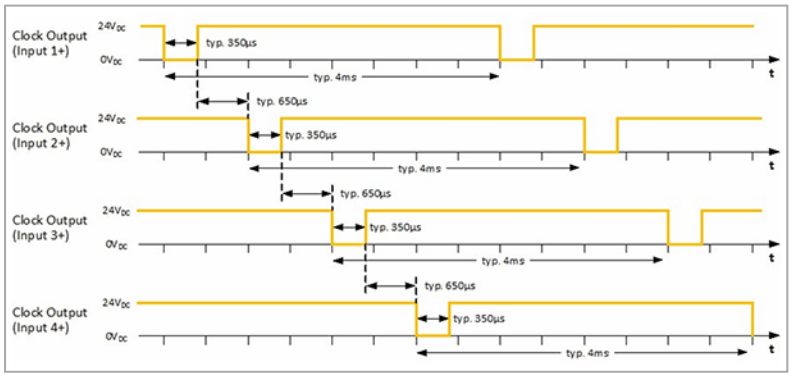


Figure 3-44: Typical course of test pulses of the inputs

If self-testing sensors are to be used on the safe inputs, please refer to chapter Configuration for light barriers, light grids, light curtains etc.

5.16.10 Address Settings on Safety Terminals with 65535 Possible Addresses

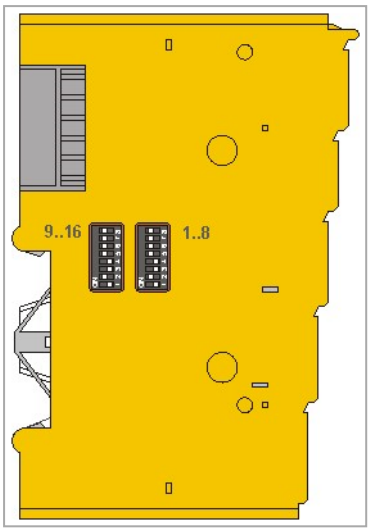


Figure 3-45: Address settings on safety terminals with 65535 possible addresses

Set the safety address for the terminal using the two dip switches (with 8 setting options) on the lefthand side of the AKT2G-SDI-004 safety terminal. Safety addresses between 1 and 65535 are available.

DIP switches																Address
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	1
OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	2
ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	3
OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	4
ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	5
OFF	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	6
ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	7
OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	8
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	65535

⚠WARNING

Safety address

Each safety address may only be used once within a network!
The address 0 is not a valid safety address!

5.16.11 Safety Terminal Address and Parameters

PrmName	Meaning	Values
FSoE_Address	DIP switch address	1 to 65535
Operating Mode	Digital / standstill monitoring 1 and 2	Digital / standstill 1 and 2

PrmName	Meaning	Values
Sensor test channel 1 active	The clock signal for connection Input1+ is checked at connection Input1-.	true / false
Sensor test channel 2 active	The clock signal for connection Input2+ is checked at connection Input2-.	true / false
Sensor test channel 3 active	The clock signal for connection Input3+ is checked at connection Input3-.	true / false
Sensor test channel 4 active	The clock signal for connection Input4+ is checked at connection Input4-.	true / false
Logic channel 1 and 2	Logic of channels 1 and 2	• single logic • asynchronous repetition OSSD (sensor test must be switched off) • any pulse repetition OSSD (sensor test must be switched off) • short cut is no module fault
Logic channel 3 and 4	Logic of channels 3 and 4	• single logic • asynchronous repetition OSSD (sensor test must be switched off) • any pulse repetition OSSD (sensor test must be switched off) • short cut is no module fault
Store Code	This parameter is required for the safety Restore Mode	0x0000
Project CRC	This parameter is required for the safety Restore Mode	0x0000

NOTE

Test pulses

If the parameters **Current Measurement active** or **Testing of outputs active** are set to TRUE, the terminal generates test pulses at the outputs. To avoid generating test pulses at the channel outputs, testing of outputs active and Current measurement active must be set to FALSE.

Please note that deactivating **Current measurement active** and/or **Testing of outputs active** may reduce the achievable performance level. A calculation example for the performance level can be found in the safety PLC application manual.

There are no known applications for which it would make sense to set **Testing of outputs active** to FALSE, while **Current measurement active** is set to TRUE.

5.16.11.1 AKT2G-SDI-004 configuration for light barriers, light grids, light curtains etc.

The AKT2G-SDI-004 also supports direct connection of contact-free protective devices with two self-testing outputs such as light barriers, light grids, light curtains, laser scanners, etc.

⚠CAUTION

Sensors with self-testing outputs!

Only sensors with self-testing outputs and a maximum sensor self-test duration of 350 µs may be connected to the AKT2G-SDI-004 (see illustration below).

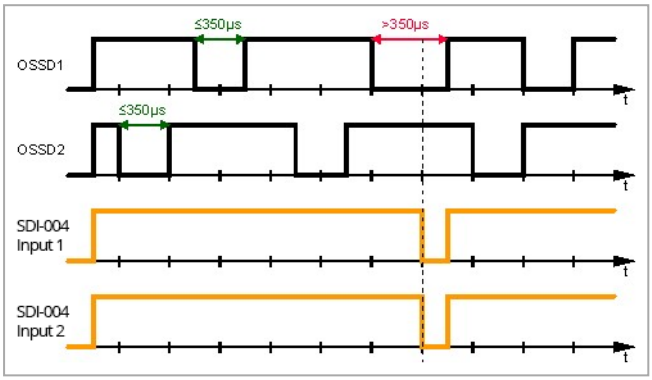


Figure 3-46: Maximum permissible sensor self-test duration of 350 µs

Parameter

To connect these sensors please set the following parameters for the AKT2G-SDI-004 in the safety PLC software:

Connect the two sensor signals either to channels 1 and 2 or channels 3 and 4 and *activate asynchronous repetition OSSD* or *any pulse repetition* for the two inputs used under parameter *Logic for channel x and y*. The difference between these settings is that with *any pulse repetition* simultaneous tests of the OSSD signals up to 350 µs are allowed.

For the two inputs used set the sensor test for the AKT2G-SDI-004 to **False**.

5.16.11.2 Configuration of the AKT2G-SDI-004 for safety switching mats

The AKT2G-SDI-004 also supports direct connection of safety switching mats.

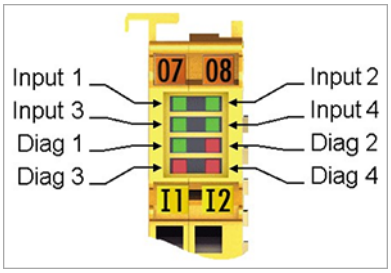
Parameter

To connect these switching mats please set the following parameters for the AKT2G-SDI-004 in the safety PLC software:

Connect the two sensor signals either to channels 1 and 2 or channels 3 and 4 and activate *short cut channel x/y is no module fault* for the two inputs used under parameter *Logic for channel x and y*.

5.16.12 AKT2G-SDI-004 Diagostic LEDs

The LEDs Diag 1 to Diag 4 display diagnostic information for the AKT2G-SDI-004.



5.16.12.1 Diag 1 (green)

The **Diag 1** LED indicates the state of the safety network.

Flashing Code	Meaning
LED illuminated continuously	normal operation: Safety communication OK
rapid flickering, alternating with 1 flash pulse	Error in S parameter (safety parameter)
rapid flickering, alternating with 2 flash pulses	Error in I parameter (Individual parameter)
rapid flickering, alternating with 3 flash pulses	Waiting for S and I parameter
rapid flickering, alternating with 4 flash pulses	S- and I-parameter correct: waiting for first host message
rapid flickering, alternating with 5 flash pulses	Watchdog error
rapid flickering, alternating with 6 flash pulses	CRC error
rapid flickering, alternating with 7 flash pulses	Sequence number error
rapid flickering, alternating with 8 flash pulses	Communication error in the safety protocol

5.16.12.2 Diag 2 (red)

The **Diag 2** LED illuminates red if the terminal detects an external supply or cross-circuit. The LED extinguishes once the error is rectified.

5.16.12.3 Diag 3 (red) and Diag 4 (red)

If the **Diag 3** LED is lit, the **Diag 4** LED indicates internal terminal errors.

5.16.12.3.1 Flashing Codes

In the case of such an error, the **Diag 4** LED on the AKT2G-SDI-004 displays flashing codes that describe the error in more detail.

A flashing code consists of four sequences, which are interrupted in each case by a short break. After the four sequences there is a long break, following which the flashing code is displayed again.

Count the individual sequences of the flashing code.

The errors indicated by the following flashing codes are reversible. After successful troubleshooting the terminal can be restarted.

Diag 3 LED	Diag 4 LED	Meaning	Remedy
	Flashing Code	Meaning	Remedy
lit	6-1-1-1	max. internal temperature exceeded	Ensure that the permissible ambient temperature is adhered to.
	7-1-1-1	internal temperature below min. value	
	2-1-2-1	max. supply voltage µC1 exceeded	Check the supply voltage.
	3-1-2-1	max. supply voltage µC2 exceeded	
	4-1-2-1	voltage fell below min. supply voltage µC1	

Diag 3 LED	Diag 4 LED	Meaning	Remedy
	5-1-2-1	voltage fell below min. supply voltage µC2	
	8-1-1-1	Temperature difference between the measuring points exceeded	Check the installation position and the ambient temperature.

If another flashing code is displayed, this means that there is an internal terminal error that has stopped the terminal. In this case the terminal must be checked by Kollmorgen.

NOTE

Note the flashing codes and return the terminal

Note the flashing code displayed and include this information with the terminal when you return it.

5.16.13 AKT2G-SDI-004 Diagostic Objects

⚠CAUTION

Do not change CoE objects!

Do not make any modifications to the CoE objects in the safety components! Any modifications of the CoE objects will permanently set the safety components to the Fail-Stop state.

Index $FA80_{hex}$: Internal temperature values

The CoE object $FA80_{hex}$ indicates the current internal temperature values of the AKT2G-SDI-004.

Index	Name	Meaning	Flags	Default
FA80:01	Temperature 1	Temperature measurement 1	RO	0_{bin}
FA80:02	Temperature 2	Temperature measurement 2	RO	0_{bin}

Index $800E_{hex}$: diagnostic information

The CoE object $800E_{hex}$ displays further diagnostic information.

Index	Name	Meaning			Flags	Default
800E:0	Diag	The following sub-indices contain detailed diagnostic information.			RO	
800E:0A	Sensor test error	Bit	Error during the sensor test		RO	
		0	1_{bin}	Error at input 1		0_{bin}
		1	1_{bin}	Error at input 2		0_{bin}
		2	1_{bin}	Error at input 3		0_{bin}
		3	1_{bin}	Error at input 4		0_{bin}

Index	Name	Meaning			Flags	Default
800E:0B	Error during two channel evaluation	Bit	Error during the contiguous evaluation of two channels, i.e. the two channels contradict each other.		RO	
		0	1_{bin}	Error in the first input pair		0_{bin}
		1	1_{bin}	Error in the second input pair		0_{bin}
800E:0C	Error in the safety mat operation mode: input pair disagree	Bits	Error in the input pair		RO	
		1, 0	11_{bin}	Error in the first input pair		00_{bin}
		3, 2	11_{bin}	Error in the second input pair		00_{bin}
800E:0D	Error in the safety mat operation mode: external supply	Bit	Error in the test pulses in the safety mat operating mode; i.e. the terminal has detected an external supply.		RO	
		0	1_{bin}	Error at input 1		0_{bin}
		1	1_{bin}	Error at input 2		0_{bin}
		2	1_{bin}	Error at input 3		0_{bin}
		3	1_{bin}	Error at input 4		0_{bin}

NOTE

Differing diagnostic messages possible

Due to the variable order or execution of the test series, diagnostic messages differing from those given in the table above are possible.

5.16.14 Certificates

The AKT2G-SDI-004-000 has been tested to the following directives and standards.

- 2006/42/EC
- EN 61508-1:2010 (up to SIL 3)
- EN 61508-2:2010 (up to SIL 3)
- EN 61508-3:2010 (up to SIL 3)
- EN 62061:2005/A2:2015 (up to SILCL 3)
- EN ISO 13849-1:2015 (Cat. 4, PL e)
- EN 81-20:2014
- EN 81-22:2014
- EN 81-50:2014
- EN 13243:2015

⚠CAUTION

Note on approval accroding to EN 81-20, EN 81-22, and EN 81-50

- The Safety components may only be used in machines that have been designed and installed in accordance with the requirements of the EN 60204-1 standard.
- Provide a surge filter for the supply voltage of the Safety components against overvoltages. (Reduction to overvoltage category II)

- EN 81 requires that in the case of devices with internal temperature monitoring, a stop must be reached in the event of an overtemperature. In this case, passengers must be able to disembark (see EN 81-20 chapter 5.10.4.3, for example). To ensure this, application measures are necessary. The internal terminal temperature of the Safety components can be read out by the user. There is a direct switch-off at the maximum permissible temperature of the respective Safety component (see Installation position and minimum distances).
- The user must select a temperature threshold below the maximum temperature such that a stop can be reached in all cases before the maximum temperature is reached. Information on the optimum terminal configuration can be found under Notes on the arrangement of Safety components and under Example configuration for temperature measurement.
- For the use of the Safety components according to EN 81-22 and EN 81-50, the conditions described in the manuals for achieving category 4 according to EN ISO 13849-1:2015 must be observed.
- The use of Safety components is limited to indoor applications.
- Basic protection against direct contact must be provided, either by fulfilling protection class IP2X or by installing the Safety components in a control cabinet which corresponds at least to protection class IP54 according to EN 60529.
- The ambient conditions regarding temperature, humidity, heat dissipation, EMC and vibrations, as specified in the operating instructions under technical data, must be observed.
- The operating conditions in potentially explosive atmospheres (ATEX) are specified in the operating instructions.
- The safe state (triggering) of the application must be the de-energized state. The safe state of the Safety components is always the de-energized, switched-off state, and this cannot be changed.
- The service life specified in the operating instructions must be observed.
- If the Safety component is operated outside the permissible temperature range, it changes to "Global Shutdown" state.
- The Safety components must be installed in a control cabinet with protection class IP54 according to EN 60529, so that the requirement for contamination level 3 according to EN 60664-1 can be reduced to level 2.
- The Safety components must be supplied by a SELV/PELV power supply unit with a maximum voltage of Umax ≤ 36 VDC.

5.17 AKT2G-SDO-004-000

5.17.1 Safety terminal with 4 digital fail-safe outputs

The AKT2G-SDO-004 is a safe output terminal with digital outputs for connecting actuators (contactors, relays, etc.) with a maximum current 0.5 A (24 VDC). The Bus Terminal has 4 fail-safe outputs.

The AKT2G-SDO-004 meets the requirements of IEC 61508:2010 SIL 3, DIN EN ISO 13849-1:2015 (Cat 4, PL e), UL508, UL1998 and UL991.

The safety terminal has the typical design of an EtherCAT terminal.

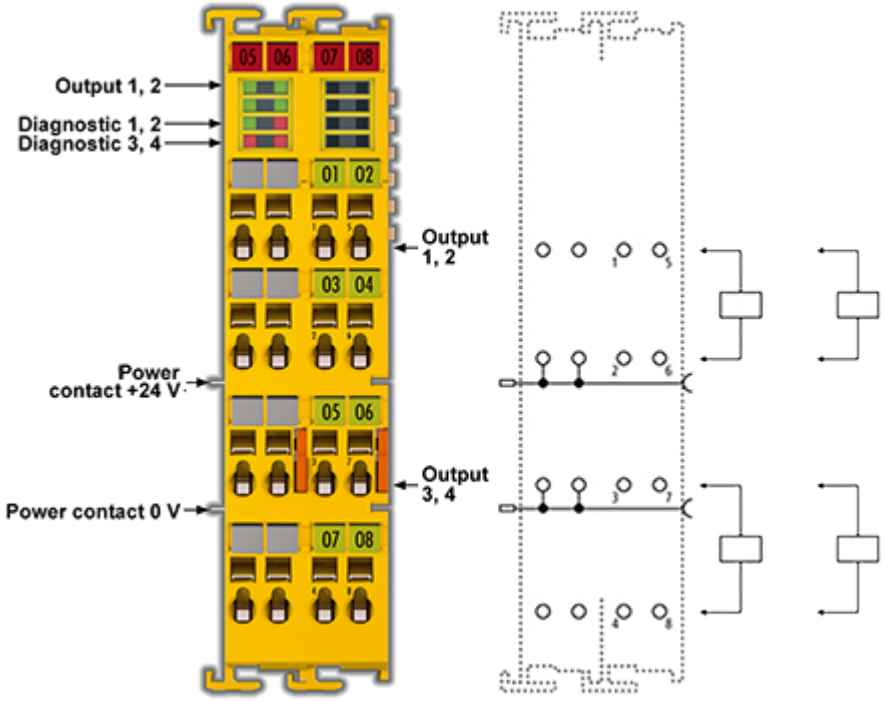


Figure 3-47: AKT2G-SDO-004-000 safety terminal with 4 digital fail-safe outputs

TIP

Be sure to review

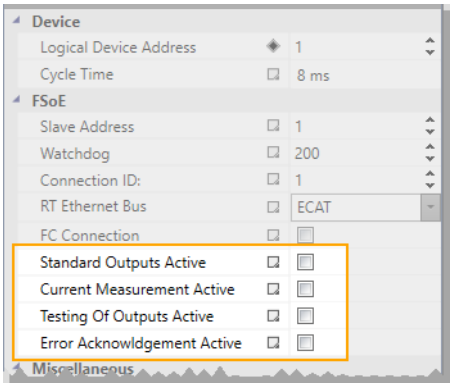
- Safety Instructions
- Safety Operation
- Safety Terminal Reaction Times
- Safety I/O Maintenance

Description of Safety Parameters

Parameter Name	Description	Values
Standard outputs	In addition the safe output can be switched off from the PLC program. The safe outputs are logically ANDed with the standard digital outputs.	True / False
Current measurement active	Current measurement for the outputs are activated	True / False
Testing of outputs active	Test pulses for the outputs are activated	True / False

Parameter Name	Description	Values
Error acknowledge active	True: Terminal errors lead to a reset of the FSoE connection (error code 14 (0x0E)). This error code is shown in the diagnostic data for the connection until it is acknowledged. False (Default): Terminal errors can only be reset by switching the power supply off and back on again.	True / False

For example, using the BBH SafePLC2 software, the parameters can be configured from the AKT2G-SDO-004-000 Properties:



5.17.2 Intended use

⚠WARNING

Caution - Risk of injury!

Safety components may only be used for the purposes described below!

The safety terminals expand the application range of the E-Bus terminal system with functions that enable them to be used for machine safety applications. The safety terminals are designed for machine safety functions and directly associated industrial automation tasks. They are therefore only approved for applications with a defined fail-safe state. This safe state is the wattless state. Fail-safety according to the relevant standards is required.

The safety terminals enable connection of:

- 24 VDC sensors (AKT2G-SDI-004) such as emergency off pushbutton switches, pull cord switches, position switches, two-hand switches, safety mats, light curtains, light barriers, laser scanner, etc.
- 24 VDC actuators (AKT2G-SDO-004 such as contactors, protection door switches with tumbler, signal lamps, servo drives, etc.

NOTE

Test pulses

When selecting actuators please ensure that the AKT2G-SDO-004 test pulses do not lead to actuator switching or diagnostic message from the AKT2G-SDO-004.

The following safety components have been developed for these tasks:

- The AKT2G-SDI-004 is an EtherCAT Terminal with 4 digital fail-safe inputs.
- The AKT2G-SDO-004 is an EtherCAT Terminal with 4 digital fail-safe outputs.

These safety components are suitable for operation on the

- Kollmorgen AKT2G-ECT-000-000 series Bus Couplers

⚠WARNING

Power supply from SELV/PELV power supply unit!

The safety components must be supplied with 24 VDC by an SELV/PELV power supply unit with an output voltage limit Umax of 36 VDC. Failure to observe this can result in a loss of safety.

⚠CAUTION

Follow the machinery directive!

The safety components may only be used in machines as defined in the machinery directive.

⚠CAUTION

Ensure traceability!

The buyer has to ensure the traceability of the device via the serial number.

5.17.3 Technical Data

Product designation	AKT2G-SDO-004-000
Number of outputs	4
Status display	4 (one green LED per output)
Error reaction time	≤ watchdog times
Output current per channel	max. 500 mA, min. 20 mA with parameter **current measurement active** set
Actuators	When selecting actuators please ensure that the AKT2G-SDO-004-000 test pulses do not lead to actuator switching.
Cable length between actuator and terminal	unshielded max. 100 m shielded max. 100 m
Wire cross section	min. 0.75 mm^2
Input process image	6 bytes
Output process image	6 bytes
AKT2G-SDO-004-000 supply voltage (PELV)	24 VDC (–15%/+20%)
Current consumption via E-bus	approx. 221 mA
Power dissipation of the terminal	typically 2 W
Electrical isolation (between the channels)	no
Electrical isolation (between the channels and the E-bus)	yes
Insulation voltage (between the channels and the E-bus, under common operating conditions)	insulation tested with 500 V_{DC}
Dimensions (W x H x D)	24mm x 100mm x 68mm
Weight	approx. 100 g
Permissible ambient temperature (operation) up to SW 03	0°C to +55°C (see note in Installation position and minimum distances)
Permissible ambient temperature (operation) from SW 04 (week 02/2014)	-25°C to +55 °C (see note in Installation position and minimum distances)
Permissible ambient temperature (transport/storage)	-40°C to +70°C
Permissible air humidity	5% to 95%, non-condensing
Permissible air pressure (operation/storage/transport)	750 hPa to 1100 hPa (this corresponds to a height of approx. -690 m to 2450 m over sea level assuming an international standard atmosphere)

Product designation	AKT2G-SDO-004-000
Climate category according to EN 60721-3-3	3K3 (the deviation from 3K3 is possible only with optimal environmental conditions and also applies only to the technical data which are specified differently in this documentation)
Permissible level of contamination according to EN 60664-1	level of contamination 2 (comply with the section Safety I/O Maintenance
Impermissible operating conditions	safety terminals must not be used under the following operating conditions: • under the influence of ionizing radiation (that exceeds the level of the natural environmental radiation) • in corrosive environments • in an environment that leads to unacceptable soiling of the Bus Terminal
EMC immunity/emission	conforms to EN 61000-6-2 / EN 61000-6-4
Vibration/shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
Shocks	15 g with pulse duration 11 ms in all three axes
Protection class	IP20
Permitted operating environment	In the control cabinet or terminal box, with minimum protection class IP54 according to IEC 60529
Permissible installation position	see section Installation position and minimum distances
Approvals	CE, cULus

5.17.4 Safety Parameters

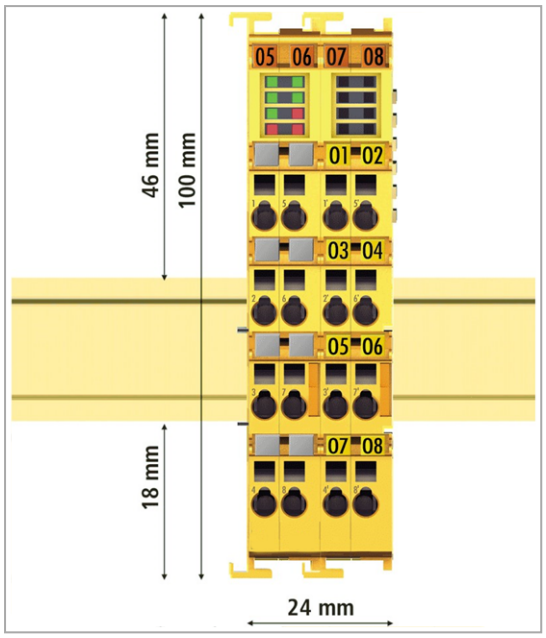
Key Figures	AKT2G-SDO-004-000
Lifetime [a]	20
Prooftest Interval [a]	not required [1]
PFH_D	1.25E-09
%SIL3	1,25 %
PFD	8.45E-05
%SIL3	8,45 %
$MTTF_d$	high
DC	high
Performance level	PL e
Category	4
HFT	1
Element classification [2]	Type B

1. Special proof tests are not required during the entire service life of the AKT2G-SDO-004 EtherCAT terminal.
2. Classification according to IEC 61508-2:2010 (chapter 7.4.4.1.2 and 7.4.4.1.3)

The AKT2G-SDO-004 EtherCAT Terminal can be used for safety-related applications within the meaning of IEC 61508:2010 up to SIL3 and EN ISO 13849-1 up to PL e (Cat4).

For the calculation or estimation of the $MTTF_d$ value from the PFH_D value, further information can be found in ISO 13849-1:2015 Table K.1.

5.17.5 Dimensions



Width	24 mm (side-by-side installation)
Height	100 mm
Depth	68 mm

Figure 3-48: Dimensions of the AKT2G-SDO-004.

5.17.6 Block Diagram of the AKT2G-SDO-004

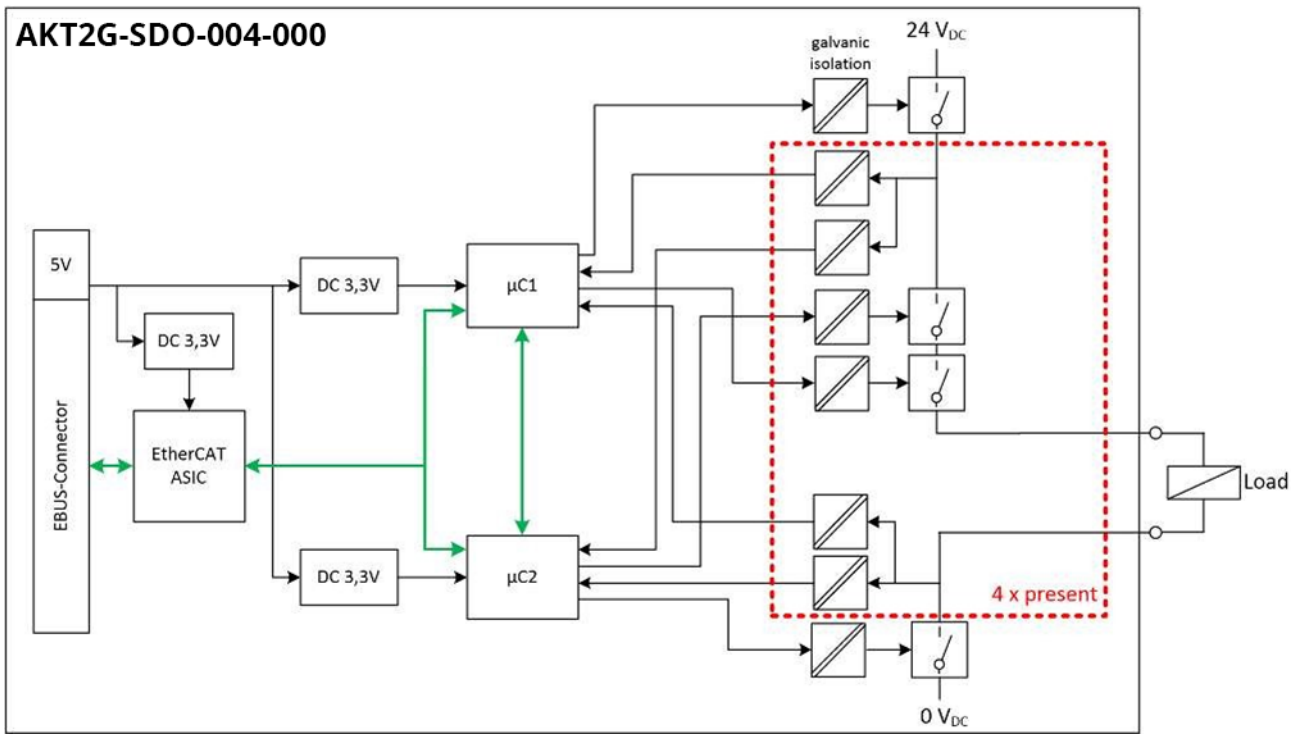


Figure 3-49: Block diagram of the AKT2G-SDO-004

The block diagram shows the basic configuration of a channel in the AKT2G-SDO-004. The part with a red border is present four times in the terminal. The high-side and low-side switches only exist once for all channels. This means that each channel has a total of four stop paths.

5.17.7 AKT2G-SDO-004 Pin Assignment

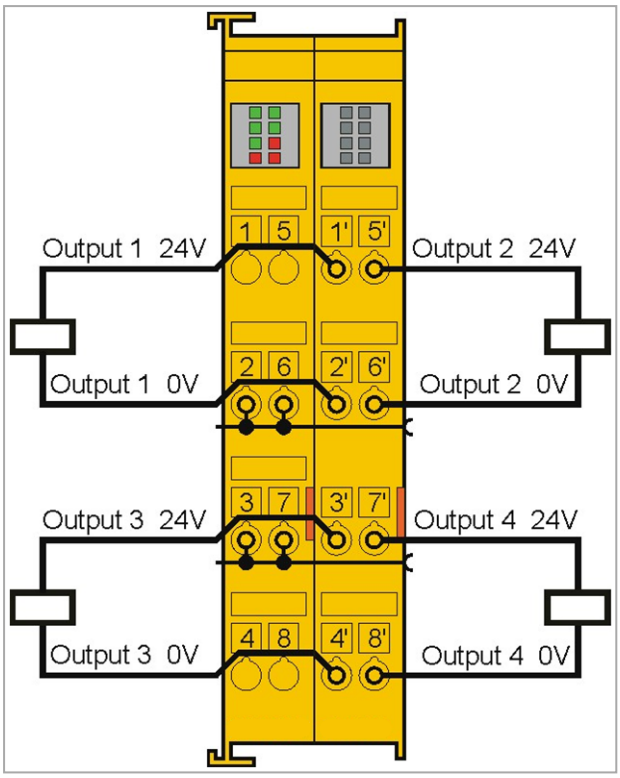


Figure 3-50: AKT2G-SDO-004 pin assignment

Terminal point	Output	Signal
1	-	not used, no function
2		positive power contact
3	-	negative power contact
4		not used, no function
5	-	not used, no function
6		positive power contact
7	-	negative power contact
8		not used, no function
1’	1	Output 1+
2’		Output 1-
3’	3	Output 3+
4’		Output 3-
5’	2	Output 2+
6’		Output 2-
7’	4	Output 4+
8’		Output 4-

NOTE

Test Pulses

When selecting actuators please ensure that the AKT2G-SDO-004 test pulses do not lead to actuator switching or diagnostic message from the AKT2G-SDO-004.

5.17.8 Signal Cables

5.17.8.1 Permitted cable length

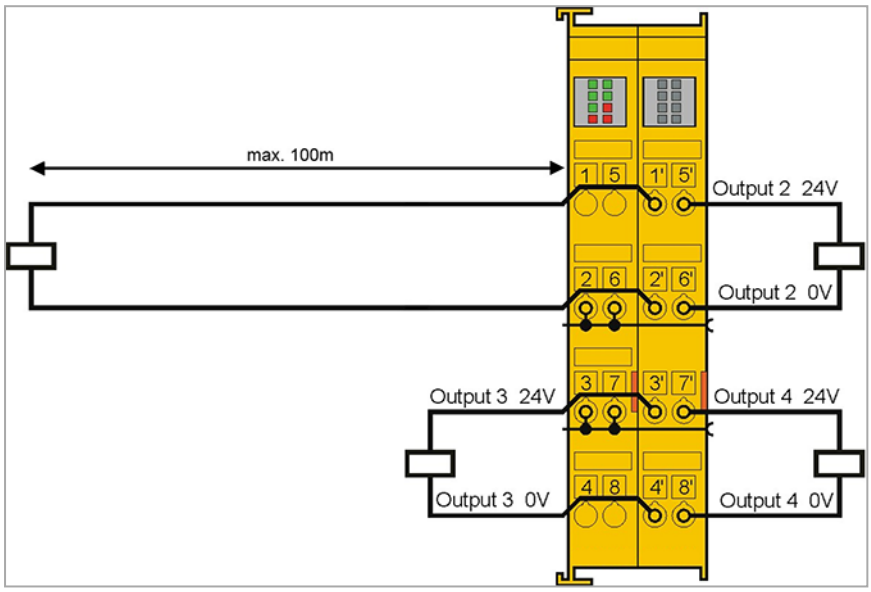


Figure 3-51: Permitted cable length

When connecting a single switching contact via its own continuous cabling (or via a non-metallic sheathed cable), the maximum permitted cable length is 100 m.

The use of contact points, connectors or additional switching contacts in the cabling reduces the maximum propagation.

5.17.8.2 Cable routing

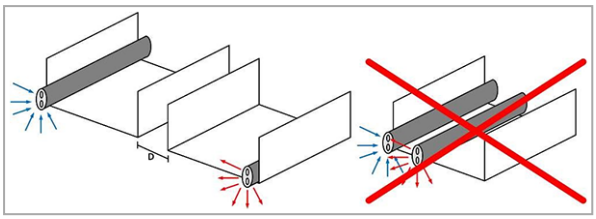


Figure 3-52: Cable routing

NOTICE

Route the signal cable separately

The signal cable must be routed separately from potential sources of interference, such as motor supply cables, 230 VAC power cables etc.!

Interference caused by cables routed in parallel can influence the signal form of the test pulses and thus cause diagnostic messages (e.g. sensor errors or OpenLoad errors).

- D: Distance between the cable ducts should be as large as possible
- blue arrows: signal line
- red arrows: potential source of interference

The common routing of signals together with other clocked signals in a common cable also reduces the maximum propagation, since crosstalk of the signals can occur over long cable lengths and cause diagnostic messages.

The test pulses can be switched off (sensor test parameter) if the connection of a common cable is unavoidable. However, this then leads to a reduction in the degree of diagnostic cover when calculating the performance level.

5.17.8.3 Test Pulses

The typical length of test pulse (switching from 24 V to 0 V and back to 24 V) is 300 µs to 800 µs. Testing usually takes place 5 to 7 times per second.

NOTE

Test pulses for the outputs

The following diagram shows a typical test pulse curve for the four outputs of an AKT2G-SDO-004. The parameters Current measurement active and Testing of outputs active are enabled.

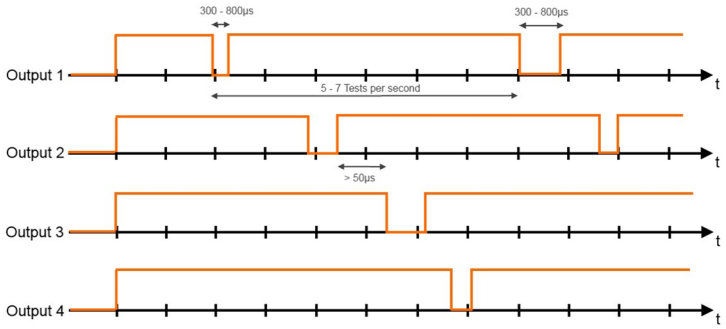


Figure 3-53: Typical course of test pulses of the outputs.

5.17.9 Address Settings on Safety Terminals with 1023 Possible Addresses

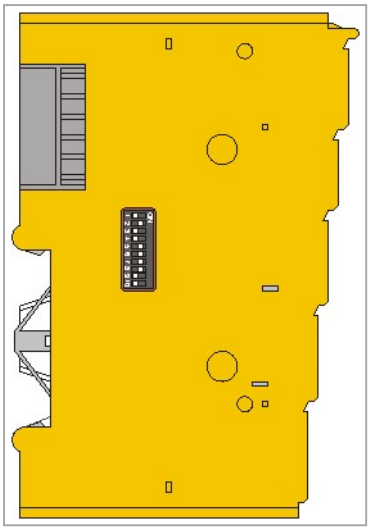


Figure 3-54: Address settings on safety terminals with 1023 possible addresses

The safety address of the terminal is set via the 10-way DIP switch on the left-hand side of the safety terminal. Safety addresses between 1 and 1023 are available.

DIP switch										Address
1	2	3	4	5	6	7	8	9	10	
ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**1**
OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**2**
ON	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**3**
OFF	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**4**
ON	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**5**
OFF	**ON**	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**6**
ON	**ON**	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	**7**
…	…	…	…	…	…	…	…	…	…	**…**
ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**1023**

⚠WARNING

Safety address

Each safety address may only be used once within a network!
The address 0 is not a valid safety address!

5.17.10 Safety Terminal Address and Parameters

PrmName	Meaning	Values
FSoE_Address	DIP switch address	1 to 1023
Standard outputs active	In addition the output can be switched off from the standard PLC. The safe output is linked with the standard logic signal AND.	true / false
Current measurement active	Current measurement for the outputs is activated	true / false

PrmName	Meaning	Values
Testing of outputs active	Test pulses for the outputs are activated	true / false
Error acknowledge active	**True:** Terminal errors lead to a reset of the safety connection (error code 14 (0x0E)). This error code is shown in the diagnostic data for the connection until the user acknowledges it via ErrAck. **False (Default):** Terminal errors can only be reset by switching the power supply off and back on again.	true / false
Store Code	This parameter is required for the safety Restore Mode	0x0000
Project CRC	This parameter is required for the safety Restore Mode	0x0000

NOTE

Test pulses

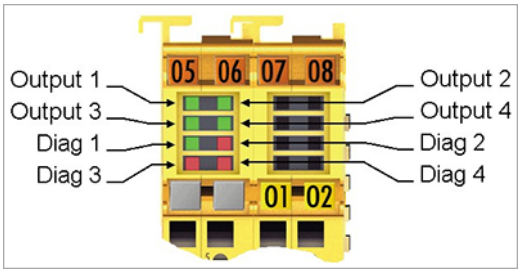
If the parameters **Current Measurement active** or **Testing of outputs active** are set to TRUE, the terminal generates test pulses at the outputs. To avoid generating test pulses at the channel outputs, testing of outputs active and Current measurement active must be set to FALSE.

Please note that deactivating **Current measurement active** and/or **Testing of outputs active** may reduce the achievable performance level. A calculation example for the performance level can be found in the safety PLC application manual.

There are no known applications for which it would make sense to set **Testing of outputs active** to FALSE, while **Current measurement active** is set to TRUE.

5.17.11 AKT2G-SDO-004 Diagostic LEDs

The LEDs Diag 1 to Diag 4 display diagnostic information for the AKT2G-SDO-004.



5.17.11.1 Diag 1 (green)

The **Diag 1** LED indicates the state of the safety network.

Flashing Code	Meaning
LED illuminated continuously	Diagnostic flashing code in preparation

5.17.11.2 Diag 2 (red)

The **Diag 2** LED indicates the state of the digital outputs.

Flashing Code	Meaning
rapid flickering, alternating with 1 flash pulse	Error at output 1

Flashing Code	Meaning
rapid flickering, alternating with 2 flash pulses	Error at output 2
rapid flickering, alternating with 3 flash pulses	Error at output 3
rapid flickering, alternating with 4 flash pulses	Error at output 4
rapid flickering, alternating with 5 flash pulses	Field voltage too low
rapid flickering, alternating with 6 flash pulses	Field voltage too high
rapid flickering, alternating with 7 flash pulses	Internal terminal temperature too low
rapid flickering, alternating with 8 flash pulses	Internal terminal temperature too high
rapid flickering, alternating with 9 flash pulses	Temperature difference error
rapid flickering, alternating with 10 flash pulses	Error in output circuit

5.17.11.3 Diag 3 (red) and Diag 4 (red)

If the **Diag 3** LED is lit, the **Diag 4** LED indicates internal terminal errors.

These errors lead to shutdown of the terminal. The terminal must be checked by Kollmorgen.

5.17.11.3.1 Flashing Codes

In the case of such an error, the **Diag 4** LED on the AKT2G-SDO-004 displays flashing codes that describe the error in more detail.

A flashing code consists of four sequences, which are interrupted in each case by a short break. After the four sequences there is a long break, following which the flashing code is displayed again.

Count the individual sequences of the flashing code.

NOTE

Note the flashing codes and return the terminal

Note the flashing code displayed and include this information with the terminal when you return it.

5.17.12 Possible Causes of Diagnostic Messages - AKT2G-SDO-004

Diagnostics	Possible cause	Remedial actions
Diag 2 LED Flash code 1 to 4 or 10	If parameters "Testing of outputs active" and/or "Current measurement active" are enabled:	
	Faulty test pulses. Cause: external supply or cross-circuit.	Eliminate cross-circuit or external supply.
	Faulty test pulses. Cause: parallel routed cables with high capacitive coupling and dynamized signals, possibly also in common cables	Isolate lines and lay in separate non-metallic sheathed cable. Create a distance between the non-metallic sheathed cables.
	Cause: Current is below the limit of 20 mA or above the limit of 500 mA.	Select actuator accordingly. Current > 20mA and < 500mA
	Regardless of whether the parameters "Testing of outputs active" and/or "Current measurement active" are enabled:	
	The output voltage lies below the permissible voltage range (24V - 15%/+20%). A possible cause is a short-circuit at the output or e.g. a voltage drop at the instant of switching.	Eliminate short-circuit. Design power supply accordingly. Check supply lines for voltage drop.
	EMC faults	Take suitable EMC measures
	Internal defect	Replace terminal
Diag 2 LED Flash code 5	Voltage at the power contacts not switched on.	Switch on voltage at the power contacts and reset the error display through PowerOn Reset of the terminal
	Voltage at the power contacts was switched on after the terminal supply	Switch on voltage at the power contacts before or at the same time as the terminal supply and reset the error display through PowerOn Reset of the terminal
	Voltage on the power contacts too low.	Increase the voltage at the power contacts and reset the error display through PowerOn Reset of the terminal
	EMC faults	Take suitable EMC measures
	Internal defect	Replace terminal

Diagnostics	Possible cause	Remedial actions
Diag 2 LED Flash code 6	Field voltage too high. Voltage on the power contacts too high.	Reduce the voltage at the power contacts and reset the error display through PowerOn Reset of the terminal
	Voltage briefly too high due to external influences, such as switching contactors off.	Use an R/C or diode-based protective circuit on the actuators
	EMC faults	Take suitable EMC measures
	Internal defect	Replace terminal
Diag 2 LED Flash code 7	Terminal temperature too low	Comply with the specified temperature range
	EMC faults	Take suitable EMC measures
	Internal defect	Replace terminal
Diag 2 LED Flash code 8	Terminal temperature too high	Comply with the specified temperature range
	EMC faults	Take suitable EMC measures
	Internal defect	Replace terminal
Diag 2 LED Flash code 9	Terminal temperature difference too large: one of the 3 internal measuring points is faulty	Replace terminal
	Terminal temperature difference too large: An internal measuring point shows an elevated temperature due to inadequate convection.	Check the installation position of the terminal and modify it according to the specifications in section Mechanical installation, if required
	EMC faults	Take suitable EMC measures
	Internal defect	Replace terminal

5.17.13 Certificates

The AKT2G-SDO-004-000 has been tested to the following directives and standards.

- 2006/42/EC
- EN 61508-1:2010 (up to SIL 3)
- EN 61508-2:2010 (up to SIL 3)
- EN 61508-3:2010 (up to SIL 3)
- EN 62061:2005/A2:2015 (up to SILCL 3)
- EN ISO 13849-1:2015 (Cat. 4, PL e)
- EN 81-20:2014
- EN 81-22:2014
- EN 81-50:2014
- EN 13243:2015

⚠CAUTION

Note on approval accroding to EN 81-20, EN 81-22, and EN 81-50

- The Safety components may only be used in machines that have been designed and installed in accordance with the requirements of the EN 60204-1 standard.

- Provide a surge filter for the supply voltage of the Safety components against overvoltages. (Reduction to overvoltage category II)
- EN 81 requires that in the case of devices with internal temperature monitoring, a stop must be reached in the event of an overtemperature. In this case, passengers must be able to disembark (see EN 81-20 chapter 5.10.4.3, for example). To ensure this, application measures are necessary. The internal terminal temperature of the Safety components can be read out by the user. There is a direct switch-off at the maximum permissible temperature of the respective Safety component (see Installation position and minimum distances).
- The user must select a temperature threshold below the maximum temperature such that a stop can be reached in all cases before the maximum temperature is reached. Information on the optimum terminal configuration can be found under Notes on the arrangement of Safety components and under Example configuration for temperature measurement.
- For the use of the Safety components according to EN 81-22 and EN 81-50, the conditions described in the manuals for achieving category 4 according to EN ISO 13849-1:2015 must be observed.
- The use of Safety components is limited to indoor applications.
- Basic protection against direct contact must be provided, either by fulfilling protection class IP2X or by installing the Safety components in a control cabinet which corresponds at least to protection class IP54 according to EN 60529.
- The ambient conditions regarding temperature, humidity, heat dissipation, EMC and vibrations, as specified in the operating instructions under technical data, must be observed.
- The operating conditions in potentially explosive atmospheres (ATEX) are specified in the operating instructions.
- The safe state (triggering) of the application must be the de-energized state. The safe state of the Safety components is always the de-energized, switched-off state, and this cannot be changed.
- The service life specified in the operating instructions must be observed.
- If the Safety component is operated outside the permissible temperature range, it changes to "Global Shutdown" state.
- The Safety components must be installed in a control cabinet with protection class IP54 according to EN 60529, so that the requirement for contamination level 3 according to EN 60664-1 can be reduced to level 2.
- The Safety components must be supplied by a SELV/PELV power supply unit with a maximum voltage of Umax ≤ 36 VDC.

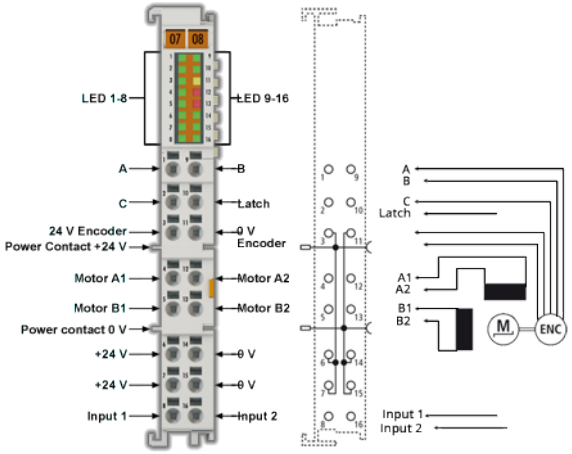
5.18 AKT2G-SM-L15-000

Stepper motor terminal, 24 V DC, 1.5 A, vector control

The AKT2G-SM-L15 EtherCAT Terminal is intended for stepper motors with low performance range. The PWM output stages cover a wide range of voltages and currents. Together with two inputs for limit switches, they are located in the EtherCAT Terminal.

The SM-L15 can be adjusted to the motor and the application by changing just a few parameters. These stepper motors can be operated with vector control. This control technique offers various benefits, such as better dynamics and lower power consumption. Together with a stepper motor and an encoder, the SM-L15 represents an inexpensive small servo axis.

The LEDs indicate status, warning and error messages as well as possibly active limitations.



More information about using steppers may be found in the online help.

5.18.1 Technical Data

Technical Data	AKT2G-SM-L15
Number of outputs	1 stepper motor, 2 phases
Number of digital inputs	2 limit position, 4 for an encoder system
Number of digital outputs	1 configurable for brake (0.5 A)
Supply voltage	24 V DC (-15%/+20%)
Motor Current/Phase (RMS) values without fan cartridge ZB8610	1.06 A
Motor Current/Phase (RMS) values with fan cartridge ZB8610	1.12 A
Maximum output current without fan cartridge ZB8610	1.5 A (overload- and short-circuit-proof)
Maximum output current with fan cartridge ZB8610	3.0 A (overload- and short-circuit-proof)
Operating modes	• Standard mode (velocity direct / position controller) • Field-oriented control (extended velocity mode / extended position mode) • Sensorless operation • Travel distance control (positioning interface)
Maximum step frequency	1000, 2000, 4000, 8000 or 16000 full steps/s (configurable)
Step pattern	up to 64-fold micro stepping (automatic switching, speed-dependent)
Current controller frequency	approx. 30 kHz
Encoder pulse frequency	maximum 400,000 increments/s (4-fold evaluation)
Input signal voltage "0"	-3 V … 2 V
Input signal voltage "1"	3.7 V … 28 V
Input Current	typ. 5 mA
Diagnostics LED	Warning strand A and B, error strand A and B, power, enable

Technical Data	AKT2G-SM-L15
Resolution	approx. 5,000 positions in typical applications (per revolution)
Power Supply	via the E-bus, encoder/driver stage: via the power contacts, motor: via terminal contacts
Current consumption from the E-bus	typ. 100 mA
Electrical isolation	500 V (E-bus/signal voltage)
Support NoCoEStorage	yes
Configuration	no address setting required
Weight	approx. 60 g
Permissible ambient temperature range during operation	0°C ... +55°C
Permissible ambient temperature range during storage	-25°C ... + 85°C
Permissible relative humidity	95%, no condensation
Dimensions (W x H x D)	approx. 27 mm x 100 mm x 70 mm (connected width: 24 mm)
Installation	on 35 mm mounting rail according to EN 60715
Vibration / shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	according to EN 61000-6-2 / EN 61000-6-4 according to IEC/EN 61800-3
EMC category	Category C3 - standard Category C2, C1 - auxiliary filter required
Protection class	IP 20
Installation position	• without fan cartridge ZB8610: standard installing position • with fan cartridge ZB8610: standard installing position, other installing positions (example 1 & 2)
Approval	CE cULus

5.18.2 AKT2G-SM-L15 LEDs & Connections

⚠WARNING

WARNING! Risk of electric shock and damage of devices possible!

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

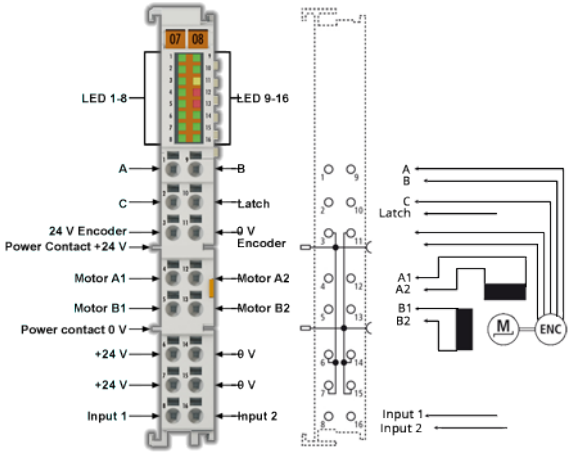


Figure 3-55: LEDs and connection of the AKT2G-SM-L15

5.18.2.1 LEDs

No.	LED	Color	Meaning	
1	RUN	green	This LED indicates the terminal's operating state:	
			off	State of the EtherCAT State Machine: **INIT** = Initialization of the terminal or **BOOTSTRAP** = Function for firmware updates of the terminal
			blinking	State of the EtherCAT State Machine: **PREOP** = Setting for mailbox communication and variant standard settings
			single flash	State of the EtherCAT State Machine: **SAFEOP** = Channel checking of the Sync Manager and the Distributed Clocks. Outputs stay in safe operation mode.
			on	State of the EtherCAT State Machine: `OP` = Normal operation mode, mailbox- and process data communication possible
2	Encoder	green	on	Encoder ready for operation
3	A	green	on	Signal at encoder input A
4	B	green	on	Signal at encoder input B
5	C	green	on	Signal at encoder input C
6	Latch	green	on	Signal at latch input
7	Turn CW	green	on	Motor is triggered clock wise
8	Input 1	green	on	Signal at digital input 1
9	Driver	green	on	Driver stage ready for operation
10	Power	green	off	The power supply voltage (24 VDC) is absent or the motor control is blocked (Index 6010:02] is not set))
			on	The power supply voltage (24 VDC) is present
11	Warning	yellow	on	Configuration error, e.g.: • Motor power supply not connected • 80°C temperature exceeded • 100% duty cycle reached • ...

No.	LED	Color	Meaning	
12	Error A	red	on	Configuration error of output stage A, e.g.: • 100°C temperature exceeded • short circuit • ...
13	Error B	red	on	Configuration error of output stage B, e.g.: • 100°C temperature exceeded • short circuit • ...
14	Enable	green	off	The motor control is blocked (Index 6010:02] is not set) or SM-L15 is not ready for operation
			on	The motor control is activated (Index 6010:02] is set) or SM-L15 is ready for operation
15	Turn CCW	green	on	Motor is triggered counter clock wise
16	Input 2	green	on	Signal at digital input 2

5.18.2.2 Terminal Points

Terminal point	Name	Signal
1	A	Encoder input A
2	C	Encoder input C (zero input). If object 7000:01 is set in the control word and a rising edge occurs at encoder input C, the current counter value is stored as a reference mark in the latch register.
3	Encoder supply +24V	Encoder supply + 24 V, internally connected with positive power contact and pin 6, 7
4	A1	Motor winding A1
5	B1	Motor winding B1
6	+24V	+24 V_{DC}, internally connected with positive power contact and pin 3, 7
7	+24V	+24 V_{DC}, internally connected with positive power contact and pin 3, 7
8	Input 1	Digital input 1 (24 V_{DC})
9	B	Encoder input B
10	Latch	Latch input. The current counter value is stored as a reference mark in the latch register, if • object 7000:02 is set and a rising edge occurs at the latch input; or • object 7000:04 is set and a falling edge occurs at the latch input.
11	Encoder supply 0V	Encoder supply 0 V, internally connected with negative power contact and pin 14, 15
12	A2	Motor winding A2

Terminal point	Name	Signal
13	B2	Motor winding B2
14	0V	0 V_{DC}, internally connected with negative power contact and pin 11, 15
15	0V	0 V_{DC}, internally connected with negative power contact and pin 11, 14
16	Input 2	Digital input 2 (24 V_{DC}), also configurable as a digital output (0,5 A)

5.18.3 AKT2G-SM-L15 General Connection Examples

⚠WARNING

Risk of injury through electric shock and damage to the device!

Bring the Bus Terminal system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals.

NOTE

Connect the motor strands correctly!

Connect the windings of a motor strand only to the terminal points of the same output driver of the stepper motor terminal, e.g.:

- one motor strand to terminal points A1 and A2,
- the other motor strand to terminal points B1 and B2.

Connecting a motor strand to the terminal points of different output drivers (e.g. to A1 and B1) can lead to destruction of the output drivers of stepper motor terminal!

5.18.3.1 Connection types

The AKT2G-SM-L15 Stepper Motor terminal has bipolar output stages and can control bipolar and unipolar motors.

NOTE

Fuse protection of the supply voltage

The electrical protection of the load voltage must be selected in such a way that the maximum flowing current is limited to 3 times the rated current (max. 1 second)!

5.18.3.1.1 Bipolar motors

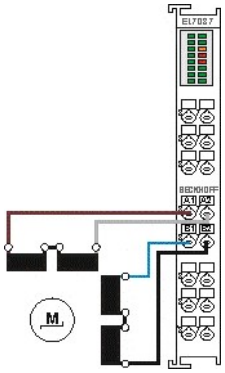


Figure 3-56: Bipolar control (serial) of a bipolar motor

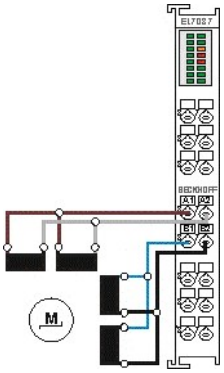


Figure 3-57: Bipolar control (parallel) of a bipolar motor

5.18.3.1.2 Unipolar motors

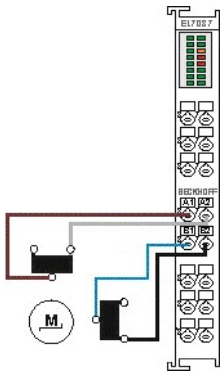


Figure 3-58: Bipolar control of a unipolar motor. Only one half of each winding is controlled.

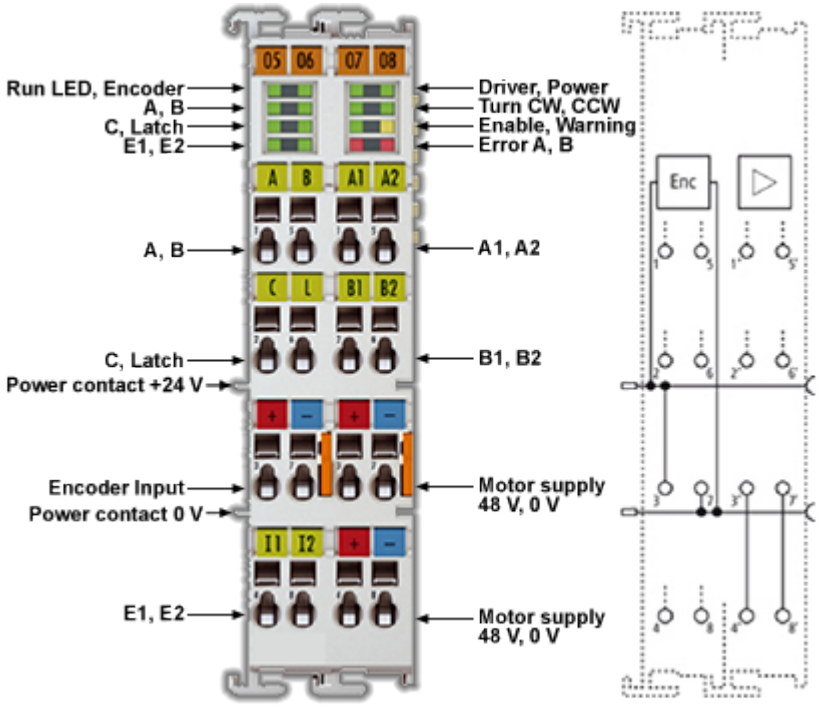
5.19 AKT2G-SM-L50-000

Stepper motor terminal, 50 V DC, 5 A, vector control

The AKT2G-SM-L50 EtherCAT Terminal is intended for stepper motors with medium performance range. The PWM output stages cover a wide range of voltages and currents. Together with two inputs for limit switches, they are located in the EtherCAT Terminal.

The SM-L50 can be adjusted to the motor and the application by changing just a few parameters. 64-fold micro-stepping ensures particularly quiet and precise motor operation. Together with a stepper motor and an encoder, the SM-L50 represents an inexpensive small servo axis.

The LEDs indicate status, warning and error messages as well as possibly active limitations.



More information about using steppers may be found in the online help.

5.19.1 Technical Data

Technical Data	AKT2G-SM-L50
Number of outputs	1 stepper motor, 2 phases

Technical Data	AKT2G-SM-L50
Number of digital inputs	2 limit position, 4 for an encoder system
Number of digital outputs	1 configurable for brake (0.5 A)
Supply voltage	8 … 50 V DC
Motor Current/Phase (RMS) values without fan cartridge ZB8610	3.53 A
Motor Current/Phase (RMS) values with fan cartridge ZB8610	4.59 A
Maximum output current without fan cartridge AKT2G-AC-FAN-001	5 A (overload- and short-circuit-proof)
Maximum output current with fan cartridge AKT2G-AC-FAN-001	6.5 A (overload- and short-circuit-proof)
Operating modes	• Standard mode (velocity direct / position controller) • Field-oriented control (extended velocity mode / extended position mode) • Sensorless operation • Travel distance control (positioning interface)
Maximum step frequency	1000, 2000, 4000, 8000 or 16000 full steps/s (configurable)
Step pattern	up to 64-fold micro stepping (automatic switching, speed-dependent)
Current controller frequency	approx. 30 kHz
Encoder pulse frequency	maximum 400,000 increments/s (4-fold evaluation)
Input signal voltage "0"	-3 V … 2 V
Input signal voltage "1"	3.7 V … 28 V
Input Current	typ. 5 mA
Diagnostics LED	Warning strand A and B, error strand A and B, power, enable
Resolution	approx. 5,000 positions in typical applications (per revolution)
Power Supply	via the E-bus, encoder/driver stage: via the power contacts, motor: via terminal contacts
Current consumption from the E-bus	typ. 140 mA
Electrical isolation	500 V (E-bus/signal voltage)
Support NoCoEStorage	yes
Configuration	no address setting required
Weight	approx. 105 g
Permissible ambient temperature range during operation	0°C ... +55°C
Permissible ambient temperature range during storage	-25°C ... + 85°C
Permissible relative humidity	95%, no condensation

Technical Data	AKT2G-SM-L50
Dimensions (W x H x D)	approx. 27 mm x 100 mm x 70 mm (connected width: 24 mm)
Installation	on 35 mm mounting rail according to EN 60715
Vibration / shock resistance	conforms to EN 60068-2-6/EN 60068-2-27
EMC immunity/emission	according to EN 61000-6-2 / EN 61000-6-4 according to IEC/EN 61800-3
EMC category	Category C3 - standard Category C2, C1 - auxiliary filter required
Protection class	IP 20
Installation position	• without fan cartridge ZB8610: standard installing position • with fan cartridge ZB8610: standard installing position, other installing positions (example 1 & 2)
Approval	CE cULus

5.19.2 AKT2G-SM-L50 LEDs & Connections

⚠WARNING

WARNING! Risk of electric shock and damage of devices possible!

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

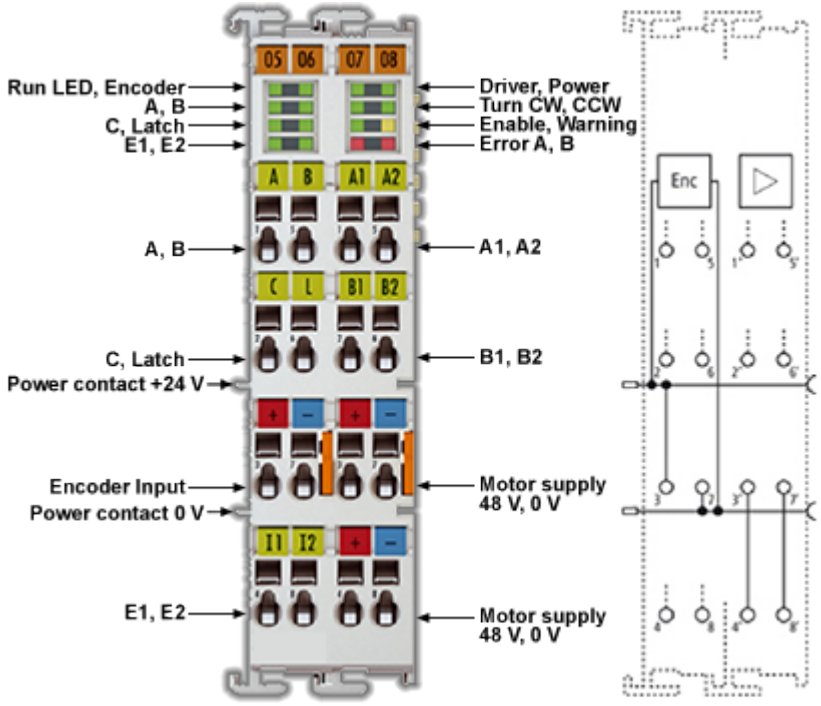


Figure 3-59: LEDs and connection of the AKT2G-SM-L50

5.19.2.1 LEDs

5.19.2.1.1 Left Prism

LED	Color	Meaning	
RUN	green	This LED indicates the terminal's operating state:	
		off	State of the EtherCAT State Machine: **INIT** = Initialization of the terminal or **BOOTSTRAP** = Function for firmware updates of the terminal
		blinking	State of the EtherCAT State Machine: **PREOP** = Setting for mailbox communication and variant standard settings
		single flash	State of the EtherCAT State Machine: **SAFEOP** = Channel checking of the Sync Manager and the Distributed Clocks. Outputs stay in safe operation mode.
		on	State of the EtherCAT State Machine: **OP** = Normal operation mode, mailbox- and process data communication possible
Encoder	green	on	Encoder ready for operation
A	green	on	Signal at encoder input A
B	green	on	Signal at encoder input B
C	green	on	Signal at encoder input C
Latch	green	on	Signal at latch input
Input 1	green	on	Signal at digital input 1
Input 2	green	on	Signal at digital input 2

5.19.2.1.2 Right Prism

LED	Color	Meaning	
Driver	green	on	Driver stage ready for operation
Power	green	off	The power supply voltage (50 V_{DC}) is absent or the motor control is blocked (Index 6010:02] is not set))
		on	The power supply voltage (50 V_{DC}) is present
Turn CW	green	on	Motor is triggered clock wise
Turn CCW	green	on	Motor is triggered counter clock wise
Enable	green	off	The motor control is blocked (Index 6010:02] is not set) or SM-L50 is not ready for operation
		on	The motor control is activated (Index 6010:02] is set) or SM-L50 is ready for operation
Warning	yellow	off	No errors
		on	Configuration error, e.g.: • Motor power supply not connected • 80°C temperature exceeded • 100% duty cycle reached • ...

LED	Color	Meaning	
Error A	red	on	Configuration error of output stage A, e.g.: • 100°C temperature exceeded • short circuit • ...
Error B	red	on	Configuration error of output stage B, e.g.: • 100°C temperature exceeded • short circuit • ...

5.19.2.2 Terminal Points

5.19.2.2.1 Left-hand section of the housing

Terminal point	Name	Signal
1	A	Encoder input A
2	C	Encoder input C (zero input). If object 7000:01 is set in the control word and a rising edge occurs at encoder input C, the current counter value is stored as a reference mark in the latch register.
3	Encoder supply +24V	Encoder supply (from positive power contact)
4	Input 1	Digital input 1 (24 V_{DC})
5	B	Encoder input B
6	Latch / Gate	Latch input. The current counter value is stored as a reference mark in the latch register, if • object 7000:02 is set and a rising edge occurs at the latch input; or • object 7000:04 is set and a falling edge occurs at the latch input.
7	Encoder supply 0V	Encoder supply (from negative power contact)
8	Input 2	Digital input 2 (24 V_{DC})

5.19.2.2.2 Right-hand section of the housing

Terminal point	Name	Signal
1'	A1	Motor winding A1
2'	B1	Motor winding B1
3'	Motor supply +50V	Feeding for output stage (max. +50 V_{DC})
4'	Motor supply +50V	Feeding for output stage (max. +50 V_{DC})
5'	A2	Motor winding A2
6'	B2	Motor winding B2
7'	Motor supply 0V	Feeding for output stage (0 V_{DC})

Terminal point	Name	Signal
8'	Motor supply 0V	Feeding for output stage (0 V_{DC})

5.19.3 AKT2G-SM-L50 General Connection Examples

⚠WARNING

Risk of injury through electric shock and damage to the device!

Bring the Bus Terminal system into a safe, de-energized state before starting mounting, disassembly or wiring of the Bus Terminals.

NOTE

Connect the motor strands correctly!

Connect the windings of a motor strand only to the terminal points of the same output driver of the stepper motor terminal, e.g.:

- one motor strand to terminal points A1 and A2,
- the other motor strand to terminal points B1 and B2.

Connecting a motor strand to the terminal points of different output drivers (e.g. to A1 and B1) can lead to destruction of the output drivers of stepper motor terminal!

NOTE

Use a brake chopper terminal (Global search and replace: AKT2G-BRC-000-000) for short deceleration ramps!

Very short deceleration ramps may lead to temporarily increased feedback. In this case the terminal would report an error. In order to avoid this, a brake chopper terminal AKT2G-BRC-000-000 should be connected in parallel to the power supply for the motor so that any energy being fed back is absorbed.

NOTE

Fuse protection of the supply voltage

The electrical protection of the load voltage must be selected in such a way that the maximum flowing current is limited to 3 times the rated current (max. 1 second)!

5.19.3.1 Connection types

The AKT2G-SM-L50 Stepper Motor terminal has bipolar output stages and can control bipolar and unipolar motors.

5.19.3.1.1 Bipolar motors

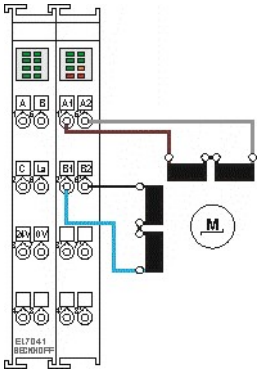


Figure 3-60: Bipolar control (serial) of a bipolar motor

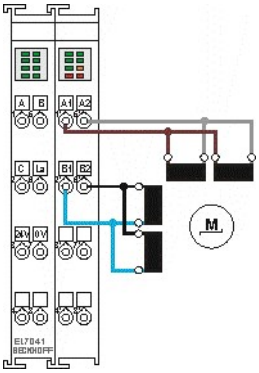


Figure 3-61: Bipolar control (parallel) of a bipolar motor

5.19.3.1.2 Unipolar Motors

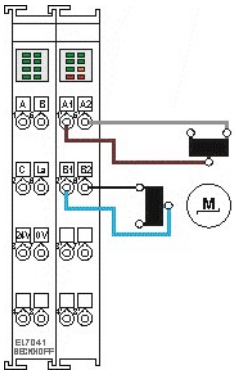


Figure 3-62: Bipolar control with only one half of each winding is controlled

5.19.3.1.3 Encoder

Connecting an encoder (24 V)

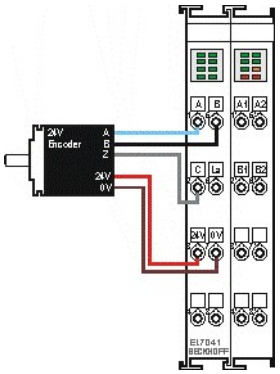


Figure 3-63: The encoder is supplied from the power contacts via terminal points 3 (+24 V) and 7 (0 V).

6 Notices on Analog Specifications

Kollmorgen I/O devices with analog inputs are characterized by a number of technical characteristic data; refer to the technical data in the respective sections. Some explanations are given below for the correct interpretation of these characteristic data.

6.1 Measuring Error / Measurement Deviation

The relative measuring error (% of the full scale value) is referenced to the full scale value and is calculated as the quotient of the largest numerical deviation from the true value (‘measuring error’) referenced to the full scale value.

The measuring error is generally valid for the entire permitted operating temperature range, also called the ‘usage error limit’ and contains random and systematic portions of the referred device (i.e. ‘all’ influences such as temperature, inherent noise, aging, etc.).

It is always to be regarded as a positive/negative span with ±, even if it is specified without ± in some cases.

$$\text{Measuring error} = \frac{\left|\text{max. deviation}\right|}{\text{full scale value}}$$

The maximum deviation can also be specified directly.

Example: Measuring range 0...10 V and measuring error < ± 0.3 % full scale value → maximum deviation ± 30 mV in the permissible operating temperature range.

NOTE

Lower measuring error

Since this specification also includes the temperature drift, a significantly lower measuring error can usually be assumed in case of a constant ambient temperature of the device and thermal stabilization after a user calibration.

This applies to analog output devices.

6.2 Temperature Coefficient tK [ppm/K]

An electronic circuit is usually temperature dependent to a greater or lesser degree. In analog measurement technology this means that when a measured value is determined by means of an electronic circuit, its deviation from the "true" value is reproducibly dependent on the ambient/operating temperature.

A manufacturer can alleviate this by using components of a higher quality or by software means.

The temperature coefficient, when indicated, allows the user to calculate the expected measuring error outside the basic accuracy at 23 °C.

Due to the extensive uncertainty considerations that are incorporated in the determination of the basic accuracy (at 23 °C), Kollmorgen recommends a quadratic summation.

Example: Let the basic accuracy at 23 °C be ±0.01% typ. (full scale value), tK = 20 ppm/K typ.; the accuracy A35 at 35 °C is wanted, hence ΔT = 12 K

$$G35 = \sqrt{(0.01\%)^2 + (12K \cdot 20\,\frac{ppm}{K})^2} = 0.026\%\ \text{full scale value, typ}$$

Remarks: ppm ≙10-6 % ≙10-2

6.3 Single-Ended / Differential Typification

For analog inputs Kollmorgen makes a basic distinction between two types: *single-ended* (SE) and *differential* (DIFF), referring to the difference in electrical connection with regard to the potential difference.

The diagram shows two-channel versions of an SE module and a DIFF module as examples for all multi- channel versions.

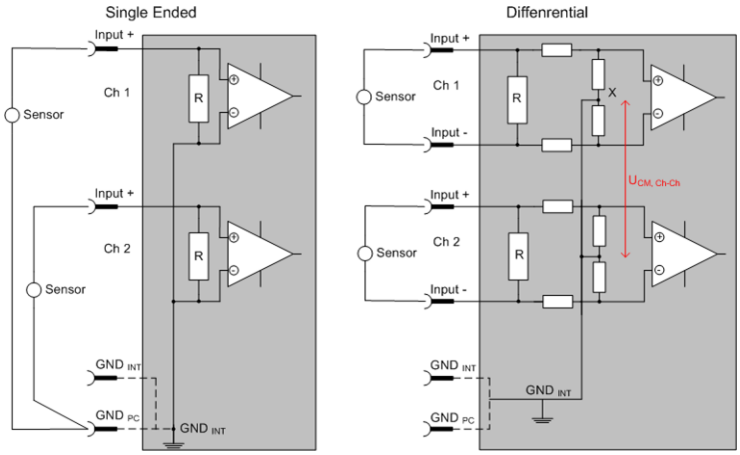


Figure 3-64: SE and DIFF module as 2-channel version

NOTE

Dashed lines indicate that the respective connection may not necessarily be present in each SE or DIFF module. Electrical isolated channels are operating as differential type in general, hence there is no direct relation (voltaic) to ground within the module established at all. Indeed, specified information to recommended and maximum voltage levels have to be taken into account.

The basic rule:

- Analog measurements always take the form of voltage measurements between two potential points. For voltage measurements a large R is used, in order to ensure a high impedance. For current measurements a small R is used as shunt. If the purpose is resistance measurement, corresponding considerations are applied.
  - Kollmorgen generally refers to these two points as input+/signal potential and input-/reference potential.
  - For measurements between two potential points two potentials have to be supplied.
  - Regarding the terms "single-wire connection" or "three-wire connection", please note the following for pure analog measurements: three- or four-wire connections can be used for sensor supply, but are not involved in the actual analog measurement, which always takes place between two potentials/wires.

    In particular this also applies to SE, even though the term suggest that only one wire is required.

- The term "electrical isolation" should be clarified in advance.

  IO modules feature 1..8 or more analog channels; with regard to the channel connection a distinction is made in terms of:

  - how the channels WITHIN a module relate to each other, or
  - how the channels of SEVERAL modules relate to each other.
  - The property of electrical isolation indicates whether the channels are directly connected to each other.
  - Terminals (and related product groups) always feature electrical isolation between the field/analog side and the bus/EtherCAT side. In other words, if two analog terminals/

boxes are not connected via the power contacts (cable), the modules are effectively electrically isolated.
- If channels within a module are electrically isolated, or if a single-channel module has no power contacts, the channels are effectively always differential. See also explanatory notes below. Differential channels are not necessarily electrically isolated.

- Analog measuring channels are subject to technical limits, both in terms of the recommended operating range (continuous operation) and the destruction limit. Please refer to the respective terminal/ box documentation for further details.

6.3.1 Explanation

- **differential (DIFF)**
  - Differential measurement is the most flexible concept. The user can freely choose both connection points, input+/signal potential and input-/reference potential, within the framework of the technical specification.
  - A differential channel can also be operated as SE, if the reference potential of several sensors is linked. This interconnection may take place via the system GND.
  - Since a differential channel is configured symmetrically internally (see Figure 3-64: SE and DIFF module as 2-channel version), there will be a mid-potential (X) between the two supplied potentials that is the same as the internal ground/reference ground for this channel. If several DIFF channels are used in a module without electrical isolation, the technical property VCM (common-mode voltage) indicates the degree to which the mean voltage of the channels may differ.
  - The internal reference ground may be accessible as connection point at the terminal/ box, in order to stabilize a defined GND potential in the terminal/ box. In this case it is particularly important to pay attention to the quality of this potential (noiselessness, voltage stability). At this GND point a wire may be connected to make sure that $V_{CM,max}$ is not exceeded in the differential sensor cable. If differential channels are not electrically isolated, usually only one $V_{CM,\ max}$ is permitted. If the channels are electrically isolated this limit should not apply, and the channels voltages may differ up to the specified separation limit.
  - Differential measurement in combination with correct sensor wiring has the special advantage that any interference affecting the sensor cable (ideally the feed and return line are arranged side by side, so that interference signals have the same effect on both wires) has very little effect on the measurement, since the potential of both lines varies jointly (hence the term common mode). In simple terms: Common-mode interference has the same effect on both wires in terms of amplitude and phasing.
  - Nevertheless, the suppression of common-mode interference within a channel or between channels is subject to technical limits, which are specified in the technical data.

- **Single Ended (SE)**
  - If the analog circuit is designed as SE, the input/reference wire is internally fixed to a certain potential that cannot be changed. This potential must be accessible from outside on at least one point for connecting the reference potential, e.g. via the power contacts (cable).
  - In other words, in situations with several channels SE offers users the option to avoid returning at least one of the two sensor cables to the terminal/ box (in contrast to DIFF). Instead, the reference wire can be consolidated at the sensors, e.g. in the system GND.
  - A disadvantage of this approach is that the separate feed and return line can result in voltage/ current variations, which a SE channel may no longer be able to handle. See common-mode interference. A V_{CM} effect cannot occur since the module channels are internally always "hard- wired" through the input/reference potential.

6.3.2 Typification of the 2/3/4-wire connection of current sensors

Current transducers/sensors/field devices (referred to in the following simply as 'sensor') with the industrial 0/4-20 mA interface typically have internal transformation electronics for the physical measured variable (temperature, current, etc.) at the current control output. These internal electronics must be supplied with energy (voltage, current). The type of cable for this supply thus separates the sensors into Self-supplied sensors or Externally Supplied Sensors:

6.3.2.1 Self-supplied sensors

- The sensor draws the energy for its own operation via the sensor/signal cable + and -.

  So that enough energy is always available for the sensor's own operation and open-circuit detection is possible, a lower limit of 4 mA has been specified for the 4-20 mA interface; i.e. the sensor allows a minimum current of 4 mA and a maximum current of 20 mA to pass.
- 2-wire connection see Fig. 2-wire connection, cf. IEC60381-1
- Such current transducers generally represent a current sink and thus like to sit between + and – as a 'variable load'. Refer also to the sensor manufacturer's information.

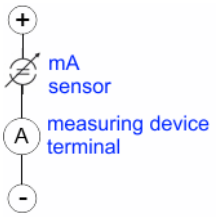


Figure 3-65: 2-wire connection

Therefore, they are to be connected according to the Kollmorgen terminology as follows:

- preferably to **"single-ended" inputs** if the +Supply connections of the terminal/ box are also to be used - connect to +Supply and Signal
- they can, however, also be connected to **differential inputs**, if the termination to GND is then manufactured on the application side – to be connected with the right polarity to +Signal and –Signal

6.3.3 Externally Supplied Sensors

- 3- and 4-wire connection see Figure 3-66: Connection of externally supplied sensors, cf. IEC60381-1
- the sensor draws the energy/operating voltage for its own operation from 2 supply cables of its own. One or two further sensor cables are used for the signal transmission of the current loop:
  - 1 sensor cable: according to the Kollmorgen terminology such sensors are to be connected to "single-ended" inputs in 3 cables with +/-/Signal lines and if necessary FE/shield
  - 2 sensor cables: for sensors with 4-wire connection based on +supply/-supply/+signal/-signal, check whether +signal can be connected to +supply or –signal to –supply.
    - Yes: then you can connect accordingly to a Kollmorgen "single-ended" input.
    - No: the Kollmorgen "differential" input for +Signal and –Signal is to be selected; +Supply and – Supply are to be connected via additional cables.

NOTE

Note: Expert organizations such as NAMUR demand a usable measuring range <4 mA/>20 mA for error detection and adjustment, see also NAMUR NE043.

The Kollmorgen device documentation must be consulted in order to see whether the respective device supports such an extended signal range.

Usually there is an internal diode existing within unipolar terminals/ boxes (and related product groups), in this case the polarity/direction of current have to be observed.

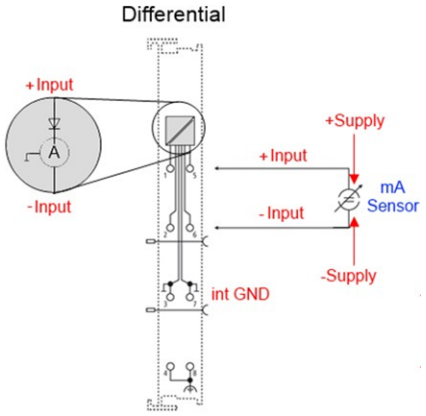


Figure 3-66: Connection of externally supplied sensors

Classification of the Kollmorgen terminals - Kollmorgen 0/4-20 mA terminals (and related product groups) are available as differential terminals (and related product groups):

Differential
AN-240, AN-400: 0-20 mA
Preferred current direction because of internal diode
The terminal is a passive differential current measuring device; passive means that the sensor is not supplied with power.

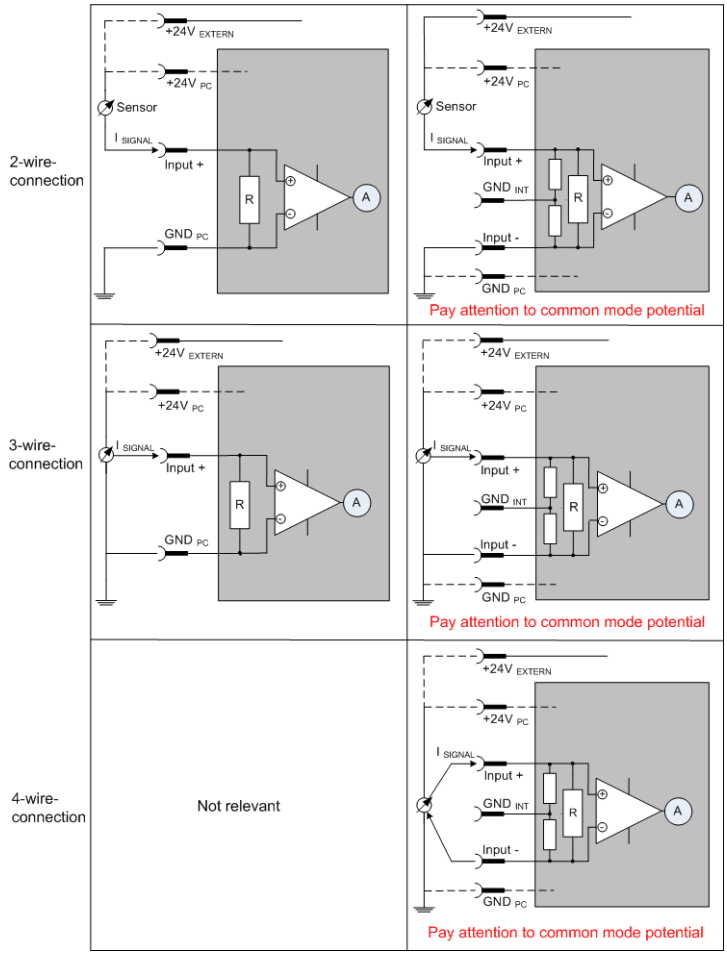


Figure 3-67: 2-, 3- and 4-wire connection at single-ended and differential inputs

6.4 Common-mode voltage and reference ground (based on differential inputs)

Common-mode voltage (V_{cm}) is defined as the average value of the voltages of the individual connections/ inputs and is measured/specified against reference ground.

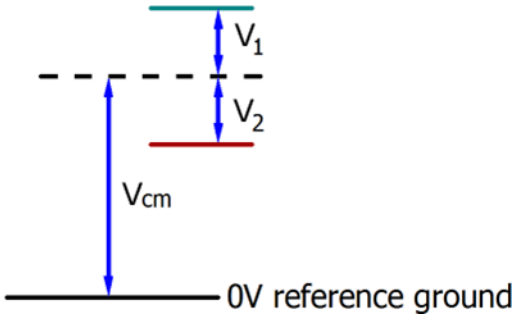


Figure 3-68: Common-mode voltage (V_{cm})

The definition of the reference ground is important for the definition of the permitted common-mode voltage range and for measurement of the common-mode rejection ratio (CMRR) for differential inputs.

The reference ground is also the potential against which the input resistance and the input impedance for single-ended inputs or the common-mode resistance and the common-mode impedance for differential inputs is measured.

The reference ground is usually accessible at or near the terminal/ box, e.g. at the terminal contacts, power contacts (cable) or a mounting rail. Please refer to the documentation regarding positioning. The reference ground should be specified for the device under consideration.

For multi-channel terminals/ boxes with resistive (=direct, ohmic, galvanic) or capacitive connection between the channels, the reference ground should preferably be the symmetry point of all channels, taking into account the connection resistances.

Reference ground samples for Kollmorgen IO devices:

1. Earth or SGND (shield GND):
   - AKT2G-AN-400: No internal ground fed out to the terminal points, although capacitive coupling to SGND

6.5 Dielectric strength

A distinction should be made between:

- • Dielectric strength (destruction limit): Exceedance can result in irreversible changes to the electronics
  - ◦Against a specified reference ground
  - ◦Differential
- • Recommended operating voltage range: If the range is exceeded, it can no longer be assumed that the system operates as specified
  - ◦Against a specified reference ground
  - ◦Differential

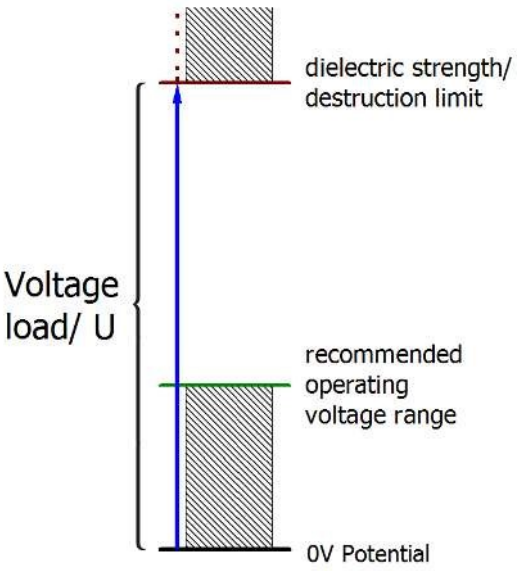


Figure 3-69: Recommended operating voltage range

The device documentation may contain particular specifications and timings, taking into account:

- Self-heating
- Rated voltage
- Insulating strength
- Edge steepness of the applied voltage or holding periods
- Normative environment (e.g. PELV)

6.6 Temporal Aspects of Analog/Digital Conversion

The conversion of the constant electrical input signal to a value-discrete digital and machine-readable form takes place in the analog Kollmorgen input modules with ADC (analog digital converter). Although different ADC technologies are in use, from a user perspective they all have a common characteristic: after the conversion a certain digital value is available in the controller for further processing. This digital value, the so-called analog process data, has a fixed temporal relationship with the “original parameter”, i.e. the electrical input value. Therefore, corresponding temporal characteristic data can be determined and specified for Kollmorgen analog input devices.

This process involves several functional components, which act more or less strongly in every AI (analog input) module:

- the electrical input circuit
- the analog/digital conversion
- the digital further processing
- the final provision of the process and diagnostic data for collection at the fieldbus (EtherCAT, K-bus, etc.)

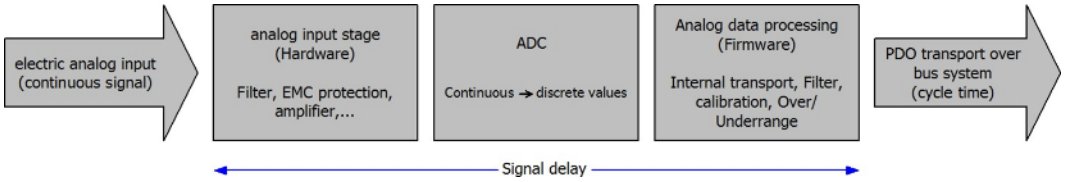


Figure 3-70: Signal processing analog input

Two aspects are crucial from a user perspective:

- “How often do I receive new values?”, i.e. a sampling rate in terms of speed with regard to the device/ channel
- What delay does the (whole) AD conversion of the device/channel cause?

  I.e. the hardware and firmware components in its entirety. For technological reasons, the signal characteristics must be taken into account when determining this information: the run times through the system differ, depending on the signal frequency.

This is the “external” view of the “Kollmorgen AI channel” system – internally the signal delay in particular is composed of different components: hardware, amplifier, conversion itself, data transport and processing. Internally a higher sampling rate may be used (e.g. in the deltaSigma converters) than is offered “externally” from the user perspective. From a user perspective of the “Kollmorgen AI channel” component this is usually irrelevant or is specified accordingly, if it is relevant for the function.

For Kollmorgen AI devices the following specification parameters for the AI channel are available for the user from a temporal perspective:

1. Minimum conversion time [ms, µs]

   This is the reciprocal value of the maximum sampling rate [sps, samples per second]:

   Indicates how often the analog channel makes a newly detected process data value available for collection by the fieldbus. Whether the fieldbus (EtherCAT, K-bus) fetches the value with the same speed (i.e. synchronous), or more quickly (if the AI channel operates in slow FreeRun mode) or more slowly (e.g. with oversampling), is then a question of the fieldbus setting and which modes the AI device supports.

   For EtherCAT devices the so-called toggle bit indicates (by toggling) for the diagnostic PDOs when a newly determined analog value is available.

   Accordingly, a maximum conversion time, i.e. a smallest sampling rate supported by the AI device, can be specified.

   Corresponds to IEC 61131-2, section 7.10.2 2, “Sampling repeat time”

2. Typical signal delay

   Corresponds to IEC 61131-2, section 7.10.2 1, “Sampling duration”. From this perspective it includes all internal hardware and firmware components, but not “external” delay components from the fieldbus.

   This delay is particularly relevant for absolute time considerations, if AI channels also provide a time stamp that corresponds to the amplitude value – which can be assumed to match the physically prevailing amplitude value at the time.

   Due to the frequency-dependent signal delay time, a dedicated value can only be specified for a given signal. The value also depends on potentially variable filter settings of the channel.

   A typical characterization in the device documentation may be:

   1. Signal delay (step response)

      Keywords: Settling time

      The square wave signal can be generated externally with a frequency generator (note impedance!) The 90 % limit is used as detection threshold.

      The signal delay [ms, µs] is then the time interval between the (ideal) electrical square wave signal and the time at which the analog process value has reached the 90 % amplitude.

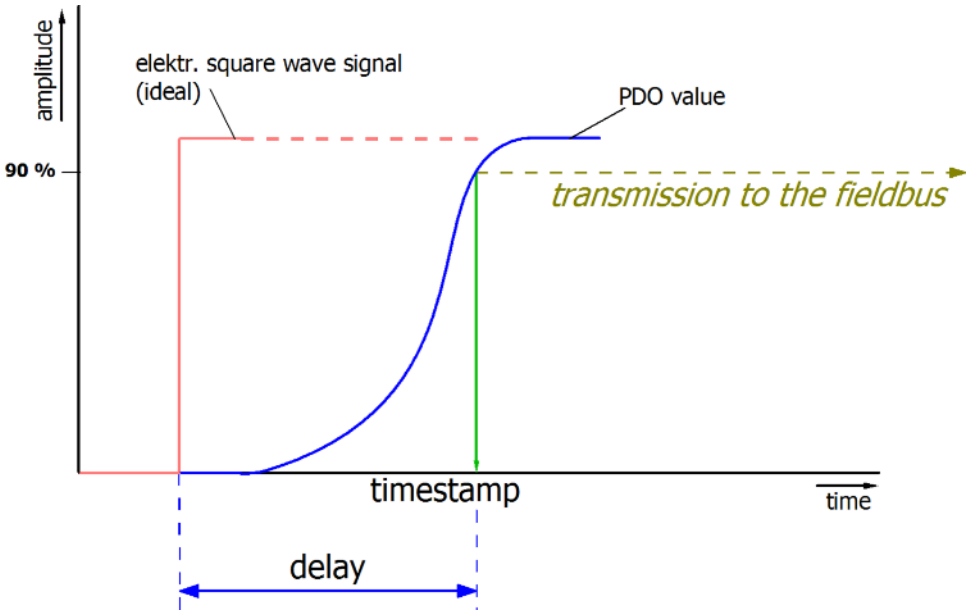


Figure 3-71: Diagram signal delay (step response)

   2. Signal delay (linear)

      Keyword: Group delay

      Describes the delay of a signal with constant frequency

      A test signal can be generated externally with a frequency generator, e.g. as sawtooth or sine. A simultaneous square wave signal would be used as reference.

      The signal delay [ms, µs] is then the interval between the applied electrical signal with a particular amplitude and the moment at which the analog process value reaches the same value.

      A meaningful range must be selected for the test frequency, e.g. 1/20 of the maximum sampling rate.

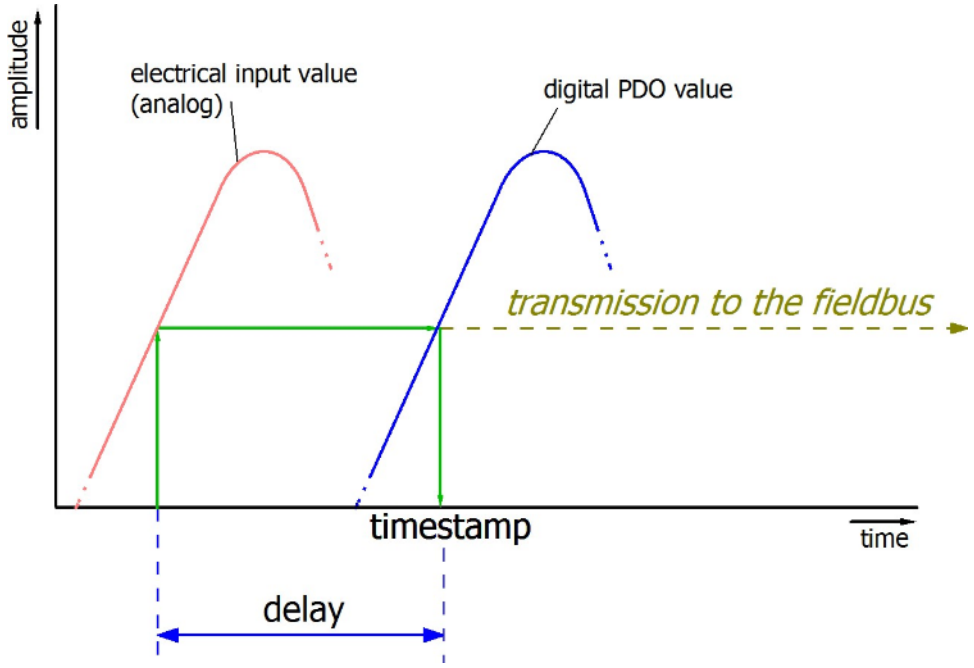


Figure 3-72: Diagram signal delay (linear)

3. Additional Information

   May be provided in the specification, e.g.

   - Actual sampling rate of the ADC (if different from the channel sampling rate)
   - Time correction values for run times with different filter settings
   - etc.

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