

Documentation | EN

KL320x/KS320x

Analog Input Terminals for Pt100 (RTD) or NTC10K

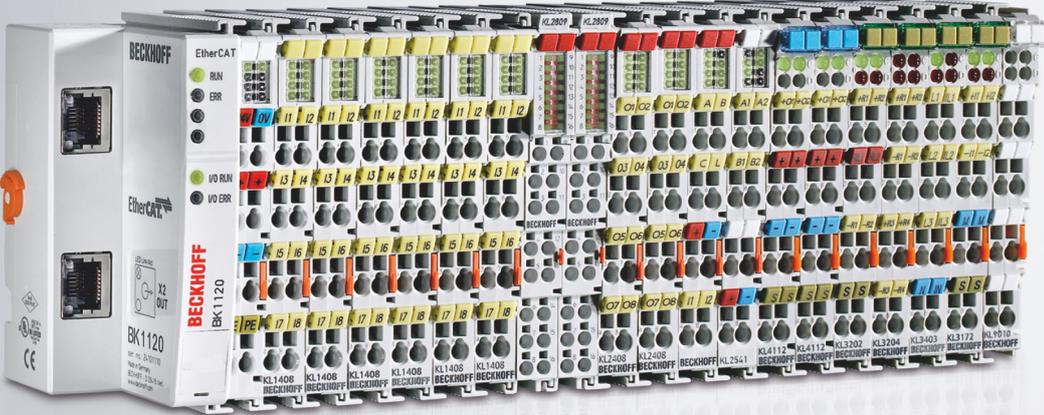


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1 Foreword

1.1 Notes on the documentation

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 documentation and the following notes and explanations are followed when installing and commissioning these components.

It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

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.

Trademarks

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The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

The logo for EtherCAT, featuring the word "EtherCAT" in a bold, black, sans-serif font. A red arrow points from the top of the "A" towards the right, ending above the "T". A registered trademark symbol (®) is located to the right of the "T".

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1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability

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 Beckhoff Automation GmbH & Co. KG.

Personnel qualification

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

Description of instructions

In this documentation the following instructions are used.
These instructions must be read carefully and followed without fail!

DANGER

Serious risk of injury!

Failure to follow this safety instruction directly endangers the life and health of persons.

WARNING

Risk of injury!

Failure to follow this safety instruction endangers the life and health of persons.

CAUTION

Personal injuries!

Failure to follow this safety instruction can lead to injuries to persons.

NOTE

Damage to environment/equipment or data loss

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.



Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Documentation Issue Status

Version	Comment
4.6	<ul style="list-style-type: none"> Chapter <i>Technical data</i> updated Chapter <i>Basic Function Principles</i> updated
4.5	<ul style="list-style-type: none"> Chapter <i>Technical data</i> updated Document structure updated Chapter <i>Instruction for ESD protection</i> added Chapter <i>Disposal</i> added New title page Revision status updated
4.4	<ul style="list-style-type: none"> Firmware and hardware versions updated Chapter <i>Basic Function Principles</i> updated
4.3	<ul style="list-style-type: none"> Update Firmware and hardware versions Chapter <i>Technical data</i> updated Chapter <i>Installation instructions for enhanced mechanical load capacity</i> added Chapter <i>TwinCAT</i> including Link to FB_KL320xConfig added
4.2	<ul style="list-style-type: none"> KL3204-0030 added
4.1	<ul style="list-style-type: none"> Update appendix
4.0	<ul style="list-style-type: none"> Migration in ST4 Update structure

Firmware and hardware versions

Documentation Version	KL3201, KS3201		KL3202, KS3202	
	Firmware	Hardware	Firmware	Hardware
4.6	3G	10	3G	10
4.5	3G	10	3G	10
4.4	3G	09	3G	09
4.3	3G	09	3G	09
4.0	3G	08	3G	08

Documentation Version	KL3204, KS3204		KL3204-0030	
	Firmware	Hardware	Firmware	Hardware
4.6	3E	06	42	06
4.5	3E	06	42	06
4.4	3E	05	42	05
4.3	3E	05	42	05
4.0	3E	05	42	05

The firmware and hardware versions (delivery state) can be taken from the serial number printed on the side of the terminal.

Syntax of the serial number

Structure of the serial number: WW YY FF HH
 WW - week of production (CW, calendar week)
 YY - year of production
 FF - firmware version
 HH - hardware version

Example with serial number 47 15 1A 00:
 47 - week of production 47
 15 - year of production 2015
 1A - firmware version 1A
 00 - hardware version 00

2 Product overview

2.1 Introduction

KL3201, KL3202

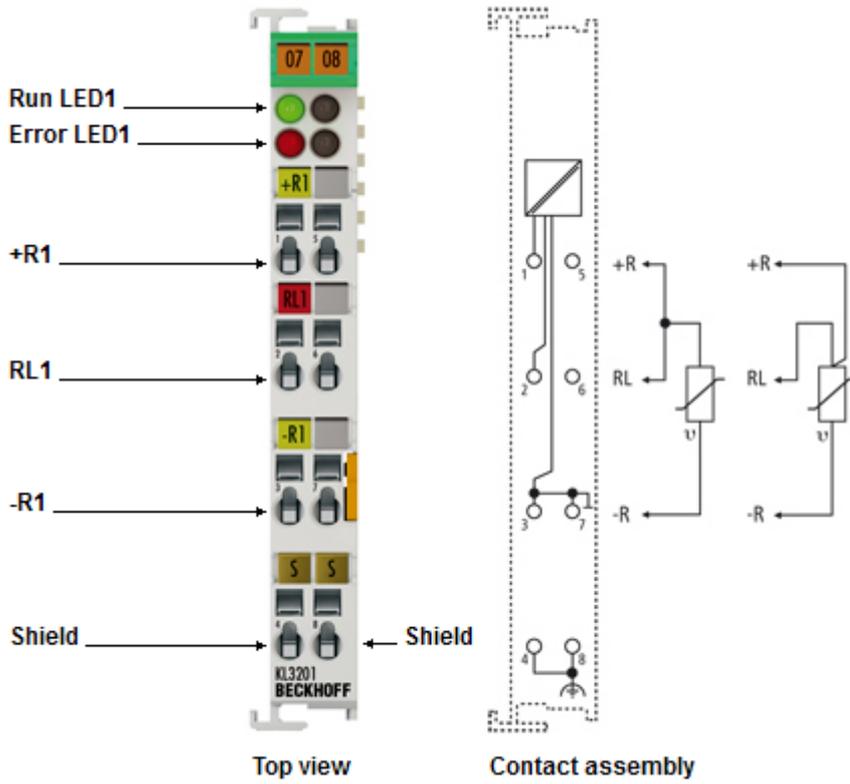


Fig. 1: KL3201

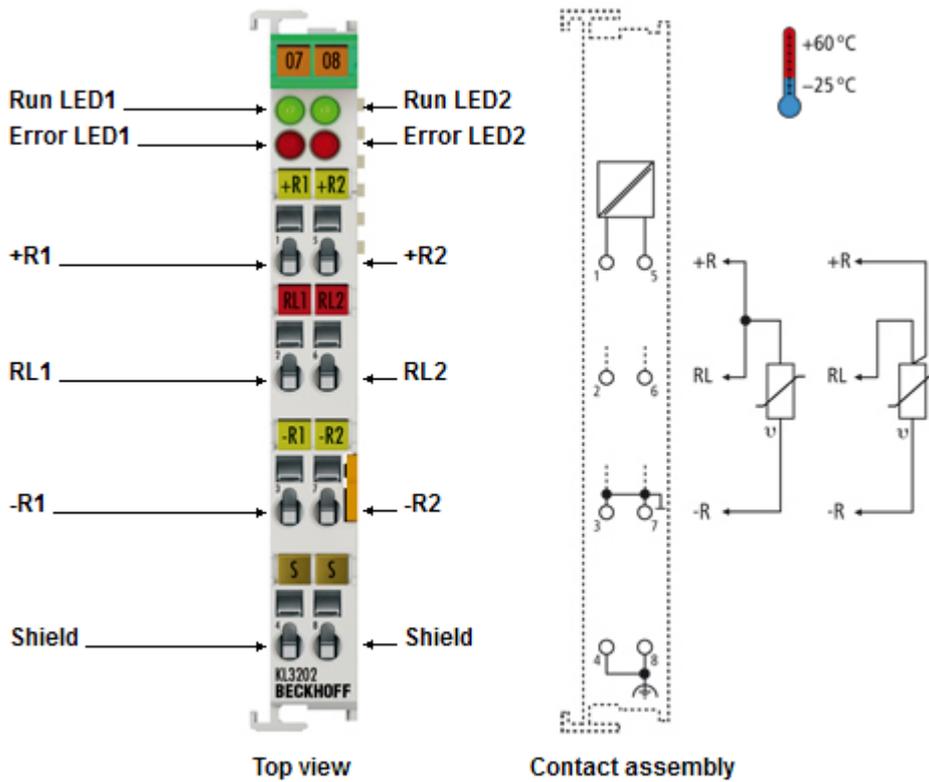


Fig. 2: KL3202

The KL3201 and KL3202 analog input terminals allow resistance sensors to be connected directly. The Bus Terminal's circuitry can operate the sensors using 2-wire or 3-wire connection techniques.

Linearization over the full temperature range is realized with the aid of a microprocessor. The temperature range can be selected freely. The Bus Terminal's standard settings are: Resolution 0.1°C in the temperature range of PT100 sensors in 3-wire connection.

The two Run LEDs indicate data exchange with the Bus Coupler, the error LEDs show sensor faults (e.g. broken wire).

KL3204-0000

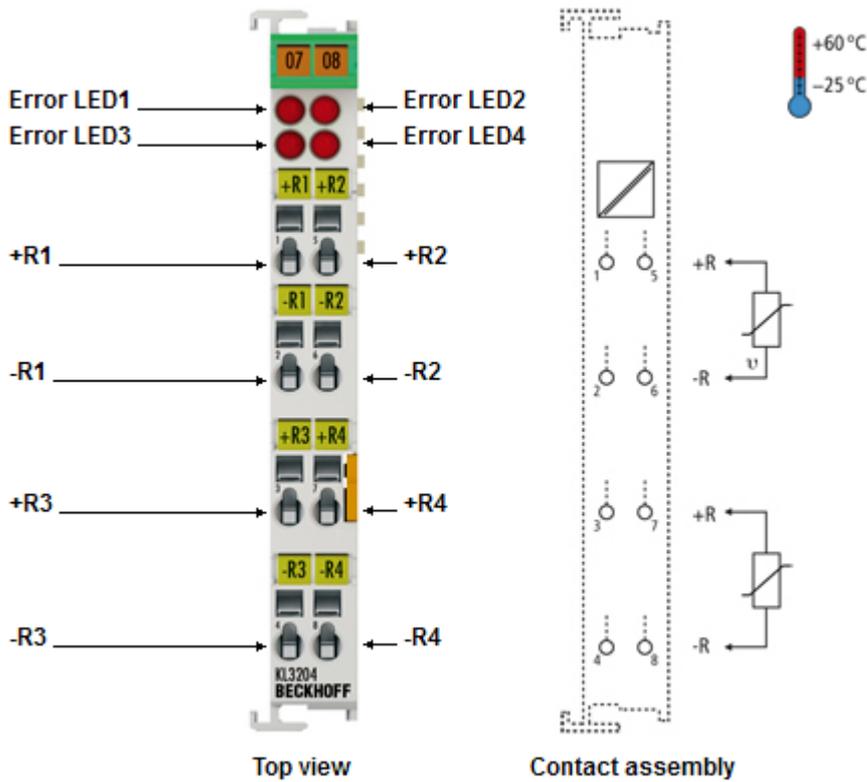


Fig. 3: KL3204-0000

The KL3204-0000 analog input terminal allows resistance sensors to be connected directly. The Bus Terminal's circuitry can handle sensors using the 2-wire technique.

Linearization over the full temperature range is realized with the aid of a microprocessor. The temperature range can be selected freely. The Bus Terminal's standard settings are: Resolution 0.1°C over the temperature range of PT100 sensors.

The error LEDs indicate sensor faults (e.g. a broken wire). The KL3204-0000 combines four channels in a single housing.

KL3204-0030

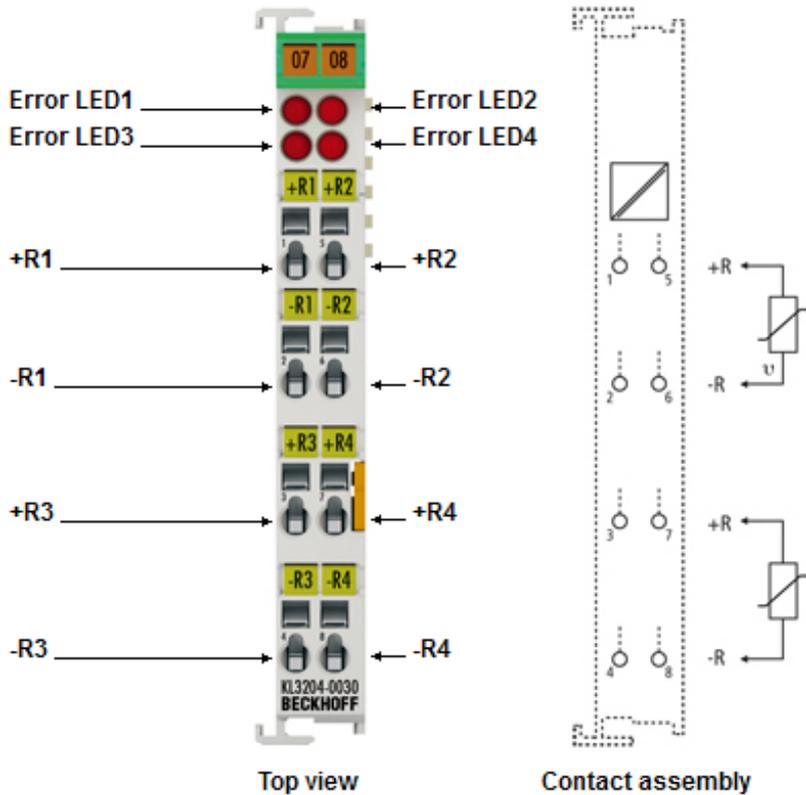


Fig. 4: KL3204-0030

The KL3204-0030 analog input terminal enables four NTC resistance sensors to be connected directly. The Bus Terminal's circuitry can handle sensors using the 2-wire technique. Linearization over the full temperature range is realised with the aid of a microprocessor. The standard setting of the Bus Terminal is a resolution of 0.1°C in the temperature range of the NTC 10 kΩ sensors. The error LEDs indicate sensor faults (e.g. a broken wire). The KL3204-0030 combines four channels in a single housing.

2.2 Technical data

Technical data	KL3201, KS3201	KL3202, KS3202	KL3204, KS3204	KL3204-0030
Number of inputs	1	2	4	
Power supply	via the K-bus			
Sensor types	PT100, PT200, PT500, PT1000, Ni100, Ni120, Ni1000 resistance measurement (e.g. potentiometer connection)			NTC (10 kΩ), no resistance output
Connection technology	2 or 3-wire (pre-set to 3-wire)		2-wire	
Temperature range	-200°C ... +850°C (PT sensors); -60°C ... +250°C (Ni sensors)			
Resolution	0.1°C per digit (measuring range 10 to 5000 Ω: 0.5°C per digit)			
Electrical isolation	500 V (K-bus/signal voltage)			
Conversion time	~ 200 ms	~ 250 ms		
Measuring current	typically 0.5 mA			typically <0.5 mA
Measuring error (total meas. range)	< ± 1°C	< ± 1 C (at 0°C ... +55°C) < ± 1.5% (when the extended temperature range is used)		
Bit width in process image	Input: 1 x 16 bit data (1 x 8 bit Control/ Status optional)	Input: 2 x 16 bit data (2 x 8 bit Control/ Status optional)	Input: 4 x 16 bit data (4 x 8 bit Control/ Status optional)	
Current consumption from K-bus	typically 60 mA			
Configuration	no address setting, configuration via bus coupler or controller			
Special features	Wiring fail indication			
Weight	approx. 70 g			
Permissible ambient temperature range (operation)	0°C ... +55°C	-25°C ... +60°C in operation (extended temperature range)		0°C ... +55°C
Permissible ambient temperature range (storage)	-25°C ... +85°C	-40°C ... +85°C		-25°C ... +85°C
Relative humidity	95%, no condensation			
Enhanced mechanical load capacity	yes, see also installation instructions for enhanced mechanical load capacity [► 20]			no
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			
Installation position	variable			
Protection class	IP20			
Approvals / markings*	CE, UKCA, cULus, EAC, GL ATEX [► 28]	CE, UKCA, cULus, EAC, GL ATEX [► 29]		CE, UKCA, cULus, EAC

*) Real applicable approvals/markings see type plate on the side (product marking).

Ex marking

Standard	Marking
ATEX	II 3 G Ex nA IIC T4 Gc

2.3 Basic function principles

Properties

The KL320x analog input terminals enable resistance sensors to be connected directly. The conversion and linearization of the resistance value into a temperature is done locally in the terminal. The measured values are output in the following scaling:

- **for KL3201, KL3202, KL3204:**
 - Temperature measuring ranges: 1/10 °C (1 digit = 0.1 °C)
The elements PT100, NI100, PT200, PT500, NI120, NI1000 and PT1000 are implemented as resistance sensors over the specified measuring range.
 - Measuring range 10 to 5000 Ω: 1/2 Ω (1 digit = 0.5 Ω)
 - Measuring range 10 to 1200 Ω: 1/16 Ω (1 digit = 0.0625 Ω)
(The internal resolution of the resistance value is 1/255 Ω)
- **for KL3204-0030 (temperature output only, NTC10K carel characteristic curve, resistance at 0 °C: 27280 Ω):**
 - Measuring range -40 °C to 110 °C: 1/10 °C (1 digit = 0.1 °C)
No resistance output possible!

In addition to this, a wire break or short circuit is reported to the bus coupler or to the controller, and indicated by the ERROR LED.

The terminal can be fully configured over the fieldbus. A self-defined scaling of the output can, for instance, be performed, or the temperature conversion can be switched off (not for KL3204-0030).

Process data output format

In the delivery state, the measured value is displayed in increments of 1/10° C in two's complement format (integer). The complete measuring range is output for each resistance sensor. Other display types can be selected via the feature register (e.g. sign/amount representation, Siemens output format).

Measured value	Hexadecimal output	Signed integer output
-250.0°C	0xF63C	-2500
-200.0°C	0xF830	-2000
-100.0°C	0xFC18	-1000
-0.1°C	0xFFFF	-1
0.0°C	0x0000	0
0.1°C	0x0001	1
100.0°C	0x03E8	1000
200.0°C	0x07D0	2000
500.0°C	0x1388	5000
850.0°C	0x2134	8500

Resistance limit values

- R > 400 Ω: Bits 1 and 6 (over range and error bits) in the status byte are set.

The linearization of the characteristic curve is continued with the coefficients of the upper range limit up to the limit stop of the A/D converter (approx. 500 Ω for PT100).

- R < 18 Ω: Bits 0 and 6 (under range and error bits) in the status byte are set.

The smallest negative number is displayed (0x8001 corresponds to -32767).
For over range or under range the red error LED is switched on.

Process data

The process data that are transferred to the terminal bus are calculated using the following equations:

Variable	Meaning
X_RL	ADC value of the supply cables
X_RTD	ADC value of the temperature sensor, including one supply cable
X_R	ADC value of the temperature sensor
A_a, B_a	Manufacturer gain and offset calibration (R17, R18)
A_h, B_h	Manufacturer scaling
A_w, B_w:	User scaling
Y_R	Temperature sensor resistance value
Y_T	measured temperature in 1/16 °C
Y_THS	Temperature after manufacturer scaling (1/10 °C)
Y_TAS	Temperature after user scaling
Y_AUS	Process data to PLC

a) Calculation of the resistance value:

$$X_R = X_{RTD} - X_{RL} \quad (1.0)$$

$$Y_R = A_a * (X_R - B_a) \quad (1.1)$$

b) Curve linearization:

$$Y_T = a1 * Y_{R2} + b1 * Y_R + c1 \quad (1.2)$$

or

$$Y_T = Y_R \text{ if output in } \Omega \quad (1.3)$$

c) Neither user nor manufacturer scaling are active:

$$Y_{AUS} = Y_T \quad (1.4)$$

d) Manufacturer scaling active (factory setting):

$$Y_{THS} = A_h * Y_T + B_h \quad (1.5)$$

$$Y_{AUS} = Y_{THS}$$

e) User scaling active:

$$Y_{TAS} = A_w * Y_T + B_w \quad (1.6)$$

$$Y_{AUS} = Y_{TAS}$$

f) Manufacturer and user scaling active: (1.7)

$$Y_1 = A_h * Y_T + B_h$$

$$Y_2 = A_w * Y_1 + B_w$$

$$Y_{AUS} = Y_2$$

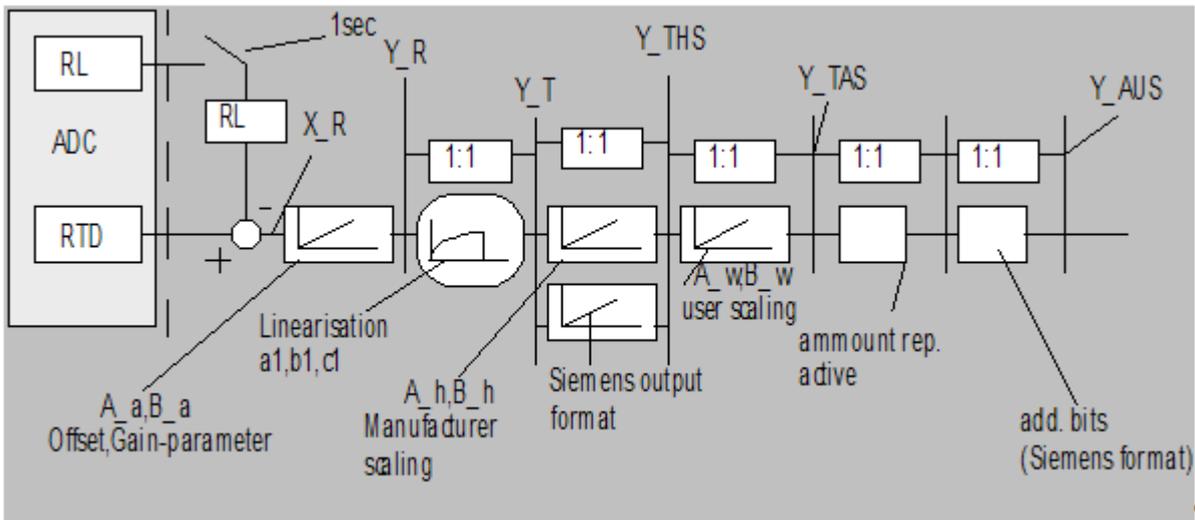


Fig. 5: Data flow of the KL320x

2.4 Continuative documentation for I/O components with analog in and outputs

NOTE



Continuative documentation for I/O components with analog in and outputs

Pay also attention to the continuative documentation

I/O Analog Manual

Notes on I/O components with analog inputs and outputs,

which is available for download on the Beckhoff homepage <https://www.beckhoff.com> on the respective product pages!

It explains the basics of sensor technology and contains notes on analog measured values.

3 Mounting and wiring

3.1 Instructions for ESD protection

NOTE

Destruction 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 probably, when handling with the devices.
- Each assembly must be terminated at the right hand end with a KL9010 bus end terminal, to ensure the protection class and ESD protection.

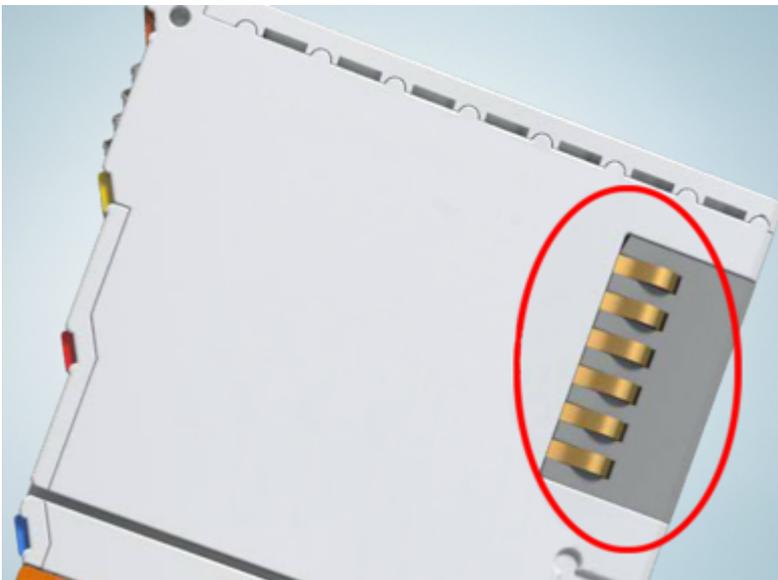


Fig. 6: Spring contacts of the Beckhoff I/O components

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!

Assembly

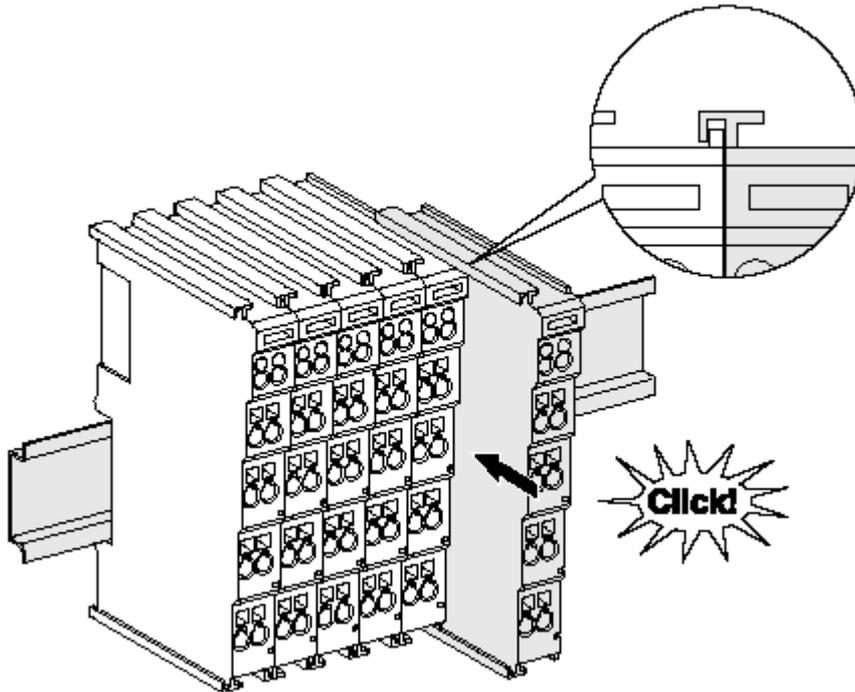


Fig. 7: Attaching on mounting rail

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.

i 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).

Disassembly

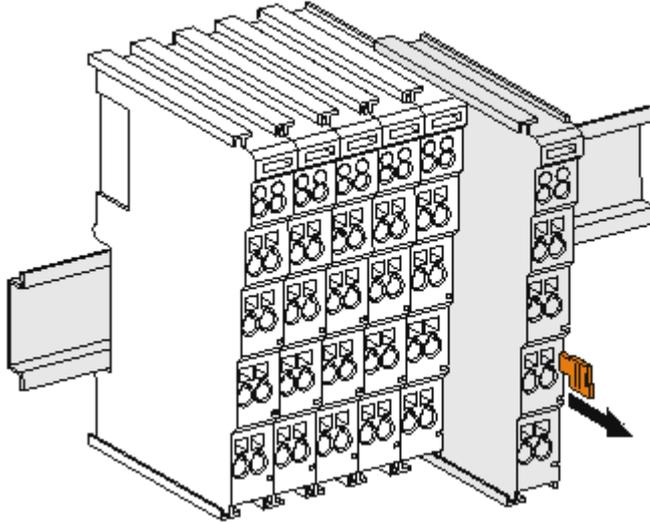


Fig. 8: Disassembling of terminal

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.

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 K-Bus/E-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.

i 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 (KL91xx, KL92xx or EL91xx, EL92xx) interrupt the power contacts and thus represent the start of a new supply rail.

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.

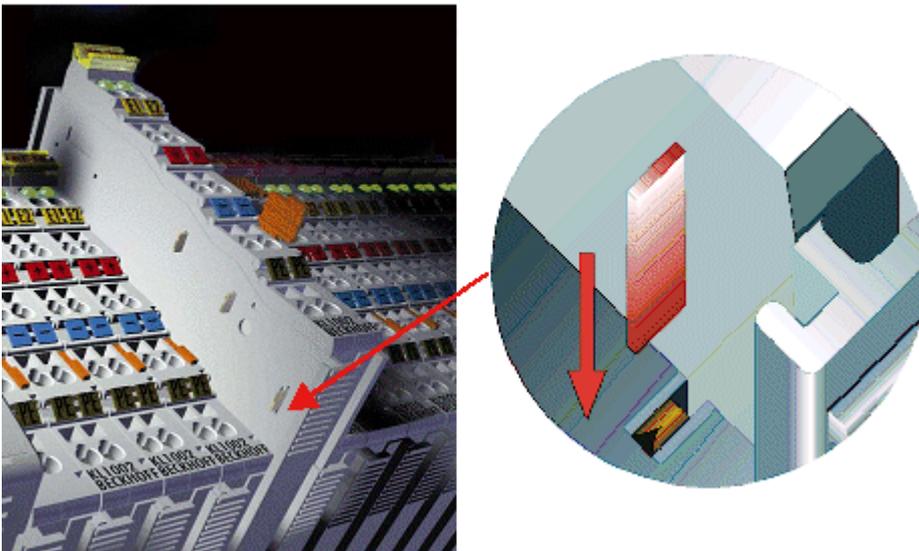


Fig. 9: Power contact on left side

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 Disposal



Products marked with a crossed-out wheeled bin shall not be discarded with the normal waste stream. The device is considered as waste electrical and electronic equipment. The national regulations for the disposal of waste electrical and electronic equipment must be observed.

3.4 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!

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

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.

3.5 Connection

3.5.1 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!

Overview

The bus terminal system offers different connection options for optimum adaptation to the respective application:

- The terminals of ELxxxx and KLxxxx series with standard wiring include electronics and connection level in a single enclosure.
- The terminals of ESxxxx and KSxxxx series feature a pluggable connection level and enable steady wiring while replacing.
- The High Density Terminals (HD Terminals) include electronics and connection level in a single enclosure and have advanced packaging density.

Standard wiring (ELxxxx / KLxxxx)



Fig. 10: Standard wiring

The terminals of ELxxxx and KLxxxx series have been tried and tested for years. They feature integrated screwless spring force technology for fast and simple assembly.

Pluggable wiring (ESxxxx / KSxxxx)



Fig. 11: Pluggable wiring

The terminals of ESxxxx and KSxxxx series feature a pluggable connection level. The assembly and wiring procedure is the same as for the ELxxxx and KLxxxx series. The pluggable connection level enables the complete wiring to be removed as a plug connector from the top of the housing for servicing. The lower section can be removed from the terminal block by pulling the unlocking tab. Insert the new component and plug in the connector with the wiring. This reduces the installation time and eliminates the risk of wires being mixed up.

The familiar dimensions of the terminal only had to be changed slightly. The new connector adds about 3 mm. The maximum height of the terminal remains unchanged.

A tab for strain relief of the cable simplifies assembly in many applications and prevents tangling of individual connection wires when the connector is removed.

Conductor cross sections between 0.08 mm² and 2.5 mm² can continue to be used with the proven spring force technology.

The overview and nomenclature of the product names for ESxxxx and KSxxxx series has been retained as known from ELxxxx and KLxxxx series.

High Density Terminals (HD Terminals)



Fig. 12: High Density Terminals

The terminals from these series with 16 terminal points are distinguished by a particularly compact design, as the packaging density is twice as large as that of the standard 12 mm bus terminals. Massive conductors and conductors with a wire end sleeve can be inserted directly into the spring loaded terminal point without tools.

● Wiring HD Terminals

i The High Density Terminals of the ELx8xx and KLx8xx series doesn't support pluggable wiring.

Ultrasonically “bonded” (ultrasonically welded) conductors

● Ultrasonically “bonded” conductors

i It is also possible to connect the Standard and High Density Terminals with ultrasonically “bonded” (ultrasonically welded) conductors. In this case, please note the tables concerning the wire-size width [► 23]!

3.5.2 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!

Terminals for standard wiring ELxxxx/KLxxxx and for pluggable wiring ESxxxx/KSxxxx

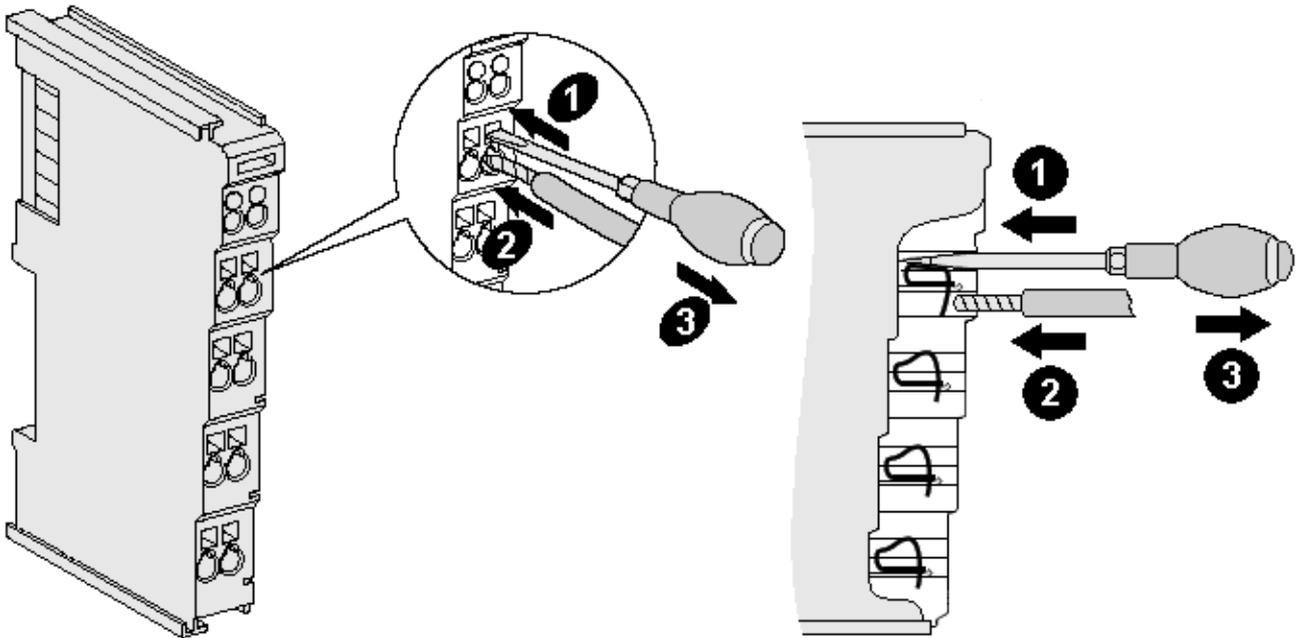


Fig. 13: Connecting a cable on a terminal point

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	ELxxxx, KLxxxx	ESxxxx, KSxxxx
Wire size width (single core wires)	0.08 ... 2.5 mm ²	0.08 ... 2.5 mm ²
Wire size width (fine-wire conductors)	0.08 ... 2.5 mm ²	0.08 ... 2.5 mm ²
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm ²	0.14 ... 1.5 mm ²
Wire stripping length	8 ... 9 mm	9 ... 10 mm

High Density Terminals (HD Terminals [▶ 22]) with 16 terminal points

The conductors of the HD Terminals are connected without tools for single-wire conductors using the direct plug-in technique, i.e. after stripping the wire is simply plugged into the terminal point. The cables are released, as usual, using the contact release with the aid of a screwdriver. See the following table for the suitable wire size width.

Terminal housing	High Density Housing
Wire size width (single core wires)	0.08 ... 1.5 mm ²
Wire size width (fine-wire conductors)	0.25 ... 1.5 mm ²
Wire size width (conductors with a wire end sleeve)	0.14 ... 0.75 mm ²
Wire size width (ultrasonically "bonded" conductors)	only 1.5 mm ² (see notice [▶ 22])
Wire stripping length	8 ... 9 mm

3.5.3 Shielding



Shielding

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

3.6 Contact assignment and LEDs

⚠ 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.

KL3201/KS3201

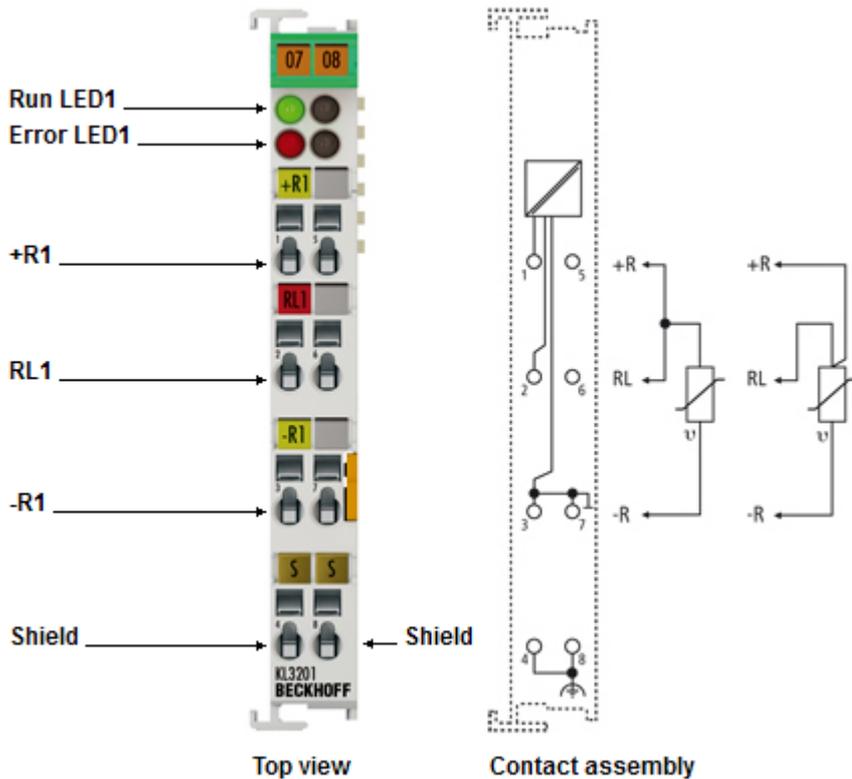


Fig. 14: KL3201 - Contact assignment and LEDs

Terminal point	No.	Comment
+R1	1	Input +R1
RL1	2	Input RL
-R1	3	Input -R1 (internally connected with terminal point 7)
Shield	4	Shield, FE (internally connected to terminal point 8)
n.c.	5	not connected
n.c.	6	not connected
-R1	7	Input -R1 (internally connected with terminal point 3)
Shield	8	Shield, FE (internally connected to terminal point 4)

LED displays

LED	Color	Description	
Run	green	On	Normal operation
		Off	Watchdog-timer overflow has occurred. If no process data is transmitted to the bus coupler for 100 ms, the green LEDs go out
Error	red	On	The respective channel is affected by a short circuit or broken wire. The resistance is in the invalid range of the characteristic curve.
		Off	The resistance is in the valid range of the characteristic curve.

KL3202/KS3202

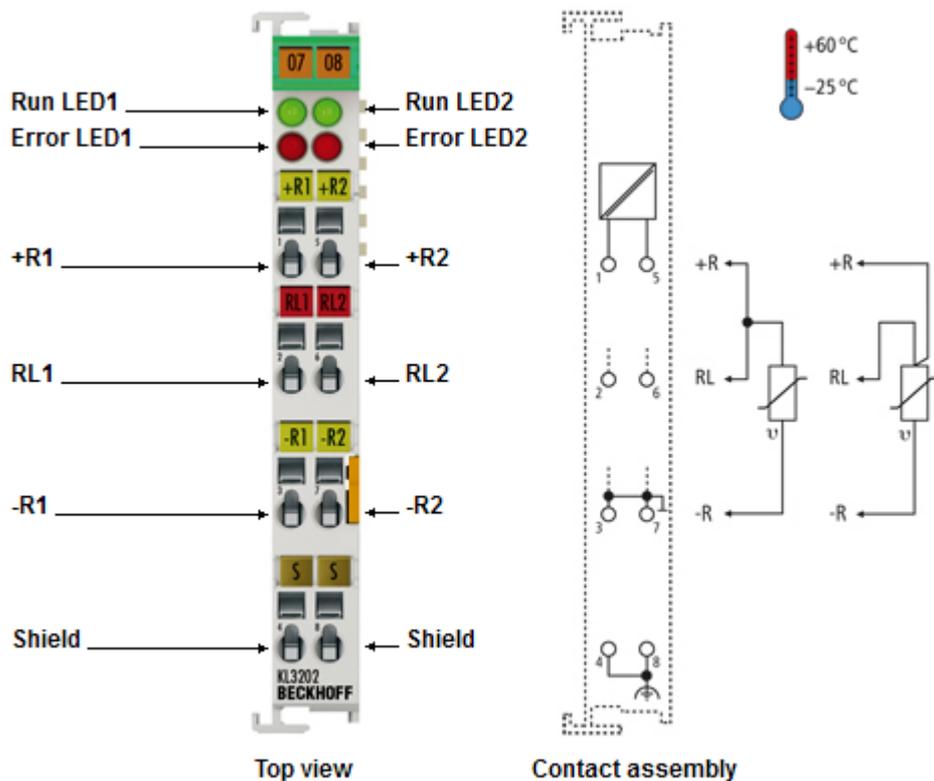


Fig. 15: KL3202 - Contact assignment and LEDs

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

LED displays

LED	Color	Description	
Run	green	On	Normal operation
		Off	Watchdog-timer overflow has occurred. If no process data is transmitted to the bus coupler for 100 ms, the green LEDs go out
Error	red	On	The respective channel is affected by a short circuit or broken wire. The resistance is in the invalid range of the characteristic curve.
		Off	The resistance is in the valid range of the characteristic curve.

KL3204/KS3204, KL3204-0030

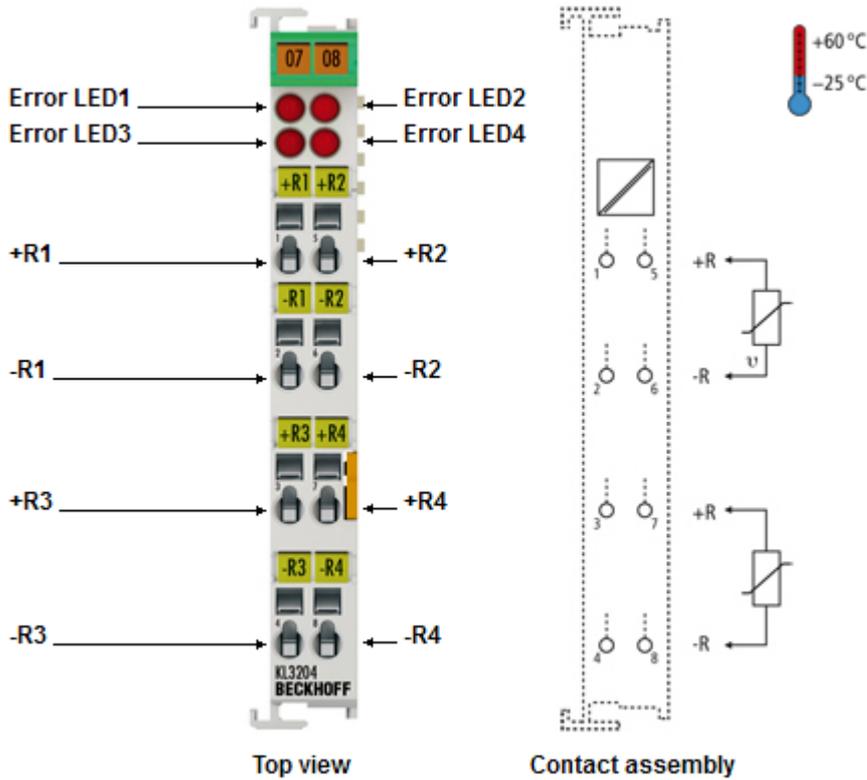


Fig. 16: KL3204, KL3204-0030 - Contact assignment and LEDs

Terminal point	No.	Comment
+R1	1	Input +R1
-R1	2	Input -R1
+R3	3	Input +R3
-R3	4	Input -R3
+R2	5	Input +R2
-R2	6	Input -R2
+R4	7	Input +R4
-R4	8	Input -R4

LED displays

LED	Color	Description	
Error	red	On	The respective channel is affected by a short circuit or broken wire. The resistance is in the invalid range of the characteristic curve.
		Off	The resistance is in the valid range of the characteristic curve.

3.7 ATEX - Special conditions (standard temperature range)

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components with standard temperature range 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 60079-31 for group IIIA or IIIB and IP6X for group IIIC, 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 0 to 55°C for the use of Beckhoff fieldbus components standard temperature range 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 KL92xx/EL92xx 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!

Standards

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

- EN 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

Marking

The Beckhoff fieldbus components with standard temperature range certified according to the ATEX directive for potentially explosive areas bear one of the following markings:



II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: 0 ... +55°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or



II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: 0 ... +55°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

3.8 ATEX - Special conditions (extended temperature range)

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff 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 60079-31 for group IIIA or IIIB and IP6X for group IIIC, 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 Beckhoff 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 KL92xx/EL92xx 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!

Standards

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

- EN 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

Marking

The Beckhoff fieldbus components with extended temperature range (ET) certified according to the ATEX directive for potentially explosive areas bear the following marking:



II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: -25 ... +60°C
 II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
 (only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or



II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: -25 ... +60°C
 II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
 (only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

3.9 Continuitive documentation for ATEX and IECEx

NOTE



Continuitive documentation about explosion protection according to ATEX and IECEx

Pay also attention to the continuative documentation

Ex. Protection for Terminal Systems

Notes on the use of the Beckhoff terminal systems in hazardous areas according to ATEX and IECEx,

that is available for [download](#) within the download area of your product on the Beckhoff homepage www.beckhoff.com!

4 KS2000 Configuration software

4.1 KS2000 - Introduction

The KS2000 configuration software permits configuration, commissioning and parameterization of bus couplers, of the affiliated bus terminals and of Fieldbus Box Modules. The connection between bus coupler / Fieldbus Box Module and the PC is established by means of the serial configuration cable or the fieldbus.



Fig. 17: KS2000 configuration software

Configuration

You can configure the Fieldbus stations with the Configuration Software KS2000 offline. That means, setting up a terminal station with all settings on the couplers and terminals resp. the Fieldbus Box Modules can be prepared before the commissioning phase. Later on, this configuration can be transferred to the terminal station in the commissioning phase by means of a download. For documentation purposes, you are provided with the breakdown of the terminal station, a parts list of modules used and a list of the parameters you have modified. After an upload, existing fieldbus stations are at your disposal for further editing.

Parameterization

KS2000 offers simple access to the parameters of a fieldbus station: specific high-level dialogs are available for all bus couplers, all intelligent bus terminals and Fieldbus Box modules with the aid of which settings can be modified easily. Alternatively, you have full access to all internal registers of the bus couplers and intelligent terminals. Refer to the register description for the meanings of the registers.

Commissioning

The KS2000 software facilitates commissioning of machine components or their fieldbus stations: Configured settings can be transferred to the fieldbus modules by means of a download. After a *login* to the terminal station, it is possible to define settings in couplers, terminals and Fieldbus Box modules directly *online*. The same high-level dialogs and register access are available for this purpose as in the configuration phase.

The KS2000 offers access to the process images of the bus couplers and Fieldbus Box modules.

- Thus, the coupler's input and output images can be observed by monitoring.
- Process values can be specified in the output image for commissioning of the output modules.

All possibilities in the *online mode* can be used in parallel with the actual fieldbus mode of the terminal station. The fieldbus protocol always has the higher priority in this case.

5 Programming

5.1 Data structures

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

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

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

5.1.1 Mapping

As already described in the Terminal Configuration section, each Bus Terminal is mapped in the Bus Coupler. In the delivery state, this mapping occurs with the default settings of the Bus Coupler for this terminal. The default setting can be changed with the KS2000 configuration software or with a master configuration software (e.g. TwinCAT System Manager or ComProfibus).

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

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

Key

- Complete evaluation:
The terminal is mapped with control and status byte.
- Motorola format:
Motorola or Intel format can be set.
- Word alignment:
The terminal is at word limit in the Bus Coupler.
- Ch n SB:
status byte for channel n (appears in the input process image).
- Ch n CB:
control byte for channel n (appears in the output process image).
- Ch n D0:
channel n, data byte 0 (byte with the lowest value)
- Ch n D1:
channel n, data byte 1 (byte with the highest value)
- "-":
This byte is not used or occupied by the terminal.
- res.: reserved:
This byte occupies process data memory, although it is not used.

5.1.1.1 KL3201

Default mapping for:**CANopen, CANCAL, DeviceNet, ControlNet, Modbus, RS232, RS485**

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

Default mapping for:**PROFIBUS, Interbus**

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

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

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

Default mapping for:**Lightbus, EtherCAT, Ethernet and Bus Terminal Controller (BCxxxx, BXxxxx)**

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

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes	0	res.	Ch0 CB/SB
Motorola format: yes	1	Ch0 D0	Ch0 D1
Word alignment: yes	2	-	-
	3	-	-

5.1.1.2 KL3202

Default mapping for:

CANopen, CANCAL, DeviceNet, ControlNet, Modbus, RS232, RS485

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

Default mapping for:

PROFIBUS, Interbus

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

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

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

Default mapping for:

Lightbus, EtherCAT, Ethernet and Bus Terminal Controller (BCxxxx, BXxxxx)

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

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes	0	res.	Ch0 CB/SB
Motorola format: yes	1	Ch0 D0	Ch0 D1
Word alignment: yes	2	res.	Ch1 CB/SB
	3	Ch1 D0	Ch1 D1

5.1.1.3 KL3204, KL3204-0030

Default mapping for:

CANopen, CANCAL, DeviceNet, ControlNet, Modbus, RS232, RS485

Conditions	Word offset	High byte	Low byte
Complete evaluation: no	0	Ch0 D1	Ch0 D0
Motorola format: no	1	Ch1 D1	Ch1 D0
Word alignment: any	2	Ch2 D1	Ch2 D0
	3	Ch3 D1	Ch3 D0

Default mapping for:

PROFIBUS, Interbus

Conditions	Word offset	High byte	Low byte
Complete evaluation: no	0	Ch0 D0	Ch0 D1
Motorola format: ja	1	Ch1 D0	Ch1 D1
Word alignment: any	2	Ch2 D0	Ch2 D1
	3	Ch3 D0	Ch3 D1

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes	0	Ch0 D0	Ch0 CB/SB
Motorola format: no	1	Ch1 CB/SB	Ch0 D1
Word alignment: no	2	Ch1 D1	Ch1 D0
	3	Ch2 D0	Ch2 CB/SB
	4	Ch3 CB/SB	Ch2 D1
	5	Ch3 D1	Ch3 D0

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes	0	Ch0 D1	Ch0 CB/SB
Motorola format: yes	1	Ch1 CB/SB	Ch0 D0
Word alignment: no	2	Ch1 D0	Ch1 D1
	3	Ch2 D1	Ch2 CB/SB
	4	Ch3 CB/SB	Ch2 D0
	5	Ch3 D0	Ch3 D1

Default mapping for:

Lightbus, EtherCAT, Ethernet and Bus Terminal Controller (BCxxxx, BXxxxx)

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

Conditions	Word offset	High byte	Low byte
Complete evaluation: yes	0	res.	Ch0 CB/SB
Motorola format: yes	1	Ch0 D0	Ch0 D1
Word alignment: yes	2	res.	Ch1 CB/SB
	3	Ch1 D0	Ch1 D1

5.1.2 Terminal configuration

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

BK2000 - Lightbus Coupler

In the BK2000 Lightbus coupler, the control and status byte is mapped in addition to the data bytes. This is always located in the low byte at the offset address of the terminal channel.

Example for KL3202:

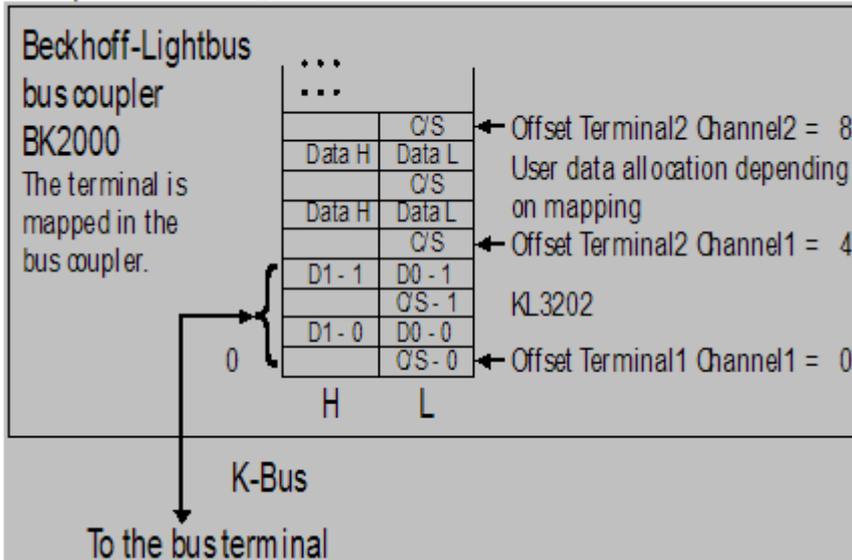


Fig. 18: Mapping BK2000

BK3000 - PROFIBUS coupler

For the BK3000 PROFIBUS coupler, the master configuration should specify for which terminal channels the control and status byte is to be inserted. If the control and status byte are not evaluated, the terminals occupy 2 bytes per channel:

- KL3201: 2 bytes of input data
- KL3202: 4 bytes of input data
- KL32x4: 8 bytes of input data

Example for KL3202:

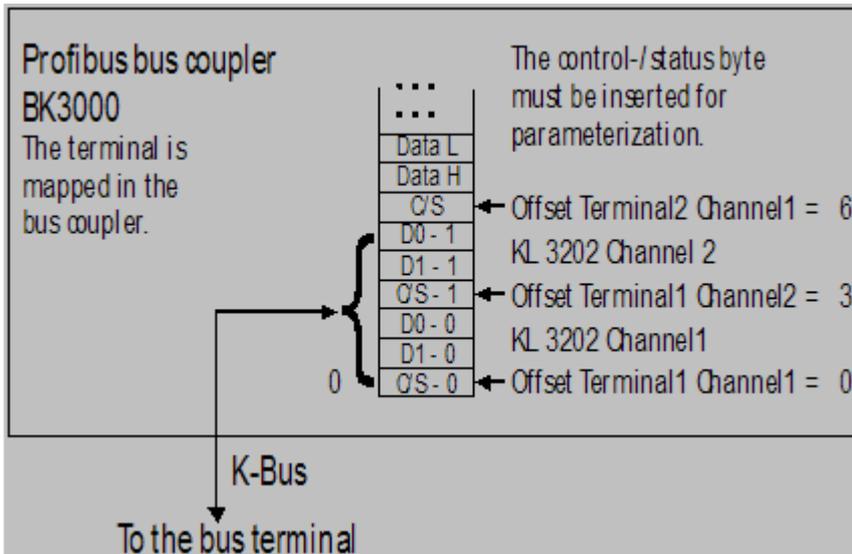


Fig. 19: Mapping BK3000

BK4000 - Interbus Coupler

The BK4000 Interbus Coupler maps the terminals in the delivery state with 2 bytes per channel:

- KL3201: 2 bytes of input data
- KL3202: 4 bytes of input data
- KL3204: 8 bytes of input data

Parameterization via the fieldbus is not possible. If the control and status byte is to be used, the KS2000 configuration software is required.

Example for KL3202:

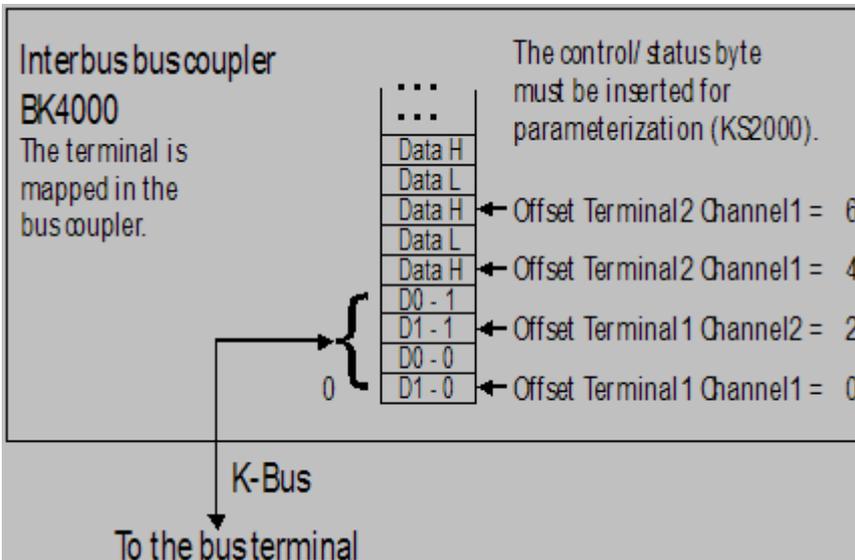


Fig. 20: Mapping BK4000

Overview of mapping configurations

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

Parameterization with KS2000

The parameterizations can be carried out independently of the fieldbus system with the KS2000 configuration software via the serial configuration interface in the Bus Coupler.

5.1.3 Register overview

These registers exist once for each channel.

Address	Name	Default value	R/W	Storage medium
R0	Raw ADC value	variable	R	RAM
R1	Unprocessed ADC value for the leads	variable	R	
R2	reserved	0x0000	R	
R3	...	...	...	...
R5	reserved	0x0000	R	
R6	Diagnostic register	variable	R	RAM
R7	Command register not used	0x0000	R	
R8	Terminal type	e.g. 3202	R	ROM
R9	Software version number	0x????	R	ROM
R10	Multiplex shift register	0x0218/0130	R	ROM
R11	Signal channels	0x0218	R	ROM
R12	Minimum data length	0x0098	R	ROM
R13	Data structure	0x0000	R	ROM
R14	reserved	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	Hardware compensation: Offset	specific	R/W	SEEROM
R18	Hardware compensation: Gain	specific	R/W	SEEROM
R19	Manufacturer scaling: Offset	0x0000	R/W	SEEROM
R20	Manufacturer scaling: Gain	0x00A0	R/W	SEEROM
R21	Offset register two-wire connection method	specific	R/W	SEEROM
R22	reserved	0x0000	R/W	SEEROM
R3	...	...	...	...
R30	reserved	0x0000	R/W	SEEROM
R31	Code word register	variable	R/W	RAM
R32	Feature register	0x0106	R/W	SEEROM
R33	User scaling: Offset	0x0000	R/W	SEEROM
R34	User scaling: Gain	0x0100	R/W	SEEROM
R35	reserved	0x0000	R/W	SEEROM
R36	reserved	0x0000	R/W	SEEROM
R37	Filter constant	0x0138	R/W	SEEROM
R38	reserved	0x0000	R/W	SEEROM
R3	...	...	...	...
R63	reserved	0x0000	R/W	SEEROM

5.1.4 General description of registers

Complex terminals that possess a processor are able to exchange data bi-directionally with the higher-level controller. These terminals are referred to below as intelligent Bus Terminals. These include analog inputs, analog outputs, serial interface terminals (RS485, RS232, TTY etc.), counter terminals, encoder interface, SSI interface, PWM terminal and all other parameterizable terminals.

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

This structure is divided into the following areas:

(A detailed list of all registers can be found in the Appendix.)

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

5.1.4.1 Process variables

R0 to R7: Registers in the internal RAM of the terminal

The process variables can be used in addition to the actual process image. Their function is specific to the terminal.

R0 to R5: Terminal-specific registers

The function of these registers depend on the respective terminal type (see terminal-specific register description).

- **R6: Diagnostic register**
The diagnostic register can contain additional diagnostic information. Parity errors, for instance, that occur in serial interface terminals during data transmission are indicated here.
- **R7: Command register**
High-Byte_Write = function parameter
Low-Byte_Write = function number
High-Byte_Read = function result
Low-Byte_Read = function number

5.1.4.2 Type register

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

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

- **R8: Terminal type**
The terminal type in register R8 is needed to identify the terminal.
- **R9: Software version (X.y)**
The software version can be read as a string of ASCII characters.
- **R10: Data length**
R10 contains the number of multiplexed shift registers and their length in bits.
The Bus Coupler sees this structure.
- **R11: Signal channels**
Related to R10, this contains the number of channels that are logically present. Thus for example a shift register that is physically present can perfectly well consist of several signal channels.

- **R12: Minimum data length**

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

- **R13: Data type register**

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

- **R14: reserved**

- **R15: Alignment bits (RAM)**

The alignment bits are used to place the analog terminal in the Bus Coupler on a byte boundary.

5.1.4.3 Manufacturer parameters

R16 to R30: Manufacturer parameter area (SEEPROM)

The manufacturer parameters are specific for each type of terminal. They are programmed by the manufacturer, but can also be modified by the controller. The manufacturer parameters are stored in a serial EEPROM in the terminal, and are retained in the event of voltage drop-out.

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

5.1.4.4 User parameters

R31 to R47: User parameter area (SEEPROM)

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

- **R31: Code word register in RAM**

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

- **R32: Feature register**

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

R33 to R47: Terminal-specific registers

The function of these registers depend on the respective terminal type (see terminal-specific register description).

5.1.4.5 Extended user area

R47 to R63

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

5.1.5 Terminal-specific register description

5.1.5.1 Process variables

- **R0: Raw ADC value X_R**

This register contains the raw ADC value.

- **R1: Raw ADC value of the line resistance between +R1 - RL1 or +R2 - RL2**

- **R2 to R5: Reserved**

- **R6: Diagnostic register**

- High byte: not used
- Low byte: Status byte

5.1.5.2 Manufacturer parameters

- **R17: Hardware compensation - offset (B_a)**

16 bit signed integer

This register is used for offset compensation of the terminal (Eq. 1.1).

Register value approx. 0xEDXX

- **R18: Hardware compensation - gain (A_a)**

16 bits * 16⁻⁵ (approx. 0.01907 Ω/digit)

This register is used for gain compensation of the terminal (Eq. 1.1).

Register value approx. 0x27XX

- **R19: Manufacturer scaling - offset (B_h)**

16 bit signed integer [0x0000]

This register contains the offset of the manufacturer's straight-line equation (1.5). The straight-line equation is activated via register R32.

- **R20: Manufacturer scaling - gain (A_h)**

16 bits signed integer *2⁻⁸ [0x00A0]

This register contains the scaling factor of the manufacturer's straight-line equation (1.5). The straight-line equation is activated via register R32.

• **R21: Additional offset register for two-wire connection**

The value of register 1 at short circuit +R1-RL1 or +R2-RL2

[approx. 0x01AX]

5.1.5.3 User parameters

• **R32: Feature register**

[0x0106]

The feature register specifies the terminal's operating mode.

Feature bit no.		Description of the operating mode
Bit 0	1	User scaling (R33, R44) active [0]
Bit 1	1	Manufacturer scaling (R19, R20) active [1]
Bit 2	1	Watchdog timer active [1] In the delivery state, the watchdog timer is switched on.
Bit 3	1	Sign / amount representation [0] Sign / amount representation is active instead of two's-complement representation (-1 = 0x8001).
Bit 4	1	Siemens output format [0] This bit is used for inserting status information on the lowest 3 bits (see below).
Bit 5,6	-	reserved, do not change
Bit 7	1	Activates filter constant in R37 [0]
Bit 8	1	Over range Protection [1] If the temperature exceeds 850°C the status bits are correspondingly set and the output value is restricted to 850°C.
Bit 9	-	reserved, do not change
Bit 10	1	Two-wire connection [0]
Bit 11	-	reserved, do not change
Bit 15,14,13,12	Element	Valid measuring range
0 0 0 0	PT100	-200°C to 850°C
0 0 0 1	NI100	-60°C to 250°C
0 0 1 0	PT1000	-200°C to 850°C
0 0 1 1	PT500	-200°C to 850°C
0 1 0 0	PT200	-200° C to 850°C
0 1 0 1	NI1000	-200°C to 850°C
0 1 1 0	NI120	-80°C to 320°C
1 1 1 0	Output in Ω	10.0 Ω to 5000.0 Ω
1 1 1 1	Output in Ω	10.0 Ω to 1200.0 Ω

5.1.5.4 Output format

If only manufacturer scaling via the feature register is active, the output format is as follows:

- 1 digit corresponds to 1/10 °C or
- 1 digit corresponds to 1/10 Ω

If no scaling is active, the output format is as follows:

- 1 digit corresponds to 1/16 °C or
- 1 digit corresponds to 1/16 Ω

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

Bit Measured value	Bits 15-3	Bit 2 X	Bit 1 Error	Bit 0 Overflow
out of range		0	0	1
in range	Process data	0	0	0

- **R33: User scaling - offset (B_w)**

16 bit signed integer

This register contains the offset of the user straight-line equation (1.6). The straight-line equation is activated via register R32.

- **R34: User scaling (A_w)**

16 bits signed integer* 2⁻⁸.

This register contains the scaling factor of the user straight-line equation (1.6). The straight-line equation is activated via register R32.

- **R35 and R36: reserved**

- **R37: Filter constant**

[0x0000]

Filter constants:	First notch [Hz]	Conversion time [ms]
0x0000	25	250
0x50	100	65
0xA0	50	125
0x140	25	250
0x280	12.5	500



- **Validity of the documentation**

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

5.1.6 Control and status byte

5.1.6.1 Control byte for process data exchange

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

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

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

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

Control byte:

- Bit 7 = 0_{bin}
- Bit 6 = 1_{bin}: Terminal compensation function is activated
- Bit 4 = 1_{bin}: Calibration gain
- Bit 3 = 1 offset calibration
- Bit 2 = 0_{bin}: slower cycle = 1000 ms
1_{bin}: fast cycle = 50 ms
- Bit 1 = 1_{bin}: up
- Bit 0 = 1_{bin}: down

5.1.6.2 Status byte for process data exchange

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

Status byte:

- Bit 7 = 0_{bin}
- Bit 6 = 1_{bin}: Error (general error bit)
- Bit 5 to bit 2: reserved
- Bit 1 = 1_{bin}: Overrange
- Bit 0 = 1_{bin}: Underrange

5.1.6.3 Compensation

Implemented straight-line equation:

$$Y[\Omega] = (X_{\text{Adc}} * G + B_{\text{h}}) * A_{\text{h}} + 100 \Omega$$

Hence:

B_h consists of a component that depends on the gain of the A/D converter and a constant for calculating the axis offset of 100 Ω. The gain-dependent component calculates the offset of the external components (the offset of the component can be varied via adjustable amplification).

This procedure is necessary, because compensation at 0 Ω is technically not possible. The line is therefore compensated around the point 100 Ω (offset to the point and rotated around this point).

$$B_{\text{h}}: (B_{\text{off}} * G + B_{\text{100}})$$

- Offset calibration should therefore be carried out for PT100 at 100 Ω (or PT1000 at 1000 Ω).

- Gain compensation is then carried out independently of the offset, e.g. at 300 Ω. 300 Ω corresponds to 557.7°C = 0x15C9

5.1.6.4 Default setting of the registers

- R17: 0xED68 corresponds to -90.8 Ω
- R18: 0x4E20 corresponds to $2000 * 16^{-5} = 0,01907 \text{ Ω/digit}$
- R19: 0x0000
- R20: 0x00A0
- R32: 0x0106
- R33: 0x0000
- R34: 0x0100

The gain and offset compensation only has to be carried out once, i.e. it does not have to be repeated or corrected for any of the other implemented elements.

For the two-wire connection, with short-circuited line resistance (+R1-RI1) the raw ADC value of the line resistance (contained in R1) has to be entered in register R21.

5.1.6.5 KL3202 as resistance input 0 to 1 kΩ

If the KL3202 is used for resistance measurements, the following values should be written into the following registers:

- **R32: Feature register: 0xF401**

i.e. user scaling active with display of the measured value in Ohm and two-wire connection.

- **R33: User scaling - offset (0x0000)**

- **R34: User scaling - gain (0x0010)**

the display of the measured value follows:

Resistance in Ω	Output value
0	0
1000	1000

5.1.7 Register communication

5.1.7.1 Register access via process data exchange

Bit 7 = 1_{bin}: Register mode

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

Bit 6 = 0_{bin}: read

Bit 6 = 1_{bin}: write

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

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

Bit 0 to 5: Address

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

Control byte in register mode

MSB

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

- REG = 0_{bin}: Process data exchange
- REG = 1_{bin}: Access to register structure
- W/R = 0_{bin}: Read register
- W/R = 1_{bin}: Write register
- A5...A0 = register address

Address bits A5 to A0 can be used to address a total of 64 registers.

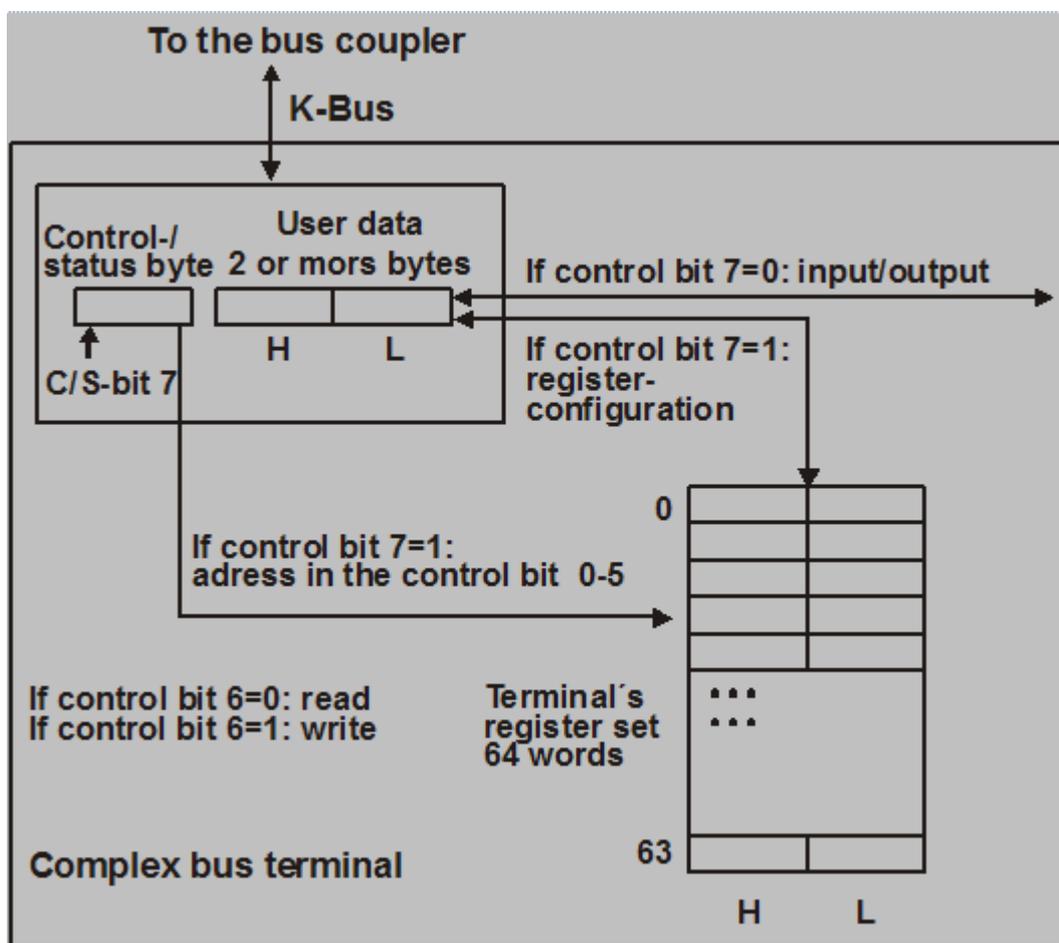


Fig. 21: Register-Modus Control Byte

The control or status byte occupies the lowest address of a logical channel. The corresponding register values are located in the following 2 data bytes. (The BK2000 is an exception: here, an unused (reserved) data byte is automatically inserted after the control or status byte, and the register value is therefore placed on a word boundary).

5.1.7.2 Example 1

Reading of register 8 in the BK2000 with a KL3202 and the end terminal:

If the following bytes are transferred from the control to the terminal,

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataOUT 1	DataOUT 0	Not used	Control byte
Value	0xXX	0xXX	0xXX	0x88

the terminal returns the following type identifier (0x0C82 corresponds to unsigned integer 3202).

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataIN 1	DataIN 0	Not used	Status byte
Value	0x0C	0x82	0x00	0x88

5.1.7.3 Example 2

Writing of register 31 in the BK2000 with an intelligent terminal and the end terminal:

If the following bytes (code word) are transferred from the control to the terminal,

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataOUT 1	DataOUT 0	Not used	Control byte
Value	0x12	0x35	0xXX	0xDF

the code word is set, and the terminal returns the register address with bit 7 for register access as acknowledgement.

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataIN 1	DataIN 0	Not used	Status byte
Value	0x00	0x00	0x00	0x9F

5.1.8 Examples of Register Communication

The numbering of the bytes in the examples corresponds to the display without word alignment.

5.1.8.1 Example 1: Reading the firmware version from register 9

Output Data

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

Explanation:

- Bit 0.7 set means: Register communication switched on.
- Bit 0.6 not set means: reading the register.
- Bits 0.5 to 0.0 specify the register number 9 with 00 1001_{bin}.
- The output data word (byte 1 and byte 2) has no meaning during read access. To change a register, write the required value into the output word.

Input Data (answer of the Bus Terminal)

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

Explanation:

- The terminal returns the value of the control byte as a receipt in the status byte.

- The terminal returns the firmware version 0x3341 in the input data word (byte 1 and byte 2). This is to be interpreted as an ASCII code:
 - ASCII code 0x33 represents the digit 3
 - ASCII code 0x41 represents the letter A
 The firmware version is thus 3A.

5.1.8.2 Example 2: Writing to an user register



Code word

In normal mode all user registers are read-only with the exception of Register 31. In order to deactivate this write protection you must write the code word (0x1235) into Register 31. If a value other than 0x1235 is written into Register 31, write protection is reactivated. Please note that changes to a register only become effective after restarting the terminal (power-off/power-on).

I. Write the code word (0x1235) into register 31.

Output Data

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

Explanation:

- Bit 0.7 set means: Register communication switched on.
- Bit 0.6 set means: writing to the register.
- Bits 0.5 to 0.0 specify the register number 31 with 01 1111_{bin}.
- The output data word (byte 1 and byte 2) contains the code word (0x1235) for deactivating write protection.

Input Data (answer of the Bus Terminal)

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

Explanation:

- The terminal returns a value as a receipt in the status byte that differs only in bit 0.6 from the value of the control byte.
- The input data word (byte 1 and byte 2) is of no importance after the write access. Any values still displayed are invalid!

II. Read Register 31 (check the set code word)

Output Data

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

Explanation:

- Bit 0.7 set means: Register communication switched on.
- Bit 0.6 not set means: reading the register.
- Bits 0.5 to 0.0 specify the register number 31 with 01 1111_{bin}.
- The output data word (byte 1 and byte 2) has no meaning during read access.

Input Data (answer of the Bus Terminal)

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

Explanation:

- The terminal returns the value of the control byte as a receipt in the status byte.
- The terminal returns the current value of the code word register in the input data word (byte 1 and byte 2).

III. Write to Register 32 (change contents of the feature register)**Output data**

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

Explanation:

- Bit 0.7 set means: Register communication switched on.
- Bit 0.6 set means: writing to the register.
- Bits 0.5 to 0.0 indicate register number 32 with 10 0000_{bin}.
- The output data word (byte 1 and byte 2) contains the new value for the feature register.

⚠ CAUTION**Observe the register description!**

The value of 0x0002 given here is just an example!

The bits of the feature register change the properties of the terminal and have a different meaning, depending on the type of terminal. Refer to the description of the feature register of your terminal (chapter *Register description*) regarding the meaning of the individual bits before changing the values.

Input data (response from the Bus Terminal)

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

Explanation:

- The terminal returns a value as a receipt in the status byte that differs only in bit 0.6 from the value of the control byte.
- The input data word (byte 1 and byte 2) is of no importance after the write access. Any values still displayed are invalid!

IV. Read register 32 (check changed feature register)**Output Data**

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

Explanation:

- Bit 0.7 set means: Register communication switched on.
- Bit 0.6 not set means: reading the register.
- Bits 0.5 to 0.0 indicate register number 32 with 10 0000_{bin}.
- The output data word (byte 1 and byte 2) has no meaning during read access.

Input Data (answer of the Bus Terminal)

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

Explanation:

- The terminal returns the value of the control byte as a receipt in the status byte.
- The terminal returns the current value of the feature register in the input data word (byte 1 and byte 2).

V. Write register 31 (reset code word)

Output Data

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

Explanation:

- Bit 0.7 set means: Register communication switched on.
- Bit 0.6 set means: writing to the register.
- Bits 0.5 to 0.0 specify the register number 31 with 01 1111_{bin}.
- The output data word (byte 1 and byte 2) contains 0x0000 for reactivating write protection.

Input Data (answer of the Bus Terminal)

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

Explanation:

- The terminal returns a value as a receipt in the status byte that differs only in bit 0.6 from the value of the control byte.
- The input data word (byte 1 and byte 2) is of no importance after the write access. Any values still displayed are invalid!

5.2 TwinCAT



PLC and Motion Control on the PC

TwinCAT - The Windows Control and Automation Technology

The TwinCAT automation software converts any compatible PC into a real-time controller with multi-PLC, NC axis control, programming environment and operating station. TwinCAT replaces conventional PLC and NC controllers as well as operating devices:

- open, compatible PC hardware
- Embedding of IEC 61131-3 software PLC, software NC and software CNC in Windows
- Programming and runtime systems optionally together on one PC or separated
- Connection to all common fieldbus systems
- PC interfaces are supported
- Data communication with user interfaces and other programs by means of open Microsoft standards (OPC, OCX, DLL, etc.)

TwinCAT architecture

TwinCAT consists of runtime systems for real-time execution of control programs and development environments for programming, diagnosis and configuration. Any Windows programs, for instance visualization programs or Office programs, can access TwinCAT data via Microsoft interfaces, or can execute commands.

A practically oriented software solution

TwinCAT offers a precise time-base in which programs are executed with the highest deterministic features, independently of other processor tasks. The real-time load on a PC is set with TwinCAT: This achieves a defined operating behavior. TwinCAT displays the system load for running programs. A loading threshold can be set, in order to assure a defined computing capacity for the operating programs and for Windows. If this threshold is exceeded, a system message is generated.

TwinCAT supports system diagnosis

The general use of hardware and software from the open PC world requires some checking: Unsuitable components can upset the PC system. Beckhoff integrates a handy display of the real-time jitter in order to provide administrators with a simple means of evaluating hardware and software. A system message during operation can draw attention to error states.

Start/stop behavior

Depending on the setting, TwinCAT is started and stopped manually or automatically. Since TwinCAT is integrated into Windows as a service, an operator is not needed to start the system: switching on is enough.

Restarting and data backup

When a program is started or restarted, TwinCAT loads programs and remanent data. To backup data, and to shut down Windows correctly, a UPS (uninterruptible power supply) is of great value.

TwinCAT and "Blue Screen"

The TwinCAT system can be configured such that real-time capability is maintained in the event of a BSOD (Blue-Screen-of-Death) operating system crash. Real-time tasks such as PLC and NC can thus continue to run and place the controlled process in a safe state. Ultimately, it is the decision of the programmer whether or not to utilize this feature, bearing in mind that data or programs may already have been destroyed by the BSOD.

World-wide connection through message routing - "remote" connection is inherent to the system

According to the requirement for operating resources, the TwinCAT software devices can be distributed: TwinCAT PLC programs can be executed on PCs and on Beckhoff Bus Terminal controllers. A "message router" manages and distributes all the messages, both in the system and via TCP/IP connections. PC systems can be connected to one another by TCP/IP; Bus Terminal controllers are connected via serial interfaces and fieldbus systems (EtherCAT, Lightbus, PROFIBUS DP, PROFINET, Interbus, CANopen, DeviceNet, RS232, RS485, Ethernet TCP/IP, Ethernet/IP).

World-wide access

Since standard TCP/IP services from Windows are used, this data exchange can take place worldwide. The system offers scalable communication capacity and timeout periods for the monitoring of communications. OPC provides a standardized means for accessing many different SCADA packets. The SOAP (Simple Object Access Protocol) enables a connection between two computers to be established by means of an internet connection via standard HTTP. A TwinCAT component is available for this purpose.

Beckhoff Information System

Further information on the TwinCAT automation software can be found in the Beckhoff Information System.

The setup for installing the Beckhoff Information System is available to you on the Beckhoff *Products & Solutions* DVD and on our website for [download](#).

In addition, the online version of the Beckhoff Information System can be found at <https://infosys.beckhoff.com>.

5.2.1 TwinCAT libraries

TwinCAT libraries

See software documentation in the Beckhoff Information System.

TwinCAT 2: TwinCAT PLC Lib: [TcIoFunctions](#)

TwinCAT 3: TwinCAT 3 PLC Lib: [Tc2_IoFunctions](#)

5.2.2 Function block FB_KL320xConfig

The function block FB-KL320xConfig can be used to configure the KL320x terminals. A more detailed description can be found in the Beckhoff Information System:

TwinCAT2: [TwinCAT PLC Lib: I/O functions/Bus Terminal configuration](#)

TwinCAT3: [TwinCAT 3 PLC Lib:Tc2 I/O functions/Function blocks/Bus Terminal configuration](#)

6 Appendix

6.1 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on her internet pages: <https://www.beckhoff.com>

You will also find further documentation for Beckhoff components there.

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Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

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- and extensive training program for Beckhoff system components

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