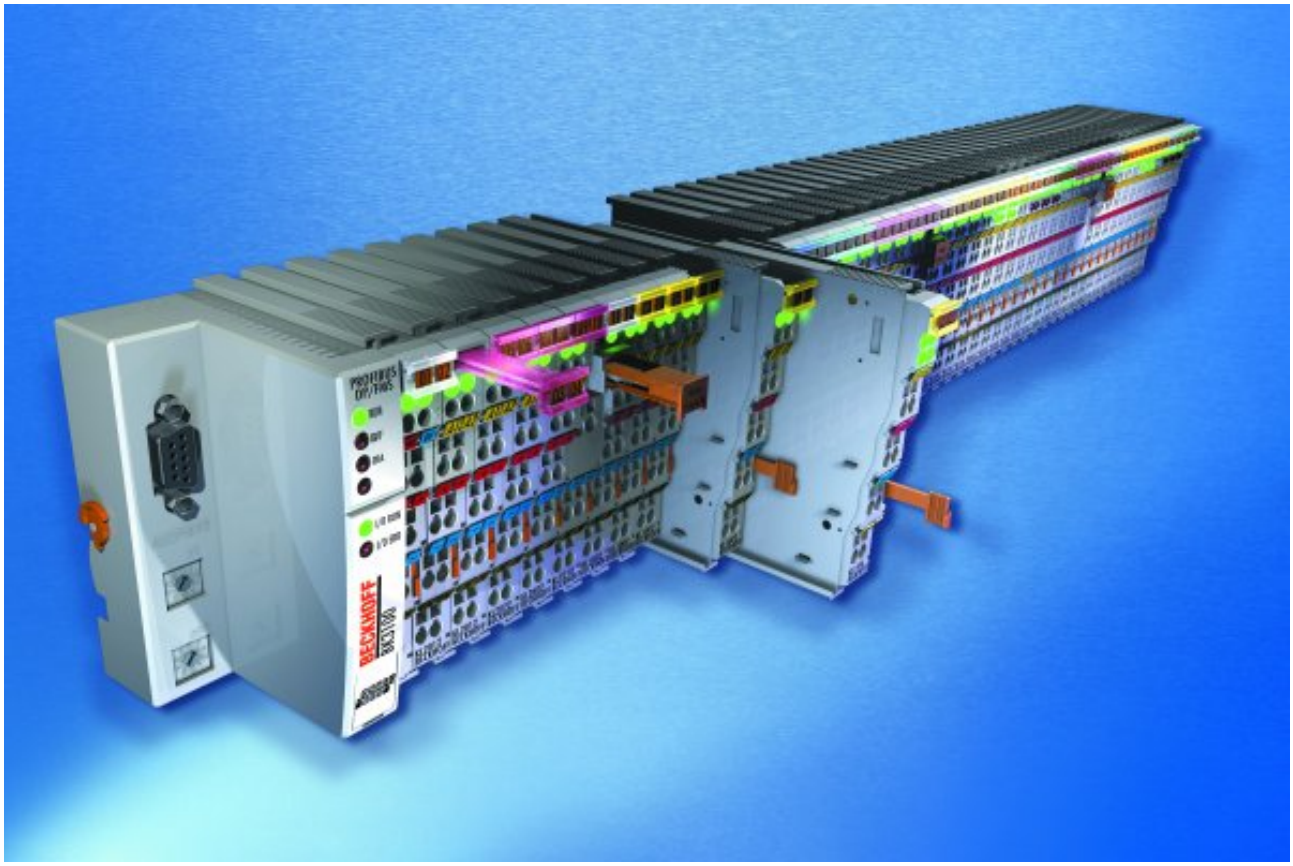

Documentation

KL5051

Bidirectional SSI encoder interface

Version: 3.0
Date: 2018-05-29

BECKHOFF

Table of content

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.

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Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, DE102004044764, DE102007017835 with corresponding applications or registrations in various other countries.

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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 symbols

In this documentation 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.
 **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.

1.3 Documentation issue status

Version	Comment
3.0	• Migration • Structure update • Update chapters *Technical data* and *Introduction* • Description *SSI principles* and *Referencing an SSI signal* added • Chapter *Mounting and wiring* added • Chapters *KS2000 configuration software* and *Access from the user program* added

Firmware (FW) and hardware (HW) versions

Documentation, version	KL5051	
	FW	HW
3.0	3A	02

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

Syntax of the serial number

Structure of the serial number: WW YY FF HH

WW - week of production (calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with ser. no.: 35 04 1B 01:

35 - week of production 35
4 - year of production 2004
1B - firmware version 1B
1 - hardware version 1

2 Product overview

2.1 KL5051 - Introduction

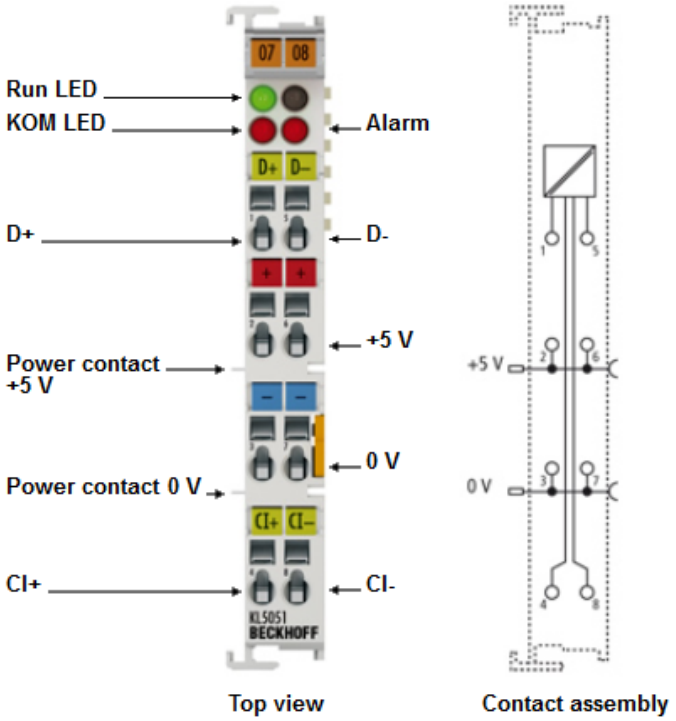

Fig. 1: KL5051

The KL5051 bidirectional SSI interface terminal enables the connection of digital servo drives. The encoder is powered via the SSI interface, which consists of two logic channels. The first channel is used for the positioning of the drive, while the second channel is used to set releases, to transmit parameter data and to read status information and parameter values. The 5 V_{DC} supply voltage can be generated with the KL9505 power supply terminal and fed into the power contacts.

2.2 KL5051 - Technical data

Technical data	KL5051
Encoder connection	Binary input: D+, D-; binary output: Cl+, Cl-
Power supply	5 V_{DC} via power contacts (KL9505)
Current consumption	Typically 85 mA without encoder
Encoder supply	5 V_{DC}
Current consumption K-bus	typically 75 mA
Data transfer rate	1 MHz
Data direction	bidirectional
Signal output	Differential signal (RS422)
Signal input	Differential signal (RS422)
Electrical isolation	500 V (K-bus / field voltage)
Bit width in process image	Input / Output: 2 x 16 bit data, 2 x 8 bit control/status
Weight	approx. 80 g
Dimensions (W x H x D)	approx. 15 mm x 100 mm x 70 mm (width aligned: 12 mm)
Mounting [▶ 12]	on 35 mm mounting rail according to EN 60715
Permissible ambient temperature range during operation	0°C ... + 55°C
Permissible ambient temperature range during storage	-25°C ... + 85°C
Permissible relative air humidity	95 %, no condensation
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27, see also Installation instructions for enhanced mechanical load capacity [▶ 16]
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection class	IP20
Installation position	variable
Approval	CE, cULus, ATEX [▶ 21]

2.3 Basic function principles

The KL5051 bidirectional SSI interface terminal is used to connect the digital servo drive digifas®7100/7200 from Seidel to the Bus Coupler or controller. The interface consists of two logical channels:

- The drive is positioned via the first channel,
- the second channel is used to set releases, to transfer parameter data and to read status information or parameter values.

It is therefore possible for a subordinate axis controller to deal with positioning on channel 1, while the higher-level controller sets releases on channel 2 and performs the monitoring tasks.

LED display

The Run LED indicates the operating state of the terminal.

- green Run LED:
  - On: normal operation
  - Off: Watchdog timer overflow has occurred. If no process data are transmitted by the Bus Coupler for 100 ms, the green LEDs go out.
- Com error
  - On: Communication error, e.g. open circuit on the data or clock line
  - Off: normal operation
- Alarm:
  - On: The connected device has issued a fault message.
  - Off: normal operation

SSI principles

SSI communication sequence

- The SSI master starts pulsing on the clock line with a fixed cycle into the shift register of the SSI slave.
- The slave generally "pushes back" data with a width of 25 bits on the data line. An SSI encoder should determine its position with the first falling edge of the signal at the *Clock* input ("latching"), which is then transferred.
- Once the specified number of bits was pushed, the clock signal is terminated.
- After a pause, polling by the SSI master recommences.

The last data bit can be a PowerFail bit, i.e. the slave signals a power failure. This output depends on the slave.

The number of bit changes equals the clock frequency, i.e. the maximum data transfer rate for a 1 MHz cycle is 1 Mbit/s.

Referencing an SSI signal

An SSI encoder is an absolute encoder, which means, that the position value is available without referencing immediately after switching on.
Many SSI encoders offer the option of referencing or zeroing the position value via an additional digital input. Depending on the signal voltage of the digital input on the encoder, this can be set, for example via a digital output terminal EL2xxx.

Process data

The KL5051 is mapped with 6 bytes of input data and 6 bytes of output data.

- A0, A1, A2 and E0, E1, E2 form the channel for setting and logging the operating data of the servo.
- A3, A4, A5 and E3, E4, E5 form the channel for logging the servo status and for setting the servo control. In addition it is used for parameterizing the servo drive.

Byte	Function	Byte	Function
A0	Operating data control	**E0**	Operating data status
A1	Velocity command value	**E1**	Actual position value
A2	Velocity command value	**E2**	Actual position value
A3	Parameter control	**E3**	Parameter status
A4	Parameter/control servo	**E4**	Parameter/status servo
A5	Parameter/control servo	**E5**	Parameter/status servo

In A1, A2 the velocity command value is specified as 16-bit signed integer. The maximum set value specifications can be found in the servo manual.

E1, E2 contain the absolute actual position value as 16 bit unsigned integer. The resolution of the actual position value is 65536 steps per revolution.

Actual position value in E1, E2	Angle of rotation
0x0000	0 °
0x3FFF	90 °
0xBFFF	270 °

3 Mounting and wiring

3.1 Instructions for ESD protection

Attention	**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. a) Avoid contact with highly insulating materials (synthetic fibers, plastic film etc.). b) Surroundings (working place, packaging and personnel) should by grounded probably, when handling with the devices. c) Each assembly must be terminated at the right hand end with an EL9011 bus end cap, to ensure the protection class and ESD protection.

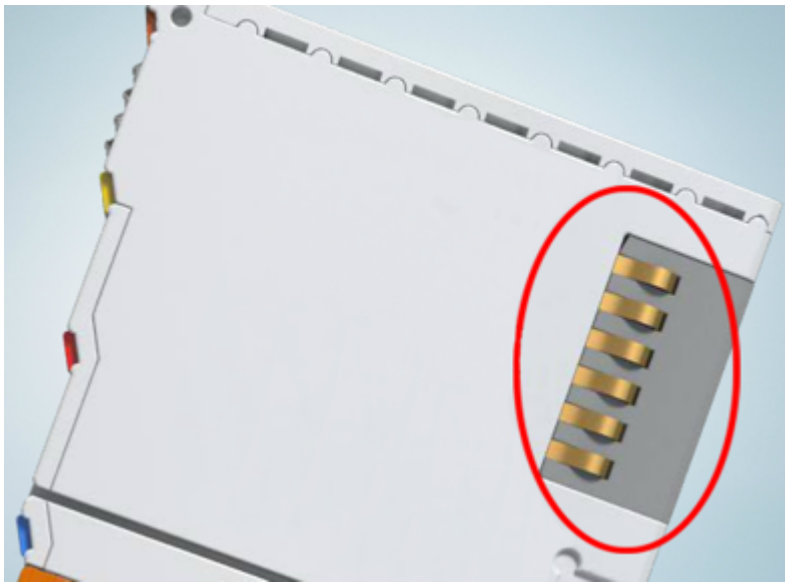

Fig. 2: Spring contacts of the Beckhoff I/O components

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

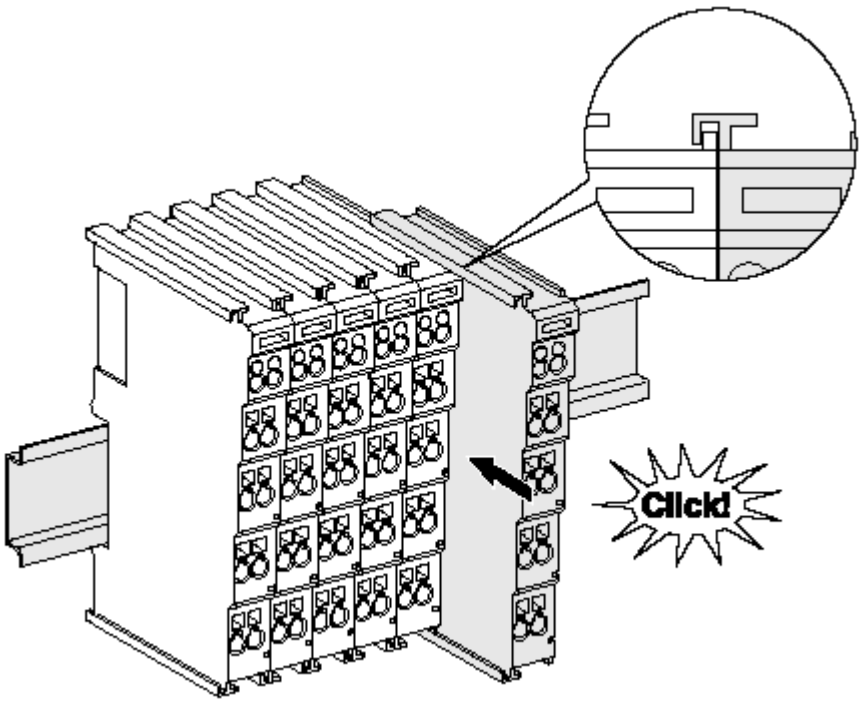

Fig. 3: Attaching on mounting rail

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.

Note	**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

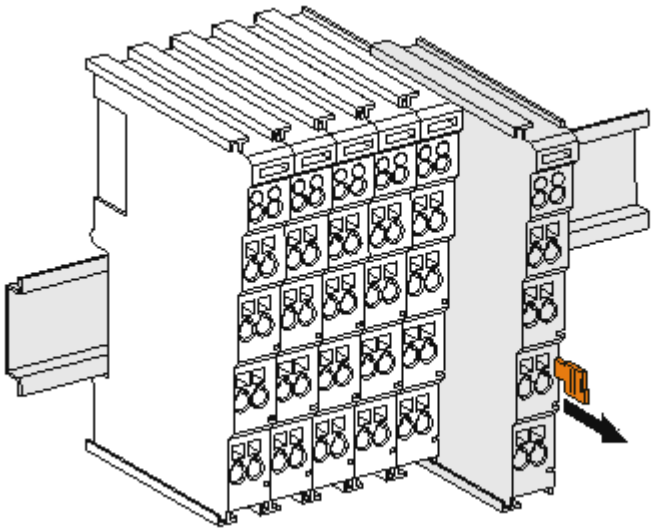

Fig. 4: Disassembling of terminal

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.

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 (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.

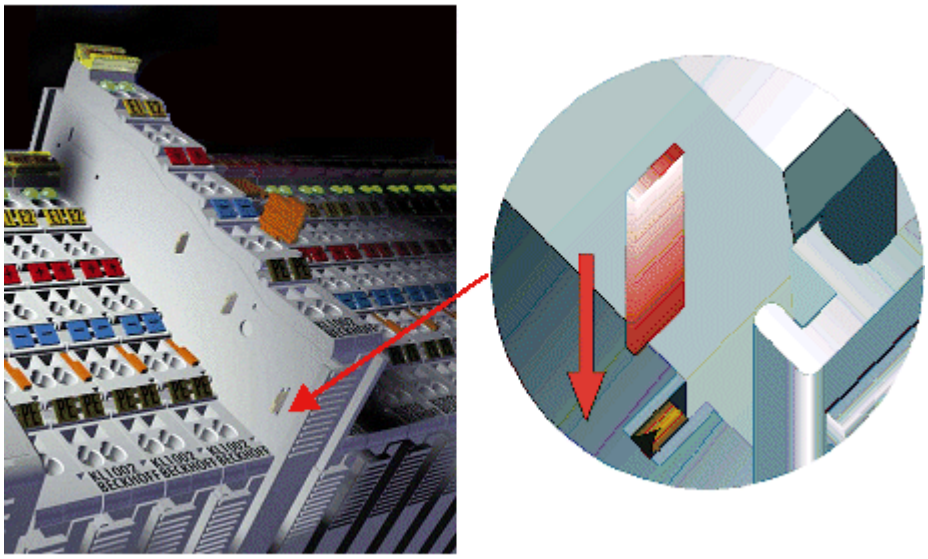

Fig. 5: *Power contact on left side*

Attention	**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!

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.

3.4 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!

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. 6: 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)

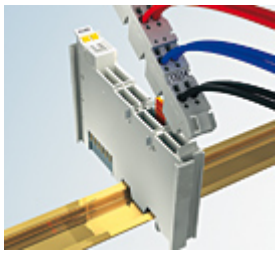

Fig. 7: Pluggable wiring

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 mm^2 and 2.5 mm^2 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. 8: *High Density Terminals*

The Bus 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.

Note	**Wiring HD Terminals** The High Density (HD) Terminals of the ELx8xx and KLx8xx series doesn't support pluggable wiring.

Ultrasonically "bonded" (ultrasonically welded) conductors

Note	**Ultrasonically “bonded" conductors** 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 below!

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!

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

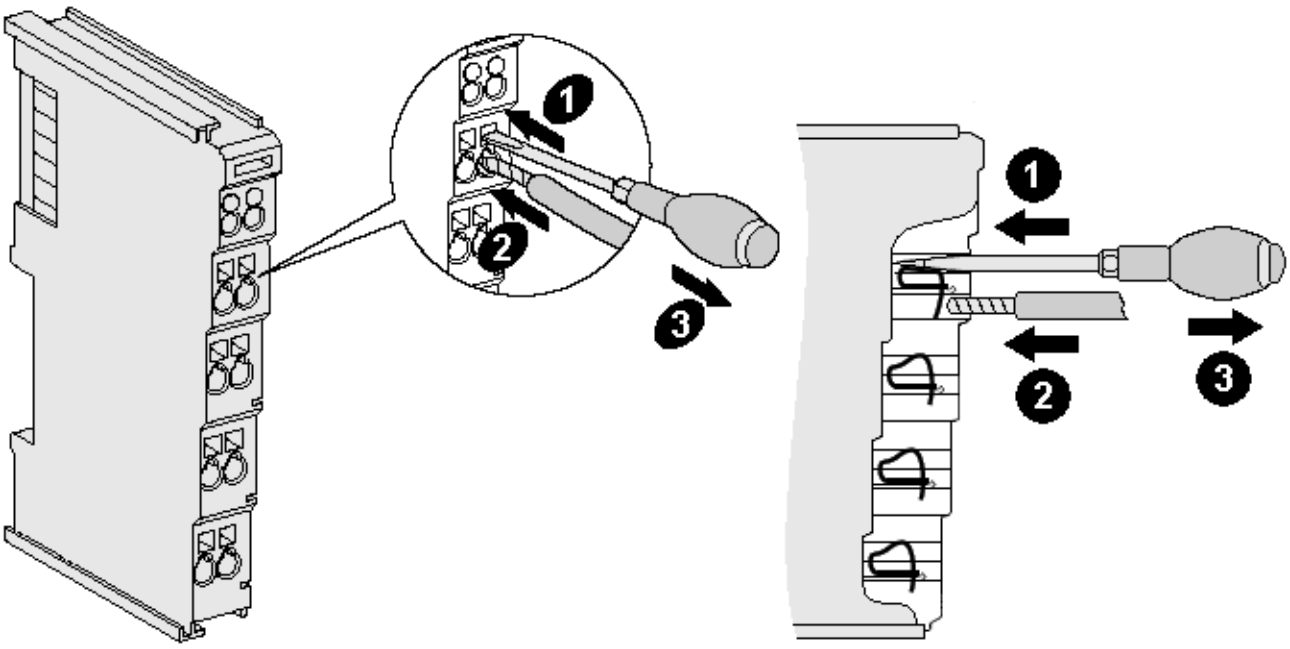

Fig. 9: Connecting a cable on a terminal point

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 mm²	0.08 ... 2.5 mm²
Wire size width (fine-wire conductors)	0.08 ... 2.5 mm²	0,08 ... 2.5 mm²
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm²	0.14 ... 1.5 mm²
Wire stripping length	8 ... 9 mm	9 ... 10 mm

High Density Terminals (HD Terminals [▶ 17]) 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 mm²
Wire size width (fine-wire conductors)	0.25 ... 1.5 mm²
Wire size width (conductors with a wire end sleeve)	0.14 ... 0.75 mm²
Wire size width (ultrasonically “bonded" conductors)	only 1.5 mm²
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.

3.5 KL5051 - Connection and LED description

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!

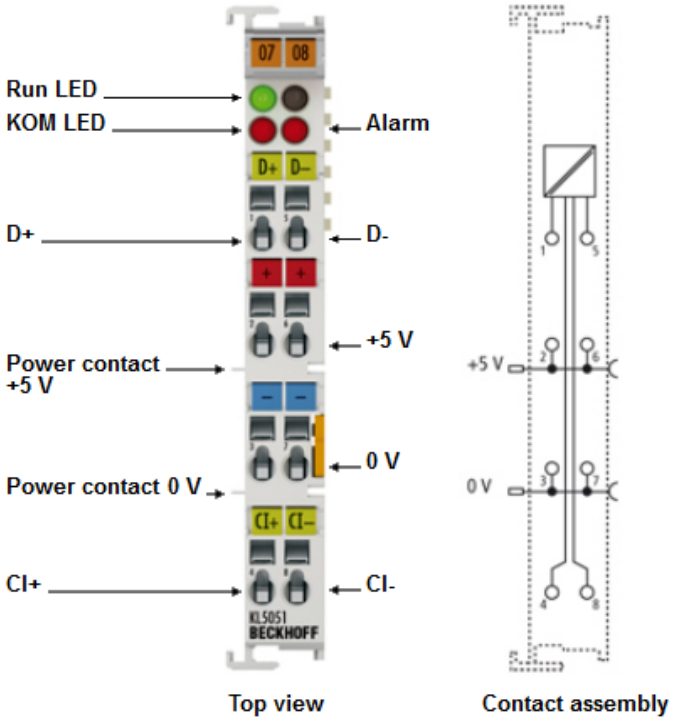

Fig. 10: KL5051 - Connection and LEDs

KL5051 connection		
Terminal point	**No.**	**Comment**
D+	1	SSI data input D+
+5 V	2	+5 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)
Cl+	4	Clock output CL+
D-	5	SSI data input D-
+5 V	6	+5 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)
Cl-	8	Clock output CL-

LED description KL5051			
LED	**Color**	**Description**	
LED Run1	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 LED goes out.
KOM-LED	red	On:	Communication error, e.g. open circuit on the data or clock line
		Off:	normal operation
Alarm	red	On:	The connected device has issued a fault message.
		Off:	normal operation

3.6 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 94/9/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 60529! The environmental conditions during use are thereby to be taken into account! • 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

Marking

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

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

or

 **II 3G KEMA 10ATEX0075 X Ex nC IIC T4 Gc Ta: 0 … 55°C**

3.7 ATEX Documentation

Note	**Notes about operation of the Beckhoff terminal systems in potentially explosive areas (ATEX)** Pay also attention to the continuative documentation Notes about operation of the Beckhoff terminal systems in potentially explosive areas (ATEX) that is available in the download area of the Beckhoff homepage http:\\www.beckhoff.com!

4 Configuration Software KS2000

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. 11: 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 Access from the user program

5.1 KL5051 - Terminal configuration

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

BK2000 Lightbus Coupler

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

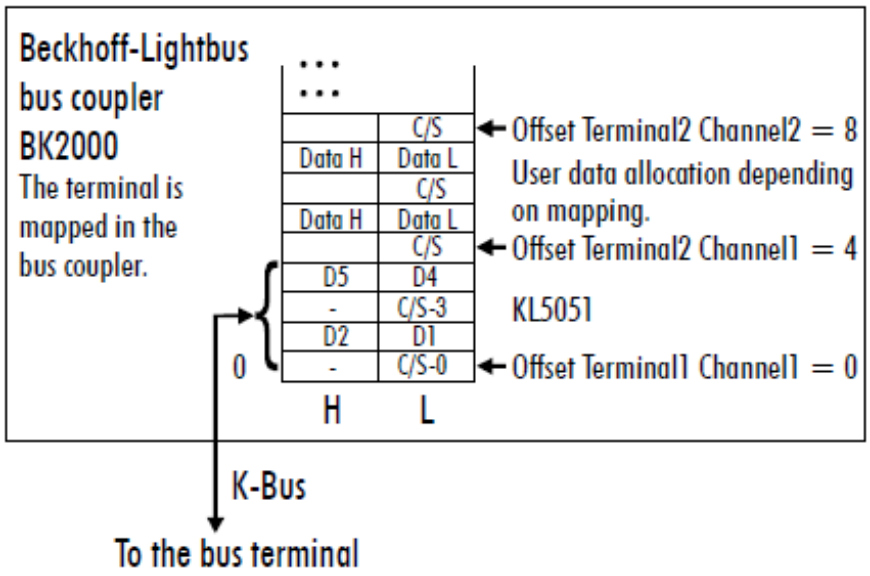

Fig. 12: Mapping in the Lightbus Coupler – example for KL5051

BK3000 Profibus Coupler

In the case of the Profibus coupler BK3000, the KL5051 is always mapped with 6 bytes of input and 6 bytes of output data.

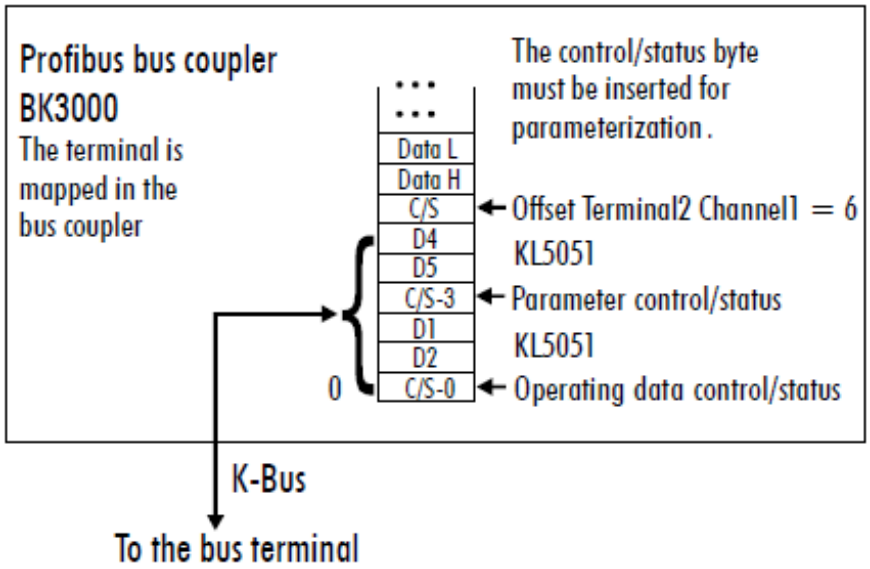

Fig. 13: Mapping in the Profibus Coupler – example for KL5051

BK4000 Interbus Coupler

By default, the Interbus coupler BK4000 maps KL5051 with 6 bytes of input and 6 bytes of output data.

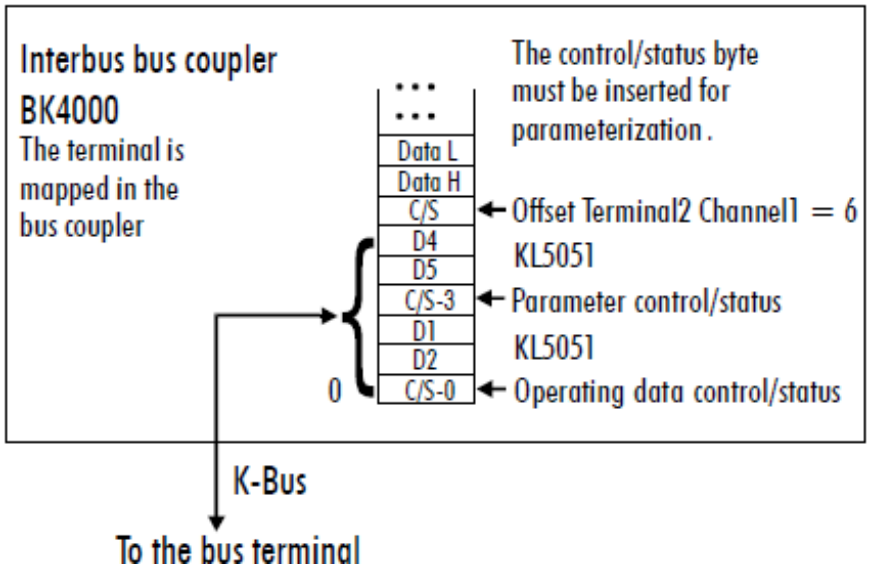

Fig. 14: Mapping in the Interbus Coupler – example for KL5051

Other Bus Couplers and further information

Further information about the mapping configuration of Bus Couplers can be found in the Appendix of the respective Bus Coupler manual under *Master configuration*.

The chapter on Mapping in the Bus Coupler [▶ 27] contains an overview of possible mapping configurations, depending on the configurable parameters.

Note	**Parameterization with KS2000** The KS2000 configuration software can be used for parameterizations via the serial interface of the Bus Coupler, independent of the fieldbus system.

5.2 Mapping in the Bus Coupler

As already described in the *Terminal Configuration* section, each Bus Terminal is mapped in the Bus Coupler. This mapping is usually done with the default setting in the Bus Coupler / Bus Terminal. The KS2000 configuration software or a master configuration software (e.g. ComProfibus or TwinCAT System Manager) can be used to change this default setting.

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

The following tables provide information about how the terminals map themselves in the Bus Coupler, depending on the parameters set.

The KL5051 is mapped into the bus coupler depending on the set parameters. The KL5051 is mapped with 6 bytes of input data and 6 bytes of output data.

Default mapping for: CANopen, CANCAL, DeviceNet, ControlNet, RS232 and RS485 couplers

Conditions	Word offset	High byte	Low byte
Complete evaluation: any Motorola format: no Word alignment: no	0	D1	CB/SB-0
	1	CB/SB-3	D2
	2	D5	D4
	3	-	-

Default mapping for: Profibus and Interbus Coupler

Conditions	Word offset	High byte	Low byte
Complete evaluation: any Motorola format: yes Word alignment: no	0	D2	CB/SB-0
	1	CB/SB-3	D1
	2	D4	D5
	3	-	-

Default mapping for: Lightbus & EtherCAT coupler and Bus Terminal Controller (BCxxxx, BXxxxx)

Conditions	Word offset	High byte	Low byte
Complete evaluation: any Motorola format: no Word alignment: yes	0	-	CB/SB-0
	1	D2	D1
	2	-	CB/SB-3
	3	D5	D4

Conditions	Word offset	High byte	Low byte
Complete evaluation: any Motorola format: yes Word alignment: yes	0	-	CB/SB-0
	1	D1	D2
	2	-	CB/SB-3
	3	D4	D5

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 positioned on a word boundary in the Bus Coupler.
CB-0(A0)	Control byte (appears in the process image of the outputs).
SB-0(E0)	Status byte (appears in the process image of the inputs).
CB-3(A3)	Control byte (appears in the process image of the outputs).
SB-3(E3)	Status byte (appears in the process image of the inputs).
D1, D2, D4, D5 = A1, E1, A2, E2, A4, E4, A5, E5	
"-"	This byte is not used or occupied by the terminal.

5.3 Register overview

Address	Name	Default value	R/W	Storage medium
R0…R5	reserved	0x0000	R	
R6 [▶ 28]	Diagnostic register not used	0x0000	R	
R7 [▶ 28]	Command register - not used	0x0000	R	
R8 [▶ 28]	Terminal type	5051	R	ROM
R9 [▶ 28]	Software version number	0x????	R	ROM
R10 [▶ 28]	Multiplex shift register	0x0218	R	ROM
R11 [▶ 29]	Signal channels	0x0130	R	ROM
R12 [▶ 29]	Minimum data length	0x3030	R	ROM
R13 [▶ 29]	Data structure	0x0000	R	ROM
R14	reserved	0x0000	R	
R15 [▶ 29]	Alignment register	variable	R/W	RAM
R16 [▶ 29]	Hardware version number	0x????	R/W	SEEROM
R17…R30	reserved	0x0000	R/W	SEEROM
R31 [▶ 29]	Code word register	variable	R/W	RAM
R32 [▶ 29]	Feature register	0x0000	R/W	SEEROM
R33…R47	reserved	0x0000	R/W	SEEROM

5.4 Register description

The registers can be read or written via the register communication. They are used for the parameterization of the terminal.

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: reserved**
- **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

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.

R16 to R30: Manufacturer parameter area (SEEROM)

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

These registers can only be altered after a code word has been set in R31 [▶ 29].

R31 to R47: User parameter area (SEEROM)

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

Note

• R31: Code word register in RAM

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

- **R32: Feature register**
  This register specifies the operation modes of the terminal. Thus, for instance, a user-specific scaling can be activated for the analog I/Os.
- **R33 - R47**
  Registers that depend on the terminal type.
- **R47 - R63**
  Extended registers with additional functions.

5.5 Register communication

Register access via process data exchange

- **Bit 7=1: Register mode**
  If bit 7 of the control byte is set, the first two bytes of the user data are not used for process data exchange but written into the register set of the terminal or read from it.
- **Bit 6=0: read, bit 6=1: write**
  Bit 6 of the control bytes is used to specify whether a register should be read or written.
  - **Bit 6=0:** A register is read without changing it. The value can be found in the input process image.
  - **Bit 6=1:** The user data are written into a register. The process is complete once the status byte in the input process image has returned an acknowledgment (see example).
- **Bit 0 to 5: Address**
  The address of the register to be addressed is entered in bits 0 to 5 of the control byte

Control byte in register mode (REG=1)

Bit	7	6	5	4	3	2	1	0
Name	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
Addresses A5...A0 can be used to address a total of 64 registers.

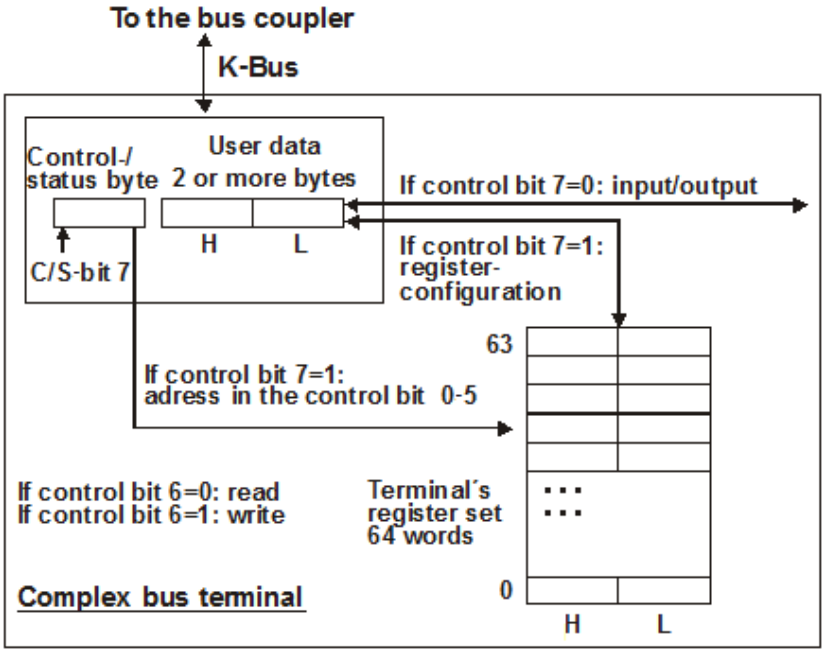

Fig. 15: Register mode control byte

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 data byte is inserted after the control or status byte, and the register value is therefore placed on a word boundary).

Example 1:
Reading of register 8 in the BK2000 with a KL5051 and the end terminal:

If the following bytes are transferred from the controller 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 (0x13BB corresponds to unsigned integer 5051)

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataIN 1	DataIN 0	Not used	Status byte
Value	0xBB	0x13	0x00	0x88

Sample 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 controller 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 acknowledgment.

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

5.6 Data exchange, function

Communication with the servo drive takes place via the process data (A0-A5, E0-E5). With

- A0/E0 is the control/status byte for the operating data communication and
- A3/E3 is the control/status byte for the parameter and server status communication with the device.

Operating data status byte E0

The operating data status byte issues potential servo drive error messages in process data exchange.

MSB

REG=0	ERROR	ALARM	KOM_ERR	CRC_ERR			

Bit	Description
ERROR	This is set when ALARM or KOM_ERR is set.
ALARM	The alarm bit of the servo drive is displayed here.
KOM_ERR	There has been a communication problem. No valid data is exchanged. Possible causes: • The servo interface is de-energized or not ready for operation. • An open circuit is present, or the connection lines of the terminal are reversed.
CRC_ERR	Faulty telegrams occur during data transmission (possibly EMC issue).

Parameter control byte A3 when the servo control is set (bit 7 = 0)

Various actions are performed in the servo drive with this control byte.

MSB

REG=0		RD_PARH	RD_PARL	RS_ANS	RF	/NSTOP	/PSTOP

Bit	Description
REG	This bit switches between servo parameter and servo control/status communication.
RD_PARH	Read parameter High Word (parameter address in A4)
RD_PARL	Read parameter Low Word (parameter address in A4)
RS_ANS	Reset of communication monitoring or lag error. If the servo reports a fault, e.g. communication monitoring has been triggered, the fault can be reset by setting this bit. If the error message in status byte E3 (SERV_ERR) is not reset (e.g. internal temperature too high), the servo drive must be de-energized (this is the only way to reset the other error messages).
RF	Controller enable. The output stage is enabled and the brake (if available) is enabled at the same time.
/NSTOP (active low)	Negative set values are set to zero.
/PSTOP (active low)	Positive set values are set to zero.

Parameter status byte E3 during acquisition of the servo status

Once enabled, the servo status word is continuously read and updated by the servo.

MSB

REG=0	KOM_ERR	RD_PARH_Q	RD_PARL_Q	SERV_ERR	RF_Q	/NSTOP_Q	/PSTOP_Q

Bit	Description
REG	0: The channel consisting of A3, A4, A5, E3, E4, E5 is in the operation mode with which the servo control/status is operated.
KOM_ERR	An error has occurred during data transfer.
RD_PARH_Q	E4, E5 contains the high word of the requested parameter value.
RD_PARL_Q	E4, E5 contains the low word of the requested parameter value.
SERV_ERR	The power section of the servo reports an error.
RF_Q	The output stage and any existing brake are enabled.
/NSTOP_Q (active low)	1: Negative set values are possible. 0: Negative set values are set to zero.
/PSTOP (active low)	1: Positive set values are possible. 0: Positive set values are set to zero.

Parameter control byte A3 in parameter operation mode (bit 7 = 1)

The parameter data is written to a buffer with the parameter address and transferred to the servo on request. This request can be made with the last buffer entry. The data frame is formed by the terminal, and the checksum is checked and evaluated. The parameter data form a maximum of one double word, but shorter parameter data can also be sent.

MSB

REG=1		RD_PARH	RD_PARL		PUT_HW	PUT_LW	TRS_BUF

Bit	Description
REG	This bit switches between servo parameter and servo control/status communication.
RD_PARH	Read parameter High Word (parameter address in A4)
RD_PARL	Read parameter Low Word (parameter address in A4)
PUT_HW	Write high word of the parameter to the buffer (A4, A5 parameter High Word).
PUT_LW	Write low word of the parameter to the buffer (A4, A5 parameter Hight Word).
TRS_BUF	Write data from the buffer to the parameter address set by A4.

Parameter status byte E3 in Parameter operation mode

During parameter communication (REG = 1) with the servo, various acknowledgements are output in the status byte.

MSB

REG=1	KOM_ERR	RD_PARH_Q	RD_PARL_Q	SERV_ERR	PUT_HW_Q	PUT_LW_Q	TRS_BUF_Q

Bit	Description
REG	1: The channel consisting of A3, A4, A5, E3, E4, E5 is in the operation mode with which the parameter communication takes place.
KOM_ERR	An error has occurred during data transfer.
RD_PARH_Q	E4, E5 contains the high word of the requested parameter value.
RD_PARL_Q	E4, E5 contains the low word of the requested parameter value.
SERV_ERR	The power section of the servo reports an error.
PUT_HW_Q	The High Word was written to the buffer.
PUT_LW_Q	The Low Word was written to the buffer.
TRS_BUF_Q	Data was successfully transferred.

5.7 Examples of Register Communication

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

5.7.1 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.

5.7.2 Example 2: Writing to an user register

Note

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})	0xXX	0xXX

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})	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 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})	0xXX	0xXX

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})	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 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})	0xXX	0xXX

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!

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!

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List of illustrations