

# **KL3102**

## **2-Channel Analog Input Terminal –10 V...+10 V Configuration Instructions**

**Version 2.0.2  
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**BECKHOFF**

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# Foreword

## Notes on the documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components.

### Liability Conditions

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.

The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. None of the statements of this manual represents a guarantee (Garantie) in the meaning of § 443 BGB of the German Civil Code or a statement about the contractually expected fitness for a particular purpose in the meaning of § 434 par. 1 sentence 1 BGB. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. 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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# Safety Instructions

## State at Delivery

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.

## Description of safety symbols

The following safety symbols are used in this documentation. They are intended to alert the reader to the associated safety instructions..



***Danger***

This symbol is intended to highlight risks for the life or health of personnel.



***Attention***

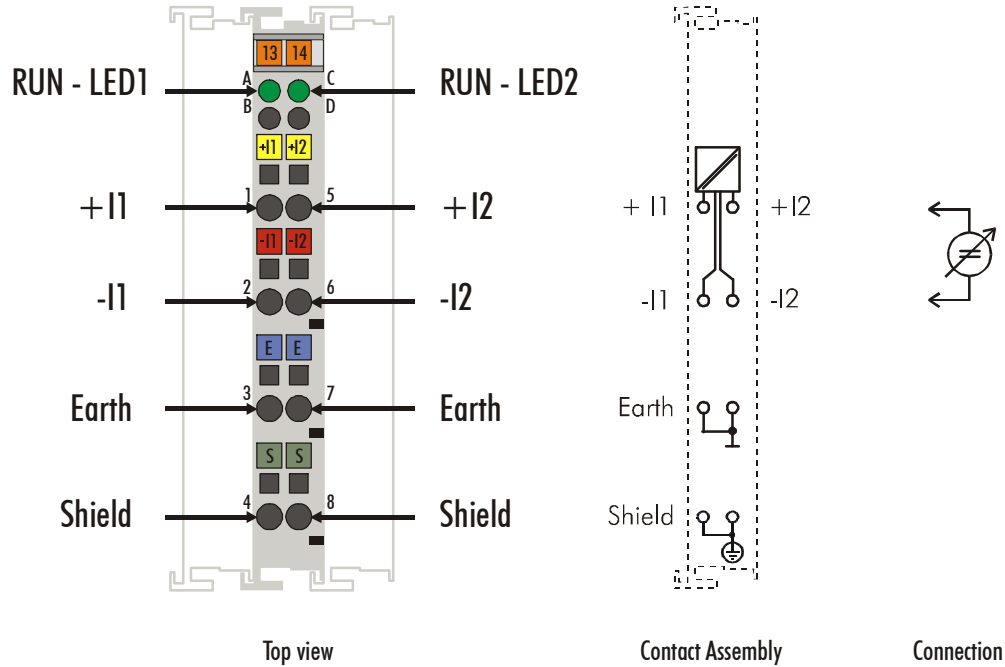
This symbol is intended to highlight risks for equipment, materials or the environment.



***Note***

This symbol indicates information that contributes to better understanding.

# Technical data



Technical data	KL3102
Number of inputs	2
Power supply	via the K-Bus
Signal voltage	-10 V ... +10 V
Internal resistance	> 200 kΩ
Common mode voltage $U_{CM}$	35 V max.
Resolution	16 Bit (for 0 ... 10 V range: 15 bits resolution)
Conversion time	140 ms, configurable to 2 ms
Filter	50 Hz, configurable
Measuring error (total measuring range)	< ± 0.3% (of the upper range value)
Electrical isolation	500 Vrms (K-Bus / signal voltage)
Current consumption from K-Bus	65 mA typ.
Bit width in the process image	I: 2 x 16 bits data, (2 x 8 bits control/status optional)
Configuration	no address or configuration setting
Weight approx.	70 g
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/Shock resistance	conforms to IEC 68-2-6 / IEC 68-2-27
EMC resistance Burst / ESD	conforms to EN 50082 (ESD, Burst) / EN 50081
Installation position	any
Type of protection	IP20

## Description of functions

The analog input terminal KL3102 processes signals within the range from -10 to +10 V with a resolution of 16 bits (65535 increments). The inputs of the KL3102 are differential inputs which share a common earth. As a result the KL3102 is ideally suited to measuring earth free voltage drops. In the standard version a filter is active with a stop frequency (64.5 dB) of 50 Hz. The filter constant and with it connected the conversion time is adjustable in wide areas.

Output format of process data

In the default setting, process data is represented in the two's complement (-1 corresponds to 0xFFFF). By way of the feature register, other modes of representation can be selected (e.g. signed amount representation, Siemens output format).

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

LED display

The two RUN LEDs indicate the operating state of the affiliated terminal channel.

RUN LED:

On – normal operation

Off – a watchdog-timer overflow has occurred. The green LEDs go off if no process data is transferred by the bus coupler for 100 ms.

Process data

The process data that is transferred to the bus coupler is calculated on the basis of the following equations:

X\_adc: AD converter output values

Y\_au: Process data to the PLC

B\_a,A\_a: Manufacturer gain and offset adjustment (R17, R18)

B\_h,A\_h: Manufacturer scaling (R19, R20)

B\_w,A\_w: User scaling (R33, R34)

a) neither user nor manufacturer scaling active:

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

$$Y_{aus} = Y_a$$

b) Manufacturer scaling active: (default)

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

$$Y_{aus} = Y_1$$

c) User scaling active:

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

$$Y_{aus} = Y_2$$

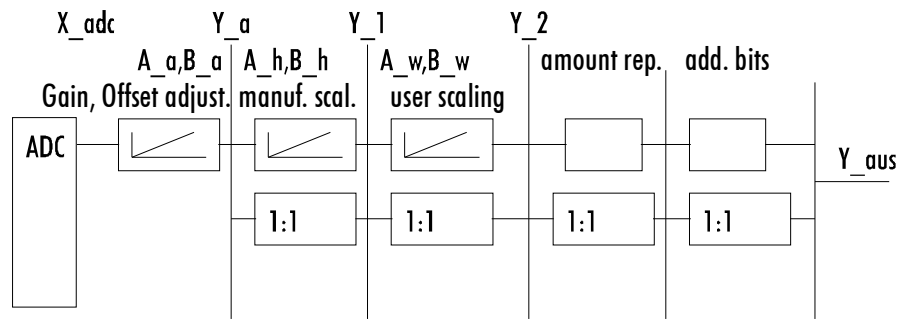
d) Manufacturer and user scaling active:

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

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

$$Y_{aus} = Y_2$$

The straight-line equations are activated by means of R32.



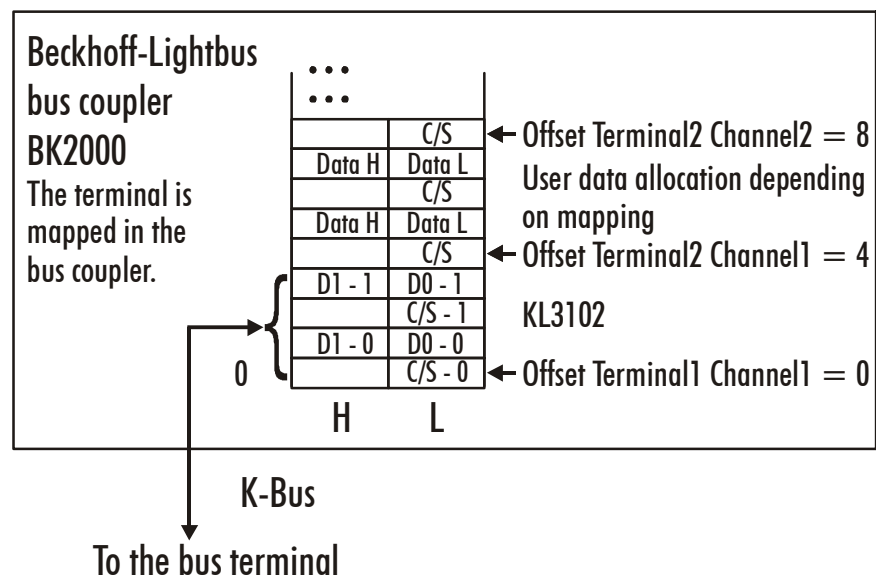
## Terminal configuration

The terminal can be configured and parameterized by way of the internal register structure.

Each terminal channel is mapped in the bus coupler. The terminal's data is mapped differently in the bus coupler's memory depending on the type of the bus coupler and on the set mapping configuration (e.g. Motorola / Intel format, word alignment,...). For parameterization of a terminal, the control /status byte must also be mapped.

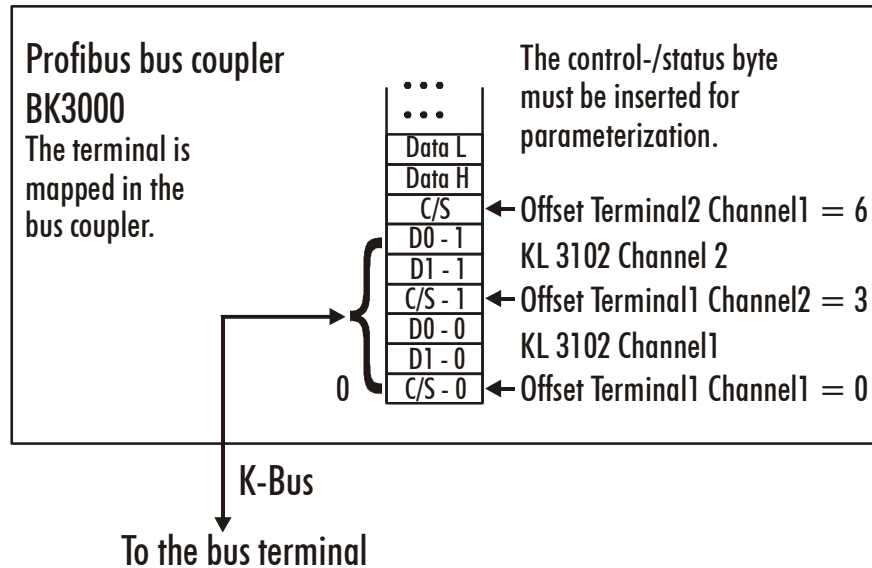
Beckhoff Lightbus Coupler BK2000

In the case of the Beckhoff Lightbus coupler BK2000, the control /status byte is always mapped besides the data bytes. It is always in the low byte at the offset address of the terminal channel.



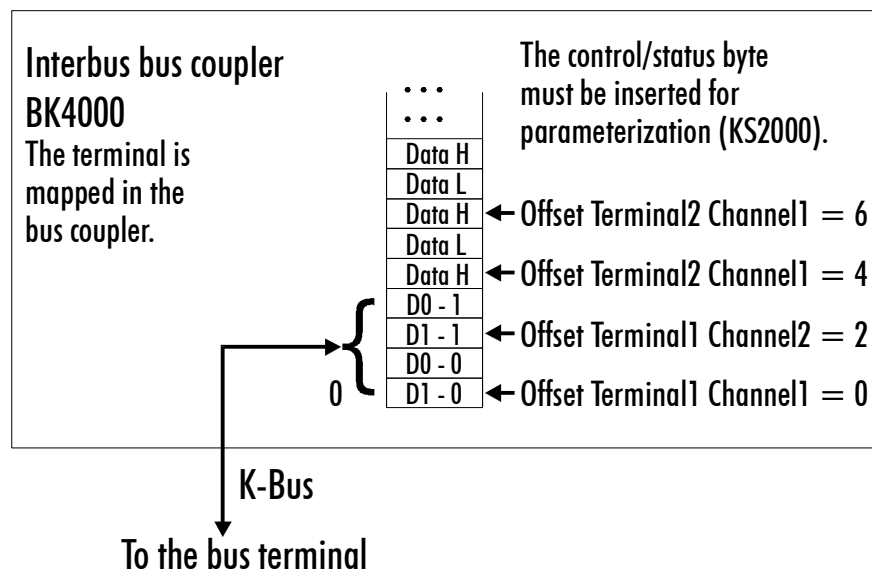
Profibus Coupler BK3000

In the case of the Profibus coupler BK3000, for which terminal channels the control /status byte is also to be inserted must be defined in the master configuration. If the control /status byte is not evaluated, the KL3102 occupies 4 bytes of input data (2 bytes of user data per channel).



**Interbus Coupler BK4000**

By default, the Interbus coupler BK4000 maps the KL3102 with 4 bytes of input data (2 bytes of user data per channel). Parameterization via the field bus is not possible. The KS2000 software is required for configuration if use is to be made of the control /status byte.



Other bus couplers and further information



You will find further information on the mapping configuration of bus couplers in the annex of the respective bus coupler manual under the heading of "Configuration of masters".

The annex contains an overview of the possible mapping configurations depending on the adjustable parameters.

Parameterization with the KS2000 software

Parameterization operations can be carried out independently of the field bus system using the Beckhoff KS2000 configuration software via the serial configuration interface in the bus coupler.



## Register description

The complex terminals can be adjusted to different operating modes or functionalities. The " general description of register " describes the contents of the registers, which are identical for all complex terminals.

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

The access to the internal registers of the terminal is described in the section " register communication ".

## General register description

Complex terminals that possess a processor are capable of bidirectionally ex-changing data with the higher-level control system. Below, these terminals are referred to as intelligent bus terminals. They include the analog inputs (0-10V, -10-10V, 0-20mA, 4-20mA), the analog outputs (0-10V, -10-10V, 0-20mA, 4-20mA), serial interface terminals (RS485, RS232, TTY, data transfer terminals), counter terminals, encoder interfaces, SSI interfaces, PWM terminals and all other parameterizable terminals.

Internally, all intelligent terminals possess a data structure that is identical in terms of it's essential characteristics. This data area is organized in words and embraces 64 memory locations. The essential data and parameters of the terminal can be read and adjusted by way of the structure. Function calls with corresponding parameters are also possible. Each logical channel of an intelligent terminal has such a structure (therefore, 4-channel analog terminals have 4 register sets).

This structure is broken down into the following areas:  
(You will find a list of all registers at the end of this documentation).

Area	Address
Process variables	0-7
Type registers	8-15
Manufacturer parameters	16-30
User parameters	31-47
Extended user area	48-63

Process variables

### **R0 - R7: Registers in the terminal's internal RAM:**

The process variables can be used in addition to the actual process image and their functions are specific to the terminal.

**R0 - R5: These registers have a function that depends on the terminal type.**

#### **R6: Diagnostic register**

The diagnostic register may contain additional diagnostic information. In the case of serial interface terminals, for example, parity errors that have occurred during data transfer are indicated.

#### **R7: Command register**

High-Byte\_Write = function parameter

Low-Byte\_Write = function number

High-Byte\_Read = function result

Low-Byte\_Read = function number

## Type registers

**R8 - R15 Registers in the terminal's internal ROM**

The type and system parameters are programmed permanently by the manufacturer and can only be read by the user but cannot be modified.

**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 an ASCII character string.

**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**

In comparison with R10, the number of logically existing channels is located here. For example, one physically existing shift register may consist of several signal channels.

**R12: Minimum data length**

The respective byte contains the minimum data length of a channel to be transferred. If the MSB is set, then the control/status byte is not necessarily needed for the function of the terminal and, with appropriate configuration of the coupler, is not transferred to the control system.

**R13: Data type register**

Data type register	
0x00	Terminal without valid data type
0x01	Byte array
0x02	1 byte n bytes structure
0x03	Word array
0x04	1 byte n words structure
0x05	Double word array
0x06	1 byte n double words structure
0x07	1 byte 1 double word structure
0x08	1 byte 1 double word structure
0x11	Byte-array with a variable logical channel length
0x12	1 byte n bytes structure with a variable logical channel length (eg 60xx)
0x13	Word-array with a variable logical channel length
0x14	1 byte n words structure with a variable logical channel length
0x15	Double word array with a variable logical channel length
0x16	1 byte n double words structure with a variable logical channel length

**R14: not used****R15: Alignment bits (RAM)**

The analog terminal is set to a byte limit in the terminal bus with the alignment bits.

## Manufacturer parameters

**R16 - R30 is the area of the Manufacturer Parameters (SEEROM)**

The manufacturer parameters are specific to each terminal type. They are programmed by the manufacturer but can also be modified from the control system. The manufacturer parameters are stored permanently in a serial EEPROM and are therefore not destroyed by power failures.

These registers can only be modified after setting a code word in R31.

User parameters

**R31 - R47 Application parameters area (SEEROM)**

The application parameters are specific to each terminal type. They can be modified by the programmer. The application parameters are stored permanently in a serial EEPROM in the terminal and cannot be destroyed by power failures. The user area is write protected over a Codeword.



Note

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

The code word **0x1235** must be entered here to enable modification of parameters in the user area. Write-protection is set if a different value is entered in this register. When write protection is inactive, the code word is returned during reading of the register. The register contains the value zero when write protection is active.

**R32: Feature-register**

This register defines the operating modes of the terminal. For example, a user-specific scaling can be activated for the analog I/O's.

**R33 - R47**

Registers that depend on the terminal type

Extended application area

**R47 - R63**

These registers have not yet been implemented.

## Terminal-specific register description

Process variables

**R0: Raw ADC value X\_R**

This register contains the ADC raw value afflicted with gain and offset errors.

**R1 - R5: No function****R6: Diagnostic register**

High byte: not used

Low byte: status byte

Manufacturer's Parameters

**R17: Offset – Hardware B\_a**

ca. 0x00XX

16 bit signed integer

The terminal's offset is adjusted via this register (eq. 1.1).

**R18: Gain-Hardware A\_a**

ca. 0x24XX

16 Bit signed Integer \* 2<sup>-16</sup> +1

The terminal's gain is adjusted by means of this register (eq. 1.1).

In doing so a 1 corresponds to 0x0000, a 2 corresponds to 0xFFFF.

**R19: Manufacturer –Offset B\_h**

[0x0000]

16 bit signed integer

This register contains the offset of the manufacturer's straight-line equation (1.3). The straight-line equation is activated via R32.

**R20: Manufacturer scaling A\_h**

[0x0100]

16 Bit signed Integer \* 2<sup>-8</sup>

This register contains the scaling factor of the manufacturer's straight-line equation (1.3). The straight-line equation is activated via R32.

A 1 corresponds to the register value 0x0400.

## Application parameters

**R32: Feature register**

[0x0000]

The feature register determines the operating modes of the terminal.

Feature Bit No.		Mode description
Bit 0	1	User scaling (R33, R34) active [0]
Bit 1	1	Manufacturer scaling (R19, R20) active [0]
Bit 2	1	Watchdog timer active [0] By default, the watchdog-timer is on.
Bit 3	1	Signed amount representation [0] The signed amount format is active instead of the 2's complement. (-1 = 0x8001)
Bits 7-4	-	not used, don't change
Bit 9	1	Limit 1 active [0] The process data is compared against limit 1 (R35) and corresponding status bits are set.
Bit 10	1	Limit 2 active [0] The process data is compared against limit 1 (R36) and corresponding status bits are set.
Bits 15-11	-	not used, don't change

**R33: User-Offset B\_w**

[0x0000]

16 bit signed integer

This register contains the offset of the user straight-line equation (1.4). The straight-line equation is activated via R32.

**R34: User scaling A\_w**

[0x0100]

16 bit signed integer \* 2<sup>-8</sup>

This register contains the scaling factor of the user straight-line equation (1.4). The straight-line equation is activated via R32.

**R35: Limit 1 in Y\_2**

[0x0000]

If the process data exceeds or falls below this limit, the corresponding bits are set in the status byte.

**R36: Limit 2 in Y\_2**

[0x0000]

If the process data exceeds or falls below this limit, the corresponding bits are set in the status byte.

**R37: Filter constant of the ADC**

[35C0]

The KL3102 possesses two low-pass filter stages. The first level consists of a sinc<sup>3</sup> filter. This is always active. Second consists of a FIR filter 22.order, which can be deactivated.

R37.0 Fast-Bit =1: It takes place a fast reaction to branches at the input despite active filter stage. With branches the filter is gone around.

R37.1 Skip-Bit =1: The FIR filter stage is deactivated.

SKIP=1

$$F_g = 81076 / N_f$$

SKIP=0

$$F_g = 11981 / N_f$$

$$F_{stop} = 43008 / N_f$$

R37.2 not used

R37.3 not used

R37.15 – R37.4 Filter constant Nf

The filter constant determines the 3 dB critical frequency of the sinc<sup>3</sup> of the filter. The scope extends from 150 to 2047. The 3 dB critical frequency F\_g or the 64.5 dB stop frequency F\_stop:

R37	F_Stop [Hz]	cycle time [ms]
0x35C0	50	140
0x2660	70	100
0x1330	140	50
0x7FF1		40
0x3FF1		20
0x1001		<4
	F_g [Hz]	
0x7FF2	39,6	40
0x3FF2	77,36	20
0x1002	158	<4

## Control/Status byte

CONTROL byte in  
process data transfer  
Gain and offset adjustment

The control byte is transferred from the controller to the terminal. It can be used in the register mode (REG = 1) or in process data transfer (REG = 0). The gain and offset of the terminal can be adjusted with the control byte (process data transfer). The code word must be entered in R31 to enable adjustment of the terminal. The terminal's gain and offset can then be adjusted.

The parameters are not permanently stored until the code word is reset!

Control byte:

Bit 7 = 0

Bit 6 = 1 Terminal adjustment function is activated

Bit 4 = 1 gain adjustment

Bit 2 = 0 slow clock = 1000 ms

1 fast clock = 50 ms

Bit 1 = 1 up

Bit 0 = 1 down

Bit 3 = 1 offset adjustment

Bit 2 = 0 slow clock = 1000 ms

1 fast clock = 50 ms

Bit 1 = 1 up

Bit 0 = 1 down

Status byte in  
process data transfer

The status byte is transferred from the terminal to the controller. The status byte contains various status bits of the analog input terminal KL3102:

Status byte:

Bit 7 = 0

Bit 6 = 1: ERROR – General error bit

Bit5	Bit4	
0	0	Limit 2 not activated
0	1	Process data less than Limit 2
1	0	Process data more than Limit 2
1	1	Process data equal to Limit 2

Bit3	Bit2	
0	0	Limit 1 not activated
0	1	Process data less than Limit 1
1	0	Process data more than Limit 1
1	1	Process data equal to Limit 1

Bit 1 = 1: Over range

Bit 0 = 1: Under range

## Register communication KL3102

Register access via  
process data transfer  
Bit 7 = 1: register mode

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

Bit 6 = 0: read  
Bit 6 = 1: write

In bit 6 of the control byte, you define whether a register is to be read or written. When bit 6 is not set, a register is read without modification. The value can be taken from the input process image.

When bit 6 is set, the user data is written into a register. The operation is concluded as soon as the status byte in the input process image has supplied an acknowledgement (see examples).

Bits 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 the  
register mode

MSB

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

REG = 0: Process data transfer

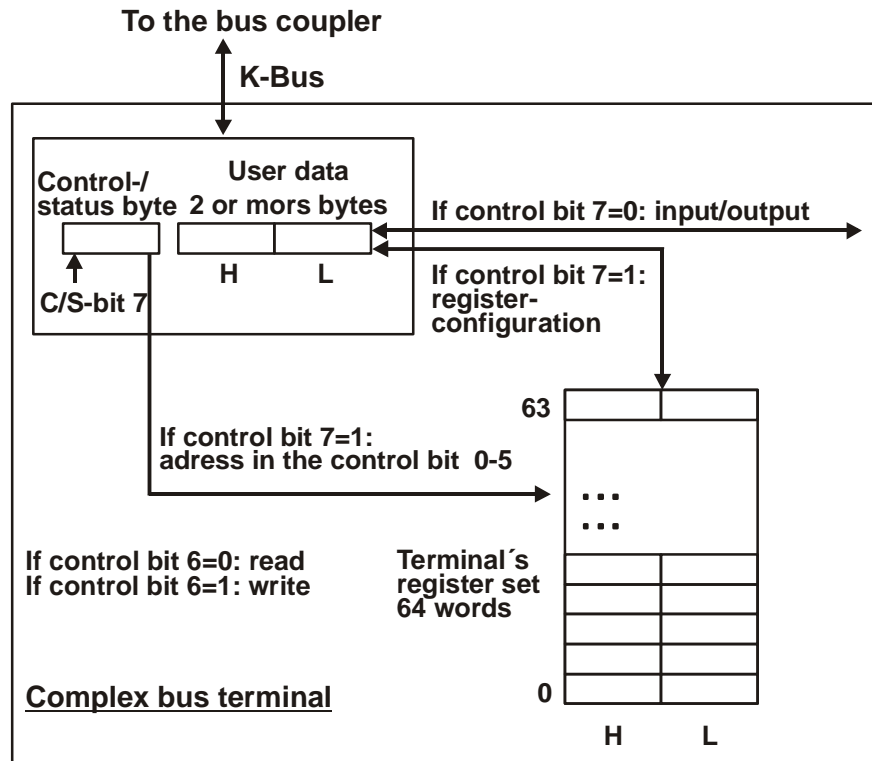
REG = 1: Access to register structure

W/R = 0: Read register

W/R = 1: Write register

A5...A0 = Register address

A total of 64 registers can be addressed with the addresses A5....A0.



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 to the rule: here, an unused data byte is inserted after the control or status byte, thus setting the register value to a word limit).

Example

Reading register 8 in the BK2000 with a KI3022 and the end terminal.

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

Byte0	Byte1	Byte2	Byte3
Control	Not used	Data OUT, high byte	Data OUT, low byte
0x88	0xXX	0xXX	0xXX

the terminal returns the following type designation (0x0BCE corresponds to the unsigned integer 3022).

Byte0	Byte1	Byte2	Byte3
Status	Not used	Data IN, high byte	Data IN, low byte
0x88	0x00	0x0B	0xCE

A further example

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

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

Byte0	Byte1	Byte2	Byte3
Control	Not used	Data OUT, high byte	Data OUT, low byte
0xDF	0xXX	0x12	0x35

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

Byte0	Byte1	Byte2	Byte3
Status	Not used	Data IN, high byte	Data IN, low byte
0x9F	0x00	0x00	0x00

## Annex

As already described in the chapter terminal configuration, each bus terminal is mapped in the bus coupler. In the standard case, this mapping is done with the default setting in the bus coupler / bus terminal. This default setting can be modified with the Beckhoff KS2000 configuration software or using master configuration software (e.g. ComProfibus or TwinCAT System Manager). The following tables provide information on how the KL3102 maps itself in the bus coupler depending on the set parameters.

### Mapping in the bus coupler

Mapping in the bus coupler The KL3102 is mapped in the bus coupler depending on the set parameters. If the terminal is evaluated completely, the terminal occupies memory space in the process image of the inputs and outputs.

Default: CANCEL,  
CANopen, RS232,  
RS485, ControlNet,  
DeviceNet

		I/O Offset	High Byte	Low Byte
Complete evaluation	= 0	3		
MOTOROLA format	= 0	2		
Word alignment	= X	1	D1 - 1	D0 - 1
		0	D1 - 0	D0 - 0

Default: Interbus,  
Profibus

		I/O Offset	High Byte	Low Byte
Complete evaluation	= 0	3		
MOTOROLA format	= 1	2		
Word alignment	= X	1	D0 - 1	D1 - 1
		0	D0 - 0	D1 - 0

		I/O Offset	High Byte	Low Byte
Complete evaluation	= 1	4		
MOTOROLA format	= 0	3	D1 - 1	D0 - 1
Word alignment	= 0	2	CT/ST - 1	D1 - 0
		1	D0 - 0	CT/ST - 0

		I/O Offset	High Byte	Low Byte
Complete evaluation	= 1	4		
MOTOROLA format	= 1	3	D0 - 1	D1 - 1
Word alignment	= 0	2	CT/ST - 1	D0 - 0
		1	D1 - 0	CT/ST - 0

Default: Lightbus,  
Bus Terminal Controller  
(BCxxxx)

		I/O Offset	High Byte	Low Byte
Complete evaluation	= 1	4	D1 - 1	D0 - 1
MOTOROLA format	= 0	3	-	CT/ST - 1
Word alignment	= 1	2	D1 - 0	D0 - 0
		1	-	CT/ST - 0

		I/O Offset	High Byte	Low Byte
Complete evaluation	= 1	4	D0 - 1	D1 - 1
MOTOROLA format	= 1	3	-	CT/ST - 1
Word alignment	= 1	2	D0 - 0	D1 - 0
		1	-	CT/ST - 0



## Key

Complete evaluation: the terminal is mapped with control / status byte.  
Motorola format: The Motorola or Intel format can be set.  
Word alignment: The terminal is at a word limit in the bus coupler.  
CT: Control Byte (appears in the PI of the outputs).  
ST: Status Byte (appears in the PI of the inputs).  
D0 - 0 : D0 = Data-Low-Byte, 0 = Channel 0  
D1 - 1 : D1 = Data-High-Byte, 1 = Channel 1

## Table of the register

Register set

Address	Description	Default	R/W	Storage medium
R0	Raw ADC value	variable	R	RAM
R1	not used	0x0000	R	
R2	not used	0x0000	R	
R3	not used	0x0000	R	
R4	not used	0x0000	R	
R5	not used	0x0000	R	
R6	Diagnostic register	variable	R	RAM
R7	Command register - not used	0x0000	R	
R8	Terminal type	3102	R	ROM
R9	Software version number	0x????	R	ROM
R10	Multiplex-shift register	0x0218	R	ROM
R11	Signal channels	0x0218	R	ROM
R12	minimum data length	0x0098	R	ROM
R13	Data structure	0x0000	R	ROM
R14	not used	0x0000	R	
R15	Alignment-register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	Hardware offset adjustment	specific	R/W	SEEROM
R18	Hardware gain adjustment	specific	R/W	SEEROM
R19	Manufacturer scaling: offset	0x0000	R/W	SEEROM
R20	Manufacturer scaling: gain	0x0100	R/W	SEEROM
R21	not used	0x0000	R/W	SEEROM
R22	not used	0x0000	R/W	SEEROM
R23	not used	0x0000	R/W	SEEROM
R24	not used	0x0000	R/W	SEEROM
R25	not used	0x0000	R/W	SEEROM
R26	not used	0x0000	R/W	SEEROM
R27	not used	0x0000	R/W	SEEROM
R28	not used	0x0000	R/W	SEEROM
R29	not used	0x0000	R/W	SEEROM
R30	not used	0x0000	R/W	SEEROM
R31	Code word register	variable	R/W	RAM
R32	Feature register	0x0000	R/W	SEEROM
R33	User offset	0x0000	R/W	SEEROM
R34	User gain	0x0100	R/W	SEEROM
R35	Limit 1	0x0000	R/W	SEEROM
R36	Limit 2	0x0000	R/W	SEEROM
R37	Filter constant	0x35C0	R/W	SEEROM
R38	not used	0x0000	R/W	SEEROM
R39	not used	0x0000	R/W	SEEROM
R40	not used	0x0000	R/W	SEEROM
R41	not used	0x0000	R/W	SEEROM
R42	not used	0x0000	R/W	SEEROM
R43	not used	0x0000	R/W	SEEROM
R44	not used	0x0000	R/W	SEEROM
R45	not used	0x0000	R/W	SEEROM
R46	not used	0x0000	R/W	SEEROM
R47	not used	0x0000	R/W	SEEROM

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You will also find further documentation for Beckhoff components there.

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