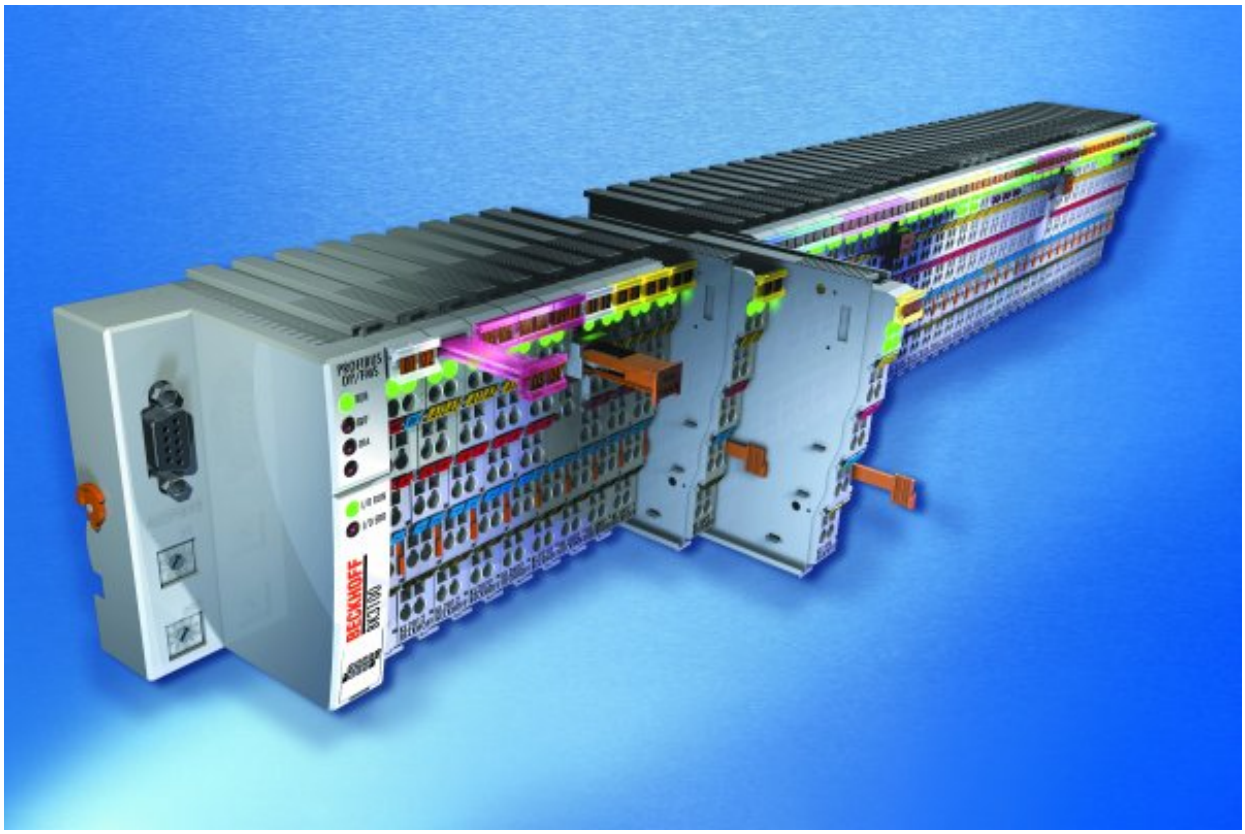


Configuration Instructions for

KL5111-0000, KS5111-0000

Interface Terminal for Incremental Encoder

Version: 3.0.1
Date: 2008-09-16

BECKHOFF

Table of Contents

1 Foreword

1.1 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.

1.1.1 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.

1.1.2 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.

1.1.3 Copyright

1.1.4 Description of safety symbols

The following safety symbols are used in this operating manual. 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.

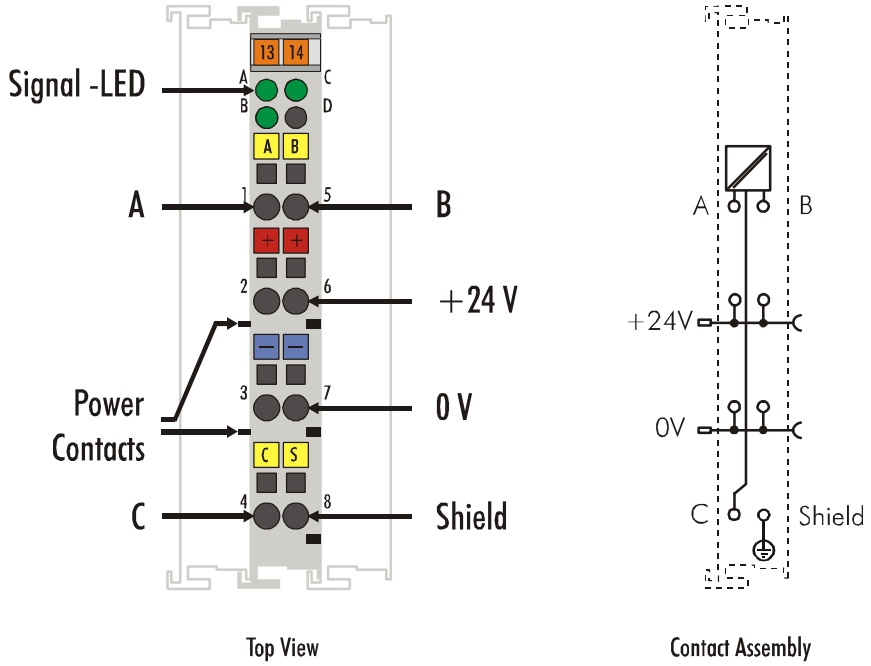
 **Attention** This symbol is intended to highlight risks for equipment, materials or the environment.

 **Note** This symbol indicates information that contributes to better understanding.

1.2 Documentation Issue Status

Version	Comment
3.0.1	Formal corrections
3.0.0	Description of feature register corrected
2.0	- Technical data updated - Register description updated
1.0	First release

2 Product Overview



2.1 Technical Data

Technical Data	KL5111-0000, KS5111-0000
Sensor connection	A, B, C; 24 V
Sensor operating voltage	24 V_{DC}
Counter	16 bits binary
Cut off frequency	1 MHz
Quadrature decoder	4 time evaluation
Zero pulse latch	16 Bit
Commands	read, set, activate
Supply voltage	24 V_{DC} (20 ... 29 V)
Current consumption of Power contacts	typically 0,1 A (without sensor load current)
Bit width in the process image	E/A: 2 x 16 Bit Data, 2 x 8 Bit Control / Status
Current consumption from K-Bus	typically 50 mA
Weight	app. 60 g
Permissible ambient temperature range during operation	0°C ... +55°C
Permissible ambient temperature range during storage	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration / shock resistance	according to EN 60068-2-6 / EN 60068-2-27, EN 60068-2-29
EMC resistance Burst / ESD	according to EN 61000-6-2 / EN 61000-6-4
Installation position	any
Protection class	IP20
Approval	CE

2.2 Description of functions

The incremental encoder interface terminal KL5111 enables the connection of any incremental encoders to the bus coupler or to the controller. The terminal can be operated in two modes (which can be set via the feature register). The terminal is supplied as an incremental encoder interface. In this mode, the terminal evaluates the sensor signals A, B, C as a four-fold quadrature decoder. The sensor is powered with the available power supply voltage (24 V DC). The KL5111 can also be used as a 16-bit up/down counter. A period measurement with a resolution of 200 ns of the input A is possible independently of the set mode.

LED display
The signal LEDs indicate the status of the sensor inputs A, B, C. The corresponding LED is activated with every high signal at the input.

Connections
A, B, zero signals

Shield connection

24 V_{DC} power contacts for sensor powering with automatic potential bridging to the neighboring terminal

Operation modes
These can be set via the feature register (default: incremental encoder):

A, B, zero pulse incremental encoder (default)

Up/down counter with:

- A = Count , the positive edges of the input pulses are counted
- B = = Up/down input
  B = 0: up counting direction
  B = 1: down counting direction
- C = Gate-Eingang
  C = 0: counter enabled
  C = 1: counter disabled

Functions
- Counting
- Counter setting
- Arming the zero pulse and storing the valid value
- Determining the period between two pulses with a resolution of two 200 ns (the time between two positive edges of the input signal A is evaluated)
- Indication of the input signals A, B, C, in the process data
- Indication of a counter overflow or underflow.

Process data
The KL5111 occupies 6 bytes of input data and 6 bytes of output data. The control/status byte is at the least significant byte offset. The data word D0/D1 contains the counter word (read/set) and the data word D3/D4 contains the latch word (read).

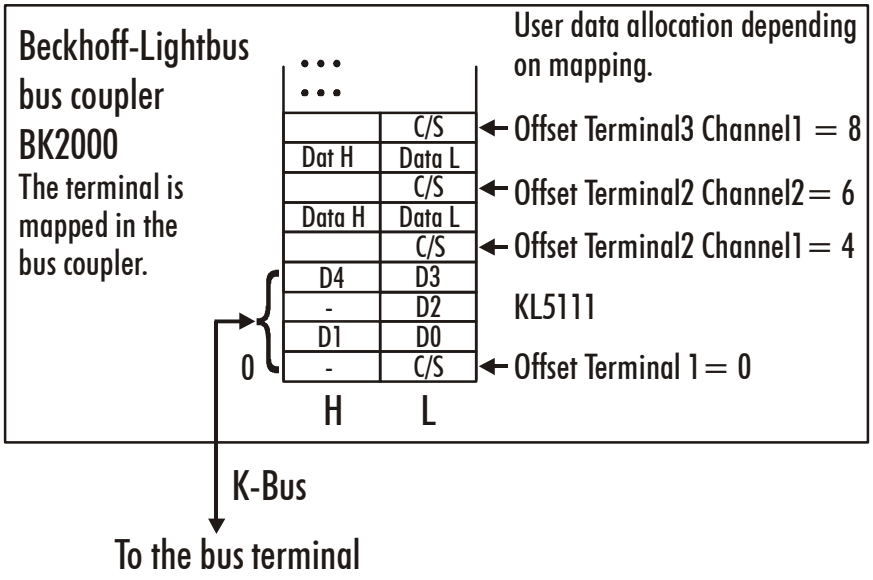
2.3 Terminal configuration

The terminal can be configured and parameterized via the internal register structure.

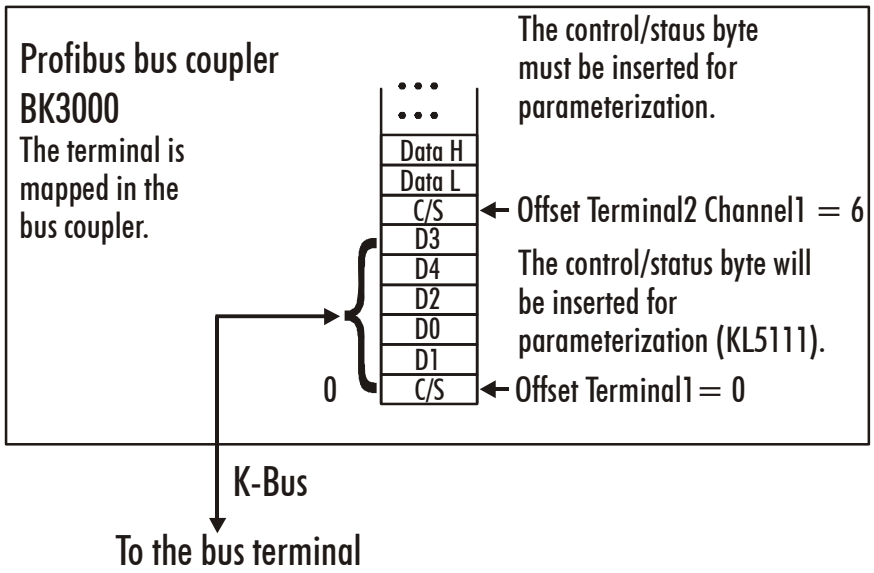
Each terminal channel is mapped in the bus coupler. The data of the terminal is mapped differently in the memory of the bus coupler depending on the type of the bus coupler and on the set mapping configuration (e.g. Motorola/ Intel format, word alignment,...).

Contrary to the analog input and output terminals, in the case of the KL5111 the control and status byte is always mapped regardless of the higher-level field bus system.

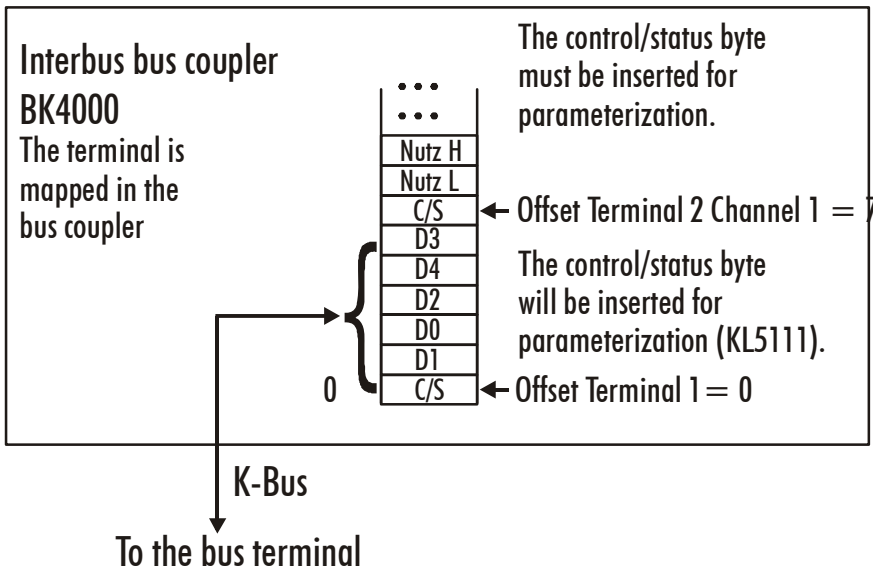
Lightbus Coupler BK2000
In the case of the Lightbus coupler BK2000, the control /status byte is also always (ie. in the case of all analog terminals) mapped in addition to the data bytes. It is always in the low byte at the offset address of the terminal channel.



PROFIBUS Coupler BK3000
In the case of the PROFIBUS coupler BK3000, the Kl5111 is always mapped with 6 bytes of input data and 6 bytes of output data.



Interbus Coupler BK4000
By default, the Interbus coupler BK4000 maps the Kl5111 with 6 bytes of input data and 6 bytes of output data.



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 and under the heading of *Configuration of Masters*.

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

Parameterization with the KS2000 Configuration Software
Independently of the field bus system, parameters can be set via the serial configuration interface in the bus coupler using the Beckhoff KS2000 configuration software.

3 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*.

3.1 Register Overview

Nr.	Description	Default value	R/W	Storage medium
R0	reserved	0x0000	R	
...	...	...	...	...
R5	reserved	0x0000	R	
R6	Diagnostic register (not used)	0x0000	R	
R7	Command register (not used)	0x0000	R	
R8	Terminal type	5111	R	ROM
R9	Firmware-Version	0x????	R	ROM
R10	Multiplex shift register	0x0218	R	ROM
R11	Signal channels	0x0130	R	ROM
R12	minimum data length	0x3030	R	ROM
R13	Data structure	0x0000	R	ROM
R14	reserved	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version	0x????	R/W	SEEROM
R17	reserved	0x0000	R/W	SEEROM
...	...	...	...	...
R30	reserved	0x0000	R/W	SEEROM
R31	Code word register	variable	R/W	RAM
R32	Feature register	0x0000	R/W	SEEROM
R33	Time window for frequency measurement	0x0000	R/W	SEEROM
R34	reserved	0x0000	R/W	SEEROM
...	...	...	...	...
R61	reserved	0x0000	R/W	SEEROM

3.2 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 to 10V, -10 to 10V, 0 to 20mA, 4 to 20mA), the analog outputs (0 to 10V, -10 to 10V, 0 to 20mA, 4 to 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:

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

3.2.1 Process variables

R0 to R7: Registers in the terminal’s internal RAM
The process variables can be used in additional to the actual process image and their functions are specific to the terminal.

R0 to 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

3.2.1.1 R8 to 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: Firmware Version X.y
The Firmware-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	Description
0x00	Terminal without 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 a with a variable logical channel length
0x12	Structure 1 Byte, n Bytes with variable logical channel length (e.g. 60xx)
0x13	Word-Array with a variable logical channel length
0x14	Structure 1 Byte, n Words with a variable logical channel length
0x15	Double word -Array with a variable logical channel length
0x16	Structure 1 Byte, n Double words 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.

3.2.2 Manufacturer Parameters

3.2.2.1 R16 to R30: 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.

3.2.3 User Parameters

3.2.3.1 R31 to R47 User Parameters (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.

R31: Code Word-Register in the RAM

Note

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/Os.

3.2.3.2 R33 to R47

Registers that depend on the terminal type.

3.3 Terminal-specific register description

3.3.1 Application parameters

R32: Feature Register
The feature register determines the operating modes of the terminal (default . 0x0000).

Bit	Value	Description	default
R32.15	0_{bin}	Encoder interface is activated	0_{bin}
	1_{bin}	Counter mode is activated 16-bit up/down counter Input A: counter Input B: counting direction (high = down, low = up) Input C: high = counter disabled, low = counter enabled	
R32.14	-	reserved	0_{bin}
...	...	...	...
R32.9	-	reserved	0_{bin}
R32.8	0_{bin}	Period time is measured if bit CB.1 of control byte is set	0_{bin}
	1_{bin}	In place of the period time a frequency measurement is executed. Impulses in a time window are counted. The time window is over R33 adjustable.	
R32.7	-	reserved	0_{bin}
...	...	...	...
R32.1	-	reserved	0_{bin}
R32.0	0_{bin}	the underflow/overflow signals are output in the status byte.	0_{bin}
	1_{bin}	The signals A; B, C are output in the terminal's status byte.	

R33: Time window for frequency measurement
Defines the length of the time window for frequency measurement (default: 0x0000).

Resolution: 1 ms/Digit
1 Digit = 1 ms

The measured frequency is displayed in process data bytes D3 and D4.

The process data bytes D3 and D4 show the number of pulses counted within the time window defined by R32. The frequency can be calculated from this.

Note Please note that bit CB.1 of control byte has also to be set for frequency measurement!

3.4 Control and Status Byte

3.4.1 Process data exchange

3.4.1.1 Control-Byte during process data exchange

The control byte is transferred from the controller to the terminal. It can be used in the register mode (RegAcc = 1) or during process data exchange (RegAcc=0). Various actions are triggered in the KL5111 with the control byte:

Bit	CB.7	CB.6	CB.5	CB.4	CB.3	CB.2	CB.1	CB.0
Name	RegAcc	-	-	-	-	Cnt_Set	RD-Period	En_Latch

Bit	**Name**	**Function**
CB.7	RegAcc=0	Process data exchange
CB.6	-	reserved
...	...	...
CB.3	-	reserved
CB.2	Cnt_Set	The counter is set with a rising edge of Cnt_Set to the value that is specified via the process data.
CB.1	RD-Period	If CB.1 is set and Bit R32.8 of Feature Register is not set: The periods between two positive edges of the input A are measured with a resolution of 200 ns and displayed at data bytes DataIN2, DataIN3 and DataIN4. If CB.1 and Bit R32.8 of Feature Register is set: The pulses within a time window defined by R33 are counted and displayed at data bytes DataIN3 and DataIN4.
CB.0	En_Latch	The zero point latch (C input) is activated. With the first external latch pulse after the validity of the En_Latch bit, the counter value is stored in the latch register (this has priority over En_LatchX). The following pulses have no influence on the latch register when the bit is set (not used if the V/R mode is active, i.e. bit 15 is set in the feature register).

3.4.1.2 Status-Byte during process data exchange

The status byte is transferred from the terminal to the controller. The status byte contains various status bits of the KL5101.

Remark: the signal bits A, B, C are output in the data byte D2 (bits 3, 4, 5)

Bit	CB.7	CB.6	CB.5	CB.4	CB.3	CB.2	CB.1	CB.0
Name	RegAcc	-	-	Overflow	Underflow	CntSet_Acc	RD_Period_Q	Latch_Val

Bit	Name	Function
SB.7	RegAcc=0	Acknowledge for process data exchange
SB.6	-	reserved
SB.5	-	reserved
SB.4	Overflow	This bit is set if an overflow (65535 to 0) of the 16-bit counter occurs. It is reset if the counter exceeds a third of the measurement range (21845 to 21846) or as soon as an underflow occurs.
SB.3	Underflow	This bit is set if an underflow (0 to 65535) of the 16-bit counter occurs. It is reset when the counter drops below two thirdds of the measurement range (43690 to 43689) or as soon as an overflow occurs.
SB.2	CntSet_Acc	The data for setting the counter has been accepted from the terminal.

SB.1	RD_Period_Q	if bit R32.8 of Feature Register is not set:
		Die data bytes DataIN2, DataIN3 and DataIN4 contain the period
		if bit R32.8 8 of Feature Register is set:
		DataIN3 und DataIN4 contain the counted pulses

SB.0	Latch_Val	A zero point latch has occurred. The data DIN3, DIN4 in the process image corresponds to the latched value when the bit is set if the period has not been requested. To reactivate the latch input, EN_LATC must first be cancelled, acknowledgement of cancellation must be waited for and then the bit must be set again. (Not used if the V/R mode is active, i.e. bit 15 is set in the feature register).

or if bit 0 is set in the feature register:

Bit	CB.7	CB.6	CB.5	CB.4	CB.3	CB.2	CB.1	CB.0
Name	RegAcc	-	A-Signal	B-Signal	C-Signal	CntSet_Acc	RD_Period_Q	Latch_Val

Bit	Name	Function
SB.7	RegAcc=0	Acknowledge for process data exchange
SB.6	-	reserved
SB.5	A-Signal	status of the input A
SB.4	B-Signal	status of the input B
SB.3	C-Signal	status of the input C
SB.2	CntSet_Acc	The data for setting the counter has been accepted from the terminal.

SB.1	RD_Period_Q	if bit R32.8 of Feature Register is not set:
		Die data bytes DataIN2, DataIN3 and DataIN4 contain the period
		if bit R32.8 8 of Feature Register is set:
		DataIN3 und DataIN4 contain the counted pulses

SB.0	Latch_Val	A zero point latch has occurred. The data DataIN3, DataIN4 in the process image corresponds to the latched value when the bit is set if the period has not been requested. To reactivate the latch input, EN_LATC must first be cancelled, acknowledgement of cancellation must be waited for and then the bit must be set again. (Not used if the V/R mode is active, i.e. bit 15 is set in the feature register).

3.4.2 Register Communication

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.

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).

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

3.4.2.1 Control byte during Register Communication

Bit	CB.7	CB.6	CB.5	CB.4	CB.3	CB.2	CB.1	CB.0
Name	RegAcc	R/W	Reg-No.					

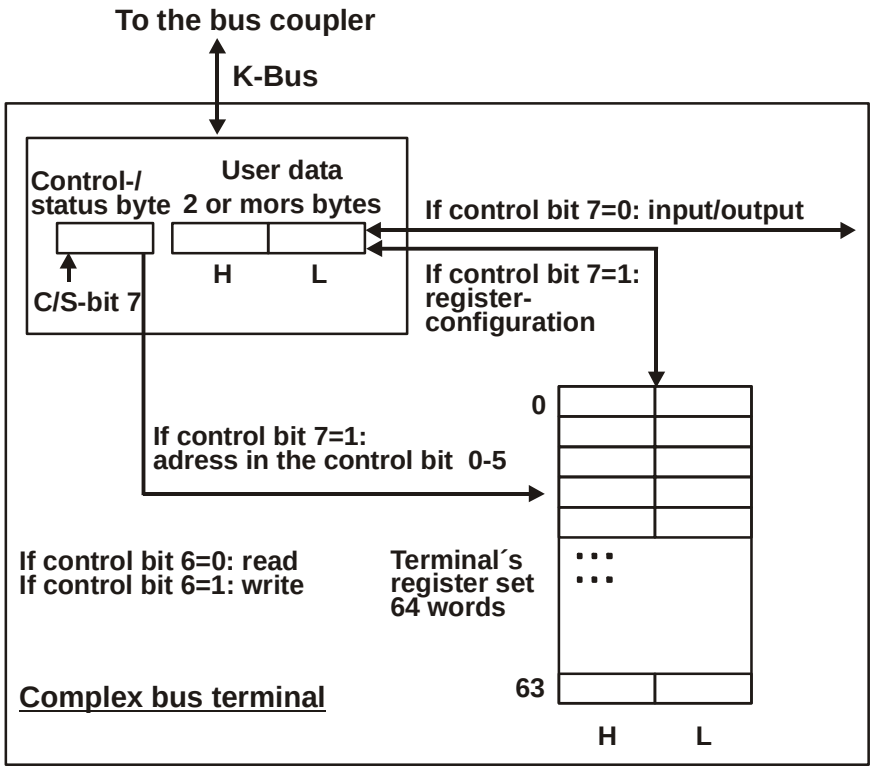
Bit	**Name**	**Function**
CB.7	RegAcc=1	Register Communication
CB.6	R/W	Bit 6=0: read, Bit 6=1: write
CB.5	Reg-No.	Register number of the register that is to be read or written
...		
CB.0		

3.4.2.2 Status byte during Register Communication

Bit	SB.7	SB.6	SB.5	SB.4	SB.3	SB.2	SB.1	SB.0
Name	RegAcc	R/W	Reg-No.					

Bit	**Name**	**Function**
CB.7	RegAcc=1	acknowledge for Register Communication
CB.6	R/W	Bit 6=0: read
CB.5	Reg-No.	Register number of the register that has been read or written
...		
CB.0		

3.4.3 Examples for the Register Communication



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 1
Reading register 8 in the BK2000 with a Kl3002 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	Nicht benutzt	Control-Byte
Wert	0xXX	0xXX	0xXX	0x88

the terminal returns the following type designation (0x0BBA corresponds to the unsigned integer 3002).

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataIN 1	DataIN 0	Nicht benutzt	Status-Byte
Wert	0x0B	0xBA	0x00	0x88

Example 2
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,

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataOUT 1	DataOUT 0	Nicht benutzt	Control-Byte
Wert	0x12	0x35	0xXX	0xDF

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

Byte	Byte 3	Byte 2	Byte 1	Byte 0
Name	DataIN 1	DataIN 0	Nicht benutzt	Status-Byte
Wert	0x00	0x00	0x00	0x9F

3.5 Mapping in the bus coupler

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

The KL5111 occupies memory space in the input and output process image. The following tables provide information about the KL5111's mapping, depending on the conditions set in the Bus Coupler.

Default mapping for
CANopen, CANCAL, DeviceNet, ControlNet, Modbus, RS232 und RS485 Couplers

Conditions		Word Offset	High byte	Low byte
Complete evaluation:	any	0	D0	CB/SB
Motorola format:	no	1	D2	D1
Word alignment:	no	2	D4	D3

Default mapping for Profibus and Interbus Couplers

Conditions		Word offset	High byte	Low byte
Complete evaluation:	any	0	D1	CB/SB
Motorola format:	yes	1	D2	D0
Word alignment:	no	2	D3	D4

Default mapping for
EtherCAT, Lightbus and Ethernet Couplers and Bus Terminal Controllers (BCxxxx, BXxxxx)

Conditions		Word offset	High byte	Low byte
Complete evaluation:	any	0	-	CB/SB
Motorola format:	no	1	D1	D0
Word alignment:	yes	2	-	D2
		3	D4	D3

Conditions		Word offset	High byte	Low byte
Complete evaluation:	any	0	-	CB/SB
Motorola format:	yes	1	D0	D1
Word alignment:	yes	2	-	D2
		3	D3	D4

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.
CB: Control Byte (appears in the output process image)
SB: Status Byte (appears in the input process image)
D0: byte of the Counter Word with the lowest value (read /set)
D1: byte of the Counter Word with the highest value (read /set)
D2: together with D3/D4 this byte contains the cycle duration
D3: byte of the Latch Word with the lowest value (read)
D4: byte of the Latch Word with the highest value (read)

4 Appendix

4.1 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.

4.1.1 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: http://www.beckhoff.com
You will also find further documentation for Beckhoff components there.

4.2 Beckhoff Headquarters

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