KL5121

Incremental Encoder Interface with programmable Outputs Configuration Instructions

Version 2.1
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BECKHOFF

Contents

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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Copyright

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.

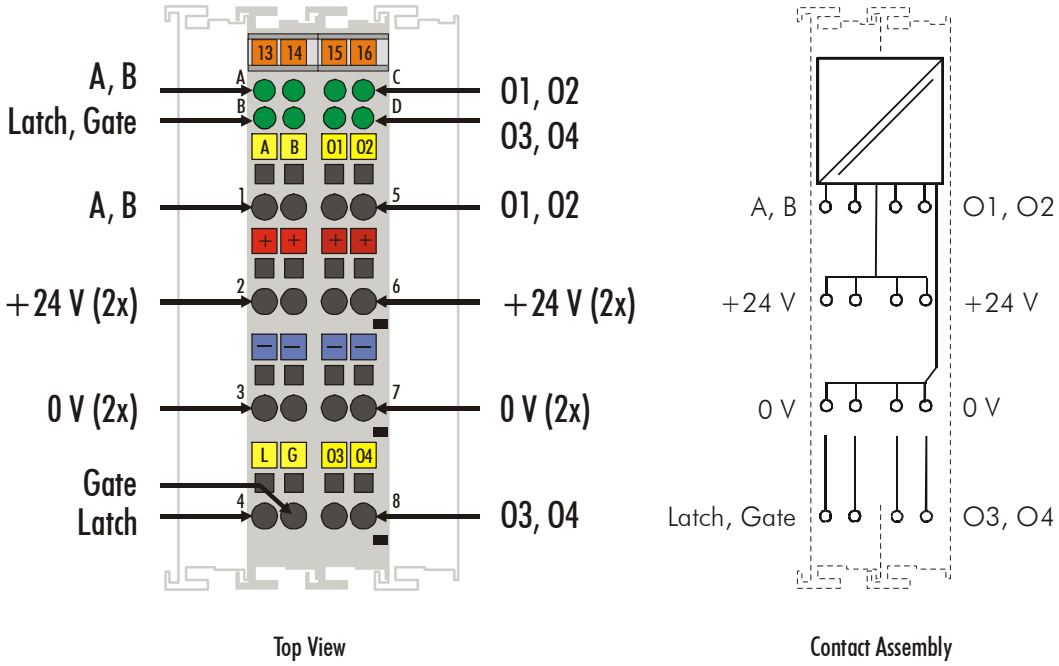

Attention

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



Top View Contact Assembly

Technical data	KL5121
Sensor connection	A, B, Latch, Gate
Sensor operating voltage	24 V DC
Counter	16 bits binary
Cut off frequency	1 MHz
Output voltage	24 V DC
Max. current per output	0.5 A
Switching time of the outputs	< 100 µs
Supply voltage	24 V DC (20 V ... 29 V)
Current consumption of Power contacts	0.1 A (without sensor load current)
Bit width in the Process image	I/O: 2 x 16 bits data, 2 x 8 bits control/status
Current consumption from K-Bus	30 mA
Weight approx..	60 g
Operating temperature	0℃ ... +55℃
Storage temperature	-25℃ ... +85℃
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

Four-channel linear path control can be implemented with the KL5121 function terminal. For this purpose the terminal reads in the incremental signal (which is either supplied by an encoder or by a pulse generator), obtains the position of the workpiece from another input (latch), and switches on the outputs at defined counter states which have previously been stored in the form of a table. Automatic speed correction is carried out separately for each channel (adjustable by means of registers in the terminal). The workpiece's sensor edge can be configured, so that rising edges, falling edges or both may be used. The switching times for the individual output channels are < 100 µS. A maximum of 60 switching values can be entered, and the number for each channel can vary from 0 to 60. The counter is limited to 16 bits, a tracking of the workpieces is not possible.

Operating modes

Set by the control byte:
- linear path control with 4 output channels
- alternative: PWM type of output with pre-set on and off times (nozzle test)

LED display

The signal LEDs indicate the state of the sensor inputs A and B, the latch and gate logic inputs and of the four outputs O1, O2, O3 and O4.

Process data

The KL5121 always occupies 6 bytes of input data and 6 bytes of output data. The control/status byte is located at the lowest byte offset.
There are two logical data channels: data channel 0 to enable the output functions and for reading in the status information, while data channel 1 is used to transmit the switch values in the terminal's output table.

Connections

The KL5121 has 4 logical 24 V inputs and 4 logical 24 V outputs, as well as 8 contacts for the 24 V DC supply of external devices.

A, B: sensor inputs (incremental encoder or pulse generator)
Latch (workpiece sensor input): the latch input recognises the workpiece, with the result that the 16 bit counter is set to zero when the latch input is activated. The latch input can be configured by way of the feature register.
Gate (enable input): the gate enables the latch input. The gate input can be configured by way of the feature register.
O1, O2, O3, O4: 24 V switch output
24 V/0 V: 24 V DC supply voltage for the external devices (e.g. encoder)

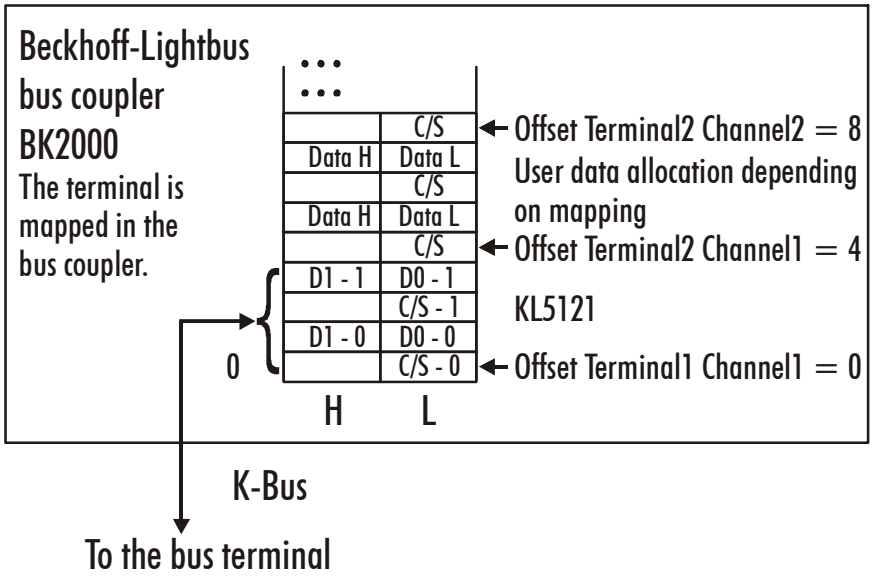
Terminal configuration

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 (eg.Motorola / Intel format, word alignment,...).

In contrast to analogue input and output terminals, the KL5121 always also maps the control and status byte, independently of the supervising fieldbus system.

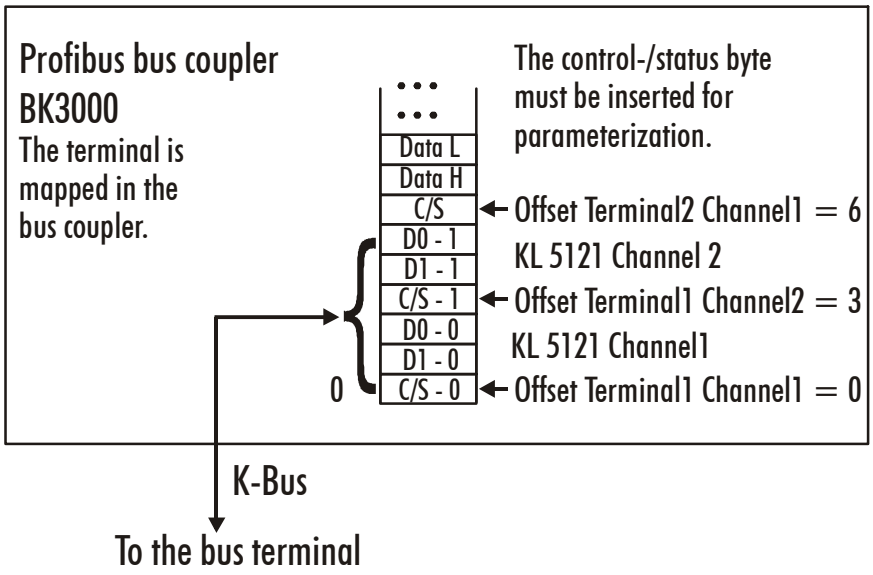
Beckhoff Lightbus Coupler BK2000

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.



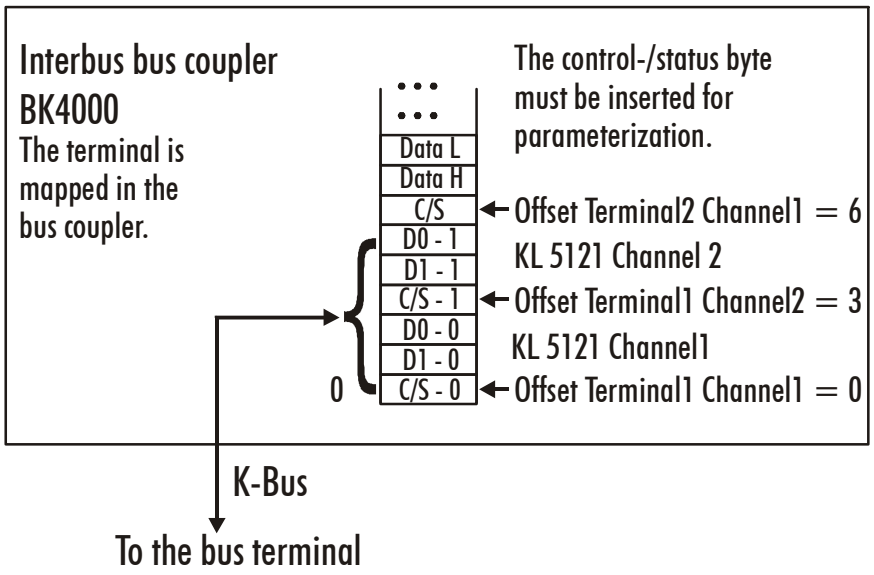
Profibus Coupler BK3000

In the BK3000 Profibus coupler, the KL5121 is always mapped with 6 bytes of input data and 6 bytes of output data.



Interbus Coupler BK4000

The BK4000 Interbus coupler normally maps the KL5121 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 under the heading of "Configuration of masters".

Note

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

Parametrization with the KS2000 software

Parametrization operations can be carried out independantly 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 parametrizable 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 additional 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 der Klemme
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-R3: Pulse for speed correction of channels 1-4

R4-R7: No function

Manufacturer parameter

R17-R30: Not used

Application parameter

R32: Feature register:
This register describes the (hardware) settings for channels 1-4 [0x0062]

Feature Bit No.		Description of the operating mode
Bit 0	0/1	0: encoder operating mode with 4-fold evaluation [0] 1: up/down counter (pulse generator) with A as counter input and B as U/D input
Bit 1	0/1	Latch input: 0: rising edge is ignored 1: evaluate rising edge as start signal [1]
Bit 2	0/1	Latch input: 0: falling edge is ignored [0] 1: evaluate falling edge as start signal
Bit 3	0/1	0: the outputs are switched according to positive logic [0] 1: the outputs are switched according to negative logic
Bit 4	0/1	0: watchdog timer active [0] 1: watchdog timer active. If the terminal does not receive any process data from the K-bus for 100 ms the outputs are reset.
Bit 5	1	1: workpiece sensor input (latch) is active [1] when there is a positive level at the enable input (gate)
Bit 6	1	1: workpiece sensor input (latch) is active [1] when there is a negative level at the enable input (gate)
Bit 7-11	-	Not used, don't change
Bit 12-15	0000 0001	Pulse operation (R33-R35 activated) [0000] Line operation (not yet implemented)

R33: Pulse duration Ti for channel 1
[0x01F4] = 0.5 ms
Ti specifies pulse duration for the pulsed operation mode of channel 1 [µs]

R34: Hold-up time Tv for channel 1
[0x1388] = 5 ms
The pulses counted in the hold-up time Tv are included in the calculation of the speed correction [µs]

R35: Period Td for channel 1
[0x4E20] = 20 ms
Period Td for the channel 1 nozzle test

R40-R43: Channel 2 register

R48-R51: Channel 3 register

R56-R59: Channel 4 register

Register communication KL5121

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

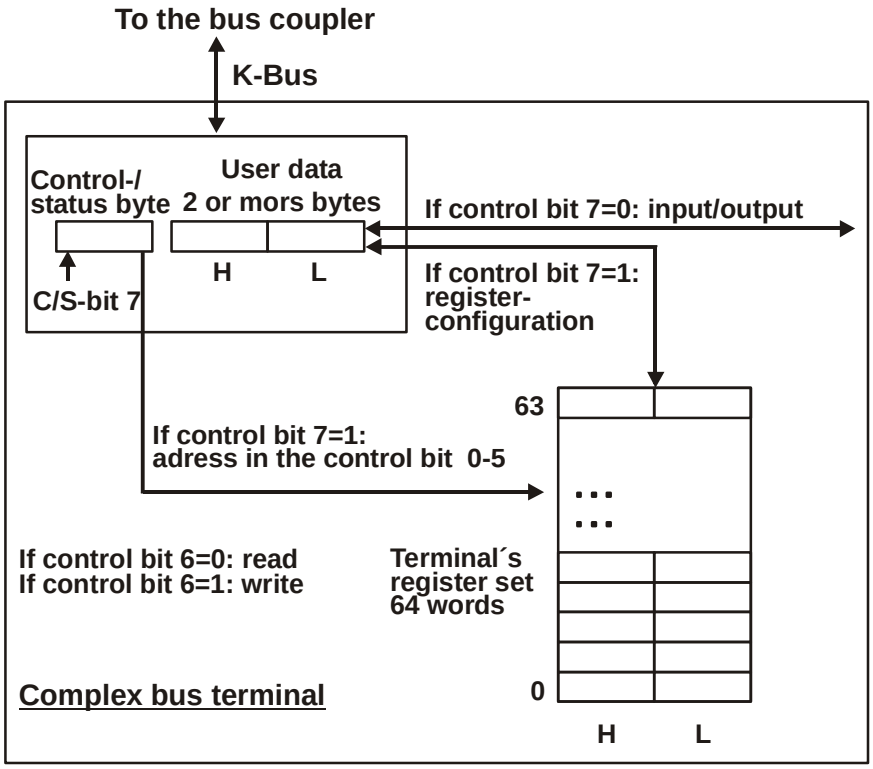
The address of the register to be addressed is entered in bits 0 to 5 of the control byte.

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

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

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

Data transfer, function

Process data

The KL5121 terminal occupies 6 bytes in the coupler's input process image and 6 bytes in the output process image. There are two logical channels: data channel 0 and data channel 1.

Data channel 0

Data channel zero consists of the control byte 0, input data word 0, status byte 0 and output data word 0. Enables for the output functions are communicated through channel zero, and status information is read in. Parameter data can also be accessed.

Controller output data

CT-0: control byte 0
D0-0, D1-0: the terminal's input data word 0

Controller input data

ST-0: status byte 0
D0-0, D1-0: the terminal's output data word 0

Control byte 0

Control byte 0 is only used for register access.

MSB

REG=0							

Status byte 0

The state of the inputs can be read through status byte 0.

MSB

REG=0	**ERROR_ BIT (reserved)**				**A_INPUT**	**B_ INPUT**	**LATCH_ INPUT**

Output data word 0

The current counter state is read in the terminal's output data word zero. The terminal supplies output word zero.

Bit No.	Meaning
Bit 0-15	Current encoder counter state

Input data word 0

Channel-specific enables are made via the terminal's input word zero.
A nibble of the data word is reserved for each channel.

Channel 1:

Nibble	Meaning
0000	No enable is present. If the automatic switching function was previously active, it is reset, so that if a workpiece has already been picked up it will not be processed further when the automatic function becomes active again.
0001	Enable for the automatic switching function
0111	Enable for the "glue nozzle test". If the automatic switching function was previously active it is interrupted, and is continued again when there is a change of operating mode, provided that the enable is not reset (e.g. from 0001 to 0111 to 0001)
0011	Output to high level. Interruption of the switching function if it was previously active.
0101	Output to low level. Interruption of the switching function if it was previously active.

The other nibbles for channels 2 - 4 are used similarly.

Data channel 1

Data channel 1 transfers the switch values to the terminal. They are temporarily stored in the terminal's RAM. Access to this data set is identical to access to the terminal's register set.

Controller output data

CT-1: control byte 1
D0-1, D1-1: the terminal's input data word 1

Controller input data

ST-1: status byte 1
D0-1, D1-1: the terminal's output data word 1

Control byte 1

Control byte 1 is transmitted from the controller to the terminal, and is used for access to the output table.

Bit No.		Meaning
Bit 0-5	000000-111111	Address bits A0 to A5 of the output table
Bit 6	0/1	0: read 1: write
Bit 7	0/1	Table bit This bit must be set for table accesses. If the controller sees a falling edge in the terminal here, evaluation of the output table is started, so that, if sorting or other tasks are necessary, they will be performed.

Status byte 1

Status byte 1 is transmitted from the terminal to the controller.

Bit No.		Meaning
Bit 0-5	000000-111111	Address bits A0 to A5 of the output table
Bit 6	0/1	Don't care
Bit	1	Acknowledge for table access

Output data word 1

Output data word AW1 returns the addressed table entry for a table access.

Bit No.	Meaning
Bit 0-15	Content of the addressed table entry

Input data word 1

Input data word EW1 is written into the table by a controller write access.

Bit No.	Meaning
Bit 0-15	Entry in the output table

Output table

The appropriate values for the corresponding function must be entered into the output table (max. 60 switching values).

Index	Entry
0	Number, N, of entries for the first output
1	Number, M, of entries for the second output
2	Number, O, of entries for the third output
3	Number, P, of entries for the fourth output
4	Switch value 1 channel 1
...	
N+4	Switch value N channel 1
N+5	Switch value 1 channel 2
...	
N+M+4	Switch value M channel 2
N+M+5	Switch value 1 channel 3
...	
N+M+O+4	Switch value O channel 3
N+M+O+5	Switch value 1 channel 4
N+M+O+P+4	Switch value P channel 4

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 KL5121 maps itself in the bus coupler depending on the set parameters.

Mapping in the bus coupler

The KL5121 is mapped into the bus coupler depending on the set parameters. The terminal always occupies memory space in the process image of the inputs and outputs.

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

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

Default: Interbus, Profibus

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

Default: Lightbus, Bus Terminal Controller (BCxxxx)

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

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

Legend

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	Pulses for speed factor 1	variable	R	RAM
R1	Pulses for speed factor 2	variable	R	RAM
R2	Pulses for speed factor 3	variable	R	RAM
R3	Pulses for speed factor 4	variable	R	RAM
R4	not used	0x0000	R	
R5	not used	0x0000	R	
R6	Diagnostic register – not used	0x0000	R	
R7	Command register - not used	0x0000	R	
R8	Terminal type	5121	R	ROM
R9	Software version number	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	0x0007	R	ROM
R14	not used	0x0000	R	
R15	Alignment register	variable	R/W	RAM
R16	Hardware version number	0x????	R/W	SEEROM
R17	not used	0x0000	R/W	SEEROM
R18	not used	0x0000	R/W	SEEROM
R19	not used	0x0000	R/W	SEEROM
R20	not used	0x0000	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	Changed default setting	variable	R/W	SEEROM
R30	not used	0x0000	R/W	SEEROM
R31	Codeword register	variable	R/W	RAM
R32	Feature register 1	0x0062	R/W	SEEROM
R33	Pulse length Ti channel 1	0x01F4	R/W	SEEROM
R34	Hold-up time Tv channel 1	0x1388	R/W	SEEROM
R35	Period Td for the channel 1 nozzle test	0x4E20	R/W	SEEROM
R36	not used	0x0000	R/W	SEEROM
R37	not used	0x0000	R/W	SEEROM
R38	not used	0x0000	R/W	SEEROM
R39	not used	0x0000	R/W	SEEROM
R40	Feature register 2	0x0000	R/W	SEEROM
R41	Pulse length Ti channel 2	0x01F4	R/W	SEEROM
R42	Hold-up time Tv channel 2	0x1388	R/W	SEEROM
R43	Period Td for the channel 2 nozzle test	0x4E20	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

Address	Description	Default	R/W	Storage medium
R48	Feature register 3	0x0000	R/W	SEEROM
R49	Pulse duration Ti for channel 3	0x01F4	R/W	SEEROM
R50	Hold-up time Tv for channel 3	0x1388	R/W	SEEROM
R51	Period Td for the channel 3 nozzle test	0x4E20	R/W	SEEROM
R52	not used	0x0000	R/W	SEEROM
R53	not used	0x0000	R/W	SEEROM
R54	not used	0x0000	R/W	SEEROM
R55	not used	0x0000	R/W	SEEROM
R56	Feature register 4	0x0000	R/W	SEEROM
R57	Pulse duration Ti for channel 4	0x01F4	R/W	SEEROM
R58	Hold-up time Tv for channel 4	0x1388	R/W	SEEROM
R59	Period Td for the channel 4 nozzle test	0x4E20	R/W	SEEROM
R60	not used	0x0000	R/W	SEEROM
R61	not used	0x0000	R/W	SEEROM
R62	not used	0x0000	R/W	SEEROM
R63	not used	0x0000	R/W	SEEROM

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