TECHNICAL DESCRIPTION

Beam data for diagnostics and automation

RK512 telegrams via Ethernet

SICK
Sensor Intelligence.

Described product

RK512 communication protocol

Manufacturer

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Legal information

Original document

This document is an original document of SICK AG.

Contents

1 About this document

Please read this chapter carefully before working with this documentation and the devices.

1.1 Function of this document

This document describes how, with the aid of a UE1840 EFI Ethernet gateway or in a system with a Flexi Soft safety controller with a corresponding Ethernet gateway, you can read beam data from a safety light curtain or from a multiple light beam safety device with EFI interface.

The communication with the SICK devices is undertaken with the aid of RK512 telegrams using a SICK-specific serial protocol.

This document is a supplement to the following operating instructions:

Operating instructions	SICK part no.
M4000 Advanced	8010795
M4000 Advanced Curtain	8011563
UE403	8010853
C4000 Entry/Exit	8010236
C4000 Palletizer and C4000 Fusion	8012248
C4000 Standard/Advanced	8009856
EFI — Enhanced Function Interface	8012621
EFI gateways	8011506
Flexi Soft Designer Software	8012479
Flexi Soft safety controller hardware	8012477
Flexi Soft Gateways	8012663

Table 1: Reference documents

WARNING
Read the operating instructions!

Please follow the operating instructions for the devices used and read them carefully to obtain general information for instance on mounting, installation and commissioning the devices.

Pay attention to the safety notes!

Please follow the safety notes in these instructions as well as in the operating instructions for the devices used before you place the system in operation for the first time!

Do not use the data for safety functions!

The RK512 communication protocol described here does not meet the requirements for safety-related data exchange. For this reason the data exchanged using this protocol are not allowed to be used for safety functions.

1.2 The target group of this document

This technical description is intended for system specialists in the area of hardware and software development who want to integrate and evaluate the beam data in their application, e.g. as part of standard automation or an HMI.

1.3 Depth of information

This technical description contains information on the following topics:

- Description of the RK512 protocol used
- Steps necessary to establish communication

1.4 Scope

Unless otherwise stated, this document applies to the following devices:

- M4000 Advanced and M4000 Area multiple light beam safety devices with and without UE403 switching amplifier
- Safety light curtains C4000 Standard, C4000 Advanced, C4000 Entry/Exit, C4000 Palletizer, C4000 Fusion and M4000 Advanced Curtain with and without UE403 switching amplifier
- UE1840 EFI Ethernet gateway
- Flexi Soft modular safety controller with main module FX3-CPU1 or higher and EtherNet/IP, Modbus TCP, PROFINET IO or EtherCAT gateway

2 System description

2.1 System structure

2.1.1 Access via UE1840 EFI Ethernet gateway

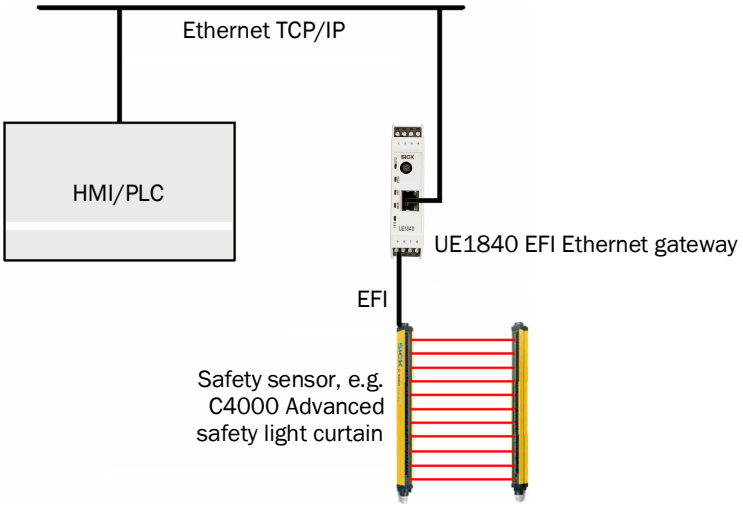

Figure 1: Access via UE1840 EFI Ethernet gateway

2.1.2 Access via Flexi Soft Ethernet gateway

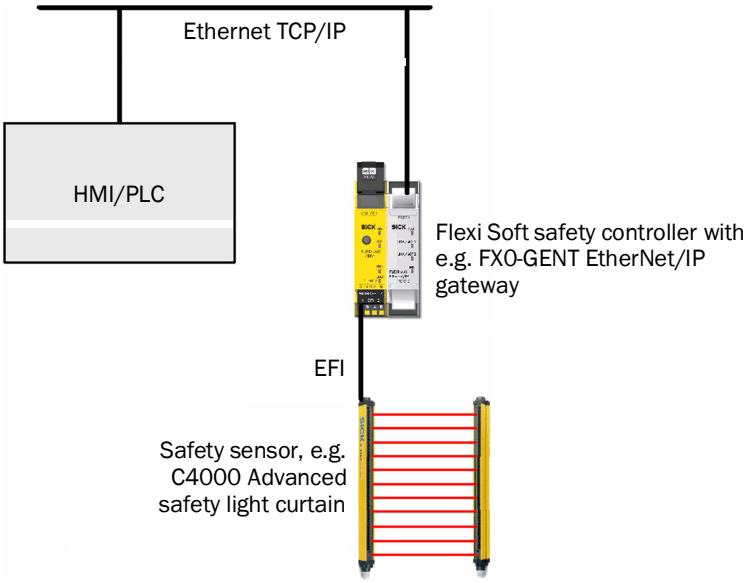

Figure 2: Access via Flexi Soft Ethernet gateway

2.2 Electrical interface

2.2.1 TCP/IP

The TCP/IP interface is supported by Flexi Soft Ethernet gateways (e.g. PROFINET IO, Modbus TCP, EtherNet/IP) and the UE1840 EFI Ethernet gateway.

The electrical interface is an RJ45 connection. For the electrical connection, please follow the operating instructions for the Flexi Soft gateways (SICK part no. 8012663) or for the EFI gateways (SICK part no. 8011506).

Ethernet protocol	TCP/IP
IP address	Corresponds to the IP address in the gateway configuration in Flexi Soft Designer or in CDS
Port	9000

Table 2: Parameter for TCP/IP

2.3 Telegram structure

2.3.1 Introduction

To read the beam data a protocol derived from Siemens RK512 is used. Siemens RK512 does not provide a mechanism for checking the completeness of the address information. For this reason it has been expanded to meet SICK requirements.

For this purpose the original RK512 data set is filled with an exact repetition of bytes 4 to 9 (count starts at 0) from the command telegram header, the SICK RK512 data as well as the checksum (CRC) for the data.

In this document the SICK-specific modified protocol is called RK512.

Communication according to the RK512 standard is based on “Command” and “Reply” telegrams. A command telegram is either a send telegram (“Send Command”) or a fetch telegram (“Fetch Command”) and is replied to with a corresponding reply telegram (“Send Reply” or “Fetch Reply”).

The client (e.g. the main computer, HMI, PLC) is always the active user that sends command telegrams. The server (Flexi Soft safety controller, UE1840 EFI Ethernet gateway or the safety sensor) reacts with reply telegrams, but cannot send telegrams on its own. If data need to be regularly renewed, the client must send a new command telegram for each update.

Reading data from the server

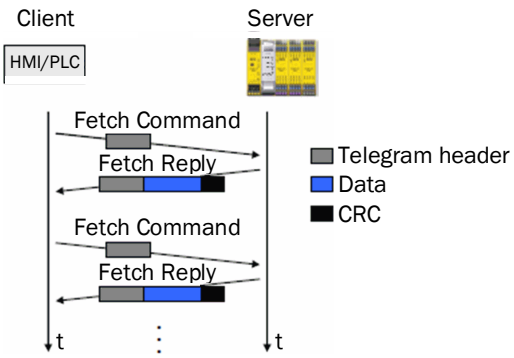

Figure 3: Reading data from the server

The client sends fetch telegrams with the header for fetch telegrams without further data, and the server replies with a reply telegram that contains the requested data underneath the telegram header.

Writing data to the server

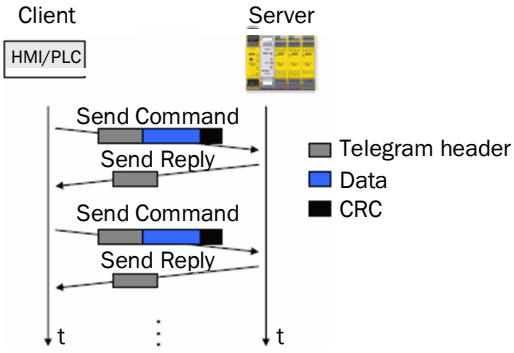

Figure 4: Writing data to the server

The client sends telegrams that contain the data underneath the telegram header; the receiver replies with a reply telegram without further data.

2.3.2 Reading data

In the following tables the value in the row Size in Words gives the number of 16-bit words (2 bytes). It is not possible to access individual bytes. Values in the telegram header comprising two bytes are sent with the high byte (HB) first.

The data are also sent as 16-bit words; however here the low byte (LB) is sent first.

Command for reading data

The client sends the following telegram to the server to read data:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	–
1		0x00	
2	Telegram type	0x45	Fetch Command
3	Data type	0x44	Access to register interface
4	Source address	0x00 ... 0xFF	Data block number
5		0x00	–
6	Size in words	0x0000 ... 0xFFFF	= Size of register interface block [words] + 4 (repetition of byte 4-9 and CRC), e.g. block size: 32 words ➜ size: 32 + 4 = 36 words
7			
8	Coordination flag	0xFF	–
9	Device address	0x00 ... 0xFF	Device-dependent, see section 2.3.5

Table 3: Command for reading data

Reply to command to read data

The server sends the following reply telegram to the client:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x00	Fetch Reply
3	Error code	0x00 ... 0xFF	0x00: No error 0x01 ... 0xFF: See Table 12.
Repetition (not if there is an error)			
4	Source address	0x00 ... 0xFF	Data block number
5		0x00	–
6	Size in words	0x0000 ... 0xFFFF	= Size of register interface block [words] + 4 (repetition of byte 4-9 and CRC), e.g. block size: 32 words ➜ size: 32 + 4 = 36 words
7			
8	Coordination flag	0xFF	
9	Device address	0x00 ... 0xFF	Device-dependent, see section 2.3.5
Data (not if there is an error)			
10	Data byte 0		
...	...		
m	Data byte n		
CRC (not if there is an error)			
m + 1	CRC low byte		Calculated from byte 4 to byte m
m + 2	CRC high byte		

Table 4: Reply to command to read data

If the error code (byte 3) is not 0, then the repetition of the data and the CRC parts (bytes 4 ... m+2) is not sent. The error telegram comprises only 4 bytes in all cases.

2.3.3 Writing data

Command for writing data

The client sends the following telegram to the server to write data:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x41	Send Command
3	Data type	0x44	Access to register interface
4	Destination address	0x00 ... 0xFF	Data block number
5		0x00	–
6	Size in words	0x0000 ... 0xFFFF	= Size of register interface block [words] + 4 (repetition of byte 4-9 and CRC), e.g. block size: 32 words ➜ size: 32 + 4 = 36 words
7			
8	Coordination flag	0xFF	
9	Device address	0x00 ... 0xFF	Device-dependent, see section 2.3.5
Repetition			
10	Destination address		Same as byte 4
11			Same as byte 5
12	Size in words		Same as byte 6
13			Same as byte 7
14	Coordination flag		Same as byte 8
15	Device address		Same as byte 9
Data			
16	Data byte 0		
...	...		
m	Data byte n		
CRC			
m + 1	CRC low byte		Calculated from byte 10 to byte m
m + 2	CRC high byte		

Table 5: Command for writing data

Reply to the command to write data

The server sends the following reply telegram to the client for confirmation:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x00	Send Reply
3	Error code	0x00 ... 0xFF	0x00: No error 0x01 ... 0xFF: See Table 12.

Table 6: Reply to command to write data

2.3.4 Example telegrams

Writing data

The client sends the following telegram to the server to write data to block 25:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x41	Send Command
3	Data type	0x44	Access to register interface
4	Destination address	0x19	Data block number 25
5		0x00	–
6	Size in words	0x00	= Size of register interface block [words] + 4 (repetition of byte 4-9 and CRC), e.g. block size: 1 word ➜ size: 1 + 4 = 5 words (= 0x0005)
7		0x05	
8	Coordination flag	0xFF	
9	Device address	0x4E	Device-dependent, see section 2.3.5
Repetition			
10	Destination address	0x19	Same as byte 4
11		0x00	Same as byte 5
12	Size	0x00	Same as byte 6
13		0x05	Same as byte 7
14	Coordination flag	0xFF	Same as byte 8
15	Device address	0x4E	Same as byte 9
Data			
16	Data byte 0	0x0F	Sent data
17	Data byte 1	0x0E	

Byte	Telegram fields	Contents	Meaning
CRC			
18	CRC low byte	0xD1	Calculated from byte 10 to byte 17
19	CRC high byte	0x16	

Table 7: Example for a command telegram to write data

Reply of the server:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x00	Send Reply
3	Error code	0x00	0x00: No error

Table 8: Example for a reply telegram to a command to write data

Reading data

The client sends the following telegram to read the beam data from block 110:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x45	Fetch Command
3	Data type	0x44	Access to register interface
4	Source address	0x6E	Data block number
5		0x00	–
6	Size in words	0x00	= Size of register interface block [words] + 4 (repetition of byte 4-9 and CRC), e.g. block size: 15 words ➜ size: 15 + 4 = 19 words (= 0x0013)
7		0x13	
8	Coordination flag	0xFF	
9	Device address	0x01	Safety light curtain (host) or multiple light beam safety device, see section 2.3.5

Table 9: Example for a command telegram to read data

Reply of the M4000:

Byte	Telegram fields	Contents	Meaning
Header			
0	Telegram identifier	0x00	
1		0x00	
2	Telegram type	0x00	Fetch Reply
3	Error code	0x00	0x00: No error
Repetition (not if there is an error)			
4	Source address	0x6E	Data block number
5		0x00	–
6	Size in words	0x00	= Size of register interface block [words] + 4 (repetition of byte 4-9 and CRC), e.g. block size: 15 words ➜ size: 15 + 4 = 19 words (= 0x0013)
7		0x13	
8	Coordination flag	0xFF	
9	Device address	0x01	Safety light curtain (host) or multiple light beam safety device, see section 2.3.5
Data (not if there is an error)			
10	Data byte 0	0xFF	
11	Data byte 1	0xFF	
...	...	0xFF	
23	Data byte 13	0xFF	
24	Data byte 14	0x00	
25	Data byte 15	0x00	
CRC (not if there is an error)			
26	CRC low byte	0x0A	Calculated from byte 4 to byte 25
27	CRC high byte	0xE6	

Table 10: Example for a reply telegram to a command to read data

2.3.5 Device address

The meaning of the device address is a follows:

Address	Device
0x01	• Safety light curtain (host) or • Multiple light beam safety device
0x4D	• Flexi Soft main module with address 13 or • UE1840 EFI Ethernet gateway with address 13
0x4E	• Flexi Soft main module with address 14 or • UE1840 EFI Ethernet gateway with address 14

Table 11: Device addresses

NOTE

- If an M4000 Advanced is operated in combination with a UE403 on a UE1840 or on a Flexi Soft, the address of the UE403 must be compared with the address of the UE1840 or the Flexi Soft:
  - If the UE403 is operated with address 13, then the UE1840 must be set to “Operate gateway with sensors” or the Flexi Soft must be set to address 14.
  - If the UE403 is operated with address 14, then the UE1840 must be set to “Operate gateway with control system” or the Flexi Soft must be set to address 13.
- If a C4000 is used, the address of the Flexi Soft or the UE1840 must always be 14.

2.3.6 Special case treatment

Timeout on the client

A timeout should be programmed in the client for waiting for the reply from the Flexi Soft or from the UE1840. The timeout required, measured from the complete transmission of the command telegram, can be calculated with the aid of the following formula:

Timeout = 1 s + n × 8 ms = 1.088 s + telegram size in words × 8 ms

n = Length in words of the command and fetch telegram

= Size of the data block + 11 words for telegram header and CRC

NOTE

- The timeout counter should only be started after the complete transmission of the command telegram.
- To prevent premature timeout, the time calculated using the formula should be generously increased if the application allows.

2.3.7 Error codes in the reply telegram

If the Flexi Soft or the UE1840 detects an error, then the reply telegram contains an error code. Such an error telegram comprises only 4 bytes in all cases. The fourth byte contains the error code.

Error code in the reply telegram	Meaning
0x00	No error
0x01	Access to register interface not currently allowed
0x02	Access to register interface currently denied
0x03	Invalid password
0x04	Device token not available
0x05	Parameter invalid, telegram header or content of the reply telegram
0x08	RK512 handler is busy, RK512 command telegram cannot be processed
0x0A	Source or destination address invalid or timeout occurred
0x0C	Coordination flag invalid or number of the main module invalid
0x10	Telegram identifier invalid
0x14	Invalid data block number or size
0x16	Invalid telegram type
0x34	RK512 block size not correct, limit for the block size exceeded or error in the “repetition” part of the telegram
0x45	Invalid block number

Table 12: Error codes of the reply telegram

2.3.8 Data sequence

The telegrams are transmitted starting with byte 0.

2.3.9 Calculation of the checksum (CRC)

CRC width	16 bit
Polynomial	$x^{16} + x^{12} + x^5 + x^0$, 0x1021 (CCITT CRC)
Start value	0xFFFF
Byte sequence	Data from the lowest address to the highest address

Table 13: Calculation of the checksum (CRC)

Examples for the verification of the CRC calculation

Byte 0 ... 13 in hex: 41 00 00 08 FF 4F 00 00 00 00 00 00 00 00

- CRC = B3 F1 (low byty, high byte)

Byte 0 ... 9 in hex: 00 01 02 03 04 05 06 07 08 09

- CRC = 41 C2 (low byty, high byte)

2.3.10 Token system

There are two different tokens.

Firstly there is a network token in the Flexi Soft or in the UE1840. This network token is required to prevent the interruption of the communication with Flexi Soft safety controller or the EFI gateway by another user.

Secondly there is an EFI token on each EFI channel. Any user who wants to communicate via an EFI channel must first obtain this token.

After each communication process all tokens must be released to make possible other communication processes (internally between the devices or externally with configuration and diagnostic systems).

3 Reading beam data via Ethernet

3.1 Introduction

Reading beam data from a light curtain [1] is undertaken in two steps. The light curtain is connected to an Ethernet gateway via EFI. As soon as an EFI connection exists between the light curtain and the gateway, the beam data from the light curtain are available via the gateway. A client (e.g. a PLC) can now connect to the gateway via Ethernet (TCP/IP) and retrieve the data.

To read the beam data, the SICK-specific modified RK512 protocol described in section 2.3 “Telegram structure” is used. The client sends the RK512 telegrams to the server by embedding them in a TCP/IP frame.

3.2 Communication of the client with the gateway

3.2.1 Connecting the client to the gateway

Open a standard socket connection to the gateway on TCP port 9000 and reserve the network token using the following command:

Gateway or Flexi Soft address setting	RK512 command [hex]	Meaning
13	00 00 41 44 1C 00 00 05 FF 0D 1C 00 00 05 FF 0D 0D 6F 8D DC	Reserve the network token
14	00 00 41 44 1C 00 00 05 FF 0E 1C 00 00 05 FF 0E 0E 6F 8E D0	Reserve the network token

Table 14: Command for connecting

RK512 reply [hex]	Meaning
00 00 00 xx	xx = 00: No error xx ≠ 00: Error. Another process is blocking the device. Try again after 1 or 2 seconds.

Table 15: Gateway response

3.2.2 Setting the EFI diverter

The UE1840 or the Flexi Soft has two EFI connections, EFI1 and EFI2. Depending on the address of the UE1840 or the Flexi Soft and the location of the light curtain connection, send the following command to set the EFI diverter.

[1] The term “light curtain” here represents all safety light curtains and multiple light beam safety devices listed in section 1.4 “Scope” on page 5.

Location of the light curtain connection	Gateway or Flexi Soft address setting	RK512 command [hex]
EFI1	13	00 00 41 44 06 00 00 05 FF 4D 06 00 00 05 FF 4D 01 00 CC B5
	14	00 00 41 44 06 00 00 05 FF 4E 06 00 00 05 FF 4E 01 00 9C EC
EFI2	13	00 00 41 44 06 00 00 05 FF 4D 06 00 00 05 FF 4D 02 00 9F E0
	14	00 00 41 44 06 00 00 05 FF 4E 06 00 00 05 FF 4E 02 00 CF B9

Table 16: Command for setting the EFI diverter

RK512 reply [hex]	Meaning
00 00 00 xx	xx = 00: No error xx ≠ 00: Error. See Table 12.

Table 17: Gateway response

All the following commands to an address that is different to the actual device address are routed to the EFI channel set in this manner. If an EFI channel is not selected, an error message may occur or the communication will be with the wrong device.

NOTE

Connect the light curtain to the gateway via EFI2 to obtain the fastest possible data transmission.

3.2.3 Reserving the EFI token

Reserve the EFI token on the gateway using the following command:

Gateway or Flexi Soft address setting	RK512 command [hex]	Meaning
13	00 00 41 44 19 00 00 05 FF 4D 19 00 00 05 FF 4D 0D 6F 9E 89	Reserve the EFI token
14	00 00 41 44 19 00 00 05 FF 4E 19 00 00 05 FF 4E 0E 6F 9D 85	Reserve the EFI token

Table 18: Command for reserving the EFI token

RK512 reply [hex]	Meaning
00 00 00 xx	xx = 00: No error xx ≠ 00: Error. See Table 12.

Table 19: Gateway response

NOTE

- On the occurrence of an error wait 3 seconds before you send this command again.
- When the command is executed the EFI connection to the light curtain is locked. Connection to CDS is not possible before the EFI connection is released again (see section 3.2.6 “Release of the EFI token” on page 21).

3.2.4 Reading the device type and number of beams (optional)

To be able to use the beam data from various devices, e.g. M4000 or C4000 with different length and resolution, the following command can be used to read the device type and the number of beams:

RK512 command [hex]	Meaning
00 00 45 44 07 00 00 0F FF 01	Reads the device type and the number of beams on the light curtain connected.

Table 20: Command for reading the device type and the number of beams

The gateway replies as follows:

RK512 reply [hex]
00 00 00 00 07 00 00 0F FF 01 **42** 20 3D A5 03 93 02 00 0C 09 0C 04 01 00 0C 06 30 05 **3C** 00 00 00 FB 99

Table 21: Reply telegram with the data required; here M4000 and 60 beams

The 4 least significant bits of the 10th byte (count starts at zero) indicate the device type:

- 0x1 = C4000
- 0x2 = M4000

The 28th byte defines the number of beams.

3.2.5 Reading the beam data

To read the beam data, use the following command depending on the light curtain used:

Device type	Command [hex]
C4000	00 00 45 44 64 00 00 13 FF 01
M4000	00 00 45 44 6E 00 00 13 FF 01

Table 22: Command for reading the beam data

The reply telegram from the UE1840 or the Flexi Soft comprises the following:

Byte	Value [hex]	Meaning
0-3	00 00 00 00	Data ok
4-9	6E 00 00 13 FF 01	Repetition of the header for the read command
10-39	FF FF FF FF FF FF FF 0F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	Beam data The least significant bit of byte 10 indicates the status of the first beam (as seen from the display) • 1 = Free • 0 = Interrupted The bits that follow indicate the status of the other beams. The reply telegram always contains the status of 240 beams, as this is the maximum number of beams on a light curtain. If the light curtain has less than 240 beams then the bits for the beams that are not present are set to 0.
40-41	0A E6	Checksum

Table 23: Reply telegram (example of an M4000 with 60 beams, no object in protective field)

On the occurrence of an error, the device replies as follows:

Byte	Value [hex]	Meaning
0-3	00 00 00 xx	xx = Error code. See Table 12.

Table 24: Reply telegram in case of an error

Example for a reply telegram if a number of beams on the light curtain are interrupted:

RK512 reply [hex]
00 00 00 00 6E 00 00 13 FF 01 FF 01 00 F8 FF FF FF 0F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 B8 97

Table 25: Reply telegram (example of an M4000 with 60 beams, object in protective field)

Evaluating the beam data:

Byte	Value [hex]	Value [binary]	Meaning
10	FF	11111111	Beam 1-8 free
11	01	00000001	Beam 9 free Beam 10-16 interrupted
12	00	00000000	Beam 17-24 interrupted
13	F8	11111000	Beam 25-27 interrupted Beam 28-32 free
14	FF	11111111	Beam 33-40 free
15	FF	11111111	Beam 41-48 free
16	FF	11111111	Beam 49-56 free
17	0F	00001111	Beam 57-60 free Beam 61-64 not present
18-39	00	00000000	Beam 65-140 not present
40-41	B8 97		Checksum

Table 26: Beam data (example)

NOTE

The beam data can be read repeatedly as long as the connection is locked.

3.2.6 Release of the EFI token

To remove the reservation of the EFI token use the following command, depending on the address of the gateway or the Flexi Soft:

Gateway or Flexi Soft address setting	RK512 command [hex]	Meaning
13	00 00 41 44 19 00 00 05 FF 4D 19 00 00 05 FF 4D 00 00 8B 62	Annul reservation of the EFI token
14	00 00 41 44 19 00 00 05 FF 4E 19 00 00 05 FF 4E 00 00 DB 3B	Annul reservation of the EFI token

Table 27: Command for releasing the EFI token

RK512 reply [hex]	Meaning
00 00 00 xx	xx = 00: No error xx ≠ 00: Error. See Table 12.

Table 28: Gateway response

3.2.7 Releasing connection with the gateway

To release the reservation of the network token use the following command, depending on the address of the gateway or the Flexi Soft:

Gateway or Flexi Soft address setting	RK512 command [hex]	Meaning
13	00 00 41 44 1C 00 00 05 FF 0D 1C 00 00 05 FF 0D 00 00 98 37	Annul reservation of the network token
14	00 00 41 44 1C 00 00 05 FF 0E 1C 00 00 05 FF 0E 00 00 C8 6E	Annul reservation of the network token

Table 29: Command for releasing the connection to the gateway

RK512 reply [hex]	Meaning
00 00 00 xx	xx = 00: No error xx ≠ 00: Error. See Table 12.

Table 30: Gateway response

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