PHARO telegram listing standard

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1 About this document

Please read this chapter carefully before you work with the documentation and the PHARO.

1.1 The function of this document

This Telegram Listing Standard describes the measured-data-specific expansion of PHARO functions. It is to be considered as a supplement to the PHARO Operating Instructions.

WARNING

Please see the PHARO Operating Instructions, and read them carefully, for general information on, for example, mounting, installing and commissioning the safety laser scanner.
Pay attention on the safety instructions in chapter 2 and 8 before you operate the system for the first time!

The available data communication may not be used for safety purposes!

1.2 For whom this document is intended

This Telegram Listing Standard is intended for system specialists in hardware and software development who want to integrate and evaluate the scanner's own measured value data within their host application.

1.3 Depth of information

This Telegram Listing Standard contains information on the following topics:

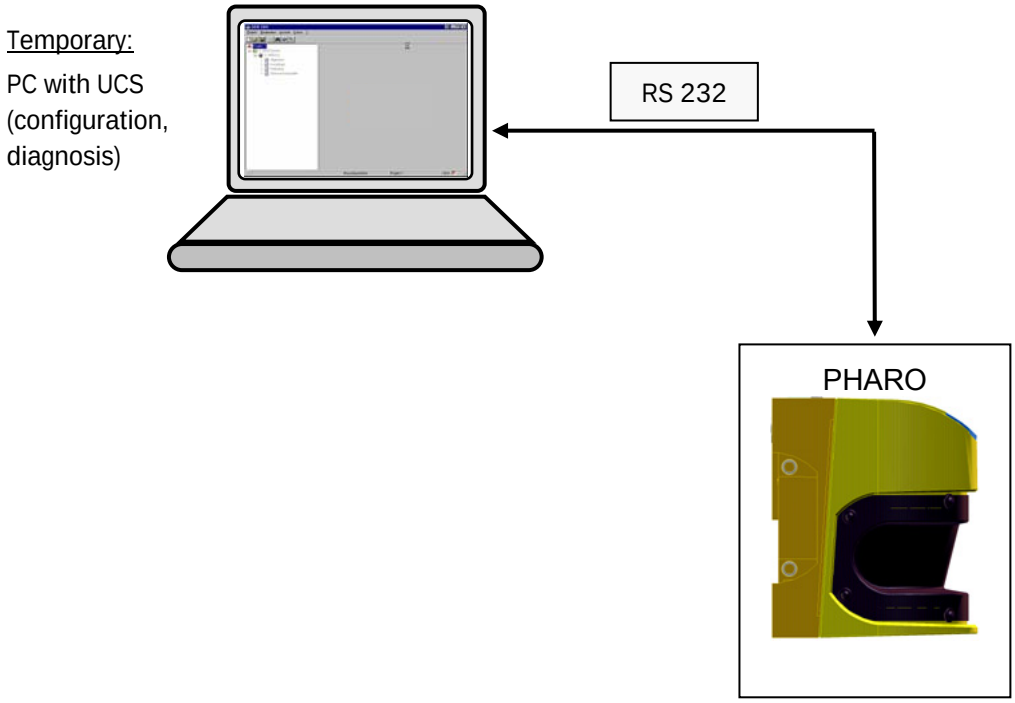
- Description of the RS-422 interface
- Description of the RK512 protocol used
- Description of special scanner-specific functions
- Information on use
- Error diagnosis

1.4 Scope of validity

This Telegram Listing Standard is applicable for the laser scanner PHARO.

2 System description

2.1 System structure



2.2 Electrical interface

The electrical interface is implemented according to the EIA RS-422-A Standard.

Electrical connection is described in the “Electrical installation” chapter of the PHARO Operating Instructions.

2.2.1 Transmission and data format

The baud rate of RS-422 measurement data output can be selected with the UCS from among the following baud rates:

- 9600 baud
- 19200 baud
- 38400 baud
- 125 Kbaud
- 250 Kbaud
- 500 Kbaud

In the default state the interface is pre-configured with a baud rate of 125 Kbaud.

One data byte consists of 1 start bit, 8 data bits, 1 stop bit, no parity bit.

2.3 Telegram structure

Communication according to the RK512 standard is based on “command” and “reply” telegrams. A command telegram is either a “send” or a “fetch” telegram.

The host computer transmits send telegrams with the data to be transferred after the telegram header; the recipient answers with a reply telegram without any further data. The host computer transmits fetch telegrams with the header of a fetch telegram without any subsequent data, and the sensor responds with a reply telegram which contains the requested data after the telegram header.

The value in the size field always describes the number of 16-bit words; individual bytes cannot be accessed.

In the telegram header, values that consist of 2 bytes are transmitted with the high byte (HB) first. In the case of data bytes, the 16-bit words with the low byte (LB) are transferred first.

2.3.1 The command telegram

The telegram header of the command telegram consist of 10 bytes with the following meanings:

Byte	Telegram fields	Content	Meaning
1	Telegram identifier	0x00	
2		0x00	
3	Command telegram type	'A' (0x41) or 'E' (0x45)	Send telegram or fetch telegram
4	Command data type	'D' (0x44)	
5	Destination address/ source address	0x00 to 0xFF	Data block number
6		0x00	
7	Size	0 to 65535	Block size in word
8			
9	Co-ordination flag (byte number)	0xFF	
10	Device address	0 to 15	0x07 PHARO

Table: Structure of command telegram

2.3.2 The reply telegram

The telegram header of the reply telegram consists of 4 bytes with the following meanings:

Byte	Telegram fields	Content	Meaning
1	Telegram identifier	0x00 (always)	
2		0x00 (always)	
3	Reply telegram type	0x00 (always)	Reply telegram
4	Reply error number	0x00 0x01 to 0xFF	No error See Error Table for error numbers

Table: Structure of reply telegram

2.3.3 Reply telegram error codes

The reply telegram is the answer of the PHARO to a send or fetch telegram.

If the PHARO detects an error it shows this in the error number of the reply telegram, and no data is sent after the reply telegram header.

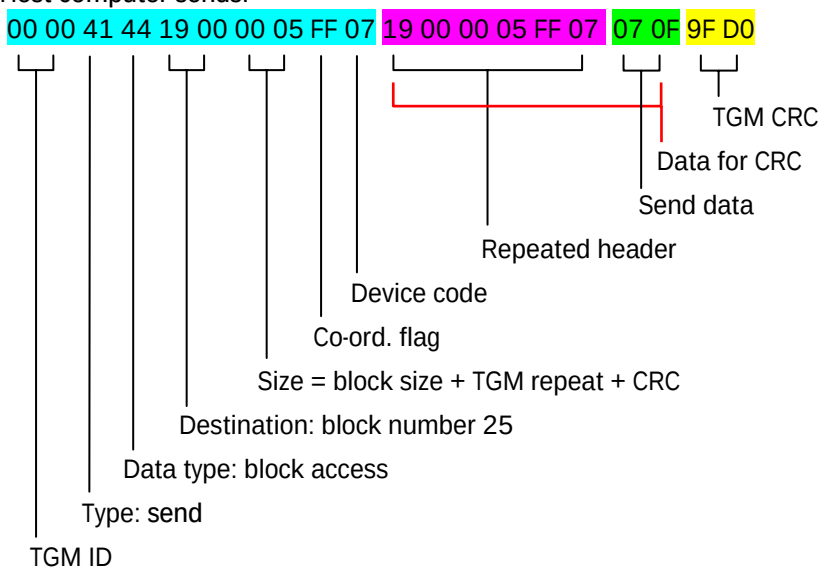
Error code in reply telegram	RK512 protocol communication error
0x00	No error
0x0A	One of the communication monitoring processes failed
0x0C	The data word number of the destination address or source address in command telegram (byte 6) is impermissible (not defined in Interface Register)
	The co-ordination flag (byte number) in command telegram (byte 9) does not equal 0xFF The device code in the command telegram (byte 10, bits 0 to 3) is invalid (i.e. equals 0)
	The CPU number in the command telegram (byte 10, bits 5 to 7) is impermissible
0x10	The telegram identifier in the command telegram (byte 1) is not equal to 0x00 or 0xFF or is not followed by a further 0x00 byte (byte 2)
	The command data type in the command telegram (byte 4) is impermissible
0x14	The data block number of the destination address or source address in the command telegram (byte 5) is impermissible (not defined in the Interface Register)
0x16	The command telegram type in the command telegram (byte 3) is impermissible
0x34	Telegram format error Possible causes: • The length quoted in the size field of the command telegram (bytes 7 and 8) exceeds the number of entries after the defined address in the data block • The length of the send telegram data was greater that that defined in the size field • The length of the send telegram data was smaller than that defined in the size field • A fetch telegram with useful data has been received • The send telegram was correctly received but the CRC on the data is wrong or the first six data bytes do not match bytes 5 to 10 from the telegram header
0x36	A command telegram has been received though no reply telegram has been received yet
0x01	The current device status does not permit access to the data block
0x02	Access to the data block by the current user group is not permitted
0x03	Incorrect password
0x04	System token is occupied
0x05	Incorrect parameter

Table: Reply telegram error codes

2.4 Standard communication

Example of a send telegram: “Write the token in block 25”

Host computer sends:

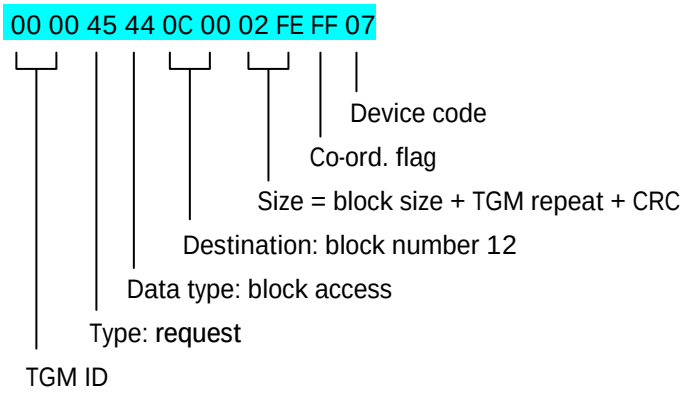


PHARO reply:

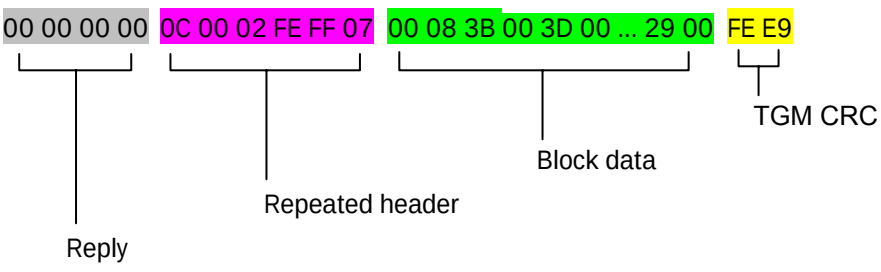
00 00 00 00

Example of a fetch telegram: “Read operating data block 12”

Host computer sends:



PHARO reply:



2.5 Flexible telegrams

Some host computers require the interrupt burden for the UART to be kept as low as possible. In such cases (Request Mode) a data block of flexible length can be used in the reply telegram (block 112).

2.6 Continuous output

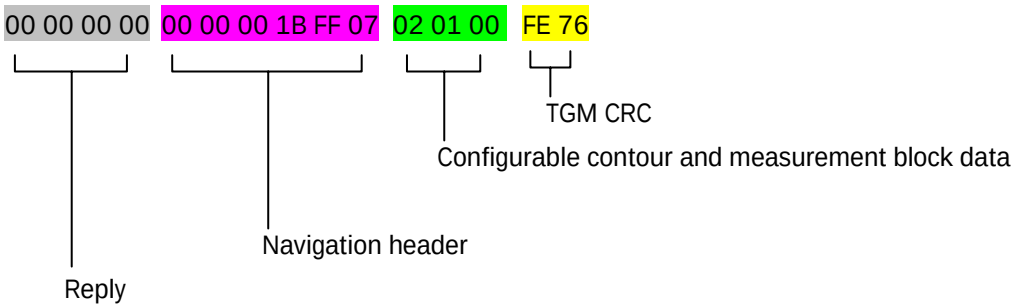
In order to be able to build up telegram traffic that is as efficient as possible, the PHARO can be configured in such a way that it permanently transmits the measured values and some additional information at the RS-422 interface. Continuous output is not affected by telegram traffic via the other interfaces available. It is not necessary to reserve the token for the RS-422 interface for continuous data output (in Request Mode only one interface can possess the token at any time).

Continuous data output must first be stopped (see Chap. 3.6: Stopping continuous data output) in order to be able to transmit a request telegram from the host computer via the RS-422 interface during continuous data output (e.g. changing Trigger Modes).

Example: Continuous data output telegram structure

00 00 00 00 00 00 00 1B FF 07 02 01 00 00 17 01 00 00 00 00

CC CC 08 00 00 00 E8 23 19 00 E8 23 32 00 E8 23 7D 00 E8 23 96 00 E8 23 C8 00 E8 23 E1 00 E8 23 38 4A E8 23 FE 76



2.7 Data confidence

As the RK512 standard does not offer any mechanism for checking the integrity of the data received, such a mechanism is supplemented in the data of the RK512 telegram. This involves the exact repetition of bytes 5 to 10 from the header of a command telegram in the first six data bytes and a CRC that is formed via the data bytes and added to them. Accordingly, the number of words defined in the size field of the telegram header of a command telegram is raised by 4 words.

The CRC is 16 bits and is formed according to the polynomial $x^{16}+x^{12}+x^5+x^0$ (0x1021). This CCITT-CRC is applied in the entire communication stack where a CRC is required for safeguarding the data transmitted.

A simple routine for CRC calculation follows as an example:

```
static const unsigned short crc_table[256] = {
0x0000, 0x1021, 0x2042, 0x3063, 0x4084, 0x50a5, 0x60c6, 0x70e7,
0x8108, 0x9129, 0xa14a, 0xb16b, 0xc18c, 0xd1ad, 0xe1ce, 0xf1ef,
0x1231, 0x0210, 0x3273, 0x2252, 0x52b5, 0x4294, 0x72f7, 0x62d6,
0x9339, 0x8318, 0xb37b, 0xa35a, 0xd3bd, 0xc39c, 0xf3ff, 0xe3de,
0x2462, 0x3443, 0x0420, 0x1401, 0x64e6, 0x74c7, 0x44a4, 0x5485,
0xa56a, 0xb54b, 0x8528, 0x9509, 0xe5ee, 0xf5cf, 0xc5ac, 0xd58d,
0x3653, 0x2672, 0x1611, 0x0630, 0x76d7, 0x66f6, 0x5695, 0x46b4,
0xb75b, 0xa77a, 0x9719, 0x8738, 0xf7df, 0xe7fe, 0xd79d, 0xc7bc,
0x48c4, 0x58e5, 0x6886, 0x78a7, 0x0840, 0x1861, 0x2802, 0x3823,
0xc9cc, 0xd9ed, 0xe98e, 0xf9af, 0x8948, 0x9969, 0xa90a, 0xb92b,
0x5af5, 0x4ad4, 0x7ab7, 0x6a96, 0x1a71, 0x0a50, 0x3a33, 0x2a12,
0xdbfd, 0xcbdc, 0xfbbf, 0xeb9e, 0x9b79, 0x8b58, 0xbb3b, 0xab1a,
0x6ca6, 0x7c87, 0x4ce4, 0x5cc5, 0x2c22, 0x3c03, 0x0c60, 0x1c41,
0xedae, 0xfd8f, 0xcdec, 0xddcd, 0xad2a, 0xbd0b, 0x8d68, 0x9d49,
0x7e97, 0x6eb6, 0x5ed5, 0x4ef4, 0x3e13, 0x2e32, 0x1e51, 0x0e70,
0xff9f, 0xefbe, 0xdfdd, 0xcffc, 0xbf1b, 0xaf3a, 0x9f59, 0x8f78,
0x9188, 0x81a9, 0xb1ca, 0xa1eb, 0xd10c, 0xc12d, 0xf14e, 0xe16f,
0x1080, 0x00a1, 0x30c2, 0x20e3, 0x5004, 0x4025, 0x7046, 0x6067,
0x83b9, 0x9398, 0xa3fb, 0xb3da, 0xc33d, 0xd31c, 0xe37f, 0xf35e,
0x02b1, 0x1290, 0x22f3, 0x32d2, 0x4235, 0x5214, 0x6277, 0x7256,
0xb5ea, 0xa5cb, 0x95a8, 0x8589, 0xf56e, 0xe54f, 0xd52c, 0xc50d,
0x34e2, 0x24c3, 0x14a0, 0x0481, 0x7466, 0x6447, 0x5424, 0x4405,
0xa7db, 0xb7fa, 0x8799, 0x97b8, 0xe75f, 0xf77e, 0xc71d, 0xd73c,
0x26d3, 0x36f2, 0x0691, 0x16b0, 0x6657, 0x7676, 0x4615, 0x5634,
0xd94c, 0xc96d, 0xf90e, 0xe92f, 0x99c8, 0x89e9, 0xb98a, 0xa9ab,
0x5844, 0x4865, 0x7806, 0x6827, 0x18c0, 0x08e1, 0x3882, 0x28a3,
0xcb7d, 0xdb5c, 0xeb3f, 0xfb1e, 0x8bf9, 0x9bd8, 0xabbb, 0xbb9a,
0x4a75, 0x5a54, 0x6a37, 0x7a16, 0x0af1, 0x1ad0, 0x2ab3, 0x3a92,
0xfd2e, 0xed0f, 0xdd6c, 0xcd4d, 0xbdaa, 0xad8b, 0x9de8, 0x8dc9,
0x7c26, 0x6c07, 0x5c64, 0x4c45, 0x3ca2, 0x2c83, 0x1ce0, 0x0cc1,
0xef1f, 0xff3e, 0xcf5d, 0xdf7c, 0xaf9b, 0xbfba, 0x8fd9, 0x9ff8,
0x6e17, 0x7e36, 0x4e55, 0x5e74, 0x2e93, 0x3eb2, 0x0ed1, 0x1ef0
};
WORD CRC16 (BYTE *Data, DWORD length)
{
   WORD CRC_16 = 0xFFFF;
   WORD i;
   for (i = 0; i < length; i++)
   {
      CRC_16 = (CRC_16 << 8) ^ (crc_table[(CRC_16 >> 8) ^ (Data[i])]);
   }
   return CRC_16;
}
```

3 Types of communication

3.1 The system token

The token administrates the various communication portals (RS 232, RS 422). A device does not permit simultaneous access to different interfaces. The token is demanded and must be successfully allocated before any data can be read or written.

If continuous data output is taking place at the measurement data interface (RS 422), communication can take place simultaneously via the RS 232. Continuous data output is not affected by this.

Exception:

In order to carry out a request telegram during simultaneous data output at the RS 422, the continuous output of measurement must be stopped first.

The connected device must always be addressed from a serial interface in order to receive the token. Without having been assigned the token, it is impossible to access the data of a device. The token is not saved during a power reset and must be requested again thereafter.

3.2 Request Mode

In Request Mode the measurement data is requested by the host computer (e.g. block 12 scan data). Send and fetch telegrams are used.

Measurement blocks with static lengths (block 12) and measurement blocks with flexible lengths (block 112) can be requested.

Example: There is only one PHARO and measurement data is to be received

1. Power on
2. Get token (send telegram with device code 0x07)
3. Read scan data set 1 (fetch telegram with device code 0x07)
4. Read scan data set 2 (fetch telegram with device code 0x07)
5. Read scan data set n (fetch telegram with device code 0x07)
6. Release token (send telegram with device code 0x07)

Example for Request Mode

Get token:

Host computer, send: 00 00 41 44 19 00 00 05 FF 07 19 00 00 05 FF 07 07 0F 9F D0

PHARO, reply: 00 00 00 00

Read scan data (block 12):

Host computer, send: 00 00 45 44 0C 00 02 FE FF 07

PHARO, reply: 00 00 00 00 0C 00 02 FE FF 07 00 08 3B 00 3D 00 ..... 29 00 FE E9

Read extended scan data (block 112):

Host computer, send: 00 00 45 44 70 00 03 02 FF 07

PHARO, reply: 00 00 00 00 70 00 03 02 FF 07 01 00 00 00 14 4B 00 26 8B

Release token:

Host computer, send: 00 00 41 44 19 00 00 05 FF 07 19 00 00 05 FF 07 00 00 E7 B8

PHARO, reply: 00 00 00 00

3.3 Continuous data output

During continuous data output, the output of measurement data takes place automatically, the telegrams only need to be read.

Continuous data output is activated during configuration.

Structure of continuous data output:

data output always starts as follows:

00 00 00 00 4 byte reply header

00 00 data block number 0x0000 for data output

xx xx size of telegram

FF 07 co-ordination flag and device code, here 0x07

02 01 protocol version number 0x0102, fixed

0x 00 status normal 0x0000 or lockout 0x0001

17 01 00 00 scan number (time stamp), here 0x00000117

02 00 telegram number, here 0x0002

The following block measurement data with the BBBB flag is output if measurement data output is configured:

BB BB ID for measurement data, if measurement data configured
11 11 ID for measurement data from angular range 1
xx xx measured values from angular range 1
...

The CRC is output in conclusion:

xx xx 16 bit CRC

Measurement data format (2 bytes):

Bits 15-13	Bits 12-0
Status bits Bit 15: measured value detected within simultaneous protective field B Bit 14: measured value detected within protective field A Bit 13: glare (dazzling) detected	Measured distance in centimetres

The navigation version number 0x0102 should be checked by host computer and is dependent on the firmware in sensor.

With a different version number, the structure of the continuous data output may differ from the example above.

3.4 Example of continuous data output

Configuration: Output of all measured values of a complete scan.

Reception of a measurement data set:

...

00 00 00 00 00 00 03 04 FF 07 02 01 00 00 17 01 00 00 00 00 BB BB 11 11 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 . . . E8 03 FB B7

...

3.5 Stopping continuous data output

A request telegram cannot be sent from the host computer while a PHARO is transmitting continuous measurement data.

The host computer must first stop the continuous data output. This takes place through the transmission of a character 0x41. Now the host computer can communicate in Request Mode, as long as the configurable silent time has not yet elapsed. Thereafter the output of measurement data automatically restarts.

3.6 Fixed configured continuous data output modes

Measurement data output is initially configured as fixed with the UCS.

This configuration is permanently retained in the device, as long as no new configuration is transferred to the device.

This configuration is loaded from the system plug's memory at each Power Up.

3.7 Additional time stamps and telegram numbers

In a moving transport vehicle, the allocation of a measured value set with a time stamp for the host computer is necessary so that the measured value set is evaluated with the correct position and the correct orientation of the vehicle. For this reason, there is a global counter in the sensor (32-bit) that is output with block 112 (Request Mode) in addition to the continuous measured value output. This counter is internally incremented at each scan, i.e. every 30 ms or 60 ms depending on the configuration.

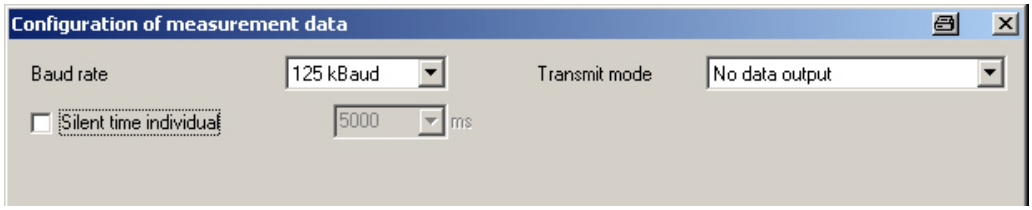
In addition, these blocks each have their own telegram number that is only incremented on output of the block.

4 Configuring the measurement data

4.1 UCS measurement data configuration

Configuration of measuring data output takes place via the *PHARO* device symbol in the *Measuring data* contextual menu.

4.2 Configuration of measurement data



Baud rate

The baud rate of the RS-422 interface can be set as follows:

9 600, 19 200, 38 400, 125 000, 250 000, 500 000

Silent time indivitual

The silent time defines the length of the time period for transmitting the silent bytes, with which continuous data output can be interrupted to allow access to the interface.

The default silent time is 5000 ms.

Transmit mode

No data output: data is only provided on request

Continuous data output: data is provided continuously

5 Error diagnosis

The following possibilities are available for the diagnosis of settings on your sensor:

You can read blocks, that you have changed online, back from the sensor at any time to ensure that the settings in the device are correct.

The following diagnostic possibilities are available with the help of UCS:

- you can display the configuration saved in the device
- you can show the current setting of the sensor in the operating state report

6 Glossary

RK512 telegram header	Protocol definition for data communication
Device code	Device address for communication
Continuous Mode	Permanent measurement data transmission mode
Measurement data	Distance values measured by sensor
Silent time	Pause period during continuous data output
Scan data set	Distance values of a measurement range (0...190°)
Angular range	Segment in the scanning field
Time stamp	A time mark that is determined on generation of data
Bull's eye	Complete area of the laser beam hits an object
UCS	User Configuration Software

7 Appendix

7.1 Description of the data blocks used

7.1.1 Scan data block (block no. 12)

Block description

Data Block Name	Block No.	Block Size	Access		Non-volatile
			PHARO	Ext. Device	
Scan data block	12	1524 Byte	W	R 0-4	No

Block Registers	Block Words	Register Size	RI Identifier
Monitoring data	0	2 Byte	RI_SCAN_STATUS
Scan data pulse 1-761	1-761	1522 Byte	RI_SCAN_DATA

Register description

Register Name	Block Word	Field Bits	Field Name	Field Description
Monitoring data	0	0-3	Monitoring case	0-15: Active monitoring case
		4-7	n/u	n/u
		8-10	Control area A	0-7: Monitoring area of control area A
		11	Control area A activated	0: Control area A inactive 1: Control area A active
		12-14	Control area B	0-7: Monitoring area of control area B
		15	Control area B activated	0: Control area B inactive 1: Control area B active
Scan data pulse 1	1	0-12	Distance	Distance [cm]
		13-15	Status flags	Bit 15: Pulse within control area B detected Bit 14: Pulse within control area A detected Bit 13: glare (dazzling) detected
Scan data pulses 2-761	2-761	See scan data pulse 1		

7.1.2 Configuration master block (block no. 25)

Block description

Data Block Name	Block No.	Block Size	Access		Non-volatile
			PHARO	Ext. Device	
Config. master block	25	2 Byte	R W	R 0-4 W 0-4	No

Block Registers	Block Words	Register Size	RI Identifier
Master ID register	0	2 Byte	RI_MSTR_ID

Register description

Register Name	Block Word	Field Bits	Field Name	Field Description
Master ID register	0	0-3	Device address	Device address that passed request to host of master token: 0x7: PHARO Other: prohibited
		4-7	n/u	n/u
		8-11	Token requester	0xF: PC 7 host PC Other: prohibited
		12-15	Interface of token requester	Valid only for PC as token requester 0x0: External serial interface 0x1: Navigation data interface Other: prohibited

Remark:

By using the physical device address this block can be accessed without being assigned the token (only read access).

Write 0x0000 to the master ID register to return the token.

7.1.3 Extended scan data block (block no. 112)

Block description

Data Block Name	Block No.	Block Size	Access		Non-volatile
			PHARO	Ext. Device	
Extended scan data block	112	772 or 1532 Byte	W	R 0-4	No

Block Registers	Block Words	Register Size	RI Identifier
Telegram number	0-1	4 Byte	RI_EX_SCAN_TELEGRAM_NO
Scan number	2-3	4 Byte	RI_EX_SCAN_SCAN_NO
Monitoring data	4	2 Byte	RI_EX_SCAN_STATUS
Scan data pulse 1-381 or 1-761	5-765	762 or 1522 Byte	RI_EX_SCAN_DATA

Register description

Register Name	Block Word	Field Bits	Field Name	Field Description
Telegram number	0-1	0-31	Telegram number	Current telegram number
Scan number	2-3	0-31	Scan number	Scan number since power-up
Monitoring data	4	0-3	Monitoring case	0-15: Active monitoring case
		4-7	n/u	n/u
		8-10	Control area A	0-7: Monitoring area of control area A
		11	Control area A activated	0: Control area A inactive 1: Control area A active
		12-14	Control area B	0-7: Monitoring area of control area B
		15	Control area B activated	0: Control area B inactive 1: Control area B active
Scan data pulse 1	5	0-12	Distance	Distance [cm]
		13-15	Status flags	Bit 15: Pulse detected within control area B Bit 14: Pulse detected within control area A Bit 13: glare (dazzling) detected
Scan data pulse 2- 381 or 2-761	5-385 or 5-765	See scan data pulse 1		

Remark:

Telegram size depends on scan resolution.