

### Abbreviations

LZR: laser scanner platform

ToF: Time-of-Flight

MDI: measured distance information

## 1. Introduction

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This application note contains useful information for communication with the LZR<sup>®</sup>-U92x family of raw data laser scanners from BEA/Sensorio.

This document is divided into four parts:

- Part 1 provides a general description of the laser scanner platform LZR and his general characteristics and functions.
- Part 2 provides a detailed description of the communication protocol and how to communicate with the laser.
- Part 3 provides additional information concerning several parameters.
- Part 4 lists the different versions and there specific features and settings

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## 2. LZR: general description (part 1)

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### 2.1. Reminder: The laser scanner platform LZR

The LZR platform is an active optoelectronic laser measurement system based on the Time-of-Flight (ToF) principle. This device generally scans its surroundings with the aid of a very short light pulse, also called laser beam, deflected at different angular positions by a rotating mirror (see Figure 1). If this laser beam is incident on an object, it is reflected to the sensor head. Based on the time delay measured between the moment of emitting the light pulse and the moment of receiving the reflected part of the same light pulse, the distance to the object can be determined.

Two different types of mirror exist:

- **"Mirror 0°"** or mirror type 1: this mirror is a perfect cube with four mirrored faces. With this mirror type, the laser scanner will scan four times the same two-dimensional plane while performing one complete rotation.
- **"Mirror 6°"** or mirror type 2: this mirror has almost the shape of a cube, but the four mirrored faces are slightly inclined. In this case, the laser scanner will not only scan one single two-dimensional plane while performing one complete rotation, but it will scan four slightly inclined planes (one plane per mirrored face).

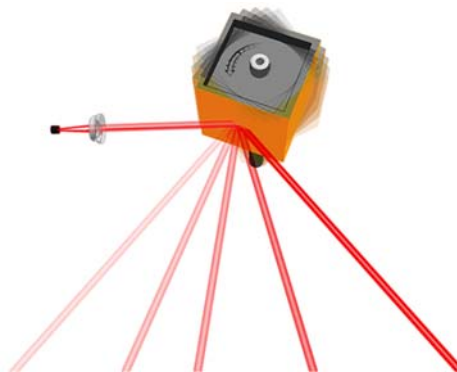
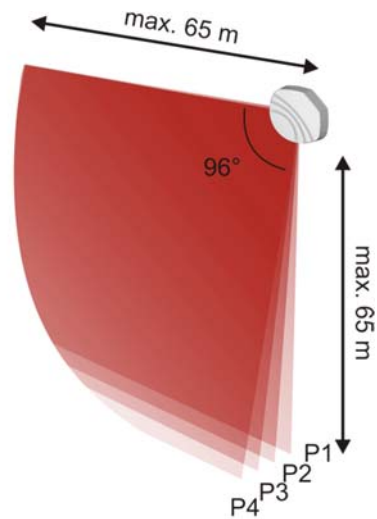


Figure 1

The following picture shows the laser scanner (LZR) and its four planes (P1, P2, P3, P4) for the mirror type 6° and how it is generally installed when used vertically.

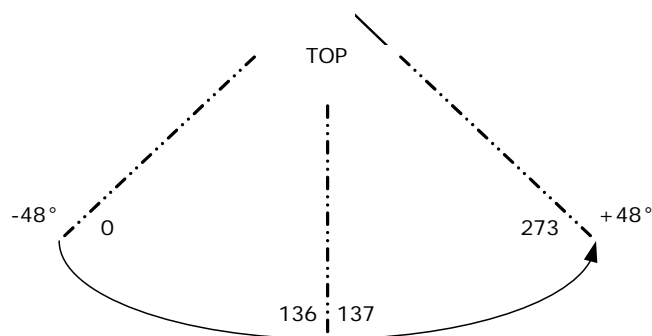


**Figure 2**

## 2.2. The LZR's main characteristics

Technology	ToF (Time-of-Flight)
Number of planes	max. 4
Tilt angle shift between planes	0° for mirror type 1 / approximately 2° for mirror type 2
Number of measurement points per plane	max. 274
Optical angular opening area	max. 96°
Angular resolution	max. $96^\circ/273 = 0,3516^\circ$
Speed of motor rotation	900 rpm
Scanning frequency	mirror type 1: 60 Hz; mirror type 2: 15 Hz
Measurement area	max. 65 m

The following picture (Figure 3) shows the correlation between the measurement points, also called spots, and the angular scanning position.



**Figure 3**

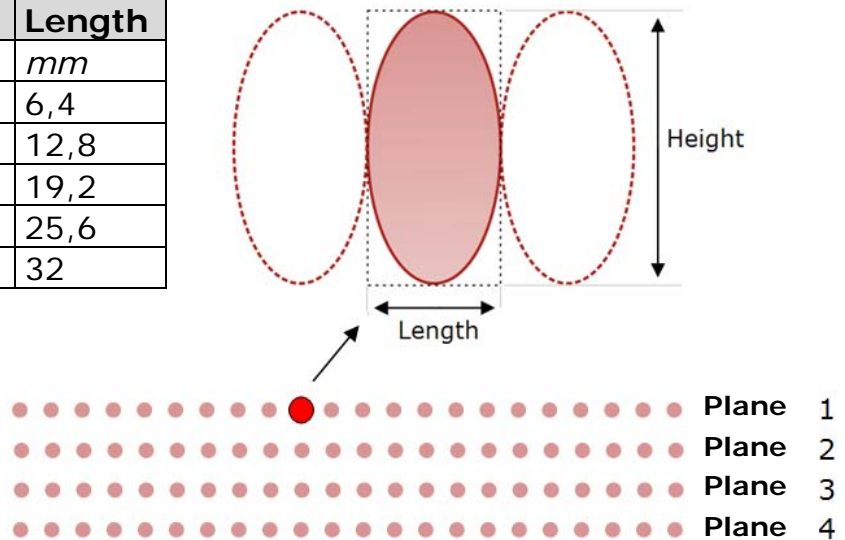
Distance measurement of spot 0	-48°
Distance measurement of spot 273	+48°

## 2.3. Characteristics of the laser spot

Spot size depending on scanning distance:

Distance	Height	Length
<i>m</i>	<i>mm</i>	<i>mm</i>
1	16	6,4
2	32	12,8
3	48	19,2
4	64	25,6
5	80	32

Table 1



Basic relation spot length vs spot height:  $1 \times 2,5$  (length x height)

Characteristics of the distance measurement:

The maximum measurement distance range of the LZR-U910 is 65m. Therefore, all objects at 65m or at any distance higher than 65m will lead to a measurement distance value of 65m. The detection of a target with min. 2% remission factor is ensured until 10 m (in clear conditions).

## 3. LZR: communication protocol (part 2)

The LZR-U92x family is based on a serial, bi-directional, half-duplex communication system with RS-485 interface. Via this interface, the laser scanner can communicate and exchange data with a connected host. Following communication modes exist:

### 1. Laser Scanner => Host

- **Measured Distance Information (MDI):** the laser scanner sends the MDI to the host
- **Settings:** if requested by the host via a "Read-out request", the laser scanner can transmit to the host his settings/his configuration

### 2. Host => Laser Scanner

- **Select mode:** the host can chose between two communication modes, either the "measure mode", where the laser scanner will transmit the MDI, or the "configuration mode", where the host can configure the laser scanner
- **Request for MDI:** the host can send a request frame for MDI, either as single shot or as continuous measurement

- **Set parameters:** via the bus system the host can define the settings of the laser scanner
- **Read-out (request) parameters:** via the bus system the host can query the laser scanner's settings
- **Specific actions:** via the bus system the host can also launch specific actions, such as Error Log reset

### 3.1. Main characteristics of the serial communication

Type	Asynchronous
Electrical interface	RS-485
Communication mode	half-duplex
Data transmission speed	max. 921600
Topology	Point to point
Encoding	1 start bit, 1 stop bit, no parity bit
Data word length	8 bits
Bytes order	little-endian, LSB (Least Significant Byte) first

### 3.2. Communication frame

Each communication frame consists of a "Header", a "message" and a "Footer" part (see Figure 4).

	Header		Message		Footer
Code	SYNC	SIZE	CMD	DATA	CHK
Length (byte)	4	2	2		2

**Figure 4**  
**Communication frame: basic structure**

Rem.: byte order = little-endian, LSB (Least Significant Byte) first

The basic structure of the communication frame is valid for all communication modes (see details above). However, the exact content could change depending on the mode used.

Following a description of the basic codes:

#### **SYNC:**

This code is used to allow synchronization between the laser scanner and the host.

Size	4 bytes
Value	0xFFFE FDFC
Structure	LSB first, MSB last

#### **SIZE:**

This code is used to transmit the length of the block "message".

Size	2 bytes
Value	length of the "message" frame
Structure	LSB first, MSB last

**CMD:**

This code is used to transmit a specific command/request from the host to the laser scanner.

If the command/request implies an answer from the laser scanner (for details, please refer to the subsequent chapters), this answer will be included in the *DATA* part of the answer frame.

Size 2 bytes  
Value number acc. to the desired command  
Structure LSB first, MSB last

**DATA:**

The content of this code can be different depending on the communication mode. In case of transmission from the laser scanner to the host, this code is used to transmit the data information according to the request sent by the host before. The data information could be the MDI or settings information of the laser scanner. In case of configuration of the laser scanner, this code is used to transmit the desired settings from the host to the laser scanner.

In case of transmission of a request from the host to the laser scanner the “*DATA*” part of the communication frame is not used.

Size (depends on the communication mode)  
Value Empty, MDI (expressed in mm) or setting information  
Structure LSB first, MSB last

**CHK:**

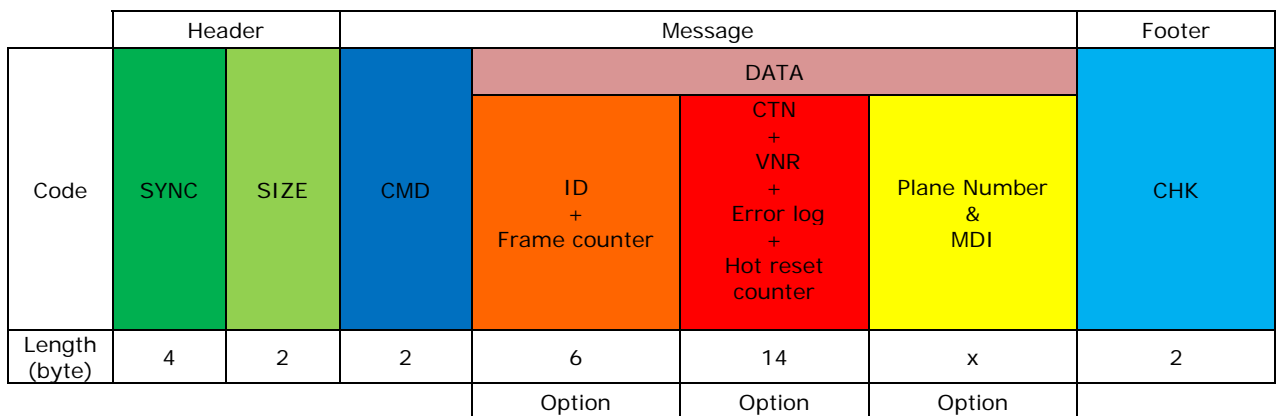
This code is used to transmit the checksum, which is the sum of all bytes of the “message” part of the communication frame.

Size 2 bytes  
Principle The calculation of the CHK is performed only on the “message” part of the communication frame  
Calculation The CHK equals the sum of all bytes of the “message” part of the communication frame  
Structure LSB first, MSB last

**3.2.1 Laser Scanner => Host**

**3.2.1.1 MDI**

The general structure of the communication frame while transmitting the MDI is shown below in Figure 5.



**Figure 5**

Codes with the remark “Option” can be enabled or disabled via a specific command.

Following a description of the basic symbols dedicated to the MDI mode.

**CMD:**

The code will indicate if the MDI has been sent subsequently to a single-shot request or to a continuous measuring request.

Size        2 bytes  
Value       50011 (single-shot or continuous measuring)  
Structure   LSB first, MSB last

**ID + Frame counter:**

This information will only be transmitted if enabled via the command **SETRAWDATACONFIG**.

Size        6 bytes  
Value       ID + Frame counter  
Structure   LSB first, MSB last

ID: this number corresponds to the identification number (also called CAN number) of the laser scanner. The ID number of a laser scanner is a unique number.

Size        4 bytes  
Value       Identification number (CAN number) of the laser scanner  
Structure   LSB first, MSB last

Frame counter: this parameter indicates the number of complete communication frames sent since the last power on and since the last command for a "Frame counter reset" (see command **SETRAWDATAFRAMECOUNTERRESET**).

The maximum value of this parameter is 65000. Once this value achieved, it will start again to count from 0.

Size        2 bytes  
Value       number of complete communication frames sent (max. 65000)  
Structure   LSB first, MSB last

**CTN + VNR+ Error log + Hot reset counter:**

This information will only be transmitted if enabled via the command **SETRAWDATACONFIG** (more information about those parameters can be found in part 3 of this document)

Size        14 bytes  
Value       CTN + VNR + Error log + Hot reset counter  
Structure   LSB first, MSB last

CTN: this parameter is representative for the internal temperature of the LZR

Size        2 bytes  
Value       typically between 150 and 905  
Structure   LSB first, MSB last



**VNR:** this parameter is representative for the internal voltage level of the LZR

Size            2 bytes  
 Value           typically between 64 and 270  
 Structure        LSB first, MSB last

**Error log:** the error log provides the last 9<sup>th</sup> errors which occurred inside the LZR. It is handled according the FIFO principle (First In – First Out). For more information, please refer to section 4.

Size            9 bytes  
 Value           refer to section 4  
 Structure        LSB first, MSB last

**Hot reset counter:** this parameter indicates the number of error occurred since the last power on. The maximum value of this parameter is 255. Once this value achieved, it will start again to count from 0.

Size            1 bytes  
 Value           Number of total errors occurred since the last power on (max. value 255)  
 Structure        LSB first, MSB last

The section of the communication frame dedicated to the *Plane Number* and the *MDI* can have different structures depending on the mirror type used and the settings of the laser scanner (see following sections).

### 3.2.1.1.1 Mirror 0°

In case of the Mirror 0°, the MDI is sent after each face of the mirror; the system is working at a frequency of 60Hz (the mirror turns with 900rpm).

The following graph (see Figure 6) shows the structure of the communication frame.

~ Message ~				
Code	Plane	MDI		
Value	Value 0 => Plane P2 Value 1 => Plane P4 Value 2 => Plane P1 Value 3 => Plane P3	D0	...	Dn
Length (byte)	1	Max. 548		
	Option			

**Figure 6**

**Plane number:**

If enabled via the command **SETRAWDATACONFIG** this number indicates for which plane the MDI is currently sent.

Size            1 byte  
 Value           0, 1, 2 or 3  
 Structure        LSB first, MSB last

The following table summarizes the link between the plane number and the values 0, 1, 2, 3.

Plane	Value
Plane P1	2
Plane P2	0
Plane P3	3
Plane P4	1

**Table 2**

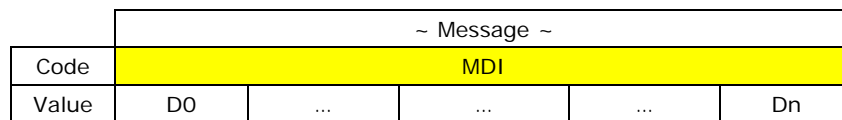
**MDI:**

This part contains the complete measured distance information related to the curtain specified in the section “Plane number”. Each distance is encoded via 2 bytes.

The length of this code depends on the configuration of the laser scanner (starting spot, number of distance values, gap between successive spots). The maximum length is 548 bytes (= 274 x 2bytes).

Size	max. 548 bytes
Value	MDI data for one plane (all distances are in mm)
Structure	LSB first, MSB last

The structure of the MDI data is explained by the following graph:



**Figure 7**

where D0 is the distance measurement related to the first measured angle position and Dn is the distance measurement related to the last measured angle position on one specific plane.

D0 is defined by the parameter “starting spot number”.

Dn is defined by the parameters “starting spot number”, “number of distance values” and “gap between two successive spots”; for more information please refer to part 3 of this document.

All distance measurements made by the laser scanner are expressed in mm.

**3.2.1.1.2 Mirror 6°**

In case of the Mirror 6°, the MDI is sent after each complete rotation of the mirror; the system is working at a frequency of 15Hz (the mirror turns with 900rpm).

The communication frame will transmit at once the MDI of all four planes.

The following graph shows the structure of the communication frame. Items which are specified as “Option” can be activated or deactivated via the settings of the laser scanner. Only if they are activated, they will be part of the communication frame.

~ Message ~								
Code	Plane P2	MDI Plane P2	Plane P4	MDI Plane P4	Plane P1	MDI Plane P1	Plane P3	MDI Plane P3
Value	0	D0...Dn	1	D0...Dn	2	D0...Dn	3	D0...Dn
Length (byte)	1	Max. 548	1	Max. 548	1	Max. 548	1	Max. 548
	Option		Option		Option		Option	

**Figure 8**

**Plane number:**

If enabled via the command **SETRAWDATACONFIG** this number indicates to which plane the following MDI package is referring.

Size	1 bytes
Value	0, 1, 2 or 3
Structure	LSB first, MSB last

The following table summarizes the link between the plane number and the values 0, 1, 2, 3.

Plane	Value
Plane P1	2
Plane P2	0
Plane P3	3
Plane P4	1

**Table 3**

**MDI:**

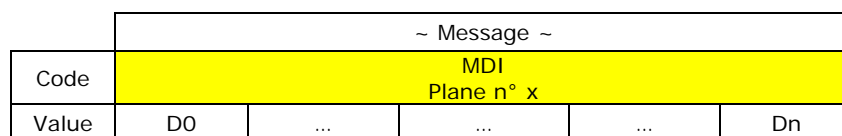
This part contains the complete measured distance information related to the plane specified in the respective section "*Plane number*".

Each distance is encoded via 2 bytes.

The length of this code depends on the configuration of the laser scanner (starting spot, number of distance values and gap between successive spots). The maximum length is 548 bytes (= 274 x 2bytes).

Size	max. 548 bytes
Value	MDI data for one plane (all distances are in mm)
Structure	LSB first, MSB last

The structure of one MDI data package is explained by the following graph:



**Figure 9**

D0 is the distance measurement related to the first measured angle position and Dn is the distance measurement related to the last measured angle position on one specific plane.

D0 is defined by the parameter "starting spot number".

Dn is defined by the parameters "starting spot number", "number of distance values" and "gap between two successive spots"; for more information please refer to part 3 of this document.

All distance measurements made by the laser scanner are expressed in mm.

The MDI related to one specific plane is only transmitted if the plane is enabled (see command **SETRAWDATACONFIG**).

### 3.2.1.2 Settings

After having received the specific request, the laser scanner will send his corresponding settings.

Five different requests exist:

- **GETRAWDATAMODE**
- **GETRAWDATACONFIG**
- **GETRAWDATAINFORMATION**
- **GETRAWDATAREDLASER**
- **GETRAWDATAHEARTBEAT**

The different requests will be explained in more details in section 3.2.2.

The general structure of the communication frame corresponds to the one shown in Figure 10.

	Header		Message				Footer
Code	SYNC	SIZE	CMD		DATA		CHK
Value			C0	C1	D0	.	Dn
Length (byte)	4	2	2				2

**Figure 10**

The following is a description of the basic symbols.

#### **CMD:**

This code will indicate subsequently to which request the laser scanner sends his settings.

Size        2 bytes (C0, C1)

Value       50002, 50004, 50008, 50010, 50013, 50015 (for more details see section 3.2.2)

Structure   LSB first, MSB last

#### **DATA:**

The content of this code depends on the request subsequently to which the laser scanner sends his corresponding settings. For a detailed description please refer to section 3.2.2.

Size        depends on the request

Value       D0 to Dn; the exact value depends on the request (please refer to section 3.2.2 for more information)

Structure   LSB first, MSB last

### 3.2.2 Host => Laser Scanner

When communicating to the laser scanner, the host can send either a request (for MDI, to read-out parameters of the laser scanner or to launch a specific action) or a command either to define the communication mode ("measuring" or "configuration") or to define settings of the laser scanner. The different cases are described in more details in the following sections.

In response to each request/command, the laser scanner will sent a specific answer. Details can be found in the following sections.

The general structure of the communication frame when sending a request/command is as follows (see Figure 11):

	Header		Message				Footer
Code	SYNC	SIZE	CMD		DATA		CHK
Value			C0	C1	D0	.	Dn
Length (byte)	4	2	2				2

**Figure 11**

**CMD:**

This code will specify the request/command sent by the host. When answering to a specific request/command, the communication frame sent from the laser scanner to the host will include the respective command in this code.

Size        2 bytes  
 Value      C0, C1; number acc. to the desired command  
 Structure  LSB first, MSB last

**DATA:**

Depending on the request/command, this code can contain different kind of information (MDI, settings, etc.). His length can also vary depending on the request/command. Sometimes it can even be empty.

Size        (depends on the request/command)  
               Each Dx is encoded in 1 or 2 bytes  
 Value      D0 to Dn; the exact value depends on the specific request/command (for detailed information see below)  
 Structure  LSB first, MSB last

**3.2.2.1 Select mode**

To switch from the "measure mode" to the "configuration mode" a specific character of 1 byte length has to be sent to the LZR (see also section 3.3 for further information):

Request:  
 0xA5  
Answer:  
**C0/C1:** 50002  
**D0:**

- 2 = configuration mode

To switch from the "configuration mode" to the "measure mode" use following command:

**SETRAWDATAMODE:**  
Request:  
**C0/C1:** 50001  
**D0 :**

- 1 = measure mode

Answer:  
**C0/C1:** 50002  
**D0:**

- 1 = measure mode

**3.2.2.2 Request for MDI**

There are two different kinds of requests for MDI: either a single shot measurement (only one single complete MDI package is sent) or continuous measurements. To activate the continuous measurement mode, you have to leave the configuration mode by using the command **SETRAWDATAMODE** (D0 = 1). Once this command has been sent the laser scanner will transmit continuously the MDI.

Whereas when the single shot measurement is chosen (see command **GETRAWDATADISTANCEVALUES**), only one complete MDI package will be sent. Afterwards the laser scanner will be again in configuration mode.

When using a 0° mirror, a complete MDI package corresponds to the measurements of one single mirror face. When using the Mirror 6°, a complete MDI package corresponds to the measurements of all 4 mirror faces.

**GETRAWDATADISTANCEVALUES**: get a single shot measurement

Request:

**CO/C1**: 50011

Answer (see also section MDI)

**CO/C1**: 50011

**D0->D5 (option)**: ID + Frame counter

**D6->D19 (option)**: CTN, VNR, Error log, Hot reset counter

**[D20 (option)]**: plane number

**D21->Dx]**: raw data

**Dx+1/Dx+2**: CHK

### 3.2.2.3 Set parameters

For a detailed description of the different parameters, please refer to the part 3 of this document.

**SETRAWDATACONFIG**: allows to set most of the laser scanner's configurable parameters

Request:

**CO/C1**: 50003

**D0**: Baud rate

- 0 = 57600
- 1 = 115200
- 2 = 230400
- 3 = 460800
- 4 = 921600

**D1**: 0

**D2**: Enable/disable LZR information (CTN, VNR, Error log, Hot reset counter)

- 0 = disable
- 1 = enable

**D3**: Red laser timeout (unit = 15 sec) [0-255]

- 0 = disable
- 1-255 = timeout

**D4**: Enable/disable test frame

- 0 = disable
- 1 = enable

**D5**: Enable/disable plane 0

- 0 = disable
- 1 = enable

**D6**: Enable/disable plane 1

- 0 = disable
- 1 = enable

**D7:** Enable/disable plane 2

- 0 = disable
- 1 = enable

**D8:** Enable/disable plane 3

- 0 = disable
- 1 = enable

**D9:** 0

**D10/D11:** Number of distance values [1-274]

**D12/D13:** Starting spot number [0-273]

**D14/D15:** Jump between 2 successive spots [0-273]

**D16:** Apd distance range

- 0 = 8 meters\*
- 1 = 12 meters\*
- 2 = 16 meters\*

\*Typical values

**D17:** Enable/disable transmission of the CAN ID and frame counter

- 0 = disable
- 1 = enable

**D18:** Enable/disable the diode lifetime management

- 0 = disable
- 1 = enable

**D19:** Polarity of the input 1

- 0 = high
- 1 = low

**D20:** Delay of 2 heartbeat messages (unit = 1 sec) [0-255]

**D21:** Enable/disable led 1

- 0 = disable
- 1 = enable

**D22:** Enable/disable led 2

- 0 = disable
- 1 = enable.

**D23:** Enable/disable led blue

- 0 = disable
- 1 = enable

**D24:** Enable/disable led error

- 0 = disable
- 1 = enable

**D25:** Duration of LEDs at boot-up [0-255]

- 0 = managed through input 2
- 1-254 = (unit = 1 sec)
- 255 = always on

**D26/27:** Maximum distance range [0-65000]\*

\*To improve immunity to fog, decrease the maximum distance range if possible.

**D28:** Enable/disable plan number inside the frame

- 0 = disable
- 1 = enable

**D29:** Immunity level [1-4]

**D30/31:** Hot reset timer (unit = 1 sec)

**D32:** Hot reset counter

- 0 = disable
- 1-255 = number of reset

Answer:

See answer

## GETRAWDATACONFIG

**SETRAWDATAERRORLOGRESET:** allows resetting the error logs and the hot reset counter

Request:

**CO/C1:** 50006

Answer:

**CO/C1:** 50006

**SETRAWDATAFRAMECOUNTERRESET:** allows resetting the frame counter

Request:

**CO/C1:** 50014

Answer:

**CO/C1:** 50014

### 3.2.2.4 Read-out parameters

For a detailed description of the different parameters, please refer to the part 3 of this document.

**GETRAWDATAMODE:** it informs in which communication mode the laser scanner is currently working, i.e. either "measuring" or "configuration". As the request can only be sent by the host while being in the "configuration" mode, the answer from the laser scanner to the request GETRAWDATAMODE will always be DO = 2

Request:

**CO/C1:** 50002

Answer:

**CO/C1:** 50002

**DO:**

- 1 = measuring mode
- 2 = configuration mode

**GETRAWDATACONFIG:** it provides the setting information about most of the laser scanner's configurable parameters

Request:

**CO/C1:** 50004

Answer:

**CO/C1:** 50004

**DO/D1/D2/D3:** status bits, i.e. if a bit is set (= 1) the value defined for the respective parameter is not valid

- Bit 0 = Baud rate
- Bit 1 = Interlaced mode
- Bit 2 = LZR infos
- Bit 3 = Red laser timeout
- Bit 4 = Enable/disable test frame
- Bit 5 = Enable/disable plane 0
- Bit 6 = Enable/disable plane 1
- Bit 7 = Enable/disable plane 2
- Bit 8 = Enable/disable plane 3
- Bit 9 = Enable/disable pulse width
- Bit 10 = Number of distance values
- Bit 11 = Starting spot number
- Bit 12 = Jump between 2 successive spots
- Bit 13 = Apd distance range
- Bit 14 = Enable/disable transmission of the can id + frame counter
- Bit 15 = Enable/disable the diode lifetime management



- *Bit 16 = Polarity of the input 1*
- *Bit 17 = Delay of 2 heartbeat messages*
- *Bit 18 = Enable/disable led 1*
- *Bit 19 = Enable/disable led 2*
- *Bit 20 = Enable/disable led blue*
- *Bit 21 = Enable/disable led error*
- *Bit 22 = Duration of LEDs at boot-up*
- *Bit 23 = Maximum distance range*
- *Bit 24 = Enable/disable faces information inside the frame*
- *Bit 25 = Enable/disable rain filter*
- *Bit 26 = Hot reset timer*
- *Bit 27 = Hot reset counter*
- *Bit 31 = communication charge*

**D4/D5:** *communication charge in %*

**D6:** *Baud rate*

- *0 = 57600*
- *1 = 115200*
- *2 = 230400*
- *3 = 460800*
- *4 = 921600*

**D7:** *0*

**D8:** *LZR information (CTN, VNR, Error log, Hot reset counter)*

- *0 = disabled*
- *1 = enabled*

**D9:** *Red laser timeout*

**D10:** *Enable/disable test frame*

- *0 = disabled*
- *1 = enabled*

**D11:** *Enable/disable plane 0*

- *0 = disabled*
- *1 = enabled*

**D12:** *Enable/disable plane 1*

- *0 = disabled*
- *1 = enabled*

**D13:** *Enable/disable plane 2*

- *0 = disabled*
- *1 = enabled*

**D14:** *Enable/disable plane 3*

- *0 = disabled*
- *1 = enabled*

**D15:** *Enable/disable pulse width*

- *0 = disabled*
- *1 = enabled*

**D16/D17:** *Number of distance values [1-274]*

**D18/D19:** *Starting spot number [0-273]*

**D20/D21:** *Jump between 2 successive spots [0-273]*

**D22:** *Apd distance range*

- *0 = 8 meters*
- *1 = 12 meters*
- *2 = 16 meters*

**D23:** *Enable/disable transmission of the can id and frame counter*

- *0 = disabled*
- *1 = enabled*

**D24:** *Enable/disable the diode lifetime management*

- *0 = disabled*

- 1 = enabled
- D25:** Polarity of the input 1
- 0 = high
  - 1 = low
- D26:** Delay of 2 heartbeat messages (unit = 1 sec) [0-255]
- D27:** Enable/disable led 1
- 0 = disabled
  - 1 = enabled
- D28:** Enable/disable led 2
- 0 = disabled
  - 1 = enabled.
- D29:** Enable/disable led blue
- 0 = disabled
  - 1 = enabled
- D30:** Enable/disable led error
- 0 = disabled
  - 1 = enabled
- D31:** Duration of LEDs at boot-up [0-255]
- 0 = managed through input 2
  - 1-254 = (unit = 1 sec)
  - 255 = always on
- D32/D33:** Maximum distance range [0-65000]
- D34:** Enable/disable plan number inside the frame
- 0 = disabled
  - 1 = enabled
- D35:** Immunity level [1-4]
- D36/37:** Hot reset timer (unit = 1 sec)
- D38:** Hot reset counter
- 0 = disable
  - 1-255 = number of reset

**GETRAWDATAINFORMATION:** it provides the error log as well as the CTN, VNR, CAN ID and the software version

Request:

**C0/C1:** 50008

Answer:

**C0/C1:** 50008

**D0:** error 1 (last error occurred)

**D1:** error 2

**D2:** error 3

**D3:** error 4

**D4:** error 5

**D5:** error 6

**D6:** error 7

**D7:** error 8

**D8:** error 9

**D9:** hot reset counter

**D10/D11:** CTN

**D12/D13:** VNR

**D14/D15/D16/D17:** CAN Id

**D18:** Software version

**GETRAWDATAREDLASER:** it informs if the three visible red LEDs are activated or deactivated

Request:

**CO/C1: 50010**

Answer:

**CO/C1: 50010**

**DO: status of the three visible red LEDs**

- 0 = Off
- 1 = On

**GETRAWDATAHEARTBEAT:** it informs if the heartbeat modus is active or not

Request:

**CO/C1: 50013**

Answer:

**CO/C1: 50013**

**DO: status of the heartbeat modus**

- 0 = Off
- 1 = On

### 3.2.2.5 Specific actions

**SETRAWDATACONFIGSTORE:** allows storing the last loaded parameter settings into the Eeprom. To get the laser scanner working with those new parameters stored in the Eeprom, you have to reboot (i.e. power off, power on) the laser scanner. Please note, that after having performed this command and as long as no reboot is performed, the laser scanner will be in a "seized" status

Request:

**CO/C1: 50005**

Answer:

**CO/C1: 50005**

**SETRAWDATACONFIGRESTORE:** allows restoring the factory settings of the laser scanner

Request:

**CO/C1: 50007**

Answer:

**CO/C1: 50007**

**SETRAWDATAREDLASER:** allows activating/deactivating the three visible red LEDs

Request:

**CO/C1: 50009**

**DO: status**

- 0 = off
- 1 = on

Answer:

**CO/C1: 50010**

**DO: status of the three visible red LEDs**

- 0 = Off
- 1 = On

**SETRAWDATAHEARTBEAT:** allows activating/deactivating the Heart Beat modus

Request:

**CO/C1: 50012**

**DO : status**

- 0 = off
- 1 = on

Answer:

**CO/C1: 50012**

**DO: status of the Heart Beat modus**

- 0 = Off
- 1 = On

The following is again a list of all commands/requests:

- **SETRAWDATAMODE**
- **SETRAWDATACONFIGSETRAWDATACONFIG**
- **SETRAWDATACONFIGSTORE**
- **SETRAWDATACONFIGRESTORE**
- **SETRAWDATAERRORLOGRESET**
- **SETRAWDATAFRAMECOUNTERRESET**
- **SETRAWDATAREDLASER**
- **SETRAWDATAHEARTBEAT**
  
- **GETRAWDATAMODE**
- **GETRAWDATADISTANCEVALUES**
- **GETRAWDATACONFIG**
- **GETRAWDATAINFORMATION**
- **GETRAWDATAREDLASER**
- **GETRAWDATAHEARTBEAT**

### 3.3. How to establish the communication?

#### 3.3.1 General description

When coming out of factory the laser scanner is automatically in the so-called “measuring” mode, i.e. after power-on and as soon as the first complete MDI package is available, the laser scanner will start to provide MDI packages. The laser always works in “transmission” mode. Therefore, the host should be working in “reception” mode.

In order to enter into “active” communication with the laser scanner and to transmit any request/command or information to the laser scanner, the host should put the laser scanner in the “configuration” mode by use of the specific character **0xA5**. In order to assure that the laser scanner can capture this specific character below timing diagram (see figure 12) should be respected. If this is not the case, the laser scanner will not be able to capture the character 0xA5 and will continue to send MDI packages.

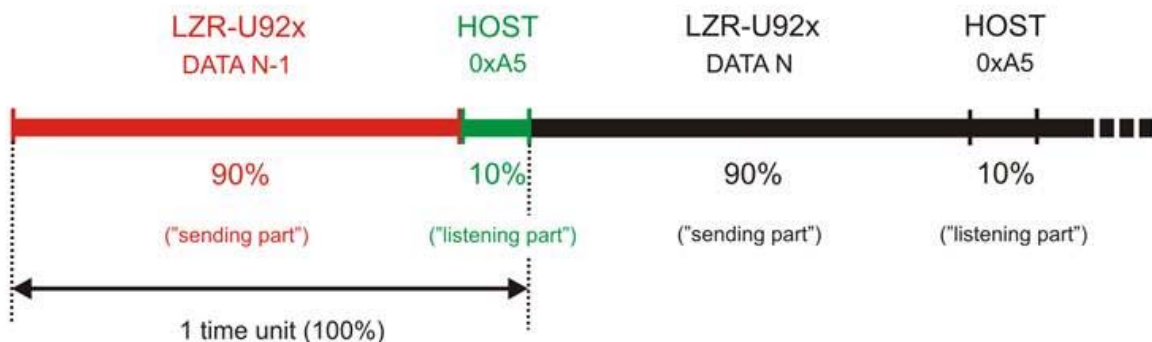


Figure 12: Timing Diagram

It can easily be determined if the specific character has been captured or not by the laser scanner, by checking the data package sent by the latter one following the sending of the character 0xA5 by the host. If the package sent by the laser scanner does not correspond to the command **GETRAWDATAMODE** with D0 = 2, then the laser scanner did not capture the character 0xA5 and is still in the “measure” mode (the code “CMD” will be set at 5011).

Therefore, if it cannot be assured that the timing diagram is respected, it could be necessary to send the character **0xA5** several times before it's really captured by the laser scanner and acknowledged by the latter one through sending the command **GETRAWDATAMODE** with D0 = 2. Once the laser scanner is in the configuration mode, the host can send further commands or requests to the LZR.

In order to come back to the measuring mode so that the LZR transmits again MDI packages, either put the LZR back into the measuring mode by use of the command **SETRAWDATAMODE** or send a request for a single shot measurement (command **GETRAWDATADISTANCEVALUES**). After a request for single shot measurement, the LZR will be again in the configuration mode.

In order to be able to set the configurable parameters of the LZR or to perform a read-out of the LZR's settings, you have to be in the configuration mode.

Below is an example of a "dialogue" between a laser scanner and a host. The graph (figure 13) shows some example of requests/commands/specific actions sent by the host and the corresponding answer of the laser scanner.

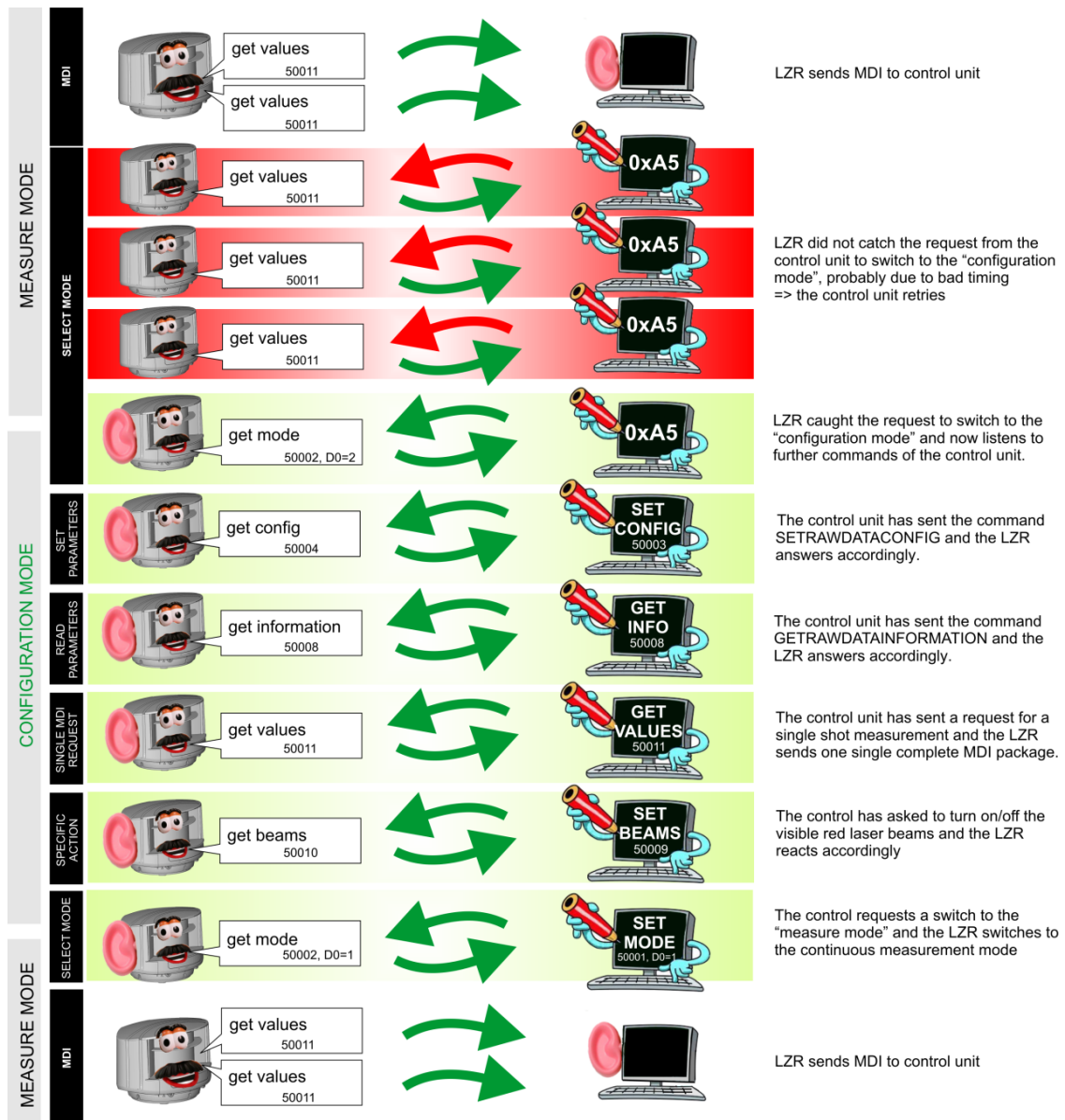


Figure 13

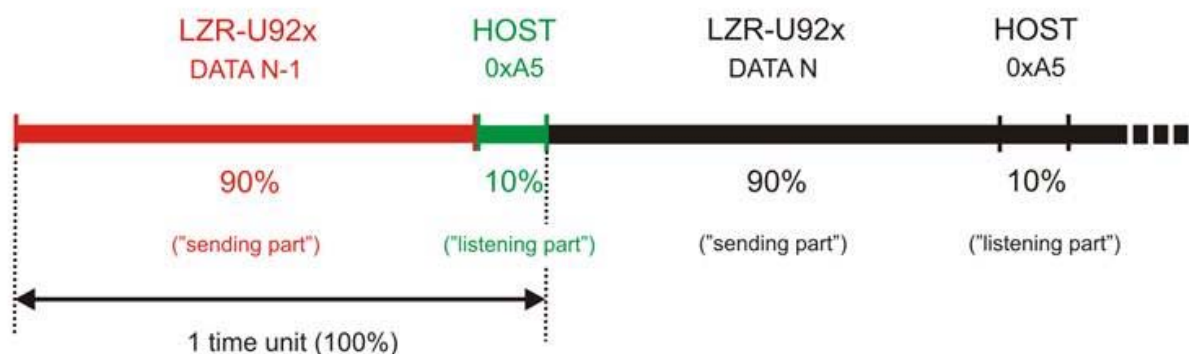
When you change settings of the LZR by use of the command **SETRAWDATACONFIG**, those changes are only stored in the RAM memory of the LZR, i.e. they are only valid until the next power-off of the LZR and will be lost afterwards. Once the laser scanner has been powered off, the settings are not active anymore. To get those changes validated and definitively stored into the Eeprom of the LZR (i.e. to get them stored into the LZR), you have to perform the command **SETRAWDATACONFIGSTORE** followed by a reboot of the laser scanner. As long as no reboot is done (after sending the command **SETRAWDATACONFIGSTORE**), the laser scanner will be in a "seized" status.

### 3.3.2 Timing diagram

This section provides some additional information about the timing diagram.

The detailed timing diagram depends on the mirror used. Therefore, timings are different between the mirror 0° and the mirror 6°. However, the principles are the same.

Assume that we are using the mirror 6°. As this mirror rotates with 900rpm, one complete rotation takes of about 67m (= 1 time unit = 100%). The complete MDI data package of rotation N-1 has to be sent while the next rotation (N) is going on, i.e. during the next time unit/during the next 67ms. In order to assure, that the laser scanner has the possibility, i.e. the time, to capture the request from the host to switch to the "configuration" mode (sending of the character 0xA5), the MDI packages are always sent – at the latest - during the first 90% ("sending part") of the time unit of 67ms, i.e. during the first 60ms. The last 10% ("listening part"), i.e. 7ms, can be used by the host to send the character 0xA5 to the laser scanner.



This is the worst case, i.e. if the maximum data charge is chosen and therefore if the maximum "sending part" is used. When reducing the amount of MDI data to be sent (by changing the parameters "starting spot number", "number of distance values" and "gap between two successive spots"), the "sending part" can be decreased and the "listening part" can be increased.

When using the mirror 0°, the time unit is not 67ms but 16ms; the percentages stay the same.

## 4. Parameters (part 3)

In this part you can find additional information related to some of the configurable parameters.

## 4.1. Baud rate

The user has the choice between 5 different baud rates: 57.6kbps, 115.2kbps, 230.4kbps, 460.8kbps and 921.6kbps.

The choice of the baud rate has a direct impact on the timing diagram as well as on the maximum number of data measurements (which is defined through the parameters "Starting spot number", "Number of distance values" and "Gap between two successive spots") which can be transmitted by the laser scanner.

The following table summarizes the communication bus charge for the different baud rates if all data measurements should be transmitted.

Baud rate [bps]	Communication bus charge [%]
57600	573
115200	286
230400	143
460800	72
921600	36

**Table 4**

This table shows that the total number of data measurements can only be transmitted while using a baud rate of 460800 or 921600. When using the other baud rates, the number of data measurements has to be reduced.

The same table also shows that while using a baud rate of 921600, 36% of the time unit are used to transmit data. During the rest, i.e. 64%, the host can try to enter into communication with the laser scanner by sending the special character Ax05.

## 4.2. Starting spot number, Number of distance values, Gap between two successive spots

The three parameters "Starting spot number", "Number of distance values" and "Gap between successive spots" allow to define the set of data measurements (MDI) for one plane which will be transmitted via the communication frame. In fact, the set of data measurements is determined by defining the first measurement point (Starting spot number), the angular resolution between two successive measurement points (Gap between successive spots) and the number of measurement points (counted from the starting point on; Number of distance values).

The set of data measurements defined by those 3 parameters is valid for all four planes.

Following one example:

Assume that you would like to use the full angular range ( $-48^\circ$  to  $+48^\circ$ ) with an angular resolution of  $3,5^\circ$  instead of  $0,35^\circ$ ; i.e. only each 10<sup>th</sup> spot should be considered and transmitted via the communication frame.

In order to reduce the MDI to this set of measurement data the 3 parameters should be set as follows:

- Starting spot number: 0 (which corresponds to the angular position of  $-48^\circ$ , see Figure 3

- Gap between successive spots: 10 (as only each 10<sup>th</sup> measurement data, i.e. each 10<sup>th</sup> spot, should be considered)
- Number of distance values: 27 (as in total we have maximum 274 measurement points per plane, if only each 10<sup>th</sup> point is taken into account this means  $274/10=27,4$ , thus 27 measurement points)

### 4.3. Error Log

The Error Log provides the last 9 errors which occurred in the laser scanner. The stack (log file) of errors is handled according the FIFO principle (First In, First Out), i.e. once the stack (log file) is full, the latest error will be deleted of the log and be replaced by newest error information.

The following table summarizes the different types of errors communicated by the laser scanner.

Error number	Type	Description proposal
4	Environmental Error	Motor cannot start at power-on
8		Bad Motor speed
9		The motor has been blocked
18		Internal temperature out of permitted range
1	Internal Error	If the problem persists and blocks the LZR, please contact BEA
2		
3		
5		
6		
7		
10		
11		
12		
13		
14		
15		
16		
17		
19		
20		
21		
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33		
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41		
42		

#### 4.4. Heartbeat mode (Standby mode)

The infrared laser diode, that is pulsed in the distance measurement process, can be switched ON/OFF either by using an external input signal (via Pin 6 & Pin 7; see UG) or by using the command **SETRAWDATAHEARTBEAT**.

Distance data frames are only sent on serial link when the infrared laser diode is pulsing.

When the infrared laser diode is switched OFF, no data is available, so no data frame is sent. In this standby mode, a "heartbeat" message is sent on the serial link informing the host system monitoring that the LZR is still alive but idle.

The "heartbeat" message follows the same structure as the data frame but with all data values set to 0.

	Header		Message				Footer
Code	SYNC	SIZE	CMD	ID + Frame counter	CTN + VNR + Error log + Hot reset counter	Plane Number & MDI	CHK
Value	0xFFFE FD FC		50011			0	
				Option	Option	Option	

The repeat rate of the "heartbeat" transmission is per default 5 seconds, but can be adapted by using the command **SETRAWDATACONFIG (value D20)**.

When using the external input signal (Pin 6 & Pin 7), the input signal is de-bounced in a way that a pulse signal shorter than 100ms will not change the state of the laser diode.

The polarity of the input can be defined by the command **SETRAWDATACONFIG (D19)**.

The logical levels are assigned as follows:

- Logical Low Level: < 3V
- Logical High Level: 10 – 35V

In order to activate the heartbeat mode (i.e. to switch off the infrared laser diode) the dedicated voltage signal (defined by the polarity of the input) should be applied.

## 5. LZR-U92x family (part 4)

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The following table provides an overview of the LZR-U92x family and the main characteristics.

Parameter	U920	U921
Drum	6°	0°
Data sent after	1 complete rotation	each mirror face
Frequency	15 Hz	60 Hz