Ethernet data protocol

LD-MRS

Table of Content

1 Introduction

This document describes how data is received and transmitted from repectively to the LD-MRS via the Ethernet connection.
Adressed systems are LD-MRS 400001 and LD-MRS 400102 sensors or applications using the current API/software versions (e.g. LD-MRS View).

2 General information

2.1 Ethernet configuration

The LD-MRS uses default ethernet configurations until changed by the user.

LD-MRS use the default IP address 192.168.0.1
with the subnet mask 255.255.255.0.
The default port is 12002.

2.2 Data encoding

Attention! See the data type description if little or big endian byte order is used!

NTP64 timestamps represent the time encoded in 8 bytes. In order to decode NTP64 timestamps, the corresponding 8 bytes need to be interpreted as UINT64 to ensure correct data encoding.
The higher 4 bytes are the number of seconds since 1.1.1900 - 0:00:00. The lower 4 bytes represent the fractional seconds with a resolution of 2^{-32} s. These 2 values must be interpreted as UINT32.

2.3 Data header

Each message always starts with a data header. To resync just search for the magic word (0xAFFEC0C2).
The data header is encoded in network byte order / big endian format.

Bytes	Offset	Data header:	datatype	Description
4	0	Magic word (0xAFFEC0C2)	UINT32	The magic word is used for searching Ibeo messages and to distinguish between different versions.
4	4	Size of previous messages	UINT32	Helps to navigate backwards through a file. Unused in live data.
4	8	Size of this message	UINT32	Helps to read the message data. Size of message content without this header.
1	12	Reserved	UINT8	-
1	13	DeviceID	UINT8	ID of the connected device. Unused in data received directly from LD-MRS sensors.
2	14	Data type	UINT16	Specifies the data type within this message.
8	16	NTP time	NTP64	Time when this message was created.
	24	Message data	-	Depending on data type.

3 LD-MRS scan data: Data type 0x2202

Scan data available from LD-MRS. Each scan data block starts with a header followed by the scan point list.
The data is encoded in little endian format!

For angle information the unit angle ticks is used. A LD-MRS uses 11520 ticks per rotation (see also Angle ticks per rotation below). Thus the angular resolution is 1/32°. This value is needed to convert angle ticks:

$$\text{angle} = 2\pi \frac{\text{angle ticks}}{\text{angle ticks per rotation}}$$

Angles are given in the ISO 8855 / DIN 70000 scanner coordinate system.

Bytes	Offset	Scan header	Data type	Description
2	0	Scan number	UINT16	The number of this scan. The number will be increased from scan to scan.
2	2	Scanner status	bit field 16 bits	0x0007: reserved 0x0008: set frequency reached 0x0010: external sync signal detected 0x0020: sync ok 0x0040: sync master (instead of slave) 0xFF80: reserved
2	4	Sync phase offset	UINT16	Phase difference (conversion factor 409.6 ns) between sync signal and scanner mirror crossing the synchronization angle.
8	6	Scan start time NTP	NTP64	NTP time when the first/last measurement was done.
8	14	Scan end time NTP	NTP64	
2	22	Angle ticks per rotation	UINT16	Number of angle ticks per rotation.
2	24	Start angle	INT16	Start/end angle in angle ticks of this scan.
2	26	End angle	INT16	
2	28	Scan points	UINT16	Number of scan point transmitted in this scan.
2	30	Reserved	INT16	
2	32	Reserved	INT16	
2	34	Reserved	INT16	
2	36	Reserved	INT16	-
2	38	Reserved	INT16	
2	40	Reserved	INT16	
2	42	Reserved	UINT16	-
	44	Scan Point List	Scan Point	Array of scan points. See number of scan points above and point information below.

Bytes	Offset	Scan point:	datatype	Description
1	0	Layer	UINT4	Scan layer of this point (zero-based).
		Echo	UINT4	Echo number of this point (zero-based).
1	1	Flags	Bit field 8 bits	0x01: transparent point 0x02: clutter (atmospheric) 0x08: dirt 0xF: reserved
2	2	Horizontal angle	INT16	Angle of this point in angle ticks in the scanner coordinate system
2	4	Radial distance	UINT16	Distance of this point in the scanner coordinate system in cm
2	6	Echo pulse width	UINT16	Detected width of this echo pulse in cm
2	8	Reserved	UINT16	-
	10			

4 LD-MRS errors and warnings - Data type 0x2030

As soon as a LD-MRSdetects an error or wants to emit a warning, this message is sent.
Errors and warning bits are reset after sending this message.
This message will be sent periodically as long as errors of warnings persist.
The data is encoded in little endian format!

Bytes	Offset	LD-MRS error/warning registers:	datatype	Description
2	0	Error register 1	bit field 16 bits	See below
2	2	Error register 2	bit field 16 bits	
2	4	Warning register 1	bit field 16 bits	
2	6	Warning register 2	bit field 16 bits	
2	8	reserved	bit field 16 bits	
2	10	reserved	bit field 16 bits	
2	12	reserved	bit field 16 bits	
2	14	reserved	bit field 16 bits	

4.1 Error register 1

Bytes	Comment
Bit 0-1	Contact support
Bit 2	scan buffer transmitted incompletely, decrease scan resolution/frequency/range; contact support
Bit 3	Scan buffer overflow , decrease scan resolution/frequency/range; contact support
Bit 4-13	Contact support
Bit 5-7	reserved
Bit 8-9	Bit 9: APD Over Temperature, provide cooling Bit 8: APD Under Temperature, provide heating Bit 8 and 9: APD Temperature Sensor defect, contact support
Bit 14-15	Reserved

4.2 Error register 2

Bytes	Comment
Bit 0-3	Contact support
Bit 4	Incorrect configuration data, load correct configuration values
Bit 5	Configuration contains incorrect parameters, load correct configuration values
Bit 6	Data processing timeout, decrease scan resolution or scan frequency
Bit 7	Contact support
Bit 8-15	Reserved

4.3 Warning register 1

Bytes	Comment
Bit 0	Internal communication error
Bit 1-2	Internal warning
Bit 3	Warning temperature very low
Bit 4	Warning: temperature very high
Bit 5-6	Internal warning
Bit 7	Synchronization errer, check syncronization- and scan frequency
Bit 8-15	Reserved

4.4 Warning register 2

Bytes	Comment
Bit 0	Reserved
Bit 1	Ethernet Interface blocked, check Ethernet connection
Bit 2	Reserved
Bit 3	Contact support
Bit 4	Error receiving Ethernet data, check Ethernet connection/data
Bit5	Incorrect or forbidden command received, check command
Bit 6	Memory access failure, restart LD-MRS, contact support
Bit 7-15	Reserved

5 LD-MRS command interface

For sending commands to the LD-MRS the data type 0x2010 is used. The data is encoded in little endian format!

Bytes	Offset	LD-MRS command	datatype	Description
2	0	Command ID	UINT16	See detailed list of commands and according options/parameters.
2	2	Reserved	UINT16	Unused, but these 2 bytes must be sent for all commands.
	4	Command Data	-	Depending on command. May be completely missing for some commands.

The LD-MRS replies to a command with a dedicated reply message. The datatype is 0x2020. The data is encoded in little endian format!

Bytes	Offset	LD-MRS reply	Content type	Description
2	0	Reply ID	UINT16	If a command succeeded, the reply ID is equal to the corresponding command ID. If a command failed, the reply ID is the command ID + 0x8000. Thus, the most significant bit indicates a failed command.
	2	Reply data	-	Depending on the corresponding command this reply is related to. May be completely missing for some commands and if a command failed. See detailed command description below.

5.1 LD-MRS commands and command replies – data types 0x2010/ 0x2020

5.1.1 Reset

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0000	UINT16	ID - Reset DSP
2	2	Reserved0	UINT16	-

In case of command Reset no reply is sent.

5.1.2 Get Status

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0001	UINT16	ID - Status request
2	2	Reserved0	UINT16	-

Bytes	Offset	LD-MRS reply	Content type	Description
2	0	0x0001	UINT16	ID - Status request
2	2	Firmware version	UINT16	e. g. 0x1230 = version 1.2.3, 0x123B = version 1.2.3b
2	4	FPGA version	UINT16	e. g. 0x1230 = version 1.2.3, 0x123B = version 1.2.3b
2	6	Scanner status	UINT16	Bit field, with the following meaning for every bit: Bit 15 ...6: reserved / internal Bit 5: phase locked Bit 4: external sync signal available Bit 3: frequency locked Bit 2: reserved / internal Bit 1: laser on Bit 0: motor on
4	8		UINT32	reserved / internal
2	12	temperature	UINT16	T[°C] = - (temperature - 579.2364) / 3.63
2	14	serial number 0	UINT16	YYCW (z. B. YYCW = 0x0740 = year '07, calendar week 40)
2	16	serial number 1	UINT16	Counter of serial number
2	18		UINT16	reserved / internal
6	20	FPGA time stamp	[3] * UINT16	YYYY MMDD hhmm (FPGA version state)
6	26	DSP time stamp	[3] * UINT16	YYYY MMDD hhmm (Firmware version state)

5.1.3 SaveConfig

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0004	UINT16	Current sensor configuration will be saved permanently. Multiple SetParameter commands may be sent before saving the changes permanently.
2	2	Reserved	UINT16	-

The command SaveConfig will be acknowledged by the same command ID without command reply data.

5.1.4 Set Parameter

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0010	UINT16	Set a single Parameter by its index to the sensor memory. Parameter is set only temporarily until a SaveConfig command (see 5.1.3) is sent.
2	2	Reserved	UINT16	-
2	4	Parameter index	UINT16	Refer to LD-MRS parameter list (see 5.2).
4	6	Parameter	UINT32	Set parameter accordingly to parameter list. If e.g. a 2 byte value is set, use the first 2 bytes. Fill the remaining 2 bytes with 0.

The command Set Parameter will be acknowledged by the same command ID without any command reply data.

5.1.5 Get Parameter

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0011	UINT16	ID - Read a single Parameter with its index from the LD-MRS.
2	2	Reserved	UINT16	-
2	4	Parameter index	UINT16	Refer to LD-MRS parameter list (see 5.2).

Bytes	Offset	LD-MRS reply	Content type	Description
2	0	0x0011	UINT16	ID - Read a single Parameter by its index from the LD-MRS.
2	2	Parameter index	UINT16	Refer to LD-MRS parameter list (see 5.2).

4	4	Parameter	UINT32	

5.1.6 Reset Default Parameters

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x001A	UINT16	ID - Resets all parameters to the factory defaults.
2	2	Reserved	UINT16	-

The command Reset Default Parameters will be acknowledged by the same command ID without any command reply data.

5.1.7 Start Measure

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0020	UINT16	ID - Starts the measurement with the current settings.
2	2	Reserved0	UINT16	-

The command Start Measure will be acknowledged by the same command ID without any command reply data.

5.1.8 Stop Measure

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0021	UINT16	ID - Stops the measurement.
2	2	Reserved	UINT16	-

The command Stop Measure will be acknowledged by the same command ID without any command reply data.

5.1.9 SetNTPTimestampSec

Bytes	Offset	LD-MRS command:	datatype	Description
2	0	0x0030	UINT16	ID - sets the second of NTPtimestamp.
4	2	Reserved	UINT32	-
4	6	Timestamp	UINT32	Seconds (NTP format). The time will be set in the sensor when the fractional seconds command is received (see below).

The command SetNTPTimestampSec will be acknowledged by the same command ID without any command reply data. Timestamp will be used when the SetNTPTimestampFracSec command is received (see below).

5.1.10 SetNTPTimestampFracSec

Attention: Before this command can be executed, first command "SetNTPTimestampSec" (0x0030) must be sent (see 5.1.9)!

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0031	UINT16	ID - sets the fractional second of NTPtimestamp.
4	2	Reserved	UINT32	-
6	6	Timestamp	UINT32	Fractional seconds (NTP format).

The command SetNTPTimestampFracSec will be acknowledged by the same command ID without any command reply data.

5.2 LD-MRS parameter list

This table gives an overview of available LD-MRS parameters. Please refer to 5.1.4 and 5.1.5 for details on getting and setting these parameters.

IP address, subnet mask and standard gateway encode the data as UINT32 value which is built like that: aa.bb.cc.dd = 0xaabbccdd. Due to little endian byte order this value must be sent as 0xddccbbaa.

Bytes	Parameter index	LD-MRS parameter	datatype	Description
4	0x1000	IP address	UINT32	Valid: all
2	0x1001	TCP Port	UINT32	Valid: all
4	0x1002	Subnet Mask	UINT32	Valid: all
4	0x1003	Standard gateway	UINT32	Valid: all
2	0x1012	Data Output Flag	16 bit field	Bit true: disable output, false: enable output. 0xFFFF is invalid. bit0: ETH scan data bit1: reserved bit2: reserved bit3: reserved bit4: ETH errors/warnings bit5: reserved bit6: reserved bit7...15: reservedl
2	0x1100	Start angle	INT16	In 1/32°, in the sensor coordinate system. Valid: 1600…-1919. Start angle > end angle!

Bytes	Parameter index	LD-MRS parameter	datatype	Description
2	0x1101	End angle	INT16	In 1/32°, in the sensor coordinate system. Valid: 1599…-1920. Start angle > end angle!
2	0x1102	Scan frequency	UINT16	In 1/256 Hz. Valid: 3200 (12.5 Hz) 6400 (25.0 Hz) 12800 (50.0 Hz)
2	0x1103	Sync angle offset	INT14 (!) (16 bits transferred)	In 1/32° in the sensor coordinate system. Valid: -5760…+5759 (-180°…+180°). Bits 14 and 15 are ignored!
2	0x1104	angular resolution type	UINT16	0: focused 1: constant 2: reserved
2	0x1105	angleTicksPerRotation	UINT16	11520 (read only), constant for LD-MRS

5.3 Example

This example shows how to set the IP address via Ethernet to 10.152.36.200.

Bytes	Offset	Data header - Big endian byte order!	Data type	Content
4	0	Magic word	UINT32	0xAFFEC0C2
4	4	Size of previous message	UINT32	Not mandatory. Set e.g. to 0: 0x00000000
4	8	Size of this message	UINT32	0x000000XX
1	12	Reserved	UINT8	0x00
1	13	Device ID	UINT8	Not mandatory. Set e.g. to 7: 0x07
2	14	Data type: LD-MRS command	UINT16	0x2010
8	16	NTP timestamp	UINT64	Not mandatory. Set e.g. to 0: 0x0000000000000000
Bytes	Offset	Message data - Little endian byte order!	Data type	Content
2	24	Command ID: Set parameter	UINT16	0x0010 (send encoded as 0x1000)
2	26	Reserved	UINT16	0x0000
2	28	Parameter index: IP address	UINT16	0x1000 (send encoded as 0x0010)
4	30	Parameter data (here: 10.152.36.200)	UINT32	0x0A9824C8 (send encoded as 0xC824980A)
	34			

Take care: IP address changes will be effective after the next sensor restart (DSP reset or power cycle). Nevertheless the change can be seen e.g. in LD-MRS View in the device configuration dialog immediately.

Ibeo API scan data - Data type 0x2204

Scan data available from Ibeo API. Each scan data block starts with a header followed by the scanner info list and the scan point list.
Each scan point has a device ID which refers to a sensor in the sensor info list.
The data is encoded in network byte order / big endian format.

Bytes	Offset	Scan header	datatype	Description
8	0	Scan start time	NTP64	NTP time when the first measurement was done.
4	8	Scan end time offset	UINT32	Time difference between last and first measurement in us.
4	12	Flags	Bit field: 32 bits	Bit 0: reserved Bit 1: dirt labeled Bit 2: rain labeled Bits 3…11: reserved reserved

2	16	Scan number	UINT16	The number of this scan. The number will be increased from scan to scan. Overflow occurs after 2^{16} scans.
2	18	Scan points	UINT16	Number of scan points transmitted in this scan.
1	20	Number of scanner infos	UINT8	Number of scanner infos transmitted in this scan.
3	21	Reserved	3 bytes	-
	24	Scanner info list	Scanner info	Array of scanner infos. See number of scanner infos above and scanner info below.
	24 + scanner infos * 40	Scan point List	Scan point	Array of scan points. See number of scan points above and point information below.
	24 + scanner infos * 40 + scan points * 28			

Bytes	Offset	Scanner info	datatype	Description
1	0	Device ID	UINT8	Device ID of this scanner.
1	1	Scanner type	UINT8	6 = LD-MRS
2	2	Scan number	UINT16	The scan number coming from the scanner device. The number will be increased from scan to scan. Overflow occurs after 2^{16} scans.
4	4	Reserved	4 bytes	-
4	8	Start angle	FLOAT32	Field of view of this scanner given in its local coordinate system. In radians normalized to [–π, +π[.
4	12	End angle	FLOAT32	
4	16	reserved	UINT32	
4	20	reserved	UINT32	
4	24	reserved	UINT32	
4	28	reserved	UINT32	
4	32	reserved	UINT32	
4	36	reserved	UINT32	
	40			

Bytes	Offset	Scan point	datatype	Description
4	0	X position	FLOAT32	X position of this scan point in m.
4	4	Y position	FLOAT32	Y position of this scan point in m.
4	8	Z position	FLOAT32	Z position of this scan point in m.
4	12	Echo width	FLOAT32	Echo width of this scan point in m.
1	16	Device ID	UINT8	ID of the device measuring this point.
1	17	Layer	UINT8	Scan layer of this point (zero-based).
1	18	Echo	UINT8	Echo number of this point (zero-based).
1	19	Reserved	1 byte	-
4	20	Timestamp (µs)	UINT32	Time offset in µs when this scan point was measured based on the scan start time.
2	24	Flags	Bit field: 16 bits	0x0001: reserved 0x0002: dirt 0x0004: rain/snow/spray/fog/… 0xFFF8: reserved
2	26	Reserved	2 bytes	-
	28			