Ethernet data protocol

LD-MRS400001
LD-MRS400102
LD-MRS400001S01
LD-MRS400102S01

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.

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 255.0.0.0.
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:
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.

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 the 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:	datatype	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 in angle ticks 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	Mounting position yaw angle	INT16	Rotation of the scanner around the axes of the reference coordinate system. All angles are given in angle ticks. Order of translation and rotation is essential: Yaw->Pitch->Roll->Translation. Scan data is given in the scanner coordinate system without any transformation. Mounting position of the
2	32	Mounting position pitch angle	INT16	
2	34	Mounting position roll angle	INT16	
2	36	Mounting position x	INT16	
2	38	Mounting position y	INT16	
2	40	Mounting position z	INT16	

				scanner relative to the reference coordinate system (ISO 8855 / DIN 70000 coordinate system). The origin is located on flat ground under the center of the rear axle. X-axis faces to the vehicle front resp. straight driving direction. Y-axis faces left. The mounting position is needed for ego motion compensation (only available if scanner x-y-plane is almost parallel to the ground). All coordinates are given in centimeters. Order of translation and rotation is essential (Rotation -> Translation). The mounting position is used for ego motion compensation, not to transform scan data but is available for further processing steps.
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 0xF0: 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 object data: Data type 0x2221

Object data available from LD-MRS4xxxxx.S01
Each data block starts with a header followed by the object list. Each object has a list of contour points.
The data is encoded in little endian format!

Bytes	Offset	Object header:	datatype	Description
8	0	Scan start timestamp	NTP64	Time stamp of the first measurement of the scan these objects are updated with.
2	8	Number of objects	UINT16	The number of objects transmitted in this message.
	10	List of objects	Object	Array of objects.

Bytes	Offset	Object: content	datatype	Description
2	0	Object ID	UINT16	ID of this object from tracking.
2	2	Object age	UINT16	Number of scans this object has been tracked for.
2	4	Object prediction age	UINT16	Number of scans this object has currently been predicted for without measurement update. Set to 0 as soon as a measurement update is available.
2	6	Relative timestamp	UINT16	Timestamp of this object relative to the scan start time in ms. The time is based on the object reference point.
4	8	Reference point	Point2D	Depending on tracking this is the tracked object reference point (e.g. center of gravity) in cm. See below for Point2D.
4	12	Reference point sigma	Point2D	Standard deviation of the estimated reference point position in cm.
4	16	Closest point	Point2D	Unfiltered position of the closest object point in cm.
4	20	Bounding box center	Point2D	Center and size in cm of a rectangle in the reference coordinate system containing all object points. See below for Size2D.
4	24	Bounding box size	Size2D	
4	28	Object box center	Point2D	Box center in the reference coordinate system in cm.
4	32	Object box size	Size2D	

2	36	Object box orientation	INT16	Box size in cm and orientation in 1/32° in the object coordinate system (box rotated in the direction of the velocity vector; in reference coordinate system).
4	38	Absolute velocity	Point2D	Velocity of this object in cm/s with ego motion taken into account. This velocity is based on the reference coordinate system which is compensated by the ego motion. Value set to 0x8000 if invalid.
4	42	Absolute velocity sigma	Size2D	Standard deviation of the estimated absolute velocity in cm/s.
4	46	Relative velocity	Point2D	Velocity of this object in cm/s without ego motion compensation (sensor/vehicle is seen as stationary).
2	50	Reserved	UINT16	reserved
2	52	Reserved	UINT16	reserved
2	54	Reserved	UINT16	reserved
2	56	Number of contour points	UINT16	The number of objects transmitted in this message.
	58	List of contour points	Point2D	Array of contour points in cm.

Bytes	Offset	Point2D:	datatype	Description
2	0	Position x	INT16	X-part/coordinate of this value/point.
2	2	Position y	INT16	Y-part/coordinate of this value/point.
	4			

Bytes	Offset	Size2D	datatype	Description
2	0	Size x	UINT16	X-value/size/width.
2	2	Size y	UINT16	Y-value/size/length.
	4			

5 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	

5.1 Error register 1

Bytes	Comment
Bit 0	contact support
Bit 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	contact support
Bit 5	
Bit 6	
Bit 7	
Bit8…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 10	contact support
Bit 11	contact support

Bit 12	contact support
Bit 13	contact support
Bit 14-15	Reserved

5.2 Error register 2

Bytes	Comment
Bit 0	contact support
Bit 1	contact support
Bit 2	contact support
Bit 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
Bit8…15	reserved

5.3 Warning register 1

Bytes	Comment
Bit0	
Bit1	
Bit2	
Bit3	warning of insufficient temperature
Bit4	warning of exceeding temperature
Bit5	
Bit6	
Bit 7	check syncronisation- and scan frequency
Bit7…15	reserved

5.4 Warning register 2

Bytes	Comment
Bit0	
Bit1	Ethernet Interface blocked, check Ethernet connection
Bit2	
Bit3	contact support
Bit4	check Ethernet data
Bit5	incorrect or forbidden command received, check command
Bit6	memory access failure, restart LD-MRS, contact support
Bit7	
Bit8	
Bit9	
Bit10	
Bit11…15	reserved

6 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 used used 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.

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

6.1.1 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.

6.1.2 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	4	Firmware version	UINT16	e. g. 0x1230 = version 1.2.3, 0x123B = version 1.2.3b
2	6	FPGA version	UINT16	e. g. 0x1230 = version 1.2.3, 0x123B = version 1.2.3b
2	8	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	12		UINT32	reserved / internal
2	14	temperature	UINT16	T[°C] = - (temperature - 579.2364) / 3.63
2	16	serial number 0	UINT16	YYCW (z. B. YYCW = 0x0740 = year '07, calendar week 40)
2	18	serial number 1	UINT16	Counter of serial number
2	20		UINT16	reserved / internal
6	26	FPGA time stamp	[3] * UINT16	YYYY MMDD hhmm (FPGA version state)
6	28	DSP time stamp	[3] * UINT16	YYYY MMDD hhmm (Firmware version state)

6.1.3 SaveConfig

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0004	UINT16	ID - Current sensor configuration will be saved permanently. Multiple SetParameter commands may be sent before saving the changes permanently.
2	2	Reserved0	UINT16	-

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

6.1.4 Set Parameter

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0010	UINT16	ID - Set a single Parameter by its index to the sensor memory. Parameter is set only temporarily until a SaveConfig command (see 6.1.3) is sent.
2	2	Reserved0	UINT16	-
2	4	Parameter index	UINT16	Refer to LD-MRS parameter list (see 6.2).
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.

6.1.5 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	Reserved0	UINT16	-
2	4	Parameter index	UINT16	Refer to LD-MRS parameter list (see 6.2).

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 6.2).
4	4	Parameter	UINT32	

6.1.6 Reset Default Parameters

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x001A	UINT16	ID - Resets all parameters to the factory defaults.
2	2	Reserved0	UINT16	-

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

6.1.7 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.

6.1.8 Stop Measure

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0021	UINT16	ID - Stops the measurement.
2	2	Reserved0	UINT16	-

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

6.1.9 SetNTPTimestampSec

Bytes	Offset	LD-MRS command:	datatype	Description
2	0	0x0030	UINT16	ID - sets the second of NTPtimestamp.
2	2	Reserved0	UINT16	-
4	4	Timestamp	UINT32	Seconds (NTP format). The time will be set in the sensor when the fractional seconds command is received (see 0).

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

6.1.10 SetNTPTimestampFracSec

Attention: Before this command can be executed, first command "SetNTPTimestampSec" (0x0030) must be sent (see 6.1.9)!

Bytes	Offset	LD-MRS command	datatype	Description
2	0	0x0031	UINT16	ID - sets the fractional second of NTPtimestamp.
2	2	Reserved0	UINT16	-
4	4	Timestamp	UINT32	Fractional seconds (NTP format).

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

6.2 LD-MRS parameter list

This table gives an overview of available LD-MRS parameters. Please refer to 6.1.4 and 6.1.5 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
4	0x1010	CAN Base ID	UINT32	Valid: value <= 0x7F0
2	0x1011	CAN Baud Rate	UINT16	in kBaud - next matching value (1000 kBaud, 500 kBaud, 250 kBaud, 125 kBaud) will be used.

Bytes	Parameter index	LD-MRS parameter	datatype	Description
2	0x1012	Data Output Flag	16 bit field	Bit true: disable output, false: enable output. 0xFFFF is invalid. bit0: ETH scan data bit1: reserved/internal bit2: ETH object data bit3: ETH vehicle data bit4: ETH errors/warnings bit5: CAN errors/warnings bit6: CAN object data bit7...15: reserved
2	0x1013	maxObjectsViaCAN	UINT16	<= 65 (max. number of objects) limited by tracking and CAN bus capacity.
2	0x1014	ContourPointDensity	UINT16	Valid: < 3 0: closest point only 1: low density 2: high density
2	0x1015	ObjectPriorizationCriterion	UINT16	Valid: < 2 Used to reduce transmitted objects via CAN. Decision which objects are discarded is based on this criterion. 0: Radial 1: Look ahead
2	0x1016	CAN object data options	16 bit field	Valid: all bit 0: 0 = absolute velocities, 1 = relative velocities bit 1: 0 = boxes are object boxes, 1 = boxes are bounding boxes bits 2…15: reserved
2	0x1017	Minimum Object Age	UINT16	Valid: all Minimum tracking age (number of scans) of an object to be transmitted.

Bytes	Parameter index	LD-MRS parameter	datatype	Description
2	0x1018	Maximum Prediction Age	UINT16	Valid: all Maximum prediction age (number of scans) of an object to be transmitted.
2	0x1100	Start angle	INT16	In 1/32°, in the sensor coordinate system. Valid: 1600…-1919. Start angle > end angle!
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
2	0x1200	SensorMounting_X	INT16	In cm, related to vehicle reference point, rear axle. Order of translation and rotation is essential (Rotation -> Translation).
2	0x1201	SensorMounting_Y	INT16	In cm, related to vehicle reference point, rear axle. Order of translation and rotation is essential (Rotation -> Translation).

Bytes	Parameter index	LD-MRS parameter	datatype	Description
2	0x1202	SensorMounting_Z	INT16	In cm, related to vehicle reference point, rear axle. Order of translation and rotation is essential (Rotation -> Translation).
2	0x1203	SensorMounting_Yaw	INT16	In 1/32°, order of translation and rotation is essential (Yaw->Pitch->Roll-> Translation).
2	0x1204	SensorMounting_Pitch	INT16	In 1/32°, order of translation and rotation is essential (Yaw->Pitch->Roll-> Translation).
2	0x1205	SensorMounting_Roll	INT16	In 1/32°, order of translation and rotation is essential (Yaw->Pitch->Roll-> Translation).
2	0x1206	VehicleFrontToFrontAxle	UINT16	valid: all; in cm
2	0x1207	FrontAxleToRearAxle	UINT16	valid: all; in cm
2	0x1208	RearAxleToVehicleRear	UINT16	valid: all; in cm
2	0x1209	RearAxleToVehicleRear	UINT16	valid: all; in cm
2	0x120A	steerRatioType	UINT16	0: TBD 1: TBD
4	0x120C	SteerRatioPoly0	Float32	valid: all
4	0x120D	SteerRatioPoly1	Float32	valid: all
4	0x120E	SteerRatioPoly2	Float32	valid: all
4	0x120F	SteerRatioPoly3	Float32	valid: all
2	0x1210	Vehicle Motion Data Flags	16 bit field	Bit 0: Vehicle Motion data expected: 1=true, 0=false Bits 1 to 15: reserved

6.3 Example

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

Bytes	Offset	data header Big endian byte order!	datatype	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!	datatype	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			

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