KY-LOC 1D.02.01 User Manual

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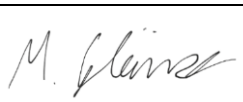
			17.05.2021	
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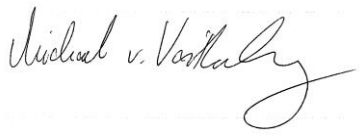
			17.05.2021	
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Documents Cancellation Notification:

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Doc Number	Version	Name

Document Change Details

Change			Changed Chapters	Description of Change
No.	Date	Version		
1	24.11.2020	1.0	All	First Version
2	03.02.2021	2.0	All	Minor Error corrections
3	05.02.2021	3.0	2.3-2.5,4.4	DoC Update USA and Canada. Power Supply and ES1 Limit added
4	17.05.2021	4.0	2.3-2.6, 3.1, 4.5	Corrections for FCC and CA and corrected Connector Pins of X1

Reference Documents

Siglum	Doc Number	Title
RD-1	KY.DOC.0124	Datasheet

*Appropriate version to be obtained from supplier

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List of Abbreviations

Acronym	Definition
AC	Alternating Current
CCC	China Compulsory Certification
CE	European Conformity Marking
DC	Direct Current
DE	Germany
ETH	Ethernet
EU	European Union
FCC	Federal Communications Commission
FW	Firmware
GND	Ground
HF	High Frequency
HW	Hardware
ICD	Interface Control Document
ID	Identification
IEC	IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components
IEEE	Institute of Electrical and Electronics Engineers
ISM	Industrial Scientific Medical Frequency Band
LAN	Local Area Network
LED	Light Emitting Diode
LOS	Line of Sight
MAC	Medium Access Control
N.A.	Not applicable
PE	Protective Earth
PoE	Power over Ethernet
QA	Quality Assurance
RAL	RAL Colour Code
RF	Radio Frequency
RX	Receive
SN	Serial Number
SW	Software
TX	Transmit
UDP	User Datagram Protocol
VAC	Voltage AC
VDC	Voltage DC
WEEE	Waste Electrical and Electronic Equipment Directive

Table 1: List of Abbreviations and Terms

1 General Information

The purpose of this user manual is to provide the required information to install, configure and operate the KY-LOC 1D.02.01 System.
The user manual provides information to the following aspects:

- System description including the principles of KY-LOC 1D.02.01 operation
- Description of the individual KY-LOC 1D.02.01 parts/segments
- Mechanical installation
- Configuration of the KY-LOC 1D.02.01 system
- KY-LOC 1D.02.01 performance and limitations
- Maintenance, repair, and troubleshooting

Please read this user manual carefully before powering up and start working with the KY-LOC 1D.02.01 system.

2 Warnings and Notices

2.1 General Notes

This manual is subject to change.

Before installing and starting up a device, please observe the safety instructions listed in the following sections. This will help you use the device in the appropriate way and avoid making serious errors that may impair your health and damage the devices. We therefore recommend that you keep this manual near the devices.
Please observe the relevant user documentation when installing and operating the system. This product has been tested and found to comply with the product safety requirements according to Chapter 2.3.
KYMATI GmbH is not liable for any damages caused by unauthorised modifications of the devices.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The devices satisfy the requirements of the EU regulation Electromagnetic Compatibility, Low Voltage Directive, RoHS as well as, REACH and RED Directives. The devices carry the CE mark of conformity
(CE = Communauté Européenne = European Union).

Further to the above mentioned, be advised that all pictures are for information only and information provided in this document are subject to change without notice and do not represent a commitment on the part of KYMATI GmbH.

2.2 Signal words and their meaning

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury
Info: not used in this manual

WARNING indicates a hazardous situation which, if not avoided, may result in death or serious injury.

CAUTION indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

NOTICE indicates a very important message.

2.3 Declaration of Conformity

Declaration of Conformity

1. **Product model:**

KY-LOC 1D.02.01

2. **Name and address of the manufacturer or his authorised representative:**

Kymati GmbH
Am Hochacker 5
85630 Grasbrunn
Germany

3. **This declaration of conformity is issued under the sole responsibility of the manufacturer.**

4. **Object of the declaration:**

Equipment: Radar Sensor
Brand name: KY-LOC
Model/type: KY-LOC 1D.02.01

5. **The object of the declaration described above is in conformity with the following standards:**

- (RoHS) Directive 2011/65/EU
- (WEEE Directive) Directive 2012/19/EU
- EN 305 550 V2.1.0
- EN 301 489-3 V2.11
- EN 62311:2008
- EN 62368-1:2014

6. **Signed for and on behalf of Kymati GmbH:**

Grasbrunn, May 17, 2021

Michael von Voithenberg / QA

Martin Glänzer / Chief Technical Officer

Figure 1: Declaration of Conformity

2.4 Compliance Statement USA

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause interference.
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

2.5 Compliance Statement Canada

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:
(1) This device may not cause interference
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil contient des émetteurs / récepteurs exemptés de licence conformes aux RSS (RSS) d'Innovation, Sciences et Développement économique Canada. Le fonctionnement est soumis aux deux conditions suivantes:
(1) Cet appareil ne doit pas causer d'interférences
(2) Cet appareil doit accepter toutes les interférences, y compris celles susceptibles de provoquer un fonctionnement indésirable de l'appareil.

2.6 Health and Safety Liability Statement

The ultimate responsibility for health and safety in connection with the installation and operation of the KY-LOC 1D.02.01 system lies with the customer. The units comply with the relevant regulations as stated in section 2.3. KY-LOC 1D.02.01 operators should ensure that the health and safety regulations of the relevant country and site operations are met, and health and safety instructions are followed.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

In order to comply with FCC and ISED RF Exposure requirements, this device must be installed such that a minimum separation distance of 20cm is maintained between the device and all persons during normal operation.

2.7 Copyright

2.8 End of Life WEEE Statement

WEEE Disposal Instructions

In accordance with the European Union WEEE directive 2002/96/EC, KYMATI will arrange for the collection and treatment of Waste Electrical and Electronic Equipment (WEEE) put on the EU market after 13 August 2005 at no expense to the customer.
Equipment falling into this scope are marked with the KYMATI company label and name and with the “crossed-out wheelie bin” label. This label on the product or its packaging indicates that this product must not be disposed of with household waste. Instead, it is the user’s responsibility to return it to KYMATI GmbH for proper disposal following current national regulatory requirements.

Figure 2: Crossed-Out Wheelie Bin

WEEE collection by KYMATI GmbH

The process for collection of WEEE from a European location may be subject to change between the time when a customer purchases our product, and years later when they ultimately decide to dispose of it. The current process will be available from the KYMATI GmbH on written request.
Please take note that the KYMATI GmbH Company will refuse collection of WEEE, which has been used in a particularly hazardous environment, such as nuclear or subsequently been contaminated or polluted with hazardous substances such as propulsion fluids, oil, etc.
KYMATI GmbH company products are provided through business-to-business activities only. Those consumers who have obtained KYMATI GmbH products through other sources should return those products to their vendor.

KYMATI’s WEEE registration number is "KYMATI GmbH DE 16389341"

Information for WEEE disposal by user

This equipment does not require any special dismantling instructions, hence there is nothing listed in this manual. The equipment also does not contain any dangerous substances and preparations.

3 System Description

3.1 System Overview

A KY-LOC 1D.02.01 system consists of two units that conduct a range measurement between each other. The two units are using the time of flight of the Radar signals to measure a precise distance between each other. The units can be configured to receive the distance values on one unit or on both units. The units must be configured as Relay and Remote devices, as explained in chapter 6. By default, the Relay device does provide access to the information relevant to the distance measurement, while the remote device is only used for measuring purposes. However, is an option to have the same information on the Remote device if it is configured accordingly, as described on chapter 6.

Both units need to be powered with either DC power supply or PoE (802.11af). The unit, where the range measurement is requested, needs to be connected via a data interface, either Ethernet or RS-485. Figure 1 shows the complete system including mounting bracket for mounting on any suitable structure. If other interfaces are necessary, e.g. ProfiNET, ProfiBus, Ethernet/IP, ModBus, can be provided via the KY-XTRA B interface devices.

For FCC and CA, the system is for fixed operation only. This includes installation in fixed equipment, even if the sensor itself moves within the equipment.

3.2 System Technical Data

For the technical data please refer to the Datasheet of the device (refer to RD-1). The latest datasheet can be downloaded from the KYMATI webpage (www.kymati.com)

3.3 Range Measurement & Range Computation

To perform a range measurement between two devices, they need to be synchronised. Therefore, the Relay device sends out a synchronization signal and the Remote synchronizes onto that signal. When the devices are synchronized, they start automatically with the range measurement and stay synchronized. Additionally, the front LEDs are used to show whether the devices are synchronizing or synchronized, for more information please refer to chapter 4. If the devices lose their wireless connection to each other (e.g. object in between) for a long time, they will automatically re-synchronize.

3.4 Intended Use

A system comprising of two KY-LOC 1D.02.01 radars provides accurate range information between them. All system components shall only be used for the above operation and every other use is unintended. The manufacturer will not be responsible for damages caused through incorrect usage.
Incorrect usage may be, but is not limited to:

- Any other use except of the intended application.
- Noncompliance of the provided connectors.
- Operation outside of defined environment conditions.
- Disassembling of any of its components.
- Usage of components and spare parts, which are not in the manufacturer's scope of delivery or are not authorized by the manufacturer.

The system is not certified for safety critical applications. The KY-LOC 1D.02.01 therefore does not satisfy any safety class requirements and must only be used as assisting system in safety-critical applications, such as anti-collision.

4 Device Description

The following chapter describes the sensor mechanics as well as the electrical interfaces in detail.

4.1 Mechanical Data

Colour

The unit is powder coated in colour RAL 5001 – The painting is non-conductive.

Dimensions

The following figures specify the outside dimensions as well as the mechanical and electrical connection points.
All dimensions in mm.

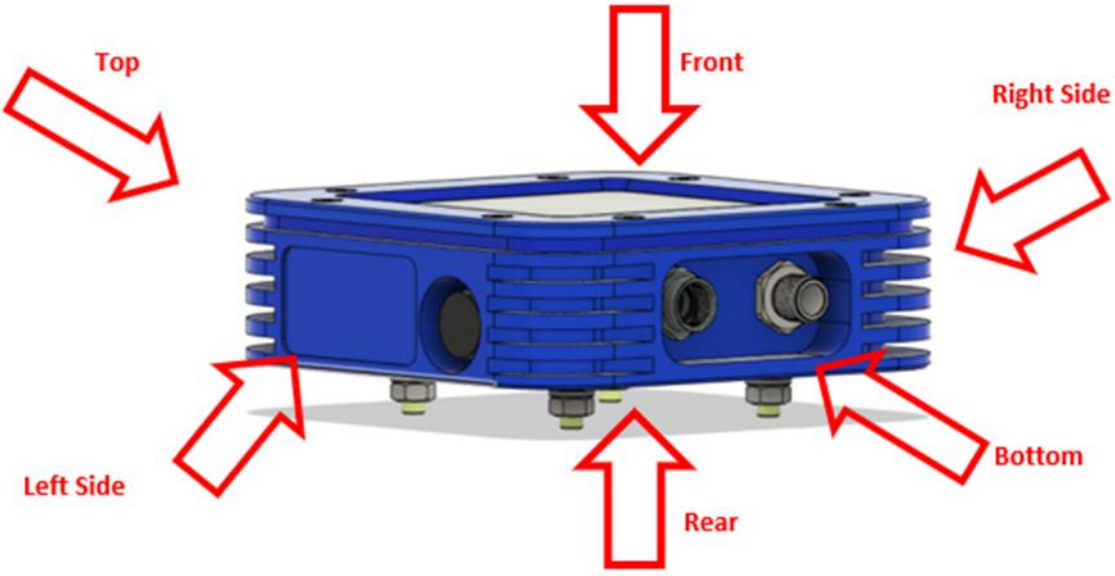

Figure 3: KY-LOC 1D.02.01 side definition

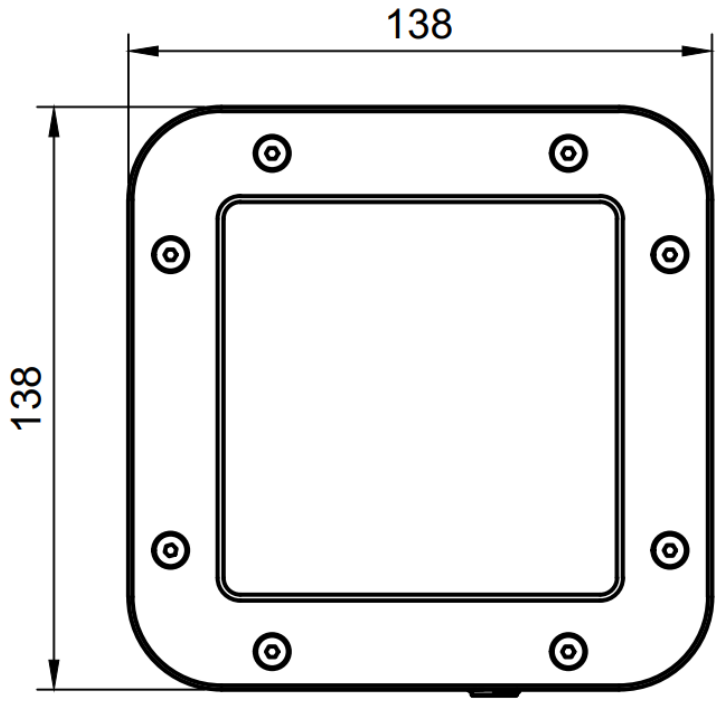

Figure 4: KY-LOC 1D.02.01 Mechanical Drawing (Front View)

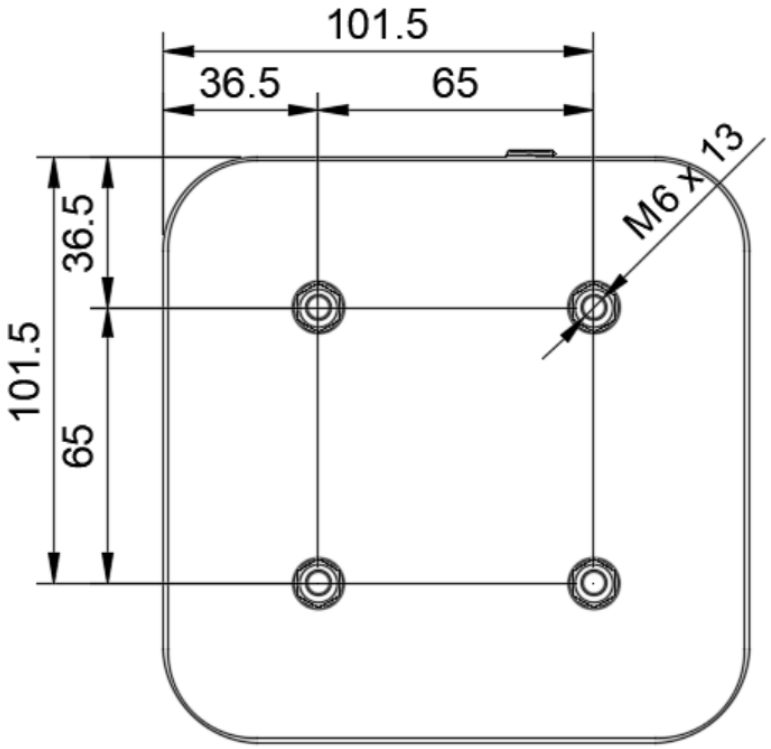

Figure 5: KY-LOC 1D.02.01 Mechanical Drawing (Back View)

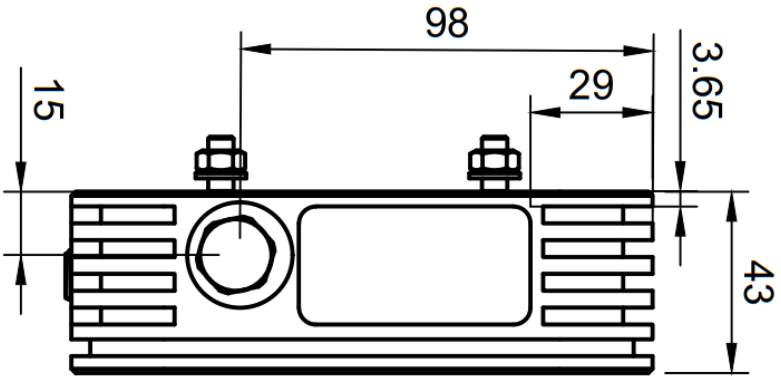

Figure 6: KY-LOC 1D.02.01 Mechanical Drawing (Left Side View)

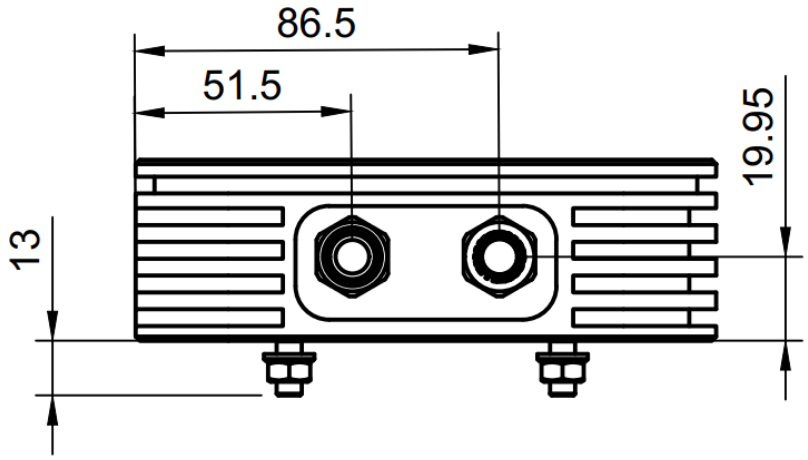

Figure 7: KY-LOC 1D.02.01 Mechanical Drawing (Bottom View)

4.2 Mounting

The KY-LOC 1D.02.01 has 4 x M6x13 bolts (at the rear) for mounting purpose. Use only stainless steel M6 DIN 985 nuts plus 6,4 mm washer according to:

- 1.4301 / AISI 304 / V2A (X5CrNi18/10) or
- 1.4571 / AISI 316 / V4A (X6CrNiMoTi17-12-2)

to mount the bracket.

⚠ CAUTION **For safety reasons only self-securing stainless-steel nuts with a strength value of 12.9 shall be used.**

The device can be mounted in any position, but the two devices need to have the same orientation facing each other. It is recommended to install the KY-LOC 1D.02.01 with the original KYMATI bracket (KY-XTRA M.01.01 – more information can be found under www.kymati.com).

CAUTION

If there is rain or similar situations where water can fill the hole of the pressure valve it is not allowed to mount the device with the pressure valve (see chapter 4.3) on the top side.

The KY-LOC 1D.02.01 shall be mounted tightly so that it cannot be moved unintentionally.

WARNING

A falling protection, part of KY-XTRA M.01.01, is mandatory for the device to avoid any accidents or damages. It is recommended to use one of the 4xM6 bolts on the back of the device.

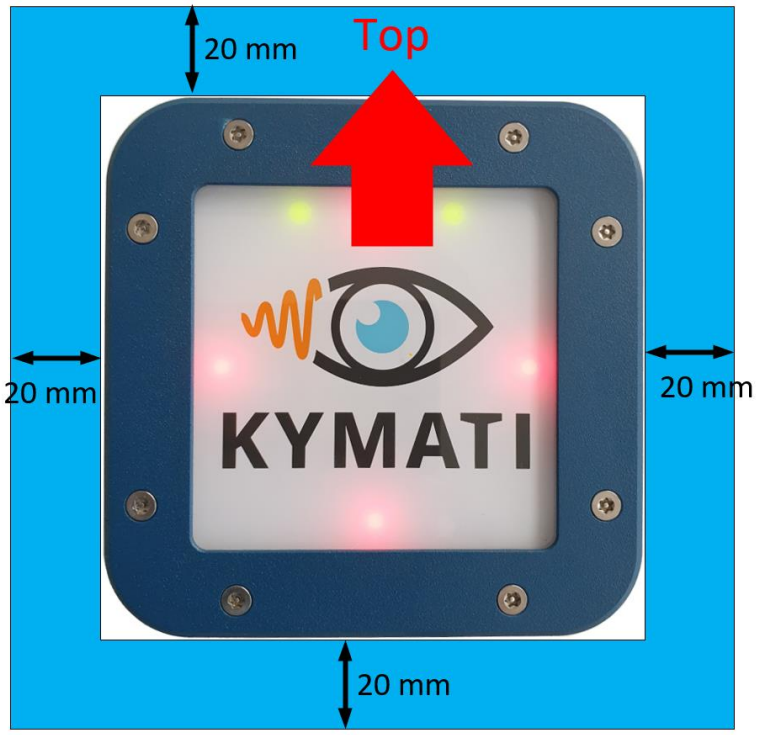

Figure 8: Recommended KY-LOC 1D.02.01 mounting

Figure 9: Falling Protection

4.3 Interfaces

A brief description of the interfaces is given below.

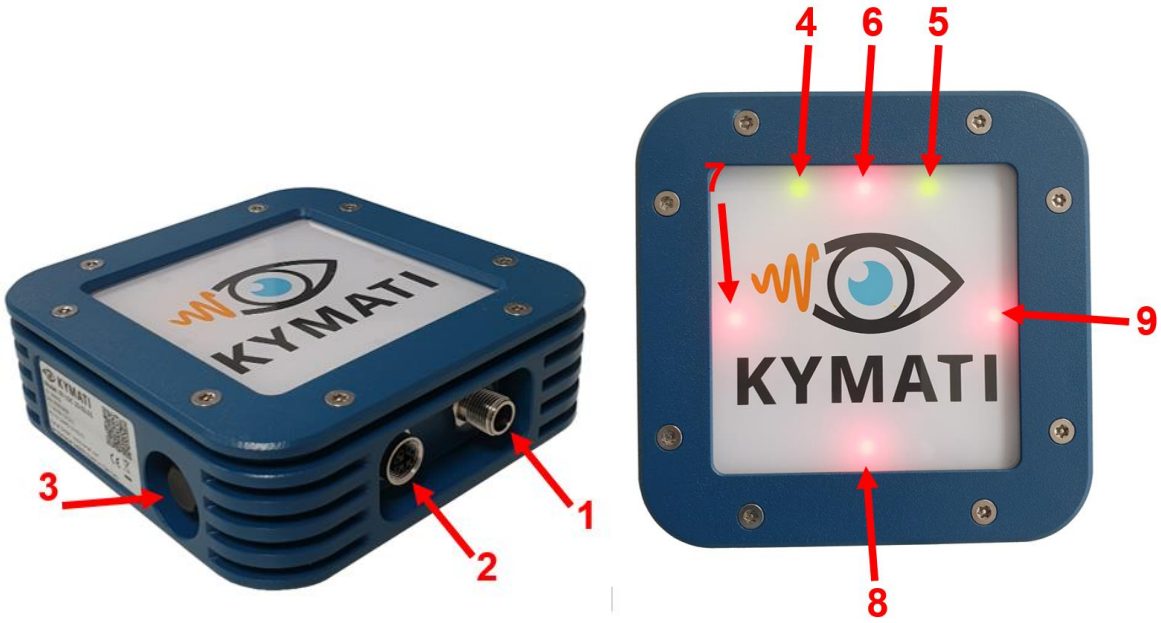

Figure 10: KY-LOC 1D.02.01 Physical Interfaces

(1) Plug for DC – IN / RS-485 (X1)
Power/RS-485 connector (X1) to power the device and to communicate via RS-485 See chapter 7.

(2) Ethernet (X2)
Ethernet connector (X2) to communicate with the device and to power the device via PoE (802.11af). See chapter 7.

(3) Pressure Valve
The pressure valve ensures that temperature changes do not cause any water ingression into the housing as well as prevents overpressure in case of heat.

(4) Power LED

(5) Status LED

(6)-(9) Information LEDs

All LEDs are described in chapter 4.6

Use connector covers if connectors are not used. The specified IP rating is only given with connectors or covers mounted.

4.4 Power Supply

The sensor shall be powered with either a DC power supply via the X1 connector or via X2 connector (PoE - 802.15af) or plugging both is also allowed.

The power supply for the sensor must comply with the ES1 limits and the voltage range stated in the datasheet.

The sensor is protected with a reverse polarity circuit to avoid damages. In case there is a wrong polarity the power LED will not illuminate, and the user must remove the power immediately.

4.5 Connectors

The sensor has 2 x M12 connectors located on the bottom side of the device. To avoid faulty connection the connectors are coded differently and on top female / male.

Figure 11: Bottom side X1 (DC/RS-485 connector) & X2 (Ethernet / PoE connector)

X1: DC/RS-485 connector:
Connector type: M12 according IEC 61076-2 -101, 102 & 109, 5 pin, male, A-coding, material: Zinc Die Cast (default) or 1404 Steel (on customer request)

Figure 12: Connector X1 pin diagram (front view of male connector with pin numbers)

X1 Connector	Function
Pin 1	RS-485-P
Pin 2	RS-485-N
Pin 3	DC In (9 - 36V DC)
Pin 4	GND
Pin 5	EXT TRG (n.a.)

Table 2: Pin Definition X1 (DC/RS-485 connector)

The DC/RS-485 connector provides a half-duplex serial RS-485 Interface. Further details on the RS-485 are mentioned in chapter 7.

There is no termination of the RS-485 interface included in the device, so the bus must be terminated externally.

The IP rating of the unit is only ensured if a connector cap (default) or a connector is mounted correctly.

X2: Ethernet connector:
Connector type: M12 according IEC 61076-2 -101, 102 & 109, 8 pin, female, X-coding, material: Zinc Die Cast (default) or 1404 Steel (on customer request) Further details on the Ethernet interface are mentioned in chapter 7.

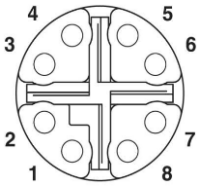

Figure 13: Connector X2 pin diagram (front view of male connector with pin numbers)

X2 Connector	Function
Pin 1	TX+
Pin 2	TX-
Pin 3	RX+
Pin 4	RX-
Pin 5	DC-
Pin 6	DC-
Pin 7	DC+
Pin 8	DC+

Table 3: Pin Definition X2 (Ethernet Connector)

The IP rating of the unit is only ensured if a connector cap (default) or a connector is mounted correctly.

4.6 Indicators

For the description of the following LEDs please refer to Figure 10.

Power LED (4)

If power is connected to the device this LED will illuminate. If this LED does not illuminate check the power connection (see Section 5.2)

Status LED (5)

The status LED indicates the following operation modes:

Mode	Description
Off	Device is not powered
On	System ready

Upper (6), left (7), bottom (8), right (9) LEDs

These LEDs indicate the following operation modes:

Mode	Description
Off	Device is not powered
Blinking	Trying to synchronize
Constant Illumination	Radar provides range measurements, i.e. radars are synchronized

In future these LEDs may be used to support the installation.

4.7 Warranty Seal & Product Label

Each unit is labelled with a warranty seal. If the seal is damaged or broken the warranty is void.

Figure 14: KY-LOC 1D.02.01 Warranty Seal

The Product label is permanently attached to the left side of the device and indicates the PMN, HIV; Serial Number,

5 System Installation

5.1 Wiring Diagram

To power the device, there are three options:

1.) An external DC power supply via the connector X1 can be used
2.) A PoE (802.11af) can be provided via X2
3.) or both interfaces can be used to power the device to have a redundant power supply.

For data communication there are two interfaces. A RS-485 interface on connector X1 and an Ethernet interface on connector X2 (see Figure 11).

Only one data interface should be used at a time.

All possible communication, if configured properly, and power options are supported by the sensor.

If other interfaces/protocols like Profinet, Profibus, Ethernet/IP, ModBus, digital I/Os or similar are needed, an accessory from the KY-XTRA B family is necessary (for more details please visit www.kymati.com).

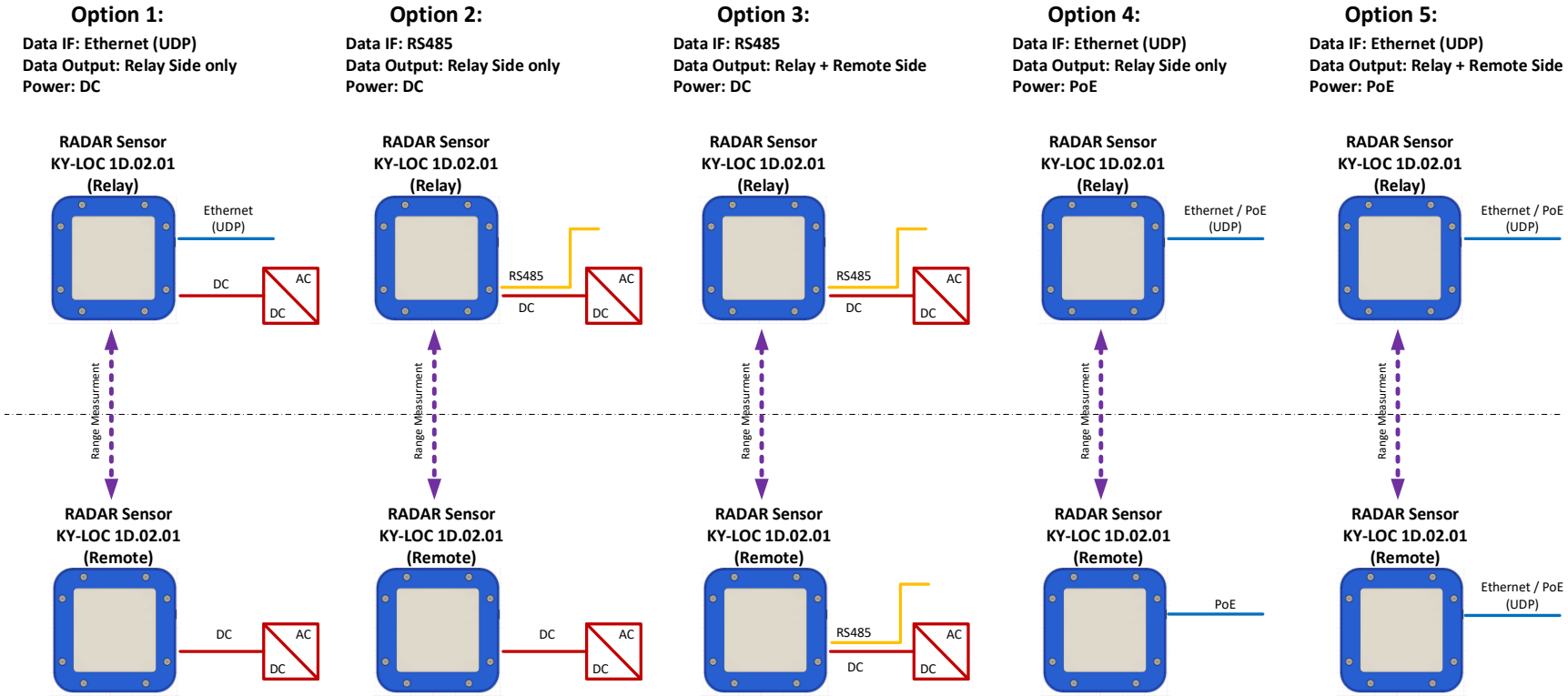

Figure 15: Sensor Wiring Options

5.2 Installation and Setup

All installation, repair and servicing work must be carried out by qualified and trained technicians!

The power supply source must be chosen in accordance with the power supply requirements.

6 Setting Up the Devices and System Operation

This chapter describes how to operate the KY-LOC 1D.02.01 sensor. The following steps must be taken to have a basic measurement running:

1. Install the devices (see chapter 6.1)
2. Power up the devices (see chapter 6.2)
3. Configure the communication links (see “Communication Setup” message in Chapter 7)
4. Configure one device as Relay device (see chapter 7)
5. Connect to the device and run the system (see chapter 6.5)
6. Do the first measurement run (see chapter 6.6)

After this procedure, the system may be installed and will start automatically measuring if both sensors are powered and synchronized.

6.1 Installation of the KY-LOC 1D.02.01 Sensor

For a proper operation, the following parts must be considered:

- The devices must face each other. For long range operation they should be aligned better than 5 °.
- Minimum of 2 m distance between the two units must be maintained to guarantee the specified accuracy.
- The orientation of the devices must be the same (please refer to chapter 3.2).
- The vertical and horizontal offset must be smaller than 0.5 m.

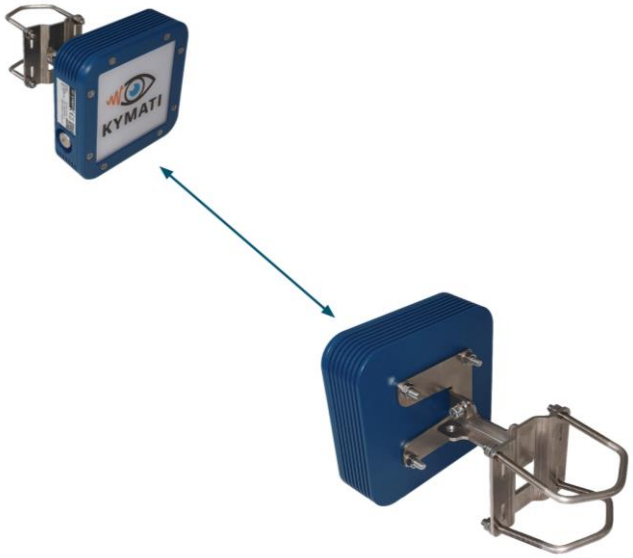

Figure 16: Typical Set-up

In default mode, only the relay can send out the distance information via its own interfaces.

After mounting the device, the cable must be connected. On the Remote side only power is needed, at the side of the Relay, power and communication is necessary (chapter 5.1). If the Remote does not have a communication, the device must be configured in advance via a communication cable.

Do not use unintended force to mount the connectors. If the connector does not fit, check the coding/index notch of the connector.

Open connector sockets need to be protected with a cap. Only with sealed connectors, the device has its stated IP rating

6.2 Powering Up

First connect all cables to the devices and then power up them.

After the installation of the devices the power can be turned on. Therefore, a proper power supply as described in chapter 4.4 must be used.

After power up, the power LED shall illuminate constantly, stating that the device is properly powered. In case of wrong polarity, the device has a polarity protection, hence if the power LED is not illuminating, the power must be removed immediately.

6.3 Initial Configuration

The devices must be configured during initial setup and the parameters must be configured through the communication interface. To configure the device the Ethernet or the RS-485 interface can be used. How to connect to the device is described above.

It is only possible to configure the devices via the RS-485 or the Ethernet Interface. So, both devices must be connected to configure them. This can be done before installation.

Each device should first be configured with a valid Ethernet configuration with a reachable destination target (for example the controlling host) or a valid RS-485 Bus Identifier. See the “Communication Setup” Message in Chapter 7. Please note that this approach can also be used to recover a device in case of misconfiguration through the use of a Product ID and the Serial Number (S/N) which both can be found on the Product label on the side of the device.

Once the communication setup has been done, it is recommended to download the configuration and store it. This configuration can be used in case of a replacement of the device to bring settings fast to a new device or to copy the configuration to another system. All configurable parameters are described in Chapter 7.

6.4 Connect to the System

After the sensors are powered, the KY-LOC 1D.02.01 will start automatically. The Relay will start sending out a signal and the Remote tries to synchronize to that signal. This can take up to 120 seconds. If the devices are synchronized, they start measuring the distance. The distance can be read out via one of the interfaces described in chapter 7.

6.5 Running the System

The KY-LOC 1D.02.01 is working correct when the status LED is illuminating constantly. The device is equipped with a power LED. This LED is the indicator that power is available at the device. Normally the LED glows continuously. When the information LEDs are illuminating constantly then valid range information is available.

6.6 First Run

Before using the system, a reference measurement should be recorded. Therefore, the system should be running from the minimal distance to the maximum possible distance and the range and SNR values should be recorded during the movement. Afterwards the Zero Point should be set. Therefore, the device carrying the moving sensor should drive to the position were the zero of the measurement should be. At this position, the zero command should be executed.

6.7 Turning off the System

To turn the KY-LOC 1D.02.01 off, switch off the power supply. The status LED and power LED will turn off. After unintended power cycle, the system will be automatically restart.

7 Interface Description

There are two possibilities to communicate with the device, either through RS-485 or Ethernet.

RS-485 (TIA / EIA-485-A)
The RS-485 is a unidirectional 2 wire interface, with cable lengths up to 100m. The wires should have a termination Resistor of 120 Ω at both ends.

RS-485 Parameters	RS-485 Values
Transmission Rate	921.6 KBaud
Start Bit	1 (logical low)
Stop Bit	1 (logical high)
Parity Bits	None
Data Bits	8
Flow Control	None

Table 4: RS-485 SW Interface Configuration

To communicate with KYMATI Radars through a RS-485 connection, messages need to be encoded or decoded using byte stuffing into/from a protocol frame as shown in the Figure below.

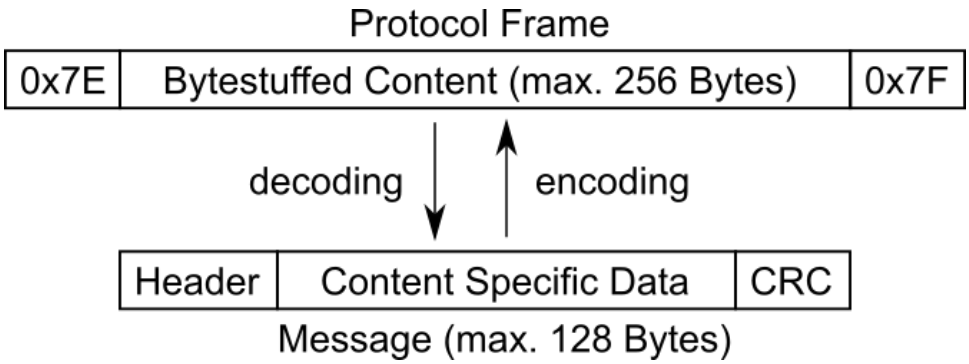

Figure 1: Protocol Description

The byte 0x7E is used to detect the beginning and 0x7F is used to detect the end of valid protocol frame. In this setting we use the byte stuffing technique based on the following transition table:

Original Byte	Stuffed Byte Sequence
0x7E	0x7D 0x5E == 0x7D (0x7E XOR 0x20)
0x7D	0x7D 0x5D == 0x7D (0x7D XOR 0x20)
0x7F	0x7D 0x5F == 0x7D (0x7F XOR 0x20)

Table 5: Transition table

During encoding, we search for the original bytes listed in the transition table inside a given message and replace it with the stuffed byte sequence. The encoding can be implemented

through a bitwise XOR operation between the original byte and the modifier byte 0x20. During the decoding step one must search for the byte 0x7D, remove it and apply the modifier byte through a bitwise XOR operation to the following byte. All other bytes not listed in the transition table are not altered. The maximum size of such a single protocol frame is 258 bytes, if one has to translate every single byte in our message.

Ethernet (TIA-568A/B)
The Ethernet is a standard 100 BASE-T Ethernet according to IEEE 802.3 Clause 24. The wiring is according to TIA-568A/B.

When communicating with the KYMATI Radars through an Ethernet connection, the messages are directly encapsulated into UDP packets without any need for byte stuffing. During bootup, the device will automatically send UDP packets to 192.168.75.1 on port 27513.

All data types and data structure fields use the little-endian byte ordering (also known as Intel byte order).

A KYMATI Radar message has a maximum size of 128 bytes and consists of three parts: A header field, a CRC field and a dynamic field which depends on the actual content being transmitted.

The header part with a size of 8 bytes is described in the following table:

Field	Offset	Datatype	Description
Version	0	Unsigned Integer (16 Bit)	Version of the Protocol Current Version: 2
ContentType	2	Unsigned Integer (16 Bit)	Specifies the type of the content specific data field: see Chapter 4 for possible values.
Source Bus Identifier	4	Unsigned Integer (8 Bit)	Field which contains the identifier of the source device on the bus. Host/Controller Device is always 0
Destination Bus Identifier	5	Unsigned Integer (8 Bit)	Field which contains the identifier of the destination device on the bus. Host/Controller Device has always 0.
Source Routing Identifier	6	Unsigned Integer (8 Bit)	Device Internal Source Address
Destination Routing Identifier	7	Unsigned Integer (8 Bit)	Device Internal Destination Address

The CRC part with a size of 2 Bytes is described in the following table:

Name	Offset	Datatype	Description
CRC	0	Unsigned Integer (16 Bit)	CRCCCITT with generator 0x1021 and seed 0xFFFF

The CRC is computed on Header and the Content specific data field.
The CRC field is always at the end of a KYMATI Radar message.

The Content specific data field is determined by the "ContentType" Field of the header part and can have a maximum size of 118 bytes.

When sending messages from a Host over Ethernet or RS-485 use the "HOST (0)" value for the "Source Bus Identifier". The "Destination Bus Identifier" field is ignored when communicating through Ethernet. For RS-485 connections, however, this field is either the actual bus identifier on the bus, or the special value 0xFF, which can be used to broadcast a message to all devices simultaneously. Please note that there will be no response messages for broadcasts to avoid message collisions on the RS-485 bus.

The following values for the source and destination routing identifiers are supported:

Routing Identifier Name	Value
Microcontroller	0
RS-485	1
Ethernet	2

When sending messages from a host over Ethernet to the device use the "Ethernet" value for the "Source Routing Identifier" field. Similarly, when sending messages from a Host over RS-485 use the "RS-485" value. If this is not set correctly, the responses will be sent back through the wrong connection.

When receiving messages from the device the corresponding source and destination fields will be flipped.

In the case of an Ethernet connection, there is also an option to use a fixed size message format for a more convenient use with PLCs. In that case, the content specific data field is padded with additional zero bytes such that the messages are always 128 bytes in size, including the header and CRC field. The CRC computation then also includes the additional padding bytes.

For some commands, a series of messages needs to be exchanged between the host and the device in a specific order. If the device does not get an expected message in a certain amount of time, it will automatically abort the current command and will wait for a new command.

7.1 Device Commands

The KYMATI Secondary Radar protocol currently supports the following content types:

Description	Content Type
Status	0x0001
Properties	0x0100
Firmware Update	0x0101
Communication Setup	0x0102
Measurement	0x1000

All offsets mentioned in this chapter are with respect to the start of the content specific data field in the KYMATI Radar message.

Further, all messages in this chapter use the Destination Routing Identifier "Microcontroller".

Status (ContentType = 0x0001)

This content is used to indicate the current status of the device (IDLE) or can be used as feedback for the last issued command, for example ACK(nowledged) in case of success or N(ot) ACK(nowledged) in case of an error.
Once the bootup of the device was completed, it periodically sends an IDLE Status message every second in the case that no other operation is currently in progress.

Field	Offset	Datatype	Description
value	0	Unsigned Integer (8 Bit)	1 = IDLE 2 = ACK 3 = NACK
reserved	1	Unsigned Integer (8 Bit)	
reserved	2	Unsigned Integer (8 Bit)	
reserved	3	Unsigned Integer (8 Bit)	

Properties (ContentType = 0x0100)

This content is used to get or set different parameters of the KYMATI Radar to further control the internal processing algorithms.

The table below shows the content for a parameter request to either read or write a parameter in a parameter set.

Field	Offset	Datatype	Description
operation	0	Unsigned integer (8 bit)	1 = Read Property 2 = Write Property
set	1	Unsigned integer (8 bit)	Property set: 1 = Device 2 = Measurement
id	2	Unsigned integer (16 bit)	The property Identifier inside the given parameter set.
size	4	Unsigned integer (8 bit)	Maximum Size 110 bytes
reserved	5		
reserved	6		

reserved	7		
value	8	Byte Array of Length “size”	Write: The new value for the property or ignored otherwise. Read: this field can be ignored in the response but will be set in the request.

The device will send the same content as response but with the “value” field set to the current or updated value of the given parameter.

Device Parameters (ParameterSet = Device)

Parameter	Permission	Parameter Id	Datatype	Description
Save all parameters to non-volatile storage	Write Only	1	Unsigned integer (32 bit)	All parameters which have been updated during runtime will be stored to non-volatile storage. Value: 1
Restore factory settings	Write Only	2	Unsigned integer (32 bit)	Restore all parameters to factory defaults. Value: 1
Product ID	Read Only	3	Character Array of 8 Bytes	Identifier for product series
Serial Number	Read Only	4	Character Array of 8 Bytes	Unique Identifier of the device
MAC Address	Read Only	5	Character Array of 6 Bytes	MAC Address of the Device used for Ethernet communication.
RS-485 Bus Identifier	Read / Write	6	Unsigned integer (8 bit)	Identifier of the Device on the RS-485 Bus. Must not be 0 or 0xFF.
Device IP Address	Read / Write	7	Unsigned integer (32 bit)	Example: 192.168.75.200 = 0xC0 A8 4B C8
Device IP Netmask	Read / Write	8	Unsigned integer (32 bit)	Default: 255.255.255.0 = 0xFF FF FF 00
Device IP Gateway	Read / Write	9	Unsigned integer (32 bit)	Default: 192.168.75.1 Note: this address may be different than the Destination IP Address

Destination IP Address	Read / Write	10	Unsigned integer (32 bit)	IP address where all response messages are sent to when using the Ethernet connection. Default: 192.168.75.01 = 0xC0 A8 4B 01
Destination IP Port	Read / Write	11	Unsigned integer (32 bit)	Port where all response messages are sent to when using the Ethernet connection. Default: 27513
Hardware Revision ID	Read Only	12	Unsigned integer (8 bit)	Revision of the PCB Board.
Microcontroller Chip ID	Read Only	13	Byte Array of Length 16	128 bit Identifier of the Microcontroller
Radar Chip ID	Read Only	14	Byte Array of Length 16	128 bit Identifier of the Radar Chip
Microcontroller Firmware Version	Read Only	15	Byte Array of Length 20	
Radar Firmware Version	Read Only	16	Byte Array of Length 20	

Measurement Parameters (ParameterSet = Measurement)

Parameter	Parameter Id	Datatype	Description
Relay/Remote	0	Unsigned Integer (8 bit)	0 = Relay 1 = Remote
Frequency Channel	1	Unsigned Integer (8 bit)	0-5
Frequency Band	2	Unsigned Integer (8 bit)	0-7
Reserved	3	Unsigned Integer (8 bit)	
Reserved	4	Unsigned Integer (8 bit)	
Reserved	5	Unsigned Integer (8 bit)	

Firmware Update (ContentType = 0x0101)

This content is used to upload a given firmware image in the device's non-volatile storage. The entire firmware update process involves three phases: Exchange of firmware file size, erasing flash sectors on the device and sending the actual firmware file content.

In the first phase, the host sends the file size to the device which then responds with an ACK Status Message using the following content data frame:

Field	Offset	Datatype	Description
State	0	Unsigned Integer (8 bit)	Current State of the Firmware Update: 1 = Exchange of File Size
Firmware Type	1	Unsigned Integer (8 bit)	1 = Microcontroller 2 = Radar
reserved	2		
reserved	3		
filesize	4	Unsigned Integer (32 bit)	The total size of the firmware file to be uploaded to the device.

The file size is then used on both host and device side to compute the number of sectors to be erased (sector size: 4096 bytes) and how many messages must be used to transmit the entire firmware content.

In the second phase, one must send the following content to the device “ceil(file size / 4096)” times to erase the flash on the device.

Field	Offset	Datatype	Description
State	0	Unsigned Integer (8 bit)	Current State of the Firmware Update 2 = Erase Flash sector
Firmware Type	1	Unsigned Integer (8 bit)	1 = Microcontroller 2 = Radar
reserved	2		
reserved	3		

Every erase message is confirmed with an ACK Status Message.

In the third phase, we partition the actual file content into multiple messages.
The total number of necessary messages is given by the maximum size per firmware update message: “ceil(file size / 114)”

Field	Offset	Datatype	Description
State	0	Unsigned Integer (8 bit)	Current State of the Firmware Update: 3 = Exchange of File Segment
Firmware Type	1	Unsigned Integer (8 bit)	1 = Microcontroller 2 = Radar
reserved	2		
reserved	3		
<data>	4	Array of unsigned bytes (8 Bit)	Content of firmware file data segment. Maximum size: 114 Bytes

The device confirms the reception of each file segment with an ACK Status Message.

In case of an error in any of the steps, a NACK Status Message is sent from the device along with an optional Text message describing the error.
The new firmware will become active during the next reboot of the device.

Improper use of these messages may render the KYMATI Radar unusable.

Communication Setup (ContentType = 0x102)

This message can be used to (re-) configure the communication settings.
For Ethernet communication, send this message either to the local broadcast address of the current subnet or to the universal broadcast address (255.255.255.255) on Port 27513.
Set the Source Routing Identifier to the communication port you are using, e.g. “Ethernet” or Please use “Broadcast (0xFF) for the Destination Bus Identifier.

Field	Offset	Datatype	Description	
Product ID	8	8	Array of Characters (8 Bit)	Device specific see: Radar Label
Serial Number	16	8	Array of Characters (8 Bit)	Device specific see: Radar Label
New RS-485 Bus Identifier	24	1	Unsigned Integer (8 Bit)	Any value except 0 or 0xFF
reserved	25	1		
reserved	26	1		
reserved	27	1		
New Device IP Address	28	4	Unsigned Integer (32 Bit)	e.g “192.168.78.200” is 0xC0A84EC8
New Device Netmask Address	32	4	Unsigned Integer (32 Bit)	e.g. “255.255.255.0” is 0xFFFFFF00
New Device Gateway Address	36	4	Unsigned Integer (32 Bit)	e.g. “192.168.78.1” is 0xC0A84E01
New Destination IP Address	40	4	Unsigned Integer (32 Bit)	e.g. “192.168.78.1” is 0xC0A84E01
New Destination Port	44	2	Unsigned Integer (16 Bit)	Default: 27513

After reception and validation of this message, the device will change the internal parameters and automatically reboot.

Measurement (ContentType = 0x1000)

This content is used to start a measurement and get the associated measurement results which depend on whether the KYMATI Radar is configured as a Primary Radar or a Secondary Radar. Once all respective data has been sent, the Radar will send an ACK Status message in case of success or a NACK Status message in case of an error.

Field	Offset	Datatype	Description
state	0	Unsigned Integer (8 bit)	Current state of measurement: 1 = Get latest measurement
output	1	Unsigned Integer (8 bit)	Bitfield to specify data which shall be output after a successful measurement: Secondary Radar Mode: Bit 0: 1D Range Data
reserved	2		
reserved	3		

The device will then respond with the following message:

Field	Offset	Datatype	Description
state	0	Unsigned Integer (8 bit)	Current state of measurement: 2 = 1D Range Data
reserved	1	Unsigned Integer (8 bit)	
reserved	2	Unsigned Integer (8 bit)	
reserved	3	Unsigned Integer (8 bit)	
Range [m]	4	IEEE Float (32 bit)	Range information
Velocity [m/s]	8	IEEE Float (32 bit)	Velocity information
SNR [dB]	12	IEEE Float (32 bit)	Signal to noise ratio
Confidence Level	16	Unsigned Integer (8 bit)	0-100
reserved	17	Unsigned Integer (8 bit)	
reserved	18	Unsigned Integer (8 bit)	
reserved	19	Unsigned Integer (8 bit)	

8 Operational Limitations

8.1 Fresnel Zone Clearance

To prevent performance degradation, the Fresnel zone clearance (at least of 1st order) between two sensors should be respected. The following notation is used hereafter:

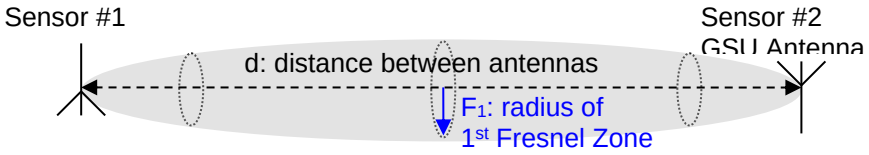

Figure 17: First Fresnel Zone

The Fresnel Zone is the grey area shown in Figure 17. It is mainly depending on the system frequency and the distance between the two sensors.
The maximum radius of the first Fresnel zone can be computed with the following formula, where it has already been predefined that KY-LOC 1D.02.01 operates at f = 61 GHz:

$$F_{1,\max} = 0.1137 \cdot \sqrt{d}$$

$F_{1,\max}$ (max. radius of the Fresnel Zone) is in units of meters, as well as the antenna distance d.

Distance [m]	Max Radius of Frenzel Zone [m]
50	0.80
100	1.14
300	1.97
500	2.54

Table 6: Maximum radius of Fresnel zone at different distances.

This also implies that the two sensors have to be mounted in such a way that there is still some spacing to neighbouring objects, in order to respect the Fresnel zone clearance.

Objects obstructing the Fresnel Zone can cause signal degradation depending on the amount of the obstruction. E.g. it shall be avoided to place any objects in the field of view of the sensor or mount the sensor in locations close to obstacles, which might affect the overall range performance and/or the measurement quality.

8.2 Line of Sight Clearance

The most important technical aspect for the system is to have a continuous Line of Sight condition between the remote device and the relay device at any time. A proper Line of Sight analysis during the first time shall be made taking also possible temporary objects into account.

If objects are in the line of sight it may be that the device measures a wrong distance or even loose the contact and therefore also the synchronization totally. In the case of a total loss, the synchronisation like the one at start-up will take place when the object is no longer in the line of sight, which might affect the overall range performance and/or the measurement quality.

8.3 Simultaneous Operation

Adjacent KY-LOC 1D.02.01 systems must use of different channel configurations avoiding interference between the different systems. It is in the responsibility of the system operator to ensure that either adjacent KY-LOC 1D.02.01 systems make use of different channel configurations or, when re-using the same channel configuration for different KY-LOC 1D.02.01 systems, an adequate spatial separation is kept between different KY-LOC 1D.02.01 systems. Currently the system supports up to 6 channels and in the future, this might increase based on the customer needs (software upgrade).

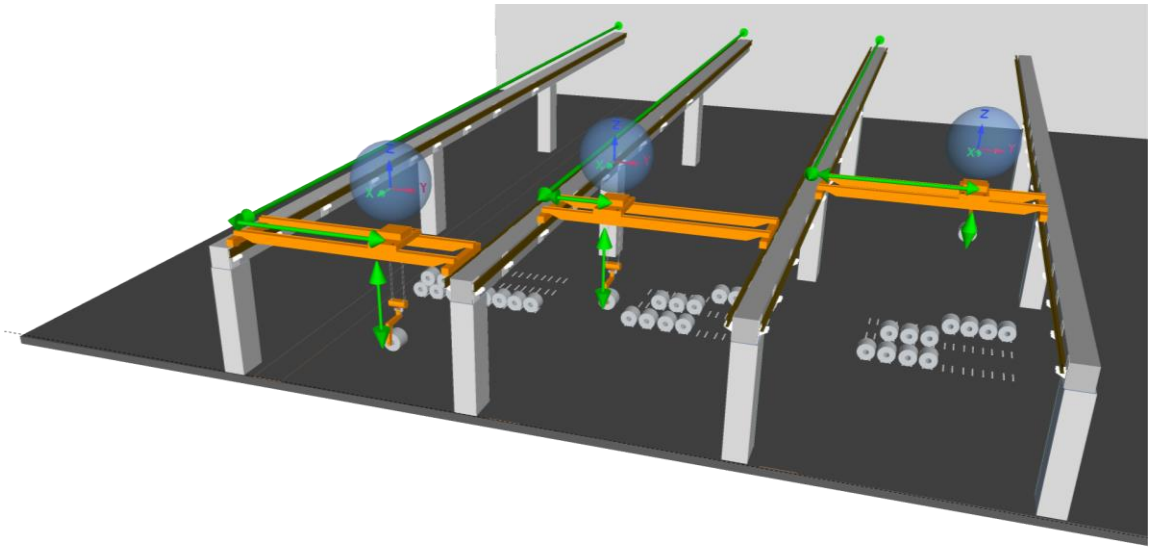

Figure 18: Typical installation of multiple devices operating at the same area.

9 Maintenance and Repair

Do not open KY-LOC 1D.02.01 units. In case it is opened, the warranty has expired.

All KY-LOC 1D.02.01 Units are maintenance free. In case of any problem with one or more devices, check first chapter 10. If the problem remains the KY-LOC 1D.02.01 unit might be damaged. Under any circumstances the units shall not be opened, and repair must not be attempted by the customer.

9.1 Replacement of Equipment

The following points must be considered if a KY-LOC 1D.02.01 device needs to be replaced:

- The device should be mounted in the same place as the old ones to achieve the same results
- The new device should be configured with the same settings as the old device. This can be done by uploading the configuration file of the old device. User should ensure that these files are accessible in case of a replacement. Please refer to chapter 6 for more information
- The steps described in chapter 6 should be performed especially the zero calibration is necessary to get the same results out of the device as before

9.2 Cleaning and Painting

External pollution can be removed with a rag and water. Do not use detergents, solvents, or other chemicals. Painting especially of the front cover is not allowed.

9.3 Connectors

The electrical connectors are limited to 100 mating cycles.

10 Troubleshooting

Please contact the KYMATI Service Team if you cannot fix your problem with the given instructions.

10.1 Diagnostic Information and LED Status

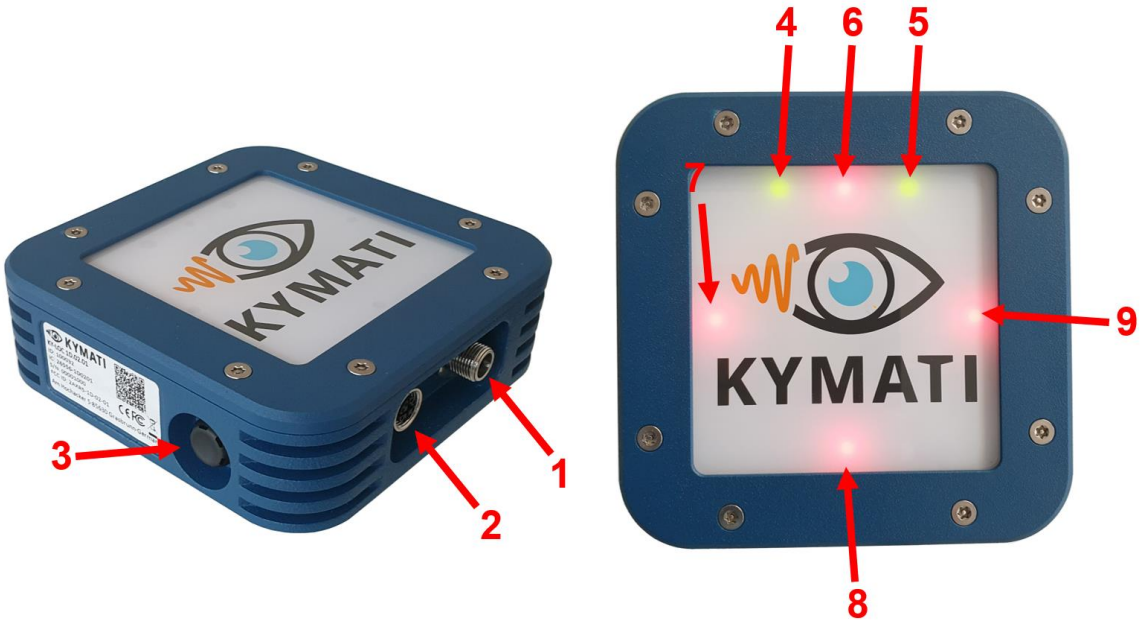

Figure 19: KY-LOC 1D.02.01 Physical Interfaces

Power LED (4)

If power is connected to the device this LED will illuminate. If this LED does not illuminate check the power connection (see Section 5.2)

Status LED (5)

The status LED indicates the following operation modes:

Mode	Description
Off	Device is not powered
On	System ready

Upper (6), left (7), bottom (8), right (9) LEDs

These LEDs indicates the following operation modes:

Mode	Description
Off	Device is not powered
Blinking	Trying to synchronize
Constant Illumination	Radar provides range measurements, i.e. radars are synchronized

In future these LEDs may be used to support the installation.

10.2 Plug does not fit

Only use connectors specified by Kymati.

Do not wear gloves when applying the connectors. Take care of the index position and do not apply unnecessary force.

Problem: One of the plugs does not fit into the connector.

Solution:

- Make sure, that you have the correct connector and that you attach it at the correct plug.
- Make sure, that no pins are bent.
- The plugs only fit at one position. The plugs have an index notch that indicates the correct position. The connector must be carefully rotated, until it suits. Afterwards it can be fastened with the screw cap.

10.3 Status LED does not flash

Problem: After turning the KY-LOC 1D.02.01 sensor on, the status LED does not flash.

Solution: Turn off the KY-LOC 1D.02.01 power supply, wait 5 seconds and turn it on again.

11 Contact and Responsible Party

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