# LOYTEC Bluetooth Devices

Device Operation for LOYTEC Products

# User Manual

**LOYTEC electronics GmbH**

Contact

LOYTEC electronics GmbH
Blumengasse 35
1170 Vienna
AUSTRIA/EUROPE
support@loytec.com
http://www.loytec.com

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# Contents

# Abbreviations

| | |
|---|---|
| 100Base-T | 100 Mbps Ethernet network with RJ-45 plug |
| Aggregation | Collection of several CEA-709 packets into a single CEA-852 packet |
| AST | Alarming, Scheduling, Trending |
| BACnet | Building Automation and Control Network |
| BBMD | BACnet Broadcast Management Device |
| BDT | Broadcast Distribution Table |
| BBMD | BACnet Broadcast Management Device |
| BLE | Bluetooth Low Energy |
| BOOTP | Bootstrap Protocol, RFC 1497 |
| CA | Certification Authority |
| CEA-709 | Protocol standard for LONWORKS networks |
| CEA-852 | Protocol standard for tunneling CEA-709 packets over IP channels |
| CN | Control Network |
| COV | change-of-value |
| CR | Channel Routing |
| CRPL | Challenge Response Pair List (Replay Protection) |
| CS | Configuration Server that manages CEA-852 IP devices |
| DA | Data Access (Web service) |
| DALI | Digital Addressable Lighting Interface, see IEC 62386 |
| DFU | Device Firmware Update |
| DHCP | Dynamic Host Configuration Protocol, RFC 2131, RFC 2132 |
| DIF, DIFE | Data Information Field, Data Information Field Extension |
| DL | Data Logger (Web service) |
| DNS | Domain Name Server, RFC 1034 |
| DST | Daylight Saving Time |
| EEP | EnOcean Equipment Profile |
| GMT | Greenwich Mean Time |
| IP | Internet Protocol |
| IP-852 | logical IP channel that tunnels CEA-709 packets according CEA-852 |
| IV | Initialization Vector |
| LAN | Local Area Network |
| LSD Tool | LOYTEC System Diagnostics Tool |
| MAC | Media Access Control |
| MD5 | Message Digest 5, a secure hash function, see Internet RFC 1321 |
| M-Bus | Meter-Bus (Standards EN 13757-2, EN 13757-3) |
| MIB | Management Information Base |
| MS/TP | Master/Slave Token Passing (this is a BACnet data link layer) |
| NAT | Network Address Translation, see Internet RFC 1631 |
| NV | Network Variable |
| OPC | Open Process Control |
| OPC UA | OPC Unified Architecture |
| PEM | Privacy Enhanced Mail |

PIR ..... Passive Infra-Red
PLC ..... Programmable Logic Controller
RNI ..... Remote Network Interface
RSTP ..... Rapid Spanning Tree Protocol (Standard IEEE 802.1D-2004)
RTT ..... Round-Trip Time
RTU ..... Remote Terminal Unit
SCPT ..... Standard Configuration Property Type
SIG ..... Special Interest Group (Bluetooth-SIG)
SL ..... Send List
SMI ..... Standard Motor Interface
SMTP ..... Simple Mail Transfer Protocol
SNMP ..... Simple Network Management Protocol
SNTP ..... Simple Network Time Protocol
SSH ..... Secure Shell
SSL ..... Secure Socket Layer
STP ..... Spanning Tree Protocol (Standard IEEE 802.1D)
TLS ..... Transport Layer Security
TTL ..... Time To Live (parameter, Bluetooth Mesh Protocol)
UCPT ..... User-defined Configuration Property Type
UI ..... User Interface
UNVT ..... User-defined Network Variable Type
UTC ..... Universal Time Coordinated
VIF, VIFE ..... Value Information Field, Value Information Field Extension
WIFI ..... Wireless Fidelity (Wi-Fi Alliance)
WLAN ..... Wireless LAN
XML ..... eXtensible Markup Language

# 1 Introduction

## 1.1 Overview

The LOYTEC product family includes high performance, reliable and secure network infrastructure components, embedded automation servers, universal gateways, touch panels, I/O modules, room controllers, and lighting controllers. The different device models contain a number of components and network technologies, such as BACnet, CEA-709, KNX, Modbus, M-Bus, MP-Bus, DALI, Bluetooth, SMI, EnOcean and Bluetooth.

This user manual describes the Bluetooth-related behavior of LOYTEC LOYBT devices. The manual covers installation guidelines, the basic functionalities and description of the device dependent feature sets.

LOYTEC LOYBT devices are separated in several main categories according to their Bluetooth-mesh functionality. After a general short introduction to Bluetooth Mesh and installation guidelines, the categories of LOYTEC Controller with Bluetooth Mesh Interface, LOYBT input devices and LOYBT ballasts are covered in different chapters.

## 1.2 Scope

This document covers common operations on LOYTEC LOYBT devices with firmware version 2.2.0 (if not explicitly stated otherwise).

For integration and specific usage in a LOYTEC environment refer to the LOYTEC Device User Manual [1].

# 2 Safety Instructions

**ATTENTION**

**General Safety Instructions**

Please regard the following general instructions for project planning and execution:

- Regard all measures or prohibitions of the respective country to avoid danger of electricity and high voltage.
- Other relevant regulations of the respective country.
- House installation regulations of the respective country.
- Regulations of the utility company.
- Any specifications, diagrams, dispositions, cable lists and regulations of the customer or system integrator.
- Any third-party regulations (e.g., general contractor or client).

**ATTENTION**

**Country-specific Safety Regulations**

Failure to observe country-specific safety regulations can lead to property damage and personal injury. Therefore, comply with the country-specific regulations and the corresponding safety guidelines.

**CAUTION**

**Electrical Safety**

Essentially, electrical safety in building automation systems from LOYTEC is based on the use of extra-low voltage and safe isolation from mains voltage.

**CAUTION**

**IEC (SELV, PELV) (world-wide)**

Depending on the extra-low voltage earthing (24VAC), this results in an application according to SELV or PELV in accordance with IEC 60364-4-41:

- Ungrounded = SELV (Safety Extra Low Voltage),
- Earth ground = PELV (Protected Extra Low Voltage).

**CAUTION**

**NEC (North America)**

Class 2 transformers with energy limitation to 100 VA or Class 2 circuits with max. 100 VA (using a non-energy-limiting transformer of max. 400VA) combined with overcurrent limits (T-4A fuses) can be used for each individual 24VAC device. Several fuses for several isolated secondary circuits per transformer are possible. The same applies to power supplies with 24VDC.

**CAUTION**

**Device Safety**

Device safety is guaranteed by supply with low voltage 24VAC or 24VDC and a double insulation between mains voltage 230VAC, 24VAC circuits and the housing or by supply via Power over Ethernet (PoE Class 1). In addition, the specific regulations for electrical wiring according to this manual must be observed.

**ATTENTION**

**Installation Personnel**

Only qualified staff may carry out electrical installations.

**CAUTION**

**Installation according Safety Class II**

LOYTEC devices, which are designed in compliance with safety class II, must be mounted accordingly.

The following requirements apply:

- Protection against electric shock has to be ensured by an appropriate enclosure.
- Ensure proper working cable relief for installation in safety class II equipment.

**ATTENTION**

**Mounting Location**

LOYTEC devices are designed to be installed in an enclosure:

- Switching cabinets
- Distribution boxes
- Mounting in false ceilings
- Luminaire integration

**ATTENTION**

**Environment Conditions**

LOYTEC devices have to be installed in a dry and clean environment. In addition, the permissible environment conditions specified in the product data sheet must be observed.

**CAUTION**

**Earth Ground of ⊥ (System Zero AC/DC 24V)**

The following items must be observed when earth-grounding system zero ⊥ 24VAC:

- In principle, both earth-grounding and non-grounding of system zero of the operating voltage 24VAC is permitted. Important are the local regulations and customs. Due to functional requirements, earth ground may be necessary or inadmissible.
- It is recommended to ground 24VAC systems unless this contradicts the manufacturer's instructions.
- To avoid earth loops, systems with PELV may only be connected to earth ground at one point in the system. Unless otherwise stated, usually at the transformer.
- The same applies to 24VDC power supplies.

**CAUTION**

**Functional Earth ⏚**

Functional earth must be connected to the building's protective earthing (PE) system on the installation side.

**CAUTION**

**Operating Voltage 24V AC/DC**

The power supply must meet the requirements for SELV or PELV. Permitted deviation of the nominal voltage:

- At the transformer or power supply: 24V AC/DC ±10%
- At the device: 24V AC or DC ±10 %

**CAUTION**

**Specification for 24VAC Transformers**

IEC: safety transformers according to IEC 61558 with double insulation, designed for 100% duty cycle to supply SELV or PELV circuits.

U.S.: Class 2 circuits according to UL 5085-3.

For efficiency reasons, the power drawn from the transformer should be at least 50% of the nominal load.

The nominal power of the transformer must be at least 25 VA. Using a transformer of smaller size, the ratio of open circuit voltage to voltage at full load becomes unfavorable (> + 20%).

**CAUTION**

**Specification for 24VDC Power Supplies**

Power supplies must be designed for 100% duty cycle to supply SELV or PELV circuits.

U.S.: Class 2 circuits according to UL 5085-3.

For efficiency reasons, the power drawn from the power supply should be at least 50% of the nominal load.

**CAUTION**

**Protection of the 24VAC Supply Voltage**

Transformers must be protected on the secondary circuit, according to the transformer dimensions and the effective load of all connected devices:

Always protect the 24VAC conductor (system potential),

Additionally protect the conductor ⊥ (system zero) where required.

**CAUTION**

**Protection of the 24VDC Supply Voltage**

24 VDC power supplies must be short-circuit proof or have an internal micro fuse.

Local regulations must be observed.

**CAUTION**

**Protection of Mains Voltage**

Transformers/24VDC power supplies must be protected on the primary circuit using a control cabinet fuse.

**CAUTION**

**Power over Ethernet (PoE)**

LPAD-7 Touch Panels require a PoE Class 1 power supply (max. 12W), which must be compliant to IEEE 802.3at-2009.

For the power supply of the PoE switches observe the manufacturer's specifications.

**CAUTION**

**Device Installation/Removal in De-Energized State Only**

Ensure that power supply is switched off before starting to install or uninstall LOYTEC devices. Do NOT connect or disconnect equipment with the power switched on, unless instructed otherwise. Do NOT assemble or disassemble devices with power switched on, unless instructed otherwise.

**CAUTION**

**Power supply protection**

When installing LOYTEC devices, ensure that the power source is adequately protected by means of a suitably-rated fuse or thermal circuit breaker.

**CAUTION**

**Power supply voltage**

Do not connect a voltage supply greater than the specified maximum rating. Refer to product label and/or datasheet for the correct voltage.

**CAUTION**

**DALI is FELV (Functional Extra Low Voltage)**

A DALI-line is treated to be FELV. Since it is non-SELV the relevant installation regulations for low voltage apply.

**ATTENTION**

**DALI wiring**

A DALI-line may be installed within the same cable or as single conductors within the same tube as mains supply. The DALI-line is either limited to a maximum length of 300 m using a minimum cross-section of 1.5 $mm^2$ (AWG15) or it must be ensured that the voltage drop on the DALI-line does not exceed 2 V.

**CAUTION**

**Attention to External Voltages**

Any kind of introduction or spreading of dangerous voltages onto the low-voltage circuits of the system (e.g. due to incorrect wiring) must be avoided at any circumstance and represents an immediate life danger or can lead to the entire or partial destruction of the building automation system.

# 3 Bluetooth Low Energy (BLE)

## 3.1 Introduction

Bluetooth Low Energy is a technology for short range radio transmission of small data packages. It operates in the license-free ISM band between 2.402 and 2.480 GHz. It may interact and be disturbed by other technologies using this frequency range like WLAN or radio emitting sources like microwave-ovens.

Bluetooth Low Energy has been introduced in the Bluetooth 4.0 specification in 2010. By defining transmit and receive timeslots for a dedicated connection between two devices, the energy-consumption for radio-communication has been dramatically reduced since the radio has to be turned on only during these slots. While the Generic Access Profile (GAP) controls connections and advertising in Bluetooth, the Generic Attribute Profile (GATT) defines the way how BLE-devices transfer data back and forth by services and characteristics.

Bluetooth Low Energy (BLE) enables several features, the most important ones are mentioned here:

- Beaconing: advertising of Bluetooth beacons that can be used as identifiers
- Connections: services are used to provide device specific data
- Asset Tracking: scanning for available Bluetooth beacons and determine a location based on the RSSI

Nevertheless, BLE is still a point-to-point (connection) or point-to-multipoint (broadcast) communication.

### 3.1.1 Bluetooth Mesh Basics

In 2017 the Bluetooth SIG introduced Bluetooth Mesh on top of the Bluetooth 4.2 specification. It allows many-to-many connections by using advertising channels only. It is based on the introduction of a forwarding-mechanism (relay-function) and a publish/subscribe method for data exchange.

LOYTEC supports Bluetooth SIG qualified mesh only.

***Note:*** ***This means proprietary Bluetooth Mesh solutions such as Casambi, BlueRange, Wirepas, CSRmesh, Mindtree, MeshTek, Estimote, etc. are not supported!***

The basic concepts to allow multipoint-to-multipoint communication in BLE-based systems are simple:

- Use of **advertising channels 37, 38 & 39** only (any device can listen). A further advantage of these channels is that they do not interfere with WLAN-channels 1, 6 and 11.

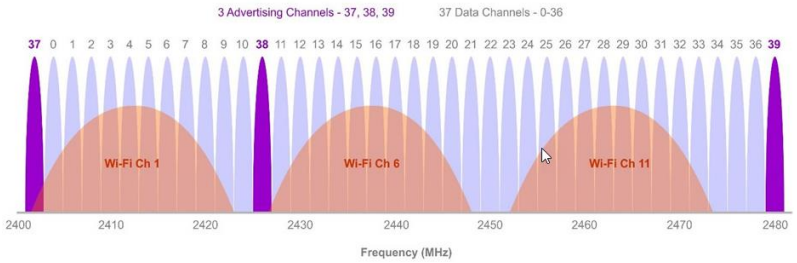



Figure 1: BLE and Wi-Fi Channels.

- **Managed Flooding** approach, which means that any message in the network can be forwarded multiple times (defined by the TTL-parameter). The target device is subscribed to the target address. Most important methods and parameters:
  - TTL (Time To Live, Number of Hops).
  - Message Cache (Withdraw messages that have already been received).
  - Publish/Subscribe (Process only messages you are subscribed to).

- Each node (device in the mesh network) comes with a set of the following device capabilities and features, none of them is mandatory, but finally all are required in different situations:
  - **Relay Feature**: capability of forwarding mesh-messages based on network key and TTL.
  - **Proxy Feature**: service to access the mesh-network via a GATT-connection, typically via a mobile device.
  - **Low Power Feature**: required for battery powered devices, so that they can be inactive most of the time to save energy.
  - **Friend Feature**: required for support of devices with low power feature. A friend has the capability to store configuration commands for a low power device when it is in sleep mode.

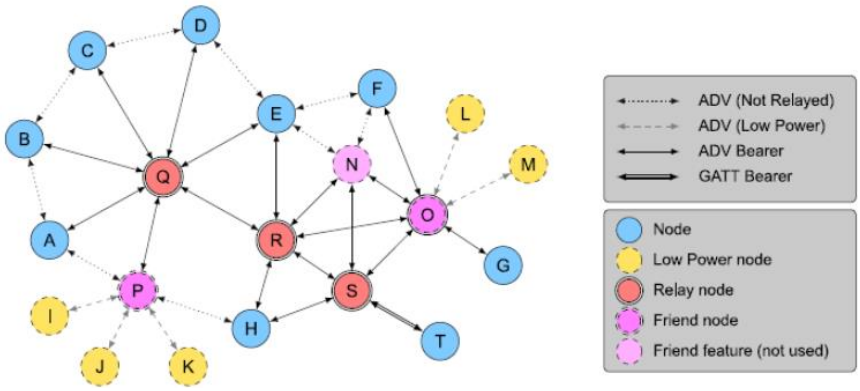



Figure 2: Bluetooth Mesh ecosystem with all features

- **Security is mandatory** in Bluetooth Mesh and is provided by the following methods:
  - Multi-level encryption (network key, application key, device key).
  - Key refresh procedure.
  - Replay protection (IV index, sequence number).
  - Trashcan protection (node blacklisting).
  - Authentication during provisioning (out of band).

- The **application** in Bluetooth Mesh ecosystems is built on so called **models**. Each model describes a set of features represented by states and interacted with a defined command set. There are mandatory models (so called foundation models, which are

used to setup the mesh network and the basic functions) and optional application specific models (some generic, sensor or lighting specific) as well as vendor models.

In the latest version of the specification several useful features have been introduced, LOYTEC Devices already support Remote Provisioning and the mandatory set of requirements defined in the Networked Lighting Control Profiles (NLC).

For a more detailed description on Bluetooth Mesh operation, models and profiles refer to Bluetooth SIG Mesh Protocol[1] v 1.1 [2], the Mesh Model v1.1 specification [3] and the NLC Profiles [4] – [9].

### 3.1.2 Bluetooth Mesh Network Limitations

There are several limitations in a Bluetooth Mesh network that must be considered:

- Maximum number of nodes in a network is limited by the maximum number of elements which is 16384.
- Maximum number of group addresses is 16384 (of which 4096 are reserved).
- Forwarding is limited by the TTL-parameter (Time to Live), the theoretical maximum is 126 hops.
- The size of message cache affects the efficiency of relaying (suppression of circular relaying).
- Sequence Number & IV–index are not a limitation per se, but can result in unprovisioned devices (after a device has been offline for more than 48 weeks it may happen that the device cannot be recovered and has to be reprovisioned)
- Length of Subscription List – this parameter limits the number of addresses a device can listen to (or groups a device can be a member of).
- The CRPL parameter defines the length of the list of element addresses which are processed by a node (thus the parameter limits the number of nodes a node can interact with).
- The latency in a Bluetooth Mesh network is heavily depending on mesh size and payload as well as on message size (segmented and unsegmented messages).
- Turning unprovisioned mesh beacons into a node by a provisioning process requires a direct connection and is limiting the range between provisioner and mesh device unless there are nodes in the system which support remote provisioning (introduced by Bluetooth SIG in Mesh version 1.1).

[1] previously called Mesh Profile

# 4 LOYTEC Controllers with Bluetooth Mesh Interface

## 4.1 Overview

Various LOYTEC controllers provide a SIG-compliant Bluetooth Mesh interface. The feature set of the application controller is perfectly suited to support all features of ballasts and input devices of the LOYBT product portfolio. Besides of the gateway function to the building management, the controller allows commissioning, device configuration, firmware update etc. A LOYTEC controller with programmable logic and data point interface is the heart of a LOYTEC Bluetooth Mesh system. For a detailed description refer to the LOYTEC Device User Manual [1].

LOYTEC controllers with a SIG-compliant Bluetooth Mesh interface are:

- LPAD7-30G2/30G3, Touch Panel
- LPAD7-31G2/31G3, Programmable Touch Panel
- LPAD7-41G2/42G3, Programmable Touch Panel with microphone
- LROC-800, Programmable Room Controller

# 5 LOYBT - Input Devices

## 5.1 Overview

LOYTEC provides different types of input devices with a Bluetooth Mesh interface. This chapter deals with the characteristics of those devices.

## 5.2 LOYTEC LOYBT-TEMPx Battery Powered Environmental Sensor

This section covers common operations on LOYBT-TEMPx devices with firmware version 1.6.0.

### 5.2.1 Device Description

The LOYBT-TEMPx Bluetooth sensor is a battery powered sensor for measuring environmental properties like room temperature and relative humidity. It is based on the Bluetooth SIG qualified mesh stack (declaration-ID: D060851, reference-design: 154767, Bluetooth 5.1). It acts as low-power node in a Bluetooth Mesh network and publishes sensor data on change of value as well as periodically. In addition, the sensor also reports its battery status.

The device allows to perform temperature and humidity measurements at the location of your choice.

The type LOYBT-TEMP2 additionally offers presence detection based on an integrated vibration sensor. Vacant and occupied workspaces can be determined if the sensor is placed properly, e.g. by being mounted on the backside of a chair.

Due to the energy-saving operation of low power nodes the device is sleeping most of the time.

The enclosure contains 3 holes on the front side. The sensor, a service-button (in the center) and a status-LED (see also Figure 3) are located behind these holes.

The service button has a central function for commissioning and waking up the device for any desired interaction. The status LED gives feedback about the current state during device interaction.

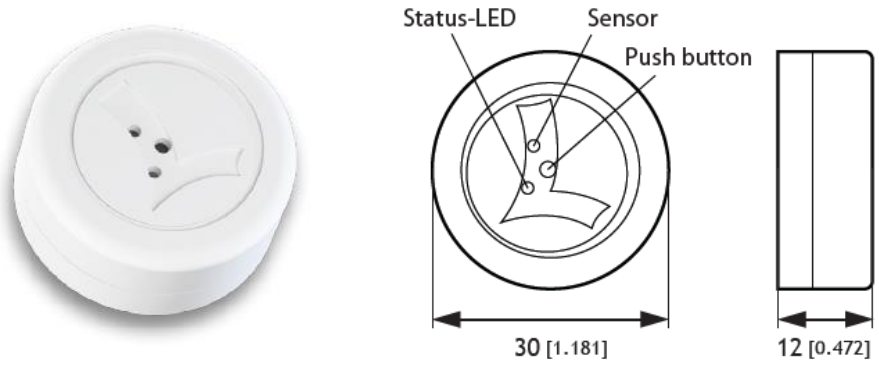



Figure 3: LOYBT-TEMPx environmental sensor

### Service-Button

A short button press wakes up the device and initiates different actions dependent on the current state of the device:

- If the LOYBT-TEMPx is unprovisioned, the provisioning process is initiated.
- If the LOYBT-TEMPx is provisioned, the device starts a publication sequence that contains additional data like firmware version and build timestamp. At the beginning of the wake-up period the friendship is terminated, the device can listen to standard mesh messages (node-reset, fmw-update initialization etc.). Before the device finally goes to sleep again, friendship relation is tried to be reestablished.

A long button press (15 seconds) resets the device to factory default (and removes the device from the mesh network). The unprovisioned state is finally indicated by the Status LED (Blinking 3 times).

During DFU-mode (special mode for transferring firmware image via a connection) a 5 second button press will abort this process and bring the device back in mesh operation.

### Status LED

The LOYBT-TEMPx provides a red status-LED. The behavior of this LED is as follows:

- Blinking 3 times on power-up if unprovisioned
- Blinking 3 times if device gets unprovisioned (e.g., after device reset)
- Blinking 1 time on power-up if provisioned
- Blinking 1 time after wake-up caused by a button press
- Indicating provisioning/configuration state if attention timer feature is used (continues blinking)[2]
- Indicating a firmware update procedure (continues short flash blinking, 5 seconds interval)

[2] Using the attention timer will result in blinking at any time, but the LOYBT-TEMPx has to be awake to receive the command.

### Battery

A CR2032 lithium battery is used as power supply for the LOYBT-TEMPx. To ensure a long battery lifetime, the device is in sleep mode most of the time. Depending on the state it wakes up in different intervals for various actions. The expected lifetime is shown in Table 1. The lifetime calculation is only valid if cadence in sensor setup server and periodic publishing are not used (not configured). This way the sensor is publishing sensor data only at a predefined interval of 5 minutes or if the temperature changes more than 0.5°C since the last reported measurement. Additional publications would reduce the battery lifetime.

| Device State | Current Consumption | Expected Battery Lifetime[3] |
|---|---|---|
| Unprovisioned | 3 µA | > 2 years |
| provisioned, in friendship | 4.5 µA | > 1.3 years |
| Provisioned, not in friendship | 6.4 µA | > 1 year |

Table 1: LOYBT-TEMPx battery lifetime.

### Models and Sensor Properties

The model composition for the LOYBT-TEMPx is shown in Table 2.

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x0000 | Configuration Server | Primary | Network Configuration |
| 0x0002 | Health Server | Primary | Status Report |
| 0x1000 | Generic OnOff Server | Primary | LED |
| 0x100C | Generic Battery Server | Primary | Battery Status |
| 0x1100 | Generic Sensor Server | Primary | Temperature, Humidity, Occupancy |
| 0x1101 | Generic Sensor Setup Server | Primary | Temperature, Humidity, Occupancy |
| 0x0AA00001 | LOYTEC Device Server | Primary | Device Extension |

Table 2: LOYBT-TEMPx composition data.

***Recommendation:*** *Due to the low-power behavior of the device cadence and publication interval for sensor data shall not be configured. Instead, the internal mechanism shall be used, only the publication address must be configured[4].*

[3] The calculation of the lifetime considers an efficiency of 30% of the CR2032 (220mAh) battery, the efficiency includes self-discharge and a high safety margin to ensure that the current peaks during wake-up can still be provided by an already discharged battery.

[4] LOYTEC controllers are following this recommendation and configure the publication address only.

The properties provided by the sensor server are listed in Table 3.

| Message Type | Property-ID | Property Name | Characteristic[5] |
|---|---|---|---|
| Sensor Status (0x52) | 0x0075 | Precise Present Ambient Temperature | Temperature |
| Sensor Status (0x52) | 0x0076 | Present Ambient Relative Humidity | Humidity |
| Sensor Status (0x52) | 0x004D | Presence Detected (LOYBT-TEMP2 only) | Boolean |

Table 3: LOYBT-TEMPx message types and properties[6].

The properties provided by the generic battery server[7] are listed in Table 4.

| Message Type | Property Name |
|---|---|
| Generic Battery Status (0x8224) | Generic Battery Level |
| Generic Battery Status (0x8224) | Generic Battery Flags |

Table 4: LOYBT-TEMPx message types and properties.

### Provisioning and Configuration[8]

The provisioning and the configuration of the device is different to normal mesh nodes due to the LOYBT-TEMPxs low power feature. Manual interaction is required to wake-up the device. Additionally, the device will be awake only for a defined amount of time before it goes to sleep again (typically 30 seconds). This time-window can be used for provisioning and configuration of the LOYBT-TEMPx. To provision the LOYBT-TEMPx successfully the provision algorithm has to align with the following constraints:

- Initiate the provisioning by pressing the button on the device (device wake up).
- Afterwards the device is emitting an unprovisioned beacon (30 seconds window).
- The provisioner can now scan for the device and add it to the mesh-network.
- Once the device is provisioned, another 30 seconds window allows for device configuration. This period can be used to configure device publications (typically for the sensor server and battery server models). The attention timer can also be used by the provisioner to indicate this state via feedback LED.
- After the configuration window is finished the device tries to establish friendship and goes to sleep.

[5] Characteristics according to GATT Specification Supplement v4 [10].

[6] Properties according Mesh Device Properties v2 Specification [11].

[7] According to Mesh Model v1.1 Specification [3].

[8] When using the Bluetooth Mesh commissioning page on a suitable LOYTEC controller the required actions are reduced to a single press for device wakeup, everything else will be done automatically. For details refer to the Bluetooth chapter in the LOYTEC Device User Manual [1].

#### Operation in a Bluetooth Mesh network

The sensor is waking up every minute for measurements (temperature, humidity, battery voltage). If the temperature has changed more than 0.5°C since the last sensor data publication the new values are reported immediately. Otherwise, the sensor data is reported once every 5 minutes (this periodic publication also includes presence in case of a LOYBT-TEMP2). The reported battery level is an average over the last 10 minutes whereas reported temperature and humidity are actual values.

For the LOYBT-TEMP2 an additional wake up triggered by an occupancy event (vibration) can occur. A status change (vacant -> occupied) is reported immediately by a sensor status message via the PRESENCE DETECTED property. The status gets vacant again if no movement has been detected for a full period of two consecutive periodic reports.

On a button press event, the device wakes up and disables friendship. Afterwards it publishes the sensor data and additional vendor specific properties (firmware version and build timestamp). A 5 second window begins at this point, which allows to interact with the device (e.g., remove it from mesh, change configuration etc.). At the end of this window the device tries to establish friendship again and goes to sleep.

### 5.2.2 Intended Use

The LOYBT-TEMPx environmental sensor is a battery powered low power device for integration in SIG-compliant Bluetooth Mesh ecosystems. After adding the sensor to a mesh-ecosystem the device can be placed at the location of your choice (even outside the range of a friend-device).

It provides temperature, rel. humidity and battery status periodically every 5 minutes. In addition, it publishes sensor data on change of temperature value of at least 0.5°C since last publication.

Additionally, the LOYBT-TEMP2 can be used to detect vacant and occupied workspaces.

Operating conditions are temperatures from 0 °C to 50 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP20.

### 5.2.3 Installation Instructions

- The device is suitable for wall mounting, either with a screw or adhesive tape.
- Follow the safety instructions (see chapter 2).
- Press the button on the device to initiate Provisioning and Device Configuration.
- Once the device is provisioned either wait at least 5 minutes or press the button again to get sensor data.
- The device can be placed anywhere in the range of the mesh-system. For long battery life a mounting position near a device supporting the friend-feature is recommended.

## 5.3 LOYTEC LOYBT-MSx(-B) Multi-Sensor

### 5.3.1 Device Description

The LOYBT-MSx is a multi-sensor based on the Bluetooth SIG qualified mesh stack (Declaration-ID: Design number (DN) Q301729, contains qualified designs: 239299 (controller subsystem Bluetooth 5.4), 239354 (host subsystem Bluetooth 5.4) and 226841 (Mesh Protocol 1.1, Mesh Model 1.1 and NLC-Profiles 1.0).

The LOYBT-MSx series represents a generation of wirelessly integrated LOYTEC multi-sensors. They perform motion/presence detection, illuminance, temperature and humidity measurements, provide digital inputs, support the L-RC1 remote control and feature a Bluetooth Mesh to DALI gateway.

Figure 4: LOYBT-MS2 and LOYBT-MS2-B multi-sensor for office applications.

Figure 5: LOYBT-MS3 and LOYBT-MS3-B multi-sensor.

Figure 6: LOYBT-MS4 multi-sensor with flat lens.

The multi-sensors are powered either via a DC-power supply (12V or 24V, e.g. LOY-POW2404) or a DALI power supply (e.g. LDALI-PWR1). If a DALI power supply is used

additional DALI ballasts can be connected to the DALI-line and be controlled via the gateway function of the sensor. The current consumption is typically 6 mA (15mA max.).

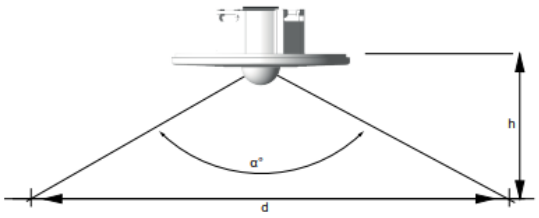
***Note:*** *The DC-power supply shall not provide currents of more than 1A.*

### Occupancy Detection - PIR

The LOYBT-MSx performs motion detection with a high resolution PIR sensor.

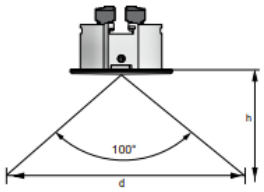
The LOYBT MS2/MS3 presence detection zone diameter of 10.8 m at 3 m mounting height is ideal to cover a typical office room or an area in an open office space. Due to the wide detection range the sensor type is also well suited for high bay applications with mounting heights of up to 12 m.

The LOYBT-MS4 provides a flat lens and the presence detection zone diameter is 7 m at 3 m mounting height. It is suitable for mounting heights of up to 5 m.




**Mounting Height / Coverage LOYBT-MS2/MS3**

| h [m] | d [m] | A [m²] | α[°] |
|---|---|---|---|
| 1.5 | 5.4 | 23 | 122 |
| 2.0 | 7.2 | 41 | 122 |
| 2.5 | 9.0 | 64 | 122 |
| 2.7 | 9.7 | 75 | 122 |
| 3.0 | 10.8 | 92 | 122 |
| 3.5 | 12.6 | 125 | 122 |
| 4.0 | 14.4 | 164 | 122 |
| 4.5 | 16.2 | 207 | 122 |
| 5.0 | 18.0 | 256 | 122 |
| 6.0 | 18.0 | 256 | 112 |
| 8.0 | 18.0 | 256 | 96.7 |
| 10.0 | 18.0 | 256 | 84 |
| 12.0 | 18.0 | 256 | 73.6 |




**Mounting Height / Coverage LOYBT-MS4**

| h [m] | d [m] | A [m²] | α[°] |
|---|---|---|---|
| 1.5 | 3.6 | 10.0 | 100 |
| 2.0 | 4.8 | 17.8 | 100 |
| 2.5 | 6.0 | 27.9 | 100 |
| 2.7 | 6.4 | 32.5 | 100 |
| 3.0 | 7.2 | 40.2 | 100 |
| 3.5 | 8.3 | 54.7 | 100 |
| 4.0 | 9.5 | 71.4 | 100 |
| 4.5 | 10.7 | 90.3 | 100 |
| 5.0 | 11.9 | 111.5 | 100 |

Figure 7: LOYBT-MSx multi-sensor PIR detection range

### Occupancy Detection - Acoustic

Beside the PIR sensor the LOYBT-MSx provides acoustic presence detection. This feature is disabled by default. The sensitivity can be adjusted separately for both detection methods.

Both methods are combined to generate a single occupancy signal which is represented via the PRESENCE DETECTED property of a sensor server model.

### Illuminance Measurement

The LOYBT-MSx allows to measure lux levels in the range of 0 – 4000 lux.

The measured values are represented by the PRESENT AMBIENT LIGHT LEVEL property of a separate sensor server instance.

| | |
|---|---|
| *Note:* | *The illuminance sensor is reporting approximately the same value as a lux meter when placed at the same position. Nevertheless, the spectral distribution of the light source may result in different values when comparing the reported measurements with those of a lux-meter.* |

| | |
|---|---|
| *Note:* | *Since the light sensor is never placed exactly on the position at which the illuminance must be measured (the sensor is mounted in the ceiling whereas a minimum illuminance is defined for the workspace below), a calibration routine is required to identify the relationship between sensor and illuminance measurements on the target position. The LOYTEC controllers provide such a calibration routine (refer to [1]).* |

### Temperature and Humidity Measurement

In addition to occupancy and lux measurement, the LOYBT-MSx comes with integrated temperature and humidity sensors. In room automation applications, the additional sensor values can be used to calculate the current dew point. The sensor can perform temperature measurements in the range from -5 °C to 60 °C with a resolution of 0.1 °C and an accuracy of ±0.2 °C. The relative humidity (0 % to 100 %) is provided with a resolution of 0.5 % and an accuracy of ±2.2 % (@25 °C between 20 % and 80 % R.H.).

The values are represented by the PRECISE AMBIENT TEMPERATURE and PRESENT AMBIENT RELATIVE HUMIDITY properties of a separate sensor server instance.

### Digital Inputs

On the back of the sensor, there is a connector for three digital inputs, allowing to connect conventional switches and push-buttons, window contacts, dew point sensor, etc.

The wire length connected to the digital inputs shall be below 10 m.

The values of input are represented via the LOYTEC DIIR vendor model.

### Infrared Receiver

An integrated infrared receiver is designed to work with the L-RC1 infrared remote control, which is available as optional accessory (see Figure 8). The L-RC1 is an infrared remote control, optimized for room automation applications. It allows the control of the room's light, sun blinds and HVAC system.


Figure 8: L-RC1 infrared remote control for LOYBT-MSx.

Table 5 lists all button-instances of the LOYBT-MSx and the corresponding inputs.

| DALI-Instance Number | Type | Input | Description |
|---|---|---|---|
| 04 | Digital Input | DI1 | DI1 on back of LOYBT-MSx-BT |
| 05 | Digital Input | DI2 | DI2 on back of LOYBT-MSx-BT |
| 06 | Digital Input | DI3 | DI3 on back of LOYBT-MSx-BT |
| 07 | Button | IR-Remote Cmd 1 | CH1 |
| 08 | Button | IR-Remote Cmd 2 | CH2 |
| 09 | Button | IR-Remote Cmd 3 | Sunblind UP |
| 10 | Button | IR-Remote Cmd 4 | Sunblind AUTO |
| 11 | Button | IR-Remote Cmd 5 | Sunblind DOWN |
| 12 | Button | IR-Remote Cmd 6 | Lights UP |
| 13 | Button | IR-Remote Cmd 7 | Lights AUTO |
| 14 | Button | IR-Remote Cmd 8 | Lights DOWN |
| 15 | Button | IR-Remote Cmd 9 | Scene A |
| 16 | Button | IR-Remote Cmd 10 | Scene B |
| 17 | Button | IR-Remote Cmd 11 | Scene C |
| 18 | Button | IR-Remote Cmd 12 | A/C |
| 19 | Button | IR-Remote Cmd 13 | Temp + |
| 20 | Button | IR-Remote Cmd 14 | Temp - |
| 21 | Button | IR-Remote Cmd 15 | Fan AUTO |
| 22 | Button | IR-Remote Cmd 16 | Fan UP |
| 23 | Button | IR-Remote Cmd 17 | Occupied |
| 24 | Button | IR-Remote Cmd 18 | Vacant |

Table 5: Mapping of Button/Input-Instances of LOYBT-MSx.

The remote control is represented via the LOYTEC DIIR vendor model.

### Remote Bluetooth Button Switch Feature

As mentioned in [1] LOYTEC controllers with Bluetooth also support the integration of the EnOcean Bluetooth Switch PTM215B/PTM216B modules. Since those modules are communicating via common Bluetooth beacons instead of mesh-messages the range of emitted messages is limited to 1 hop. The LOYBT-MSx is capable of recognizing those messages and forward them to a LOYTEC controller via mesh. As a result the button module

based on PTM215B/PTM216B can be located inside the direct radio range of any LOYBT-MSx or LOYTEC-controller.

### Asset Tracking and Beaconing

The LOYBT-MSx series can scan for Bluetooth-beacons. A maximum of 32 active beacons (Eddystone UID+TLM or iBeacon) can be managed by the device. The asset data can be queried via a vendor model and is available on data point level on the controller. The asset data contains parameters like identifiers and RSSI-values. For more information refer to [1].

Moreover, the LOYBT-MSx supports beaconing for various frame formats (iBeacon, Eddystone-UID beacon or the LOYTEC-specific LWEB-beacon), each of which can be individually configured.

- iBeacon and Eddystone-UID beacon can be used for indoor localization and indoor navigation systems.
- The LWEB beacon offers access to LWEB-802 views via the LWEB app on a mobile device (iOS/Android) and thus provides access to room control and monitoring functions.

The beacon parameters are available as datapoints on LOYTEC-controllers. For more information refer to [1].

### Bluetooth Mesh to DALI Gateway Feature

In addition to the sensor functionality the LOYBT-MSx can act as a gateway to a DALI-subsystem. If the device is supplied by a DALI power supply (e.g. LDALI-PWR1), DALI-ballasts connected to this DALI-line can be controlled via Bluetooth Mesh ecosystem.

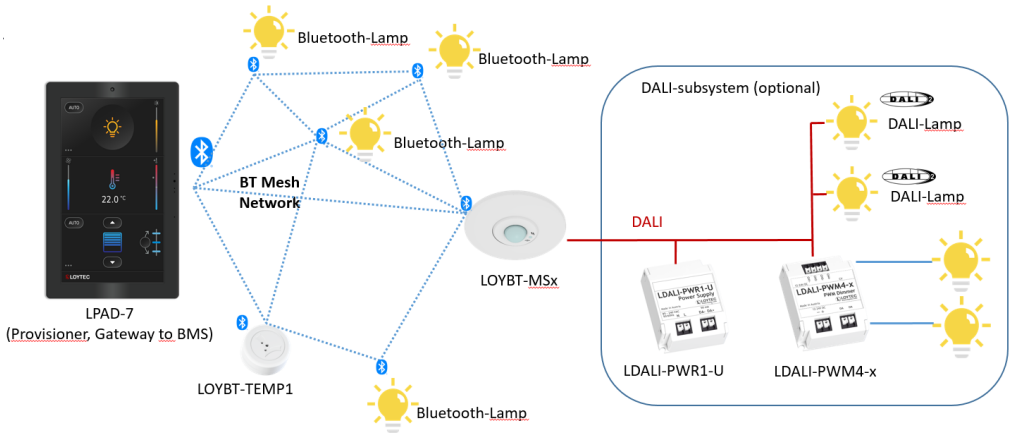



Figure 9: LOYBT-MSx acting as Bluetooth Mesh to DALI interface.

The integration of DALI ballasts into Bluetooth Mesh networks allows (re)use of proven DALI-luminaires and -technology as well as existing installations to be retrofitted easily.

Up to 16 DALI-ballasts can be integrated with the help of the gateway. They can be separated in up to 4 groups, which are exposed to the Bluetooth Mesh ecosystem as individually accessible Bluetooth Mesh luminaires. From a DALI-perspective dimmable and tunable white capable ballasts are supported.

| | |
|---|---|
| *Note:* | *The grouping of the DALI-ballasts to DALI groups 1-4 is performed via a vendor model, which is accessed by LOYTEC controllers during assignment of DALI-ballasts to lamp actuators on the commissioning page of the WebUI (refer to [1]).* |

### Status LED

The LOYBT-MSx provides a red status-LED. The behavior of this LED is as follows:

- Blinking if motion is detected if device is unprovisioned (check basic functionality and support for sensor head adjustment during installation)
- Blinking if attention timer is set (e.g. WINK-action via WebUI)
- Blinking 3 times on power-up if unprovisioned
- Blinking 3 times if device gets unprovisioned
- Blinking 1 time on power-up if provisioned

### Models

The model composition for the LOYBT-MSx is shown in Table 6.

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x0000 | Configuration Server | Primary (0) | Network Configuration |
| 0x0002 | Health Server | Primary (0) | Status Report |
| 0x0004 | Remote Provisioning Server | Primary (0) | Range Extension |
| 0x1011 | Generic Admin Property Server | Primary (0) | Device Property Report |
| 0x1012 | Generic Manufacturer Property Server | Primary (0) | Device Property Report |
| 0x1013 | Generic User Property Server | Primary (0) | Device Property Report |
| 0x0AA00001 | LOYTEC Device Server | Primary (0) | Device Extension |
| 0x0AA00003 | LOYTEC DFU Data Transfer Server | Primary (0) | Transfer Firmware Image |
| 0x0AA00005 | LOYTEC Asset Tracking Server | Primary (0) | Asset Tracking |
| 0x0AA00007 | LOYTEC Beacon Server | Primary (0) | Beacon Configuration |
| 0x0AA00009 | LOYTEC Remote Button Switch Server | Primary (0) | Bluetooth Button Switch for PTM215/216B |
| 0x0AA01007 | LOYTEC DALI Gateway Server | Primary (0) | DALI-Gateway Configuration |
| 0x1100 | Sensor Server | Sec. (1) | Occupancy |
| 0x1101 | Sensor Setup Server | Sec. (1) | Occupancy |
| 0x1100 | Sensor Server | Sec. (2) | Illuminance |
| 0x1101 | Sensor Setup Server | Sec. (2) | Illuminance |
| 0x1100 | Sensor Server | Sec. (3) | Temperature, Humidity |

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x1101 | Sensor Setup Server | Sec. (3) | Temperature, Humidity |
| 0x1000 | Generic OnOff Server | Sec. (4) | control LED for occupancy indication |
| 0x0AA01001 | LOYTEC DIIR Server | Sec. (4) | Digital Inputs, Infrared (Remote Control) |
| 0x0002 | Health Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1000 | Generic OnOff Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1002 | Generic Level Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1004 | Generic Default Transition Time Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1006 | Generic Power OnOff Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1007 | Generic Power OnOff Setup Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1300 | Light Lightness Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1301 | Light Lightness Setup Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1303 | Light CTL Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1304 | Light CTL Setup Server | Sec. (5,7,9,11) | DALI-Gateway (G1, G2, G3, G4) |
| 0x1002 | Generic Level Server | Sec. (6,8,10,12) | DALI-Gateway (G1, G2, G3, G4) – colour temperature |
| 0x1306 | Light CTL Temperature Server | Sec. (6,8,10,12) | DALI-Gateway (G1, G2, G3, G4) – colour temperature |

Table 6: LOYBT-MSx composition data.

### Properties of Sensor Server and Generic Property Server

The properties provided by the sensor servers are listed in Table 7.

| Message Type | Property ID | Property Name | Characteristic[9] |
|---|---|---|---|
| Sensor Status (0x52) | 0x004D | Presence Detected | Boolean |
| Sensor Status (0x52) | 0x004E | Present Ambient Light Level | Illuminance |
| Sensor Status (0x52) | 0x0075 | Precise Present Ambient Temperature | Temperature |
| Sensor Status (0x52) | 0x0076 | Present Ambient Relative Humidity device property | Humidity |

Table 7: LOYBT-MSx message types and properties[10].

The properties provided by the property servers are listed in Table 8.

| Message Type | Property ID | Property Name | Characteristic[11] |
|---|---|---|---|
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x000B | Device Country of Origin | Country Code |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x000E | Device Firmware Revision | Fixed String 8 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0010 | Device Hardware Revision | Fixed String 16 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0011 | Device Manufacturer Name | Fixed String 36 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0012 | Device Model Number | Fixed String 24 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0019 | Device Serial Number | Fixed String 16 |

[9] Characteristics according to GATT Specification Supplement v4 [10].

[10] Properties according Mesh Device Properties v2 Specification [11].

[11] Characteristics according to GATT Specification Supplement v4 [10].

| Message Type | Property ID | Property Name | Characteristic[11] |
|---|---|---|---|
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0013 | Device Operating Temperature Range Specification | Temperature Range |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0017 | Device Runtime Since Turn On | Time Hour 24 |

Table 8: LOYBT-MSx property server message types and properties[12].

### Provisioning, Configuration and Operation Behavior

The provisioning and the configuration of the device is identical with the handling of any other regular mesh node. Ensure that publications are configured for each of the sensor models. Furthermore, the cadence for occupancy must be setup properly to get event notifications.

Afterwards the sensor will report the sensor readings either periodically (illuminance, temperature, humidity) or event based (presence).

On power-up the sensor is automatically identifying the power supply and in case of a DALI power supply a DALI-scan is performed. All connected DALI ballasts are identified, already addressed devices keep unchanged, whereas unaddressed ballasts get a DALI address. As long as there are no DALI-groups in use all addressed devices are assigned automatically to DALI group 1 and can be controlled via the first lamp actuator (represented by the elements 5&6 of the model composition)[13]. This allows out of the box control of DALI-ballasts.

*Hint:* *A third party tool can be used for scanning, addressing and grouping (DALI group 1-4, DALI group 0 is not used). On power-up the multi-sensor will automatically find the preconfigured devices.*

*Hint:* *To reset the database of DALI-devices in the multi-sensor either the sensor or the DALI-database (via WebUI of a LOYTEC-controller) must be reset[14].*

**Reset to factory default:**

There are 3 ways to reset the LOYBT-MSx:

- Remove the device from the mesh (with the help of the provisioner)

[12] Properties according Mesh Device Properties v2 Specification [11].

[13] If there are already DALI-groups in use newly addressed devices are not assigned to any group, so that already configured groups keep unchanged.

[14] A LOYTEC controller offers simplified configuration on the WebUI (see also [1]).

- Connect the inputs DI2 and DI3 as shown in Figure 10 and power-up the device

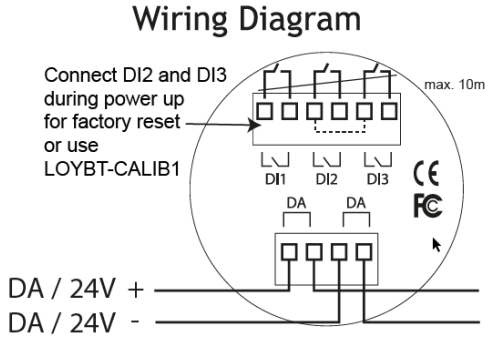



Figure 10: Wiring diagram and info about factory reset.

- As alternative the LOYBT-CALIB1 can be used (no need for physical access to the device).

### 5.3.2 Intended Use

The LOYTEC LOYBT-MSx is intended to be used as environment sensor for room automation in a Bluetooth Mesh lighting control system. The sensor provides information about presence, illuminance, temperature and humidity as well as support for other building automation related features like digital inputs for window contacts, room control via IR remote control or a Bluetooth Mesh to DALI gateway.

The sensors are intended to be used on a ceiling or in suspended ceilings. The LOYBT-MS2 can be mounted in-wall in standard flush-mounted boxes, spring snap in false ceilings and on-wall with a surface mounting box, available as an accessory. The LOYBT-MS3 and LOYBT-MS4 are designed to be used with spring snaps in suspended ceilings.

Figure 11: LOYBT-MSx mounting options.

Operating conditions are temperatures from 0 °C to 50 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP20.

### 5.3.3 Installation Instructions

- The LOYBT-MS2 can be mounted in-wall in standard flush-mounted boxes, on-wall with a surface mounting box, or spring snap in false ceilings
- The LOYBT-MS3/MS4 is intended to be mounted in false ceilings.
- Follow the safety instructions (see chapter 2).
- For different mounting options (in-wall, on-wall, spring) refer to the installation sheet.
- Use cable tie to ensure proper strain relief (see Figure 12).

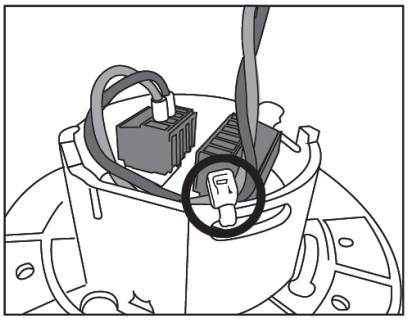


Figure 12: LOYBT-MS2/LOYBT-MS4 strain relief.

- Adjust the tilt angle of the sensor head for better coverage of the detection area.
- Use indicator (red LED) for verification of motion detection (before device commissioning).

## 5.4 LOYTEC LOYUNO-L UNOlite Indoor Air Quality Sensor

### 5.4.1 Device Description

The LOYUNO-L represents the pinnacle of indoor air quality monitoring, purposefully designed for effortless integration with BAS/BMS systems. The advanced instrument detects and analyzes a wide range of indoor air quality factors including Ultra-fine, Fine and Standard Suspended Particulates (PM1, PM2.5 and PM10), Carbon Dioxide (CO2), Total Volatile Organic Compounds (TVOC), while also monitoring Temperature and Humidity levels.

LOYUNO-L ensures accurate data, serving as a vital component in achieving LEED green or WELL certification of your building. Rigorously tested and certified for its precise sensing capabilities in detecting PM2.5, CO2, and TVOC, the LOYUNO-L meets the stringent standards set by WELL v2.

The LOYUNO-L comes equipped with Bluetooth Mesh capabilities (declaration-ID: D051757, Bluetooth 5.1), seamlessly integrating in LOYTEC Bluetooth Mesh ecosystems. In addition, the LOYUNO-L also provides a Modbus RTU and BACnet MS/TP interface for BMS integration, which makes it well-suited for both new construction projects and retrofitting BAS/BMS systems.


Figure 13: LOYUNO-L for indoor air quality monitoring.

The LOYUNO-L is either powered by a DC-power supply (12V-24V DC / 24V AC) via V+/V- terminals or by a 12V/1A dc power adapter via the DC charger input. The maximum power consumption is 6 W.

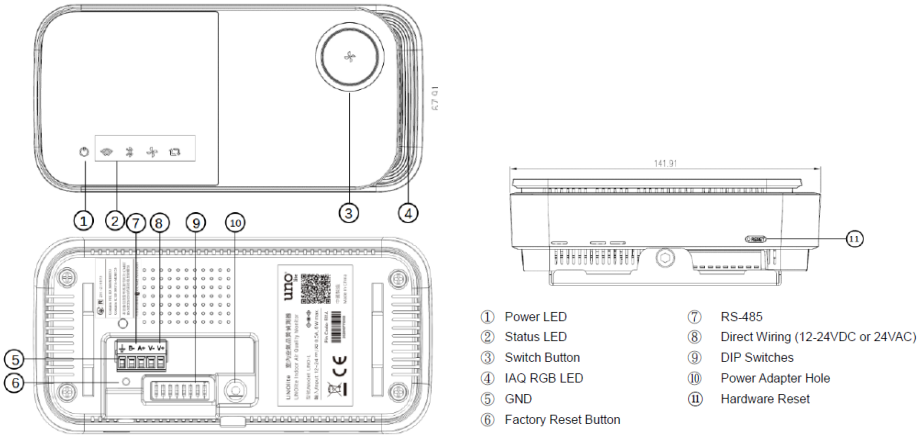



Figure 14: LOYUNO-L functional description.

### Air Quality Measurement

The LOYUNO-L evaluates particulate matter concentration for different particle sizes:

PM1 in the range from 0-1000µg/m$^3$ with an accuracy of ± (5 µg/m$^3$ + 20%) in the range of 0-100µg/m$^3$ and ±10% in the range of 100-1000µg/m$^3$ is reported via the proprietary property MASS CONCENTRATION PM1.0 (0x00C0) of the sensor model.

PM2.5 in the range from 0-1000µg/m$^3$ with an accuracy of ± (5 µg/m$^3$ + 20%) in the range of 0-100µg/m$^3$ and ±10% in the range of 100-1000µg/m$^3$ is reported via the proprietary property MASS CONCENTRATION PM2.5 (0x00C1) of the sensor model.

PM10 in the range from 0-1000µg/m$^3$ with an accuracy of ± (5 µg/m$^3$ + 20%) in the range of 0-100µg/m$^3$ and ±25% in the range of 100-1000µg/m$^3$ is reported via the proprietary property MASS CONCENTRATION PM10 (0x00C2) of the sensor model.

Moreover, it is capable to measure:

CO2 in the range from 400-5000ppm with an accuracy of ± (50ppm + 5%) is reported via the property PRESENT AMBIENT CO2 CONCENTRATION (0x0077) of the sensor model.

TVOC in the range for 0-30000ppb with an accuracy of ±15% is reported via property PRESENT AMBIENT VOC CONCENTRATION (0x0078) of the sensor model.

### Temperature and Humidity Measurement

In addition to air quality analysis, the LOYUNO-L comes with integrated temperature and humidity sensors. The sensor can perform temperature measurements in the range from 0 °C to 50 °C with an accuracy of ±1 °C (@25°C and 50 % R.H.). The relative humidity (10 % to 80 %) is provided with an accuracy of ±10 % (@25 °C and 50 % R.H.).

The temperature values are represented by the PRESENT INDOOR AMBIENT TEMPERATURE (0x0056) and PRECISE PRESENT AMBIENT TEMPERATURE (0x0075) properties, whereas the humidity is represented by the PRESENT INDOOR RELATIVE HUMIDITY (0x00A7) and PRESENT AMBIENT HUMIDITY (0x0076) properties, each of which is implemented in separate sensor server instances.

### LED Indication

The IAQ-RGB LED (number 4 in Figure 14) is used to indicate different states and can be turned on with the switch button on the front (number 3 in Figure 14):

| Indication | Description |
|---|---|
| Breathing Light BLUE | Device is booting |
| Breathing Light GREEN | Indoor Air Quality is GOOD |
| Breathing Light YELLOW | Indoor Air Quality is MODERATE |
| Breathing Light RED | Indoor Air Quality is UNHEALTHY |
| Breathing Light PURPLE | Indoor Air Quality is VERY UNHEALTHY |
| Steady OFF | IAQ-RGB LED turned off via switch button |

Table 9: LOYUNO-L RGB-LED description.

Status LED Indication:

| Indicator | Behavior | Description |
|---|---|---|
| Power | Steady Off | Device is not powered correctly. |
| Power | Steady On | Device is powered. |
| BLE | Steady Off | No BLE connection. |
| BLE | Steady On | In BLE connection. |
| BLE | Flash Rapidly | In BLE binding process. |
| Wi-Fi | Steady Off / On | Wi-Fi not used on this device type. |
| Equipment | Reserved | Reserved |
| Filter Status | Reserved | Reserved |

Table 10: LOYUNO-L status LED description.

During factory reset all LEDs flash rapidly.

If the attention timer is set (BT-mesh operation) the Status-LEDs are running a light sequence.

### Models and Sensor Properties

The model composition for the LOYUNO-L is shown in Table 11.

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x0000 | Configuration Server | Primary (0) | Network Configuration |
| 0x0002 | Health Server | Primary (0) | Status Report |
| 0x1102 | Sensor Client | Primary (0) | |
| 0x1100 | Sensor Server | Sec (1) | CO2 |
| 0x1101 | Sensor Setup Server | Sec (1) | CO2 |
| 0x1100 | Sensor Server | Sec (2) | Indoor Temperature |
| 0x1101 | Sensor Setup Server | Sec (2) | Indoor Temperature |
| 0x1100 | Sensor Server | Sec (3) | Indoor Rel. Humidity |
| 0x1101 | Sensor Setup Server | Sec (3) | Indoor Rel. Humidity |
| 0x1100 | Sensor Server | Sec (4) | VOC |
| 0x1101 | Sensor Setup Server | Sec (4) | VOC |
| 0x1100 | Sensor Server | Sec (5) | PM1.0 |

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x1101 | Sensor Setup Server | Sec (5) | PM1.0 |
| 0x1100 | Sensor Server | Sec (6) | PM2.5 |
| 0x1101 | Sensor Setup Server | Sec (6) | PM2.5 |
| 0x1100 | Sensor Server | Sec (7) | PM10 |
| 0x1101 | Sensor Setup Server | Sec (7) | PM10 |
| 0x1100 | Sensor Server | Sec (8) | - |
| 0x1101 | Sensor Setup Server | Sec (8) | - |
| 0x1100 | Sensor Server | Sec (9) | Temperature |
| 0x1101 | Sensor Setup Server | Sec (9) | Temperature |

Table 11: LOYUNO-L composition data.

The properties provided by the sensor servers are listed in Table 12.

| Message Type | Property-ID | Property Name | Characteristic[15] |
|---|---|---|---|
| Sensor Status (0x52) | 0x0056 | Present Indoor Ambient Temperature | Temperature 8 |
| Sensor Status (0x52) | 0x0075 | Precise Present Ambient Temperature | Temperature |
| Sensor Status (0x52) | 0x0076 | Present Ambient Relative Humidity | Humidity |
| Sensor Status (0x52) | 0x0077 | Present Ambient CO2 Concentration | CO2 Concentration |
| Sensor Status (0x52) | 0x0078 | Present Ambient VOC Concentration | VOC Concentration |
| Sensor Status (0x52) | 0x00A7 | Present Indoor Relative Humidity | Humidity |
| Sensor Status (0x52) | 0x00C0 | Mass concentration PM 1.0 | - |
| Sensor Status (0x52) | 0x00C1 | Mass concentration PM 2.5 | - |
| Sensor Status (0x52) | 0x00C2 | Mass concentration PM 10 | - |

Table 12: LOYUNO-L sensor server message types and properties[16].

[15] Characteristics according to GATT Specification Supplement v4 [10].

[16] Properties according Mesh Device Properties v2 Specification [11].

#### Provisioning, Configuration and Operation Behavior

The provisioning and the configuration of the device is identical to the handling of any other regular mesh node. When setting up the publication intervals consider the internal sensor refresh rate of 10 seconds. Ensure that publications are configured for each of the sensor models.

Afterwards the device will report the sensor readings periodically.

**Factory Reset:**

After booting, press the button for factory reset on the backside of the device three times within 2 seconds (see Figure 14). It is recommended to use a paper clip to press the button. This will trigger a factory reset. Next, all values will be reset and the following action will take place:

- Turn the device in unprovisioned state

Additionally (not BT-mesh related) the following values will be restored to default:

- Modbus baud rate
- BACnet saved mac address
- CO2 auto baseline calibration is ON
- Sensor calibration settings

**Hardware Reset:**

Pushing the button on the bottom of the device will trigger a power cycle (see Figure 14). It is recommended to use a paper clip to press the button.

| | |
|---|---|
| *Note:* | *Integration via Modbus, BACnet is not part of this manual. For more detailed information for Modbus refer to [12], for BACnet refer to [13].* |

### 5.4.2 Intended Use

The LOYUNO-L is intended to be used as air quality sensor. It can be integrated in a BMS/BAS via BACnet MSTP, ModBus RTU and Bluetooth Mesh. The sensor provides information about Ultra-fine, Fine and Standard Suspended Particulates (PM1, PM2.5 and PM10), Carbon Dioxide (CO2), Total Volatile Organic Compounds (TVOC), temperature and humidity.

The sensors are intended to be wall mounted indoor at a height between 0.8 m and 1.5m. With the help of the included mounting kits it can be mounted on standard junction boxes of various regions (US, EMEA, China).

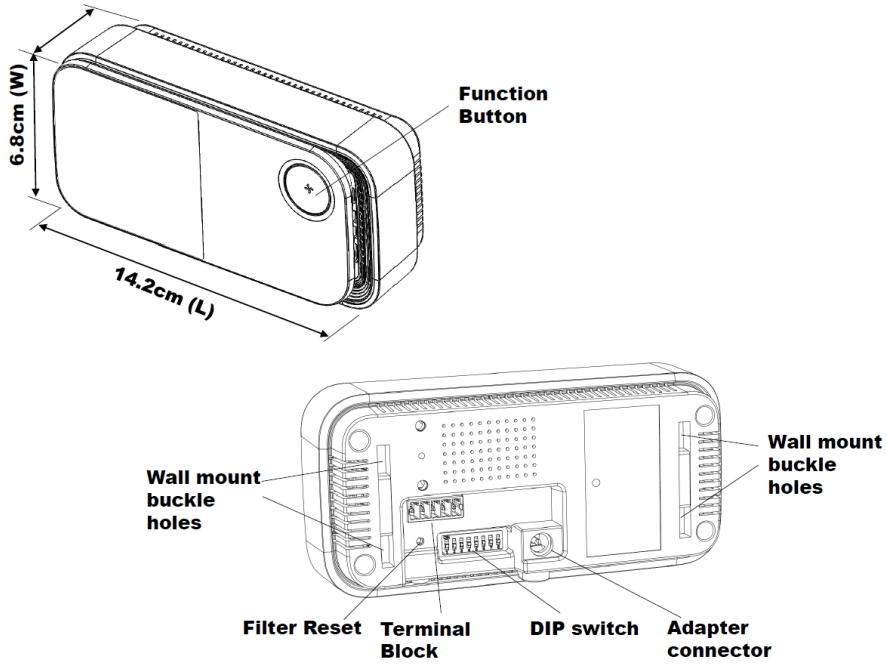



Figure 15: LOYUNO-L mechanical and electrical connections.

Operating conditions are temperatures from 0 °C to 50 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP20.

### 5.4.3 Installation Instructions

- The LOYUNO-L is intended to be mounted on-wall with the help of a mounting kit (included).
- Locate the LOYUNO-L
  - At least 5 meters away from operable windows, doors, and diffusers.
  - The optimal installation height is 0.8m to 1.5m from the ground.
  - Air is drawn into the LOYUNO-L from the lower side and there is natural air exchange on each side, it is vital that neither side of the device is covered. Any changes in airflow may affect the readings and accuracy.
  - Avoid direct sunlight.
  - Keep away from air-conditioning outlet.
  - Keep away from light heat source.
  - Keep away from fire and cooking areas.
- Follow the safety instructions (see chapter 2).
- Select suitable wall mount frame to meet different junction
  - Small Wall Mount frame (Delta Part No.: 3487312702), to be installed with 1 Gang Embedded Junction Box
  - Large Wall Mount frame (Delta Part No.: 3994041800), to be installed with 2 Gang Embedded Junction Box
  - Large Wall Mount frame cover can be mounted directly on a junction box

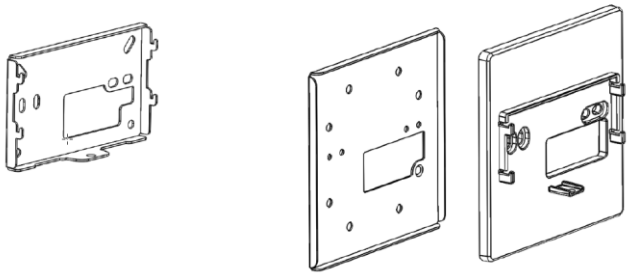


Figure 16: LOYUNO-L wall mount frames.

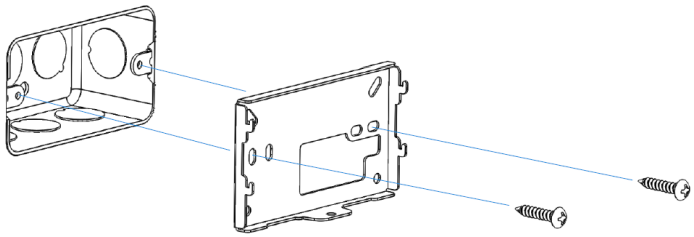


Figure 17: Install small Wall Mount frame with 1gang embedded junction box.

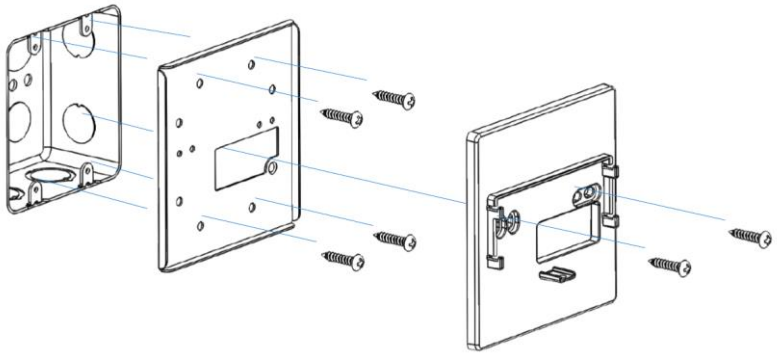


Figure 18: Install LOYUNO-L with large wall mount kit and 2 gang embedded junction box.

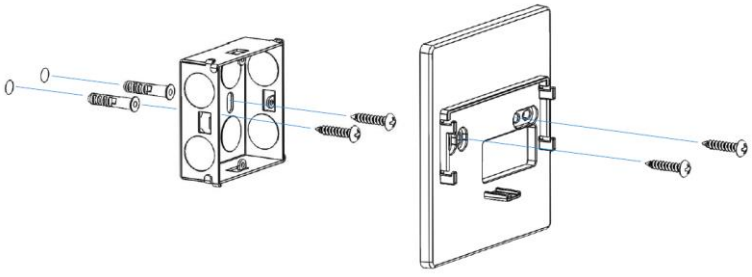


Figure 19: Install LOYUNO-L with large wall mount cover with junction box.

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- Arrange Power Lines
  - Insert wire cables to terminal plug and insert terminal plug
    Or
  - DC power plug to LOYUNO-L

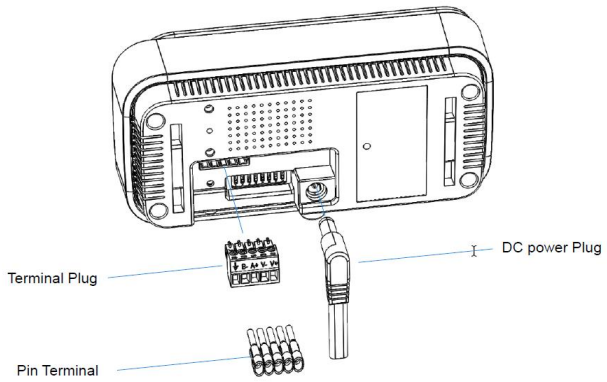


Figure 20: Connect Terminal Plug or DC Power Plug.

- Mount LOYUNO-L on four buckles of the wall mount fixture and fix the device with a M4 screw using a Hex screw-driver

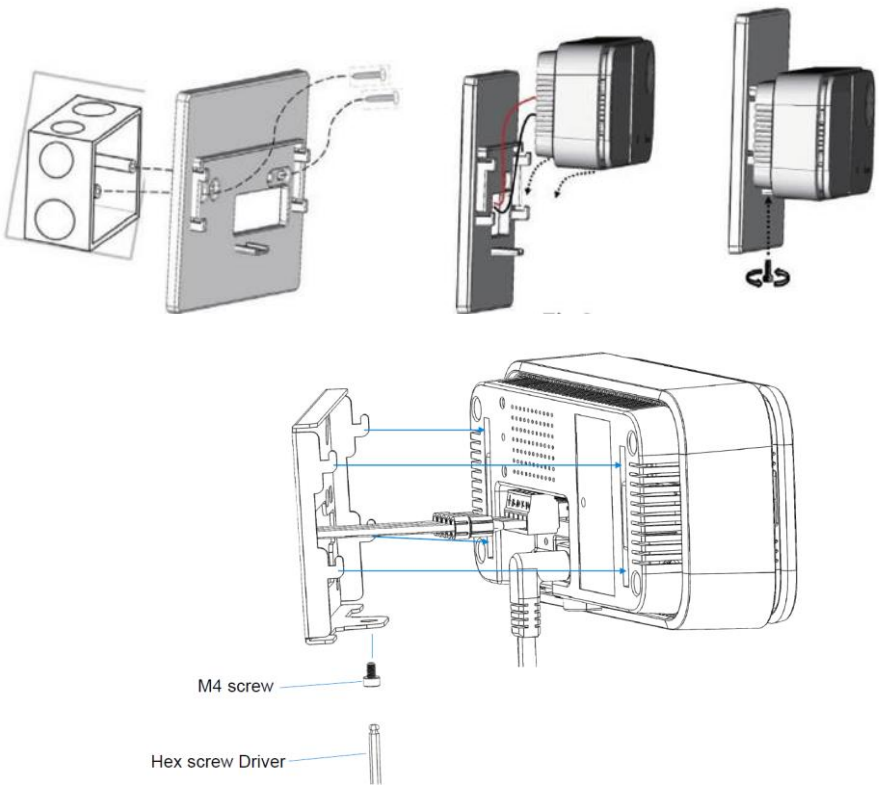


Figure 21: Mount on four buckles and fix LOYUNO-L with M4 screw.

# 6 LOYBT - Actuators

## 6.1 Overview

LOYTEC provides different types of actuators with a Bluetooth Mesh interface. This chapter deals with the characteristics of those devices.

## 6.2 LOYTEC LOYBT-SBM1 Sunblind Module

### 6.2.1 Device Description

The LOYBT-SBM1 sunblind module is a compact actuator for the control of sun blinds in a Bluetooth Mesh ecosystem. It is based on the Bluetooth SIG qualified mesh stack (Declaration-ID: Design number (DN) Q301729, contains qualified designs: 239299 (controller subsystem Bluetooth 5.4), 239354 (host subsystem Bluetooth 5.4) and 226841 (Mesh Protocol 1.1, Mesh Model 1.1 and NLC-Profiles 1.0).

The device is mains powered and comes with 2 built-in relay contacts, which are suitable to switch currents of up to 6A at 250V AC.

For sunblind control the module uses a vendor server model, which provides a command set that contains direction and duration information for the blinds connected to the relay outputs. This allows LOYTEC controllers with Bluetooth Mesh interface to control sun blinds wirelessly.

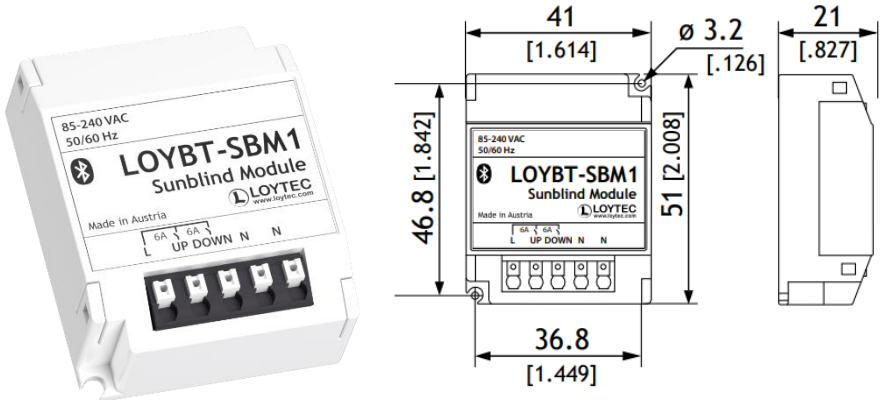


Figure 22: LOYBT-SBM1 sunblind module

The LOYBT-SBM1 is suited to control a single sunblind-motor, which is controlled by switching mains voltage to separate inputs for moving up and down (Figure 23).

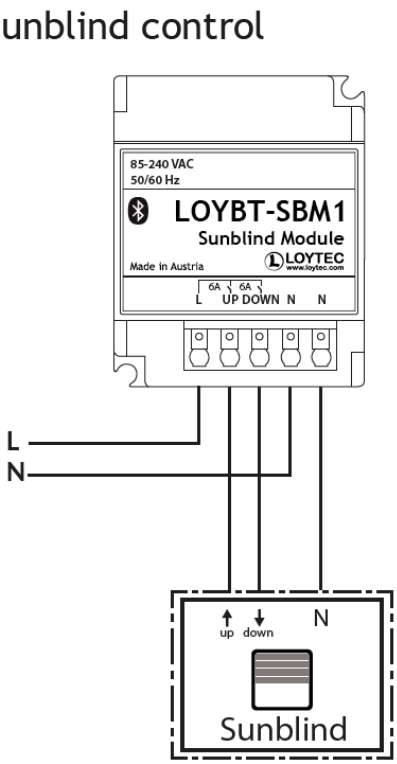


Figure 23: LOYBT-SBM1 module for control of a single sunblind motor

| *Note:* | *Sunblind control is supported via vendor models only.* |
|---|---|

### Reset-Button

A reset button on the backside of the device (operated by a proper tool or needle) allows to reset the device to factory default, which means the device is in an unprovisioned state afterwards.

| *Note:* | *Use a proper insulated tool for reset operation.* |
|---|---|

### Models

The model composition for the LOYBT-SBM1 is shown in Table 2.

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x0000 | Configuration Server | Primary(0) | Network Configuration |
| 0x0002 | Health Server | Primary(0) | |
| 0x0004 | Remote Provisioning Server | Primary(0) | Range Extension |
| 0x1011 | Generic Admin Property Server | Primary(0) | Device Property Report |

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x1012 | Generic Manufacturer Property Server | Primary(0) | Device Property Report |
| 0x1013 | Generic User Property Server | Primary(0) | Device Property Report |
| 0x0AA00001 | LOYTEC Device Server | Primary(0) | Device Extension |
| 0x0AA00003 | LOYTEC DFU Data Transfer Server | Primary(0) | Transfer Firmware Image |
| 0x0AA00009 | LOYTEC Remote Button Switch Server | Primary(0) | Bluetooth Button Switch for PTM215/216B |
| 0x0AA01005 | LOYTEC SB Server | Primary(0) | Sunblind Control |

Table 13: LOYBT-SBM1 composition data.

### Properties of Generic Property Server

The properties provided by the property server are listed in Table 14.

| Message Type | Property ID | Property Name | Characteristic[17] |
|---|---|---|---|
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x000B | Device Country of Origin | Country Code |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x000E | Device Firmware Revision | Fixed String 8 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0010 | Device Hardware Revision | Fixed String 16 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0011 | Device Manufacturer Name | Fixed String 36 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0012 | Device Model Number | Fixed String 24 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0019 | Device Serial Number | Fixed String 16 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0013 | Device Operating Temperature Range Specification | Temperature Range |

[17] Characteristics according to GATT Specification Supplement v4 [10].

| Message Type | Property ID | Property Name | Characteristic[17] |
|---|---|---|---|
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0017 | Device Runtime Since Turn On | Time Hour 24 |

Table 14: LOYBT-SBM1 message types and properties[18].

#### Provisioning, Configuration and Operation Behavior

The provisioning and the configuration of the device is identical with the handling of any other regular mesh node.

A Bluetooth enabled LOYTEC controller is needed to access the LOYTEC SB server model, which is required for sunblind control.

**Reset to factory default:**

There are 3 ways to reset the LOYBT-SBM1:

- Remove the device from the mesh (with the help of the provisioner)
- Press the reset button on the backside of the device for at least 10 seconds.
- As alternative the LOYBT-CALIB1 can be used (no need for physical access to the device).

### 6.2.2 Intended Use

The LOYTEC LOYBT-SBM1 is intended to be used as actuator for sunblind control in a Bluetooth Mesh system. The device allows to control a single sunblind motor.

The device is intended to be installed in a distribution box.

Operating conditions are temperatures from 0 °C to 50 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP20.

### 6.2.3 Installation Instructions

- The device is suitable for installation in a distribution box.
- Follow the safety instructions (see chapter 2).
- For wiring refer to the installation sheet or Figure 23.

[18] Properties according Mesh Device Properties v2 Specification [11].

## 6.3 LOYTEC LOYBT-IO1 I/O-Module

### 6.3.1 Device Description

The LOYBT-IO1 is a compact I/O module operated in a Bluetooth Mesh ecosystem. It is based on the Bluetooth SIG qualified mesh stack (Declaration-ID: Design number (DN) Q301729, contains qualified designs: 239299 (controller subsystem Bluetooth 5.4), 239354 (host subsystem Bluetooth 5.4) and 226841 (Mesh Protocol 1.1, Mesh Model 1.1 and NLC-Profiles 1.0).

The device is either mains powered (85-240 V AC) or supplied via a 24V AC / 24 V DC SELV-circuit. It comes with 12 univeral I/Os and 6 digital outputs (4x Relay, 2x TRIAC).

The LOYBT-IO1 integrates perfectly into the LOYBT product line. Bluetooth Mesh enabled LOYTEC controllers allow individual configuration of all I/Os (tailored to the respective application) via datapoints that are mapped to commands and properties of vendor models for each I/O.

| | |
|---|---|
| *Note:* | *Configuration and control of the I/Os is supported via vendor models only.* |

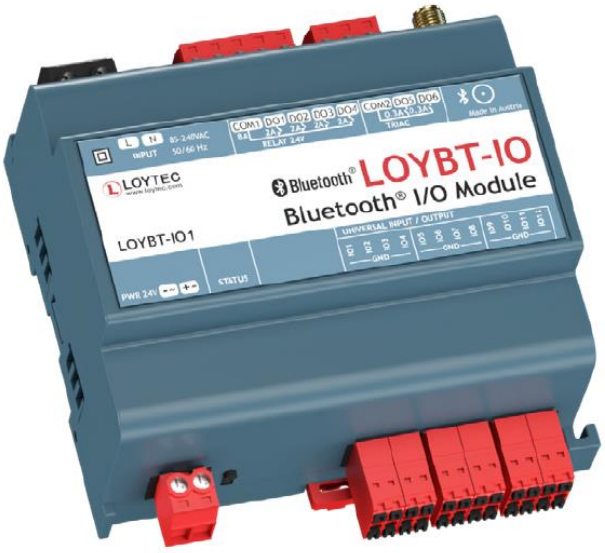


Figure 24: LOYBT-IO1 I/O-module.

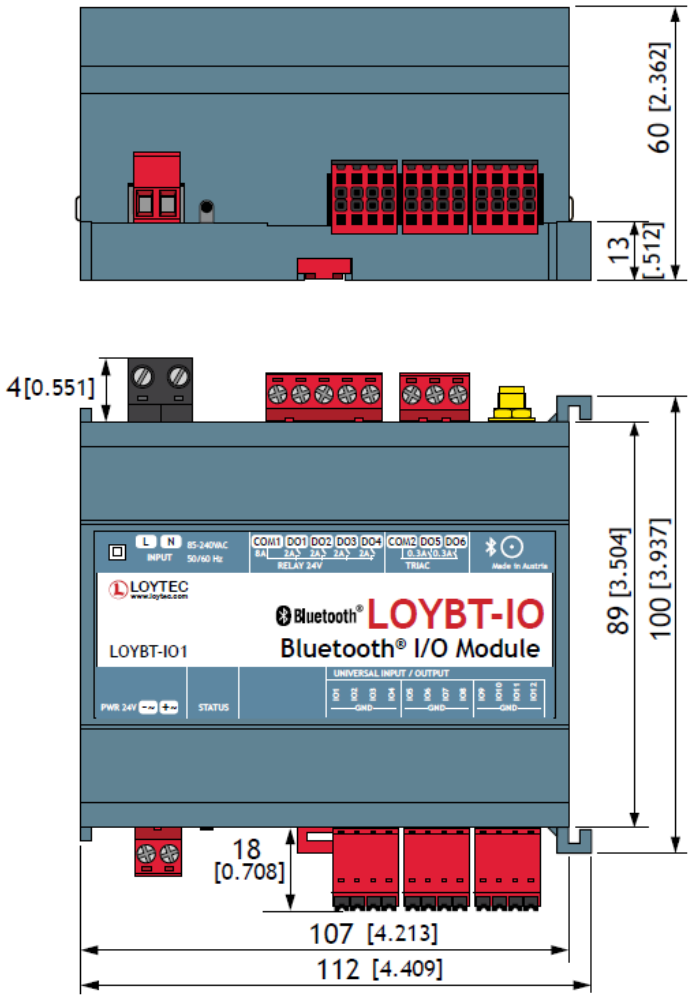


Figure 25: LOYBT-IO1 I/O-module dimensions.

### Reset-Button

A reset button on the bottom of the device allows to reset the device to factory default, which means the device is in an unprovisioned state afterwards.

### LED-Indicator

The LOYBT-IO1 provides a multicolor status-LED. The behavior of this LED is as follows:

- Blinking if attention timer is set (e.g. WINK-action via WebUI)
- Blinking 3 times on power-up if unprovisioned
- Blinking 3 times if device gets unprovisioned
- Blinking 1 time on power-up if provisioned
- Continous green during normal operation

### Models

The model composition for the LOYBT-IO1 is shown in Table 15.

| Model number | Model name | Element | Comment |
|---|---|---|---|
| 0x0000 | Configuration Server | Primary(0) | Network Configuration |
| 0x0002 | Health Server | Primary(0) | |
| 0x0004 | Remote Provisioning Server | Primary(0) | Range Extension |
| 0x1011 | Generic Admin Property Server | Primary(0) | Device Property Report |
| 0x1012 | Generic Manufacturer Property Server | Primary(0) | Device Property Report |
| 0x1013 | Generic User Property Server | Primary(0) | Device Property Report |
| 0x0AA00001 | LOYTEC Device Server | Primary(0) | Device Extension |
| 0x0AA00003 | LOYTEC DFU Data Transfer Server | Primary(0) | Transfer Firmware Image |
| 0x0AA01003 | LOYTEC LIOB Server | Sec (1-18) | I/O Parameters and Control |

Table 15: LOYBT-IO1 composition data.

### Properties of Generic Property Server

The properties provided by the property server are listed in Table 16.

| Message Type | Property ID | Property Name | Characteristic[19] |
|---|---|---|---|
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x000B | Device Country of Origin | Country Code |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x000E | Device Firmware Revision | Fixed String 8 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0010 | Device Hardware Revision | Fixed String 16 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0011 | Device Manufacturer Name | Fixed String 36 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0012 | Device Model Number | Fixed String 24 |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0019 | Device Serial Number | Fixed String 16 |

[19] Characteristics according to GATT Specification Supplement v4 [10].

| Message Type | Property ID | Property Name | Characteristic[19] |
|---|---|---|---|
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0013 | Device Operating Temperature Range Specification | Temperature Range |
| Generic User Property Status (0x4E), Generic Admin Property Status (0x4A) or Generic Manufacturer Property Status (0x46) | 0x0017 | Device Runtime Since Turn On | Time Hour 24 |

Table 16: LOYBT-IO1 message types and properties[20].

#### Provisioning, Configuration and Operation Behavior

The provisioning and the configuration of the device is identical to the handling of any other regular mesh node.

A Bluetooth enabled LOYTEC controller is needed to access the LOYTEC LIOB server model, which is required for configuration and control of the I/Os. In case of lost communication to the host controller the device enters a fail-safe state. In this state all outputs are set to their default value. The failsafe state is reflected by the error code 0x29 (Device Dropped Warning) published by the health model.

**Reset to factory default:**

There are 3 ways to reset the LOYBT-IO1:

- Remove the device from the mesh (with the help of the provisioner).
- Press the button on the bottom of the device for at least 10 seconds.
- As alternative the LOYBT-CALIB1 can be used (no need for physical access to the device).

### 6.3.2 Intended Use

The LOYTEC LOYBT-IO1 is intended to be used as I/O-module in a Bluetooth Mesh system. The devices allow control of 6 digital outputs (2 TRIACS, 4 Relays) and 12 univeral I/Os.

The device is intended for din-rail mounting in a distribution box or switching cabinet. If the mounting location is within a metal enclosure the external antenna has to be placed outside of this metal enclosure.

Operating conditions are temperatures from 0 °C to 50 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP40, the terminals are IP20.

### 6.3.3 Installation Instructions

- The device is suitable for installation in a distribution box or switching cabinet.
- Follow the safety instructions (see chapter 2).
- Follow the guidelines in the installation sheet.
- Do not connect GND and 24V Minus.

[20] Properties according Mesh Device Properties v2 Specification [11].

- Connect the external antenna to ensure proper Bluetooth connectivity.

# 7 Troubleshooting

## 7.1 Technical Support

LOYTEC offers free telephone and e-mail support for the LOYBT product series. If none of the above descriptions solves your specific problem please contact us at the following address:

***LOYTEC electronics GmbH***
***Blumengasse 35***
***A-1170 Vienna***
***Austria***

***E-Mail:*** ***support@loytec.com***
***Web:*** ***http://www.loytec.com***
***Tel:*** ***+43/1/4020805-100***
***Fax:*** ***+43/1/4020805-99***

Or

***LOYTEC Americas Inc.***
***N27 W23957 Paul Road***
***Suite 103***
***Pewaukee, WI 53072***
***USA***

***E-Mail :*** ***support@loytec-americas.com***
***Web :*** ***http://www.loytec-americas.com***
***Tel :*** ***+1 (512) 402 5319***
***Fax :*** ***+1 (262) 408 5238***

# 8 References


[1] LOYTEC Device User Manual 8.2, LOYTEC electronics GmbH, Document № 88086512, December 2023.

[2] Mesh Protocol 1.1 Specification, Bluetooth SIG, 2023.

[3] Mesh Model 1.1 Specification, Bluetooth SIG, 2023.

[4] Ambient Sensor NLC Profile 1.0, Bluetooth SIG, 2023.

[5] Basic Lightness Controller NLC Profile 1.0, Bluetooth SIG, 2023.

[6] Basic Scene Selector NLC Profile 1.0, Bluetooth SIG, 2023.

[7] Dimming Control NLC Profile 1.0, Bluetooth SIG, 2023.

[8] Energy Monitor NLC Profile 1.0, Bluetooth SIG, 2023.

[9] Occupancy Sensor NLC Profile 1.0, Bluetooth SIG, 2023.

[10] GATT Specification Supplement v4 (GSS v4), Bluetooth SIG, 2021

[11] Mesh Device Properties v2 Specification, Bluetooth SIG, 2020

[12] UNOlite Modbus User Guide V0.6

[13] UNOlite BACnet User Guide V0.4

# 9 Revision History

| Date | Version | Author | Description |
|---|---|---|---|
| 2023-06-30 | 1.2.0 | UR | Initial revision. Moved from chapter 15 of the LOYTEC Device Manual and refined device description. |
| 2024-01-30 | 1.4.0 | UR | Add Info about LOYBT-TEMP2 in LOYBT-TEMPx chapter. |
| 2024-03-31 | 1.4.2 | UR | Add chapter about LOYBT-MSx.<br>Add chapter about LOYUNO-L. |
| 2024-09-30 | 2.0.0 | UR | Update chapter about LOYBT-MSx.<br>Update information on battery lifetime of LOYBT-TEMPx.<br>Add chapter about LOYBT-SBM1. |
| 2025-04-30 | 2.2.0 | UR | Add info about current firmware version of LOYBT-TEMPx.<br>Update chapter about LOYBT-MSx. Add Asset Tracking and Beaconing.<br>Add chapter about LOYBT-IO1.<br>Update property tables of LOYBT-MSx and LOYBT-SBM1. |