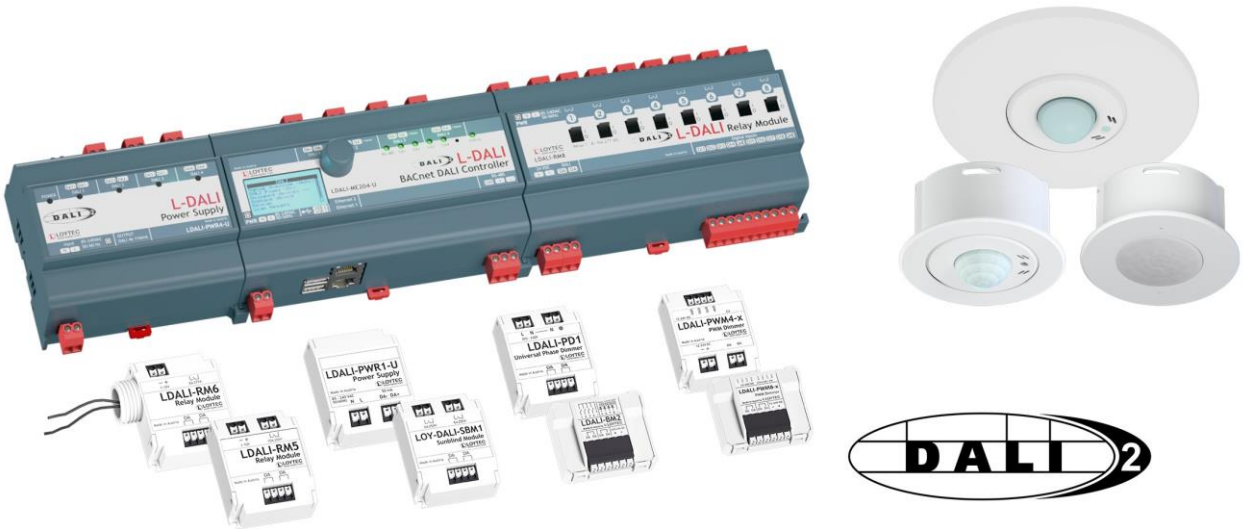
LOYTEC LDALI Device

Device Operation for LOYTEC Products

User Manual

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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
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
CS	Configuration Server that manages CEA-852 IP devices
DA	Data Access (Web service)
DALI	Digital Addressable Lighting Interface, see IEC 62386
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
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
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
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
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
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, SMI and EnOcean.

This user manual describes the DALI-related behavior of LOYTEC LDALI devices. The manual covers installation guidlelines, the basic functionality and description of the device dependent feature sets.

LOYTEC LDALI devices are separated in four main categories according to their DALI-functionality. After a general short introduction to DALI and installation guidelines, the categories DALI bus power suppies, DALI ballasts, DALI input devices and DALI application controllers are covered in different chapters.

1.2 Scope

This document covers common operations on LOYTEC LDALI devices with firmware version 4.2.

For integration and specific usage in a LOYTEC environment refer to the LDALI User Manual [2] and the LOYTEC Device User Manual [3]. The datapoint configuration is covered by the LINX Configurator 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 microfuse.

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 DALI

3.1 Introduction

DALI stands for “Digital Addressable Lighting Interface” and is the name commonly used for the communication protocol defined in the international standard IEC 62386[1]. It is used to dim and switch luminaries from most leading manufacturers. DALI also supports devices like multi-sensors (e.g. for brightness, occupancy, etc.) and intelligent switches. For further information regarding DALI please refer to https://www.digitalilluminationinterface.org.

To ensure device interoperability, DALI-2 compliant devices – bus power supplies, control devices, input devices and ballasts – can be certified by the Digital Illumination Interface Association (DiiA). Only certified devices may bear the DALI-2 logo shown in Figure 1 and are listed in the product database on the DiiA website (https://www.digitalilluminationinterface.org).



Figure 1: DALI-2 Logo.

Important: ***LOYTEC recommends using only DALI-2 certified devices wherever possible.***

3.1.1 DALI Wiring

DALI wiring is typically run together with the mains wiring using normal mains rated wire (2 wires). Table 1 shows the recommended conductor size depending on the length of the DALI wires. A total length of 300 m must not be exceeded.

DALI cable length	Recommended min. conductor size
< 100 m	0.5 mm^2
100-150 m	0.75 mm^2
150-300 m	1.5 mm^2

Table 1: Recommended minimum conductor size for DALI wiring

[1] Previous versions of the DALI standard were defined in IEC 60929 Annex E.

Though the signal is only 16 V (typical), DALI is not SELV rated and should therefore treated as mains voltage wiring[2].

DALI connections are not polarity sensitive[3].

3.1.2 DALI Interface and DALI Bus Power Consumption

Each DALI-interface connected to the DALI-line typically draws a current of a few mA from the DALI-line. The power drawn by the devices via the DALI line must be provided by a DALI bus power supply. The maximum current on a DALI-line which can be provided either by a single or by multiple bus-power supplies is 250 mA.

The bus-current consumption of DALI-devices as well as the *guaranteed current* and *maximum current* provided by bus-power supplies has to be taken into account for DALI system design.

Bus Power Supply:

While for power supplies the *maximum supply current* has to be taken into account when operating multiple bus power supplies in parallel, the *guaranteed supply current* represents the value that is provided by the bus power supply under any operating conditions.

The sum of maximum supply currents of DALI bus power supplies on a DALI-line must not exceed 250mA.

The sum of the guaranteed current consumptions of DALI bus power supplies on a DALI-line is the current which must not exceeded by the current consumption of the DALI-devices connected to this line.

Bus Power Consumption:

The maximum bus-current consumption of externally powered DALI-devices is limited by 2mA as defined in IEC62368-101.

For bus-powered devices there is no limit given by the DALI-standard, but the *maximum current* (typically the inrush current) has to be stated in the datasheet. Furthermore, for certified devices, it is listed in the DiiA database.

While the maximum current is representing the theoretically worst case, the *idle current* (often provided in the datasheet) reflects the best case with respect to current consumption. The actual current during operation (with DALI communication and different states or operating modes of the bus-powered device) will at least sometimes result in a current consumption somewhere between the idle and the maximum current.

The DALI-Alliance introduced a rule of thumb[4] to consider the times no power is available on the DALI bus due to communication. The power consumption of the DALI devices (idle current) must be multiplied by the **factor 1.2** when calculating the required DALI bus power supply current:

---

[2] basic-insulation only between DALI and mains-voltage

[3] Except for the bus power supply, in case more than one bus power supply is connected to the channel.

[4] This rule will work in most cases, but may fail sometimes.

$$\sum I_{DALI\,devices} \leq \frac{I_{PowerSupply}}{1.2}$$

For LOYTEC-devices Table 2 applies and shows the typical power drawn via the DALI line depending on device types. It represents the worst case during operation and is much more accurate compared to rule of thumb.

For DALI devices not listed in the table see the corresponding datasheet or contact the device vendor on the current drawn via the DALI line.

Device type	bus-current consumption (typical)
externally powered DALI devices	2 mA
LOYTEC LDALI-RM8 relay module (ext. powered)	2 mA
LOYTEC LDALI-PWM4-x (ext. powered)	2 mA
LOYTEC LDALI-PWM8-x (ext. powered)	2 mA
LOYTEC LDALI-MS2/MS3/MS4-BT multi-sensor	6 mA / 10 mA[5]
LOYTEC LDALI-BM2 button coupler	3 mA
LOYTEC LDALI-RM5/RM6	6 mA
LOYTEC LOY-DALI-SBM1 sunblind module	6 mA
LOYTEC LDALI-PD1 phase-cut dimmer module	6 mA
LOYTEC LDALI-RM1 relay module (EOL)	2.6 mA
LOYTEC LDALI-RM2 1-10V interface (EOL)	4.2 mA
LOYTEC LDALI-RM3/RM4 (EOL)	3.4 mA
LOYTEC LDALI-BM1 button coupler (EOL)	3.1 mA
LOYTEC LDALI-MS1 multi-sensor (EOL)	4.1 mA
LOYTEC LDALI-MS2 multi-sensor (EOL)	3.5 mA

Table 2: DALI bus power usage for different device types (@16 V DC)

3.1.3 Multi-Master Operation

The LOYTEC DALI interface in the LDALI controller and input devices is capable of multi-master operation. Thus, it can be installed in parallel to one or more other DALI master controllers on the same DALI network. However, all other DALI master controllers must be multi-master capable in order to render a working DALI system. Other DALI masters may

[5] the higher current applies if bluetooth-based functions are enabled

be DALI-2 input devices (sensors, buttons), multi-sensors with built in constant light or occupancy controller functionality, DALI switches, buttons, and touch panels, as well as other DALI controllers.

3.2 DALI Device Types

Figure 2 shows the typical structure of a DALI system.

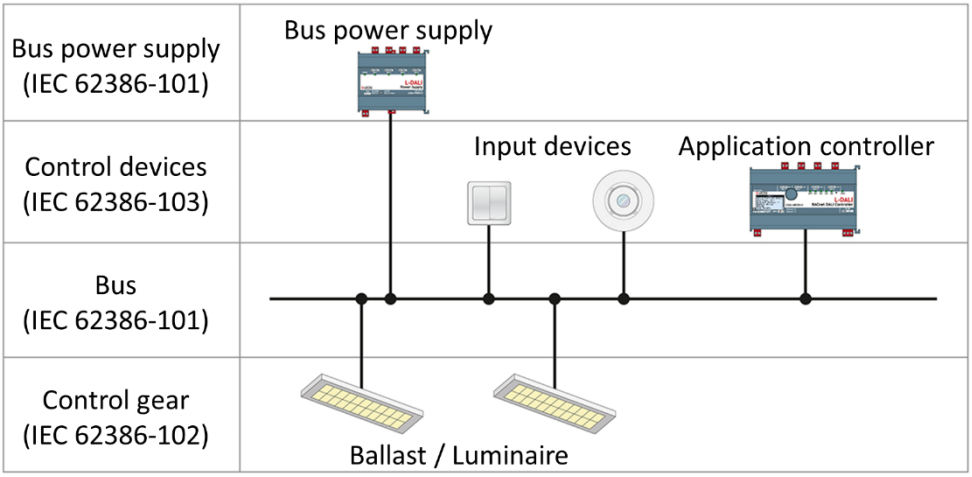


Figure 2: Typical structure of a DALI system.

Important:	***DALI repeaters are not defined by the DALI Standard[6]. Thus, interoperability with LOYTEC DALI products cannot be guaranteed. LOYTEC therefore strongly advises against using such devices!***

It consists of the following components:

Bus power supply

Each DALI channel must contain at least one bus power supply. Bus power supplies are defined in IEC 62386-101. For more information on the DALI bus power supplies see Section 3.1.2 (Power consumption), for LOYTEC bus power supplies refer to chapter 4.

DALI Ballasts

DALI ballasts are specified in the IEC 62386-102 part of the DALI standard and the DALI device types are specified in parts IEC 62386-201 to 209 (see Table 3). For LOYTEC ballasts

[6] The DALI-Alliance is currently working on a specification.

refert to chapter 5. See AN011E L-DALI Compatibility List [4] for DALI ballasts tested with the LOYTEC DALI interface.

Control gear type	Standard
Fluorescent lamps	IEC 62386-201
Self-contained emergency lighting	IEC 62386-202
Discharge lamps	IEC 62386-203
Low voltage halogen lamps	IEC 62386-204
Incandescent lamps	IEC 62386-205
Converter Digital to DC voltage	IEC 62386-206
LED modules	IEC 62386-207
Switching function	IEC 62386-208
Colour control	IEC 62386-209

Table 3: DALI control gear types.

DALI Input Devices

The DALI-2 standard covers DALI input devices (sensors and buttons) in its part IEC 62386-103.

DALI-2 input devices provide their input values via one of its instances. Each device can have up to 32 instances. Figure 3 shows a typical example of a DALI-2 input device with its instances, representing a multi-sensor (occupancy and lux instances) which supports an IR-remote (push-button instances) and has two generic instances representing a built-in temperature and humidity sensor.

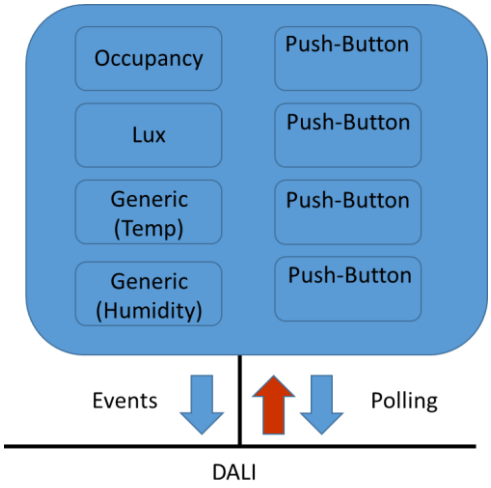


Figure 3: DALI-2 input device instances.

Different instance types are specified in the parts IEC 62386-301 to 304 of the DALI standard (62386-305&306 in progress), additional feature types which can be used in combination with instances in IEC 62386-332.

Instance/Feature type	Standard
Push-Button	IEC 62386-301
Absolute Input	IEC 62386-302
Occupancy Sensor	IEC 62386-303
Light Sensor	IEC 62386-304
Colour Sensor	*IEC 62386-305*[7]
General Purpose Sensor	*IEC 62386-306*[8]
Generic	IEC 62386-103
Input devices – Feedback (feature)	IEC 62386-332

Table 4: Instance and Feature types defined in DALI-2.

For LOYTEC input devices – sensors and button modules refer to chapter 6. See AN011E L-DALI Compatibility List [4] for DALI input devices tested with the LOYTEC DALI interface.

DALI Application controller

The DALI-2 standard covers DALI application controllers in its part IEC 62386-103. The application itself is not defined, only the command set and the behavior of the DALI-interface is defined.

The DALI application controllers are the brain of each DALI-system. Application controllers allow to use DALI sensor values or buttons as inputs in their fixed application program or program logic and control the ballasts on the DALI-line.

For LOYTEC application controller refer to chapter 7 and the LDALI User Manual [2].

[7] Standardization in progress

[8] Standardization in progress

4 LDALI: Bus Power Supplies

4.1 Overview

LOYTEC DALI bus power supplies (internal or stand alone) guarantee supply currents (maximum supply currents) of 50 mA (60 mA), 116 mA (125 mA), 160 mA (250 mA) or 232mA (250 mA) depending on the model.

Thus two 116 mA (125 mA) bus power supplies can be connected to the same DALI channel in parallel resulting in a combined DALI bus power supply of 232mA (250 mA) if needed. The DALI bus power **supply must not exceed 250 mA**[9]**.**

LOYTEC 4channel controller make use of this type of limited power supplies by providing 4 x 116 mA (125 mA). This power supply is suffient for up to 64 externally powered ballasts but may need an additional supply on the channel if additional input devices are connected.

4.2 LOYTEC LDALI-PWR4-U

4.2.1 Device Description

The LDALI-PWR4-U is a DALI-2 certified 4-channel DALI bus power supply with a guaranteed supply current of 116 mA and a maximum supply current of 125 mA per channel.

In applications at which DALI devices connected to the channel consume more than 116mA, two outputs of the power supply can be used in parallel, resulting in a guaranteed supply current of 232 mA (maximum supply current of 250 mA).

The start up time of the device is 7ms, it is short-circuit proof, contains thermal overheat protection and reinforced insulation between the outputs and the power-line.

Nominal output voltage of 18V (11 V to 20.5 V), maximum power consumption of 12W.

LED-indication: The DALI control lamp switches off in case of a thermal overload.

[9] when using several DALI bus power supplies in parallel the sum of the “maximum supply currents” must not exceed 250 mA (the value has to be provided in the datasheet of a DALI-2 certified DALI power supply).



Figure 4: LDALI-PWR4 - 4 Channel DALI Power Supply

4.2.2 Intended Use

The LDALI-PWR4 is well suited as standalone power supply. Channels can be combined to get a full DALI power supply if needed. The channels can also be combined with DALI-power supplies of other devices. It suits perfectly for LOYTEC 4-channel controller like LDALI-3E104-U, LDALI-ME204-U or LDALI-PLC4.

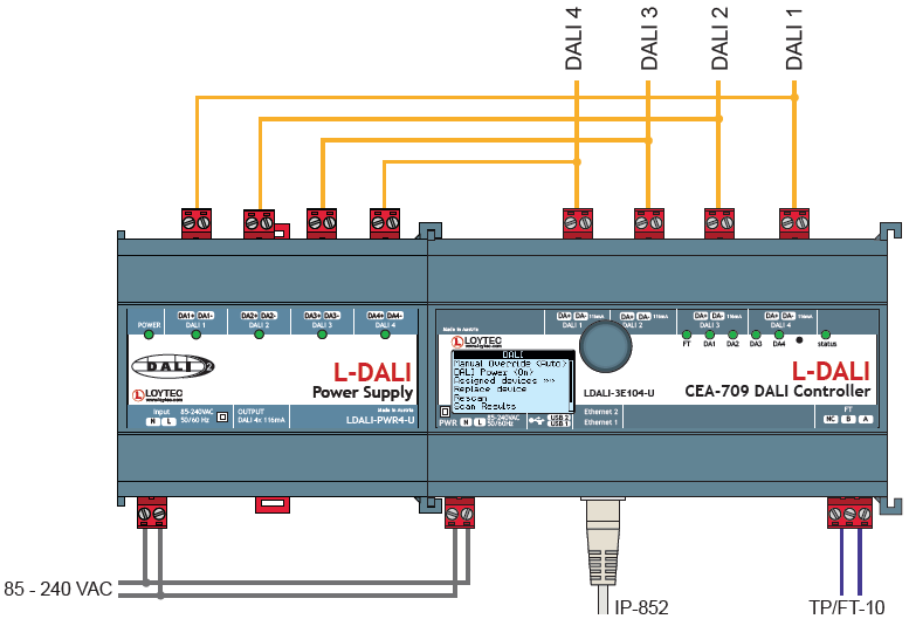


Figure 5: Multi-channel DALI-power Supply

Operating conditions are temperatures from 0 °C to 40 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP40, IP20 for the terminals.

4.2.3 Installation Instructions

- The device is suitable for din rail mouning following DIN43880, top hat rail EN50022.
- Follow the safety instructions (see chapter 2).
- When wiring DALI-outputs in parallel, make sure that all DALI-outputs are connected with the correct polarity (connect “DA+” to “DA+” and “DA-“ to “DA-“).

4.3 LOYTEC LDALI-PWR2-U

4.3.1 Device Description

The LDALI-PWR2-U is a DALI-2 certified 2-channel DALI power supply with a guaranteed supply current of 116 mA and a maximum supply current of 125 mA per channel.

In applications at which DALI devices connected to the channel consume more than 116 mA, two outputs of the power supply can be used in parallel, resulting in a guaranteed supply current of 232 mA (maximum supply current of 250 mA).

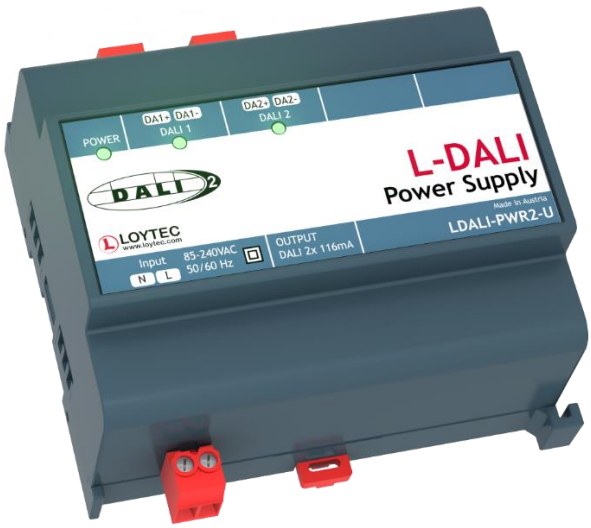


Figure 6: LDALI-PWR2-U – 2 Channel DALI Power Supply

The start up time of the device is 7ms, it is short-circuit proof, contains thermal overheat protection and reinforced insulation between the outputs and the power-line.

Nominal output voltage of 18 V (11 V to 20.5 V), maximum power consumption of 12 W.

LED-indication: The DALI control lamp switches off in case of a thermal overload.

4.3.2 Intended Use

The LDALI-PWR2 is well suited as standalone power supply. Channels can be combined to get a full DALI power supply if needed. The channels can also be combined with DALI-power supplies of other devices. It suits perfectly for LOYTEC 4-channel controller like LDALI-3E104-U, LDALI-ME204-U or LDALI-PLC4.

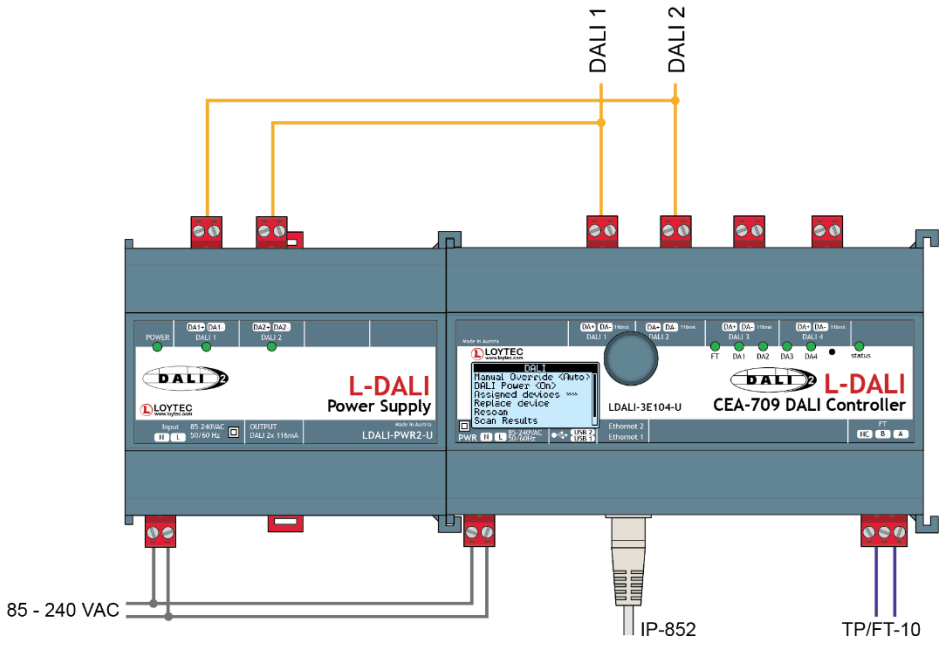


Figure 7: Multi-channel DALI-power Supply

Operating conditions are temperatures from 0 °C to 40 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree of the housing is IP40, IP20 for the terminals.

4.3.3 Installation Instructions

- The device is suitable for din rail mouning following DIN43880, top hat rail EN50022.
- Follow the safety instructions (see chapter 2).
- When wiring DALI-outputs in parallel, make sure that all DALI-outputs are connected with the correct polarity (connect “DA+” to “DA+” and “DA-“ to “DA-“).

4.4 LOYTEC LDALI-PWR1-U

4.4.1 Device Description

The LDALI-PWR1-U is a DALI-2 certified DALI bus power supply with a guaranteed supply current of 50 mA and a maximum supply current of 62 mA.

In applications with higher DALI currents up to 4 LDALI-PWR1-U can be used in parallel, resulting in a guaranteed supply current of 200 mA (maximum supply current of 248 mA).

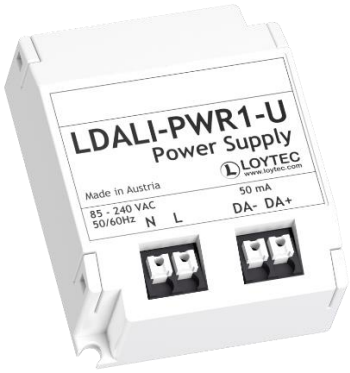


Figure 8: LDALI-PWR1-U Power Supply

The start up time of the device is 30 ms, it is short-circuit proof, contains thermal overheat protection and reinforced insulation to the power-line.

Nominal output voltage of 16 V (11 V to 20.5 V), maximum power consumption of 1.7 W.

4.4.2 Intended Use

The LDALI-PWR1 is well suited as a supply for small standalone DALI-systems with a limited number of DALI-components or even for luminaire integration. A typical LOYTEC application is the supply of a small DALI-subsystem in a BT-Mesh ecosystem (e.g. for a room), in which the sensor acts as DALI application controller and gateway to the Bluetooth-Mesh ecosystem.

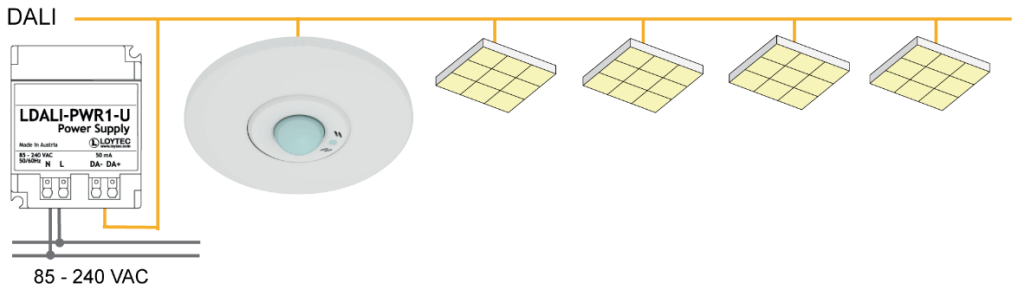


Figure 9: DALI Power Supply for a small DALI-circuit

Operating conditions are temperatures from 0 °C to 40 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree is IP20.

4.4.3 Installation Instructions

- The device is suitable for installation in distribution boxes, for mouting in false ceilings or for luminaire integration.
- Follow the safety instructions (see chapter 2).
- When wiring DALI-outputs in parallel, make sure that all DALI-outputs are connected with the correct polarity (connect “DA+” to “DA+” and “DA-“ to “DA-“).

5 LDALI: Ballast Types

5.1 Overview

LOYTEC provides different types of DALI control gear - phase-cut dimmers, constant voltage multichannel LED-drivers with special types for colour control as well as relay and converter modules (incl. a special model with manufacturer specific mode for sunblind-control).

5.2 LOYTEC LDALI-RM5/6 Relay Module

5.2.1 Device Description

The DALI-2 certified and UL-listed LDALI-RM5/6 Relay Modules enable the control of consumers without DALI interface. Typical application scenarios are the integration of non-DALI luminaires (with 1-10 V or no control interface) or other loads like fans in toilets or washrooms and motors for partition walls or screens in DALI lighting applications.

The built-in relay contact can be used for currents of up to 10A or loads of up to 2.500VA, respectively. It supports a wide voltage range of 120 V – 277 V AC and up to 30 V DC. Zero cross switching technology is used to handle large in-rush currents typically found in lighting applications. The bi-stable relay make contact is potential-free.

For legacy dimmable ballasts the LDALI-RM5/6 modules are also equipped with a 1-10 V interface, which can be used together with the relay contact to control these types of loads via DALI. The load capability of 50mA sinking current of the 1-10 V interface is the main difference to the predecessor modules LDALI RM3/RM4.



Figure 10: LDALI-RM5/6 Relay-Module

The relay module comes with two housing options. While the LDALI-RM5 is designed for installation in distribution boxes or in installation boxes behind standard plugs, the LDALI-RM6 allows installation on US-style fixtures or junction box ½" knockouts (spud-mount).

The relay module is bus-powered, the idle current (no communication, no switching) is 3.5 mA (converter mode) or 3 mA as relay (@16 V bus voltage). An internal current limiter defines the peak current (inrush) with 11 mA. A recommended value for calculations for system design is 6mA (including reload cycles after switching action and communication).

Modes of Operation

The LDALI-RM5/6 can be operated in 'Switching Function' or 'Converter' mode. The mode of the LDALI-RM5/6 defines whether a driver is connected to the 1-10 V output. The mode is selected via DALI operating mode.

- **Switching Function (Device Type 7, IEC-62386-208)**

  If the LDALI RM5/RM6 is operated in DALI operating mode 0x00, it acts as switching function. In this mode only the relay output is used.

- **Converter (Device Type 5, IEC-62386-206)**

  If a driver is connected to the 1-10 V output the LDALI-RM5/6 shall operate as converter (DALI operating mode 0x80). In this mode the output level can be adjusted from 0 V to 10 V according to the respective output level and the relay can be used as additional switch for the power supply of the connected 1-10 V. If the output level is 0% the relay is switched OFF, in any other case the relay is switched ON.

System-Failure & Power-On behavior

As a unique safety feature the relay state for fault conditions can be configured. In case of power loss on the DALI-line, the relay will switch to the position as defined with the DALI configuration register 'System Failure Level'.

Note: *Setting the 'System Failure Level' to the DALI-value '255' will disable the system failure behavior and the output level is not changed in case of a DALI bus outage.*

Note: *Since the LDALI RM5/RM6 is bus powered the system failure level of the 1-10V output in converter mode is always 100%.*

The power-on behavior is defined with the DALI configuration register 'Power_On_Level'.

Note: *Setting the 'Power On Value' to DALI-value '255' will cause a recovery of the last active output level before the power loss.*

5.2.2 Intended Use

The LDALI RM5/RM6 is intended to be used as digitally controlled switching output for standard consumers in the power grid capable for loads of up to 2500 VA @ 250 V AC or 300 W @ 30 V DC.

Alternatively in the manufacturer specific operating mode 0x80 it acts as DALI to 1-10 V converter and allows the integration and of legacy 1-10 V drivers and scaling in retrofit projects.

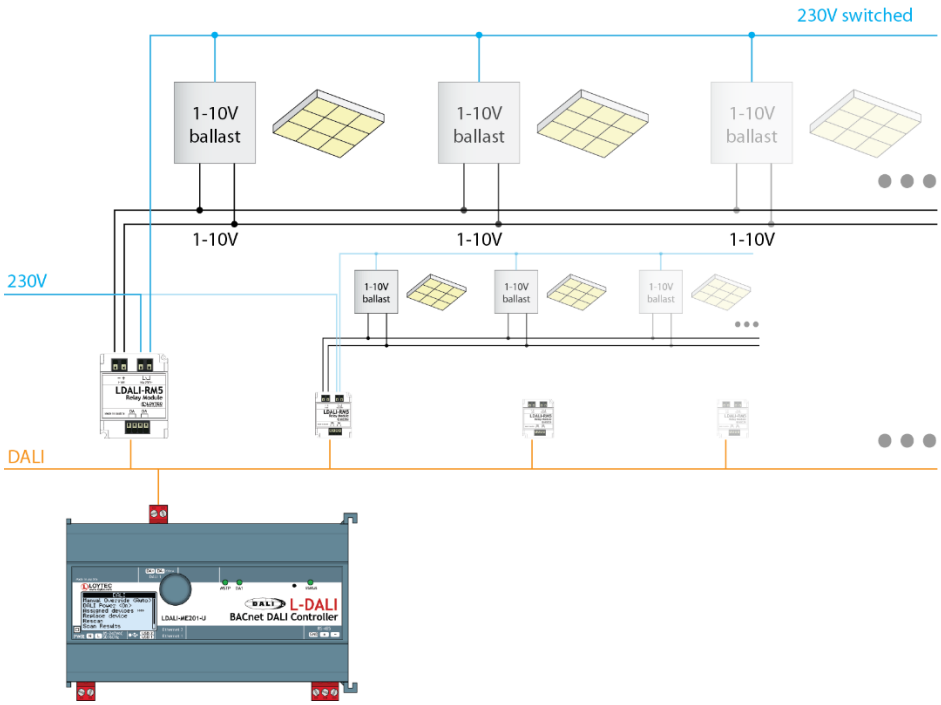


Figure 11: Application for Converter Mode with LDALI-RM5/6 Relay-Module

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

5.2.3 Installation Instructions

- The LDALI-RM5 device is suitable for installation in distribution boxes, for mouting in false ceilings or for luminaire integration.
- The LDALI-RM6 device is suitable for installation on US-stype fixtures or junction 1/2” knockouts (spud-mount).
- Follow the safety instructions (see chapter 2).

5.3 LOYTEC LDALI-RM8 Relay Module

5.3.1 Device Description

The DALI-2 certified and UL-listed LDALI-RM8 Relay Module enables the control of standard loads via DALI. Typical application scenarios are the integration of non-DALI luminaires or other loads like fans in toilets or washrooms, motors for partition walls or screens and fire protection flaps in DALI lighting applications. The device provides 8 built-in relay contacts, which can be controlled individually via separate DALI addresses.

Each relay can also be controlled manually via a switch on the device (for installation and maintenance purpose), the switch also indicates the current state of the corresponding relay.

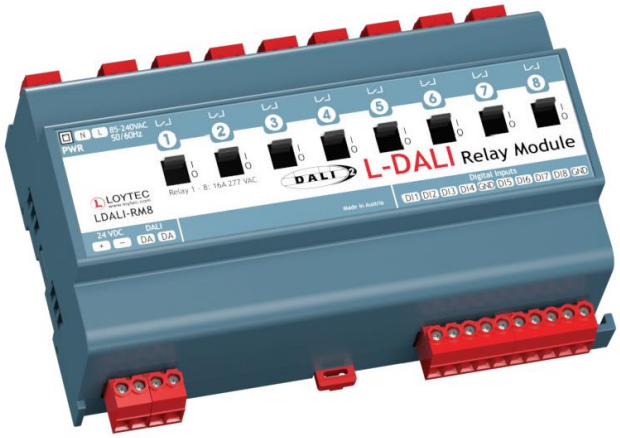


Figure 12: LDALI-RM8 Relay-Module

The built-in relay contacts can be used for currents of up to 16 A. They support a wide voltage range of 120 – 277 V AC and up to 30 V DC. The relays are suitable for loads with high inrush currents.

The device supports the DALI specification IEC 62386-208 (Device Type 7, "switching function") for non-dimmable loads.

The LDALI-RM8 is externally powered either by 24 V DC or 85 – 240 V AC, the power consumption is typically below 1 W.

DI-Override

The switching state can be controlled via DALI as long as the corresponding digital input is open. Closing the input will always switch on the relay (override). An override via DIx (digital input) is indicated by bit6 in the reply of the DT7-specific command QUERY SWITCH STATUS.

Note: The digital override inputs are dry contacts and not protected against overvoltage.

System-Failure & Power-On behavior

As a unique safety feature the relay state for fault conditions can be partially configured. In case of a power loss on the DALI bus, the relays will switch to the position as defined with the DALI configuration register "System Failure Level". In case of a power loss on the 24 V DC or 85 – 240 V AC the relays keep their state until a "Power On" occurs, at which they will switch to the state defined in the "Power On Level" configuration register.

5.3.2 Intended Use

The LDALI-RM8 is intended to be used in a switching cabinet and provides 8 digitally controlled switching output for standard consumers in the power grid capable for currents of up to 16 A and high inrush currents of up to 480 A.

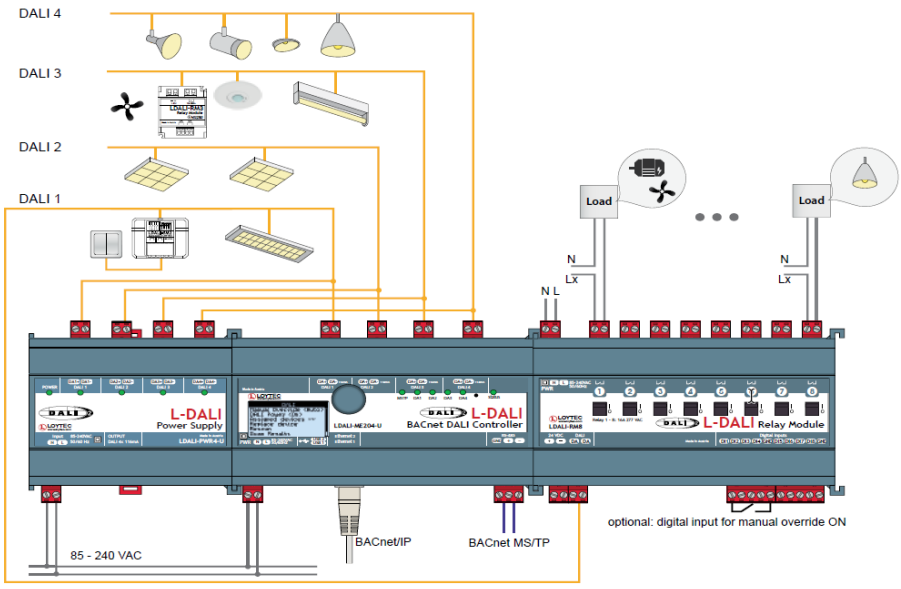


Figure 13: Load integration via LDALI-RM8 Relay-Module

Operating conditions are temperatures from 0 °C to 40 °C and relative humidity from 10 % to 90 % (non-condensing). The protection degree for the housing is IP40, for the terminals IP20.

5.3.3 Installation Instructions

- The device is suitable for din rail mouning following DIN43880, top hat rail EN50022.
- Follow the safety instructions (see chapter 2).
- Different relays can be connected to different phases.
- For power supply connect either 24 V DC or mains.
- Do not apply any voltage to the digital inputs (dry contacts).
- After installation use manual switches for testing wiring and relay function.

5.4 LOYTEC LOY-DALI-SBM1 Sunblindmodule

5.4.1 Device Description

The LOY-DALI-SBM1 is a DALI module for controlling sunblinds. The device is bus powered and comes with 2 built-in relay contacts, which are suitable to switch currents of up to 6A at 250 V AC or 30 V DC.



Figure 14: LOY-DALI-SBM1 Sunblind Module

The sunblind-module is bus-powered, the idle current (no communication, no switching) is 3.5 mA (@16 V bus voltage). An internal current limiter defines the peak current (inrush) with 11mA. A recommended value for calculations for system design is 6 mA (including reload cycles after switching action and communication).

Modes of Operation

The device provides 2 operating modes.

- The Sunblind-Mode (manufacturer specific operating mode 0x80) is well suited for sunblind control due to an extended command set. It can either be controlled in 2 different ways:
  - by transferring direction and duration information for the blinds connected to the relay outputs.
  - the actuator allows control via position and rotation values directly if the sunblind parameters for the connected sunblind are setup correctly. For sunblinds without slats (e.g. roller shutters or awnings) the rotation time can be set to 0 ms (firmware 4.2 and later). Rotation values are then ignored and only the position is controlled.

  On LOYTEC controllers the device is automatically configured to be used in this mode.

- In Relay-Mode (operating mode 0x00) the module acts as a DALI-2 certified relay module with 2 interlocked contacts: normally open and normally closed.

System-Failure & Power-On behavior

As a unique safety feature the relay state for fault conditions can be configured. In case of a power loss on the DALI-line, the relay will switch to the position as defined in the DALI configuration register ‘System Failure Level’.

Note:	*Setting the ‘System Failure Level’ to the DALI-value ‘255’ will disable the system failure behavior and the output level is not changed in case of a DALI bus outage.*

The power-on behavior is defined in the DALI configuration register ‘Power_On_Level’.

Note:	*Setting the ‘Power On Value’ to DALI-value ‘255‘ will cause a recovery of the last active output level before the power loss.*

In sunblind mode the parameter interpretation is different. While the DALI-value '255' (no change) is similar, '0' represents the state "STOPPED", '1' represents "UP" and '2' represents "DOWN". All other values are ignored.

From a safety perspective it is recommended to define the System Failure Level state to "UP".

5.4.2 Intended Use

The LOY-DALI-SBM1 is intended to enable control of sunblinds in a DALI-system. It supports a load of up to 1500 VA @ 250 V AC or 180 W @ 30 V DC.

The extended command set is supported on LOYTEC controllers.

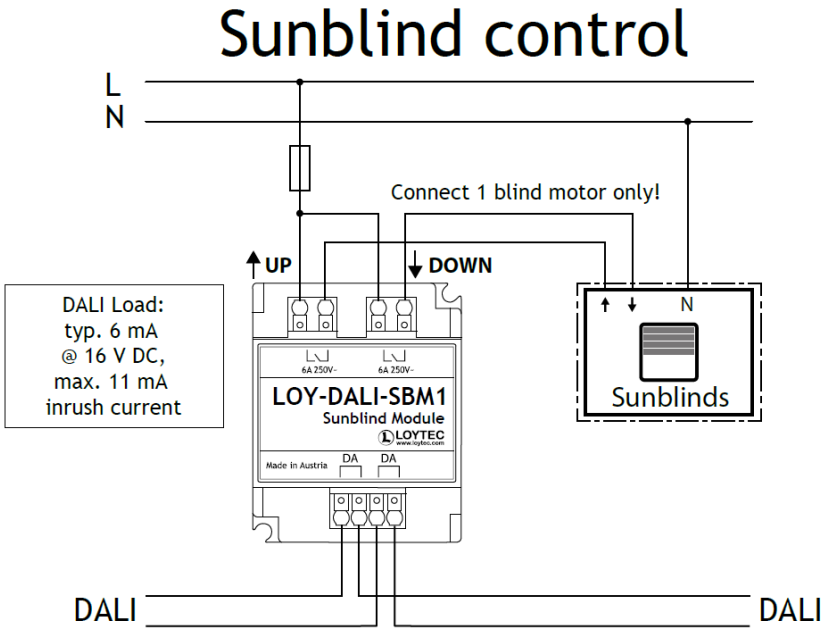


Figure 15: LOY-DALI-SBM1 used as sunblind controller

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, IP20 for terminals.

5.4.3 Installation Instructions

- The device is suitable for installation in a distribution box.
- Follow the safety instructions (see chapter 2).
- Module and sunblind-motor have to be protected by means of a suitably-rated fuse or thermal circuit breaker (see Figure 15).
- Connect only a single sunblind motor to the module.

5.5 LOYTEC LDALI-PD1 Phase-Cut Dimmer Module

5.5.1 Device Description

The DALI-2 certified LDALI-PD1 module enables the control of phase-cut dimmed consumers via a DALI-channel. Typical application scenarios are the integration of 230V LED-retrofit bulbs or halogen lamps in DALI lighting applications.

The device supports a wide voltage range from 220 V – 240 V AC 50 Hz / 60 Hz. The LDALI-PD1 is suitable for loads from 1 VA – 75 VA (R, RL, RC). The load type (RL/RC) is automatically detected and used to select a suitable dimming method (leading or trailing edge phase-cut dimming). The dimming range is 3 % to 100 %. The device is equipped with an open circuit detection that indicates a lamp failure if no load is connected[10].

Note: *LED/CFL lamps up to a rated power of 25 W may have a power factor of 0.5 only, therefore it is recommended to calculate with appropriate reserves.*



Figure 16: LDALI-PD1 Phase-Cut Dimmer Module

The phase-cut dimmer is bus-powered, the idle current (no communication, no switching) is 5 mA (@ 16 V bus voltage). An internal current limiter defines the peak current (inrush) with 11 mA. A recommended value for calculations for system design is 6 mA (including communication).

Modes of Operation

The device provides 2 operating modes.

- DALI-2 certified mode (operating mode 0x00).
- The manufacturer specific operating mode (0x80, factory default) does not carry out lamp failure detection above dimming levels of 50 %.

[10] In combination with specific light sources lamp failure detection may not work as expected. Switching to operating mode 0x80 or deactivating the lamp failure detection may solve this issue (see also [AN019E]).

System-Failure & Power-On behavior

The power-on behavior is defined with the DALI configuration register 'Power_On_Level'. Since the device is buspowered, in case of a system failure the device is off.

Note: *Setting the 'Power On Value' to DALI value '255' will cause a recovery of the last active output level of before the power loss.*

5.5.2 Intended Use

The LDALI-PD1 is intended to be used for integration of phase-cut dimmed consumers in a DALI-system. It is suitable for loads from 1VA to 75VA in the voltage range from 220 V to 240 V AC 50 Hz / 60 Hz.

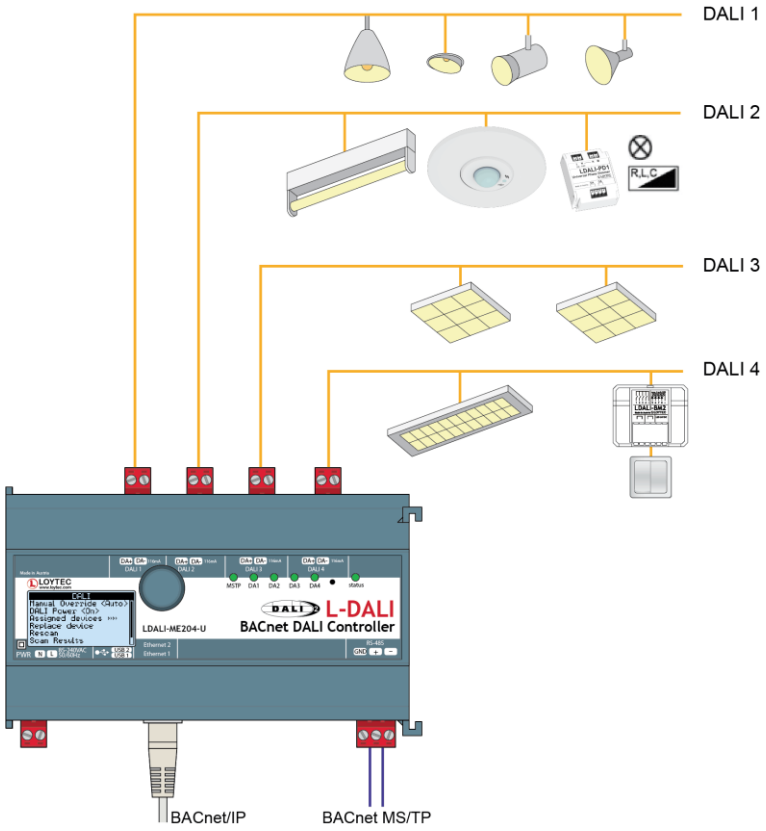


Figure 17: Application – Integration of phase-cut dimmed loads with LDALI-PD1-Module

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

Note: *Due to the enormous number of light sources and input circuits, there is always a risk with respect to interoperability (smooth dimming behavior, flicker, glimming etc.). Therefore, we highly recommend to check the compatibility with the light source before installation.*

5.5.3 Installation Instructions

- The LDALI-PD1 device is suitable for installation in distribution boxes, for mouting in false ceilings or for luminaire integration.
- Follow the safety instructions (see chapter 2).
- Compatibility test of light source and module is recommended before installation.

5.6 LOYTEC LDALI-PWM4-x

5.6.1 Device Description

The certified LDALI-PWM4 is a 4 channel constant voltage LED driver. It is suitable for constant voltage LED modules and LED strips with operating voltages from 12 V to 24 V DC. The PWM outputs offer a wide dimming range from 0.1 % to 100 % and adjustable PWM frequency (default: 250 Hz, others: 125 Hz / 500 Hz). The maximum load is limited to 3 A per channel.

The module comes with overtemperature protection as well as with open circuit and short circuit detection[11]. The compact module provides high efficiency and low standby power consumption.



Figure 18: LDALI-PWM4 Module

The LDALI-PWM4-x is externally powered by the 12 V to 24 V DC supply. The DALI bus-current consumption is below 2 mA.

From a DALI perspective the module is compliant to the DALI specifications IEC62386-101, IEC62386-102 and IEC62386-207 (Device Type 6, LED). In addition to the LDALI-PWM4 with 4 independent logical units that can be controlled by 4 separate addresses, there are 2 modules with different colour types available (IEC62386-209, Device Type 8, Colour Control).

Module Types:

- LDALI-PWM4 for the independent control of 4 logical units (DALI DT6 LED), DALI-2 certified

[11] Open circuit and short circuit lamp failure detection can be dactivated separately if needed (see also [AN019E]).

- LDALI-PWM4-TC for tunable white applications (2 logical units supporting DT8-type Tc), DALI-2 certified
- LDALI-PWM4-RGBW for colour applications (1 logical unit supporting DT8-type RGBWAF)

System Failure & Power-On behavior

In case of a power loss on the DALI-line, the resulting dim level is defined by the DALI configuration register 'System Failure Level'.

Note:	*Setting the 'System Failure Level' to DALI-value '255' will disable the system failure behavior and the output level is not changed in case of a DALI bus outage.*

The power-on behavior is defined with the DALI configuration register 'Power_On_Level'.

Note:	*Setting the 'Power On Value' to DALI-value '255' will cause a recovery of the last active output level of before the power loss.*

5.6.2 Intended Use

The LDALI-PWM4-x is intended to be used as low voltage LED-driver for 12 V to 24 V constant voltage LED-strips or LED-modules. It is suitable for loads of up to 3 A per channel.

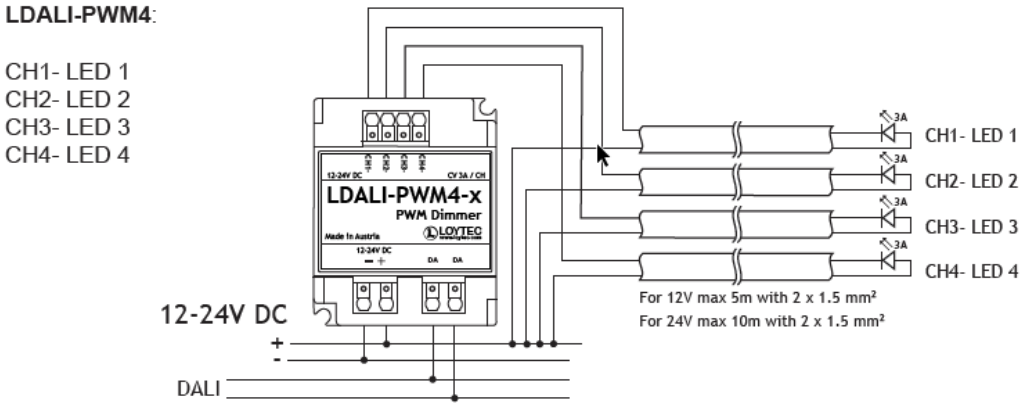


Figure 19: LDALI-PWM4 wiring

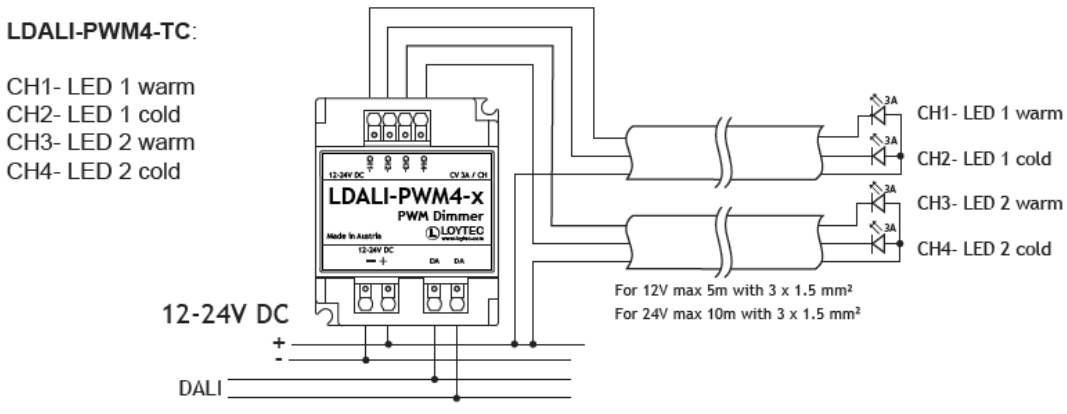


Figure 20: LDALI-PWM4-Tc wiring

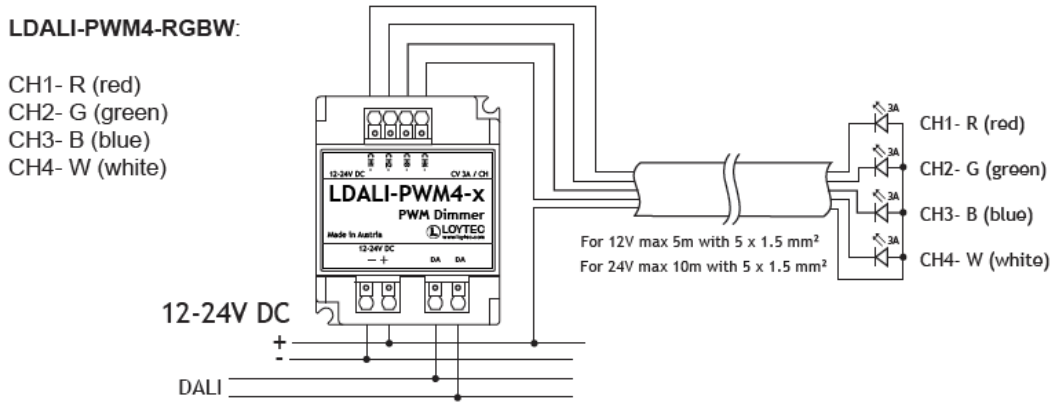


Figure 21: LDALI-PWM4-RGBW wiring

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.

Recommendation:	*For wiring keep the cable lengths between dimmer and power supply as well as between dimmer and luminaires (LED strips) as short as possible.*

5.6.3 Installation Instructions

- The LDALI-PWM4 device is suitable for installation in distribution boxes or for luminaire integration.
- Follow the safety instructions (see chapter 2).
- The SELV-behavior of the PWM-channels has to be ensured by using a proper DC power supply with a SELV 12 V to 24 V output.
- Follow the wiring diagrams and cable cross sections in Figure 19 to Figure 21. Do not use single conductors for connecting LED-strips.

6 LDALI: Input Devices

6.1 Overview

LOYTEC provides different types of DALI input devices, each of which contains a combination of different instance-types and number of instances (see also Table 4).

6.2 LOYTEC LDALI-MS2-BT / LDALI-MS3-BT / LDALI-MS4-BT Multi-Sensor

6.2.1 Device Description

The DALI-2 certified LDALI-MS2/MS3/MS4-BT represent the latest generation of LOYTEC DALI multi-sensors. They provide acoustic presence detection, temperature and humidity sensors as well as bluetooth-enabled functions in addition to PIR-based motion detection and illuminance measurement.



Figure 22: LDALI-MS2-BT multi-sensor for office applications.



Figure 23: LDALI-MS3-BT multi-sensor with for office applications with snap-in mounting option.



Figure 24: LDALI-MS4-BT multi-sensor with flat lense.

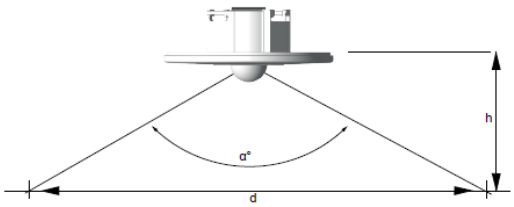
The multisensors are bus-powered, the current consumption heavily depends on enabled/disabled Bluetooth features. The idle current (no communication, @ 16 V bus voltage) is 3.5 mA / 6 mA (Bluetooth disabled/enabled). An internal current limiter defines the peak current (inrush) with 10 mA. A recommended value for calculations for system design including reload cycles after communication is 6 mA / 10 mA (Bluetooth disabled/enabled).

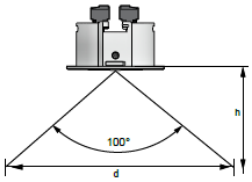
Occupancy Detection - PIR

The LDALI-MS2/MS3/MS4-BT performs motion detection with a high resolution PIR sensor.

The LDALI-MS2/MS3-BT 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 LDALI-MS4-BT provides a flat lense 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 LDALI-MS2/MS3-BT

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 LDALI-MS4-BT

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 25: LDALI-MS2/MS3/MS4-BT multi-sensor PIR detection range

Occupancy Detection - Acoustic

Beside the PIR sensor the LDALI-MS2/MS3/MS4-BT provides acoustic presence detection. This method is inactive 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 by an occupancy instance according to IEC62386-303. From firmware 4.2 the acoustic detection can optionally be restricted to a time window after the last PIR detection (1 to 254 minutes). A sound then only extends or renews the occupied state if the PIR sensor detected movement within this window, so noise alone cannot switch a vacant room to occupied. By default this restriction is off and the acoustic detection works as in previous firmware versions.

Illuminance Measurement

All models allow to measure lux level in the range of 0 – 4000 lux.

It is represented by a light sensor instance according to IEC62386-304.

Note: *The illuminance sensor is approximately reporting the same value than a luxmeter when placed at the same position. Nevertheless, the spectral distribution of the light source may result in different results when comparing the reported measurement value directly to a lux-meter.*

Note: *Since the light sensor is never placed exactly on the position at which the illuminace has to 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 measurements and illuminance measurements on the target position. The LOYTEC LDALI-controller provides such a calibration routine (refer to [2] amd [3]).*

Temperature and Humidity Measurement

In addition to occupancy and lux measurement, the LDALI-MS2/MS3/MS4-BT 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.).

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.

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 26). The L-RC1 is an infrared remote control, optimized for room automation applications. It allows the control of the room's light, sunblinds and HVAC system. Additionally, the Apple Remote Control is also supported.

Note: *The Apple Remote control must be paired with the LDALI-MS2/MS3/MS4-BT to work!*
***Pair (simple)**: Press 'Menu' + 'Next' for at least 5 seconds.*
***Unpair**: Press 'Menu' + 'Previous' for at least 5 seconds. (Pair L-RC1 again)*



Figure 26: L-RC1 infrared remote control for LDALI-MSx-BT.

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

DALI-Instance Number	Type	Input	Description
04	Digital Input	DI1	DI1 on back of LDALI-MSx-BT
05	Digital Input	DI2	DI2 on back of LDALI-MSx-BT

DALI-Instance Number	Type	Input	Description
06	Digital Input	DI3	DI3 on back of LDALI-MSx-BT
07	Button	IR-Remote Cmd 1	CH1 / Menu (Apple)
08	Button	IR-Remote Cmd 2	CH2 / Select (Apple)
09	Button	IR-Remote Cmd 3	Sunblind UP / Next (Apple)
10	Button	IR-Remote Cmd 4	Sunblind AUTO / Previous (Apple)
11	Button	IR-Remote Cmd 5	Sunblind DOWN / Up (Apple)
12	Button	IR-Remote Cmd 6	Lights UP / Down (Apple)
13	Button	IR-Remote Cmd 7	Lights AUTO / Play (Apple)
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: Instances of LDALI-MSx-BT and corresponding inputs.

Bluetooth Low Energy Based Features

The LDALI-MSx-BT comes with Bluetooth Low Energy support. The features can be enabled separately with the help of a LOYTEC-controller.

Note: *The Bluetooth Low Energy based features are only available in co-existence with a LOYTEC controller. Information on how to access these features via a LOYTEC controller is provided in the LOYTEC Device User Manual [3].*

Note: *If BLE-based features are enabled an increased supply current has to be considered in the system design (typical 10 mA instead of 6mA, see Table 2).*

Bluetooth Beacons:

The LDALI-MS2/MS3/MS4-BT supports various beacon types (iBeacon, Eddystone-UID beacon or the LOYTEC-specific LWEB beacon), 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 LDALI controllers and LROC systems. For more information refer to [3].

Asset Tracking and Asset Counting:

The LDALI-MS2/MS3/MS4-BT can scan for bluetooth-beacons in its radio range. A maximum of 32 active beacons (Eddystone UID+TLM or iBeacon) can be managed by the device.

The asset data of a sensor can be queried and is available on data point level in LDALI and LROC controllers. The asset data contains parameters like identifiers and RSSI-values. For more information refer to [3].

Status LED

The LDALI-MS2/MS3/MS4-BT provides a red status-LED. The behavior of this LED is as follows:

- Blinking if motion is detected if device is unaddressed (useful for installer to check basic functionality and support sensor head adjustment)
- Blinking for 10 seconds if device has received the IDENTIFY command (e.g. WINK-action)

6.2.2 Intended Use

The LOYTEC LDALI-MS2-BT, LDALI-MS3-BT and LDALI-MS4-BT are intended to be used as environment sensor for room automation with a DALI-based lighting control system. The sensor provides information about presence, illuminance, temperature and humidity as well as support for other building automation related features like bluetooth functions for asset tracking, and location beacons, digital inputs for window contacts or room control via IR remote control.

The sensors are intended to be used on a ceiling or in false ceilings. The LDALI-MS2-BT can be mounted in-wall in standard flush-mounted boxes, spring snap in false ceilings and on-wall with the included surface mounting box. The LDALI-MS3/MS4-BT is designed to be used with spring snaps in false ceilings.



Figure 27: LDALI-MS2-BT, LDALI-MS3-BT and LDALI-MS4-BT 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.

6.2.3 Installation Instructions

- The LDALI-MS2-BT can be mounted in-wall in standard flush-mounted boxes, on-wall with a surface mounting box, or spring snap in false ceilings
- The LDALI-MS3/MS4-BT 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 28).

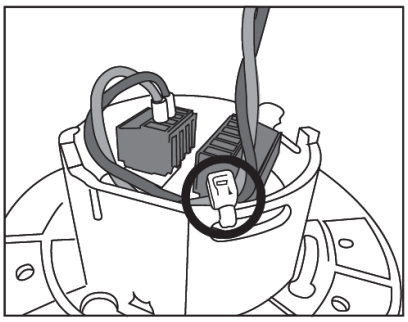


Figure 28: LDALI-MS2/MS3/MS4-BT strain relief.

- 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).

6.3 LOYTEC LDALI-BM2 Button Module

6.3.1 Device Description

The DALI-2 certified LDALI-BM2 button module is the successor of the LDALI-BM1 push button coupler. It is based on the DALI-2 standard. Similar to its predecessor, it integrates up to four customary light push buttons and switches into a DALI channel. For each pushputton instance a feedback-LED can be connected.

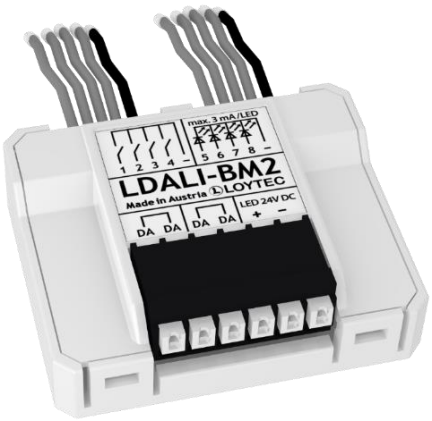


Figure 29: LDALI-BM2 button module.

The LDALI-BM2 is bus-powered. The idle current (no communication, no switching, @16V bus voltage) is 3 mA. An internal current limiter defines the peak current (inrush) with 6 mA. A recommended value for calculations for system design is 3 mA.

Note: *If feedback-LEDs are supplied via the DALI-line the current has to be taken into account in the system design.*

Instances

The LDALI-BM2 provides 4 physical inputs, 2 universal inputs (IN1, IN2) and 2 digital inputs (IN3, IN4). All inputs can be used to connect push buttons. Alternatively, the universal inputs can be used as analog inputs to connect devices like slider, dials or even resistance-based sensors like NTC temperature sensors.

Therefore, multiple DALI-instances are linked to the universal inputs. Instances 0-2 are linked to input IN1 and instances 3-5 are linked to input IN2. It is recommended to only enable one of these 3 instances at the same time!

DALI-Instance Number	Type (IEC 62386 Instance Type)	Input	Resolution [bit]
00	Push Button (1)	IN1	1
01	Generic (0)	IN1	16 (1LSB = 1 Ohm)
02	Absolute Input (2)	IN1	5 (31 = 100%)
03	Push Button (1)	IN2	1
04	Generic (0)	IN2	16 (1LSB = 1 Ohm)
05	Absolute Input (2)	IN2	5 (31 = 100 %)
06	Push Button (1)	IN3	1
07	Push Button (1)	IN4	1

Table 6: LDALI-BM2 instance layout.

For detailed information how to interpret the values provided by absolute input and generic instances refer to [4].

Feedback LEDs

The maximum current for a feedback LED is limited to 3mA. There are two ways to supply the feedback-LEDs via the “LED 24V DC” terminals:

- 24 V DC power supply: a separate supply has to be used for each DALI-line and a single-point connection has to be established between GND of the 24 V-supply and the DALI-line

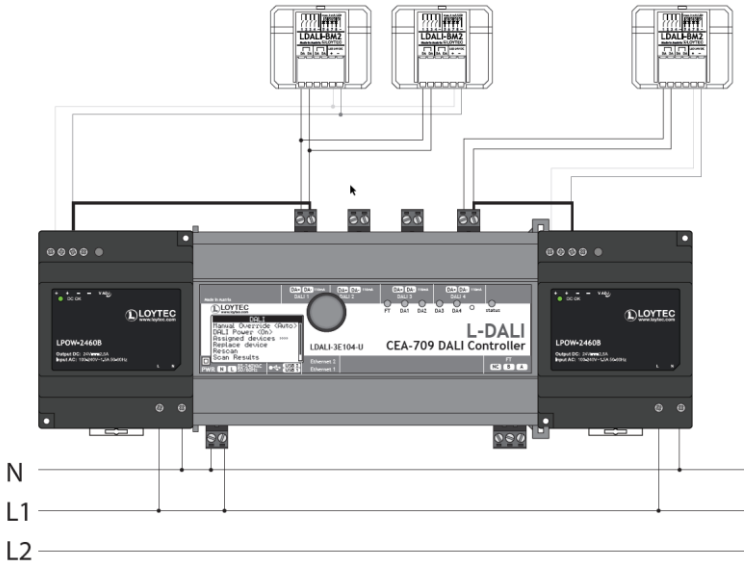


Figure 30: Feedback-LED supplied by 24V power supply

- DALI-line: take care of the DALI-line polarity and be aware of the additional current consumption of 3mA/LED on the DALI-line

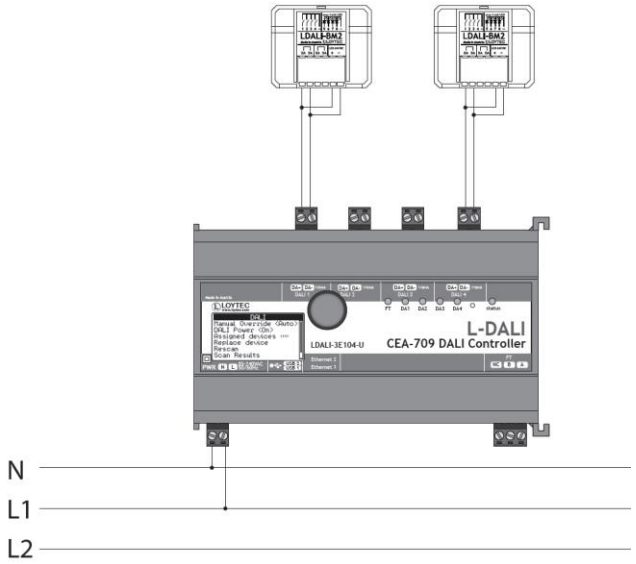


Figure 31: Feedback LEDs supplied via DALI

6.3.2 Intended Use

The LDALI-BM2 pushbutton coupler is intended to integrate customary light push buttons into a DALI-channel. It is perfectly suited to be installed directly behind the light switch.

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.

6.3.3 Installation Instructions

- The device is suitable for installation in distribution boxes or flush mounted installation directly behind the pushbutton/switch.
- Follow the safety instructions (see chapter 2).
- The maximum wire length for digital inputs and universal inputs (digital) is 10m.
- The maximum wire length for universal inputs (analog) is 50 cm.
- The digital/universal inputs are not protected against overvoltage.
- Use separate 24 V DC power supplies for supplying feedback LEDs on different DALI-lines. Establish a single point connection according Figure 30.

7 LDALI: Application Controller

7.1 Overview

Various LOYTEC controller provide a DALI-2 certified interface according IEC62386-103. The feature set of the application controller is perfectly suited to support all features of ballasts and input devices of the LDALI product portfolio, even if they are not directly related to DALI-systems like the bluetooth-feature of the mulitsensors or the integration and control of sunblinds via the sunblindmodule. Besides of the gateway function to the building management the application controllers allow commissioning, device configuration, firmware update etc. For a detailed description refer to LDALI User Manual [2] and LOYTEC Device User Manual [3].

LOYTEC controller with IEC62386-103 compliant DALI interfaces are:

- LDALI-ME201-U, L-DALI BACnet DALI Controller
- LDALI-ME202-U, L-DALI BACnet DALI Controller
- LDALI-ME204-U, L-DALI BACnet DALI Controller
- LDALI-3E101-U, L-DALI CEA709 DALI Controller
- LDALI-3E102-U, L-DALI CEA709 DALI Controller
- LDALI-3E104-U, L-DALI CEA709 DALI Controller
- LDALI-PLC2, L-DALI Programmable Lighting Controller
- LDALI-PLC4, L-DALI Programmable Lighting Controller
- LROC-400, L-ROC Room Controller
- LROC-401, L-ROC Room Controller
- LIOB-591, L-IOB I/O Controller
- LIOB-AIR20, LIOB-AIR VAV Controller (EOL)

8 Discontinued Products

8.1 Overview

This chapter contains the manuals of all discontinued products of the LOYTEC LDALI product line in the latest valid version before discontinuation.

8.2 LOYTEC LDALI-RM1 relay module (EOL)

The LDALI−RM1 relay module allows the control of standard consumers via a DALI. The built-in relay contact can be used for currents of up to 8 A respectively loads of up to 2000 VA. The module is designed for a maximum inrush current of 80 A. The module is connected directly to a DALI channel and also supplied with energy via that channel.

The LDALI−RM1 acts as a programmable switching output module. The integration of the module in the DALI network follows the same simple steps as the integration of a DALI lamp. The LDALI-RM1 is a control device for non-dimmable loads based on the DALI specification IEC 62386−208 (Device Type 7).



Figure 32: LDALI-RM1 relay module

8.3 LOYTEC LDALI-RM2 1-10V interface (EOL)

The LDALI-RM2 has the same features as the LDALI-RM1 but in addition a 1-10 V interface allowing the integration of ballasts with 1-10 V interface into a DALI system.

The integration of the module in the DALI network follows the same simple steps as the integration of a DALI lamp. The LDALI-RM2 is a control device for dimmable loads based on the DALI specification IEC 62386−206 (Device Type 5).



Figure 33: LDALI-RM2 1-10 V interface

8.4 LOYTEC LDALI-MS1 Multi-Sensor (EOL)

The LDALI-MS1 performs motion detection with a PIR sensor and allows to measure lux level in the range of 0 – 2500 lux. It is designed to be mounted in rooms of up to 5 m. For corridors and similar applications the sensor head can be tilted to detect movement in a distance of up to 12 m.



Figure 34: LDALI-MS1 Multi-Sensor with integrated IR receiver.

Note:	*Currently the dial on the back of the sensor has no function. Please leave at default position 0!*

In addition, the LDALI-MS1 is equipped with an IR receiver to be used with infrared remote controls.

Note:	*When scanning the DALI channel, each LDALI-MS1 device will appear twice in the scan results. In the sensor section as **LDALI-MS1** and in the button section as **LDALI-MS1 IRT**. The latter represents the infrared receiver and can be ignored if not infrared remote control is used.*

The LDALI-MS1 infrared receiver is compatible with the L-RC1 IR remote control, which is available as optional accessory (see Figure 26). On the LDALI-MS1 only buttons 1 to 11 are supported (see Table 5).

The LDALI-MS1 infrared receiver is compatible with the Apple Remote. That is, the Apple remote control can be used to control lights in the room. See Figure 35 for how the RC buttons are mapped to the button inputs of the LDALI-MS1 IRT. Optionally pairing is supported.

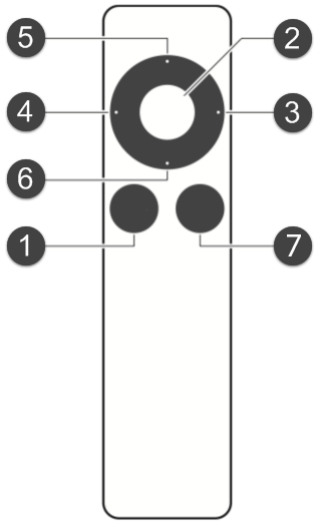


Figure 35: Mapping of Apple Remote buttons.

The LDALI-MS1 IRT supports remote controls with up to 11 buttons using the NEC IR protocol. The vendor code must be 0x43f and the command page 0xe. For unpaired devices the device ID is 0. The command code is equal to the button input index (1-11). Please contact LOYTEC if requiring a custom IR remote control unit (larger quantities).

8.5 LOYTEC LDALI-BM1 push button coupler (EOL)

The LDALI-BM1 push button coupler integrates customary light pushbuttons and switches into a DALI channel. It provides 4 free programmable digital inputs. When the push button is pressed or a switch changes its state, DALI commands are sent to a DALI group within the DALI channel. See the L-DALI User Manual [8] and the L-INX Configurator User Manual [1] on how to configure which button input performs which function.



Figure 36: LDALI-BM1 push button-coupler

8.6 LOYTEC LDALI-RM3/4 Relay Module (EOL)

The LDALI-RM3/4 Relay Modules enable the control of standard consumers via a DALI channel. Typical application scenarios are the integration of non-DALI luminaires or other loads like fans in toilets or washrooms and motors for partition walls or screens in DALI lighting applications.

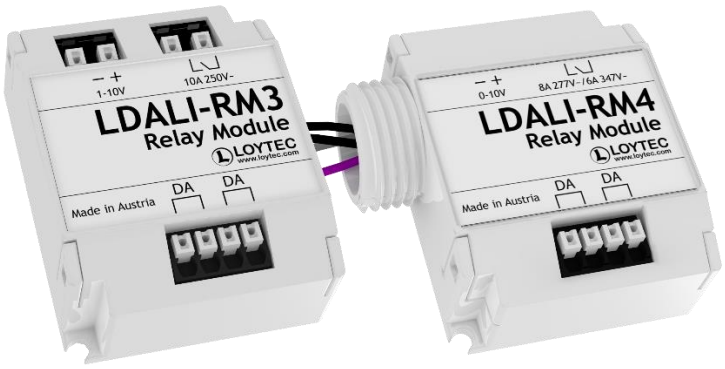


Figure 37: LDALI-RM3/4 Relay-Module

The built-in relay contact can be used for currents of up to 10 A or loads of up to 2.500 VA, respectively. It supports a wide voltage range of 120 – 347 V AC and up to 30 V DC. Zero cross switching technology is used to be able to handle the large in-rush currents typically found in lighting applications. For legacy dimmable ballasts the LDALI-RM3/4 modules are also equipped with a 0-10 V and 1-10 V interface, which can be used together with the relay contact to control these types of loads via DALI.

Modes of Operation

The LDALI-RM3/4 can be operated in 'Switching Function' or 'Converter' mode. The automatic mode detection of the LDALI-RM3/4 selects the mode on whether a driver is connected to the 1-10 V output. A "DALI Reset" on the respective device will enforce the device to start the detection procedure again.

- **Switching Function (Device Type 7, IEC-62386-208)**

  If no driver with 1-10 V interface is connected to the 1-10 V output the LDALI-RM3/4 will operate as 'switching function'. In this mode only the relay output is used.

- **Converter (Device Type 5, IEC-62386-206)**

  If a driver is connected to the 1-10 V output the LDALI-RM3/4 will operate as converter. In this mode the output level can be adjusted from 0 V to 10 V according to the respective output level. In this mode the relay is used as additional switch for the power supply of the driver which is connected to the 1-10 V output. If the output level is 0 % the relay is switched OFF, in any other case the relay is switched ON. For the first time the LDALI-RM3/4 is operated in converter mode a calibration is performed to adjust the 1-10 V output behavior correctly. This calibration procedure can take up to 2 minutes and the device will have an unexpected behavior during this period.

Note:	*It is recommended to connect the 1-10V drivers to the LDALI-RM3/RM4 before switching on the DALI power supply. This will result in a startup procedure in which mode selection and calibration procedure are executed with the correct load already connected.*

Note:	*For dimming a 1-10V lamp with a control element (dial, slider, ...) choose the 'linear dimming curve' and a fade time of 0.7 s for better dimming results.*

System-Failure & Power-On behavior

As a unique safety feature the relay state for fault conditions can be configured. In case of a power loss on the DALI-line, the relay will switch to the position as defined with the DALI configuration register 'System Failure Level'.

Note: Setting the 'System Failure Level' to invalid value ('- -') will disable the system failure behavior and the output level is not changed if a power loss on the DALI line is detected.

Note: Since the LDALI-RM3/4 is bus-powered, the system failure level of the 1-10 V output in converter mode is always at 100 %.

The power-on behavior is defined with the DALI configuration register 'Power_On_Level'.

Note: Setting the 'Power_On_Value' to invalid value ('- -') will cause the last active output level before the power-loss to be recovered.

8.7 LOYTEC LDALI-MS2 Multi-Sensor (EOL)

8.7.1 Device Description

The DALI-2 certified LDALI-MS2 is the successor of the LDALI-MS1 multi-sensor. It provides environment sensing (temperature and humidity) as well as digital inputs and IR-remote control support in additional to occupancy detection and illuminance measurement.



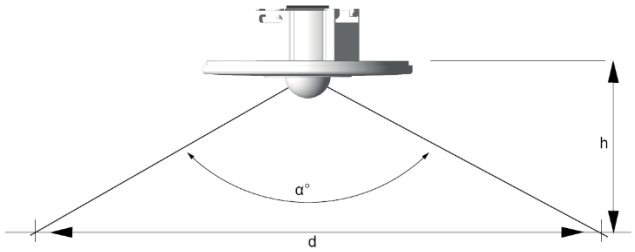
Figure 38: LDALI-MS2 multi-sensor for office applications.

The multisensor is bus-powered. The idle current (no communication, no switching, @16 V bus voltage) is 3.5 mA. An internal current limiter defines the peak current (inrush) with 6 mA. A recommended value for calculations for system design is 3.5 mA.

Occupancy Detection - PIR

The LDALI-MS2 performs motion detection with a high resolution PIR sensor.

The LDALI MS2 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.



Mounting Height / Coverage

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

Figure 39: LDALI-MS2 multi-sensor PIR detection range

The PIR sensor represented by an occupancy instance according to IEC62386-303.

Illuminance Measurement

The LDALI-MS2 allows to measure lux level in the range of 0 – 4000 lux.

It is represented by a light sensor instance according to IEC62386-304.

Note: *Since the light sensor is never placed exactly on the position at which the illuminace has to 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 measurements and illuminance measurements on the target position. The LOYTEC LDALI-controller provides such a calibration routine (refer to [2] amd [3]).*

Temperature and Humidity Measurement

In addition to occupancy and lux measurement, the LDALI-MS2 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.).

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.

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 26). The L-RC1 is an infrared remote control, optimized for room automation applications. It allows the control of the room's light, sunblinds and HVAC system. Additionally, the Apple Remote Control is also supported.

Note: *The Apple Remote control must be paired with the LDALI-MS2-BT / LDALI-MS4-BT to work!*
***Pair (simple)**: Press 'Menu' + 'Next' for at least 5 seconds.*
***Unpair**: Press 'Menu' + 'Previous' for at least 5 seconds. (Pair L-RC1 again)*



Figure 40: L-RC1 infrared remote control for LDALI-MS2.

Table 5 lists all button-instances of the LDALI-MS2 and the corresponding inputs.

DALI-Instance Number	Type	Input	Description
04	Digital Input	DI1	DI1 on back of LDALI-MSx-BT
05	Digital Input	DI2	DI2 on back of LDALI-MSx-BT
06	Digital Input	DI3	DI3 on back of LDALI-MSx-BT
07	Button	IR-Remote Cmd 1	CH1 /Menu (Apple)
08	Button	IR-Remote Cmd 2	CH2 / Select (Apple)
09	Button	IR-Remote Cmd 3	Sunblind UP / Next (Apple)

DALI-Instance Number	Type	Input	Description
10	Button	IR-Remote Cmd 4	Sunblind AUTO / Previous (Apple)
11	Button	IR-Remote Cmd 5	Sunblind DOWN / Up (Apple)
12	Button	IR-Remote Cmd 6	Lights UP / Down (Apple)
13	Button	IR-Remote Cmd 7	Lights AUTO / Play (Apple)
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 7: Instances of LDALI-MSx-BT and corresponding inputs.

Status LED

LDALI MS2 comes with a red status-LED. The behavior of this LED is as follows:

- Blinking if motion is detected if device is unaddressed (useful for installer to check basic functionality and support sensor head adjustment)
- Blinking for 10 seconds if device has received the IDENTIFY command (e.g. WINK-action)
- Blinking (short on, long off) during a firmware update when device is in bootloader.

8.7.2 Intended Use

The LOYTEC LDALI-MS2 is intended to be used as environment sensor for room automation with a DALI-based lighting control system. The sensor provides information about presence, illuminance, temperature and humidity as well as support for digital inputs (e.g. for window contacts) or room control via IR remote control.

The sensor is intended to be used on a ceiling or in false ceilings. The LDALI-MS2 can be mounted in-wall in standard flush-mounted boxes, spring snap in false ceilings and on-wall with the included surface mounting box



Figure 41: LDALI-MS2 mounting options.

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

8.7.3 Installation Instructions

- The LDALI-MS2 can be mounted in-wall in standard flush-mounted boxes, on-wall with a surface mounting box, or spring snap 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 (seeFigure 42).

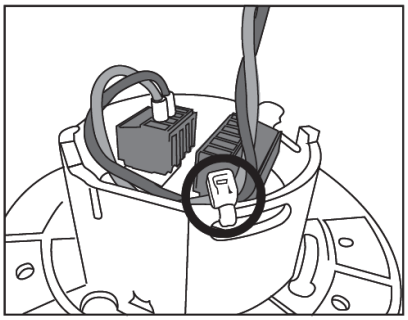


Figure 42: LDALI-MS2 strain relief.

- 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).

8.8 LOYTEC LDALI-PWM8-x (EOL)

8.8.1 Device Description

The LDALI-PWM8 is a 8 channel constant voltage LED driver. It is suitable for constant voltage LED modules and LED strips with operating voltages from 12 V to 24 V DC. The PWM outputs offer a wide dimming range from 0.1 % to 100 % and adjustable PWM frequency (default: 250 Hz, others: 125 Hz / 500 Hz). The maximum load is limited to 0.5 A per channel.

The module comes with overtemperature protection as well as with open circuit and short circuit detection[12]. The compact module provides high efficiency and low standby power consumption.

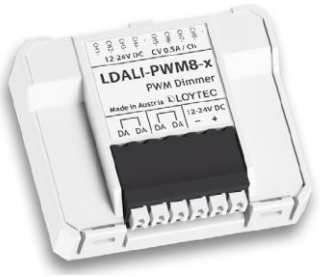


Figure 43: LDALI-PWM8 Module

The LDALI-PWM8-x is externally powered by the 12 V to 24 V DC supply. The DALI bus-current consumption is below 2 mA.

From a DALI perspective the module is compliant to the DALI specifications IEC62386-101, IEC62386-102 and IEC62386-207 (Device Type 6, LED). In addition to the LDALI-PWM8 with 8 independent logical units that can be controlled by 8 separate addresses, there are 2 modules with different colour types available (IEC62386-209, Device Type 8, Colour Control).

Module Types:

- LDALI-PWM8 for the independent control of 8 logical units (DALI DT6 LED)
- LDALI-PWM8-TC for tunable white applications (4 logical units supporting DT8-type Tc)
- LDALI-PWM8-RGBW for colour applications (2 logical unit supporting DT8-type RGBWAF)

System Failure & Power-On behavior

In case of a power loss on the DALI-line, the resulting dim level is defined by the DALI configuration register ‘System Failure Level’.

Note:	*Setting the ‘System Failure Level’ to DALI-value ‘255‘ will disable the system failure behavior and the output level is not changed in case of a DALI bus outage.*

The power-on behavior is defined with the DALI configuration register ‘Power_On_Level’.

Note:	*Setting the ‘Power On Value’ to DALI-value ‘255‘ will cause a recovery of the last active output level of before the power loss.*

8.8.2 Intended Use

The LDALI-PWM8-x is intended to be used as low voltage LED-driver for 12 V to 24 V constant voltage LED-strips or LED-modules. It is suitable for loads of up to 0.5 A per channel.

[12] Open circuit and short circuit lamp failure detection can be dactivated separately if needed (see also [AN019E]).

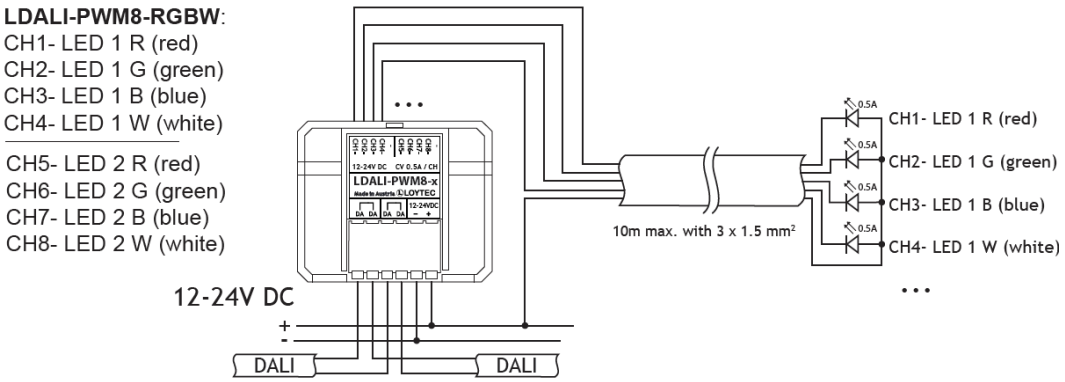


Figure 44: LDALI-PWM8 wiring

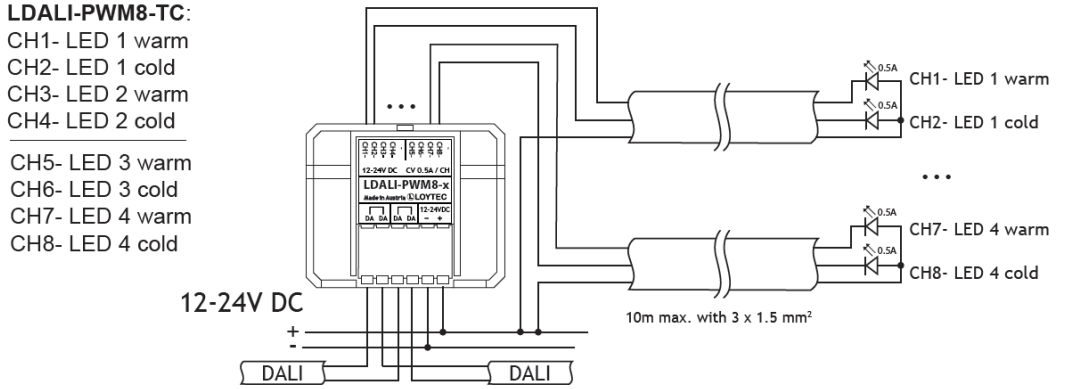


Figure 45: LDALI-PWM8-Tc wiring

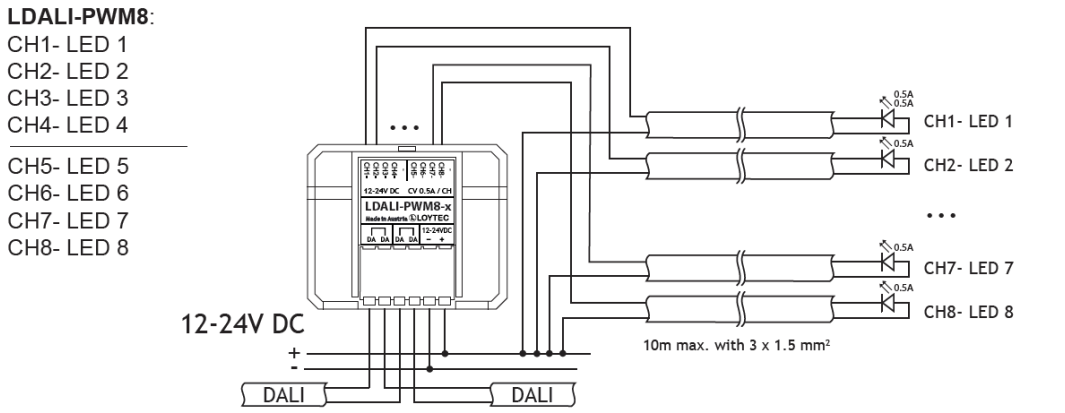


Figure 46: LDALI-PWM8-RGBW wiring

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.

Recommendation: *For wiring keep the cable lengths between dimmer and power supply as well as between dimmer and luminaires (LED strips) as short as possible.*

8.8.3 Installation Instructions

- The LDALI-PWM8 device is suitable for installation in distribution boxes or for luminaire integration.
- Follow the safety instructions (see chapter 2).
- The SELV-behavior of the PWM-channels has to be ensured by using a proper DC power supply with a SELV 12 V to 24 V output.
- Follow the wiring diagrams and cable cross sections in Figure 44 to Figure 46. Do not use single conductors for connecting LED-strips.

9 Troubleshooting

9.1 Technical Support

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

Delta Intelligent Building Technologies (Europe) GmbH
Blumengasse 35
A-1170 Vienna
Austria / Europe

e-mail : ***support@loytec.com***
Web : ***https://www.loytec.com***
tel : ***+43/1/4020805-100***

or

Delta Intelligent Building Technologies (Canada) Inc.
17850 56 Ave
Surrey, BC V3S 1C7
CANADA

e-mail: ***support@loytec-americas.com***
Web: ***https://www.loytec.com***
tel: ***+1 800.335.8221***

10 References

[1] LINX Configurator User Manual 8.6, Delta Intelligent Building Technologies (Europe) GmbH,
Document № 88086713, September 2026.

[2] L-DALI User Manual 8.6, Delta Intelligent Building Technologies (Europe) GmbH,
Document № 88077122, September 2026.

[3] LOYTEC Device User Manual 8.6, Delta Intelligent Building Technologies (Europe) GmbH,
Document № 88086514, September 2026.

[4] AN011E L-DALI Compatibility List, Delta Intelligent Building Technologies (Europe) GmbH,
Document № 86002011, March 2023.

[5] AN019E LOYTEC LDALI-Devices, Delta Intelligent Building Technologies (Europe) GmbH,
Document № 86023302, October 2026.

11 Revision History

Date	Version	Author	Description
2023-02-28	3.24	UR	Initial revision. Extracted from chapter 16 of the LOYTEC Device Manual.
2023-10-10	3.30	UR	Added chapter for LDALI-PWM8-x. Correction on LOY-DALI-SBM1. Move Chapter about LDALI-MS2 to section about Discontinued Products. Minor Textual Changes.
2024-01-30	3.32	UR	Added LDALI-MS3-BT. Minor corrections.
2025-07-31	4.0	UR	Moved chapter of LDALI-PWM8-x to EOL product section. Update LOY-DALI-SBM1 section.
2026-10-01	4.2	IV	Updated for firmware 4.2: occupancy detection of LDALI-MSx-BT, rotation time of LOY-DALI-SBM1. Company name changed to Delta Intelligent Building Technologies (Europe) GmbH. Updated references and technical support contacts. Minor corrections.