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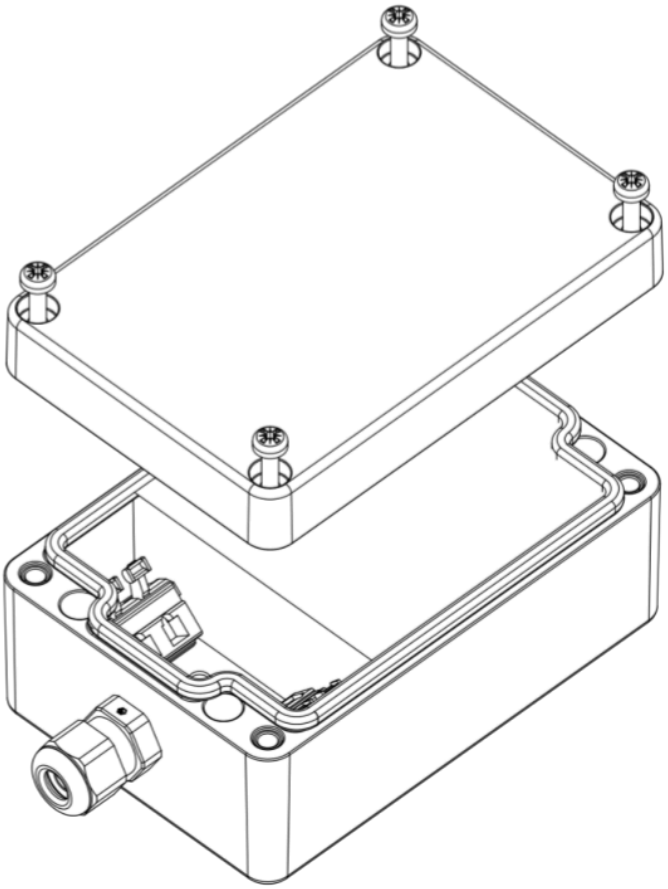
14 / 10 / 2024

SPOTSIE GATEWAY

ATEX
TECHNICAL FILE



Contents

1. Device Information

General:

Device name:	Spotise Gateway
Model:	1.0.0
Device type:	IoT WiFi/BLE gateway with integrated dual AC/DC power supplies
Manufacturer:	Connected Devices d.o.o. Ulica Republike Austrije 33, 10000 Zagreb
Type of protection:	Increased safety “e”, Protection by encapsulation “m”
ATEX markings:	II 2G Ex eb mb IIC T4...T3
Temperature class:	T4: -20°C ≤ T_{amb} ≤ +45°C T3: -20°C ≤ T_{amb} ≤ +60°C
IP rating:	IP66

Electrical data:

Power supply type:	Dual, AC and DC supplies with separate terminal blocks
Rated voltage * / current (AC):	85 VAC to 264 VAC / 100 mA
Rated voltage * / current (DC):	4.5 VDC to 36 VDC / 160 mA
Nominal voltage (AC):	230 VAC (47-63 Hz)
Nominal voltage (DC):	24 VDC
Short-circuit current (AC):	1500 A
Short-circuit current (DC):	100 A

* Absolute voltage range that the power supply can safely tolerate

Conditions:

The device enclosure has passed the impact test with a lower impact energy of 4 J. Make sure that the mounting location is safe or protected from potential impacts.

2. General Description of the Equipment

IoT (*Internet of Things*) *Bluetooth Low Energy* to *WiFi* gateway for use in explosive atmospheres, composed of the following parts:

a. PCB (*printed circuit board*), with the following block diagram,

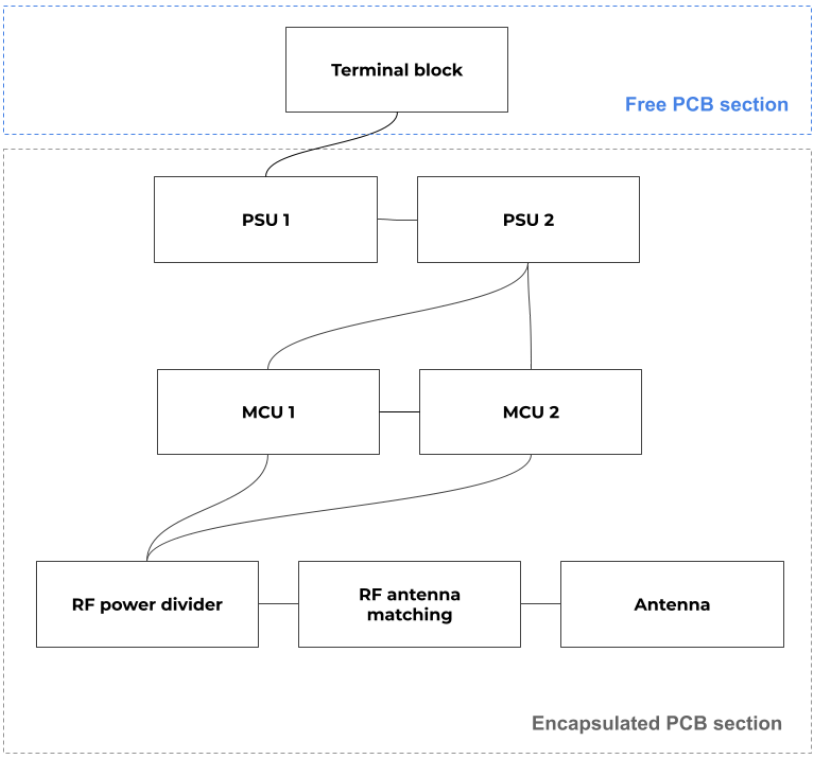


Figure 1. Block diagram showing relations between different PCB subsections (Note that a single edge between two blocks in the diagram might represent multiple connections on the PCB, see below for details). Blocks encompassed with the gray rectangle marked “Encapsulated PCB section”correspond to the PCB section encapsulated with an encapsulation compound (see below) and thus have no direct contact with the atmosphere inside the device enclosure (see below). On the other hand the terminal block section of the PCB is not encapsulated and thus in contact with the atmosphere inside the enclosure.

The PCB design process has gone through multiple iterations of changes and improvements based on knowledge and experience gathered in working on projects with equipment in explosive environments. Main focus was given to oil&gas industry and explosive gas atmospheres where IoT BLE Gateway is used to provide new levels of worker and asset security by employing best available technologies and implementing robust safety measures in the design process.

The PCB is divided into two main sections: i. terminal block section (“e” level protection) and ii. the rest of the circuit (“m” level protection)

Component descriptions:

i. 230 VAC / 24VDC connection facilities consisting of ATEX certified terminal blocks (see below) for connecting power supply to the device. There are two terminal blocks for connecting either nominal 230 VAC or 24 VDC supply voltage.

ii. Rest of the circuit (see Figure 1.), consisting of two *PSU* (*Power supply unit*) sections, two *MCU* (*Microcontroller Unit*) sections and a *RF* section. The whole of this section is encapsulated in an encapsulation compound (see below) and has no immediate contact with the surrounding atmosphere.

   Subsections:

   1. *PSU 1* connected to PCB section a) via two traces (phase and neutral) and is responsible for converting 230 VAC, 50Hz electrical power to 24 VDC.

   2. *PSU 2* connects to the output of *PSU 1* and is responsible for converting 24 VDC to 3.3 VDC which is in turn used by the two *MCU* sections.

   3. *MCU 1* consists of a ESP32-S2-WROVER module and its supporting circuitry:
      a. Enable circuit,
      b. Programming / debug headers,
      c. Flash circuit.

      It is responsible for maintaining a stable *WiFi* connection and it implements the core communication protocol with

cloud servers. Module antenna output is connected to the *RF* section (see below).

4. *MCU 2* is a nRF52840 *SoC* (*System On a Chip*) responsible for *Bluetooth Low Energy*. It maintains a link with *MCU 1* via an *I2C* bus for *BLE* related communication and an *UART* connection for logging purposes. Module antenna output is connected to the *RF* section (see below).

5. The *RF* section consists of two input signals (antenna outputs from *MCU 1* and *MCU 2*, a power divider section (which merges the two input signals into one), an antenna matching circuit and the 2.4GHz antenna itself.

b. Encapsulation compound, Wepuran VU 4447, a Polyurethane resin compound manufactured by Lackwerke Peters GmbH & Co. KG (see below).

c. Device enclosure, with part number MBP-Ex e 11750 manufactured by MULTI-BOX GmbH. This is an ATEX certified, IP66 rated, fully insulated, glass reinforced polyester box with following ATEX markings: Ex II 2G Ex e IIC T6/T5 Gb, Ex II 2D Ex tb IIIC T85°C/T100° Db.

d. Cable gland, 1.292.1201.51 model manufactured by Hummel AG Lise-Meitner-Straße 2 79211 Denzlingen Germany with the following ATEX markings: Ex eb IIC GbEx ta IIIC Da.

e. Terminal block, an ATEX certified Wago Corporation PCB terminal block with part number 256-502/000-009/999-950 and following ATEX markings: Ex eb IIC.

f. Power cable entering through the cable gland and connecting to the terminal block is not supplied with the device. But, it's included in this document to serve as an installation guide (see below).

3. General Arrangement Drawing

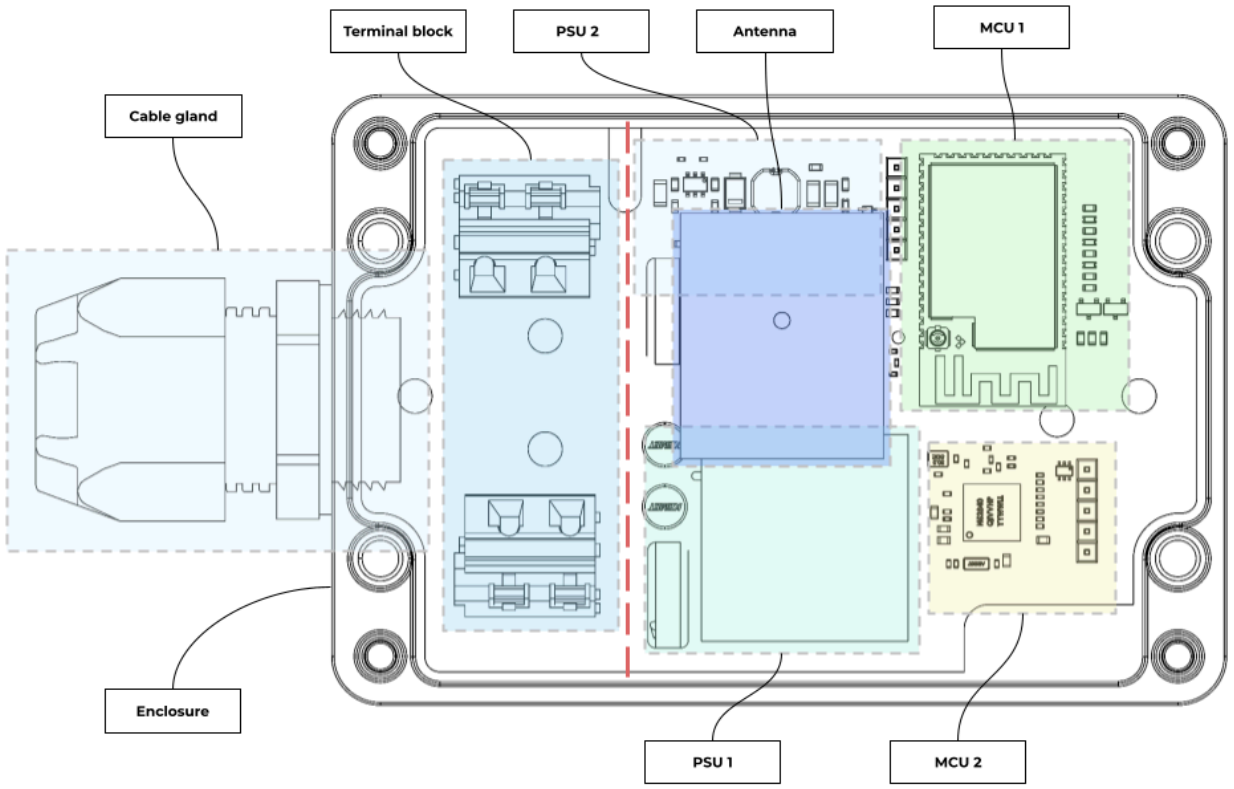


Figure 2. General arrangement of components in the enclosure with the cover, covers screws, enclosure silicon gasket, the encapsulation compound and the power cable not shown. Everything on the right side of the red dashed line is encapsulated and thus achieves equipmen protection by encapsulation ex “m”. Terminal blocks, cable gland and enclosure provide ex “e” protection.

4. Schematics and Wiring Diagrams

a. Enclosure - see *3221100360_en.pdf*

b. Terminal block - see WAGO_256-502_000-009_999-950en_AU.pdf

c. PCB - see *100054_hw-spotsie-gateway_Rev-11.pdf*

5. List of Applied Standards

d. EN IEC 60079-0:2018 - Eksplozivne atmosfere - 0. dio: Oprema - Opći zahtjevi.

e. EN IEC 60079-7:2015/A1:2018 - Eksplozivne atmosfere - 7. dio: Vrsta zaštite opreme povećana sigurnost 'e'

f. EN 60079-18:2015/A1:2017 - Eksplozivne atmosfere - 18. dio: Vrsta zaštite opreme oblaganje 'm'

6. Part Description, Specification and Assessment

a. PCB

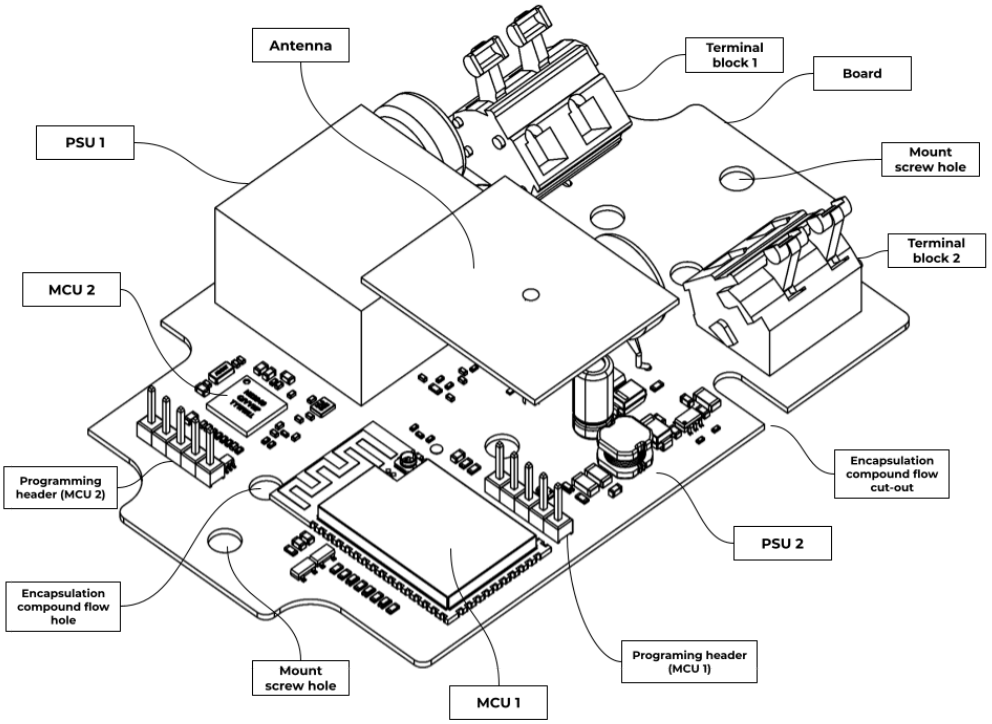


Figure 3. Printed circuit board parts (encapsulation compound not shown).

Description:

The printed circuit board consists of six subsections: terminal block, PSU 1, PSU 2, MCU 1, MCU 2 and the RF section which contains the antenna (see Figure 3.). Every subsection except the terminal block is encapsulated in an encapsulation compound and thus has no direct contact with the atmosphere inside the enclosure. The board features multiple encapsulation compound flow holes and cut-outs which help guide and distribute the encapsulation compound during the molding process onto both sides of the PCB.

The 2.4GHz antenna is constructed from a spiral conductive trace on a rectangular 25 x 30 mm printed circuit board (see Figure 3.). It is raised by a solid core wire 19 mm from the main PCB floor (see Figure 4.) and rests along one edge of the PSU 1 enclosure.

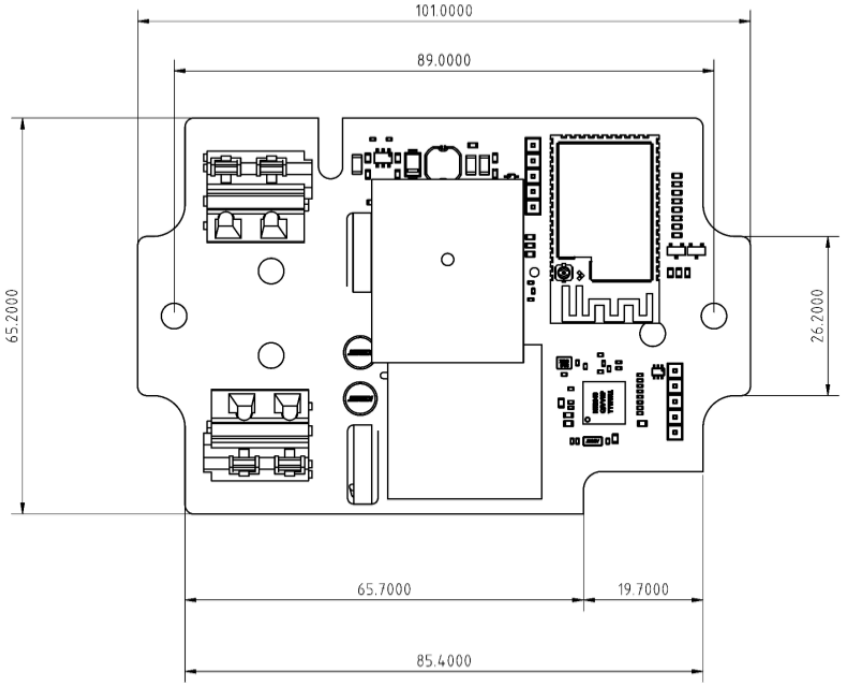


Figure 4. Top view dimensions.

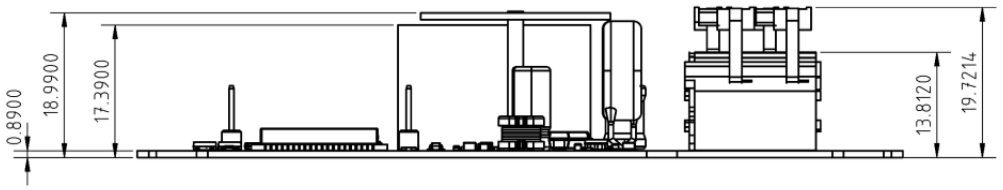


Figure 5. Side view dimensions.

Earth grounding:

As there are no bare current carrying parts inside the device enclosure there is no risk of electrical shock. The electrical circuit is protected by the PCB and component housings as well as with the encapsulation compound surrounding all the critical circuit parts. The enclosure is made of an plastic material and the risk of electrostatic discharge on the surface of the enclosure is mitigated by a graphite additive which results in a surface resistance of less than 10 GΩ. The power cable has been specified to be double insulated. Thus, the device does not require an earth ground connection.

PCB subsections:

1. PSU 1

   Manufactured by RECOM Power, model RAC05-24SK (see datasheet in appendix).
   The input side of the PSU1 is connected by two traces (line and neutral) with low-pass filters on both traces. Output of the PSU1 is the converted DC voltage and is connected to step-down converter - PSU2.

   Electrical specification:

Parameter	Condition	Min.	Typ.	Max
Input voltage range		85 V AC 120 V DC		264 V AC 370 V DC
Input Current	115 V AC 230 V AC			250 mA 100 mA
No load Power Consumption	264 V AC		75 mA	
Input Frequency Range		47 Hz		63 Hz

   Protection features:

Internal input fuse:	T1A, slow blow
Short circuit protection:	Hiccup, automatic restart
Overvoltage protection:	125% - 195%, latch off mode

Overcurrent protection:	150% - 195%, hiccup mode

Environmental:

Operating Temperature Range	-25 °C to +50 °C -25 °C to +70 °C with derating graph

Beside safety approvals for industrial and IT solutions IEC 60950-1 and UL 62368-1, the component meets EN 55032-B limits without any external components.

Certifications:

UL 62368-1
CSA C22.2 No. 62368-1-14
IEC/EN 60950-1
IEC/EN 62368-1

Compliance:

EN 61204-3
CB-Report

Assessment:

This component provides galvanic isolation (3kV AC for 1 minute or 4kV DC for 3 seconds) between the device and the external supply circuit. It also integrates an overcurrent protection which turns off the power supply in an over current event. The module will try to recover if the erroneous state has been removed. For more details see *100432_Spotsie-Gateway-ATEX-certification_rev-12.pdf*

2. PSU2

Manufactured by Alpha & Omega Semiconductor, model AOZ1282CI. PSU2 is buck regulator or step-down converter that stabilizes and reduces input voltage of 24 VDC supplied from the PSU1 or directly from the 24 V DC terminal block, to MCU operating voltage level of 3.3 VDC.

Featuring a broad acceptable input voltage range, as well as soft start, short-circuit protection, and thermal shutdown capabilities, these attributes collectively contribute to an elevated level of fidelity and robustness in the system.

Specifications:

Parameter	Condition	Min.	Typ.	Max
Input voltage range		4.5 V DC		36 V DC
Output current				1.2 A
Output voltage		0.8 V		0.85 V * $_{\text{Input voltage}}$
Switching frequency			450 kHz	

Environmental:

Operating temperature range	-40 °C to +85 °C

Assessment:

This section of the PCB has been identified as a temperature hot spot during nominal operation in sample device without the encapsulation compound present. Maximum temperature of 35.0 °C has been observed in temperature measurement test according to EN IEC 60079-0:2018 (see *TR_22_LAB_055_Byte_Lab_Spotsie_Gateway.pdf*)

3. MCU1

Manufactured by Espressif, model ESP32-S2-WROVER and supporting circuitry composed of infallible components is a low power IoT (Internet of Things) design solution that provides reliable operation in wide application use cases.

Electrical specifications:

Parameter	Condition	Min.	Typ.	Max
Input voltage range - maximum absolute ratings		-0.3 V DC		+3.6 V DC
Input voltage range - operating values		3.0 V DC	3.3 V DC	3.6 V DC
Input Current - delivered by PSU 2		0.5 A		

Environmental:

Operating temperature range	-40 °C to +85 ° C

RF specification:

RF Frequency range	2412.0 - 2462.0 MHz
Output Power	0.202 W

Certifications:

FCC 15C
CE
WiFi certified

4. MCU2

MCU 2, the NRF52840 by Nordic Semiconductor is specifically designed for energy efficient cooperation with MCU 1 on BLE related tasks with very low power consumption and advanced Bluetooth and power management features.

Specifications:

Parameter	Min.	Typ.	Max
Input voltage range	1.7 V DC		5.5 V DC
Input current - system ON, full 256 kB RAM retention		17.37 µA	
Input current - System OFF, no RAI retention, wake on reset		0.4 µA	

Environmental:

Operating temperature range	-40 °C to +85 ° C

5. RF section

RF section consists of passive components used for WIFI/BLE signal conditioning divided into wifi attenuator, power divider and WIFI/BLE antenna matching parts. These auxiliary circuits consist of infallible components that enable 2.4 GHz antenna fine tuning.

PCB specification:

Manufacturer:	ByteLab d.o.o., Medarska 69/1, Zagreb 10000, Croatia
IPC standard:	IPC-A-600 class 2
Num. of conductive layers	2 (top, bottom)
Material - substrate	FR-4 (glass-reinforced epoxy laminate)

Material - conductive layer	Electrolytic copper (E_{Cu})
Layer thickness - substrate:	1,5 mm (± 0,1 mm)
Layer thickness - conductive layer:	35 µm

Assessment:

See section 5.6 in
100432_Spotsie-Gateway-ATEX-certification_rev-12.pdf.

b. Encapsulation Compound

Description:

Chosen encapsulation compound, Wepuran VU4457, exhibits excellent protection against extreme climate influences, abrasive chemicals and mechanical damage.

Specification:

Manufacturer:	Lackwerke Peters GmbH & Co. KG
Manufacturers code:	VU 4457 series – type VU 4447/41
Base:	Polyurethane resin
Color:	Blue
Water absorption:	0.20% (24h / 23 °C)
Service temperature:	-65°C to -90 °C
Flame class - UL94:	V-0
Dielectric strength:	28 kV/mm (DIN EN 60243-1)
Surface resistance:	$2 \times 10^{12}\,\Omega$
Thermal conductivity	0.3 to 0.4 W/mK

Assessment:

Before molding the device enclosure is properly cleaned and the encapsulation compound is prepared in accordance with the manufacturer's instructions. For a detailed report see section 6. in *100432_Spotsie-Gateway-ATEX-certification_rev-12.pdf*
There are no intentional voids or free spaces inside the set casting compound. To avoid air bubbles and pockets which can form during the preparation, the compound (in liquid form) is kept inside a vacuum chamber for 30 minutes before the molding process. PCB features drain holes so the compound can flow in between the enclosure and the PCB. Water absorption and dielectric strength tests have been performed on four compound test samples according to IEC 60079-18:2014 / AMD1:2017 (see TR_22_LAB_003_Byte_Lab_material_for_encapsulation.pdf).

c. Device Enclosure

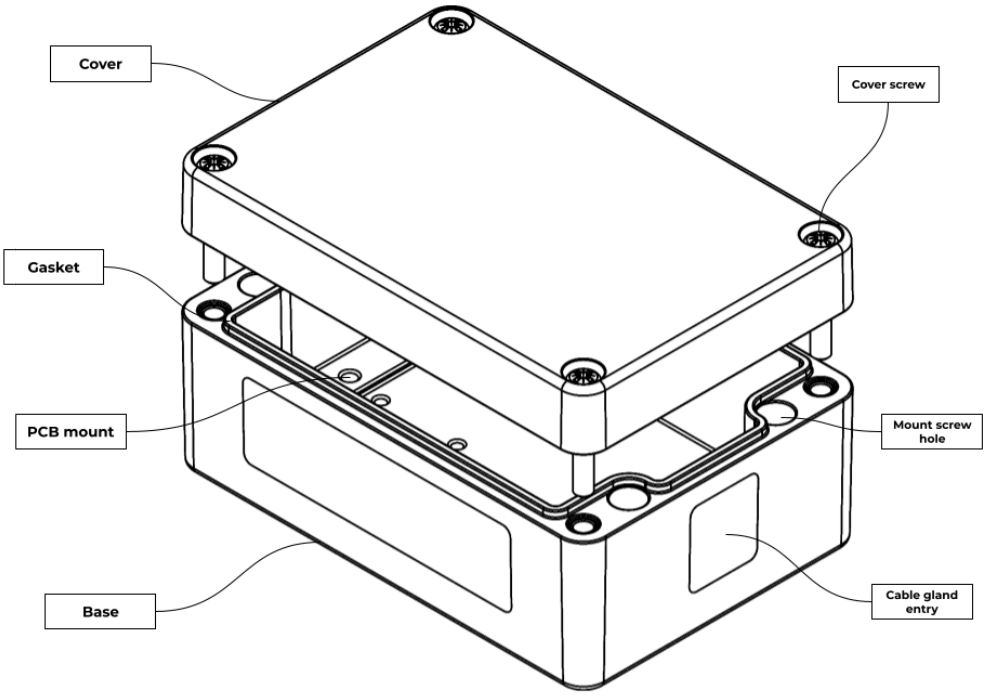


Figure 6. Device enclosure parts.

Description:

Device enclosure houses the PCB and provides one enclosure entry via the cable gland. The PCB is fixed to the enclosure with two mount screws on existing mount points provided by the enclosure. The cable gland is mounted through a hole drilled at the location marked with “Cable gland entry” on Figure 6. and secured with a Polyamide lock nut from the inside of the enclosure. The entry is also threaded, to provide a better fit. The whole enclosure mounts to a flat back surface or a mounting bracket via four mount screw holes (see Figure 4.).

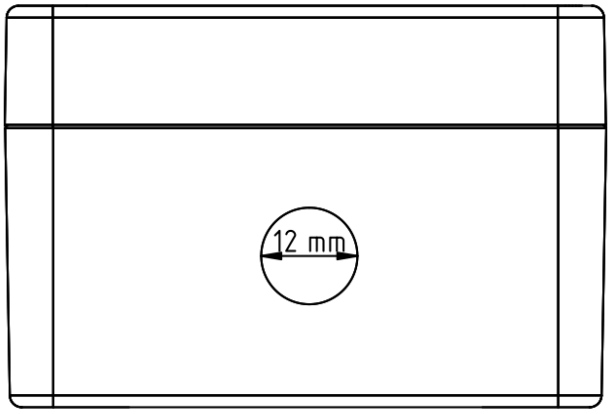


Figure 5. Enclosure side view and non-threaded entry hole drawing. Entry diameter of 12.0 - 12.2mm is taken from the cable gland mounting instructions document (see in appendix).

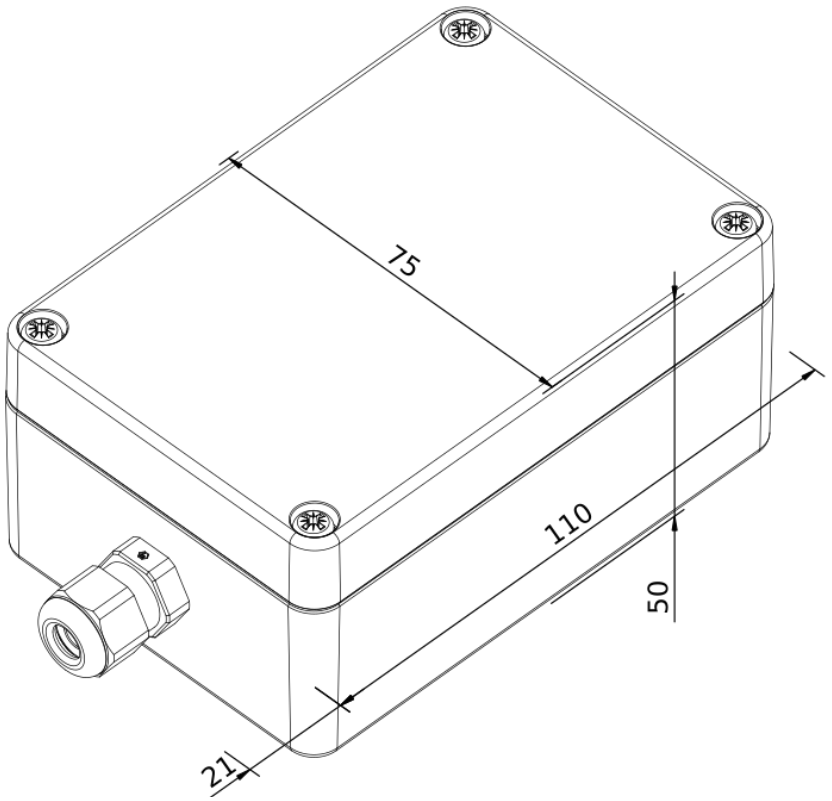


Figure 6. Enclosure dimensions (mm).

Specification:

Manufacturer:	MULTI-BOX GmbH, Wallücker Bahndamm 7, 32278 Kirchlengern, Germany
Model:	MBP-Ex e 117550
Ex marking:	Ex II 2G Ex e IIC T6/T5 Gb, Ex II 2D Ex tb IIIC T85°C/T100° Db
Certificate No.:	IBExU12ATEX1180U
Protection class:	IP66
Material - cover:	Polyester GRP
Material - base:	Polyester GRP
Material - gasket:	Silicone
Rated voltage:	max 1.1 kV
Rated current:	452 A
Service temperature:	-55 °C to +85 °C
Surface temperature - max:	+100 °C
Surface resistance:	=< 10 Ω
Tightening torque - cover screw	1.5 - 3.0 Nm
Tightening torque - earthing screw	1.2 - 2.3 Nm

Assessment:

Certificate of Conformity (see in appendix) verifies that the enclosure complies with IEC 60079-0 and IEC 60079-7 standards. We ensure that the level of protection stated by the manufacturer remains unchanged after full device assembly (see below).

The base and cover polyester material contains a graphite additive which ensures a low surface resistance, less than 10 GΩ. Thus, prevents the build up of electrostatic charge and the potential sparking resulting from it (see datasheet in appendix).

To install the cable gland, the enclosure is cautiously drilled and taped so as not to invalidate the enclosure's level of protection.

The enclosure has passed the impact test with 4J of energy (see *EC Type Examination Certificate_MBP Ex empty_11.11.2014.pdf*).

d. Cable Gland

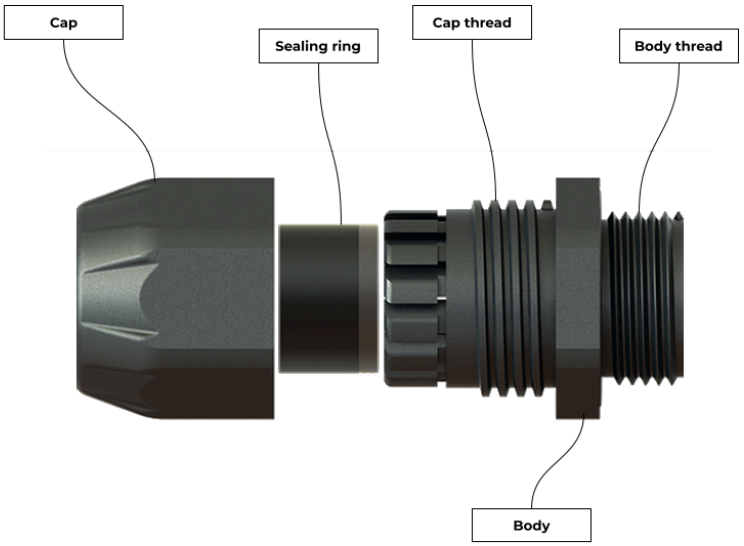


Figure 6. Cable gland assembly. Flat washer which goes against the enclosure and the lock nut are not shown.

Description:

The cable gland is fixed to the enclosure through the threaded hole described in Figure 5. A flat washer goes on the body thread against the enclosure wall. The gland is secured with a lock nut from the inside of the enclosure.

Specification:

Manufacturer:	Hummel AG Lise-Meitner-Straße 2 79211 Denzlingen Germany
Model:	1.292.1201.51
Ex marking:	Ex eb IIC GbEx ta IIIC Da

Certificate No.:	IECEx BVS 14.0020X
Protection class:	IP68, 10 bar / 30 min
Material - body:	Polyamide, fiber reinforced
Material - sealing:	NBR
Service temperature:	-20 °C to +85 °C
Tightening torque - cap:	2.0 Nm
Thread - body:	M12 x 1.5
Clamping range:	2.0 - 5.0 mm

Assessment:

EU-Type Examination Certificate (see in appendix) verifies that the cable gland complies with IEC 60079-0:2018 and IEC 60079-7:2015 standards. By following instructions from the *Safety, maintenance and mounting instructions* (see in appendix) we ensure that the level of protection stated by the manufacturer remains unchanged after full device assembly.

It’s possible to use similar ex certified cable glands by different manufacturers as long they comply with the requirements above.

e. Terminal Block

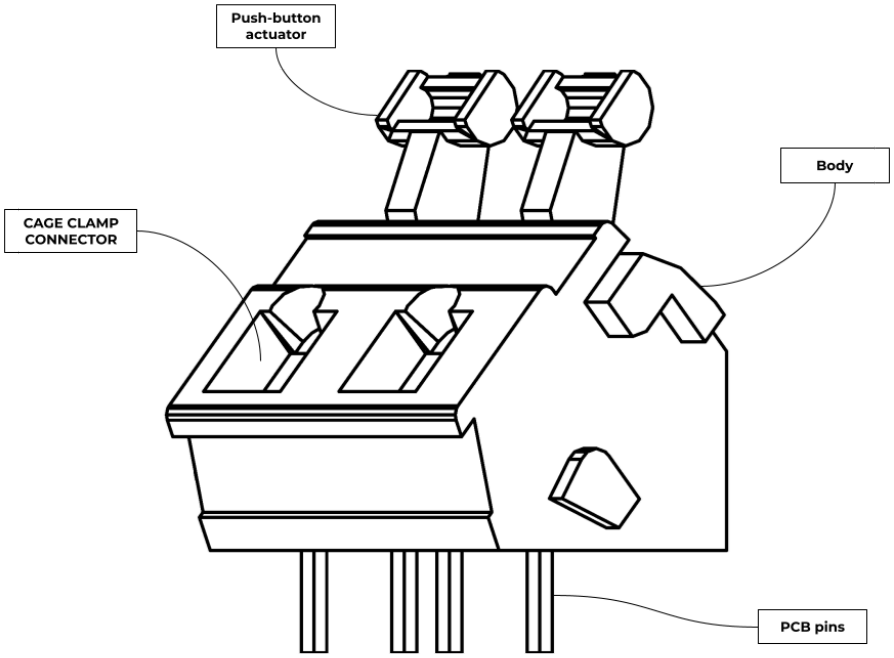


Figure 7. Terminal block parts.

Description:

Separate terminal blocks are used for 230 VAC and 24 VDC power supply to the device with placing on the PCB layout as shown on Figure 3. and Figure 4. Selected terminal block is manufactured by WAGO for PCB terminal block application with multiple approvals (IECEx, AEx, CNEX) for use in hazardous areas marked as Ex eb IIC GB by IECEx standard.

Specification:

Manufacturer:	WAGO Kontakttechnik GmbH & Co. KG, Hansastraße 27, 32423 Minden, Germany
Model:	256-502/000-009/999-950

Ex marking:	Ex eb IIC, Ex eb I Mb
Certificate No.:	PTB 06 ATEX 1061U
Material - body:	Polyamide PA66
Material - spring:	Chrome nickel spring steel (CrNi)
Material - contact	Electrolytic copper (E_{Cu})
Rated voltage:	275V
Rated current:	16A
Rated conductor cross-section:	0.08 - 2.5 mm² (solid, fine-stranded)
Rated conductor cross-section:	0.25 - 1.5 mm² (fine-stranded with insulated ferrule)
Service temperature:	-60 °C to +70 °C
Surface temperature - max:	-55 °C to +105 °C
Resistance:	1.3 mΩ
PCB pin spacing (distance between bare current carrying parts):	>= 5 mm

Assessment:

Certificate of conformity (see *ATEX-Serie-256-002.pdf*) verifies that the component complies with the IEC Standard (IEC 60079-0:2017, IEC 60079-7:2017) and that the manufacturer's quality systems, relating to the Ex products covered by this certificate. When incorporating PCB terminal blocks in the design we have followed all of the applicable standards for PCB design and manufacturing to ensure that in accordance with IEC 60079-0 the type of protection remains unchanged.

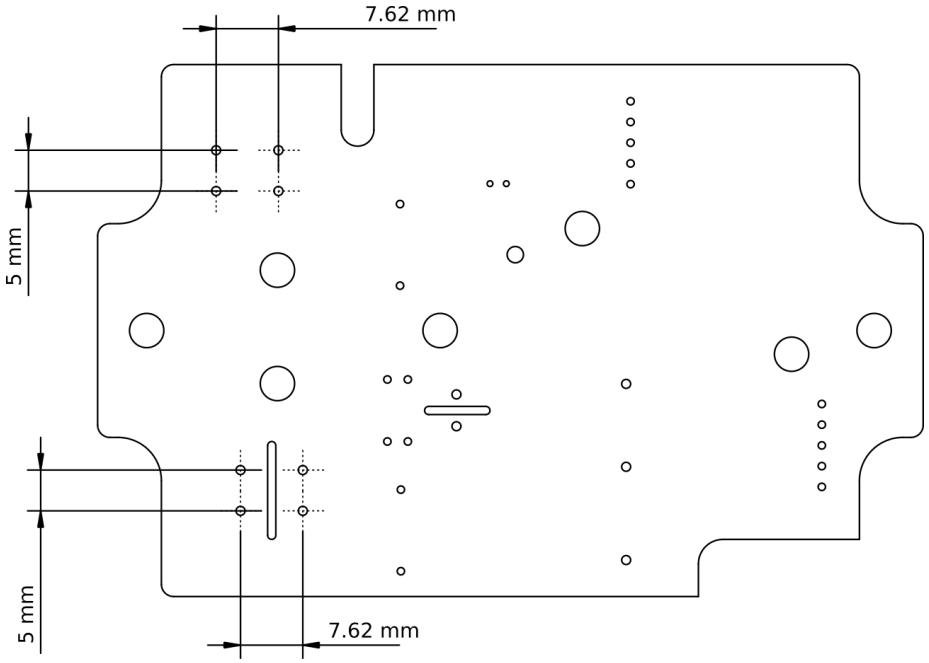


Figure 8. Terminal blocks pin spacing dimensions.

f. Power Cable

Description:

Power cable for connecting power supply to the device is not supplied with the device and is not part of the device certification. To ensure correct wiring and installation the installation needs to be performed by an authorized personnel following the device specifications given below. Devices can be supplied with AC or DC voltage levels and cable selection needs to be performed in accordance with voltage level, current-carrying capacity, voltage drop due to cable length and environmental conditions.

Specification:

Cable number of cores (AC/DC):	2
Conductor type:	Solid or fine stranded with insulated ferrule
Conductor minimum cross-section:	0.75 mm^2
Conductor maximum cross-section:	2.5 mm^2
Cable recommended cross-section:	1.0 mm^2
Cable outer minimum dimension:	2.0 mm
Cable outer maximum dimension:	5.0 mm
Cable outer recommended dimension:	5.0 mm

Assessment:

For specific use case supply cable should be chosen that satisfies environmental conditions and any additional requirement ensuring device safe installation, operation and maintenance. Supply cable needs to be protected by an electrical protective element such as a miniature circuit breaker (MCB) with characteristics meeting the requirements on breaking capacity and overload protection. Details are given in *SPOTSIE-GATEWAY-ATEX-INSTRUCTIONS.pdf*

7. Fault Examination and Tests

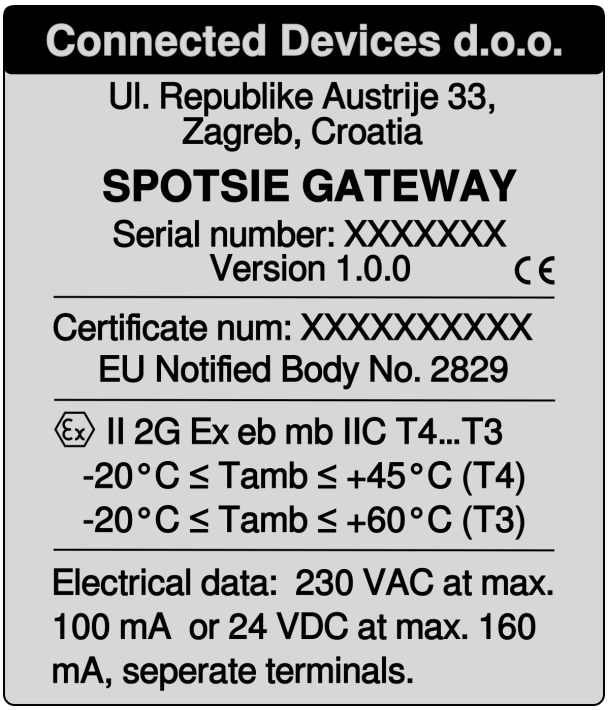
According to EN IEC 60079-0, encapsulation “m” shall be maintained in the case of the most unfavorable output load and up to one internal countable fault for level of protection “mb”.

100432_Spotsie-Gateway-ATEX-certification_rev-12.pdf lists all components divided into fallible and infallible categories according to IEC 60079-18. The fallible category has then been further analyzed and a short circuit in PSU 2 (U4) has been identified as the most unfavored countable fault. A sample device was prepared with a resistor circuit of 90Ω, simulating the worst case short circuit scenario. The PCB was then encapsulated with the compound as described in *100432_Spotsie-Gateway-ATEX-certification_rev-12.pdf*. The sample was tested for surface temperature increase with nominal voltage of 24 VDC and 160 mA nominal current taken with a 1.7 safety factor. That results with heath dissipation of 6.53W, making the device’s temperature class T3 for -20°C ≤ T_{amb} ≤ +45°C and class T4 for -20°C ≤ T_{amb} ≤ +60°C. For more details see *TR 24 LAB 087 - Spotisie Gateway temperature meassurment.pdf*.

According to EN IEC 60079-0:2017 thermal endurance tests to heath and cold have been performed on two sample devices. Both samples went through a 673 hour cycle with a temperature of 90 ± 2 °C and 90 ± 3 % relative humidity. No cracks or deformations were observed. Then both samples were subjected to a 24,5 hours cold cycle with a temperature of -27 ± 1 °C. No cracks or deformations were observed. For more details see *TR 24 LAB 093 - Spotisie Gateway - dielectric test and Thermal endurance.pdf*.

According to EN IEC 60079-18 clause 8.2.4 dielectric strength tests were performed on the two samples which have undergone the thermal endurance tests. Both samples passed the test. For more details see *TR 24 LAB 093 - Spotisie Gateway - dielectric test and Thermal endurance.pdf*.

8. Markings and Label



Specification:

Dimensions:	60 mm x 70 mm
Thickness:	0.2 mm
Material:	PVC

9. List of Documents

No.	Name	Description
1.	*100054_hw-spotsie-gateway_Rev-11.pdf*	PCB schematics and layout
2.	*100432_Spotsie-Gateway-ATEX-certification_rev-12.pdf*	Fault examination, component datasheets and encapsulation compound handling
3.	*1292120151_EN.pdf*	Cable gland datasheet
4.	*3221100360_en.pdf*	Enclosure datasheet
5.	*ATEX-Serie-256-002.pdf*	Terminal block ATEX certificate
6.	*BOM-3000-464-002.pdf*	Bill of Material
7.	*EC Type Examination Certificate_MBP Ex empty_11.11.2014.pdf*	Enclosure ATEX certificate
8.	*SPOTSIE-GATEWAY-ATEX-INSTRUCTIONS.pdf*	Instruction manual for the device
9.	*SPOTSIE-GATEWAY-ATEX-TECHNICAL-FILE.pdf*	This document
10.	*Spotsie_PCB_dimensions.pdf*	PCB dimensions
11.	*TR 24 LAB 087 - Spotisie Gateway temperature meassurment.pdf*	Test results for temperature measurement for sample simulating most unfavorable fault
12.	*TR 24 LAB 093 - Spotisie Gateway - dielectric test and Thermal endurance.pdf*	Test results for dielectric and thermal endurance tests
13.	*TR_22_LAB_003_Byte_Lab_material_for_encapsulation.pdf*	Temperature test results performed on encapsulation compound samples
14.	*TR_22_LAB_055_Byte_Lab_Spotsie_Gateway.pdf*	Temperature test results for with no encapsulation compound
15.	*WAGO_256-502_000-009_999-950en_AU.pdf*	Terminal block datasheet