Industrial Digital I/O
X2-Series Expansion Board

March 2024

Revision 001

X2BI10XD7 *Industrial Digital I/O X2-Series Expansion Board*

SFERALABS

Before opening the Strato Pi Max enclosure, disconnect all power sources and any connection to external devices, including USB and Ethernet cables.

Follow all applicable electrical safety standards, guidelines, specifications and regulations for installation, wiring and operations of Strato Pi Max.

Carefully and fully read this Strato Pi Max user guide before installation.

Strato Pi Max is not authorised for use in safety-critical applications where a failure of the product would reasonably be expected to cause personal injury or death. Safety-critical applications include, without limitation, life support devices and systems, equipment or systems for the operation of nuclear facilities and weapons systems. Strato Pi Max is neither designed nor intended for use in critical military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Strato Pi Max is solely at Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

Sfera Labs S.r.l. may make changes to specifications and product descriptions at any time, without notice. The product information on the web site or materials is subject to change without notice.

Please download and read the Sfera Labs Terms and Conditions document available at:

http://www.sferalabs.cc

Safety information

Carefully and fully read this user guide before installation and retain it for future reference.

Qualified personnel

The product described in this manual must be operated only by personnel qualified for the specific task and installation environment, in accordance with all relevant documentation and safety instructions. A qualified person should be capable of fully identifying all installation and operation risks and avoid potential hazards when working with this product.

Hazard levels

This manual contains information you must observe to ensure your personal safety and prevent damage to property. Safety information in this manual are highlighted by the safety symbols below, graded according to the degree of danger.

Indicates a hazardous situation which, if not avoided, **will** result in death or serious personal injury.

Indicates a hazardous situation which, if not avoided, **may** result in death or serious personal injury.

Indicates a hazardous situation which, if not avoided, can result in minor or moderate personal injury.

Indicates a situation which, if not avoided, can result in damage of property.

Safety instructions

General safety instructions

Protect the unit against moisture, dirt and any kind of damage during transport, storage and operation. Do not operate the unit outside the specified technical data.

Never open the housing. If not otherwise specified, install in closed housing (e.g. distribution cabinet). Earth the unit at the terminals provided, if existing, for this purpose. Do not obstruct cooling of the unit. Keep out of the reach of children.

WARNING

Life threatening voltages are present within and around an open control cabinet.

When installing this product in a control cabinet or any other areas where dangerous voltages are present, always switch off the power supply to the cabinet or equipment.

WARNING

Risk of fire if not installed and operated properly.

Follow all applicable electrical safety standards, guidelines, specifications and regulations for installation, wiring and operations of this product.

The expansion board could generate a substantial amount oh heat, particularly when subject to a significant amount of electrical load.

NOTICE

The connection of expansion devices to this product may damage the product and other connected systems, and may violate safety rules and regulations regarding radio interference and electromagnetic compatibility.

Use only appropriate tools when installing this product. Using excessive force with tools may damage the product, alter its characteristics or degrade its safety.

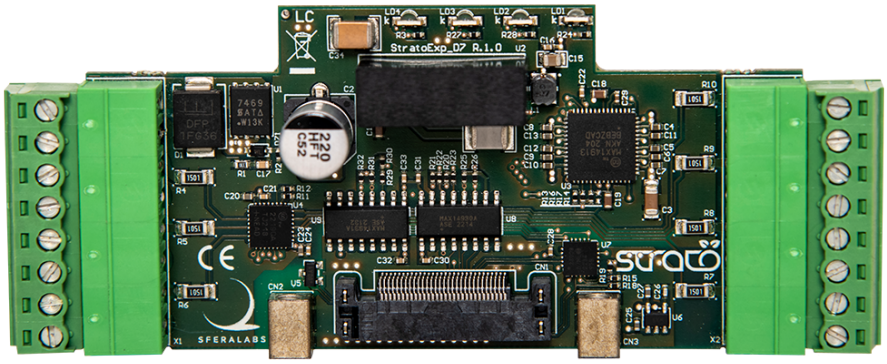
Introduction

The X2-Series X2BI10XD7 Industrial Digital I/O expansion board provides 7 current-sinking 24 V IEC 61131-2 compliant industrial digital inputs with diagnostics and 7 640 mA, 24 V outputs that can be configured as high-side switches or push-pull drivers.

The output lines have a dedicated on-board power supply input, independent of the Strato Pi Max power supply.

The inputs and outputs are galvanically isolated from the Strato Pi Max.

This manual generally refers to Strato Pi Max XL and Strato Pi Max XS as Strato Pi Max.



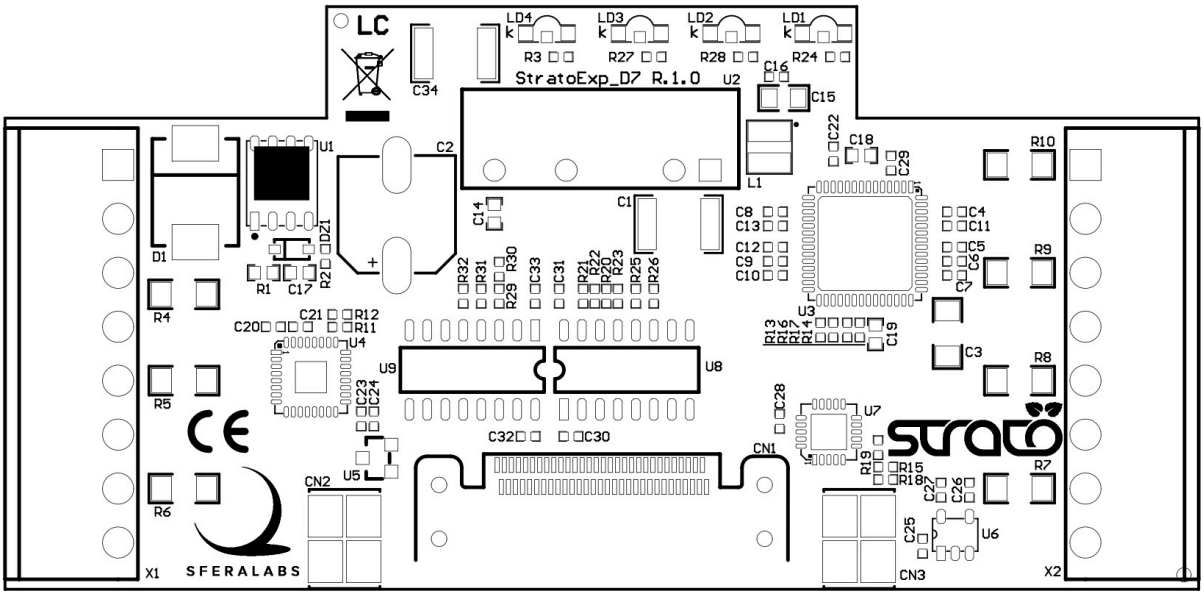
X2BI10XD7 INDUSTRIAL DIGITAL I/O X2-SERIES EXPANSION BOARD

Features

- ✓ 12÷28 Vdc dedicated I/O power supply
- ✓ 7 current-sinking 24 V IEC 61131-2 compliant industrial digital inputs with diagnostics, based on MAX22190
- ✓ 7 640 mA, 24 V outputs that can be configured as high-side switches or push-pull drivers for high-speed switching, based on MAX14912/MAX14913
- ✓ inputs protected against electrostatic discharges and temporary overvoltages
- ✓ front panel LEDs show board power supply, digital outputs fault, digital inputs fault, I/O power supply undervoltage.

Device identification

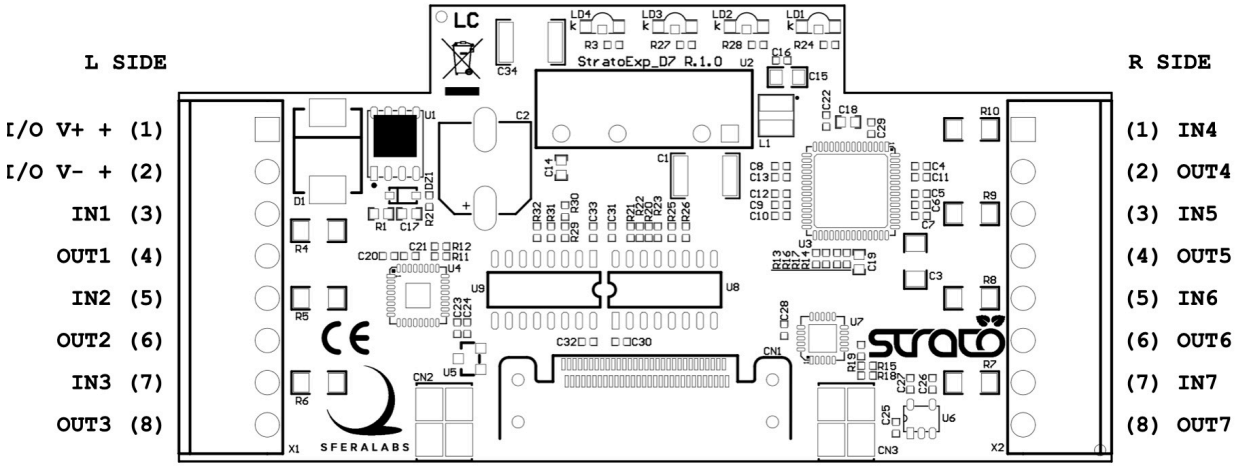
The circuit board is identified by the "**StratoExp_D7 R.1.0**" markings on the lower left corner of the circuit board (front view). One or more alphanumeric characters may be printed after the version number.



CIRCUIT BOARD IDENTIFICATION MARKINGS

Hardware setup

Connections



TERMINAL BLOCKS CONNECTIONS

In order to install or remove the expansion board, the plastic DIN rail enclosure must be removed

NOTICE

Before opening the Strato Pi Max enclosure, disconnect all power sources and any connection to external devices, including USB and Ethernet cables.

Follow the Strato Pi Max User Guide installation instructions.

This expansion board can be installed in any slot, and up to 4 boards can be fitted in Strato Pi Max XL.

Carefully align the board-to-board connectors and gently push the board in place. Note that the connectors could be damaged if not properly aligned during insertion or removal.

Use the two screws provided with the expansion board to lock the board in place.

Power supply

This expansion board can be powered with DC voltage only.

The device is split in two distinct and galvanically isolated sections, the control logic section and the digital input/output section. The control logic supply voltage is provided by the Strato Pi Max.

Digital input/output section

✓ DC: nominal voltage between 12 V and 28 V (min=10.5 V, max=36 V)

Respect the correct polarity: ground must be connected to I/O V- and positive voltage level to I/O V+.

I/O V+ is not required for the inputs. The I/O V- connection is always required.

Power and status LEDs

This expansion board has four LEDs, visible through the front panel:

A. Blue: on when the expansion board is powered

B. Red: digital outputs fault

C. Red: digital inputs fault

D. Yellow: I/O power supply (I/O V+) undervoltage.

Using the Digital I/O expansion board

IN1-IN7 digital inputs

This board has 7 current-sinking 24 V IEC 61131-2 compliant industrial digital inputs, based on a MAX22190 integrated circuit.

Wire-break detection can be enabled individually on each input line.

The MAX22190 chip is controlled by the RP2040 via its SPI serial bus, chip-select lines and a fault line.

All these control lines are galvanically isolated from the RP2040 logic section.

The fault line is asserted (low) on various, configurable, fault conditions, including wire-break.

Refer to the MAX22190 data sheet for the complete specifications of the digital input lines.

OUT1-OUT7 digital outputs

This board has 7 24 V outputs that can be configured as high-side switches or push-pull drivers for high-speed switching, based on a MAX14912/MAX14913 integrated circuit.

Open-load detection in high-side mode detects open-wire conditions in the switch on/off states. Internal active clamps accelerate the shutdown of inductive loads in high-side mode. Other diagnostic and protection features include per chip and individual line thermal shutdown, overvoltage detection, and overcurrent detection.

The MAX14912/MAX14913 chip is controlled by the RP2040 via its SPI serial bus, chip-select lines, a watchdog enable line, and a fault line.

The watchdog enable line is pulled high (enabled), so that the MAX14912/MAX14913 watchdog logic is normally active. It can be driven low by the RP2040 to disable the watchdog if needed.

The fault line is asserted (low) on various fault conditions, including open-load.

All these control lines are galvanically isolated from the RP2040 logic section.

Refer to the MAX14912/MAX14913 data sheet for the complete specifications of the digital output lines.

OUT1-OUT7 connection and protection

Besides the diagnostics and protection mechanisms implemented in the MAX14912/MAX14913 output driver, additional protections should be implemented in the RP2040 to prevent overheating and permanent damage in specific conditions. Two of these conditions are discussed below.

These protection mechanisms are implemented in the standard Strato Pi Max firmware provided by Sfera Labs. If the user uses custom firmware the protection logic described below shall be implemented.

Some use cases may require the implementation of different or additional protection logic, or be subject to other electrical and operational limitations.

Overvoltage protection

When an output line of the MAX14912/MAX14913 driver is configured as high-side and set to OFF, if a voltage is applied to that line that is higher than 0.3V + I/O V+, a considerable amount of current will flow from the output to the MAX14912/MAX14913 VDD, and to the I/O V+ terminal, if it is connected.

The MAX14912/MAX14913 will heat quickly, possibly leading to permanent damage of the chip itself and the device in general.

Setting the output to ON will still allow current to flow from out to I/O V+, but the internal resistance becomes very low, reducing the IC's dissipation and temperature.

When this condition occurs, the per-channel overvoltage bits in register 7 are set to 1. This can be used to protect the IC. The firmware should check register 7 and, if an OV flag is set, the corresponding output should be driven to ON and remain in this state for at least 10 seconds.

Connecting only passive loads to the OUT1-OUT7 lines, electrically prevents the occurrence of an overvoltage condition.

Thermal protection

If the MAX14912/MAX14913 per-channel thermal shutdown occurs, with THSD bits in register 5 being set to 1 for the affected outputs, the firmware should configure the output as high-side/OFF for at least 30 seconds, before returning to the original configuration.

Advanced usage

RP2040 I²C bus addresses

The following table lists all components connected to the RP2040 I²C bus, and their R/W addresses.

P/N	ID	SLOT	ADDR	WRITE	READ
MCP23008	U7	1	0x24 [100100]	0x48	0x49
		2	0x25 [100101]	0x4A	0x4B
		3	0x26 [100110]	0x4C	0x4D
		4	0x27 [100111]	0x4E	0x4F

I²C Configuration and control registers map

Installing one or more Industrial Digital I/O Expansion Board on Strato Pi Max adds the following registers to its I²C map.

The registers' addresses below correspond to the board installed in slot 1. Add 10 for each upper slots, i.e. registers for the board installed in slot 2 start at address 110, address 120 for slot 3, and address 130 for slot 4.

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
100			*DI7 CFG*		*DI6 CFG*		*DI5 CFG*		*DI4 CFG*		*DI3 CFG*		*DI2 CFG*		*DI1 CFG*	
101			*DO7 CFG*		*DO6 CFG*		*DO5 CFG*		*DO4 CFG*		*DO3 CFG*		*DO2 CFG*		*DO1 CFG*	
102															*JH*	*JL*
103		WB7	WB6	WB5	WB4	WB3	WB2	WB1		DI7	DI6	DI5	DI4	DI3	DI2	DI1
104		OL7	OL6	OL5	OL4	OL3	OL2	OL1		DO7	DO6	DO5	DO4	DO3	DO2	DO1
105														DI OT	DI AT2	DI AT1
106		OVL7	OVL6	OVL5	OVL4	OVL3	OVL2	OVL1		OV7	OV6	OV5	OV4	OV3	OV2	OV1
107										OT7	OT6	OT5	OT4	OT3	OT2	OT1

Register 100 (RW)

Bit 1-0, …, ***DIn CFG***: Digital input *n* configuration

…,13-12 *0 = disabled (default)*

1 = enabled w/o wire-break detection

2 = enabled w/ wire-break detection

Register 101 (RW)

Bit 1-0, …, ***DOn CFG***: Digital output *n* configuration

…,13-12 *0 = disabled (default)*

1 = enabled, high-side mode w/o open-load detection

2 = enabled, high-side mode w/ open-load detection

3 = enabled, push-pull mode

Register 102 (RW)

Bit 1 ***JL***: Outputs 1-2 join configuration

0 = disabled (default)

1 = Outputs 1-2 joined. The joined outputs configuration will be ***DO1 CFG***. ***DO1 CFG*** and ***DO3 CFG*** shall have a value of 0, 1, or 2 only (a value of 3 is switched to 1)

Bit 2 ***JH***: Outputs 4-5 and 6-7 join configuration

0 = disabled (default)

1 = Outputs 4-5 and 6-7 joined. The joined 4-5 outputs configuration will be ***DO4 CFG***. The joined 6-7 outputs configuration will be ***DO6 CFG***. ***DO4 CFG*** and ***DO6 CFG*** shall have a value of 0, 1, or 2 only (a value of 3 is switched to 1)

Register 103 (R)

Bit 0, …, 6 **DI*n***: Digital input *n* state

0 = low

1 = high

Bit 8, …, 14 **WB*n***: Digital input *n* wire-break

0 = not detected

1 = detected

Register 104 (RW)

Bit 0, …, 6 **DO*n***: Digital output *n* state

0 = low

1 = high

Bit 8, …, 14 **OL*n***: Digital input *n* open-load

0 = not detected

1 = detected

Register 105 (R)

Bit 1 **DI AT1**: Digital inputs over-temperature alarm 1

0 = not active

1 = active

Bit 2 **DI AT2**: Digital inputs over-temperature alarm 2

0 = not active

1 = active

Bit 3 **DI OT**: Digital inputs thermal shutdown

0 = not active

1 = active

Register 106 (R)

Bit 0, …, 6 **OV*n***: Digital output *n* over-voltage

0 = not detected

1 = detected

Bit 8, …, 14 **OVL*n***: Digital input *n* over-voltage lock

0 = not active

1 = active

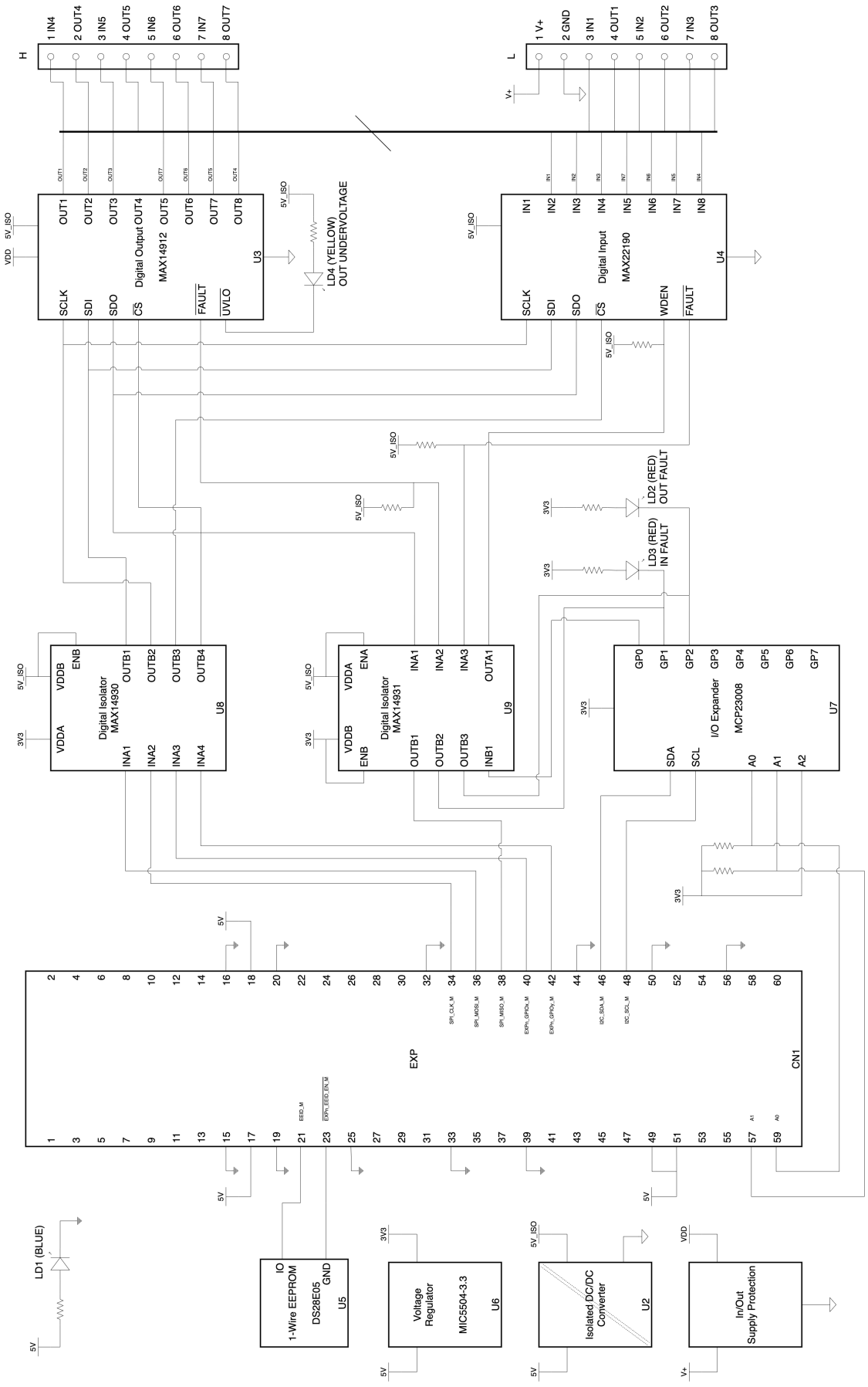
Register 107 (R)

Bit 0, …, 6 **OT*n***: Digital output *n* thermal shutdown

0 = not active

1 = active

Block diagram



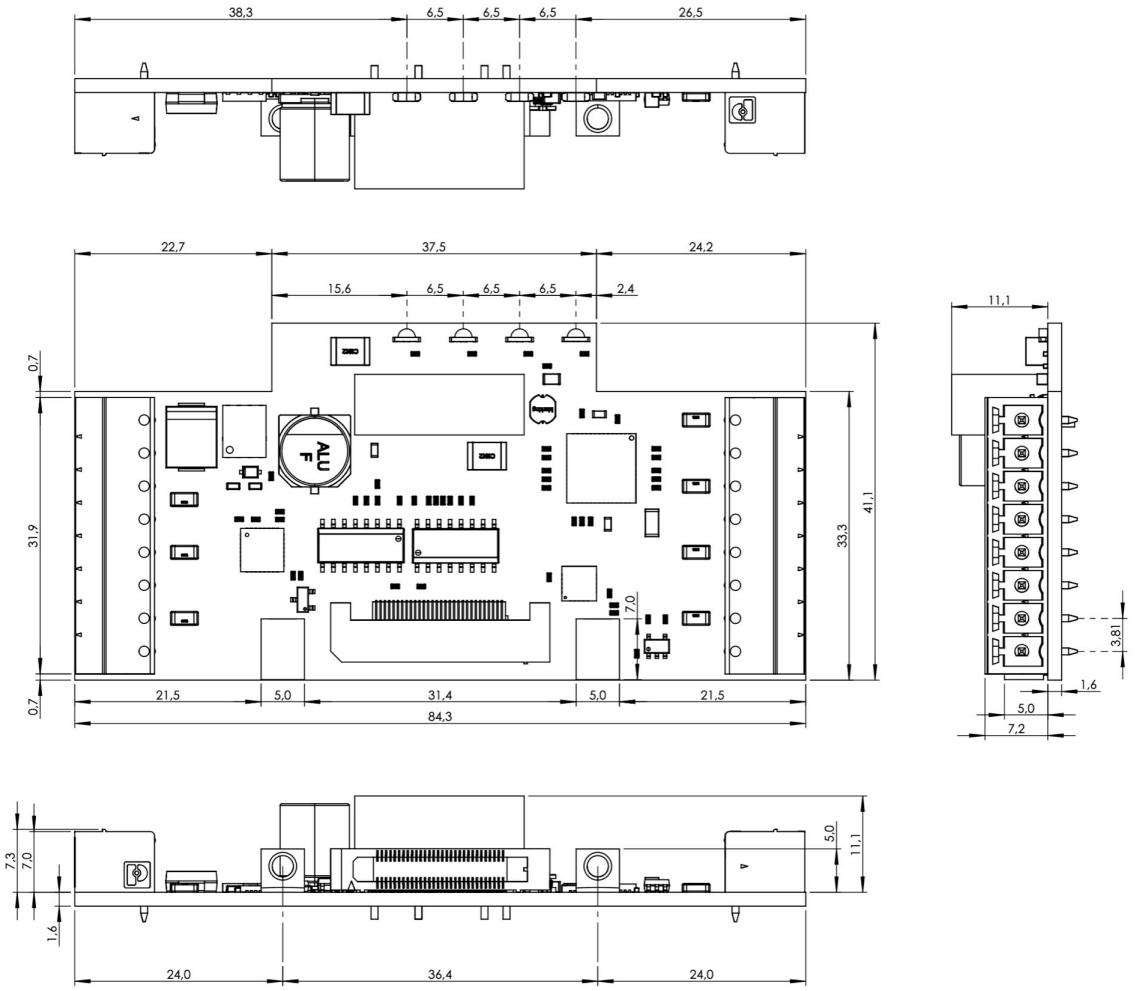
Technical specifications

Note: all values typical, at +25 °C and under normal operating conditions.

POWER SUPPLY	
I/O supply operating voltage	12…28 V⎓ nom. (10.5…36 V⎓)
I/O input current	Max 20 mA + ∑ OUT1-OUT7
IN1-IN7: DIGITAL INPUTS	
Input voltage range	+0…+36 V
Input current	2.4 mA
Voltage thresholds	Compatible with EN 61131-2 Type I and III sensors VIH: 9.9 V VIL: 7.4 V
OUT1-OUT7: DIGITAL OUTPUTS	
Driver mode	high-side or push-pull
Maximum current per output	640 mA
HS or PP high-side on-resistance	110 mOhm (Max 230 mOhm)
PP low-side on-resistance	1 Ohm (Max 2.5 Ohm)
EMI IMMUNITY STANDARDS	
Electromagnetic immunity compliance	EN 61000-4-2 (ESD) EN 61000-4-3 (Radiated RF Field) EN 61000-4-4 (Burst/fast transient) EN 61000-4-5 (Surge) EN 61000-4-6 (Conducted) EN 61000-4-8 (Power frequency magnetic field)
ENVIRONMENTAL	
Operating temperature	-20…+60 °C
Storage temperature	-30…+80 °C
Altitude	Up to 2000 m
Humidity	5% to 95% RH noncondensing
Protection degree	IP20
MECHANICAL	
3.81 mm pitch terminal block characteristics	Maximum conductor cross section: 1.3 mm2 (16AWG), or 0.5 mm2 when using ferrules (highly recommended) Recommended stripping length: 6 mm Screw thread: M2 Maximum screws tightening torque: 0.3 Nm

Dimensions	width: 84.3 mm height: 41.1 mm depth: 14.5 mm
Weight	35 g (including terminal blocks and screws)

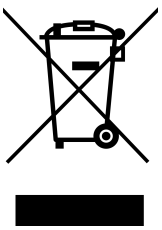
Dimensions



DIMENSIONS (mm)

Disposal

Waste Electrical & Electronic Equipment



(Applicable in the European Union and other European countries with separate collection systems). This marking on the product, accessories or literature indicates that the product should not be disposed of with other household waste at the end of their working life. To prevent possible harm to the environment or human health from uncontrolled waste disposal, separate these items from other types of waste and recycle them responsibly to promote the sustainable reuse of material resources. Household users should contact either the retailer where they purchased this product, or their local government office, for details of where and how they can take these items for environmentally safe recycling. This product and its electronic accessories should not be mixed with other commercial wastes for disposal.

Strato Pi Max contains a small non rechargeable manganese dioxide lithium coin battery.

In the Strato Pi Max, the battery is not accessible from the outside. You should first remove the case body to gain access to the Strato Pi Max circuit boards. Always remove the battery before disposing of this product.

Installation and use restrictions

Standards and regulations

The design and the setting up of electrical systems must be performed according to the relevant standards, guidelines, specifications and regulations of the relevant country. The installation, configuration and programming of the devices must be carried out by trained personnel.

The installation and wiring of connected devices must be performed according to the recommendations of the manufacturers (reported on the specific data sheet of the product) and according to the applicable standards.

All the relevant safety regulations, e.g. accident prevention regulations, law on technical work equipment, must also be observed.

Safety instructions

Carefully read the safety information section at the beginning of this document.

Set-up

For the first installation of the device proceed according to the following procedure:

- ✓ make sure all power supplies are disconnected
- ✓ install and wire the device according to the schematic diagrams on the specific product user guide
- ✓ after completing the previous steps, switch on the power supply and other related circuits.

Conformity Information

EU

This device complies with the following applicable European Community harmonised standards:

- ✓ 2014/30/EU - Electromagnetic Compatibility Directive (EMC)
- ✓ 2011/65/EU and 2015/863/EU - Restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS 3)

The following harmonised standards have been used to demonstrate conformity to these directives:

- ✓ EN61000-6-2: 2019 - EMC Immunity standard for industrial environments
- ✓ EN 61000-6-3: 2021 - EMC Emission standard for residential, commercial and light-industrial environments

The declaration of conformity is available at: https://www.sferalabs.cc

USA

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help.

Shielded cables must be used with this equipment to maintain compliance with FCC regulations.

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

CANADA

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

RCM AUSTRALIA / NEW ZEALAND

This product meets the requirements of the standard EN 61000-6-3: 2021 - Emission for residential, commercial and light-industrial environments.

Mouser Electronics

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X2BI10XD7