Industrial Digital I/O
X2-Series Expansion Board

October 2025

Revision 006

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

SFERALABS

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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.

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http://www.sferalabs.cc

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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.

DANGER

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

WARNING

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

CAUTION

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

NOTICE

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

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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.

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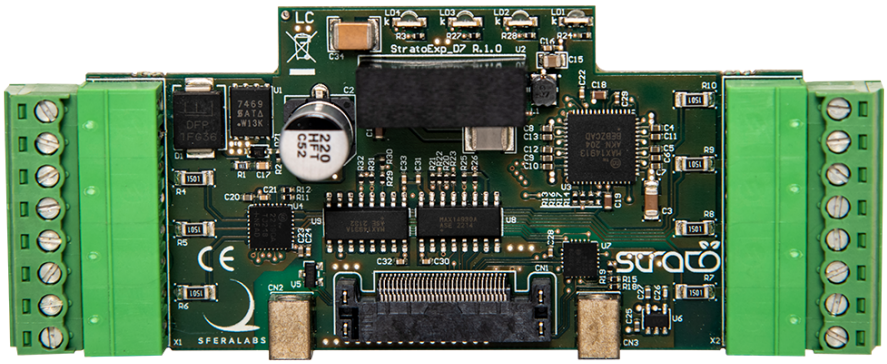
Introduction

The X2-Series X2BI10XD7 Industrial Digital I/O expansion board is designed for the Strato Pi Max[1]. It provides seven current-sinking 0…36 V, IEC 61131-2 compatible industrial digital inputs and seven 640 mA, 12…28 V outputs.

The output lines can be configured as high-side switches or push-pull drivers and 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 and feature diagnostic capabilities.

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

[1] Strato Pi Max: https://sferalabs.cc/product/strato-pi-max/

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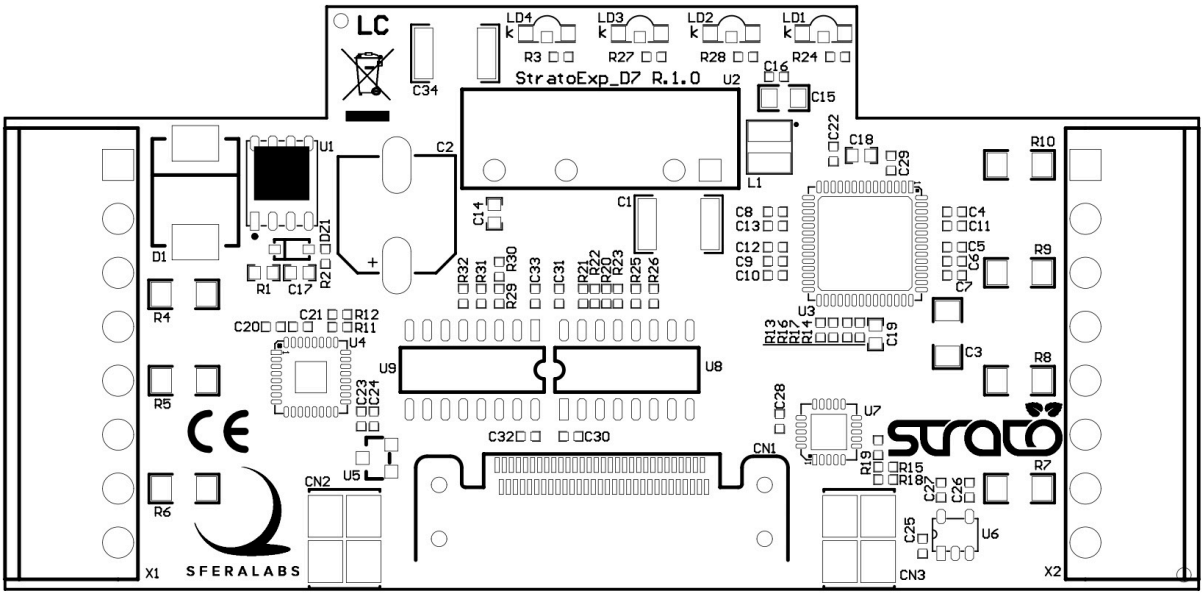
Features

- 12…28 Vdc dedicated I/O power supply
- 7 current-sinking 0…36 V IEC 61131-2 compatible industrial digital inputs with diagnostics, based on MAX22190
- 7 640 mA, 12…28 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 status, digital outputs fault, digital inputs fault, I/O power supply undervoltage.

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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.

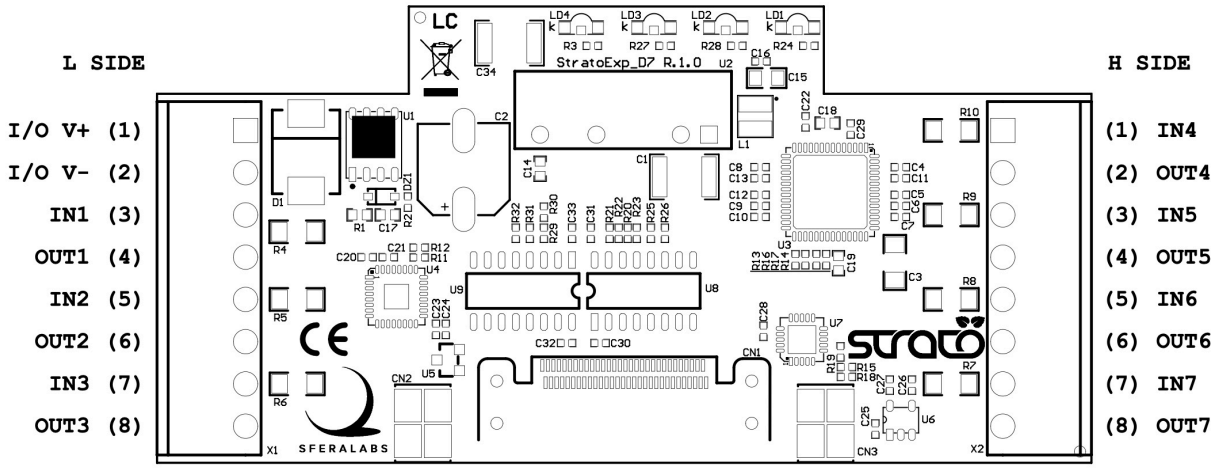


CIRCUIT BOARD IDENTIFICATION MARKINGS

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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.

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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.

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Using the Digital I/O expansion board

When one or more expansion boards are connected to the Strato Pi Max, the standard firmware automatically detects them, enabling configuration and control through its I²C registers.

For detailed information on register access and configuration parameters usage, refer to the Strato Pi Max User Guide and the accompanying Linux kernel module documentation[2].

IN1-IN7 digital inputs

This board has seven current-sinking 0…36 V industrial digital inputs, compatible with EN 61131-2 Type I and III sensors, 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 seven 12…28 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.

The high-level voltage is driven by the I/O V+ input.

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 standard Strato Pi Max firmware constantly resets the watchdog timer, it will therefore time out only in case of system failures.

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.

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[2] Strato Pi Max kernel module: https://github.com/sfera-labs/strato-pi-max-kernel-module

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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.

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Advanced usage

RP2040 I²C bus addresses

The following table lists the components added by this expansion board 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

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I²C Configuration and control registers

Installing one or more Industrial Digital I/O Expansion Boards on Strato Pi Max adds the I²C configuration and control registers described below.

Refer to the Strato Pi Max User Guide for details on registers access and configuration parameters usage.

The registers' addresses are determined by adding the address offsets listed below to the start register of the slot the board is installed in: 100 for slot 1, 125 for slot 2, 150 for slot 3, and 175 for slot 4.

ADDR OFFSET	BYTE 3								BYTE 2							
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
0																
1					FBP7 CFG	DELAY7 CFG			FBP6 CFG	DELAY6 CFG			FBP5 CFG	DELAY5 CFG		
2												WDT TOUT CFG		WDT CFG	JH CFG	JL CFG
4																
5																
6																
7		OTL7	OTL6	OTL5	OTL4	OTL3	OTL2	OTL1		OVL7	OVL6	OVL5	OVL4	OVL3	OVL2	OVL1

ADDR OFFSET	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0										WB7 CFG	WB6 CFG	WB5 CFG	WB4 CFG	WB3 CFG	WB2 CFG	WB1 CFG
1	FBP4 CFG	DELAY4 CFG			FBP3 CFG	DELAY3 CFG			FBP2 CFG	DELAY2 CFG			FBP1 CFG	DELAY1 CFG		
2		OL7 CFG	OL6 CFG	OL5 CFG	OL4 CFG	OL3 CFG	OL2 CFG	OL1 CFG		PP7 CFG	PP6 CFG	PP5 CFG	PP4 CFG	PP3 CFG	PP2 CFG	PP1 CFG
4		WB7	WB6	WB5	WB4	WB3	WB2	WB1		DI7	DI6	DI5	DI4	DI3	DI2	DI1
5		OL7	OL6	OL5	OL4	OL3	OL2	OL1		DO7	DO6	DO5	DO4	DO3	DO2	DO1
6													IN ERR	IN OT	IN AT2	IN AT1
7		OT7	OT6	OT5	OT4	OT3	OT2	OT1		OV7	OV6	OV5	OV4	OV3	OV2	OV1
8	DI1 CNT															
9	DI2 CNT															
10	DI3 CNT															
11	DI4 CNT															
12	DI5 CNT															
13	DI6 CNT															
14	DI7 CNT															

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Configuration registers (offsets 0, 1, 2) can only be written while the expansion board is disabled.

Offset 0 [R][W][C]

Bit 0, …, 6 **WB*n* CFG**: input *n* wire-break detection configuration

0 = disabled (default)

1 = enabled

Bit 15-7 reserved

Offset 1 [R][W][C]

Bit 3, …, 27 **FBP*n* CFG**: input *n* filter configuration

0 = filter enabled (default)

1 = filter bypassed

Bit 2-0, …, **DELAY*n* CFG**: input *n* filter delay configuration

…, 26-24 0 = 50 μs delay (default)

1 = 100 μs delay

2 = 400 μs delay

3 = 800 μs delay

4 = 1.6 ms delay

5 = 3.2 ms delay

6 = 12.8 ms delay

7 = 20 ms delay

Bit 31-28 reserved

Offset 2 [R][W][C]

Bit 0, …, 6 **PP*n* CFG**: output *n* configuration

0 = high-side mode (default)

1 = push-pull mode

Bit 7 reserved

Bit 8, …, 14 **OL*n* CFG**: output *n* open-load detection configuration (only for high-side mode)

0 = disabled (default)

1 = enabled

Bit 15 Reserved

Bit 16 **JL CFG**: outputs 1-2 join configuration (only for high-side mode)

0 = disabled (default)

1 = outputs 1-2 joined; configurations and status for output 1 apply to pair

Bit 17 **JH CFG**: outputs 4-5 and 6-7 join configuration

0 = disabled (default)

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1 = outputs 4-5 and 6-7 joined; configurations and status for outputs 4 and 6 apply to respective pairs

Bit 18 **WDT CFG**: outputs watchdog configuration

0 = disabled

1 = enabled (default)

Bit 20-19 **WDT TOUT CFG**: outputs watchdog timeout configuration

0 = 0.9 s (default)

1 = 0.45 s

2 = 0.15 s

Bit 31-21 reserved

Offset 4

Bit 0, …, 6 **DI*n*** [R]: input *n* state

0 = low

1 = high

Bit 7 reserved

Bit 8, …, 14 **WB*n*** [R][Z]: input *n* wire-break (requires **WB*n* CFG** set to 1)

0 = not detected (write to clear)

1 = detected (set until cleared)

Bit 15 reserved

Offset 5

Bit 0, …, 6 **DO*n*** [R][W]: output *n* state

0 = low

1 = high

Bit 7 reserved

Bit 8, …, 14 **OL*n*** [R][Z]: input *n* open-load (requires **OL*n* CFG** set to 1)

0 = not detected (write to clear)

1 = detected (set until cleared)

Bit 15 reserved

Offset 6

Bit 0 **IN AT1** [R][Z]: inputs over-temperature alarm 1

0 = not active (write to clear)

1 = active (set until cleared)

Bit 1 **IN AT2** [R][Z]: inputs over-temperature alarm 2

0 = not active (write to clear)

1 = active (set until cleared)

Bit 2 **IN OT** [R][Z]: inputs thermal shutdown

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0 = not active (write to clear)

1 = active (set until cleared)

Bit 3 **IN ERR** [R][Z]: inputs general fault

0 = not active

1 = active

Bit 15-4 reserved

Offset 7

Bit 0, …, 6 **OV*n*** [R][Z]: output *n* over-voltage

0 = not detected (write to clear)

1 = detected (set until cleared)

Bit 7 reserved

Bit 8, …, 14 **OT*n*** [R][Z]: output *n* thermal shutdown

0 = not active (write to clear)

1 = active (set until cleared)

Bit 15 reserved

Bit 16, …, 22 **OVL*n*** [R]: input *n* over-voltage protection lock

0 = not active

1 = active

Bit 23 reserved

Bit 24, …, 30 **OTL*n*** [R]: input *n* over-temperature protection lock

0 = not active

1 = active

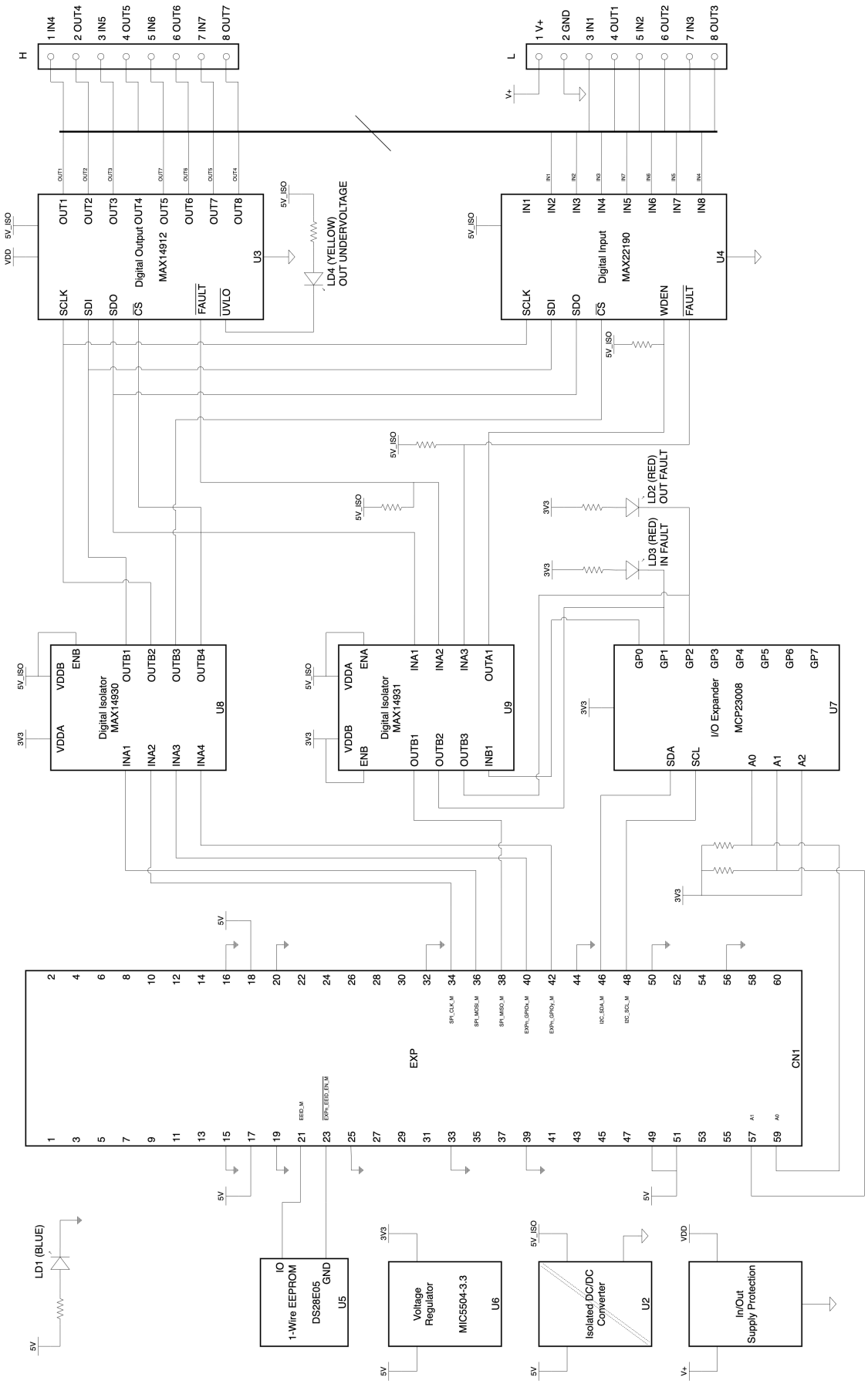
Bit 31 reserved

Offset 8, …, 14 [R] (Firmware version >= 3.24)

Bit 15-0 **DI*n* CNT**: input *n* state change counter

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Block diagram



SFERA LABS SRL - X2BI10XD7 V.1.0 BLOCK DIAGRAM R.02 - 15 MAR 2024 - COPYRIGHT 2024 SFERA LABS SRL ITALY ALL RIGHTS RESERVED

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Technical specifications

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

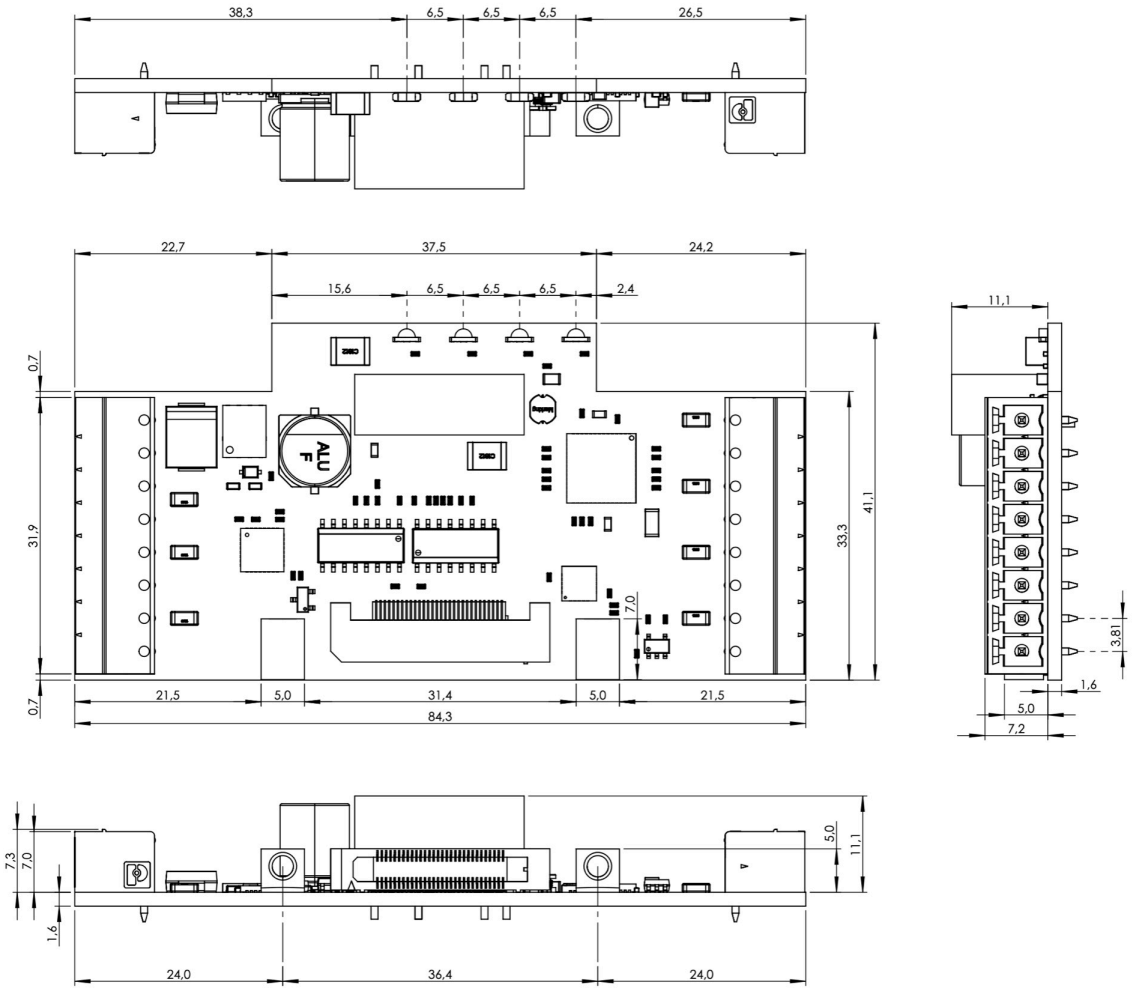
POWER SUPPLY	
I/O supply operating voltage	12…28 V⎓ nom. (10.5…36 V⎓)
I/O input current	Max 20 mA + ∑ OUT1-OUT7
IN1-IN7: DIGITAL INPUTS	
Input voltage range	+0…+36 V
Input current	2.4 mA
Voltage thresholds	Compatible with EN 61131-2 Type I and III sensors VIH: 9.9 V VIL: 7.4 V
OUT1-OUT7: DIGITAL OUTPUTS	
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
Vibration IEC 60068-2-6 (Test Fc, Operating)	0.7 g @ 5…100 Hz
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

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

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Dimensions

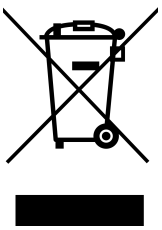


DIMENSIONS (mm)

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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.

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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.

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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.

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