Industrial Analog Inputs X2-Series Expansion Board

December 2024

Revision 001

***X2BI10XAIZ** Industrial Analog Inputs 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.

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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.

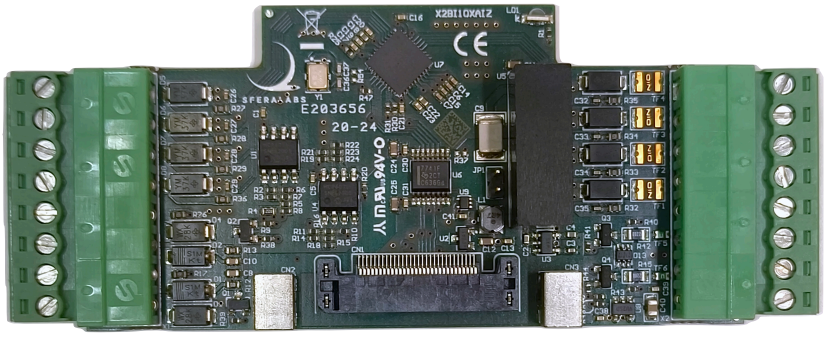
Introduction

The X2-Series X2BI10XAIZ Industrial Analog Inputs expansion board is designed for the Strato Pi Max[1]. It provides four voltage inputs, four current inputs, and two Pt100/Pt1000 temperature probe inputs.

All inputs are galvanically isolated from the Strato Pi Max. Voltage inputs can be configured individually as unipolar or bipolar and support single-ended or differential mode.

Additionally the board features a 5 V auxiliary power output and two 5 V-level I/O lines compatible with digital-protocol devices such as 1-Wire, Wiegand, or I²C devices.

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



X2BI10XAIZ INDUSTRIAL ANALOG INPUTS X2-SERIES EXPANSION BOARD

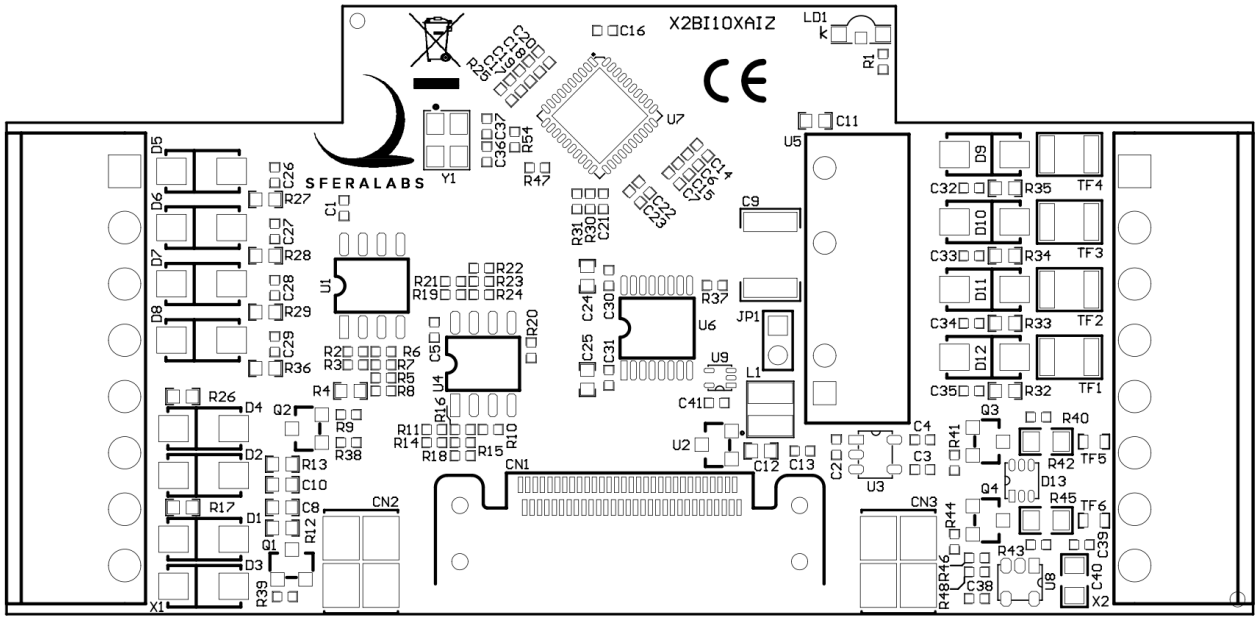
[1] Strato Pi Max: https://sferalabs.cc/product/strato-pi-max/

Features

- ✓ 4 analog voltage inputs ±20 V
- ✓ 4 analog current inputs 0-20mA
- ✓ 2 Pt100 or Pt1000 temperature sensor inputs
- ✓ the analog inputs front-end is galvanically isolated from the digital section
- ✓ 2 digital 5V-level I/O lines, compatible with 1-Wire, Wiegand, I²C
- ✓ 5Vdc auxiliary voltage output, with over-current and reverse current protection
- ✓ front panel LED showing board power status.

Device identification

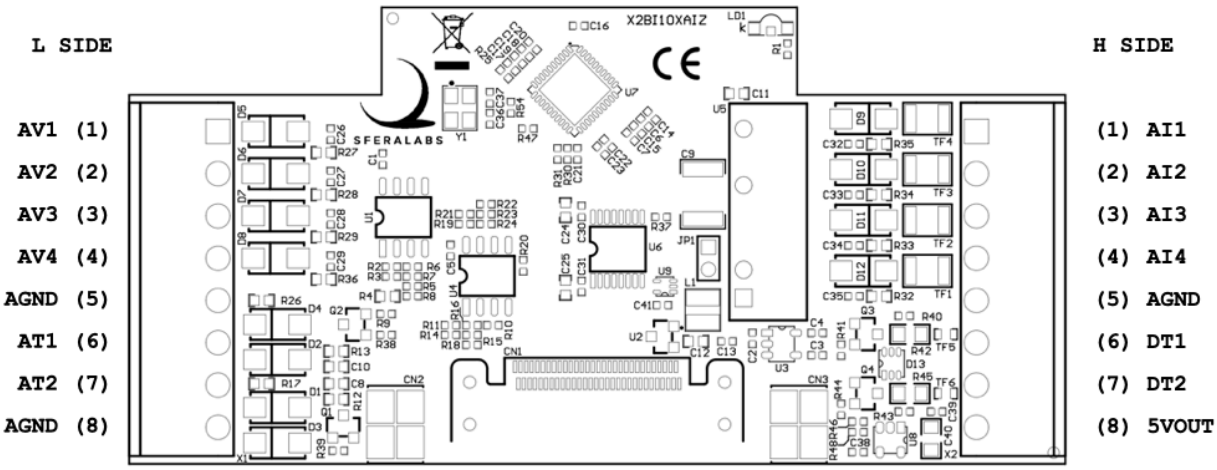
The circuit board is identified by the "**X2BI10XAIZ**" markings on the circuit board (front view). One or more alphanumeric characters may be printed after the version number.



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 LED

This expansion board has one LED, visible through the front panel:

A. Blue: on when the expansion board is powered

Terminal blocks

This expansion board has two pluggable, 3.81mm pitch, terminal blocks.

The maximum conductor cross section is 1.31 mm^2 (16 AWG), or 0.5 mm^2 when using ferrules (highly recommended). Recommended stripping length is 6 mm. Screw thread is M2. Never exceed 0.3 Nm torque when tightening the screws.

Using the Analog Inputs 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].

Analog inputs

This board has voltage, current and Pt100/Pt1000 sensors analog inputs. All analog inputs are galvanically isolated from the main power supply rail and all digital logic.

The AGND terminals are the ground reference for the analog inputs.

All these inputs are connected to a low-noise, high-resolution 24-bit analog-to-digital converter, the Analog Devices AD4112, which is factory calibrated to achieve a high degree of accuracy.

The standard firmware of the Strato Pi Max controller configures the ADC when the board is enabled, using the I²C configuration values defined by the user. It then continuously samples all active voltage and current input channels, while enabled temperature sensor inputs are sampled at 3-second intervals.

All enabled channels are sampled sequentially so disabling unused inputs increases the effective sample rate of the used channels.

For detailed information on sample rates and accuracy based on channels filter configuration, refer to the AD4112 datasheet.

AVx: Analog voltage inputs

The four analog voltage inputs can be individually configured as single-ended (referenced to AGND) or paired (AV1 with AV2, AV3 with AV4) for differential input measurement. In unipolar mode, they support a 0-20V range with up to 24-bit resolution, while in bipolar mode, they provide a -10V to +10V range with up to 23-bit resolution (functional range with lower performance is -20V to +20V).

The ADC is factory calibrated to achieve a ±0.06% accuracy (at 25°C). The voltage inputs front-end impedance is ≥1 MOhm.

NOTICE

The voltage inputs are protected from electrostatic discharge with transient voltage suppression diodes. The AD4112 voltage inputs have a ±50V absolute maximum rating. Connecting a voltage source outside the measuring range could damage the ADC or other electronic components.

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

AIx: Analog current inputs

The four analog current inputs can be individually enabled and provide a 0-24mA range.

The ADC is factory calibrated to achieve a ±0.08% accuracy (at 25°C). The current inputs front-end impedance is 240 Ohm.

NOTICE

The current inputs are protected from electrostatic discharge with transient voltage suppression diodes. Resettable fuses on each input line also protect from over-current events. Even with these protections in place, input currents exceeding 50mA could damage the ADC or other electronic components.

ATx: Temperature sensors inputs

The two inputs can be used to connect two-wire resistance temperature sensors (RTD). Both Pt100 and Pt1000 standard sensors are supported.

DTx: Digital input/output

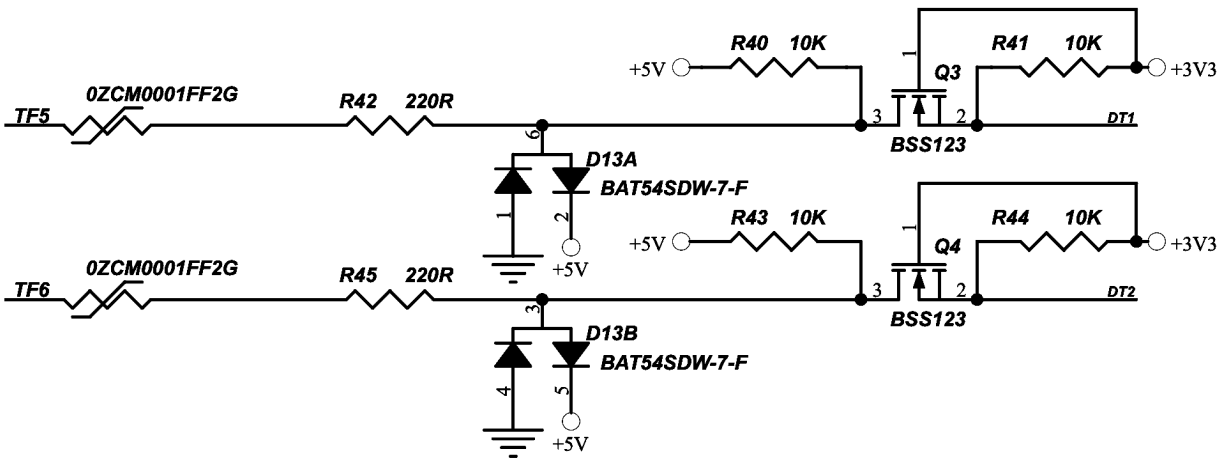
DTx are two bidirectional 5V-level I/O lines, connected to the Compute Module GPIO pins through bidirectional level shifters.

They can be used as general purpose inputs or outputs, as well as bidirectional data lines such as I²C or 1-Wire busses, Wiegand interfaces, or serial communication lines.

Each DTx front-end circuit has a 10.0kOhm pull-up and 220Ohm series resistors, and is protected from over-voltage and electrostatic discharge.

NOTICE

Never apply voltages outside the 0-5V range to this pin to avoid damage to the Strato Pi Max and Raspberry Pi Compute Module.



TTL LEVEL CONVERTER CIRCUIT AND PROTECTION

Auxiliary voltage output

The analog inputs expansion board also has an auxiliary 5Vdc voltage output pin on the terminal block, labeled 5VOUT, to supply power to external 5V loads, like 1-Wire devices. The current output limit is 500mA. An internal protection circuit shuts down the 5VOUT line if the current limit is exceeded.

I²C Configuration and control registers

Installing one or more Industrial Analog Inputs 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.

Requires firmware version >= 3.22

ADDR OFFSET	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0			AV4 BP	AV4 EN		AV3 DIFF	AV3 BP	AV3 EN			AV2 BP	AV2 EN		AV1 DIFF	AV1 BP	AV1 EN
1				AI4 EN				AI3 EN				AI2 EN				AI1 EN
2											AT2 PT	AT2 EN			AT1 PT	AT1 EN
3	AV FILTER															
4	AI FILTER															

ADDR OFFSET	BYTE 3								BYTE 1								BYTE 0							
	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
10	AV1																							
11	AV2																							
12	AV3																							
13	AV4																							
14	AI1																							
15	AI2																							
16	AI3																							
17	AI4																							
18	AT1																							
19	AT2																							
20																								5V FL

Configuration registers (offsets 0, …, 4) can only be written while the expansion board is disabled.

Offset 0 [R][W][C]

Bit 0, 4, 8, 12 **AV*n* EN**: voltage input *n* enabled configuration

0 = disabled (channel sampling skipped)

1 = enabled (default)

Bit 1, 5, 9, 13 **AV*n* BP**: voltage input *n* bipolar configuration

0 = unipolar (default)

1 = bipolar

Bit 2, 10 **AV*n* DIFF**: voltage input *n* differential configuration

0 = single-ended: AGND is the voltage reference (default)

1 = differential: voltage difference between input *n* and *n*+1

Offset 1 [R][W][C]

Bit 0, 4, 8, 12 **AI*n* EN**: current input *n* enabled configuration

0 = disabled (channel sampling skipped)

1 = enabled (default)

Offset 2 [R][W][C]

Bit 0, 4 **AT*n* EN**: temperature probe input *n* enabled configuration

0 = disabled (channel sampling skipped)

1 = enabled (default)

Bit 1, 5 **AT*n* PT**: temperature probe *n* type configuration

0 = Pt100 (default)

1 = Pt1000

Offset 3 [R][W][C]

Bit 15-0 **AV FILTER**: voltage inputs filter configuration
AD4112 configuration register value.
Refer to the AD4112 datasheet for details.
Default value: 1294 (sinc5 + sinc1 filter, 100.2 SPS data rate)

Offset 4 [R][W][C]

Bit 15-0 **AI FILTER**: current inputs filter configuration
AD4112 configuration register value.
Refer to the AD4112 datasheet for details.
Default value: 1294 (sinc5 + sinc1 filter, 100.2 SPS data rate)

Offsets 10, 11, 12, 13 [R]

Bit 23-0 **AV*n***: voltage input *n* value, signed

8388607 = overrange value

-8388607 = underrange value

-8388608 = sampling error

other = value in mV/100

Offsets 14, 15, 16, 17 [R]

Bit 23-0 **AI*n***: current input *n* value, signed

8388607 = overrange value

-8388607 = underrange value

-8388608 = sampling error

other = value in *µ*A

Offsets 18, 19 [R]

Bit 23-0 **AT*n***: temperature probe *n* value, signed

8388607 = overrange value

-8388607 = underrange value

-8388608 = sampling error

other = value in °C/100

Offset 20 [R]

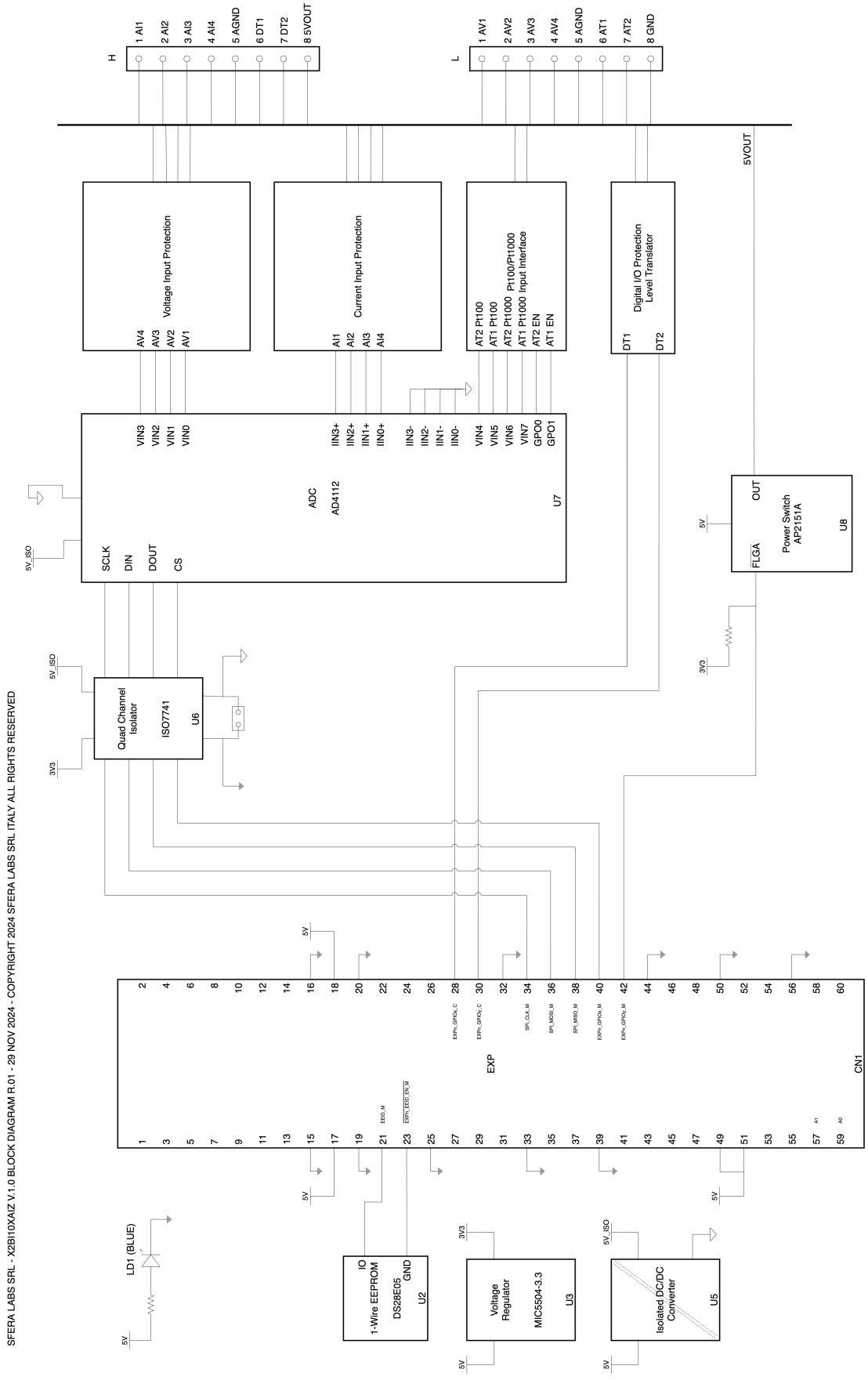
Bit 0 **5V FL**: 5V power output fault

0 = not active

1 = active

Bit 15-1 Reserved

Block diagram



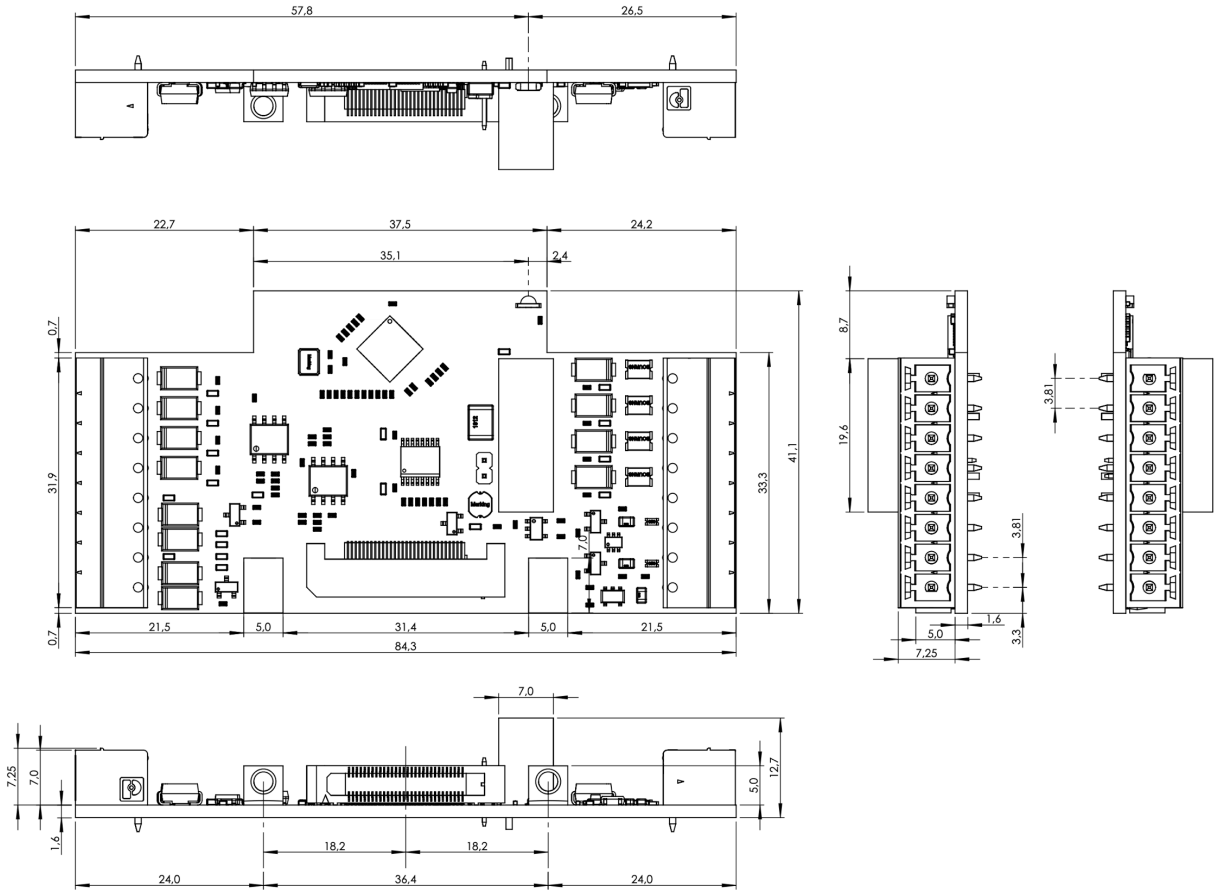
Technical specifications

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

AVx: ANALOG VOLTAGE INPUTS	
Differential input voltage range, within specified performance	-10…+10 V
Functional pin input voltage range	-20…+20 V
Absolute maximum pin input voltage	-50…+50 V
Input impedance	> 1 MOhm
Total Unadjusted Error (TUE)	±0.06 % of full-scale
Resolution	24 bits (Max)
AIx: ANALOG CURRENT INPUTS	
Input current range	-0.5…+24 mA
Absolute maximum pin input voltage	-50…+50 mA
Input impedance	240 Ohm
Total Unadjusted Error (TUE)	±0.08 % of full-scale
Resolution	24 bits (Max)
ATx: TEMPERATURE SENSORS INPUTS (PT100, PT1000)	
Temperature range, within specified performance	-150…+400 °C
Accuracy (not including Pt and cable errors)	± 0.3 °C ± 0.05 % of reading
Resolution	24 bits (Max)
DTx: DIGITAL INPUT/OUTPUT	
Output voltage	VOL: 0.2 V VOH: 5.0 V
Input voltage threshold	VIH: 2.4 V VIL: 0.8 V
Pull-up (+5 V)	10 kOhm
AUX POWER OUTPUT	
5VOUT output voltage	5 V
5VOUT output current	500 mA (Max)
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	36 g (including terminal blocks and screws)

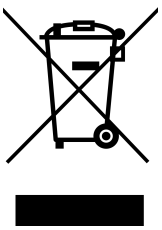
Dimensions



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.