EQX EXPANSION MODULE · EQXAIxx FAMILY

8x Analog Input Expansion Module for EQSP32 IIoT PLC Controller

1 Description

The **EQXAI08** is an 8-channel analog input expansion module designed to add high-performance voltage and current measurement capabilities to the **EQSP32** Industrial IoT controller. Each channel of the EQXAI can be software-configured independently to operate either as a 0–10 V analog voltage input (AIN) or as a 0–20/4–20 mA current-loop input (CIN), allowing a single module to support mixed sensor types within the same system.

To achieve stable and repeatable measurements in industrial environments, the EQXAI combines 12-bit ADCs with hardware and software filtering techniques. The eight input channels are sampled in two parallel acquisition groups (CH1–4 and CH5–8), enabling efficient signal acquisition while maintaining a high update rate suitable for monitoring process variables, environmental sensors, and industrial instrumentation.

Designed for robustness, the EQXAI includes current-loop protection on CIN channels and auto-recovery, ensuring reliable operation in demanding field conditions. Voltage inputs are tolerant up to 28 V, protecting the module against accidental overvoltage exposure. User zero calibration is supported for applications requiring field adjustment.

Like all EQX expansion modules, the EQXAI is housed in a compact DIN-rail mount enclosure and is powered directly through the EQSP32 board-to-board expansion connector, requiring no external power supply.

The module is automatically detected and indexed by the EQSP32 upon power-up, enabling true plug-and-play integration. Firmware updates are performed through the front-facing USB-C port, ensuring easy access to future enhancements.

Integration is further simplified through the EQSP32 library and EQ-AI generative AI model, allowing users to configure, read, and process analog measurements with minimal development effort. This makes the EQXAI an ideal solution for industrial sensor monitoring, process control, and data acquisition applications requiring reliable multi-channel analog input expansion.

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2 Key Features

- 8x independently configurable analog input channels
- Per-channel selectable 0–10 V analog voltage input (AIN) or 4–20 mA current-loop input (supports 0–20 mA sensing)
- 12-bit ADCs with hardware and software filtering
- Parallel dual-group acquisition architecture (channels 1–4 and 5–8)
- Current-loop overcurrent protection for CIN channels with auto-recovery
- 28 V tolerant analog input protection
- User zero-calibration support for field adjustment
- Automatic module detection and indexing by EQSP32
- Powered directly through the EQSP32 board-to-board expansion connector
- Front-facing USB-C port for firmware updates
- LED indicators for power and module status
- Up to 15 EQXAI on each EQSP32 controller
- Generative AI coding assistant trained with EQSP32 Library and EQXAI features
- Compact, 2SU-wide (36 mm), DIN-rail mount enclosure with 12 screw terminals for industrial control cabinets
- IP20 protection
- −20 °C to +55 °C operating ambient temperature

3 Applications

- Industrial sensor monitoring with 0–10 V and 4–20 mA transmitters
- Process control and automation systems
- Environmental monitoring (temperature, humidity, pressure, gas sensors)
- Energy and power monitoring systems
- Water and wastewater treatment instrumentation
- Building automation and HVAC monitoring
- Machine condition monitoring and diagnostics
- Industrial data acquisition and logging systems
- Retrofit of legacy analog sensors into modern IIoT systems
- Distributed measurement systems using EQSP32 expansion architecture

4 Ordering Information

Part number	Description	Inputs	Enclosure
EQXAI08	8x Analog Input Expansion Module for EQSP32	8 × 0–10 V / 0–20 mA input	2SU (36 mm) DIN-rail, IP20

Product page and ordering: erqos.com/product/eqxai

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5 Block Diagram

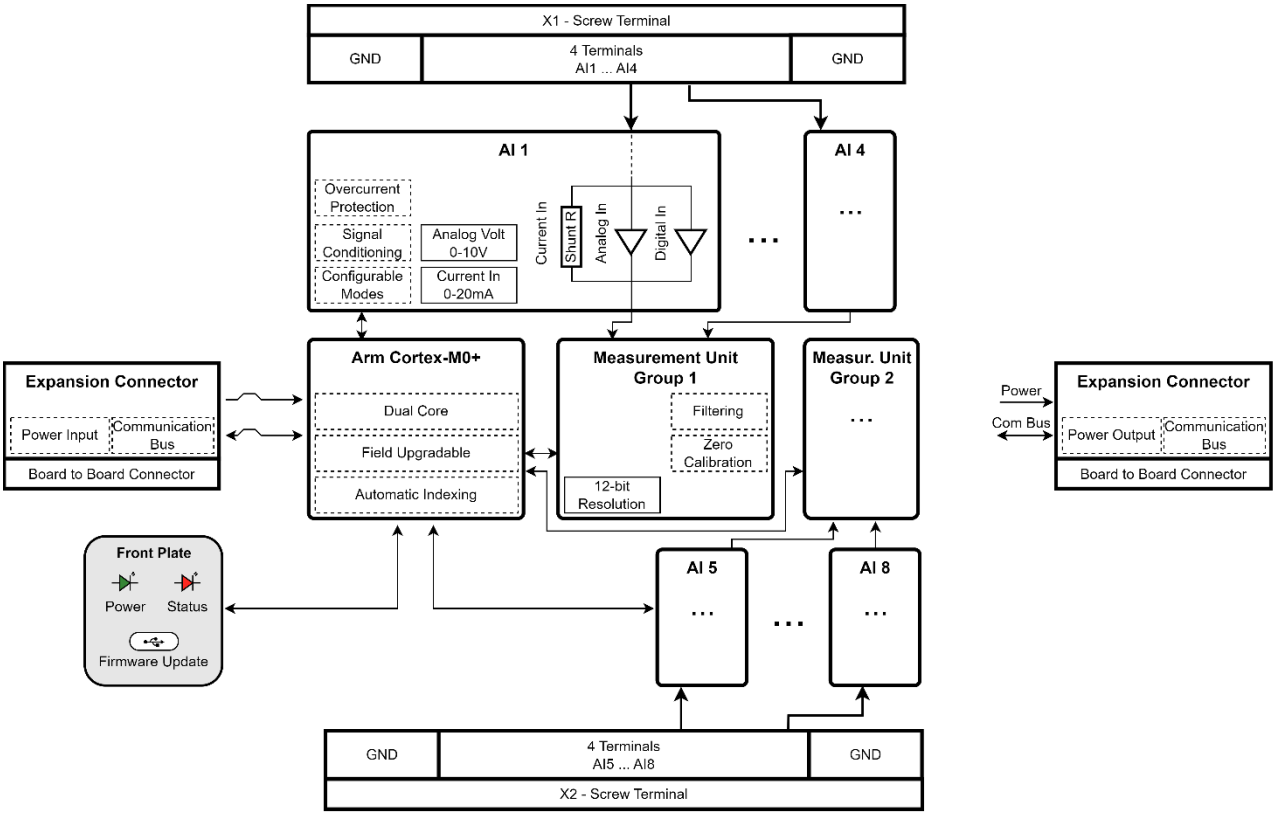

Figure 5-1. EQXAI08 block diagram

6 Specifications

6.1 System Specifications

Table 6-1. System Specifications

Section	Features
Power Management	Supplied by the board-to-board expansion connector
Analog Input Terminals	8x software-configurable analog input channels 0–10 V analog voltage inputs (AIN) 4–20 mA current-loop inputs (CIN) (supports 0–20 mA sensing)
Sampling & Resolution	12-bit ADCs Hardware and software filtering Two parallel acquisition groups: CH1–4 and CH5–8
Input Protection	28 V tolerant voltage inputs Current-loop overcurrent protection
Calibration	User zero calibration supported
Indications	Green LED for power indication Red LED for module status
Enclosure	Easy standard DIN-rail push-fit mounting with spring mechanism IP20 protection
Expandability	Push-fit expansion module mounting Automatic module detection and indexing by EQSP32
Firmware Update	Front-facing USB-C for easy firmware upgrades
Environment	–20 °C to +55 °C

6.2 Absolute Maximum Ratings

Table 6-2. Absolute Maximum Ratings

Pin	Type	Min.	Typ.	Max.	Unit
AIx to GND	Analog Voltage Input (AIN mode)	-0.5	0 to 10	28	V
	Current Loop Input (CIN mode)	0	0 to 20	21 (*)	mA

> **NOTE**
> (*) Protection disconnects the input above 21 mA.

7 Connecting EQXAI

To install the EQXAI analog input expansion module, mount it next to the EQSP32 controller on the DIN rail and slide it until the board-to-board connector is fully engaged with the expansion interface. The module is powered entirely through this connector and does not require any external power supply.

When adding or removing expansion modules, it is recommended to disconnect system power beforehand. After power is applied, the EQSP32 automatically detects and indexes all connected expansion modules, including the EQXAI, enabling immediate plug-and-play operation without additional configuration.

For safety and ease of installation, it is strongly recommended that a main circuit breaker is used to fully isolate the system's AC/DC power source when installing, removing, or rearranging expansion modules.

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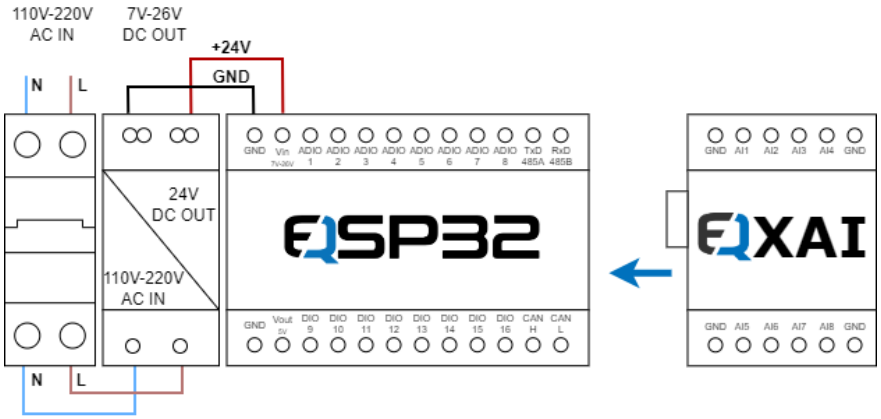

Figure 7-1. Slide EQXAI to connect on EQSP32

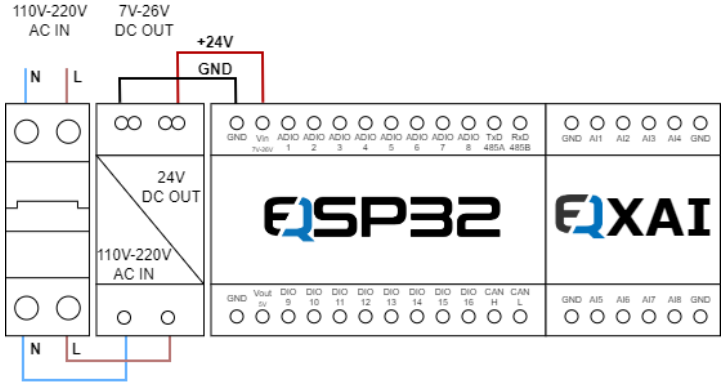

Figure 7-2. Connected EQXAI on EQSP32

> **WARNING**
> Make sure that the appropriate ground fault circuit breaker, fuses or circuit breakers and any other necessary protective components are used if there is any risk of user electrocution.

8 Visual Indications

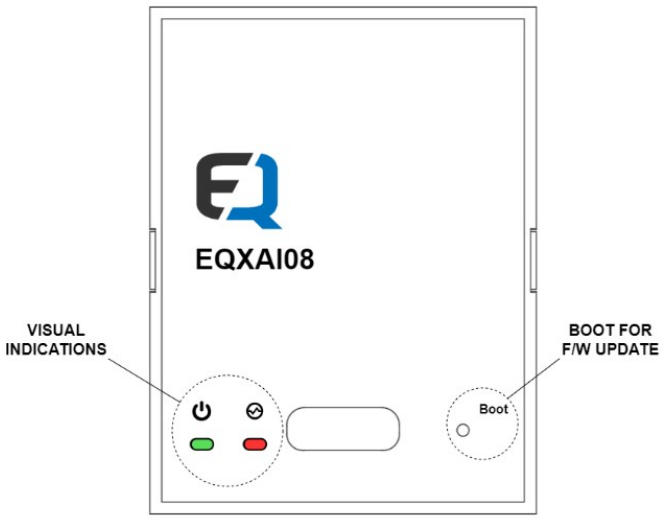

Figure 8-1. Front panel: LEDs and Boot button

When the EQXAI module is connected to the EQSP32 controller and the system is powered on, the POWER LED illuminates solid green, indicating that the module is properly powered.

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If the STATUS LED remains solid red after the automatic detection process, this indicates that the EQXAI module is not communicating correctly with the EQSP32.

During normal operation, when data exchange occurs between the EQSP32 controller and the EQXAI module, the STATUS LED will flash to indicate active communication and measurement updates.

8.1 LED Indications

Table 8-1. LED indications

State	Meaning	Pattern
Power LED		
On	Powered on	
Off	No power	
Status LED		
Off	No errors, no communication	
Fast Flashing	Data exchange	
Blinking	Auto indexing issue	
Blink Off	Hardware detection failed	
On	Communication error	

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9 Pinout

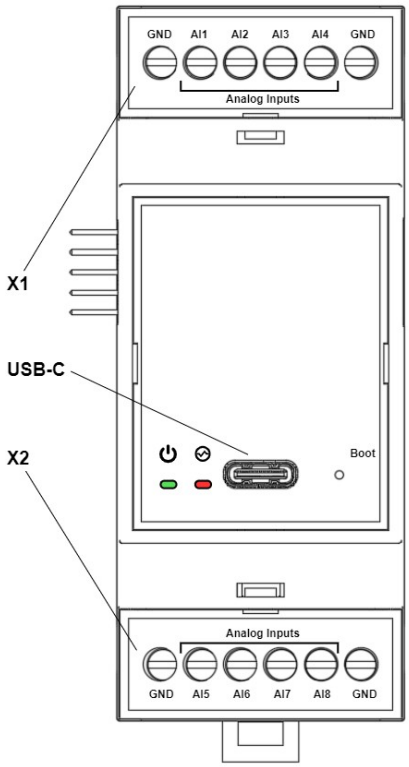

Figure 9-1. EQXAI08 terminals and front panel

X1 – Screw terminal connector 1

USB-C – Firmware update port

X2 – Screw terminal connector 2

The EQXAI08 provides eight independent analog input channels arranged across two screw-terminal blocks. All inputs share a common reference to the local module ground and are software-configurable on a per-channel basis for voltage or current measurement.

9.1 X1 – Screw Terminal Connector 1 (Analog Inputs AI1 to AI4)

The X1 screw terminal connector provides access to the first group of analog input channels on the EQXAI module.
It is used to connect voltage or current sensors to channels AI1 through AI4, with common ground terminals provided at both ends of the connector for clean and robust wiring.

Each input channel can be individually configured in software as either:

- A 0–10 V analog voltage input (AIN), or
- A 4–20 mA / 0–20 mA current-loop input (CIN).

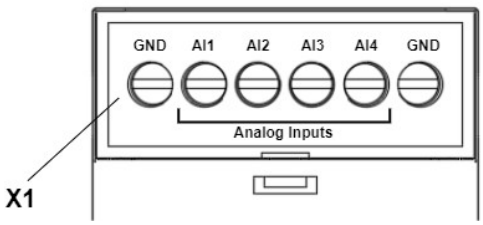

Figure 9-2. X1 terminals

Table 9-1. X1 – Screw Terminal Connector 1 (Analog Inputs AI1 to AI4)

Name	Pin	Function	Type
X1	GND	Analog ground reference - (GND) (*)	POWER IN
	AI1, ..., AI4	Analog input channels 1 through 4	AIN / CIN

> **NOTE**
> (*) DC Power Input GND is common with the system's GND.

9.2 X2 – Screw Terminal Connector 2 (Analog Inputs AI5 to AI8)

The X2 screw terminal connector provides access to the second group of analog input channels on the EQXAI module. It supports channels AI5 through AI8, with the same electrical behavior and configuration options as X1.

Channels connected through X2 can be freely mixed between voltage and current inputs, allowing flexible sensor combinations within the same module.

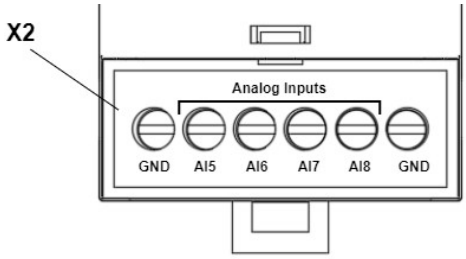

Figure 9-3. X2 terminals

Table 9-2. X2 – Screw Terminal Connector 2 (Analog Inputs AI5 to AI8)

Name	Pin	Function	Type
X2	GND	Analog ground reference - (GND) (*)	POWER IN
	AI5, ..., AI8	Analog input channels 5 through 8	AIN / CIN

> **NOTE**
> (*) DC Power Input GND is common with the system's GND.

9.3 USB-C – Firmware Update and Maintenance Port

The USB-C connector on the EQXAI module is used exclusively for:

- Firmware updates
- Maintenance and recovery operations

Normal operation requires the module to be powered through the EQSP32 board-to-board expansion connector.

10 Power Distribution

The EQXAI expansion module is powered entirely through the EQSP32 board-to-board expansion connector and does not require any external power supply. All internal circuitry—including the analog front-end, ADCs, signal conditioning stages, protection circuits, and control logic—is supplied directly by the EQSP32 controller.

Power is distributed internally from the EQSP32 through the expansion bus and the EQXAI regulates the measuring references for maximizing analog precision. This architecture ensures stable operation across all channels, even when multiple analog inputs are active simultaneously.

The front-facing USB-C port is provided exclusively for firmware updates and maintenance operations. While the module responds when powered via USB, normal measurement operation is intended to occur only when the EQXAI is powered through the EQSP32 expansion connector.

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Because power is delivered automatically through the slide-to-connect mechanical interface, the EQXAI becomes operational immediately once it is docked and the EQSP32 is powered up—no external wiring, terminals, or additional power connections are required.

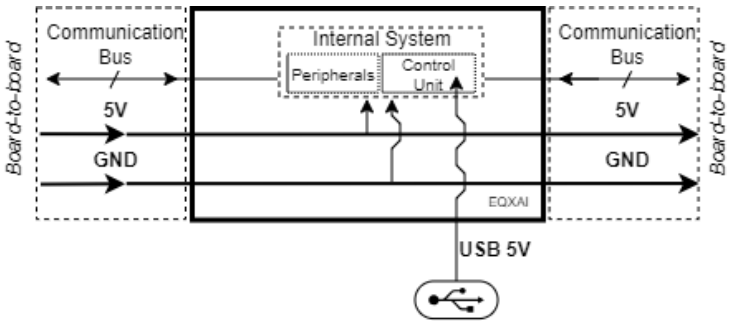

Figure 10-1. Power distribution

11 Analog Inputs – AI

The EQXAI provides eight independent analog input channels, each of which can be software-configured to operate either as a voltage input (AIN) or as a current-loop input (CIN). This allows a single module to simultaneously interface with mixed sensor types, such as voltage-output transmitters and 4–20 mA current-loop sensors, within the same system.

11.1 Equivalent AIx Circuit

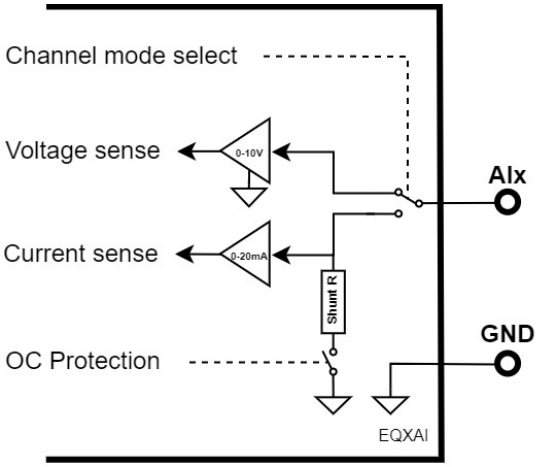

Figure 11-1. Equivalent Analog Input Circuit

11.2 Analog Input Modes Overview

All AIx terminals on the X1 and X2 connectors support both AIN and CIN operating modes.

By default, all AIx channels power up in Analog Input Voltage (AIN) mode until configured otherwise in the software.

The channel modes are not stored. The module starts with all channels in AIN after power-up or a reset, and the EQSP32 library sets the channels of a module back to AIN when it loses the connection to that module. Set the channel modes again with `eqsp32.pinMode()` each time the module is detected again.

A module that is not connected reads 0 on all channels. Use `eqsp32.isModuleDetected( EQXAI(ii) )` to tell a disconnected module from a reading of 0, and to see when it is detected again.

Each analog input (AIx pins) on X1 and X2 terminals shares a common architecture for precision analog conversion by the internal ADCs. Channel mode selection between voltage and current measurement is handled internally and does not require any external wiring changes.

Table 11-1. Analog Input Modes Overview

Mode		Type	Function	Range	Units
Analog **In**put Voltage **(AIN)**	***Default***	Input	Analog	0 – 10000	mV
Current Loop **In**put Sensing **(CIN)**		Input	Analog	0 – 2000	100x mA

In AIN mode, channels measure analog voltage signals in the 0–10 V range. The input circuitry is designed for industrial environments and is tolerant to accidental overvoltage conditions up to 28 V, protecting the module during wiring errors or transient events.

In CIN mode, channels measure 4–20 mA current-loop signals and also support 0–20 mA sensing. Each current input includes dedicated current-loop protection to ensure reliable operation in demanding field conditions. The EQXAI automatically handles current-loop monitoring and protection without requiring user intervention.

11.3 Analog Input Voltage (AIN)

In Analog Input Voltage (AIN) mode, the selected AIx channel measures single-ended analog voltage signals in the 0–10 V (0–10000 mV) range referenced to the corresponding GND terminal.

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The input circuitry is designed for industrial environments and is tolerant to accidental overvoltage conditions up to 28 V, protecting the module against wiring errors or transient events.

Connect the sensor's voltage output to the desired AIx terminal and the sensor ground to the corresponding GND terminal, as shown in the wiring diagram.
No additional external components are required.

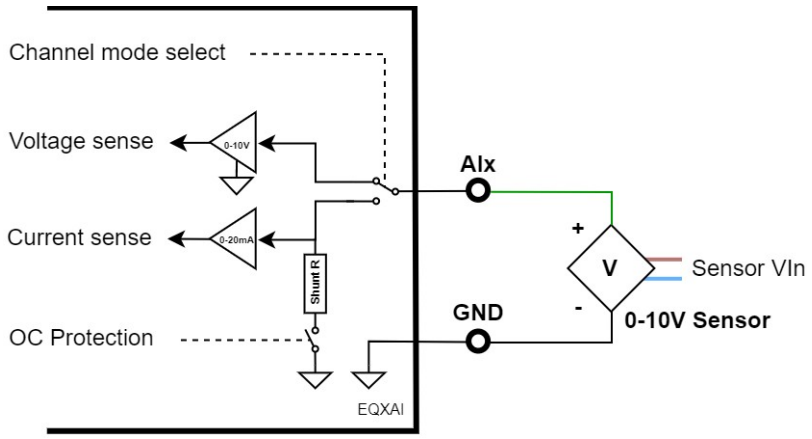

Figure 11-2. Example wiring of a 0–10 V analog voltage sensor connected to an EQXAI input

AIN Measurement Representation

In Analog Input Voltage (AIN) mode, measured values are reported in millivolts (mV).

Example:
A reported value of 5345 returned by
aV = `eqsp32.readPin( EQXAI(1, 3) );`
corresponds to the voltage measured on channel AI3 of the first EQXAI module in the expansion chain:

- 5345 mV

For convenience, the macro `CONVERT_AIN( aV )` may be used to convert the raw millivolt value to volts as a floating-point number:

- 5.345 V

Table 11-2. Library reference: Analog Input Voltage (AIN)

Configuration	
`eqsp32.pinMode( EQXAI(ii, nn), AIN )`	ii: number (index) of EQXAI module on the chain ***(*)*** nn: pin index Set the pin's operating mode to AIN (analog input voltage)
Usage	
`eqsp32.readPin( EQXAI(ii, nn) )`	Returns 0 – 10 V measurements as 0 – 10000 (mV) ii: number (index) of EQXAI module on the chain ***(*)*** nn: EQXAI pin number (channel)
Macros	
Ex. *aV* = `eqsp32.readPin( EQXAI(ii, nn) )`	
`CONVERT_AIN( aV )`	Converts the input voltage from int mV to float V aV: Is the read AIN voltage in mV

> **NOTE**
> (*) When multiple EQXAI modules are connected, they are indexed in order based on their physical position on the expansion chain. The EQXAI module closest to the EQSP32 controller is assigned index 1, the next EQXAI module index 2, and so on.
> Indexing is applied independently per module type; for example, EQXAI modules are indexed separately from EQXIO or EQXTC modules, each maintaining its own numbering sequence.

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11.4 Current Loop Input Sensing (CIN)

In Current Loop Input (CIN) mode, the selected AIx channel measures single-ended current-loop signals in the 4–20 mA range (and 0–20 mA).

Each CIN channel includes current-loop overcurrent protection, ensuring reliable operation in demanding industrial environments. This protection prevents damage to the measurement circuitry in the event of abnormal loop conditions, wiring faults, or excessive current levels.

Above 21 mA the protection disconnects the input, and `eqsp32.readPin()` returns -1 (`CIN_OC_ERROR`); a reading of exactly 21.00 mA is reported the same way. The protection reconnects the input automatically to check whether the fault is gone. Each attempt can give one reading of 0 before the input is disconnected again.

To connect a current-loop sensor, wire the loop output through the corresponding AIx terminal according to the wiring diagram. Loop-powered and externally powered 4–20 mA transmitters are both supported. No external shunt resistors or additional components are required.

4–20 mA Sensor (Externally Powered, 4-Wire)

The sensor is powered by an external supply and provides a current output signal.
Connect the sensor's current output to the desired **AIx** terminal and the sensor return to **GND**, as shown in the wiring diagram.

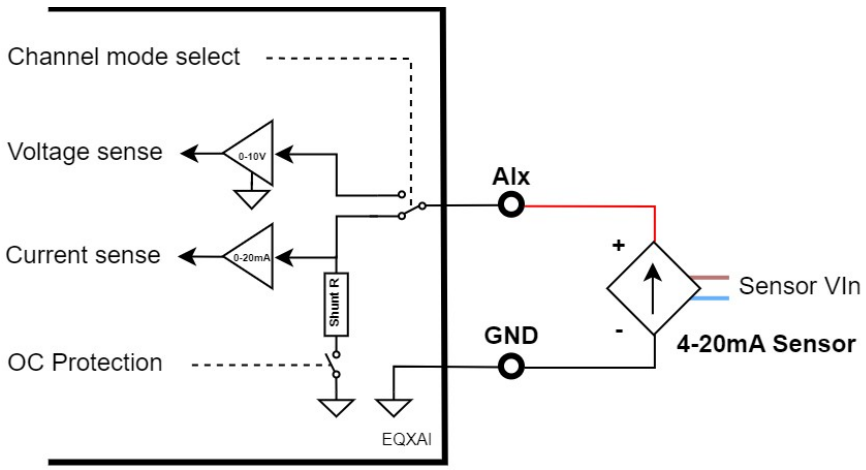

Figure 11-3. 4-Wire example: Wiring an externally powered 4–20 mA sensor (4-Wire sensor)

4–20 mA Loop-Powered Sensor (2-Wire)

The sensor is powered directly from the current loop using an external supply (e.g. 24 V).
Connect the loop supply, sensor, and EQXAI in series so that the loop current flows through the AIx input and returns via GND, as shown in the wiring diagram.

Read the related *"How 2-wire loop powered current sensors work"* article here.

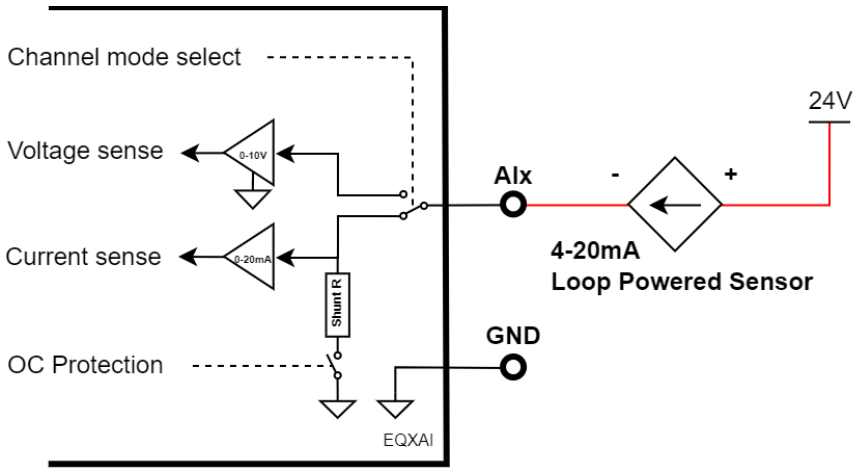

Figure 11-4. 2-Wire example: Wiring a loop-powered 4–20 mA sensor (2-Wire sensor)

CIN Measurement Representation

In Current Loop Input (CIN) mode, measured values are reported in hundredths of milliamps (×0.01 mA).

Example:
A reported value of 1784 returned by
aI = `eqsp32.readPin( EQXAI(1, 3) );`
corresponds to the current measured on channel AI3 of the first EQXAI module in the expansion chain:

- 1784 × 0.01 mA

For convenience, the macro `CONVERT_CIN( aI )` may be used to convert the raw value to milliamps as a floating-point number:

- 17.84 mA

Table 11-3. Library reference: Current Loop Input Sensing (CIN)

Configuration	
`eqsp32.pinMode( EQXAI(ii, nn), CIN )`	ii: number (index) of EQXAI module on the chain ***(*)*** nn: pin index Set the pin's operating mode to CIN (current loop inputs)
Usage	
`eqsp32.readPin( EQXAI(ii, nn) )`	Returns 0 – 20 mA measurements as 0 – 2000 (mAx100). Divide by 100 to convert the returned value to mA float. Returns -1 (`CIN_OC_ERROR`) while the overcurrent protection has disconnected the input ii: number (index) of EQXAI module on the chain ***(*)*** nn: EQXAI pin number (channel)
Macros	
Ex. *aI* = `eqsp32.readPin( EQXAI(ii, nn) )`	
`CONVERT_CIN( aI )`	Converts the current input from int mAx100 to float mA aI: Is the read CIN value in mA multiplied by 100

> **NOTE**
> (*) When multiple EQXAI modules are connected, they are indexed in order based on their physical position on the expansion chain. The EQXAI module closest to the EQSP32 controller is assigned index 1, the next EQXAI module index 2, and so on.
> Indexing is applied independently per module type; for example, EQXAI modules are indexed separately from EQXIO or EQXTC modules, each maintaining its own numbering sequence.

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12 Boot Button and Firmware Update

12.1 Boot Button

The Boot button is used exclusively to place the EQXAI module into firmware update (maintenance) mode. It is not required for normal operation.

To enter firmware update mode:

1. Press and hold the Boot button.
2. While holding the button, power the module by connecting the front-facing USB-C port to a PC host.
3. Release the Boot button after power is applied.

The module will enter maintenance mode and appear to the host computer as a USB mass-storage device.

12.2 Firmware Update Procedure

Firmware updates for the EQXAI are performed through the front-facing USB-C port like copying a file into a storage device.

To update the firmware:

1. Download the latest EQXAI firmware from the erqos.com website. *[go to website]*
2. Ensure the module is in maintenance mode (see the Boot Button section above).
3. Locate the removable storage device labeled RPI-RP2 on the host computer.
4. Copy (or drag and drop) the provided .uf2 firmware file onto the device.
5. The firmware update will start automatically.

Once the update is complete, the module will reboot.
Power-cycle the system and ensure the EQXAI is powered through the EQSP32 board-to-board expansion connector to resume normal operation and allow automatic module detection and indexing.

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13 Mechanical Dimensions

All dimensions are measured in mm with a +/-0.1 tolerance.

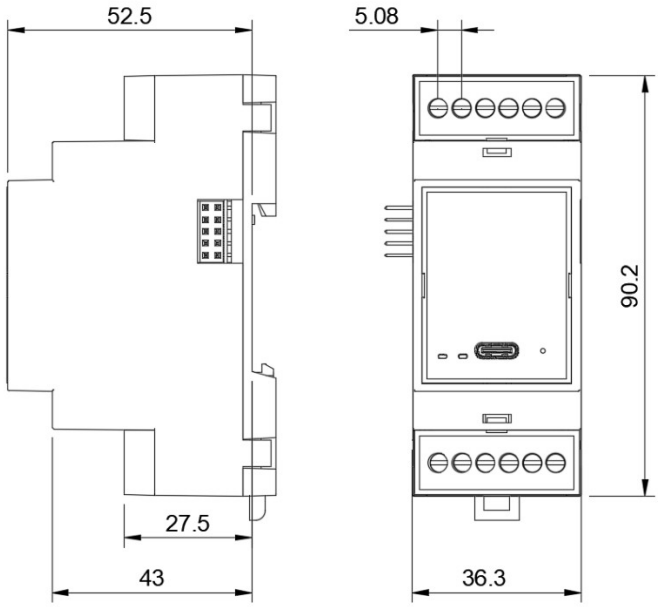

Figure 13-1. Mechanical dimensions: side and front views

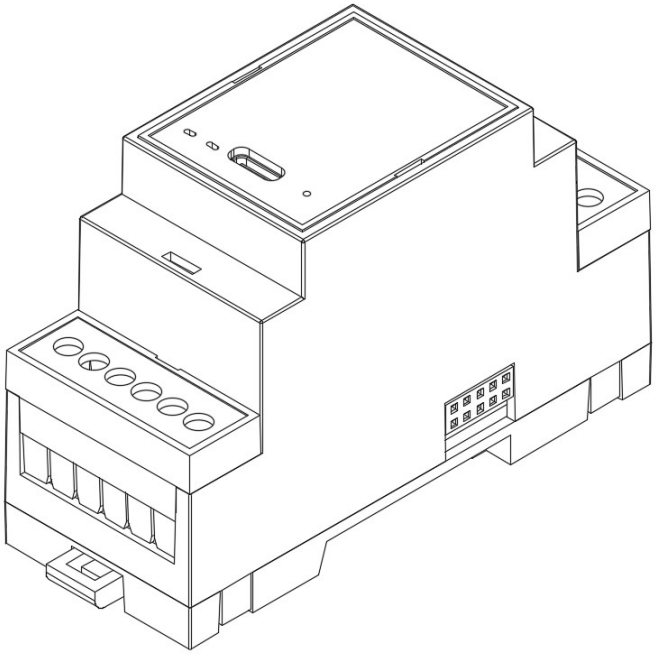

Figure 13-2. Mechanical dimensions: 3D view

14 Notices

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15 Revision History

VERSION	REVISION	STATUS
v1.1	**Rev102026**	**Released**

Table 15-1. Revision history

Version	Revision	Date	Status	Changes
v1.1	Rev102026	20 Oct 2026	Released	Added the CIN fault value.
v1.0	Rev101926	19 Oct 2026	Released	First released version.

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