Strato Pi Max User Guide

August 2026 - Revision 012

SCMX10XL4A
Strato Pi Max XL with CM4 Wireless, 2GB RAM, Lite

SCMX10XL4B
Strato Pi Max XL with CM4 Wireless, 4GB RAM, Lite

SCMX10XL4C
Strato Pi Max XL with CM4 Wireless, 8GB RAM, Lite

SCMX10XL4F
Strato Pi Max XL with CM4 Wireless, 2GB RAM, 16GB eMMC

SCMX10XL4G
Strato Pi Max XL with CM4 Wireless, 4GB RAM, 16GB eMMC

SCMX10XL4H
Strato Pi Max XL with CM4 Wireless, 8GB RAM, 16GB eMMC

SCMX10XL4K
Strato Pi Max XL with CM4 Wireless, 2GB RAM, 32GB eMMC

SCMX10XL4L
Strato Pi Max XL with CM4 Wireless, 4GB RAM, 32GB eMMC

SCMX10XL4M
Strato Pi Max XL with CM4 Wireless, 8GB RAM, 32GB eMMC

SCMX10XL5A
Strato Pi Max XL with CM5 Wireless, 2GB RAM, Lite

SCMX10XL5B
Strato Pi Max XL with CM5 Wireless, 4GB RAM, Lite

SCMX10XL5C
Strato Pi Max XL with CM5 Wireless, 8GB RAM, Lite

SCMX10XL5D
Strato Pi Max XL with CM5 Wireless, 16GB RAM, Lite

SCMX10XL5F
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SCMX10XL5M
Strato Pi Max XL with CM5 Wireless, 8GB RAM, 32GB eMMC

SCMX10XL5N
Strato Pi Max XL with CM5 Wireless, 16GB RAM, 32GB eMMC

SCMX10XL5P
Strato Pi Max XL with CM5 Wireless, 2GB RAM, 64GB eMMC

SCMX10XL5Q
Strato Pi Max XL with CM5 Wireless, 4GB RAM, 64GB eMMC

SCMX10XL5R
Strato Pi Max XL with CM5 Wireless, 8GB RAM, 64GB eMMC

SCMX10XL5S
Strato Pi Max XL with CM5 Wireless, 16GB RAM, 64GB eMMC

SCMX10XLZA
Strato Pi Max XL with Zymbit SCM4 Wireless, 2GB RAM, 16GB eMMC

SCMX10XLZB
Strato Pi Max XL with Zymbit SCM4 Wireless, 8GB RAM, 32GB eMMC

SCMX10XS4A
Strato Pi Max XS with CM4 Wireless, 2GB RAM, Lite

SCMX10XS4B
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SCMX10XS5Q
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SCMX10XS5R
Strato Pi Max XS with CM5 Wireless, 8GB RAM, 64GB eMMC

SCMX10XS5S
Strato Pi Max XS with CM5 Wireless, 16GB RAM, 64GB eMMC

SCMX10XSZA
Strato Pi Max XS with Zymbit SCM4 Wireless, 2GB RAM, 16GB eMMC

SCMX10XSZB
Strato Pi Max XS with Zymbit SCM4 Wireless, 8GB RAM, 32GB eMMC

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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 read this 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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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 Compute Module board could generate a substantial amount of heat when the software forces the CPU and/or GPU to operate at high load levels. Ensure that the product is properly installed and ventilated to prevent overheat.

The Strato Pi Max internal power supply could generate a substantial amount oh heat, particularly when subject to a significant amount of electrical load.

An internal fan significantly improves the airflow and heat dissipation. Depending on external environment conditions, the fan could collect a significant amount of dust or other impurities, that could prevent it from spinning or could reduce its effectiveness. Periodically check that the fan is not blocked or partly obstructed.

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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Battery

Strato Pi Max uses a small lithium non-rechargeable battery to power its internal real time clock (RTC).

WARNING

Improper handling of lithium batteries can result in an explosion of the batteries and/or release of harmful substances.

Worn-out or defective batteries can compromise the function of this product.

Replace the RTC lithium battery before it is completely discharged. The lithium battery must be replaced only with an identical battery. See the "Replacing the RTC backup battery" section for instructions.

Do not throw lithium batteries into fire, do not solder on the cell body, do not recharge, do not open, do not short-circuit, do not reverse polarity, do not heat above 85°C and protect from direct sunlight, moisture and condensation.

Dispose of used batteries according to local regulations and the battery manufacturer's instructions.

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Introduction

Strato Pi Max is an extremely versatile industrial server, based on the Raspberry Pi Compute Module 4 or 5 and the RP2040 microcontroller, suitable for use in professional and industrial applications where reliability and service continuity are key requirements, housed in a compact DIN rail case.

Strato Pi Max can be used for an incredible range of applications, from data acquisition and control, to home and building automation, as well as access control, hotel room control solutions, environmental monitoring and many others.

It is available in two versions:

- Strato Pi Max XL, with four expansion slots and housed in a 9 modules DIN rail case
- Strato Pi Max XS, with one expansion slots and housed in a 6 modules DIN rail case

Both come pre-installed with Raspberry Pi Compute Module 4, Raspberry Pi Compute Module 5, or Zymbit Secure Compute Module (SCM).

An optional Compute Module Antenna Kit can be fitted on the top side of the enclosure and internally wired to the Compute Module.

The information contained in this manual covers both Strato Pi Max XL and XS.

This manual generally refers to all products as Strato Pi Max.



STRATO PI MAX XL



STRATO PI MAX XS

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Features

Strato Pi Max, all versions:

- 10-50 Vdc power supply, on pluggable 5.08 mm pitch terminal block, with surge and reverse polarity protection, and 3.3 A resettable fuse
- voltage and current monitoring of power supply input voltage and current
- compatible with all versions of Raspberry Pi Compute Module 4 and 5, and with Zymbit Secure Compute Module (SCM)
- one 10/100/1000 and one 10/100 Ethernet ports
- two USB 2.0 type-A ports, with individual power control and fault detection
- user-programmable 32 bit Raspberry Pi RP2040 microcontroller based on a dual ARM Cortex-M0+ core clocked at 133 MHz, with 264 kB on-chip SRAM ,16 MB Flash memory and 2 kB SRAM with EEPROM backup. The RP2040 is interconnected to the Raspberry Pi via I²C, USB and UART
- the Compute Module can control the Reset and Bootsel lines of the RP2040, allowing in-field firmware upgrades, but also development and debugging without external hardware
- the RP2040 microcontroller handles all housekeeping tasks, including Compute Module watchdog, power management, mass storage boot sequence control and expansion boards detection and control
- the hardware watchdog independently monitors the Compute Module, and is capable of performing a full power cycle of the Compute Module. The hardware watchdog can also control the microSD switch matrix, swapping the boot card in case the watchdog is triggered, or disabling the SSD in order to boot from the eMMC or microSD
- internal fan for active cooling, with configurable automatic activation based on current load and internal temperature
- temperature sensors for system temperature monitoring
- highly accurate real time clock with temperature compensated crystal oscillator (TCXO) and replaceable CR1220 Lithium / Manganese Dioxide back-up battery
- Microchip ATECC608 secure element chip
- 3-axis accelerometer for motion and tamper detection
- front panel configurable status LEDs and push-button
- variable pitch piezoelectric buzzer, for acoustic feedback

Strato Pi Max XL:

- 4 internal expansion slots. Expansions boards are detected and identified for automatic configuration. They can be individually powered off to save power in stand-by or low power modes
- flexible mass storage options: eMMC, dual microSD, high performance M.2 NVMe SSD
- dual microSD card architecture. Strato Pi Max XL routes its two microSD card holders to the Compute Module through a high-speed switching matrix, controlled by the on-board RP2040 microcontroller. Each SD card can be set as the boot card, with the other

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available as additional storage. This enables for separate OS/data storage, SD redundancy and in-field full-system upgrades. The microSD slots are hidden, and can be accessed opening the case

- 9 modules DIN rail case

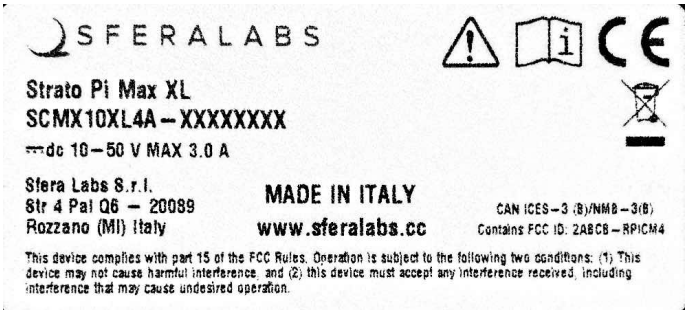
Strato Pi Max XS:

- 1 internal expansion slot. Installed boards are detected and identified for automatic configuration. Can be powered off to save power in stand-by or low power modes
- flexible mass storage options: eMMC, high performance M.2 NVMe SSD
- compact 6 modules DIN rail case

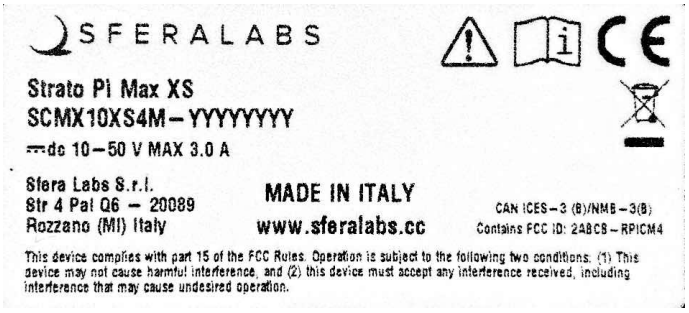
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Device identification

The device can be identified with the information provided in the rating and identification plate, permanently attached to the side of the case.



EXAMPLE STRATO PI MAX XL RATING AND IDENTIFICATION PLATE



EXAMPLE STRATO PI MAX XS RATING AND IDENTIFICATION PLATE

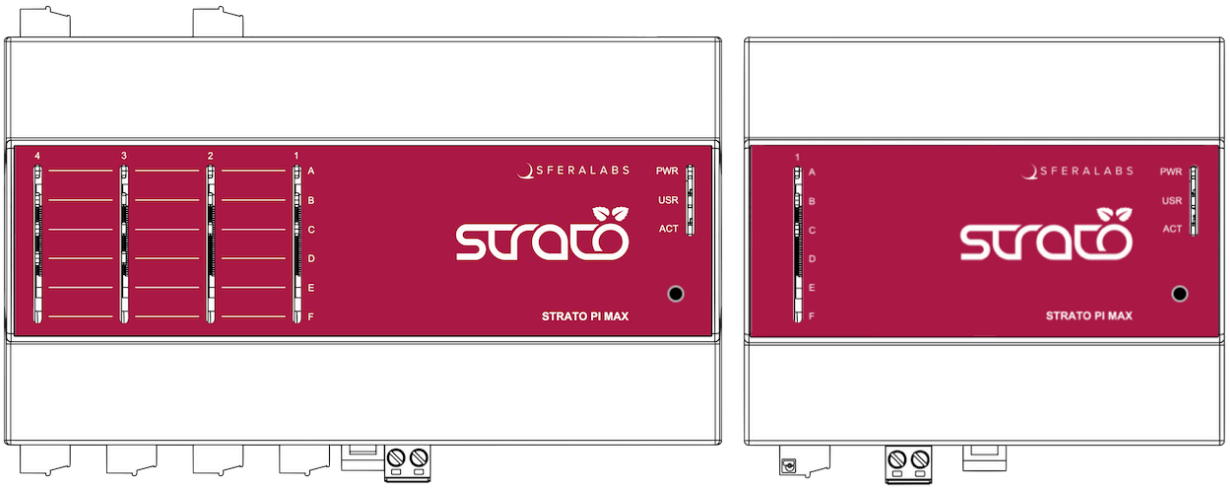
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Device overview

Strato Pi Max consists of a main board and optional expansion boards. The Strato Pi Max XS supports one expansion board, while the Strato Pi Max XL accommodates up to four.

Expansion boards are mounted internally in the expansion slots on the left end of the main board and are numbered from right to left (1 to 4).

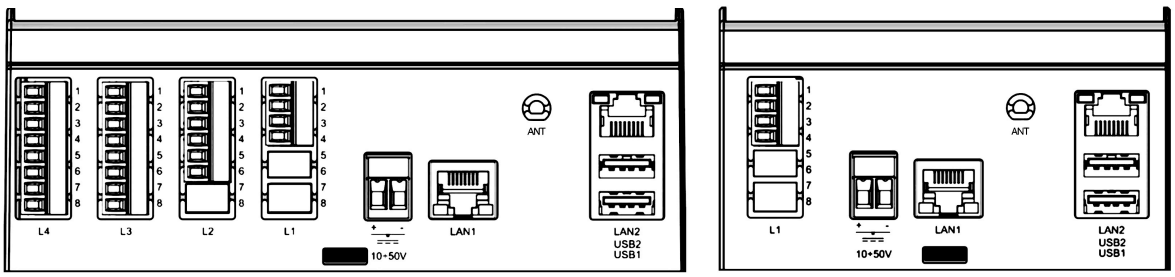
Each expansion board may include terminal block connectors on both the low (L) and high (H) sides of the module.



FRONT VIEW

The front panel of Strato Pi Max provides access to the user button and various indicator LEDs through transparent slits.

- On the right side, the main board features three LEDs: Power (PWR), User (USR), and Activity (ACT), along with the user button
- On the left side, each expansion board can have up to six indicator LEDs (A, B, …, F)



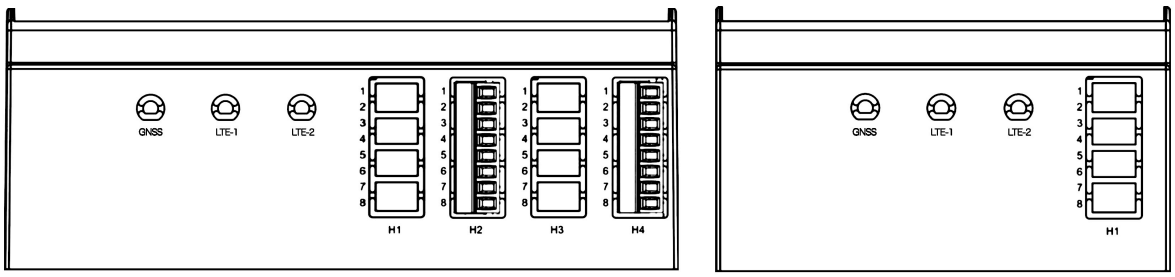
LOW (L) SIDE VIEW

The low (L) side of the module includes:

- Two USB ports (USB1, USB2)
- Two Ethernet ports (LAN1, LAN2)
- Power supply input terminal block

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- L-side terminal blocks for expansion boards
- SMA connector for the Raspberry Pi antenna (or a pre-cut opening if the antenna is not installed)
- DIN rail hook handle



HIGH (H) SIDE VIEW

The high (H) side features:

- H-side terminal blocks for expansion boards
- SMA connectors for the M.2 LTE Module expansion board antennas (or pre-cut openings if the board is not installed)

Each expansion board terminal block has up to eight screw positions, numbered individually from top to bottom (1 to 8). Unused terminal block openings are covered with removable lids, allowing for future expansion.

For details on specific expansion board LEDs and terminal blocks, refer to the respective user guide.

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Initial setup

To use your Strato Pi Max, you need to install an operating system and access it via network. The setup process includes:

- Choosing a storage device for booting
- Setting up the hardware accordingly
- Installing and configuring the OS on the chosen storage
- Optionally modifying the Compute Module's bootloader settings
- Powering on the system and establishing network access

A detailed guide for first-time setup of Strato Pi Max is available at:

https://github.com/sfera-labs/strato-pi-max

where you find step-by-step instructions for setting up and configuring Strato Pi Max, including OS installation, boot options, troubleshooting, and preparing the device for production. Key topics include:

- Bootloader configuration for optimal performance and recovery
- Managing boot scenarios for eMMC, SSD, and network boot
- Preparing for reliable OTA updates with secondary boot storage and watchdog recovery
- Security and fault-tolerance best practices for production deployment

Following this guide ensures a smooth setup process and a resilient, maintainable system.

If you have any doubts or questions, contact Sfera Labs support at support@sferalabs.cc.

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Hardware setup

For the initial set-up, the plastic DIN rail enclosure may have to be removed to access the circuit boards and internal connectors to install or remove the Compute Module, the microSD cards, PCIe/NVMe devices, or the expansion boards.

NOTICE

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

Opening the case

Follow these steps, in the exact order, to open the case:

1. Remove the green pluggable terminal blocks (power supply and expansion boards)
2. Remove the black plastic DIN rail hook
3. With a small flat screwdriver gently separate the case bottom from the top shell; lift both sides gradually; pay attention not to touch the circuit boards with the screwdriver's tip
4. The circuit boards assembly will simply slide out of the case, as it is mechanically held in place by the case bottom only
5. If the optional Compute Module Antenna Kit is installed, disconnect the U.FL connector on the cable to the U.FL-compatible connector on Compute Module before fully separating the circuit board from the case top. Follow the detailed fitting instructions from the Raspberry Pi Antenna Kit product brief document[1].

Closing the case

6. Remove the front panel. This will help aligning the circuit boards assembly with the case walls
7. If the optional Compute Module Antenna Kit is installed, connect the U.FL connector on the cable to the U.FL-compatible connector on Compute Module
8. Replace the circuit boards assembly inside the case; ensure that the USB and Ethernet connectors and terminal blocks are aligned with the openings in the case
9. Replace the case bottom, partially inserting both sides, then gently push on both sides. The case bottom must perfectly fit and firmly hook to the case cover. If it doesn't, the circuit boards assembly is not perfectly fit into the case top shell
10. Replace the front panel, ensuring that the frontal push-button is aligned to the panel's hole
11. Replace the black plastic DIN rail hook.

[1] https://datasheets.raspberrypi.com/cm5/antenna-kit-product-brief.pdf

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OPENING AND CLOSING THE CASE

Compute Module board installation

To install your own Raspberry Pi Compute Module board in Strato Pi Max, or replace a pre-installed board, only a screwdriver is required.

Align the screw holes and connectors of the Compute Module with the Strato Pi Max circuit board and gently snap in the board. Two screws secure the Compute Module to the Strato Pi Max board.

NOTICE

Both the Compute Module and the Strato Pi Max circuit board will likely be damaged if the connectors are not correctly aligned.

NOTICE

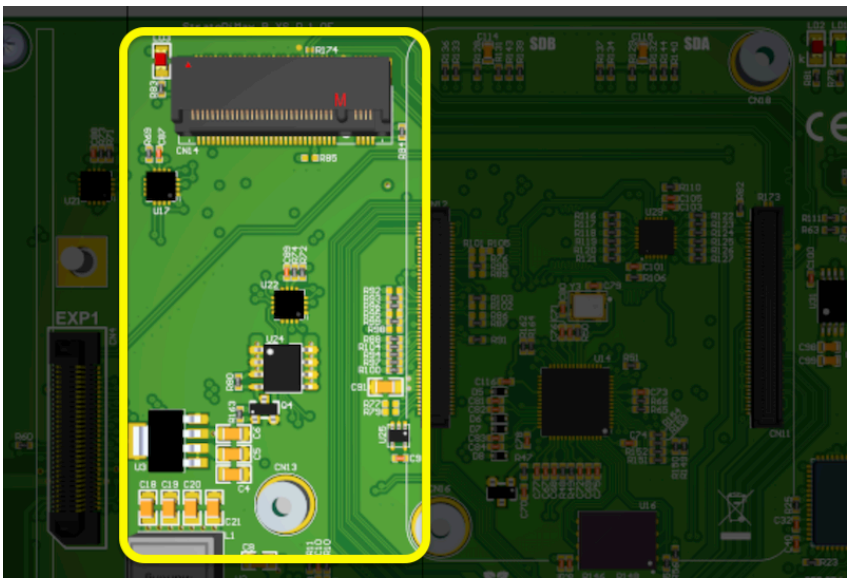
Static electricity can damage the components in your system. To protect your system's components from static damage during the installation process, touch any of the unpainted metal surfaces on your computer's frame or wear an ESD wrist strap before handling internal components. Either method will safely discharge static electricity that's naturally present in your body.

When handling the Strato Pi Max circuit board or the Compute Module, be sure to hold it along the side edges using your thumb and index finger. Avoid touching the components and pin connectors as damage can occur.

PCIe/NVMe SSD installation

The PCIe slot is located on the top side of the main circuit board, next to the Compute Module.

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PCIE SLOT

The slot is compatible with NVMe SSD drives and PCIe devices with M.2 (Key M) connector and 2242 form factor.

M.2 2230 devices can be fitted using an M.2 2230-to-2242 adapter.

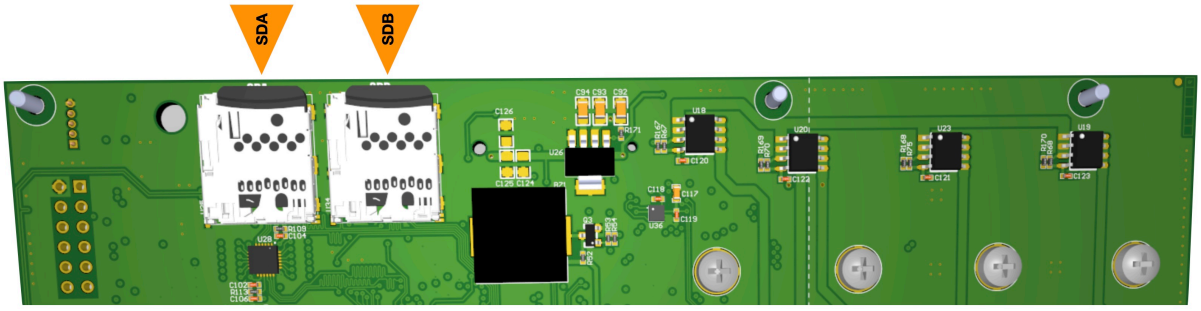
To install a device insert it at a slight angle into the M.2 socket, then push it down and lock it in place with the screw.

microSD cards installation

Strato Pi Max XL has two microSD slots to install flash memory cards.

The microSD slots are not directly accessible with the case closed. The slots are located on the bottom side of the main circuit board.

The slots are marked as SDA and SDB.



MICRO SD SLOTS

Replacing the RTC backup battery

Strato Pi Max has a hardware real time clock with a dedicated long-life non-rechargeable back-up battery.

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Strato Pi Max is shipped with a **CR1220**[2] Lithium / Manganese Dioxide (Li/MnO2) battery installed.

The battery is only used to power the RTC chip when the main power is not available. Depending on operating conditions it should last three or more years[3] if the Strato Pi Max is not powered, or up to the battery's lifetime if it regularly receives external power.

The RTC backup battery holder is on the vertical circuit board, next to the Compute Module area. 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 assembly. Follow the procedure described at the beginning of this chapter to open and replace the case.

WARNING

Improper handling of lithium batteries can result in an explosion of the batteries and/or release of harmful substances.

Worn-out or defective batteries can compromise the function of this product.

KEEP OUT OF REACH OF CHILDREN. Swallowing may lead to serious injury or death in as little as 2 hours due to chemical burns and potential perforation of the esophagus. Immediately see doctor.

WARNING

Replace the RTC lithium battery before it is completely discharged. Replace the battery every 5 years even if the battery is still working properly. The lithium battery must be replaced only with an identical **CR1220** or **BR1220** battery.

WARNING

Do not throw lithium batteries into fire, do not solder on the cell body, do not recharge, do not open, do not short-circuit, do not reverse polarity, do not heat above 85°C and protect from direct sunlight, moisture and condensation.

Dispose of used batteries according to local regulations and the battery manufacturer's instructions.

[2] BR1220 batteries (Lithium Poly-carbonmonofluoride) can also be used, for improved shelf and service life.

[3] Depending on environmental conditions.

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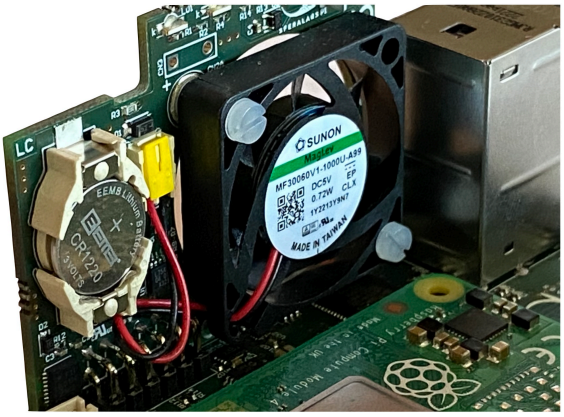
NOTICE

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

Once the circuit boards assembly is extracted from the enclosure, use a non-conductive pin or small tool to help extract the battery from its holder. Insert the new battery with a gentle push. You don't need tools to insert the battery. The battery is held into place by a spring contact.

Be sure to insert the battery so that the negative (-) terminal is facing the vertical circuit board, and touches the contact pad at the center of the battery holder, as shown in the photo below. Reattach the vertical board to the base; use light torque to tighten the screws.

The real time clock will reset its time immediately when the RTC backup battery is disconnected.



RTC BACKUP BATTERY HOLDER

Terminal blocks

Strato Pi Max has a two-poles 5.08 mm pitch pluggable terminal block for the power supply connection.

The maximum conductor cross section is 3.31 mm² (12 AWG). Recommended stripping length is 7 mm. Screw thread is M3. Never exceed 0.5 Nm torque when tightening the screws.

Power supply

Strato Pi Max can be powered with DC voltage only:

- DC: nominal voltage range 10.0 V to 50.0 V, 3 A max input current.

Respect the correct polarity (+ -). The power supply circuit implements reverse polarity protection using auto resetting fuses and surge protection. The resetting fuse threshold is 3.3 A at 20 C ambient temperature.

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The PWR blue LED, visible through the front panel of the DIN-rail case, is lit when power supply is available.

The Strato Pi Max power supply stage is optimised to deliver up to 30W total power through its 5 V main regulator. This regulator supplies all internal voltages.

When the input voltage is below 24 V, if the total power demand is very high, the input current threshold limit could be exceeded, causing the resettable fuse to trip.

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System architecture

Strato Pi Max features two processing cores: the Raspberry Pi Compute Module (CM) and the Raspberry Pi RP2040 microcontroller.

In its standard configuration, the RP2040 comes preloaded with firmware that implements the functional logic described below. It operates as an I²C slave device on the Compute Module's I²C bus, receiving commands and configuration settings.

The Compute Module is fully available for users to develop and deploy their own solutions, leveraging all the hardware and functional capabilities of Strato Pi Max.

To simplify integration, we provide a driver for Raspberry Pi OS (Debian) that grants access to all configuration parameters and functionalities offered by the RP2040 and the other subsystems via sysfs file system. This enables users to interact with these features simply by reading and writing files, using any programming language, tool, or framework that supports basic file access. See the "Software configuration and usage" chapter.

Beyond I²C, the Compute Module and RP2040 are interconnected through additional interfaces and connected to the subsystems described below. Refer to the block diagram for further details.

For specialized configurations, alternative usage scenarios, or custom RP2040 firmware, refer to the "Advanced Usage" chapter.

Power Control

Strato Pi Max features a versatile power control system that manages and monitors the power supply of all its subsystems, including the Compute Module and the RP2040 microcontroller.

The standard RP2040 firmware provides a comprehensive set of functions for system monitoring, user control, and automated power management to enhance reliability and recovery.

A configurable power-up delay ensures that the Compute Module is powered only after the main power source has remained stable for a specified duration.

The system can be configured to perform controlled power cycles of the Compute Module and other subsystems, with customizable logic, timing, and behavior parameters.

A power cycle can be triggered directly by the user application (e.g. to switch boot disk) or automatically in response to predefined events.

The power supply input voltage and current are monitored and accessible to the user.

If a UPS expansion board with external battery is installed, the reported input voltage will be near zero during battery operation, while the current indicates the draw from the battery. By default, during a controlled power cycle, the Compute Module powers on only when the main power source is restored, but configuration parameters can enable power-up even when running on the UPS backup.

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Push button

Strato Pi Max has a user-configurable push button on the front panel. It is routed to the RP2040 IO expander lines to easily control it from your application.

PWR LED

The PWR blue LED, visible through the front panel of the DIN-rail case, is lit when power supply is available.

ACT LEDs

The red and green ACT LEDs replicate the LEDs of the Raspberry Pi (4 or 5) Model B.

Under Linux the green LED will flash to signal eMMC/SD access.

If any error occurs during booting, this LED will flash an error pattern which can be decoded using the look up table on the Raspberry Pi documentation.

The red ACT LED replicates the red power LED on the Raspberry Pi (4 or 5) Model B.

USR LEDs

The red and green USR LEDs can be used for custom signaling or configured to indicate specific system states. System states are shown through short blink sequences, repeated every two seconds:

Blinks	State
1	Watchdog enabled
2	Watchdog timeout expired, power cycle not initiated
3	Power cycle initiated, down delay running
4	CM powered off by power cycle
5	User-defined power-up delay active
6	Power-up delay for system setup (e.g. required by a specific expansion board)
7	Power-up delay due to low or unstable voltage detected on power supply input

User control priority can be configured to allow both user-defined and system-driven signaling on the same LED.

By default the red LED is configured to report all the system states above, except the first one (watchdog enabled), but priority is given to user commands.

USB ports

Strato Pi Max has two external USB 2.0 ports, USB1 (bottom) and USB2 (top).

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They are connected to the Compute Module through the LAN9514 USB hub.

Both ports are individually controlled by the MIC2076, a power distribution controller with circuit protection. The MIC2076 is internally current limited and has thermal shutdown that protects the device and load (0.5 A max). A fault status output flag is asserted during over-current and thermal shutdown conditions.

The power-enable inputs and the fault status outputs are routed to the RP2040 IO expander lines to easily control and monitor connected USB devices from your application.

The USB ports are powered down during controlled power cycles.

Ethernet ports

Strato Pi Max has one 10/100/1000 (Gigabit) Ethernet port (LAN1), and one 10/100 Ethernet port (LAN2).

LAN1 is connected directly to the Compute Module's PHY interface.

LAN2 is connected to the Compute Module through the LAN9514 USB-to-Ethernet bridge.

PCIe/NVMe SSD slot

Strato Pi Max has one internal PCIe Gen2 × 1 M.2 slot (Key M) compatible with the 2242 form factor.

M.2 2230 devices can be fitted using an M.2 2230-to-2242 adapter.

The slot is directly connected to the PCIe interface of the Compute Module.

It can be used to connect NVMe SSD drives or any other compatible PCIe device.

The slot can be powered on/off through the RP2040 IO expander lines to reset the connected device and to manage boot drive selection.

SD matrix

Strato Pi Max XL implements a flexible dual microSD card architecture.

Strato Pi Max XL routes its two microSD card holders to the Compute Module through a high-speed switching matrix, controlled by the on-board microcontroller. Each SD card can be set as the boot card, with the other available as additional storage.

The Raspberry Pi Compute Module supports two SD card interfaces: the main interface is connected to the Broadcom controller and is used to boot and talk to the eMMC or SDX signals; the secondary interface is standards compliant and can interface to SD and eMMC devices.

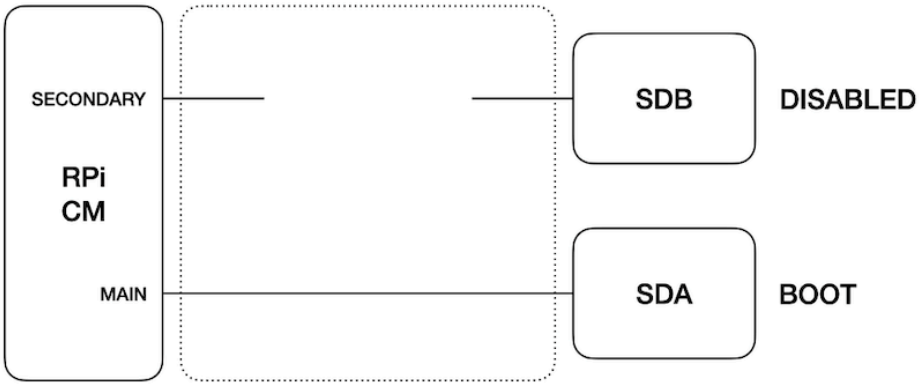
Strato Pi Max XL has two microSD slots, called SDA and SDB, and the SD matrix allows 2x2 connections between both main/secondary interfaces and SDA/SDB slots.

NOTICE

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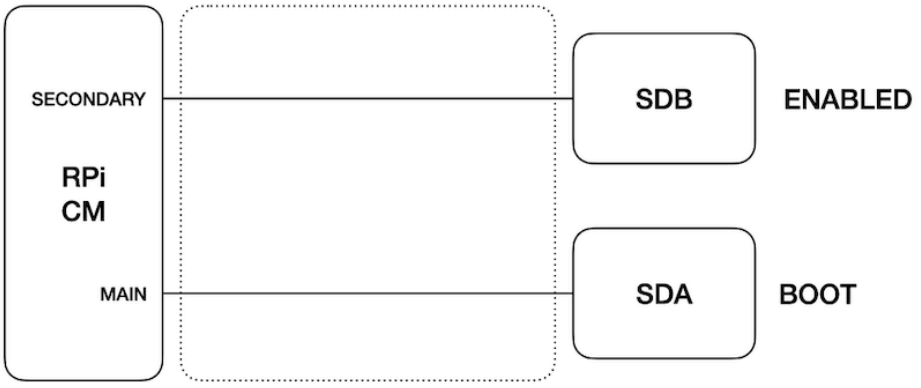
Disconnecting an SD card from the Compute Module's SD interfaces when partitions from the card are mounted at the operating system level, can result in file system and data corruption. The Strato Pi Max XL matrix and the microcontroller don't check for card usage and don't provide any safety mechanism to prevent improper disconnection of the SD cards.

The matrix is controlled by the RP2040. It has a hardware default configuration so that, when at power-up all microcontroller lines are high-impedance, it has a stable configuration, with the main interface connected to SDA and the secondary interface not connected. When the microcontroller is reset, even if the control lines change state, the matrix control logic will retain the current configuration.



SD MATRIX DEFAULT CONFIGURATION

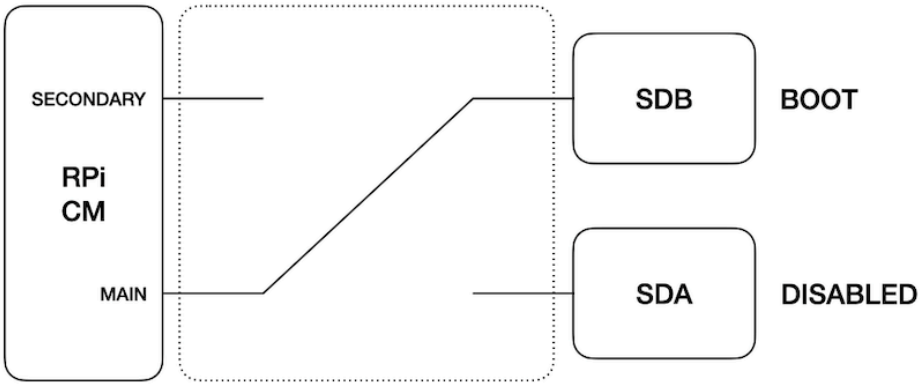
With SDA used as the boot card, SDB can be connected to the secondary interface, and used as additional storage.



SD MATRIX BOOT FROM SDA AND SDB ENABLED FOR ADDITIONAL STORAGE

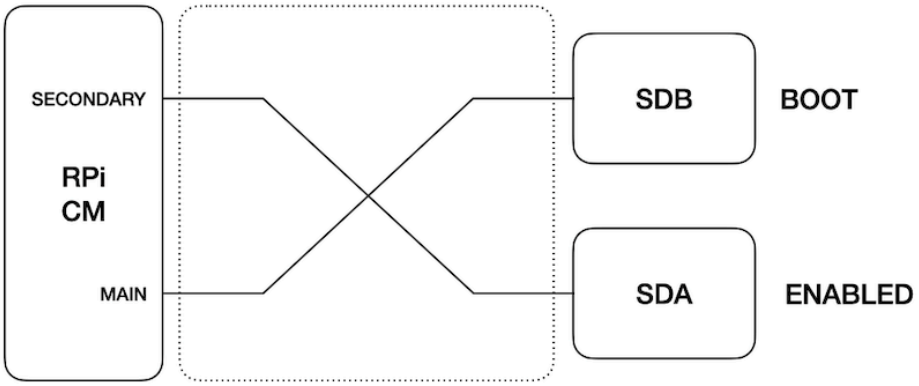
The main interface can be connected to SDB instead of SDA, so that boot will be done from SDB.

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SD MATRIX BOOT FROM SDB

With the main interface connected to SDB for boot, the SDA slot can be enabled to be used for additional storage.



SD MATRIX BOOT FROM SDB AND SDA ENABLED FOR ADDITIONAL STORAGE

It is also possible to disable both interfaces. This configuration could be used when an M.2 NVMe SSD is installed or with Compute Module versions with embedded eMMC storage, when no external SD card is needed.

Compute Module 5 notes

The Compute Module 5 features a high-speed SD interface, which may cause compatibility issues with SD cards that support these speeds.

To ensure compatibility, both the Compute Module's bootloader and the OS must be configured to avoid using these settings.

For detailed instructions, visit:
https://github.com/sfera-labs/strato-pi-max

Real Time Clock

Strato Pi Max has a NXP PCF213 hardware real time clock (RTC) with a dedicated long-life non-rechargeable back-up battery.

The RTC chip is connected to the CM's I²C bus.

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Once the RTC driver is properly installed, you will simply use the standard date and time commands to control the hardware clock. See the “Software configuration and usage” chapter.

ATECC608 secure element

Strato Pi Max embeds the ATECC608A or ATECC608B (depending on production lot) secure element chip from Microchip. The ATECC608 is connected to the Raspberry Pi Compute Module via the I²C bus (address 0x60).

Its key features are:

- Cryptographic co-processor with secure hardware-based key storage
- Protected storage for up to 16 Keys, certificates or data
- Hardware support for asymmetric sign, verify, key agreement – ECDSA: FIPS186-3 Elliptic Curve Digital Signature
  - ECDH: FIPS SP800-56A Elliptic Curve Diffie-Hellman
  - NIST standard P256 elliptic curve support
- Hardware support for symmetric algorithms
  - SHA-256 & HMAC hash including off-chip context save/restore
  - AES-128: encrypt/decrypt, Galois field multiply for GCM
- Networking key management support
  - Turnkey PRF/HKDF calculation for TLS 1.2 & 1.3
  - Ephemeral key generation and key agreement in SRAM – Small message encryption with keys entirely protected
- Secure boot support
  - Full ECDSA code signature validation, optional stored digest/signature – optional communication key disablement prior to secure boot
  - Encryption/Authentication for messages to prevent on-board attacks
- Internal high-quality FIPS 800-90 A/B/C Random Number Generator (RNG)
- Two high-endurance monotonic counters
- Guaranteed unique 72-bit serial number.

Refer to its documentation and Microchip’s software resources for usage details.

EERAM

Strato Pi Max has a Microchip 47L16 16 Kbit SRAM with EEPROM Backup. This chip combines the persistent storage characteristics of a traditional EEPROM, without the limitations in terms of number of erase cycles. It is connected to the RP2040 I²C bus.

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Internal fan and temperature sensors

Strato Pi Max has an internal fan with user-configurable activation thresholds to improve heat dissipation inside its DIN-rail enclosure, particularly in the area of the power regulators, where most of the heat is generated.

A temperature sensor, located on the vertical circuit board, can be used to monitor the current temperature.

Accelerometer

Strato Pi Max embeds the IIS2DLPC high-performance three-axis linear accelerometer with digital I²C interface connected to the RP2040 I²C bus. The IIS2DLPC has user selectable full scales of ±2g/±4g/±8g/±16g and is capable of measuring accelerations with output data rates from 1.6 Hz to 1600 Hz.

The accelerometer can be used as a tamper detection sensor, triggered when the Strato Pi Max case is moved or tilted, as well as for other motion-related applications, like vibration monitoring and impact recognition.

Hardware watchdog

Strato Pi Max implements a dedicated hardware watchdog logic, controlled by the RP2040, that triggers a power cycle of the Compute Module when unresponsive.

The watchdog logic can also switch on/off the NVMe SSD or swap the SD cards after one or more consecutive timeouts, to automatically recover from disks failures.

The watchdog is disabled by default and can be configured to be always active, which is highly recommended on deployed systems.

When enabled, you should update the heartbeat faster than the configured timeout. After timeout expiration, a second configurable delay is started, after which a power cycle is initiated.

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Software configuration and usage

All features of Strato Pi Max can be used with any operating system, programming language or framework compatible with Raspberry Pi.

This chapter describes how to install and use the drivers for the Raspberry Pi OS (Debian).

For alternative setups refer to the “Advanced usage” chapter.

For updated information, further details and examples, please visit:

https://github.com/sfera-labs/strato-pi-max

Refer to the following paragraphs only if the above link is not accessible.

Strato Pi Max main driver

The Strato Pi Max driver kernel module can be used to easily access all of Strato Pi Max features via a sysfs file system.

Download and install:

```
$ sudo apt install git raspberrypi-kernel-headers
$ git clone --depth 1 https://github.com/sfera-labs/strato-pi-max-kernel-module.git
$ cd strato-pi-max-kernel-module
$ make clean
$ make
$ sudo make install
$ dtc -@ -Hepapr -I dts -O dtb -o stratopimax.dtbo stratopimax.dts
$ sudo cp stratopimax.dtbo /boot/overlays/
```

Add the following line to config.txt:

```
dtoverlay=stratopimax
```

Optionally, to be able to use the /sys/ files not as super user, create a new group "stratopimax" and set it as the module owner group by adding an udev rule:

```
$ sudo groupadd stratopimax
$ sudo cp 99-stratopimax.rules /etc/udev/rules.d/
```

and add your user to the group, e.g., for user "pi":

```
$ sudo usermod -a -G stratopimax pi
```

Reboot:

```
$ sudo reboot
```

You will find all the available devices under the `/sys/class/stratopimax/` directory and you will be able to control all the functionalities by simply reading/writing the corresponding files from your application or any tool or framework that supports basic file access.

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Real Time Clock driver

The RTC is based on the NXP PCF2131 RTC module and is connected to the Raspberry Pi via its I²C serial bus.

Download and install:

```
$ sudo apt install git raspberrypi-kernel-headers
$ git clone --depth 1 https://github.com/sfera-labs/rtc-pcf2131
$ cd rtc-pcf2131
$ make clean
$ make
$ sudo make install
$ dtc -@ -Hepapr -I dts -O dtb -o rtc-pcf2131.dtbo rtc-pcf2131.dts
$ sudo cp rtc-pcf2131.dtbo /boot/overlays/
```

Add the following line to config.txt:

```
dtoverlay=rtc-pcf2131
```

Reboot:

```
$ sudo reboot
```

Once the RTC driver is properly installed, you will simply use the date and time commands of your OS to control the hardware clock.

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Advanced usage

Compute Module

If you are using alternative operating systems or need not to use the provided drivers, you can access all the functionalities of Strato Pi Max via dedicated GPIO pins, the I²C bus and the SPI interface.

All the features can be accessed using any of the standard methods provided by the operating system, or any library for your programming language or framework of choice.

Make sure the GPIO pins are correctly configured as inputs or outputs, depending on the function and no pull-up/pull-down is enabled.

All features of Strato Pi Max controlled via I²C are accessible on bus 1 ("i2c-1" - GPIO2/SDA1 and GPIO3/SCL1) while SPI devices are connected to SPI0 ("spi0.x" - GPIO9-11).

Refer to the block diagram for more details.

I²C bus addresses

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

P/N	ID	ADDR	WRITE	READ
LM75ADP	VU1	0x48 [1001000]	0x90	0x91
PCF2131	VU2	0x53 [01010011]	0xA6	0xA7
ATECC608	BU30	0x60 [1100000]	0xC0	0xC1
RP2040 (Sfera Labs standard firmware)	BU14	0x35 [0110101]	0x6A	0x6B

The expansion boards may use additional addresses on the Compute Module I²C bus.

I²C Configuration and control registers

The RP2040 microcontroller is connected to the Raspberry Pi Compute Module I2C1 bus.

The standard firmware running on the RP2040 microcontroller implements an I²C slave device with address 0x35 whose registers can be used to control and configure all features described in the previous chapters.

The following paragraphs describe the available control and configuration registers.

If expansion boards are installed, additional registers will be available: registers 100-124 are reserved for the expansion board in slot 1, registers 125-149 for slot 2, registers 150-174 for slot 3, and registers 175-199 for slot 4.

Refer to the user guide of the specific expansion board for details about its registers.

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Configuration parameters (marked [C] or [D] below) are persisted and retained across power cycles. Those marked [D] hold the default value copied to their corresponding runtime control field (detailed in their description) upon power-up of the Raspberry Pi Compute Module.

A power-up of the Raspberry Pi Compute Module occurs when:

- the unit is powered on (main power supply connected);
- a power cycle is explicitly initiated with the dedicated I²C request; or
- a power cycle is initiated by another process configured to do so (e.g. watchdog timeout expiration).

A software reboot of the Compute Module does not correspond to a power-up.

The following attributes denote the access mode of each register/field:

[R]: readable

[W]: writable

[Z]: can be set to zero only, i.e. cleared

The data payload of write requests have the following structure:

VALUE LSB	...	VALUE MSB	OPTIONAL MASK LSB	...	OPTIONAL MASK MSB	CRC

The data payload of read responses have the following structure:

VALUE LSB	...	VALUE MSB	CRC

Registers containing values that span on multiple bytes store the least significant byte (LSB) in the first byte (byte 0) and the most significant one (MSB) in the last byte.

Write requests on registers containing multiple fields can include an optional mask value (same length of the register bytes) to specify which bits of the register shall be written.

The CRC byte value is calculated using a CRC-8 function with polynomial $x^8 + x^5 + x^3 + x^2 + x + 1$ (i.e. 0x2F) and initial value of 0xFF. The function is applied starting with the register's address number, followed by the value bytes and the optional mask bytes from least to most significant.

FIRMWARE VERSION

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	MAJOR								MINOR							

Register 1 [R]

Bit 7-0 **MINOR**: minor version of the installed firmware

Bit 15-8 **MAJOR**: major version of the installed firmware

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CONFIGURATION COMMANDS

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
5	KEY								CMD							
6					ERR	BUSY	FAIL	OK	CMD							

Register 5 [W]

Bit 15-8 **KEY**: set to 0x2A

Bit 7-0 **CMD**: command

2 = restore factory default configuration

Register 6 [R]

Result of command written to register 5

Bit 7-0 **CMD**: processed command

Bit 8 **OK**: set to 1 when command successfully terminated

Bit 9 **FAIL**: set to 1 when command failed

Bit 10 **BUSY**: set to 1 when command being executed

Bit 11 **ERR**: set to 1 when invalid values are written in command register

Bit 15-12 reserved

BUTTON

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
14	CNT															ST

Register 14 [R]

Bit 0 **ST**: button state

0 = not pressed

1 = pressed

Bit 7-1 reserved

Bit 15-8 **CNT**: button presses counter

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BUZZER

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
17	T ON															
18	T OFF															
19	REPS															
20	TONE															

Register 17 [R][W]

Bit 15-0 **T ON**: buzzer cycle ON time in milliseconds, applied when REPS is written

Register 18 [R][W]

Bit 15-0 **T OFF**: buzzer cycle OFF time in milliseconds, applied when REPS is written

Register 19 [R][W]

Bit 15-0 **REPS**: buzzer cycle repetitions, cycle starts when written. Set to zero to repeat indefinitely

Register 20 [R][W]

Bit 15-0 **TONE**: buzzer tone in Hz

RED USR LED

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
22	T ON															
23	T OFF															
24	REPS															
25	USR PRI											WDT EXP	WDT EN	PWR OFF	PWR DWN	PWR UP

Register 22 [R][W]

Bit 15-0 **T ON**: LED cycle ON time in milliseconds, applied when REPS is written

Register 23 [R][W]

Bit 15-0 **T OFF**: LED cycle OFF time in milliseconds, applied when REPS is written

Register 24 [R][W]

Bit 15-0 **REPS**: LED cycle repetitions, cycle starts when written. Set to zero to repeat indefinitely

Register 25 [R][W][C] (FW ver. ≥ 3.42)

Configuration register for system state blink patterns (see **USR LEDs**).

Bit 0 **PWR UP**: power up delay states

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0 = don't show

1 = show (default)

Bit 1 **PWR DWN**: power cycle down delay state

0 = don't show

1 = show (default)

Bit 2 **PWR OFF**: power cycle off state

0 = don't show

1 = show (default)

Bit 3 **WDT EN**: watchdog enabled state

0 = don't show (default)

1 = show

Bit 4 **WDT EXP**: watchdog expired state

0 = don't show

1 = show (default)

Bit 14-5 reserved

Bit 15 **USR PRI**: user commands priority

0 = blink sequences of enabled system states will override any user command

1 = after a user command (write to **REPS** register), system blink sequences won't be shown until this bit is reset to 0 (default)

GREEN USR LED

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
26	T ON															
27	T OFF															
28	REPS															
29	USR PRI											WDT EXP	WDT EN	PWR OFF	PWR DWN	PWR UP

Register 26 [R][W]

Bit 15-0 **T ON**: LED cycle ON time in milliseconds, applied when REPS is written

Register 27 [R][W]

Bit 15-0 **T OFF**: LED cycle OFF time in milliseconds, applied when REPS is written

Register 28 [R][W]

Bit 15-0 **REPS**: LED cycle repetitions, cycle starts when written. Set to zero to repeat indefinitely

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Register 29 [R][W][C] (FW ver. ≥ 3.42)

Configuration register for system state blink patterns (see **USR LEDs**).

Bit 0 **PWR UP**: power up delay states

0 = don't show (default)

1 = show

Bit 1 **PWR DWN**: power cycle down delay state

0 = don't show (default)

1 = show

Bit 2 **PWR OFF**: power cycle off state

0 = don't show (default)

1 = show

Bit 3 **WDT EN**: watchdog enabled state

0 = don't show (default)

1 = show

Bit 4 **WDT EXP**: watchdog expired state

0 = don't show (default)

1 = show

Bit 14-5 reserved

Bit 15 **USR PRI**: user commands priority

0 = blink sequences of enabled system states will override any user command

1 = after a user command (write to **REPS** register), system blink sequences won't be shown until this bit is reset to 0 (default)

EXPANSION BOARDS

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
31									EN4 CFG	EN4	EN3 CFG	EN3	EN2 CFG	EN2	EN1 CFG	EN1
32									TYPE1							
33									TYPE2							
34									TYPE3							
35									TYPE4							

Register 31 [R][W]

Bit 0, 2, 4, 6 **EN*n***: expansion board *n* control

0 = disabled (power off)

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1 = enabled (power on)

Bit 1, 3, 5, 7 **EN*n* CFG** [D]: power-up value for **EN*n***

Bit 15-4 reserved

Register 32, …, 35 [R]

Bit 8-0 **TYPE*n***: expansion board *n* type

2 = Uninterruptible Power Supply

3 = CAN and dual RS-485

4 = RS-232 and RS-485

5 = Industrial digital I/O

Bit 15-8 reserved

SD CARD SWITCH

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
39											SW CFG	SW	SEC CFG	SEC	MAIN CFG	MAIN

Register 39 [R][W]

Bit 0 **MAIN**: main SD interface control

0 = disabled

1 = enabled (default)

Bit 1 **MAIN CFG** [D]: power-up value for **MAIN**

Bit 2 **SEC**: secondary SD interface control

0 = disabled (default)

1 = enabled

Bit 3 **SEC CFG** [D]: power-up value for **SEC**

Bit 4 **SW**: SD switch control

0 = main SD interface routed to SDA and secondary to SDB (default)

1 = main SD interface routed to SDB and secondary SDA

Bit 5 **SW CFG** [D]: power-up value for **SW**

Bit 15-6 reserved

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PCIE

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
42															EN CFG	EN

Register 42 [R][W]

Bit 0 **EN**: PCIe control

0 = disabled

1 = enabled (default)

Bit 1 **EN CFG** [D]: power-up value for **EN**

0 = disabled

1 = enabled (default)

Bit 15-2 reserved

USB PORTS

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
42						ERR2	EN2 CFG	EN2						ERR1	EN1 CFG	EN1

Register 42

Bit 0, 8 **EN*n*** [R][W]: USB *n* control

0 = disabled

1 = enabled (default)

Bit 1, 9 **EN*n* CFG** [R][W][D]: power-up value for **EN*n***

Bit 2, 10 **ERR*n*** [R]: USB *n* fault

0 = OK

1 = fault

Bit 7-3 reserved

Bit 15-11 reserved

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WATCHDOG

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
48														EXP	EN CFG	EN
49	TIMEOUT															
50	TIMEOUT CFG															
51	DOWN DELAY															
52	SD SWITCH															
53	PCIE EN															

Register 48

A write request to this register updates the watchdog heartbeat.

Bit 0 **EN** [R][W]: watchdog enable control

0 = disabled (default)

1 = enabled

Bit 1 **EN CFG** [R][W][D]: power-up value for **EN**

Bit 2 **EXP** [R]: timeout state

0 = watchdog timeout not expired

1 = watchdog timeout expired

Bit 15-3 reserved

Register 49 [R][W]

Bit 15-0 **TIMEOUT**: heartbeat timeout, in seconds (default = 60)

Register 50 [R][W][D]

Bit 15-0 **TIMEOUT CFG**: power-up value for **TIMEOUT**

Register 51 [R][W][C]

Bit 15-0 **DOWN DELAY**: forced power cycle delay after timeout expiration, in seconds (default = 60)

Register 52 [R][W][C]

Bit 15-0 **SD SWITCH**: SDA/SDB routing switch configuration on watchdog reset

0 = disabled (default)

1 = switch SDA/SDB upon each watchdog reset

N >= 2 = switch SDA/SDB after *N* consecutive watchdog resets with no heartbeat received in between. Requires **EN CFG** set to 1

Register 53 [R][W][C]

Bit 15-0 **PCIE EN**: PCIe power control configuration on watchdog reset

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0 = disabled (default)

1 = toggle PCIe power state upon each watchdog reset

N >= 2 = toggle PCIe power state after *N* consecutive watchdog resets with no heartbeat received in between. Requires **EN CFG** set to 1

POWER CYCLE

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
56													PCIE	SD	BK	EN
57	DOWN DELAY															
58	OFF TIME															
59	UP DELAY															

Register 56 [R][W]

Bit 0 **EN**: power cycle control

0 = disabled

1 = power cycle initiated

Bit 1 **BK** [C]: configuration for enabling power-up when a power cycle occurs while main power is not available (requires UPS expansion board)

0 = power-up only when main power is restored (default)

1 = power-up even if running on UPS backup power source

Bit 2 **SD** [C]: SDA/SDB routing switch configuration on power cycle

0 = disabled (default)

1 = switch SDA/SDB upon each power cycle

Bit 3 **PCIE** [C]: PCIe power control configuration on power cycle

0 = disabled (default)

1 = toggle PCIe power state upon each power cycle

Bit 15-4 reserved

Register 57 [R][W][C]

Bit 15-0 **DOWN DELAY**: shutdown delay from enabling, in seconds (default = 60)

Register 58 [R][W][C]

Bit 15-0 **OFF TIME**: duration of power-off, in seconds (default = 5)

Register 59 [R][W][C]

Bit 15-0 **UP DELAY**: power-up delay after main power is enabled/restored, in seconds (default = 0)

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POWER MONITORING

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
63	VIN V															
64	VIN I															

Register 63 [R]

Bit 15-0 **VIN V**: voltage measured on power supply input, in mV

Register 64 [R]

Bit 15-0 **VIN I**: current drain measured on power supply input, in mA

ACCELEROMETER

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
68	X															
69	Y															
70	Z															

Register 68 [R]

Bit 15-0 **X**: x-axis acceleration raw value (resolution: 14-bit, full scale: ±2 g)

Register 69 [R]

Bit 15-0 **Y**: y-axis acceleration raw value (resolution: 14-bit, full scale: ±2 g)

Register 70 [R]

Bit 15-0 **Z**: z-axis acceleration raw value (resolution: 14-bit, full scale: ±2 g)

SYSTEM ERRORS

ADDR	BYTE 1								BYTE 0							
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
74				UPS	ACC	IO EXP	USB		SPI	I2C SLV	I2C MSTR		CFG	RP RST	RP	STUP
75										EXP4	EXP3	EXP2	EXP1	BU22	BU21	BU17

The registers' bits are set to 1 when the corresponding error occurs and reset to 0 only when cleared by the user.

Register 74 [R][Z]

Bit 0 **STUP**: system setup failure

Bit 1 **RP**: RP2040 failure

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Bit 2	**RP RST**: RP2040 reset occurred
Bit 3	**CFG**: configuration loading/saving error
Bit 4	reserved
Bit 5	**I2C MSTR**: RP2040 I2C master failure
Bit 6	**I2C SLV**: RP2040 I2C slave failure
Bit 7	**SPI**: RP2040 SPI failure
Bit 8	reserved
Bit 9	**USB**: USB ports fault
Bit 10	**IO EXP**: I/O expanders fault (see register 75)
Bit 11	**ACC**: accelerometer fault
Bit 12	**UPS**: UPS fault
Bit 15-13	reserved

Register 75 [R][Z]

Bit 0	**BU17**: I/O expander BU17 fault
Bit 1	**BU21**: I/O expander BU21 fault
Bit 2	**BU22**: I/O expander BU22 fault
Bit 3	**EXP1**: I/O expander on expansion board in slot 1 fault
Bit 4	**EXP2**: I/O expander on expansion board in slot 2 fault
Bit 5	**EXP3**: I/O expander on expansion board in slot 3 fault
Bit 6	**EXP4**: I/O expander on expansion board in slot 4 fault
Bit 15-7	reserved

RP2040

The standard firmware running on the RP2040 microcontroller implements all the functional logic described in the previous chapters.

You can download the latest version of the standard firmware here:

https://www.sferalabs.cc/files/stratopimax/fw/latest/strato_pi_max.uf2

The microcontroller can be programmed with user-developed custom firmware, that can replace the factory installed version.

WARNING

The RP2040 microcontroller firmware implements critical logic and checks to ensure safe and reliable operations of Strato Pi Max including, but not limited to, watchdog, microSD switch matrix control, mass storage boot sequence control, power distribution voltages, currents and internal temperature monitoring.

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In order to develop a safe and reliable custom firmware, you should be fully aware of the internal hardware architecture of Strato Pi Max, and of all safety and control requirements needed for your application and installation constraints.

Firmware upload and programming

To load a .uf2 firmware file to the RP2040 simply reset it in boot mode using the RP_RUN_C and RP_BOOTSEL_C lines connected to GPIO20 and GPIO21 of the CM respectively. The RP2040 will appear as a USB storage device (`/dev/sdXX`) which can be mounted as a standard disk. After copying the .uf2 file to the disk the RP2040 will reset and run the newly loaded firmware.

A utility for controlling the RP2040 and uploading firmware from the Compute Module is available here:

https://github.com/sfera-labs/strato-pi-max

Refer to the Raspberry Pi RP2040 documentation[4] for usage and programming details.

I²C bus addresses

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

P/N	ID	ADDR	WRITE	READ
47L16	BU31	0x50 [1010000] - SRAM	0xA0	0xA1
		0x18 [0011000] - Control Register	0x30	0x31
IIS2DLPC	BU36	0x19 [0011001]	0x32	0x33
MCP23009	BU17	0x20 [100000]	0x40	0x41
MCP23009	BU21	0x21 [100001]	0x42	0x43
MCP23009	BU22	0x22 [100010]	0x44	0x45
I/O EXP slot 1		0x24 [100100]	0x48	0x49
I/O EXP slot 2		0x25 [100101]	0x4A	0x4B
I/O EXP slot 3		0x26 [100110]	0x4C	0x4D
I/O EXP slot 4		0x27 [100111]	0x4E	0x4F

[4] https://www.raspberrypi.com/documentation/microcontrollers/silicon.html#rp2040

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The expansion boards may use additional addresses on the RP2040 I²C bus.

X2-Series Standard

X2 is an electrical and mechanical open standard developed by Sfera Labs for the design of expansion boards for the Strato Pi Max family of edge servers, as well as for future products.

The goal of the X2 standard is to define a compact mechanical format for expansion boards that fit into a standard size DIN-rail enclosure, allowing a significant number of lines on pluggable terminal blocks.

The electrical and functional specifications of the X2 standard also aims at making the hardware and software design relatively simple and very flexible.

The connection lines and standard buses implemented in the X2 backplane connector are simple to implement and are arranged to integrate well into host systems with a hybrid CPU/MCU architecture, like the Strato Pi Max family.

The Strato Pi Max also serves as a reference hardware and software implementation of a host system with full support of the X2 expansion boards.

For more details, refer to the “X2-Series Standard Electrical and Mechanical Specifications” document.

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Thermal considerations for Strato Pi Max

The Raspberry Pi Compute Module draws power and generates heat proportionally to CPU and GPU load.

The Strato Pi Max main regulator, M.2 SSD and expansion boards also generate a substantial heat proportionally to the total amount of current that has to be supplied to the CM and peripherals.

The thermal behaviour of Strato Pi Max is dynamic and affected by operating conditions and the external environment temperature.

The Compute Module's CPU has the ability to throttle down its clock speed once a certain core temperature is reached. This prevents CPU overheating, also limiting the temperature inside the enclosure, when the CPU load is high for a significant amount of time.

An internal fan, close to the Compute Module and voltage regulators area of the main circuit board, plays an important role keeping the temperature inside the enclosure to reasonable levels, even under heavy load conditions. The fan starts only when temperature exceeds preset levels.

In general terms, the fan will significantly increase the airflow inside the enclosure, and improve heat transfer away from the CPU and the other nearby components.

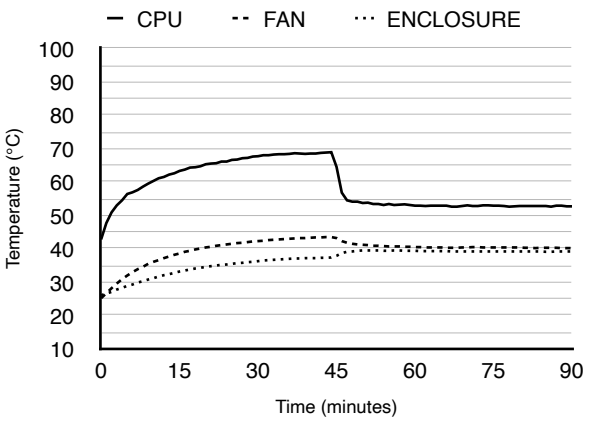
The CPU runs cooler when the fan is running, and it will take longer and higher loads to reach its throttling limits.

Under ideal conditions, the fan may reduce both the CPU temperature and the average air temperature inside the enclosure by up to 15 °C.

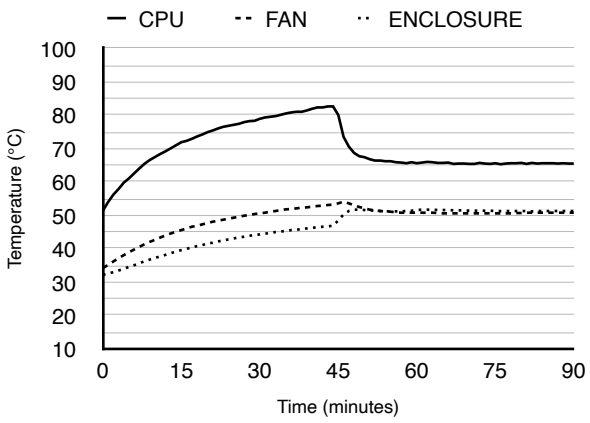
The following charts show the thermal behaviour of Strato Pi Max in different conditions, in a typical installation with the device under test installed in a standard, not ventilated DIN cabinet:

- 25 °C and 45 °C ambient temperature (the ambient temperature is measured inside the DIN cabinet, so it is the actual air temperature surrounding the Strato Pi Max enclosure)
- Raspberry Pi Compute Module 4 without heat sink, and Raspberry Pi Compute Module 5 with heat sink
- Different CPU load conditions:
  - **Low CPU**: only OS and lightweight tasks running
  - **CPU @ 200%**: two cores at constant full load (very high resource usage scenario)
  - **CPU @ 400%**: all four cores at constant full load (extreme scenario)
- 90 minutes cycles, starting from off at ambient temperature, 45 minutes fan off, then 45 minutes fan on.

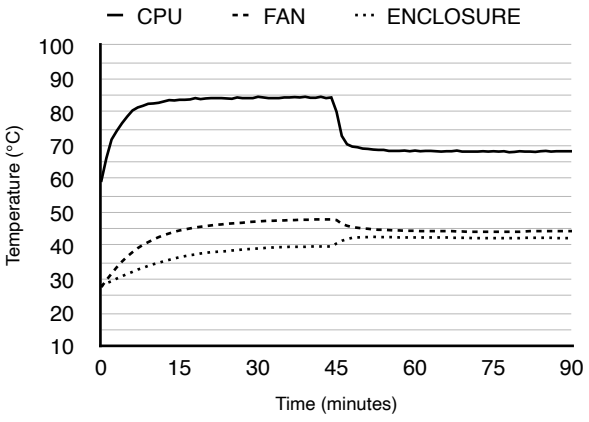
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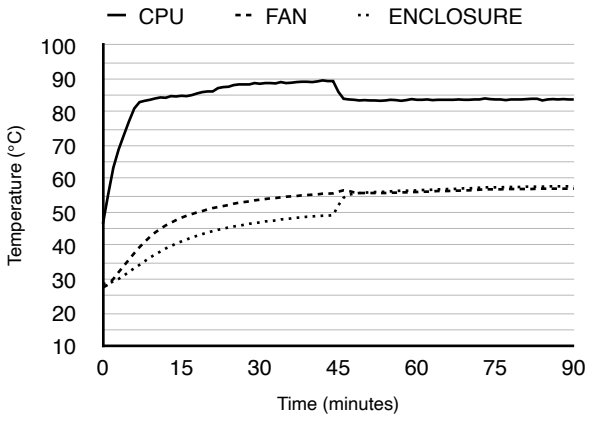
CM 4, 25 °C AMB. TEMP, LOW CPU



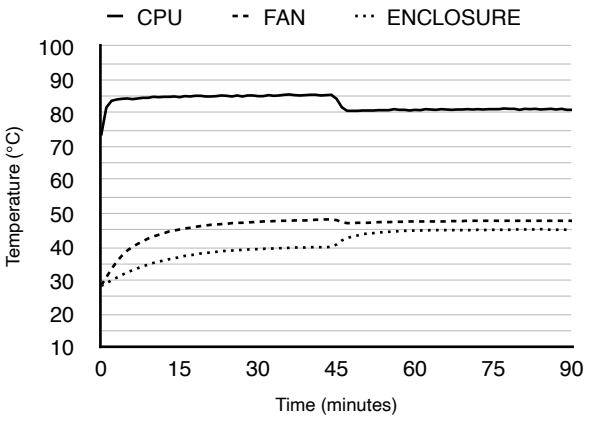
CM 5, 25 °C AMB. TEMP, LOW CPU



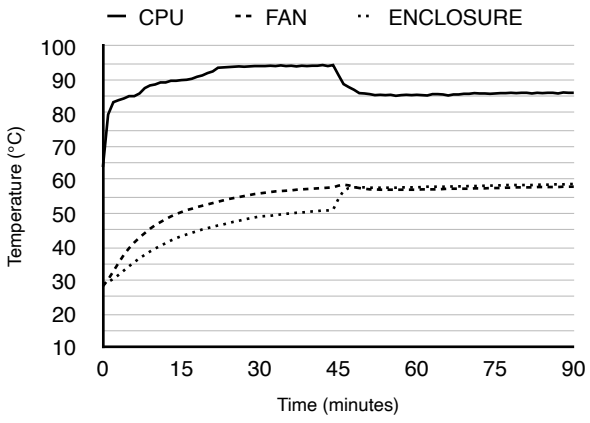
CM 4, 25 °C AMB. TEMP, CPU @ 200%



CM 5, 25 °C AMB. TEMP, CPU @ 200%

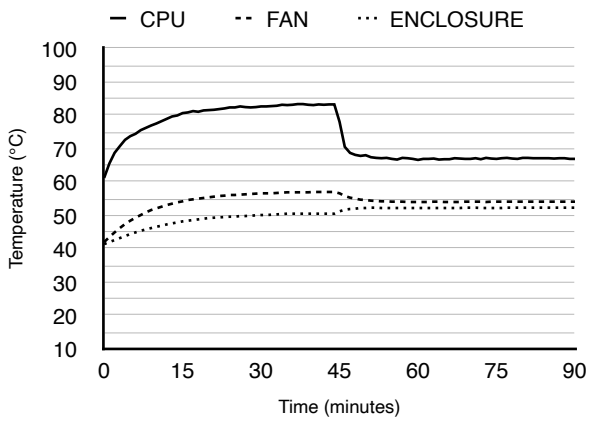


CM 4, 25 °C AMB. TEMP, CPU @ 400%

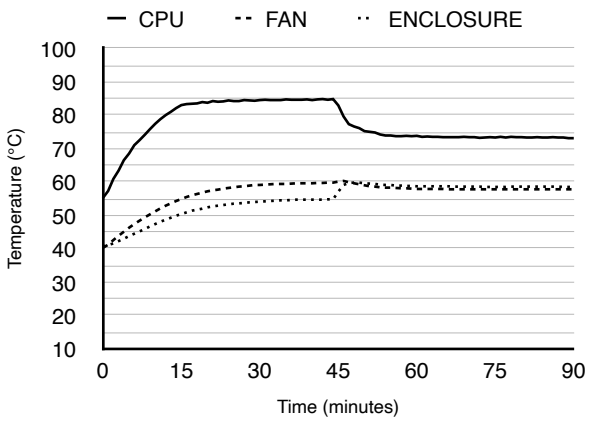


CM 5, 25 °C AMB. TEMP, CPU @ 400%

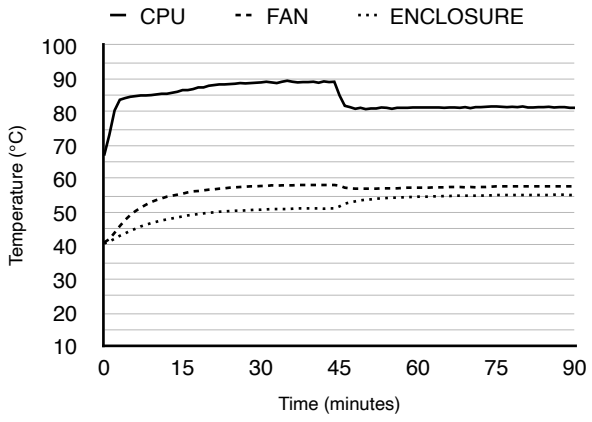
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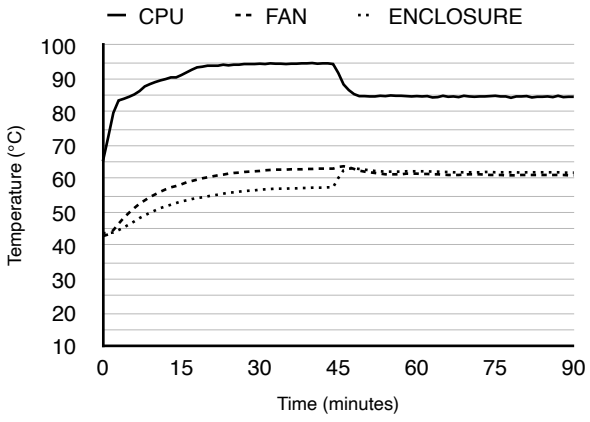
CM 4, 45 °C AMB. TEMP, LOW CPU



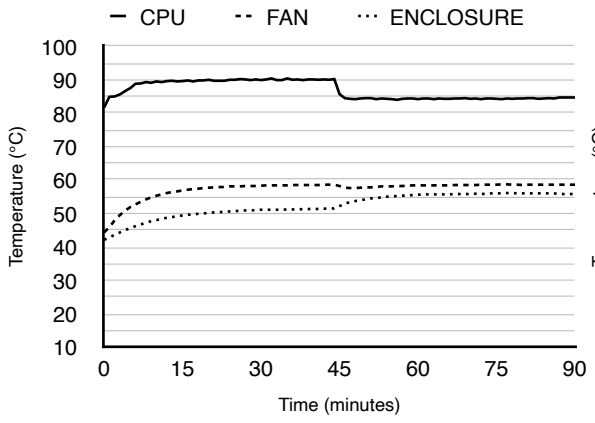
CM 5, 45 °C AMB. TEMP, LOW CPU



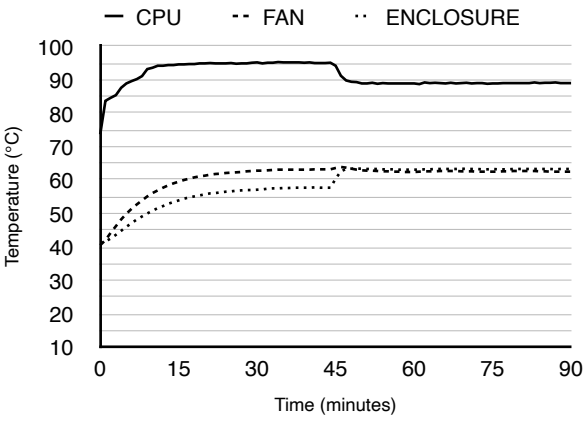
CM 4, 45 °C AMB. TEMP, CPU @ 200%



CM 5, 45 °C AMB. TEMP, CPU @ 200%



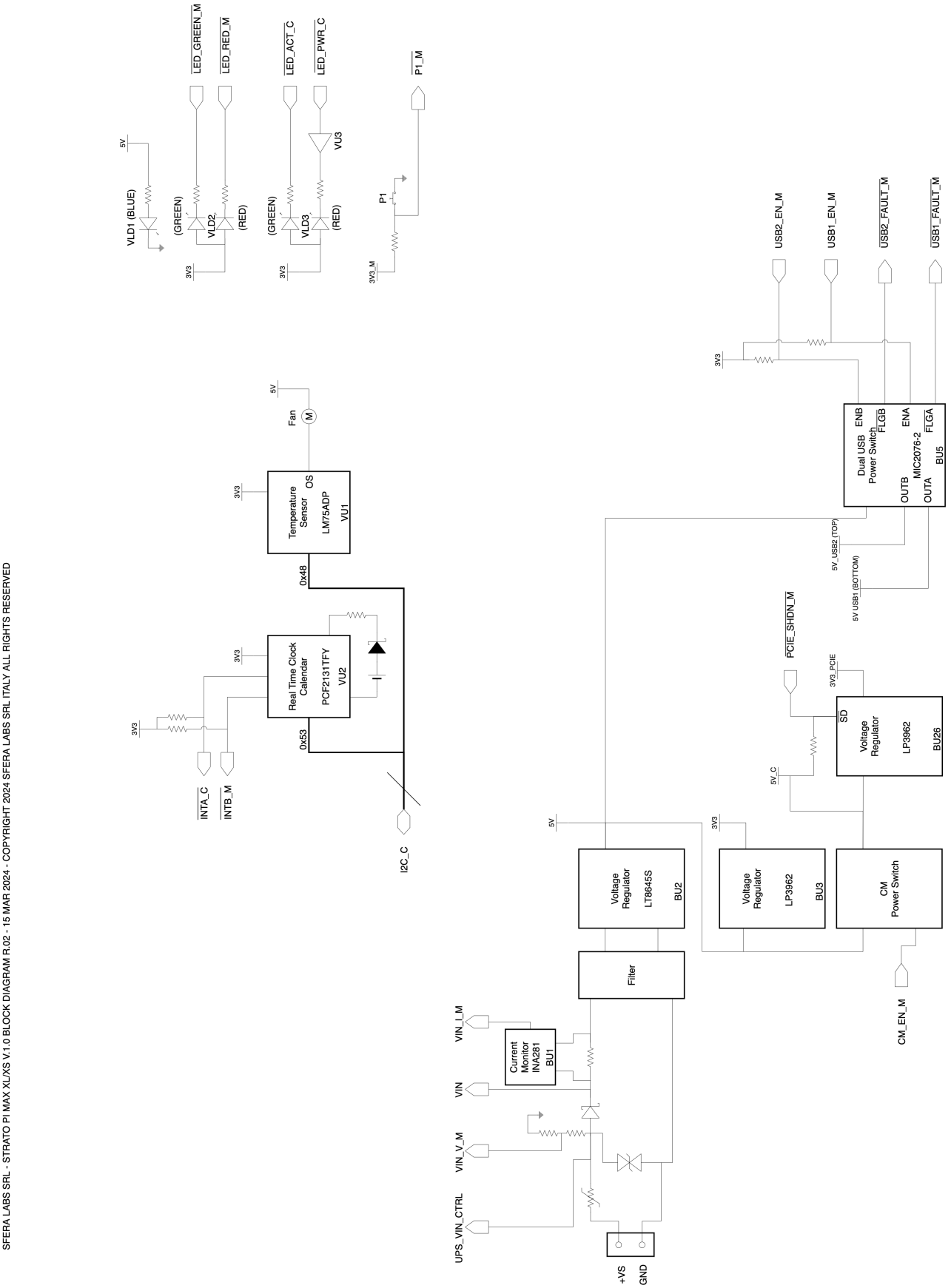
CM 4, 45 °C AMB. TEMP, CPU @ 400%



CM 5, 45 °C AMB. TEMP, CPU @ 400%

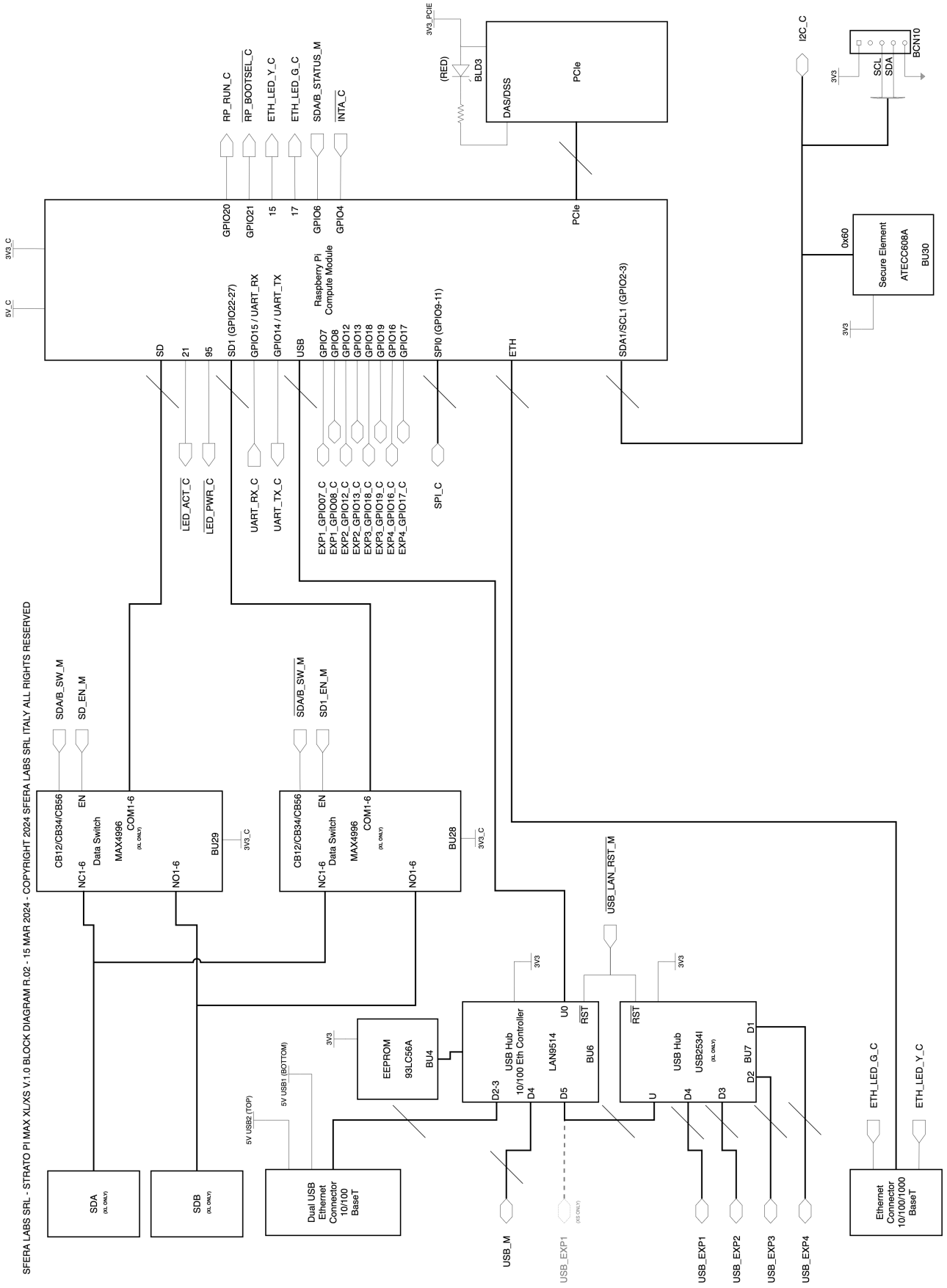
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Block diagram

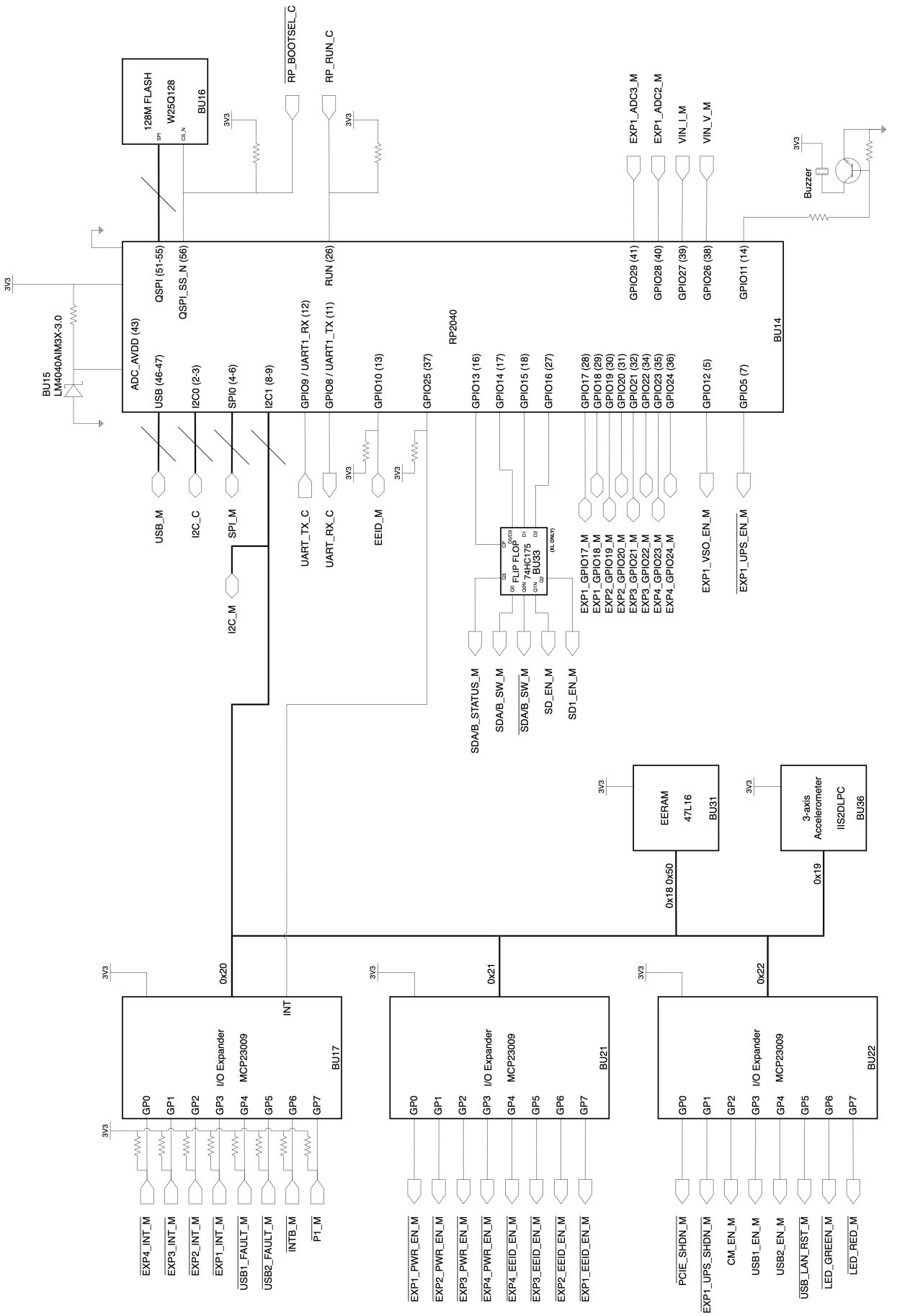


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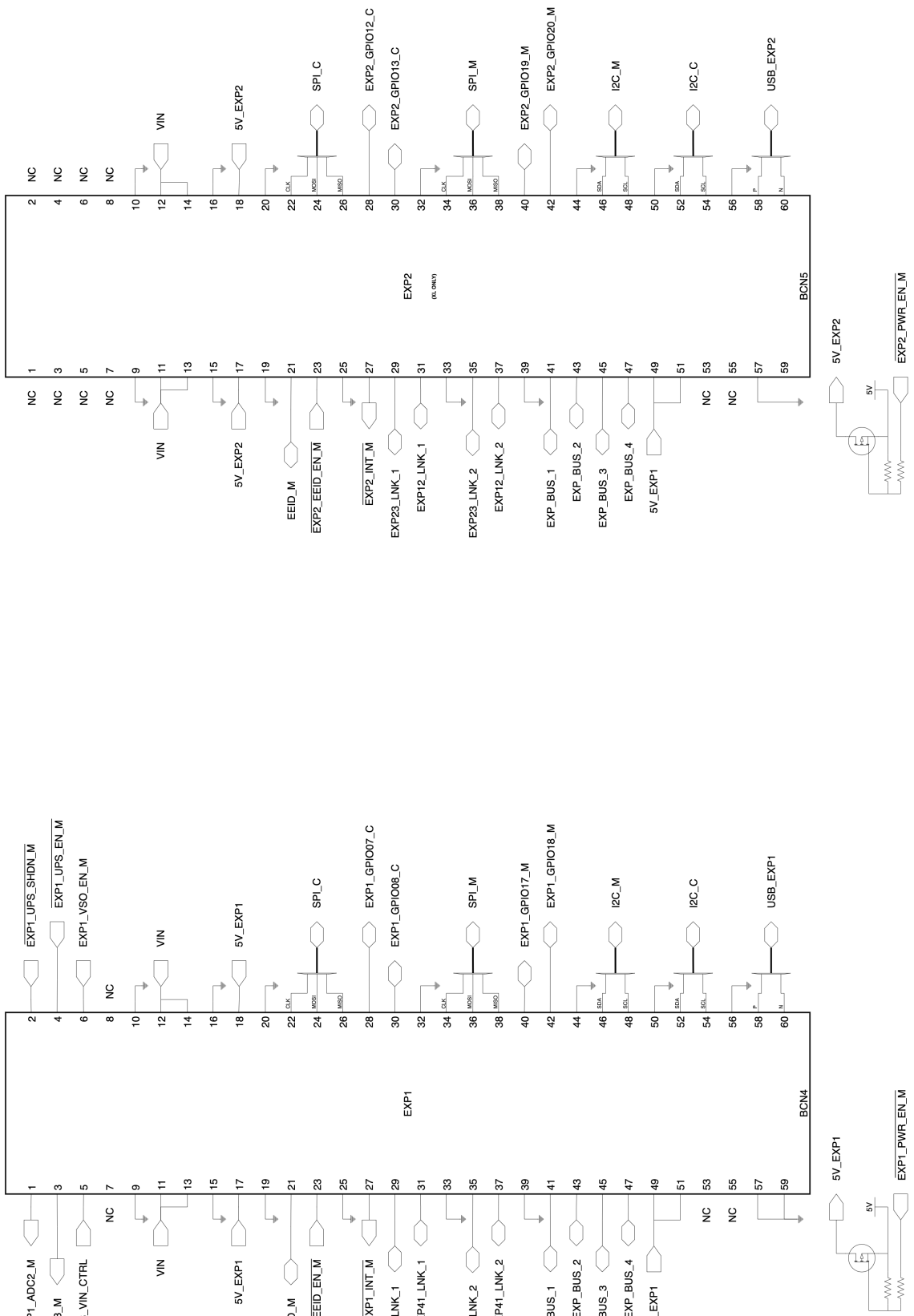


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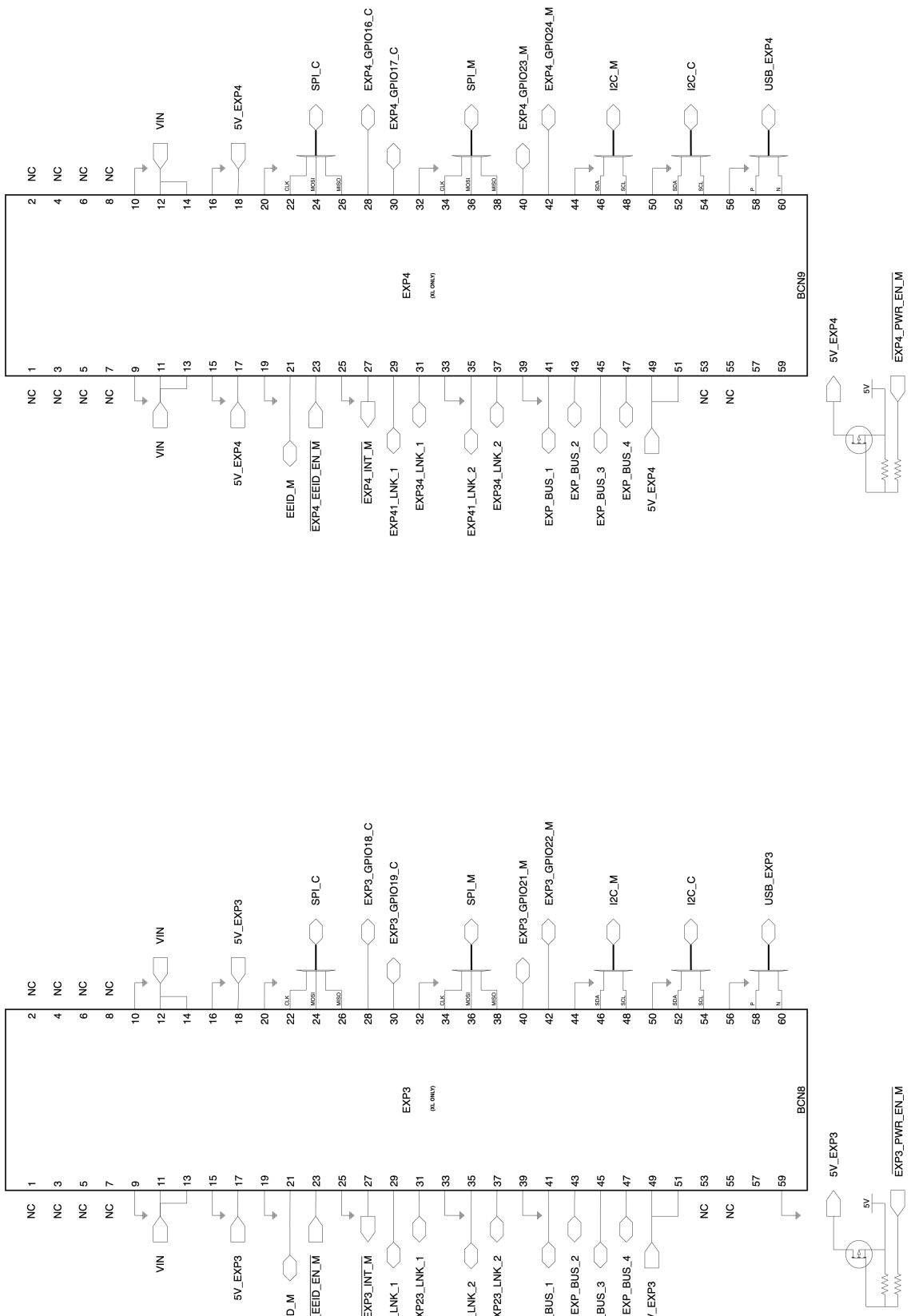
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Technical specifications

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

POWER SUPPLY	
Power supply operating voltage (VS)	⎓dc 24 V nominal (range 10-50 V), max 3.0 A. An absolute maximum input voltage of 60 V is tolerated, with reduced surge protection Reverse polarity and surge protection with 3.3 A resettable fuse
Current consumption at VS+ 12 V⎓ including Raspberry Pi CM 4, with GB Ethernet connected, M.2 NVMe SSD, no USB devices, no UPS expansion board	low CPU load: 0.37 A, 100% CPU load, before throttling: 0.51 A
Current consumption at VS+ 24 V⎓ including Raspberry Pi CM 4, with GB Ethernet connected, M.2 NVMe SSD, no USB devices, no UPS expansion board	low CPU load: 0.19 A, 100% CPU load, before throttling: 0.28 A
Current consumption at VS+ 24 V⎓ including Raspberry Pi CM 4, with GB Ethernet connected, M.2 NVMe SSD, no USB devices, UPS expansion board, VSO on 8 W, UPS enabled, battery charging	low CPU load: 0.9 A
USB1 port output current	500 mA (Max)
USB2 port output current	500 mA (Max)
RASPBERRY PI COMPATIBILITY	
Raspberry platform compatibility	Raspberry Pi Compute Module 4 Raspberry Pi Compute Module 5 Zymbit SCM4
EXPANSION SLOTS	
Sfera Labs X2	1 slot, Strato Pi Max XS 4 slots, Strato Pi Max XL
PCIe	M.2 form factor 2242
REAL TIME CLOCK	
Oscillator frequency	32768 kHz
Frequency Tolerance	±3 ppm
Backup battery	Only use CR1220 or BR1220 Lithium / Manganese Dioxide (Li/MnO2) batteries. Expected battery life without main power supply: 3 or more years, depending on environmental conditions
EERAM	

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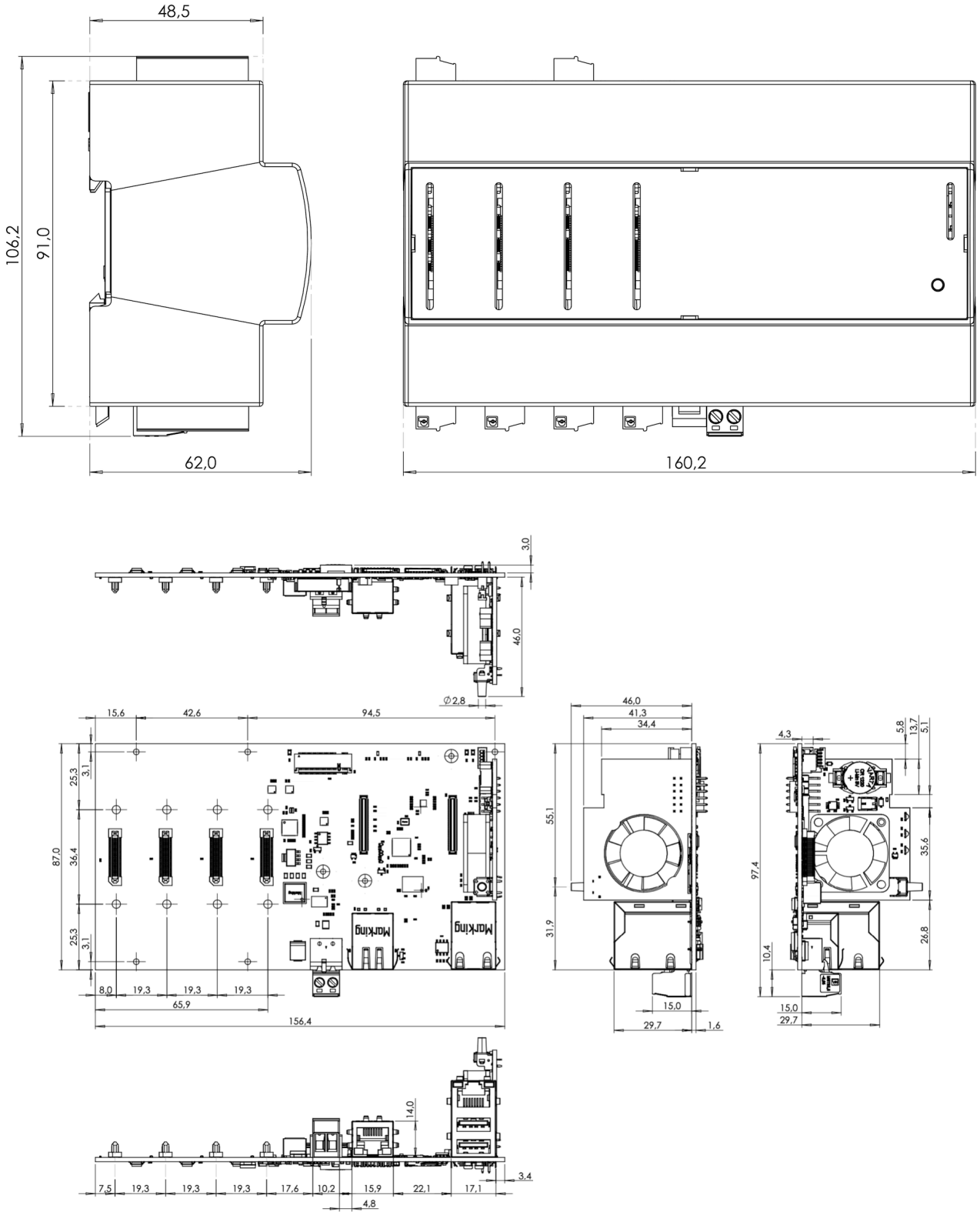
Capacity	16 Kbit (2048 x 8 bits)
SRAM r/w cycles	Infinite
EEPROM store cycles	> 1000000
Data retention	> 200 years
ACCELEROMETER	
Range	±2g/±4g/±8g/±16g full scale
Data rates	from 1.6 Hz to 1600 Hz
Bandwidth	up to 800 Hz
INTERNAL TEMPERATURE SENSORS	
Temperature accuracy	±2 °C
Resolution	11 bits (0.125 °C)
INTERNAL POWER SUPPLY VOLTAGE SENSOR	
Voltage range	0…58 V
Total Unadjusted Error (TUE)	±2.5 % of full-scale
Resolution	12 bits (8.7 RP2040 ENOB)
INTERNAL POWER SUPPLY CURRENT SENSOR	
Current range	0…4 A
Total Unadjusted Error (TUE)	±2.5 % of full-scale
Resolution	12 bits (8.7 RP2040 ENOB)
EMI IMMUNITY STANDARDS	
Electromagnetic immunity compliance	EN 61000-4-2: 2009 (ESD) EN 61000-4-3: 2020 (Radiated RF Field) EN 61000-4-4: 2012 (Burst/fast transient) EN 61000-4-5: 2014 / A1: 2017 (Surge) EN 61000-4-6: 2014 / AC: 2015 (Conducted) EN 61000-4-8: 2010 (Power freq. 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	

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5.08 mm pitch terminal block characteristics (power supply)	Maximum conductor cross section: 3.3 mm2 (12AWG) Recommended stripping length: 7 mm Screw thread: M3 Maximum screws tightening torque: 0.5 Nm
Dimensions, Strato Pi Max XL	9 module Din Rail enclosure width: 160.2 mm height: 91.0 mm depth: 62.0 mm
Dimensions, Strato Pi Max XS	6 module Din Rail enclosure width: 106.3 mm height: 90.5 mm depth: 62.0 mm
Weight, Strato Pi Max XL	260 g (including Raspberry Pi Compute Module, M.2 NVMe SSD; not including expansion boards, Compute Module Antenna Kit)
Weight, Strato Pi Max XS	190 g (including Raspberry Pi Compute Module, M.2 NVMe SSD; not including expansion board, Compute Module Antenna Kit)

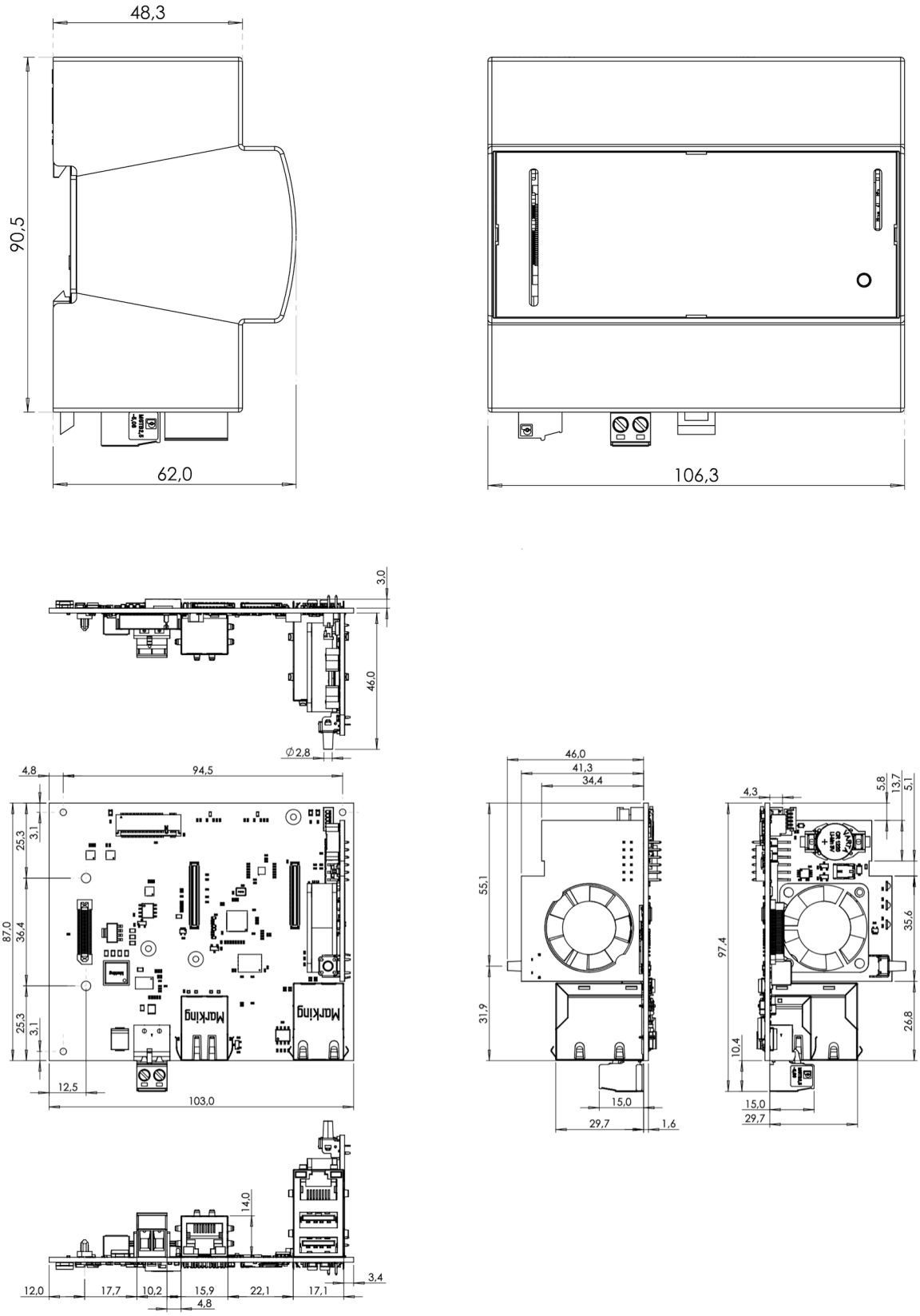
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Dimensions



STRATO PI MAX XL DIMENSIONS (mm)

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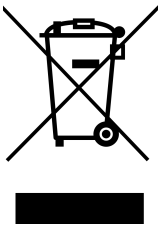


STRATO PI MAX XS DIMENSIONS (mm)

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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;

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- 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
- EN61000-6-3:2021 - 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.

Compliance information for Raspberry Pi CM

Strato Pi Max contain a standard Raspberry Pi Compute Module 4 or 5 single board computer. These boards have a WiFi and Bluetooth radio module. They are user accessible and replaceable.

EU

The Raspberry Pi Compute Module 4 and the The Raspberry Pi Compute Module 5 are in conformity with the essential requirements and other relevant requirements of the Radio Equipment Directive 2014/53/EU.

USA

Raspberry Pi Compute Module 4 FCC IDENTIFIER: **2ABCB-RPICM4**

Raspberry Pi Compute Module 5 FCC IDENTIFIER: **2ABCB-RPICM5**

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be colocated or operating in conjunction with any other antenna or transmitter, except in accordance with FCC multitransmitter product guidelines. This (WiFi DTS) device has 20 MHz bandwidth mode.

CANADA

Raspberry Pi Compute Module 4 IC CERTIFICATION No.: **20953-RPICM4**

Raspberry Pi Compute Module 5 IC CERTIFICATION No.: **20953-RPICM4**

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1)

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l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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