Exo Sense Pi User Guide

May 2021

Revision 002

ESCB10X *Exo Sense Pi*
ESCB10E *Exo Sense Pi with earthquake sensor*
ESCB10X4101008 *Exo Sense Pi with CM4 Wireless, 1GB RAM, 8GB eMMC*
ESCB10X4102016 *Exo Sense Pi with CM4 Wireless, 2GB RAM, 16GB eMMC*
ESCB10X4102000 *Exo Sense Pi with CM4 Wireless, 2GB RAM, Lite*

SFERALABS

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Safety information 4
Qualified personnel 4
Hazard levels 4
Safety instructions 5
General safety instructions 5
Battery 5
Device identification 6
Introduction 7
Features 8
Hardware setup 9
Opening the case 9
Closing the case 10
Raspberry Pi Compute Module 4 board installation 10
Replacing the RTC backup battery 11
Connections 12
Power supply 13
Software installation and configuration 14
Raspberry Pi OS Kernel module 14
Calibration 15
Raspberry Pi OS Real Time Clock installation 15
Features details 17
Temperature, humidity and air quality sensors 17
Light sensor 18
Microphone 18
PIR motion sensor 19
TTLx/DIx: TTL input/output or generic digital inputs 19
DO1: Open collector output 21
Buzzer 21
LEDs 21
RS-485 serial port 21
Real Time Clock 22
ATECC608A secure element 23
Earthquake sensor module (optional) 23
Dedicated GPIO pins 24
I²C bus addresses 24
Block diagram 25

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Board layout 26
Technical specifications 27
Dimensions 29
Disposal 30
Installation and use restrictions 30
Standards and regulations 30
Safety instructions 30
Set-up 30
Conformity Information 31
EU 31
USA 31
CANADA 32
RCM AUSTRALIA / NEW ZEALAND 32
Compliance information for Raspberry Pi CM4 32
EU 32
USA 32
CANADA 32

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Be sure to always remove the power supply before installing or removing the CM4 board inside Exo Sense Pi.

Exo Sense Pi must be operated with the plastic case installed.

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

Carefully and fully read this Exo Sense Pi user guide before installation.

Exo Sense Pi 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. Exo Sense Pi is neither designed nor intended for use in military or aerospace applications or environments and for automotive applications or environment. Customer acknowledges and agrees that any such use of Exo Sense Pi is solely at Customer's risk, and that Customer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

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

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

http://www.sferalabs.cc

Exo and Sfera Labs are trademarks of Sfera Labs S.r.l. Other brands and names may be claimed as the property of others.

Copyright © 2021 Sfera Labs S.r.l. All rights reserved.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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. 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.

Ensure that the product is properly installed and ventilated to prevent overheat.

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.

Battery

This product uses a small lithium non-rechargeable battery to power its internal real time clock (RTC).

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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.

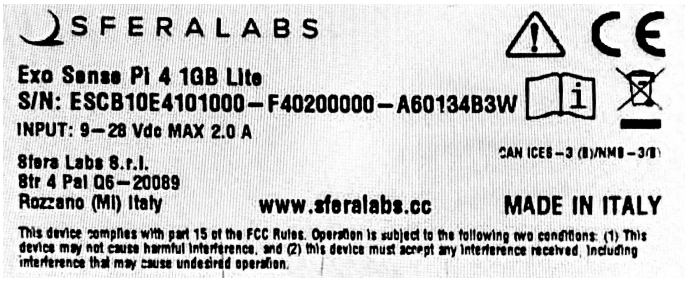
Replace the RTC lithium battery before it is completely discharged. Replace the battery every 5 years even if the battery is still working properly. The lithium battery must be replaced only with an identical **CR1025** Lithium / Manganese Dioxide (Li/MnO2) battery.

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 100°C and protect from direct sunlight, moisture and condensation.

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

Device identification

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



EXAMPLE RATING AND IDENTIFICATION PLATE

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Introduction

Exo Sense Pi is an extremely versatile indoor environment sensor. It combines the computing power and wireless capabilities of the Raspberry Pi Compute Module 4 with several environmental sensors and input/output lines.

Exo Sense Pi embeds temperature, humidity, air quality, light and PIR-based motion detection sensors, as well as a microphone for ambient noise measurements and audio recording. Two digital input/output lines and an open-collector output line are available on the terminal block. A real time clock module with battery back-up is also standard. It can optionally have a factory-installed earthquake sensor module.

An ESD-protected RS-485 bus is available for wired serial communication using the industry standard Modbus protocol or any other half-duplex serial protocol.

You can use your preferred Compute Module board. Both the Lite versions (without eMMC) and all versions with embedded eMMC are supported.



Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Features

The Exo Sense Pi key features are:

- ✓ 10÷28Vdc power supply, with surge and reverse polarity protection, and 1.1A resettable fuse
- ✓ compatible with all versions of Raspberry Pi Compute Module 4
- ✓ Sensirion SHT40 temperature and humidity sensor
- ✓ Sensirion SGP40 air quality (Volatile Organic Compounds) sensor
- ✓ Texas Instruments OPT3001 digital ambient light sensor (ALS) with high-precision human-eye response
- ✓ Panasonic EKMC PIR motion sensor
- ✓ TDK ICS-43432 digital I²S microphone for audio recording and environment noise detection
- ✓ two digital inputs for potential-free contacts or TTL level input/output with 1-Wire, I²C and Wiegand support
- ✓ one open collector output with a maximum output current of 100mA, protected against over-current and short circuits
- ✓ standard RS-485 interface to the Compute Module UART serial lines, with electrostatic discharge (ESD) protection
- ✓ real time clock with replaceable CR1025 Lithium / Manganese Dioxide back-up battery
- ✓ Microchip ATECC608 secure element chip
- ✓ GPIO/PWM-controlled piezoelectric buzzer, for acoustic feedback
- ✓ GPIO-controlled LED
- ✓ hidden micro USB port with Micro-AB receptacle (to flash the Raspberry Pi Compute Module eMMC), can be accessed opening the case
- ✓ hidden microSD slot to install the external flash memory of the Raspberry Pi Compute Module 4 Lite, can be accessed opening the case
- ✓ Optional external 10/100 Mbps Ethernet interface with PoE support (IEEE 802.3at Type 1)
- ✓ Optional earthquake sensor module
- ✓ 80x80 mm wall mount ABS case with fast snap-in terminal block for easier installation.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Hardware setup

For the initial setup, the plastic wall mount case must be removed to access the circuit board and internal connectors.

The case also needs to be opened to connect insert the μSD card or plug the microUSB connector, and if the factory configuration of the internal jumpers for the RS-485 termination resistors or digital input configuration must be changed.

NOTICE

Before opening the Exo Sense Pi case, disconnect all power sources and any connection to external devices.

Opening the case

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

1. Use a small flat screwdriver to gently separate the front plastic cover from the wall mount back
2. The circuit board should remain attached to the front plastic cover; pay attention not to drop the circuit board, as it could be not firmly attached
3. With a small flat screwdriver gently separate the circuit board from the front cover. In some cases the circuit board could separate from the front case and remain connected to the terminal block.

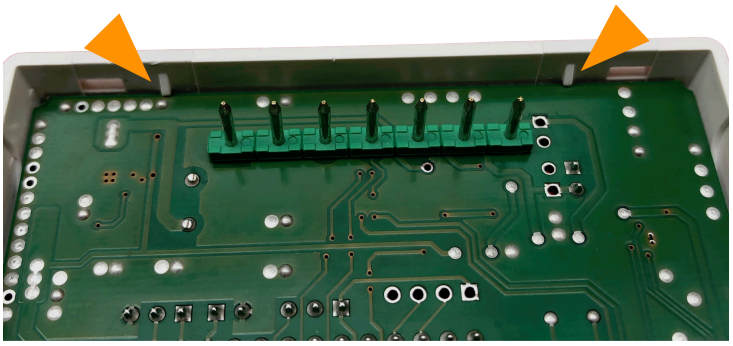


SEPARATE THE FRONT PLASTIC COVER FROM THE WALL MOUNT BACK

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Closing the case

4. Replace the circuit board assembly inside the front cover; respect the orientation, with the light sensor aligned to the optical guide
5. Align the front cover and circuit board with the wall mount back, so that the connection pins on the circuit board match the terminal block receptacles on the wall mount back
6. Gently snap in the front plastic cover to the wall mount back.



THE PCB HOLDERS OF THE FRONT COVER



ALIGN THE CONNECTION PINS WITH THE TERMINAL BLOCK

Raspberry Pi Compute Module 4 board installation

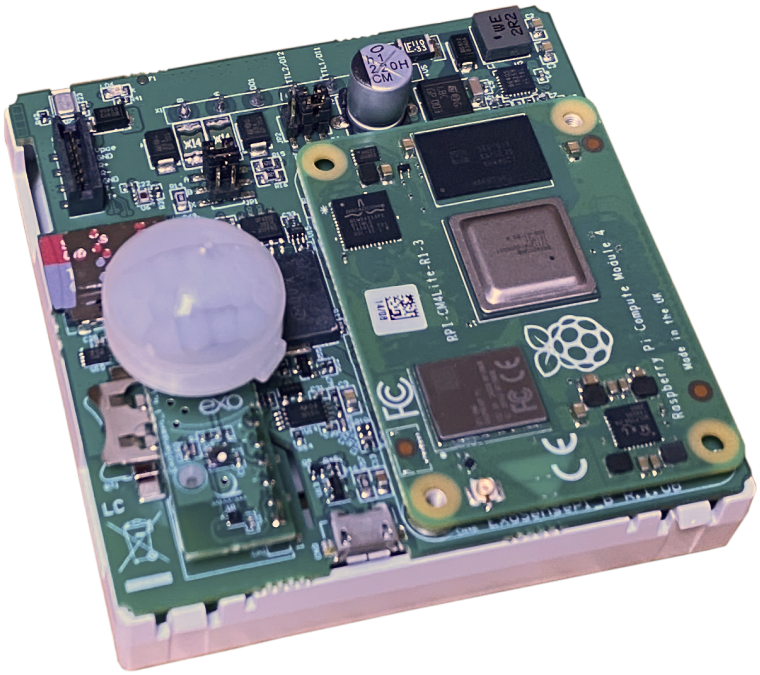
To install your own Raspberry Pi Compute Module 4 board in Exo Sense Pi, or replace a pre-installed board, only a screwdriver is required.

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

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

NOTICE

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



COMPUTE MODULE 4 BOARD INSTALLATION

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 Exo Sense Pi 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.

Replacing the RTC backup battery

The Exo Sense Pi RTC uses a **CR1025** Lithium / Manganese Dioxide (Li/MnO2) battery.

WARNING

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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.

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 **CR1025** Lithium / Manganese Dioxide (Li/MnO2) battery.

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 100°C and protect from direct sunlight, moisture and condensation.

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

The battery is not accessible from the outside. You should first remove the case top cover to gain access to the Exo Sense Pi circuit boards.

NOTICE

Before opening the Exo Sense Pi case, disconnect all power sources and any connection to external devices.

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 positive (+) terminal of the battery is in contact with the outer body of the battery holder, and the negative (-) terminal is in contact with the contact pad of the circuit board, as shown in the photo below.

Reversing the battery polarity may damage the product.

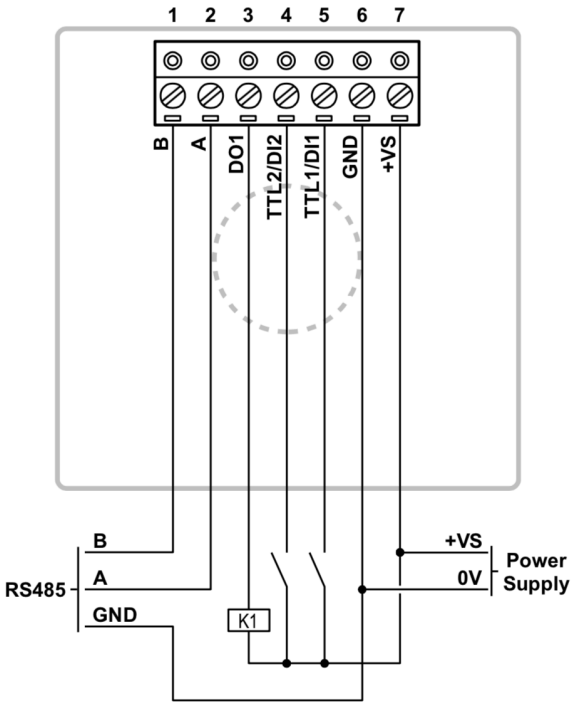
The real time clock will reset its time immediately when the RTC backup battery is disconnected.

Connections

Exo Sense Pi has a 7 position terminal block attached to the back of the wall mount case. This terminal block is connected to a 7 pin header soldered to the circuit board.

The maximum conductor cross section is 2.5 mm^2 (14 AWG). Recommended stripping length is 7 mm. Screw thread is M3. Never exceed 0.6 Nm torque when tightening the screws.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000



CONNECTION EXAMPLE

WARNING

Ensure that all cables entering the Exo Sense Pi case are isolated to avoid electrical contact with the back of the printed circuit board or other conductive elements.

The cables should be routed out of the case through the circular hole at the center of the case back frame.

Ensure the cables cannot be punctured when the case is closed and that they don't exercise mechanical pressure on the printed circuit board.

Power supply

Exo Sense Pi can be powered with DC voltage only:

✓ DC: nominal voltage in the range 10V to 28V (min=9V, max=30V)

Respect the correct polarity shown in the schematic diagram (+ -). The power supply circuit implements reverse polarity protection using an auto resetting fuse and surge protection up to ±1000V/2ohms 1.2/50µs.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Software installation and configuration

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

The following sections describe how to install utility drivers for the Raspberry Pi OS (formerly Raspbian).

If you are using other operating systems or need not to use the provided utilities, you can access all the functionalities of Exo Sense Pi via dedicated GPIO pins and the I²C bus.

All the features directly controlled via GPIO, such as digital I/O, can be accessed using any of the standard methods provided by the operating system or any available 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 sensors and other I²C devices are available on the primary I²C bus and directly accessible through standard methods.

Refer to the next chapter for details about each feature.

Raspberry Pi OS Kernel module

The Exo Sense Pi Kernel module can be used to easily access all of Exo Sense Pi features via a sysfs file system.

Refer to the instructions below to download and install the module or go to the following link for updated instructions and further details:

https://github.com/sfera-labs/exo-sense-pi-kernel-module

Download and install:

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

Add the following line to /boot/config.txt:

```
dtoverlay=exosensepi
```

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

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

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

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

Reboot:

```
$ sudo reboot
```


Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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

Calibration

Exo Sense Pi produces internal heat that influences its sensors readings. To compensate, the kernel module applies a transformation to the values reported by the temperature sensor based on calibration parameters computed by the procedure described below. The compensated temperature values are, in turn, used to adjust humidity and VOC values.

Install the calibration script and service:

```
$ sudo cp exosensepi-calibrate.service /lib/systemd/system/
$ sudo cp exosensepi-calibrate.py /usr/local/bin/
$ sudo chmod +x /usr/local/bin/exosensepi-calibrate.py
```

To perform the calibration procedure, enable the exosensepi-calibrate service:

```
$ sudo systemctl enable exosensepi-calibrate
```

Shut down the Pi and remove power. Wait for the module to cool off (about 1 hour) and power it back on.

The calibration procedure will start automatically. You will hear a short beep when it starts and the blue LED will blink while running.

The process should finish in about 30 minutes, but could run for up to 80 minutes. When it completes you will hear 3 short beeps and the blue LED will be steady on. The calibration service gets automatically disabled after completion so it won't run again on the next boot.

You will find the computed calibration parameters *temp_calib_m* and *temp_calib_b* set in /etc/modprobe.d/exosensepi.conf:

```
options exosensepi temp_calib_m=<M> temp_calib_b=<B>
```

Reboot Exo Sense Pi to have the module reload and apply the calibration parameters.

Raspberry Pi OS Real Time Clock installation

The RTC is based on the Microchip MCP79410 which is natively supported by the Raspberry Pi OS.

You can use the available "i2c-rtc,mcp7941x" dtoverlay by adding it in /boot/config.txt.

Alternatively, use the following steps to install a service that, at boot, enables and calibrates the RTC and aligns the system clock.

Enable the I²C bus using the “raspi-config” configuration utility:

```
$ sudo raspi-config
```

Go to "Interfacing options" > "I2C" and select "Yes".

Install the “i2c-tools” package:

```
$ sudo apt install i2c-tools
```

You may want to remove the "fake-hwclock" to avoid conflicts:

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

```
$ sudo apt autoremove --purge fake-hwclock
```

Download and run the installation script:

```
$ wget https://sferalabs.cc/files/mcp79410/rtc-install
$ chmod 755 rtc-install
$ sudo ./rtc-install
```

After completion, delete the installation script and reboot:

```
$ rm rtc-install
$ sudo reboot
```

On the first usage or after replacing the RTC backup battery, set the correct date/time of the RTC as follows.

If you are connected to the Internet and the system was able to reach an NTP (Network Time Protocol) server, you should see the current date and time using the “date” command:

```
$ date
Thu Sep 10 15:39:31 BST 2020
```

To set the RTC time to the current system time:

```
$ sudo hwclock -w
```

To check the date and time stored in the hardware RTC:

```
$ sudo hwclock -r
2020-09-10 15:39:40.158855+01:00
```

For other features and advanced configurations of the hardware RTC, as clock calibration and usage of the embedded EEPROM, refer to the Microchip MCP79410 documentation.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Features details

Temperature, humidity and air quality sensors

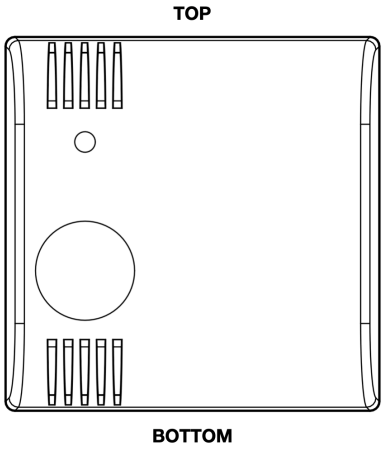
The temperature and humidity sensor is a Sensirion SHT40, connected to the Compute Module I²C bus.

The air quality (Volatile Organic Compounds) sensor is a Sensirion SGP40, also connected to the I²C bus.

Refer to the data sheets for detailed information on the usage of these sensors.

Both sensors are soldered on a raised printed circuit board close to the lower left ventilation grille. The upper grille, thanks to the air convection movement caused by the small temperature gradient between the inside of the case and the environment air temperature, creates a natural air flow to improve the performance of the sensors.

Exo Sense Pi must be mounted vertically, possibly on a vertical wall or flat surface, as illustrated. Installing Exo Sense Pi in any other position or orientation will make the temperature, humidity and air quality readings completely unreliable.

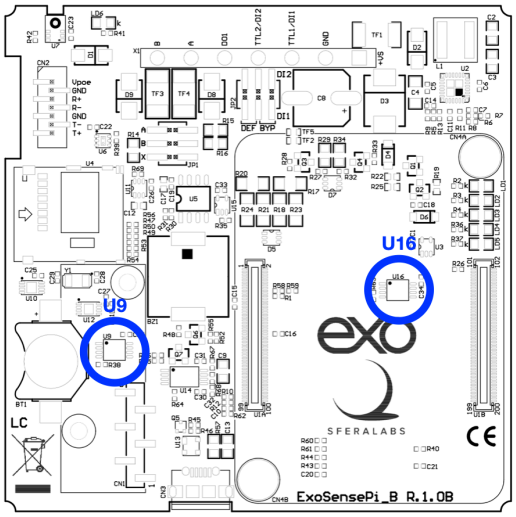


EXO SENSE PI WALL MOUNT ORIENTATION

The heat generated by the Compute Module and the Exo Sense Pi components must be taken into account and properly compensated to ensure accurate readings from the SHT40 and SGP40 sensors.

In order to detect and compensate for self-generated heat, two LM75A temperature sensors are placed on the PCB, one underneath the Compute Module (U16) and one close to the raised PCB where the SHT40 and SGP40 sensors are installed (U9). They are also connected to the I²C bus.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000



THE PCB TEMPERATURE SENSORS

Light sensor

The light sensor is based on the Texas Instruments OPT3001 Ambient Light Sensor.

This I²C sensor implements accurate optical filtering to match the human eye response to light and rejects 99% of IR. The light intensity range is from 0.01 lux to 83 klux.

Refer to the Texas Instruments OPT3001 official data sheet for detailed information on the usage of this sensor.

The OPT3001 is soldered on the Exo Sense Pi printed circuit board just below the top left ventilation grille. An optical guide is used to direct the external ambient light to the sensor's surface.

Note that the blue LED behind the top grille could theoretically interfere with the light sensor's accuracy. For best performance the LED should be off when reading the light intensity.

Microphone

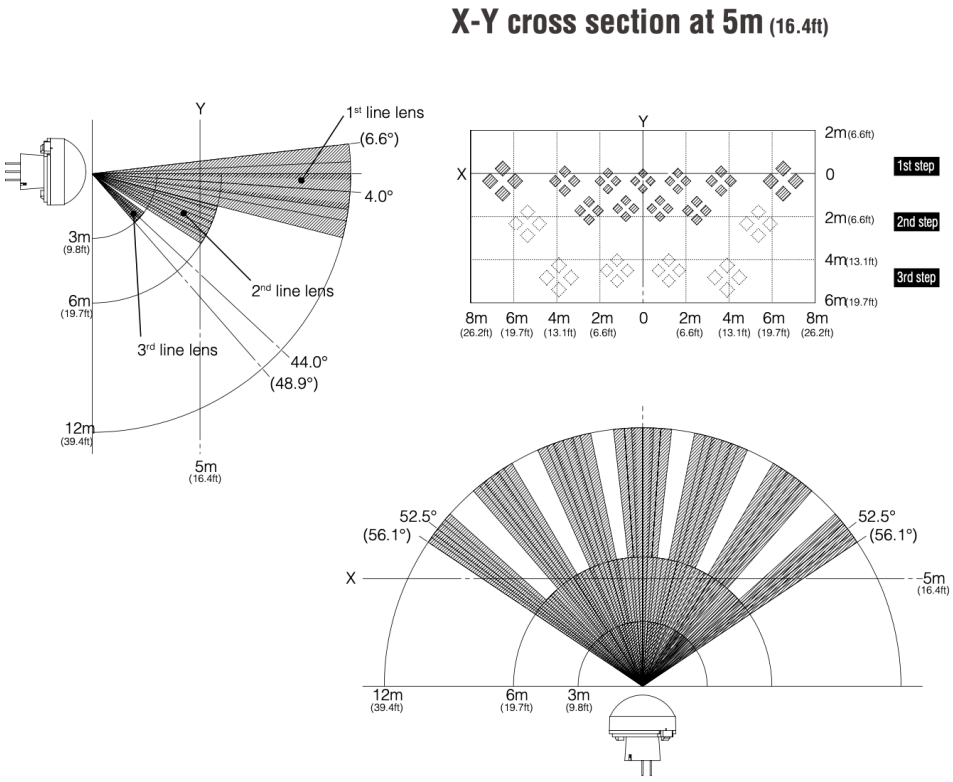
Exo Sense Pi has a TDK ICS-43432 digital I²S microphone for audio recording and environment noise detection. The I²S lines are connected to the Compute Module's PCM lines, GPIO18 (CLK), GPIO19 (FS) and GPIO20 (IN).

Refer to the ICS-43432 data sheet for additional information.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

PIR motion sensor

The Panasonic EKMC1604111 PIR motion sensor has a digital output connected to the GPIO23 line of the Compute Module. Its frontal lens is optimised for wall installations. The detection area is shown below.

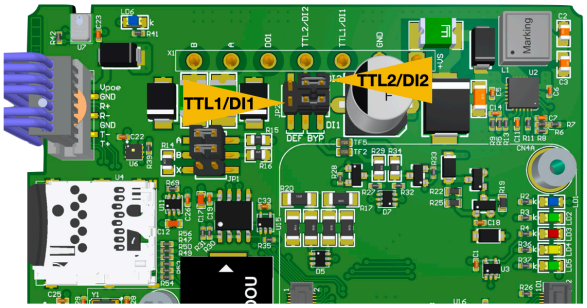


PIR SENSOR DETECTION AREA

Motion of a human body inside the detection area causes frequent state changes of the digital output.

TTLx/DIx: TTL input/output or generic digital inputs

TTL1/DI1 and TTL2/DI2 are dual-purpose pins. Using internal jumpers, they serve as TTL I/O lines or generic digital inputs.



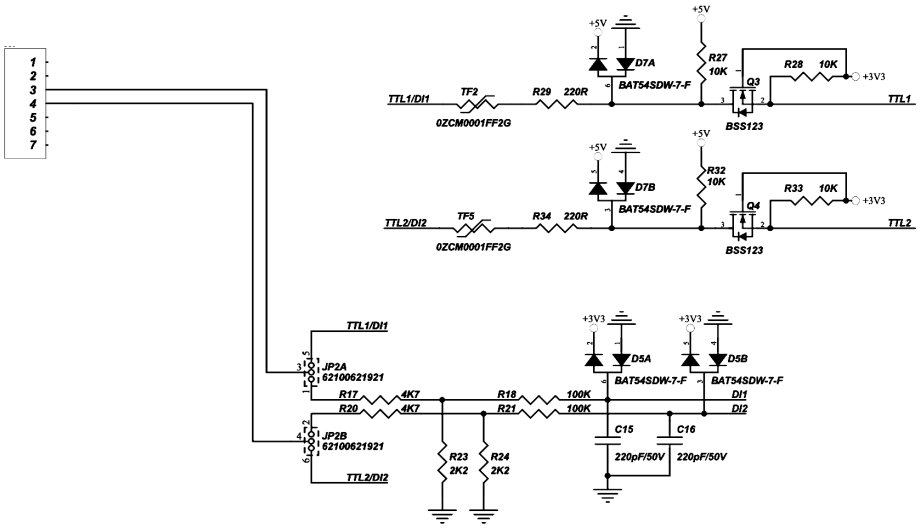
INPUT MODE SELECTION JUMPERS POSITION

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

The lower jumper selects TTL1/DI1 configuration, while the upper jumper selects TTL2/DI2.

To use the TTLx/DIx lines as generic inputs, the corresponding jumper should be between the left and center pins (DEF position).

Set the jumper across the center and right pins to use the input as TTL I/O (BYP position).



TTL LEVEL CONVERTER CIRCUIT AND INPUT MODE SELECTION JUMPERS

When these pins are configured as generic digital inputs, they are protected by a resistor network, and pulled to ground when not connected. They accept positive voltage levels up to 40 Vdc.

The DI1-DI2 front-end circuits have 2.2 kOhm pull-down and series 4.7 kOhm resistors.

WARNING

Never apply voltage levels outside the specified operating limits to DI1 or DI2.

When configured as TTL I/O lines, they can be used as SDL/SCL lines for a soft-I2C bus, as 1-Wire buses, as a Wiegand interface, or for any other digital protocol electrically compatible.

The TTL1-TTL2 front-end circuits have 10kOhm pull-up and series 220 Ohm resistors.

WARNING

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Note that the Exo Sense Pi board and the Compute Module board could be damaged if the jumpers are configured for TTL mode and voltages outside the 0÷5 V range are applied to the inputs.

DO1: Open collector output

DO1 can be used as open collector (OC) output, controlled by the Compute Module GPIO12 line.

It is connected to a discrete open collector driver with a maximum output current of 100 mA and is protected against over-current and short circuits.

When the over-current protection is triggered, the output will open, stopping the current flow. A simple reset to 0 of GPIO12 will reset the protection.

To drive a load using the OC output, connect its positive input to the +VS power supply pin and the negative input to the OC pin.

Buzzer

Exo Sense Pi has an on-board piezoelectric sounder that can be controlled as either a simple on/off buzzer with a fixed 1 kHz tone, or with a PWM signal to generate variable pitch tones.

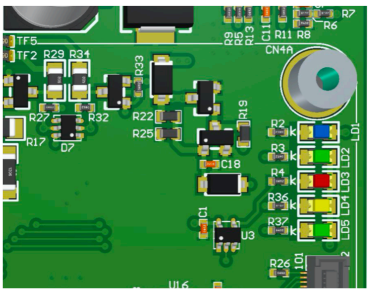
The on/off buzzer is driven by GPIO27, while GPIO13 is used for PWM control.

When the buzzer is active, it affects the microphone, as its sound will mask most or all ambient sound.

LEDs

A blue LED, visible through the top grille, is controlled by the Compute Module GPIO22 line.

Five status LEDs, only visible with the case removed, are placed on the right side of the circuit board, under the Compute Module.



STATUS LEDS

RS-485 serial port

Exo Sense Pi uses the Compute Module UART TX/RX pins (GPIO14/GPIO15) to implement a standard RS-485 serial port.

The UART is accessed as /dev/ttyAMA0 in Raspberry Pi OS.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

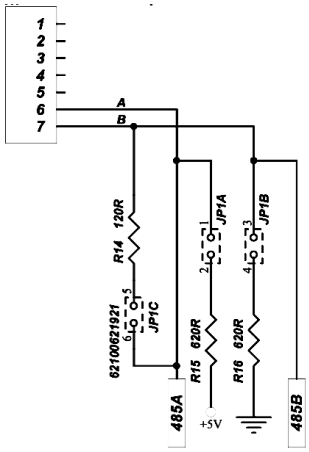
Simply connect the RS-485 A, B and GND to the RS-485 pins of the terminal block.

The RS-485 port is protected from ESD and voltage surges, and supports half-duplex communication up to to 115200 bps[1].

The RS-485 TX/RX switching is controlled by the Compute Module board GPIO6 line. You should set GPIO6 low to enable transmission on the RS-485, and set it high to allow reception of incoming data.

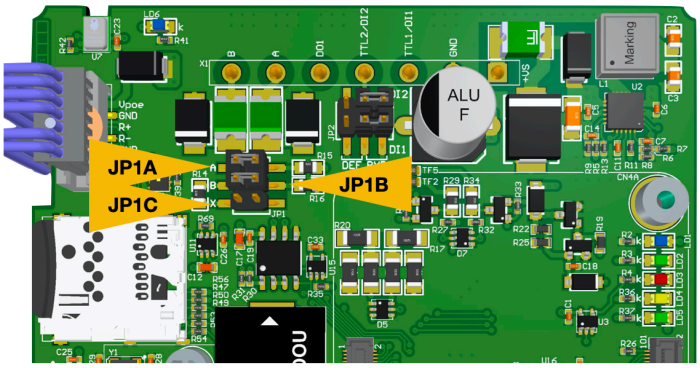
If GPIO6 is left high, the Exo Sense Pi RS-485 driver will automatically drive the RS-485 lines in the dominant state, so that it is not strictly required to control GPIO6 in order to transmit data.

A 120 Ohm termination resistor between A and B can be enabled installing jumper JP1C.



RS-485 JUMPERS SCHEMATIC

Polarization jumpers JP1A and JP2A are not factory-installed.



RS-485 TERMINATION JUMPER POSITION

Real Time Clock

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

[1] Higher speeds are possible, but not guaranteed to meet EMI requirements

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Once the RTC modules and configuration files are properly installed, you will simply use the date and time commands to control the hardware clock.

The battery is only used to power the RTC chip when the main power is not available. Depending on operating conditions it should last up to two years if the Exo Sense Pi board is not powered, more if the Exo Sense Pi receives external power.

The RTC module is based on the Microchip MCP79410 real-time clock/calendar chip. It is connected to the Compute Module board via the I²C bus.

ATECC608A secure element

Exo Sense Pi embeds the ATECC608A secure element chip from Microchip. The ATECC608A is connected to the Raspberry Pi Compute Module via the I²C bus.

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.

Earthquake sensor module (optional)

Exo Sense Pi can be shipped with an optional, factory-installed earthquake sensor module based on the OMRON D7S vibration sensor. It is connected to the Compute Module board via the I²C bus.

This module is soldered to the Exo Sense Pi circuit board and cannot be removed by the user.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Dedicated GPIO pins

The following table shows the mapping of the inputs and outputs of the Exo Sense Pi module to the related pins of the Raspberry Pi Compute Module.

Exo Sense Pi inputs and outputs	Compute Module lines
TTL1	GPIO4
TTL2	GPIO5
DI1	GPIO16
DI2	GPIO17
DO1	GPIO12
PIR	GPIO23
Buzzer (on/off)	GPIO27
Buzzer (PWM)	GPIO13
Blue LED	GPIO22
RS-485	RX (GPIO15) / TX (GPIO14)
RS-485 TX-ENABLE (N)	GPIO6
I²C SDA	SDA (GPIO2)
I²C SCL	SCL (GPIO3)

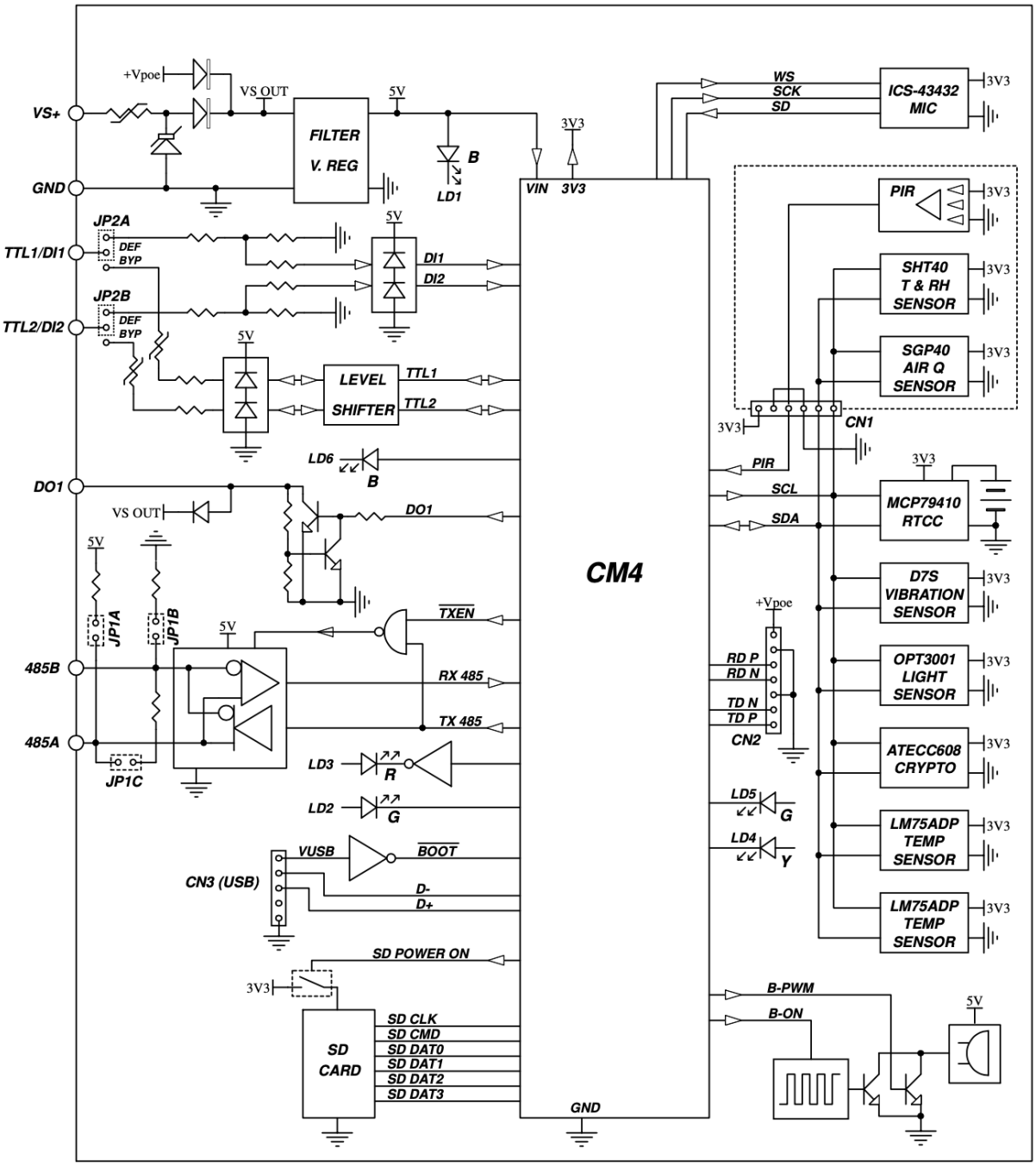
I²C bus addresses

The following table shows the addresses of the devices connected to the primary I²C bus ("i2c-1") of the Raspberry Pi Compute Module.

Device	I²C address
SHT40	0x44
OPT3001	0x45
LM75A (U9)	0x48
LM75A (U16)	0x49
D7S (optional)	0x55
MCP79410 EEPROM	0x57
SGP40	0x59
ATECC608	0x60
MCP79410 RTC	0x6f

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

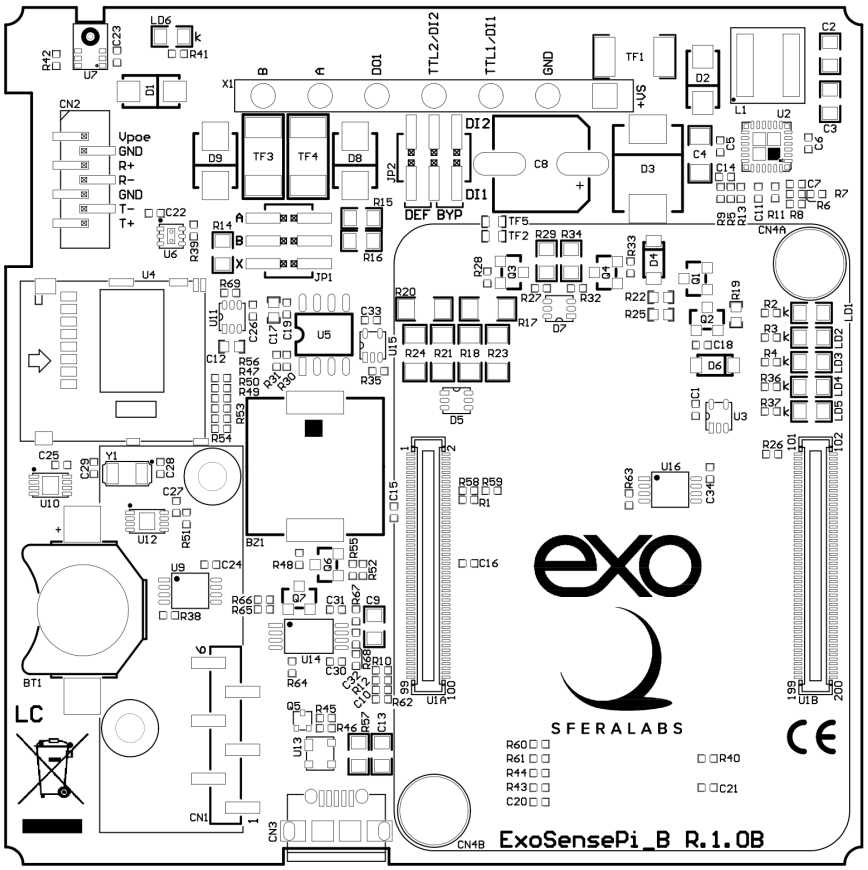
Block diagram



BLOCK DIAGRAM

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Board layout



BOARD LAYOUT (TOP VIEW)

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Technical specifications

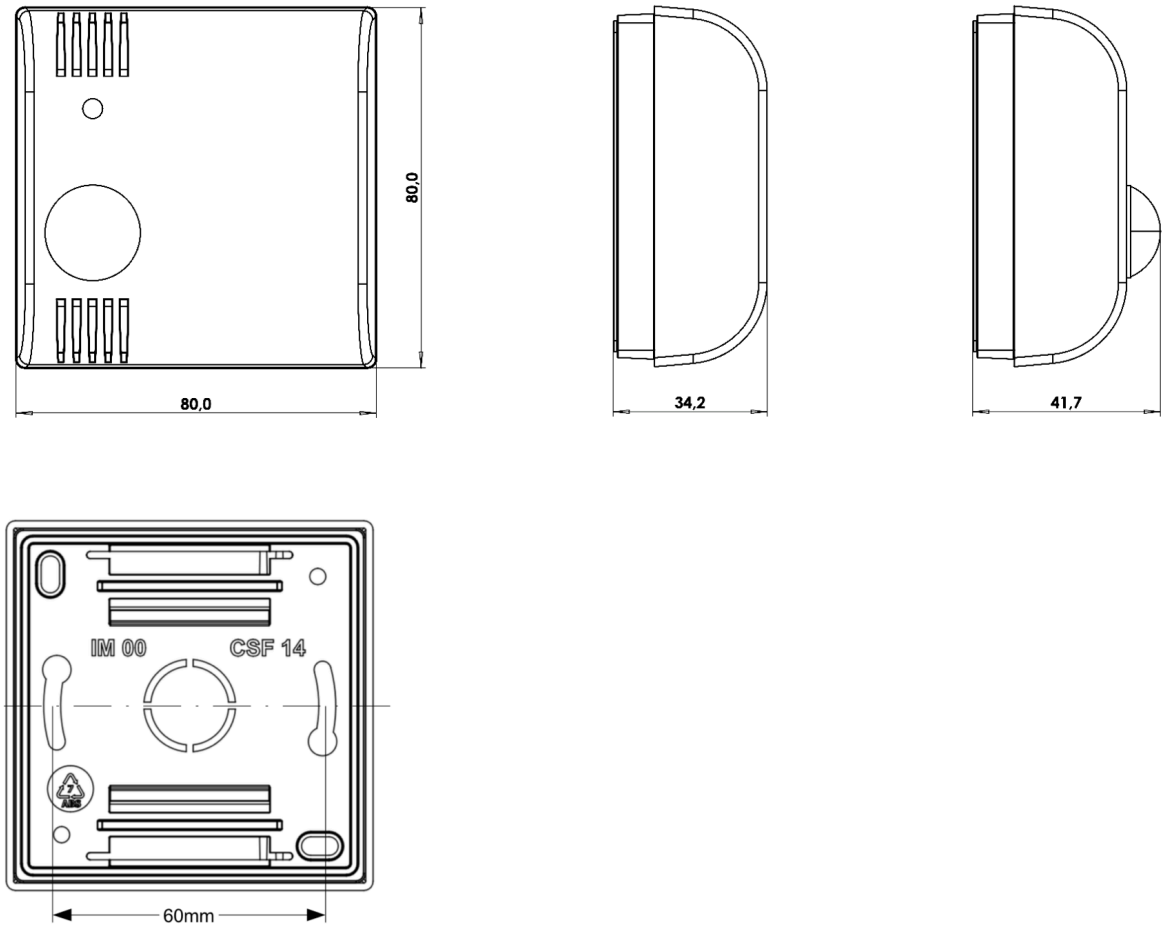
Power supply	10-28 V⎓ (VDC) Reverse polarity protection with 1.1 A resettable fuse. Surge protection up to ±1000V/2ohms 1.2/50µs
Current consumption at VS+ 12 V⎓ including Raspberry Pi CM4, with active Wi-Fi, no other connections	low CPU load: 140 mA 100% CPU load, before throttling: 380 mA Actual current consumption may vary based on working conditions
Current consumption at VS+ 24 V⎓ including Raspberry Pi CM4, with active Wi-Fi, no other connections	low CPU load: 95 mA 100% CPU load, before throttling: 210 mA Actual current consumption may vary based on working conditions
Raspberry platform compatibility	Compute Module 4, all versions (tested with CM4102000 for regulatory compliance)
Voltage range at digital inputs DIx	0…40V⎓
Current for each digital input DIx (typ.)	1.8mA at VS+ 12V⎓ 3.5mA at VS+ 24V⎓
Voltage threshold digital inputs Dix (typ.)	VIH: 4.6 V VIL: 3.6 V
Voltage range at TTL I/O TTLx	0…5 V⎓
Impedance for TTL I/O TTLx	220 Ω
Voltage threshold TTL I/O TTLx (typ.)	VIH: 1.3 V VIL: 1.1 V
Maximum recommended cable length for digital input DIx	30 meters
Maximum recommended cable length for TTL I/O TTLx	5 meters
Open collector OC1 rating	NPN type, common on VS+, short circuit protected 100 mA MAX output current
Maximum recommended cable length for open collector output OC1	2 m

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Communication ports	RS-485 half-duplex with data flow direction controlled by GPIO6 (active low), or passive mode
Baud Rates on RS-485 port	1200 to 115200 (higher speeds are possible, but not guaranteed to meet EMI requirements)
ESD-Protection Voltage on RS-485 A/B	±15kV human body model ±8kV contact discharge
Surge protection on RS-485 A/B	Surge protection up to ±500V/2ohms 1.2/50µs; 600W peak pulse power capability at 10/1000µs waveform
Fail safe feature on RS-485	Optional with jumpers (not installed)
Real time clock	Internal RTCC circuit with backup lithium battery. Only use CR1025 Lithium / Manganese Dioxide (Li/MnO2) batteries. Expected battery life without main power supply: ~2 years
7-pin terminal block characteristics	Maximum conductor cross section: 2.5 mm2 (14 AWG) Recommended stripping length: 7 mm Screw thread: M3 Maximum screws tightening torque: 0.6 Nm
Electromagnetic immunity compliance	EN 61000-4-2 (ESD) EN 61000-4-3 (Radiated RF Field) EN 61000-4-4 (Burst/fast transient) EN 61000-4-6 (Conducted) EN 61000-4-8 (Power frequency magnetic field)
Housing	Wall mount 80x80mm ABS case
Operating temperature	-10…+50 °C
Storage temperature	-20…+70 °C
Relative humidity	5% to 90% noncondensing
Protection degree	IP20
Weight	90 g (Exo Sense Pi with CM4)

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

Dimensions

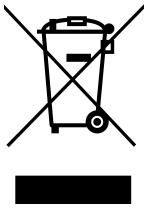


DIMENSIONS

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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, please 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.

Exo Sense Pi contains a small non rechargeable manganese dioxide lithium coin battery.

The battery is not accessible from the outside. You should first open the case body to gain access to the 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 data sheet of the product
- ✓ after completing the previous steps, switch on the the power supply and the other related circuits.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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)

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

- ✓ EN61000-6-2:2019 - EMC Immunity standard for industrial environments
- ✓ EN 61000-6-3:2007/A1:2011/AC:2012 - 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.

Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000

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 61000-6-3:2007/A1:2011/ AC:2012 - Emission for residential, commercial and light-industrial environments.

Compliance information for Raspberry Pi CM4

Exo Sense Pi models ESCB10X4101008, ESCB10X4102000 contain a standard Raspberry Pi Compute Module 4 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 wireless module is in conformity with the essential requirements and other relevant requirements of the Radio Equipment Directive 2014/53/ EU.

USA

Raspberry Pi CM 4 wireless module FCC IDENTIFIER: **2ABCB-RPIRM0**

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 CM 4 wireless module IC CERTIFICATION No.: **2ABCB-RPIRM0**

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) 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.

LRI Distribuída no Brasil pela LRI | vendas@lri.com.br | 51 2129-3000