ROSbot XL Manual

Overview

ROSbot XL is an autonomous mobile robot platform equipped with a 4x4 drive, allowing for trouble-free expansion with optional devices such as LIDAR, RGB-D cameras or a manipulator. It offers user-friendly operation with software based on the free and widely developed ROS/ROS 2. All this makes it an ideal choice for both educational and research purposes.

This is a manual. Would you need a **quick start guide** instead?

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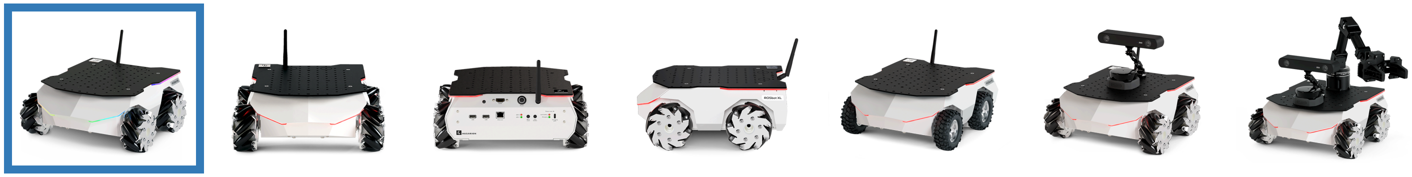


ROSbot is an affordable robot platform for rapid development of autonomous robots. It can be a base for industrial robots, custom service robots, inspection robots and robots working in swarms.

- Aluminium chassis
- 4 x DC motors with quadrature encoders
- IMU
- Built-in USB hub (2 external and 2 internal ports available)
- Built-in Li-Ion 3S battery (11.1V, 7800mAh, 86Wh)
- Power board with advanced energy management (USB-C Power Delivery compatible, protection circuits, contactless charging option)
- Selectable power supply for SBC (5V, 12V, 19V)
- Programmable RGB perimeter LEDs and speaker
- Ethernet-based communication between SBC and STM32F4-based digital controller
- Variety of compatible SBCs (Raspberry Pi, NVIDIA Jetson, Intel NUC i3)
- Universal mounting plate (for LIDARs, robot arms, etc.)

QUICK ACCESS

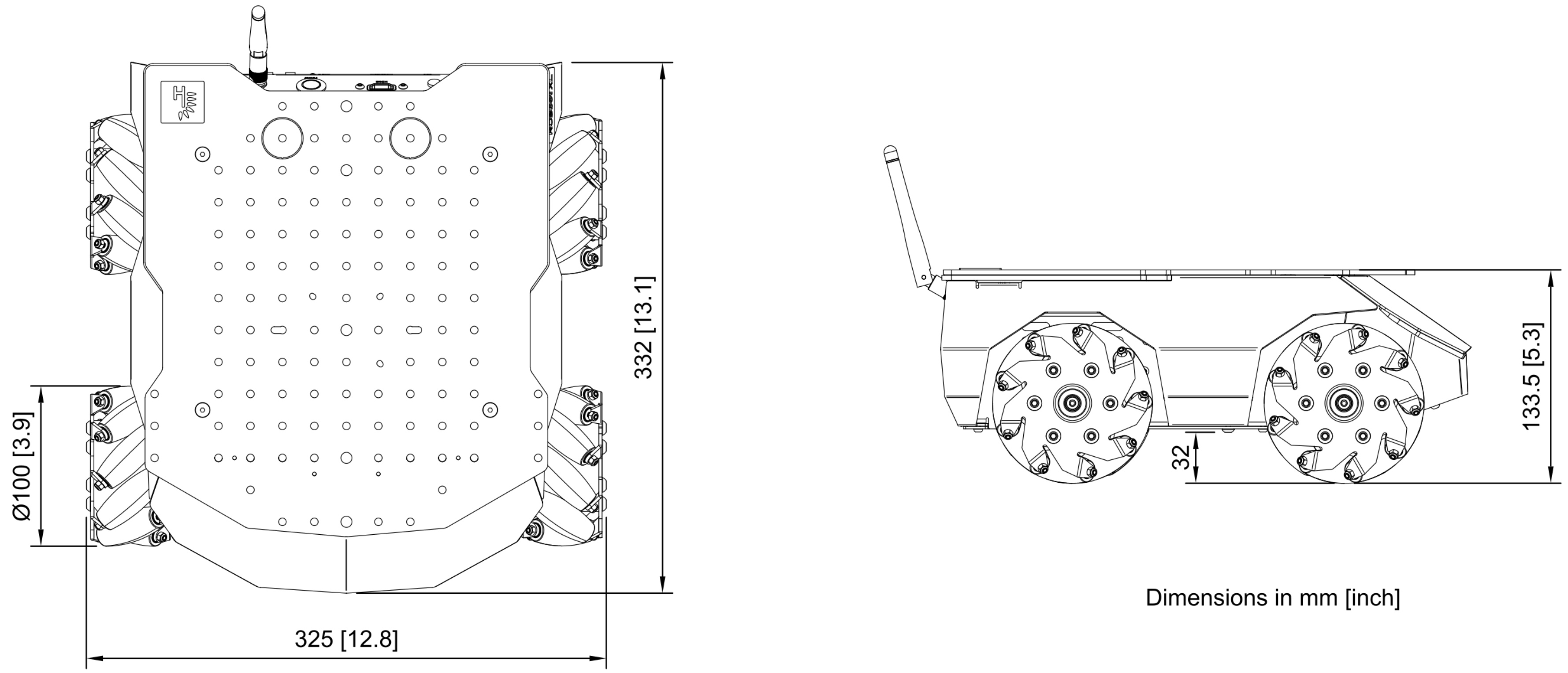
🛍️ Buy now
🌎 Read the blog

📔 Go through the manual
⚙️ Find available configurations

🚀 Learn how to start
🤖 Get familiar with ROS interface

Hardware guide

Specification



See more detailed drawing here

Attribute	Description
Dimensions without camera and LiDAR	332 x 325 x 133.5 mm / 12.8 x 13.1 x 5.3 in [L x W x H]
Wheel diameter / Clearance / Wheelbase	100 mm / 32 mm / 170 mm
Chassis material	Powder-coated aluminum plate, 1.5 mm thick, top plate 3 mm
Weight *	5380g
Maximum translational velocity	0.8 m/s
Maximum rotational velocity	180 deg/s (3.14 rad/s)

Attribute	Description
Maximum load capacity *	Up to 10 kg / 352 oz
Battery life	2h - 6h

*With mecanum wheels, RPi4 SBC and no sensors.

Components

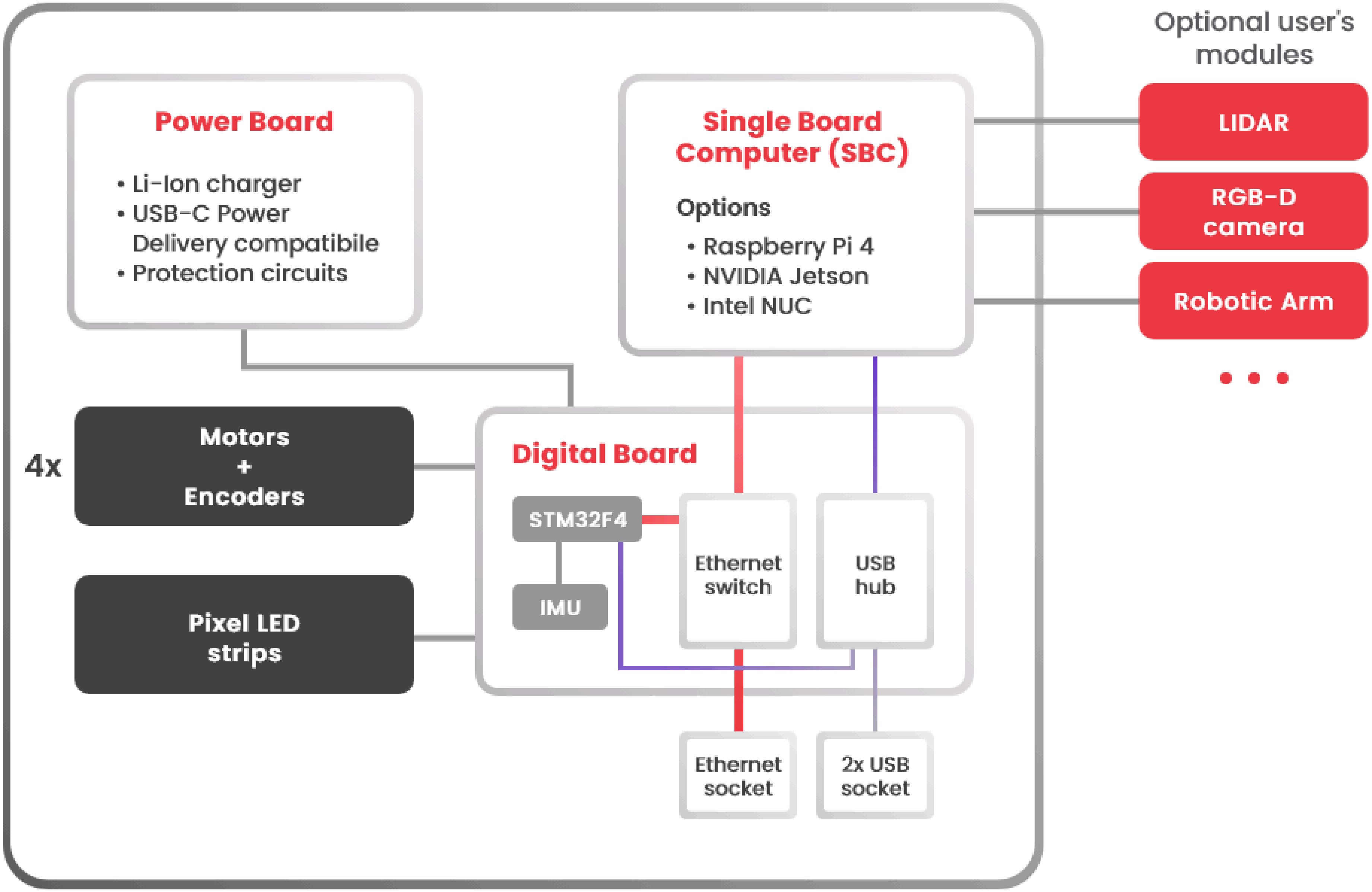
Component	Quantity	Description
SBC	1	Default user computer: **Raspberry Pi 4 (4GB RAM)**. Can also be configured with **NVIDIA Jetson Orin Nano (8GB RAM, 250GB SSD)** or **ASUS NUC (i3-1315U 16GB RAM 250GB SSD)**.
Digital Board	1	Real-time controller based on STM32F407 microcontroller.
Power Board	1	USB-C Power Delivery input (12-20V) which supports simultaneous power delivery and battery charging.
DC motor	4	Xinhe Motor XH-37D, 12VDC nominal, 10000rpm. Maximum mechanical power: 10W, no load speed at the output shaft: 200 rpm, stall torque at the output shaft: 21 kg*cm, stall current: 5.4A, gear ratio: 50
Encoder	4	Magnetic, 64cpr, 16 poles
IMU sensor	1	Intelligent 9-axis absolute orientation sensor BNO055, more details
Li-Ion Batteries	1	11.1V 7800mAh 86Wh
Antenna	1	Connected directly to Wi-Fi module.
Speaker	1	Driven from Digital Board or from SBC (selectable source).

ⓘ INFO

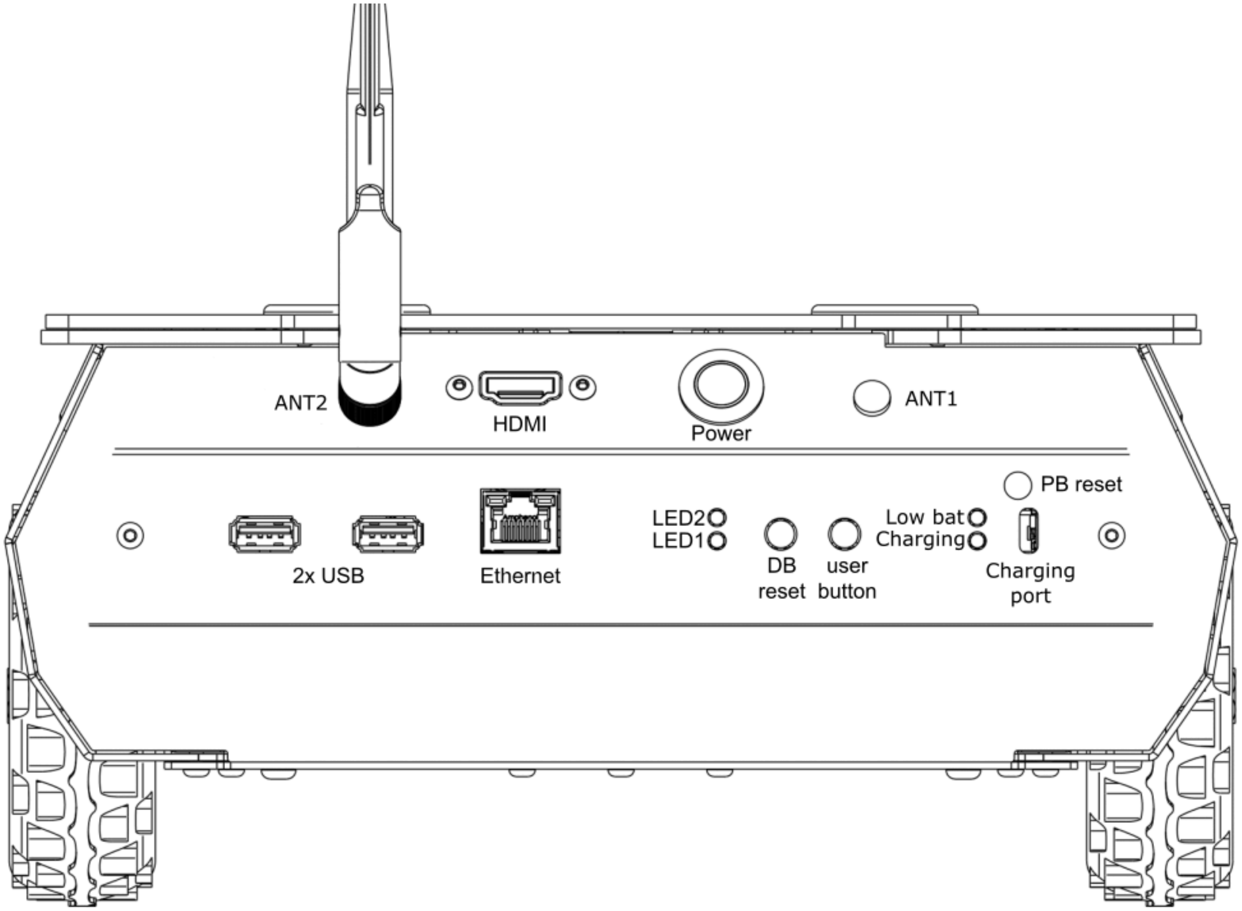
ROSbot XL is available in ready to use configuration packages adjusted for different applications.

Block diagram

A graphic representation of ROSbot XL components and connections between them. The detailed version: [PDF] ROSbot XL block diagram.



Rear panel description



Item	Quantity	Description
Antenna connector	1 (2)	Wi-Fi antenna RP-SMA socket. Required for Wi-Fi connectivity. For some SBCs, 2 antennas are used.
USB	2	USB 2.0 host ports from SBC.
HDMI	1	HDMI output from SBC.

Item	Quantity	Description
Power button	1	Turns ROSbot ON or OFF. Hold for 1.5 seconds to turn robot on, 0.5 seconds to turn off.
LEDs	4	LED1(green), LED2(red), LED3(green), LED4(red)
DB Reset	1	Button used for reset digital board.
PB Reset	1	Hidden button used for reset power board.
User button	1	Programmable button.
USB type C power input	1	USB-C Power Delivery input (12-20V) which supports simultaneous power delivery and battery charging.

LED statuses

LED	color	State	Message
LED1	green	ON	Firmware finished booting
LED2	red	Toggling	Error of RTOS'a or microROS
Low bat	red	ON	Battery level is low
Charging	green	Toggling	Battery is charging
Charging	green	ON	Battery is fully charged
Power button	white	ON	Power is ON
Power button	white	Toggling	System is shutting down
Pixel panels	RGB	Programmable	In default shows looped animation

Battery & charging

> **TIP**

An internal **battery is disconnected during transport.** Connect the battery plug before the first use. You need to unscrew the battery cover first. See Quick start for more detailed guide.

When you receive the robot, the battery level should be about 30-40%. You do not need to perform any initial procedures, however, we recommend to begin the first software setup with the charger plugged. The battery will charge to a higher level and you avoid draining it to zero, which is not recommended just after the storage/transport period. The current battery voltage can be read from the ROS API. The voltage should never fall under 9V, which is the "0%" level, and should not exceed 12.6V, which is "100%" level.

Battery & charger parameters

Parameter	Value	Comment
Battery type	Li-Ion	3S configuration
Battery voltage & capacity	11.1V 7800mAh	86.5Wh
Max. discharge current	8A	
Max. charge current	2.7A	limited by robot
Charging temp. range	0°C - 45°C	
Operating temp. range	-20°C - 60°C	
Charger	20V 65W	PD2.0/3.0 compatible

Charging

ROSbot XL integrates an on-board battery charger. The charging process starts automatically after connecting the power adapter and terminates when the battery is full. The low battery level is indicated by "Low bat" LED on the rear panel.

We strongly recommend to use the power adapter delivered with the robot. However, it is also possible to supply/charge the robot with any adapter that is compatible with Power Delivery (PD2.0/PD3.0) and provides 15V or 20V output with the minimum 3A current (the current draw is internally limited to 2.8A).

There are 4 possible modes of operation:

- a) Active, battery only.
- b) Active, battery + power adapter. In this mode the robot can be used and charged simultaneously. The battery is used only when the robot current consumption exceeds the power adapter maximum current.
- c) Inactive (powered off), battery only. Robot in this state does not draw current from battery and can remain in this state for weeks. The battery state should be checked every 6-8 weeks and recharged if the battery level is below 25%. For a prolonged storage, the best battery level is 40-50%.
- d) Inactive, battery + power adapter. In this state the battery charges with the maximum speed (2.5A maximum). Robot can be switched on at any time, with transition to mode "b)".

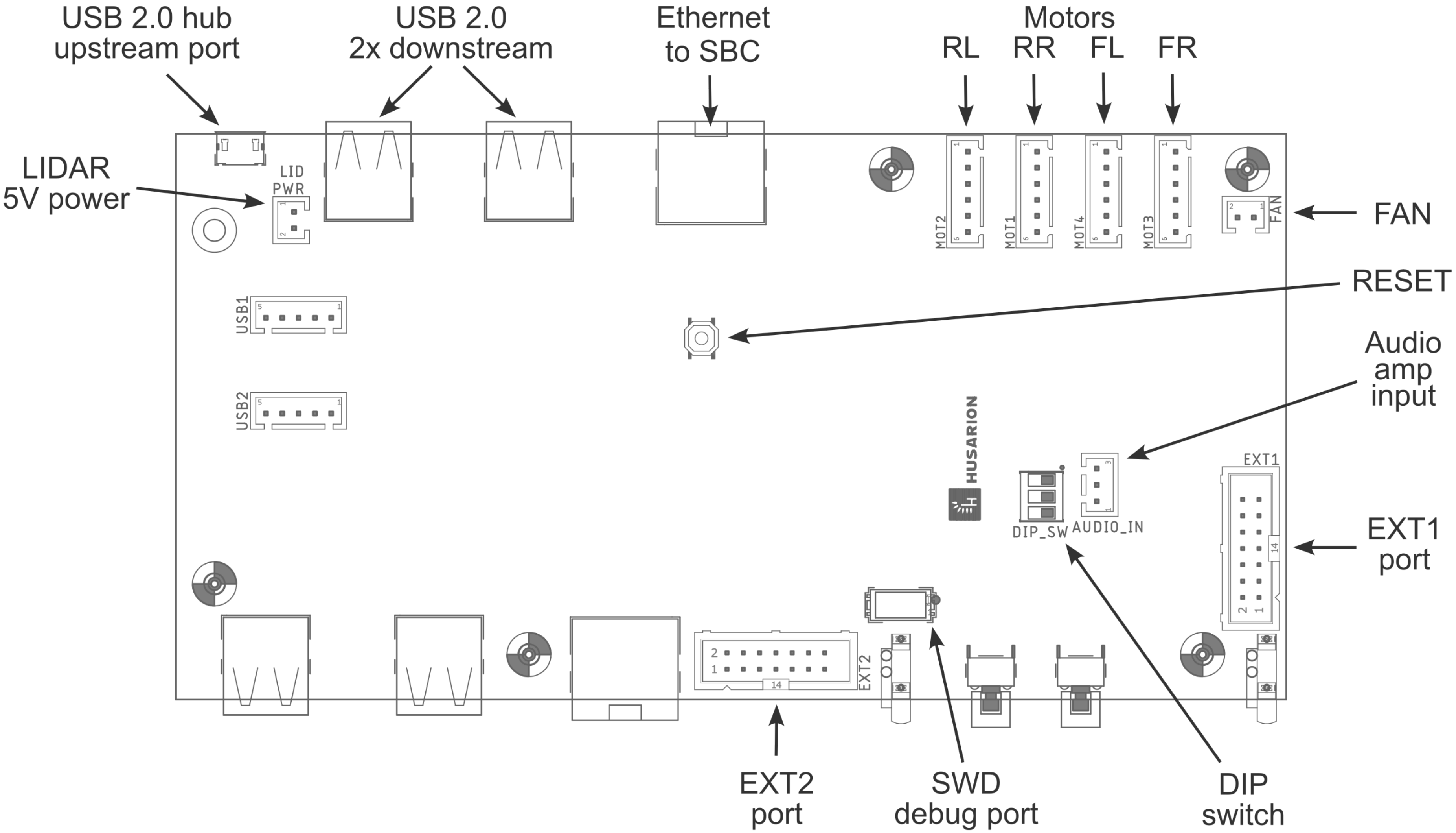
The battery charging process should take about 5-6 hours in d) mode (from 0% to 100%).

User compartment

> ⓘ **NOTE**
>
> ROSbot XL allows the user access to its interior by default. This chapter describes the items (connectors, switches, cables) that can be utilized by user. Please read it carefully before making any changes inside the robot. Please keep in mind that despite modifications are allowed, you need to have a basic experience with electronic circuits/boards to avoid damage. The interior is not protected in any way and it is very easy to make a damage to the robot. Damages made by user are not covered by our limited warranty.

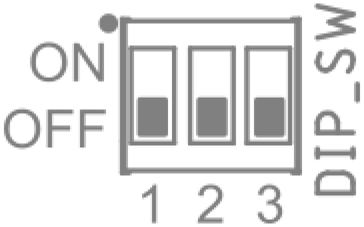
Digital board items

A digital board is the big, white PCBA, located on the rear end of the robot.



DIP switch on Digital Board (DIP_SW)

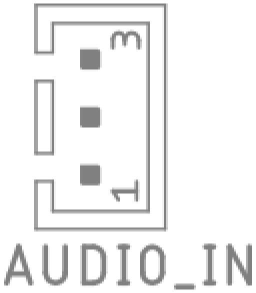
The switch sections are numbered from the left:



Section	Function	OFF setting	ON setting
1	Speaker source	audio source = SBC (via CON19)	audio source = MCU
2	none	for future use	for future use
3	MCU BOOT0	MCU boot from FLASH	MCU bootloader active

Analog audio input (AUDIO_IN)

Analog audio input of integrated amplifier and speaker. Designed for SBC audio output connection. DIP_SW section 1 shall be set to OFF when this input is used. If you ordered ROSbot XL with Raspberry Pi 4, this cable is already connected.

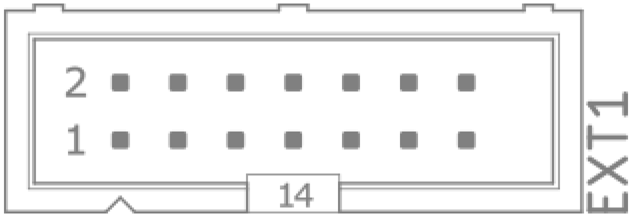


Pin	Signal	Input name	Source node
1	GND	Reference/shield ground	-
2	IN+	Differential input positive	Left channel
3	IN-	Differential input negative	Ground

Usually SBCs do not have differential audio output. Therefore, please use GND as a shield, IN+ as a signal input and IN- as a ground connection on the SBC side. This "pseudo-differential" connection helps with noise limiting. The connector plug type is JST XHP-3.

Extra GPIO - bank 1 (EXT1)

The EXT1 connector contains a few GPIOs that can be used by more experienced users. All signals are in 3.3V logic and all of them have 220R resistor in series.

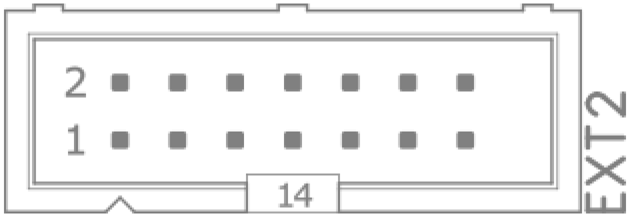


Pin	Signal name	Comment
1	EXT_GPIO2	
2	EXT_GPIO1	
3	EXT_PWM2	
4	EXT_PWM1	
5	USART6_TX	
6	USART6_RX	
7	I2C1_SCL	External pull-up needed
8	I2C1_SDA	External pull-up needed
9	SPI1_MOSI	
10	SPI1_SCK	
11	SPI1_MISO	
12	+3V3_PROT	Power supply output. OC protection at 500mA
13	GND	Ground

Pin	Signal name	Comment
14	+5V_PROT	Power supply output. OC protection at 500mA

Extra GPIO - bank 2 (EXT2)

The EXT1 connector contains a few GPIOs that can be used by more experienced users. All signals are in 3.3V logic and all of them have 220R resistor in series. In addition, the pins with ADC (Analog-to-Digital Converter) function have 100nF capacitor closer to the MCU.



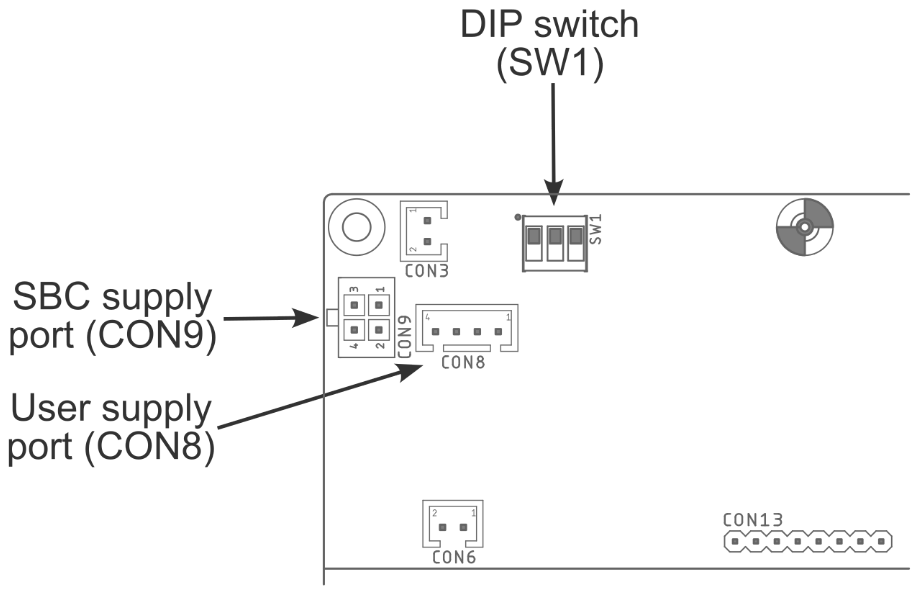
Pin	Signal name	Comment
1	GND	
2	BOOT0	pull-down on board
3	EXT_PWM3	
4	NRST	pull-up on board
5	EXT_ADC1	
6	EXT_ADC2	
7	EXT_ADC3	
8	EXT_GPIO3	
9	I2C3_SDA	External pull-up needed
10	I2C3_SCL	External pull-up needed
11	CAN1_TX	External transceiver needed

Pin	Signal name	Comment
12	CAN1_RX	External transceiver needed
13	GND	Ground
14	+5V_PROT	Power supply output. OC protection at 500mA

The connector type for both EXT1 and EXT2 ports is a commonly-known ribbon IDC cable connector, with pin-to-pin pitch 2.54mm (0.1") and the ribbon cable pitch 1.27mm (0.05"). The example model is Harting 09 18 514 5813 58U.

Power board items

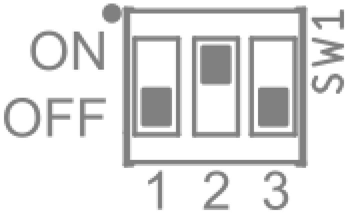
A power board is the vertically oriented, white PCBA, located in parallel to the right side of the robot. Below you can see the fragment of it - the upper left corner.



There are several items which need a better description:

DIP switch on Power Board (SW1)

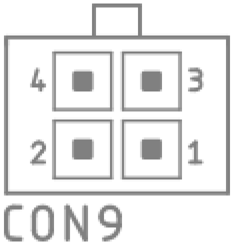
This switch changes the SBC supply voltage available on SBC supply port (CON9, pin 2) and User supply port (CON8, pin 2). The switch sections are numbered from the left:



Section	Function	Default setting	Comment
1	none	OFF	do not change
2	none	ON	do not change
3	SBC supply 19V enable	OFF	Turn to ON for 19V output. Keep OFF for 12V.

SBC supply port (CON9)

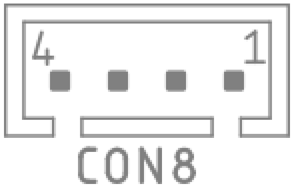
This connector is used to supply the user computer. If you purchased ROXbot XL with the chosen user computer, the power supply for this SBC is already connected here. The pinout may be useful if you would like to install or replace the SBC by yourself.



Pin	Signal	Max current	Comment
1	GND	5A	
2	+12V/+19V	4.75A/3A	set with DIP switch
3	Vbat2	5A	9V ... 12.6V
4	+5V	5A	

Compatible plug housing: Molex 43025-0400. Compatible plug terminal: Molex 43030-0007

User supply port (CON8)



Pin	Signal	Max current	Comment
1	GND	3A	
2	+12V/+19V	3A	set with DIP switch
3	Vbat1	3A	9V ... 12.6V
4	+5V	3A	

The connector plug type is JST XHP-4.

> ⓘ **NOTE**
>
> The +5V and +12/19V line are shared between CON8 and CON9. The total current for both cannot exceed the maximum current for CON9. The Vbat1/Vbat2 lines are shared with all other circuits, including motors, +5V, +12V/+19V. Therefore, depending on the total power usage, the maximum current on Vbat1/Vbat2 can be lower than specified here.

Fan

The perforated top cover provides effective cooling for the robot. The left side wall of the robot's case features a chassis fan to further improve cooling for demanding computers (such as the ASUS NUC). The fan does not run all the time, but only when the air temperature inside exceeds 35 degrees.

CAD models

To facilitate the work with the project based on ROSbot XL platform, we have prepared CAD models for download in three extension formats:

- STEP - all variants zipped [9,5MB] - contains models with mecanum or regular wheels, collision model, PCBs model and a complete model with all part variants.
- STL - all variants zipped [3,3MB] - contains models with mecanum, regular or no wheels and a collision model, in two quality levels.
- F3D - Autodesk 360 Fusion model [3,2MB] - contains a complete model with selectable features.

Software

Software packages for ROSbot XL are available in the rosbot_xl_ros repository.

Docker containers

The recommended way of running software on ROSbot XL is using docker containers, here you can find the list of available containers.

Speaker

The ROSbot XL is equipped with a speaker on board connected to the SBC. Depending on the SBC, you may test the speaker or play any audio file. First of all in the terminal export the audio device.

Raspberry Pi Other

```
export AUDIODEV=hw:$(aplay -l | grep "Headphones" | sed -n 's/card \([0-9]\+\).*device \([0-9]\+\).*/\1,\2/p')
```

If your audio device is exported check the speaker with playing the sine.

```
play -n synth 0.6 sin 180
```

To play the music or recorded audio use `aplay` command:

```
aplay <audio_file>
```

ROS / ROS 2 API

Use `bringup.launch.py` from `rosbot_xl_bringup` to start all base functionalities for ROSbot XL. It consists of the following parts:

- `scan_to_scan_filter_chain` from `laser_filters`, it subscribes to `/scan` topic and removes all points that are within the robot's footprint (defined by config `laser_filter.yaml` in `rosbot_xl_bringup` package). Filtered laserscan is then published on `/scan_filtered` topic

  Subscribes

  - `/scan` (*sensor_msgs/LaserScan*)

  Publishes

  - `/scan_filtered` (*sensor_msgs/LaserScan*)

- `ekf_node` from `robot_localization`, it is used to fuse wheel odometry and IMU data. Parameters are defined in `ekf.yaml` in `rosbot_xl_bringup/config`. It subscribes to `/rosbot_xl_base_controller/odom` and `/imu_broadcaster/imu` published by ros2 controllers and publishes fused odometry on `/odometry/filtered` topic

  Subscribes

  - `/rosbot_xl_base_controller/odom` (*nav_msgs/Odometry*)
  - `/imu_broadcaster/imu` (*sensor_msgs/Imu*)

  Publishes

  - `/tf` (*tf2_msgs/TFMessage*) - `base_link`->`odom` transform
  - `/odometry/filtered` (*nav_msgs/Odometry*)

- `controller.launch.py` from `rosbot_xl_controller`, it loads robot model defined in `rosbot_xl_description` as well as ros2 control rosbot_hardware_interfaces. It also starts controllers:

  - `joint_state_broadcaster`
  - `rosbot_xl_base_controller` - depending on the value of `mecanum` argument it can be `DiffDriveController` or `MecanumDriveController`
  - `imu_broadcaster`

  Subscribes

  - `/cmd_vel` (*geometry_msgs/Twist*)
  - `/_motors_responses` (*sensor_msgs/JointState*)
  - `/_imu/data_raw` (*sensor_msgs/Imu*)

  Publishes

  - `/tf` (*tf2_msgs/TFMessage*)
  - `/tf_static` (*tf2_msgs/TFMessage*)
  - `/_motors_cmd` (*std_msgs/Float32MultiArray*)
  - `/rosbot_xl_base_controller/odom` (*nav_msgs/Odometry*)
  - `/imu_broadcaster/imu` (*sensor_msgs/Imu*)

Use `micro_ros_agent` to communicate with Digital Board, it provides the following interface:

Subscribes

- `/_motors_cmd` (*std_msgs/Float32MultiArray*)

Publishes

- `/_motors_responses` (*sensor_msgs/JointState*)
- `/_imu/data_raw` (*sensor_msgs/Imu*)

- `/battery_state` (*sensor_msgs/BatteryState*)

Operating System image reinstallation

In some cases you will need to restore ROSbot system to its default settings:

- in case of accidental damage of the system,
- to update the OS (it can be updated remotely, but flashing the microSD card can be easier sometimes),
- to clear all user changes and restore factory settings.

This process will differ depending on ROSbot version that you have. Find the full instruction here

Reference projects

Running ROS natively is fine for relatively small projects. For more complex ones, the full dockerized setup is a better approach.

Find available projects below:

link	description
rosbot-xl-gamepad	Control the robot manually using a Logitech F710 gamepad
rosbot-xl-telepresence	Controlling ROSbot XL over the Internet with a live video feed
rosbot-xl-autonomy	Autonomous mapping & navigation demo for ROSbot XL. Using navigation2 and slam_toolbox
rosbot-xl-manipulation	Using ROSbot XL with OpenMANIPULATOR-X. Read more about this project in the dedicated tutorial (including Gazebo simulation)

ROS 2 Tutorials

ROS 2 (Robot Operating System 2) offers libraries and tools designed to aid in developing robotic applications.

We offer a collection of ROS 2 Tutorials for the ROSbot XL platform, providing a hands-on introduction to ROS 2 suitable for both beginners and advanced users. These tutorials can be run on any ROSbots, either on a physical unit or in the Gazebo simulation environment, covering topics from basic navigation to complex operations. Here is the list of ROS 2 tutorials available for ROSbot XL:

1. ROS 2 Introduction
2. Creating Nodes - Messages
3. Creating Nodes - Services
4. Kinematics and Visualization

5. Track object with OpenCV
6. Running ROS 2 on Multiple Machines
7. Transformation
8. SLAM
9. Navigation
10. Exploration

Docs and links

All helpful documents and links in one place:

- ROSbot limited warranty terms and conditions - important!
- ROSbot XL detailed block diagram
- Replacing RPi4 with NUC - guide