RB-1 MODULAR MOBILE MANIPULATOR

Hardware Manual
Version 1.0

RBTNK-DOC-161020

Robotnik Automation, S.L.L.

INDEX

1 Introduction

This Manual describes the main parts of the RB-1 modular mobile manipulator, as well as how to access to the internal components.

Every main piece includes a little description, emphasizing the elements that need a special periodical control and maintenance.

Also is inclueded how every compoennt is connected with a diagram.

Finally, a maintenance table and the basic drawings of the vehicle has been included.

2 Robot description

2.1 General overview

The next pictures shows the front view of the robot with the location of the main parts.

Figure 1 – Front view of RB-1 robot

- *Pan-Tilt Head:* The head has a Pan tilt movement provided by two dynamixel pro motors. It include one Orbbec camera. Inside the head is installed the microphone and the speaker.
- *Torso:* The torso of the robot has elevation movement. It has a range of 400 mm. The movement is provided by one dynamixel pro motor.

- *MICO or JACO arm:* The RB-1 can incorporate a MICO or JACO arm from Kinova.
- *Laser location:* Place inside the robot where is possible to install the compatible laser rangefinder describe in the section 2.2.4.1.
- *Base Orbeec:* The Orbeec camera is installed standard on the robot. This camera is used for charging in the automatic charger base.
- Front cover: Can be removed to access to the electrical box connections, the motors, the laser and the Orbecc camera.
- *Battery cover:* Can be removed to access to the battery pack.

The next pictures shows the rear view of the robot with the location of the main parts.

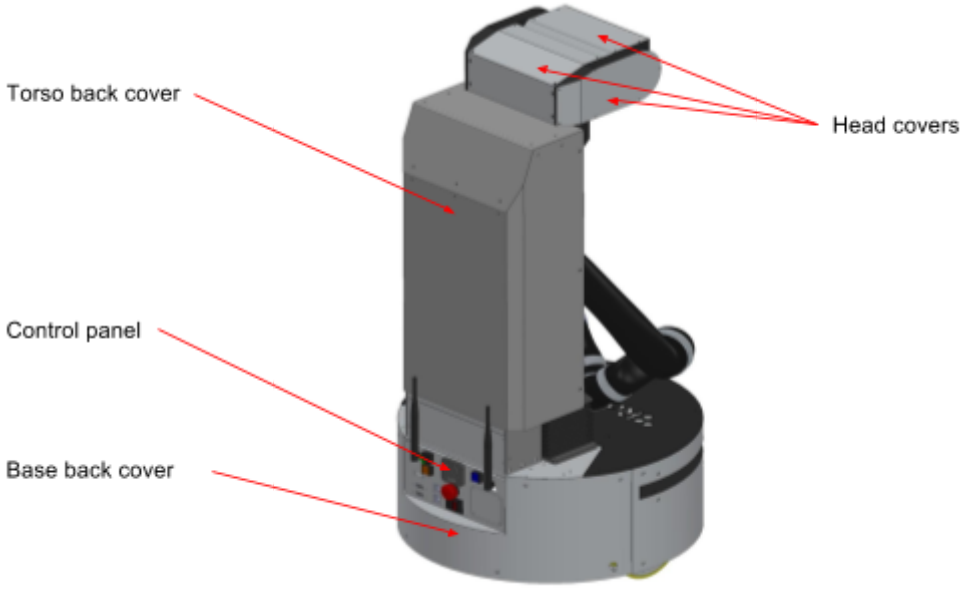


Figure 2 – Rear view of RB-1 robot

- *Torso back cover:* Can be removed to access to the internal components placed on the torso back.
- *Head covers:* Can be removed to access to the head motors and the Orbecc.
- *Base back cover:* Can be remove to acces to the robot motors.
- *Control panel:* It include the general power switch, the restart button, the cpu start button, the emergency stop, the antennas, the manual charger connector, external access to the computer and the location of the fuses.

2.2 Components description

This section describes the components included in the RB-1 modular mobile manipulator.

2.2.1 Wheels

The robot has two motor wheels and three omniwheels as it's shown in the next picture:

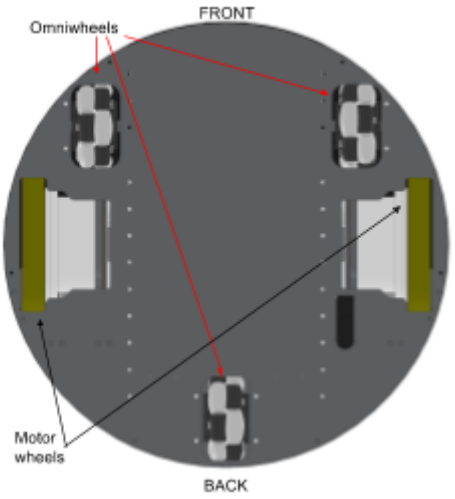


Figure 3 – Wheels location

The motor wheel is composed by a motor block and a detachable wheel. The motor block has a 250w 8 poles brushless motor with Hall Effect sensor, an encoder and a reduction gear box, all hold by an aluminum cover. These kinds of motors have a much longer life expectancy and a higher efficiency than brushed motors.

Figure 4 – Motor wheels

The omni wheels gives stability to the platform and permits the turning around the center of the robot.

2.2.2 Motor Driver

The motor drivers are two DZCANTE 020L080 with a connection board on top.

Figure 5 – Motor Driver

The drivers are programmed at Robotnik with specific a settings for each motor. The serial identifier is the default one (63), but each driver has its own CAN bus identifier (1 and 2). DO NOT change them from one motor to another.

There are several analog and digital input/outputs available in each driver, check driver datasheet for more information.

2.2.3 Electrical components

2.2.3.1 DC-DC

There is a 150W 12V DC/DC in the electronic box to provide a stable power supply for the electronic elements, for example the computer.

Figure 6- 12V DC/DC

There is a 150W 24V DC/DC in the torso to provide a stable power supply for the dynamixel motors and the arm.

Figure 7- 24V DC/DC

There is a small 5V DC/DC in the electronic box to power the control circuit of the motor drivers, the router and the USB hub.

Figure 8- 5V DC/DC

2.2.3.2 Fuses & terminal

The fuses terminal is accessible from the outside of the electronic box. Is located in the control panel on the right side.

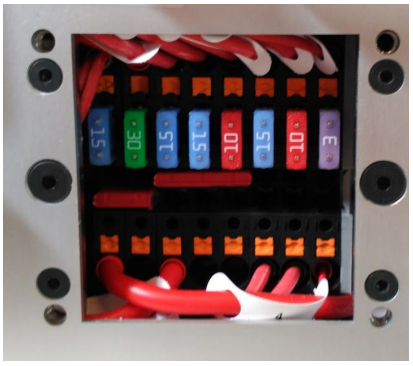


Figure 9- Fuses

The fuses are numbered from left to right.

ID	Ampers	Description
F1	15	Back panel charge connector & switch S1
F2	30	Main power protection
F3	15	Driver 1
F4	15	Driver 2
F5	10	Controle circuit protection
F6	15	Torso & arm power protection
F7	10	12V DC/DC converter protection
F8	3	5V DC/DC Converter protection

Table 1 – Fuses

The robot has two terminals inside, one is in the electronic box and the other is in the torso.

The next picture shows where is located the terminal inside the electronic box. The terminal distributes the power to all the components of the electronic box.

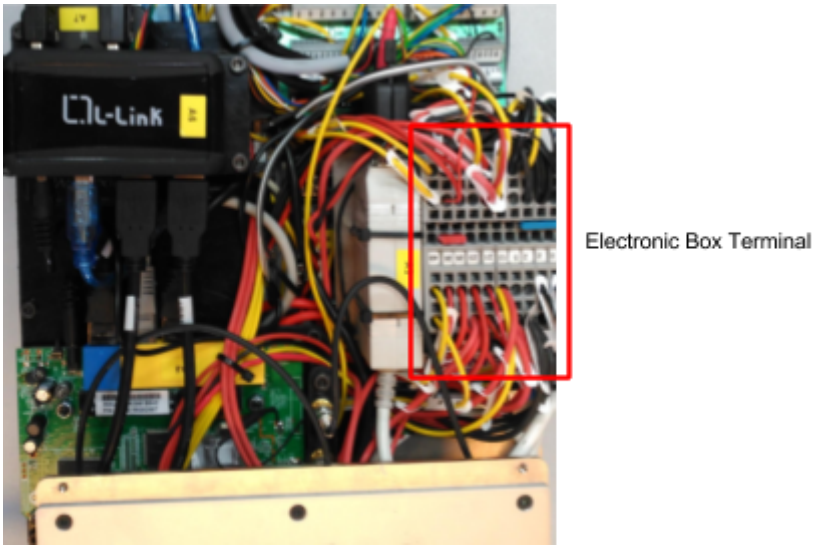


Figure 10- Electronic box terminal location

The next picture shows where is located the terminal inside the torso. The terminal distributes the power to all the components of the torso and the motors of the head.

Figure 11- Torso terminal location

2.2.4 Control components

2.2.4.1 Embbeded PC

The embbeded PC is located inside the electronic box.

The main board is an Intel NUC BOXNUC5i7RYH. The computer is completed with 8GB of RAM and a M.2 HDD.

Figure 12 – PC board

For more information go to:
http://www.intel.com/content/www/us/en/nuc/nuc-kit-nuc5i7ryh.html

The embedded Linux PC is located inside the electronic box, under the N Wireless Router. Its maintenance is equivalent to a standard PC station.

The main problem can be due to the accumulation of dust in the internal components, so it acts as thermal insulator. The heat generated by the components cannot be well dissipated because it is trapped in the dust layer.

The oil and grease particles contained in the environmental air mix with the dust, creating thus a big insulation layer that reflexes the heat to other components. This effect causes a reduction of the system useful life. On the other hand, the dust contain conductive particles that can generate short-circuits throughout the circuit boards or the peripheral cards.

The best way to extend the life of the equipment and make it free of reparations for many years is to clean it and remove the dust frequently.

2.2.4.2 Wireless Router

The wireless router is located inside the electronic box.

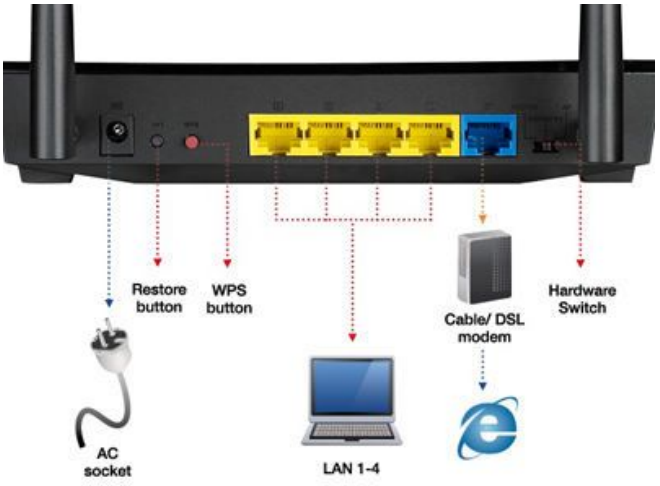


Figure 13– ASUS RT-N12

The huge 9dB antennas are changed with smaller 5dB antennas

Technical Specification

- Wireless Data Transfer Rate: 802.11n: 300Mbps
- Supports router, access point & range extender modes
- Port triggering for special applications
- DDNS and SIP•Guest network
- Virtual server and DMZ hosting
- MAC/IP filter and URL blocking
- Static routing
- UPnP architecture
- VPN pass-through (IPSec/PPTP)
- Wi-Fi schedule control

2.2.5 Sensors

2.2.5.1 Pixhawk

The Pixhawk is located inside the electronic box. It is used as an IMU (Inertial Measurement Unit) to better estimate the robot position, using the Pixhawk integrated gyroscope and accelerometers.

Figure 14 - Pixhawk FCU

Key Features:

- 168 MHz / 252 MIPS Cortex-M4F
- 14 PWM / Servo outputs (8 with failsafe and manual override, 6 auxiliary, high-power compatible)
- Abundant connectivity options for additional peripherals (UART, I2C, CAN)
- Integrated backup system for in-flight recovery and manual override with dedicated processor and stand-alone power supply (fixed-wing use)
- Backup system integrates mixing, providing consistent autopilot and manual override mixing modes (fixed wing use)
- Redundant power supply inputs and automatic failover
- External safety switch
- Multicolor LED main visual indicator
- High-power, multi-tone piezo audio indicator
- microSD card for high-rate logging over extended periods of time

Pixhawk is connected to the PC using a FTDI_USB-to-UART cable on the TELEM2 port.

More info in https://pixhawk.org/modules/pixhawk

2.2.5.2 Orbbec

The Orbbec is located in the front of the base and also in the head of the robot. The Astra 3D cameras are excellent for a wide range of scenarios, including gesture control, robotics, 3D scanning, and point cloud development.

Figure 15 - Pixhawk FCU

Key Features:

- Power: 5V (USB 2.0)
- Range: 0.4 - 8 m
- Depth image size: 640*480 (VGA) 16bit @ 30FPS
- RGB image size: 1280*960 @ 10FPS
- Data interface: USB 2.0
- Microphones: 2
- Weigth: 300 g

2.2.5.3 Hokuyo

The robot can be equipped with several models. It will be located in the front side of the base Below you can see the standard laser range finders mounted.

URG-04LX-UG01 Indoor Environment Wide Angle: 240º Angular resolution: 0.36º Scanning time: 100 ms Measuring area: 20 to 5600mm Accuracy: 60 to 1000mm : ±30mm; 1000 to 4095mm : ±3% of measurement Interface: USB	

URG-04LX Indoor Environment Wide Angle: 240° Angular resolution: 0.36º Scanning time: 100 ms Measuring area: 20 to 4095mm Accuracy:60 to 1000mm : ±10mm; 1000 to 4095mm : 1% of measurement Interface: USB, RS232	
UST-10LX Outdoor Environment Wide Angle: 270° Angular resolution: 0.25º Scanning time: 25 ms Measuring area: 0.06m to 10m Accuracy: ±40mm Interface: Ethernet	
UST-20LX Outdoor Environment Wide Angle: 270° Angular resolution: 0.25º Scanning time: 25 ms Measuring area: 0.06m to 20m Accuracy: ±40mm Interface: Ethernet	

Table 2 – Laser Range Finders

2.3 Controllers

This section describes where are the controlers of the robot.

2.3.1 Control Panel

The robot presents in its back several buttons, indicators and connectors:

Figure 16 - Control panel

- **EMERGENCY STOP**: disables the drivers and stop the robot, the torso and head movement and arm power.
- **RESTART** button: restart the power of all the motors and the arm. It has a orange light indicator.
- General **ON/OFF key** (S1): cuts the power of the whole robot. It has a green light indicator.
- **CPU** power blue indicator/switch: turns on and off the computer
- **CHARGER**: to connect the provided battery charger
- Two free **USB** 2.0 ports
- Two Ethernet ports (**WAN** ansd **LAN** port)
- **HDMI** port.
- Wi-Fi **antennas**
- **FUSES** access

2.3.2 Gamepad

The Gamepad used for the manual movements of the robot RB-1 is a Bluetooth Joystick. The NUC board has an internal bluetooth receiver.

The two joysticks are used for direction, traction and elevation and there are important controls like the speed level buttons that select between five speed ranges: very slow, slow, medium, high, and very high

Figure 17 – DUALSHOCK controller

All functions are fully explained in the section Start-up of the software manual

2.4 Battery

The robot receives the power supply from a LiFePO4 battery pack. It is composed of sixteen 3.2V LiFePO4 cells and a protection circuit module. With this set of batteries the robot is able to operate up to 10 hours or more, depending on the robot movements.

The robot circuit is powered when the general switch S1 is ON. The control DC/DC converter, that makes power to the different devices of control, is powered at the same time.

The batteries are connected to the robot through the fuses. For charging the batteries there is a connector at the back panel of the robot where the charger can be connected. It is a direct connection, so the general ON/OFF switch doesn't affect the charging. It is possible to charge the robot and keep working at the same time without any problem.

There is a 15A fuse (F0) between the connector and the batteries for safety. This fuse is on the electronic box.

Also there are two plates in the front of the battery to connect to the automatic charging station.

Figure 18- Plates for automatic charge

There is a 20A fuse (F00) between the plates and the batteries for safety. This fuse is inside the battery pack..

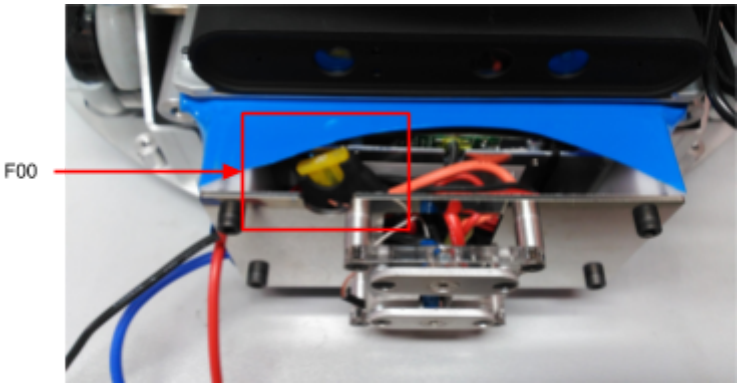


Figure 19- Fuse F00 location

Full charging time is around 45-60 minutes for the supplied charger. Do not use other chargers without checking battery specifications.

2.4.1 Battery Pack

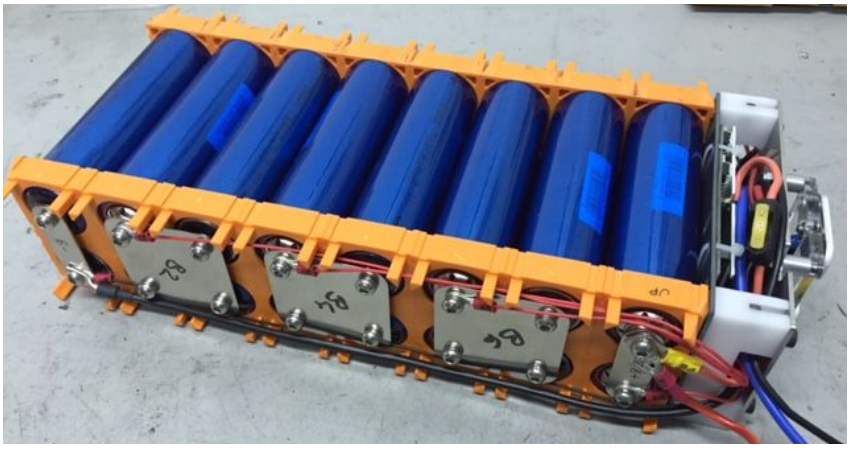


Figure 20– Battery Pack

The battery pack is composed of sixteen LiFePO4 cells and a protection circuit module. The whole package is protected with shrinkable tube.

The batteries must be kept clean and dry in order to avoid escape currents. Check the wear out of the battery wires to prevent short circuits.

The battery can be separated from the robot by taking out the battery cover and unplugging the power supply connector..

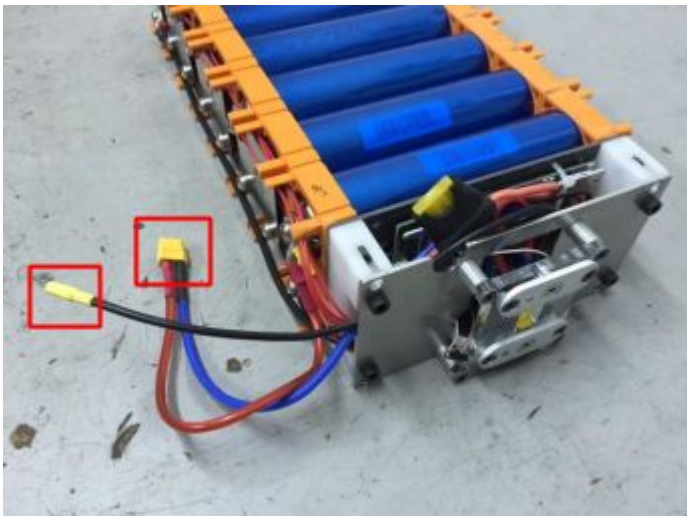


Figure 21– Power supply connector from the Battery Pack

IMPORTANT: Recharge the batteries ASAP if fully discharged. Keeping the voltage low for a long time will greatly reduce the lifecycles.

2.4.2 LiFePo4 Cell

Figure 22 LiFePo4 cell

Specifications:

- Normal capacity 15000mAh
- Normal voltage 3.2V
- Inter impedance <8mOhms
- Maximum continuous Discharge Current 10C(150A)
- Charging Temperature: -10 – 45ºC (14 – 113º F)
- Discharging Temperature: - 20 – 60ºC (14 – 140ºF)
- Cycle Performance: >2000 (80% of initial capacity at 1C rate)
- Standard Charging current: 1C (15A), Max. 5C (75A)
- Weight: 500g

2.4.3 Protection circuit module

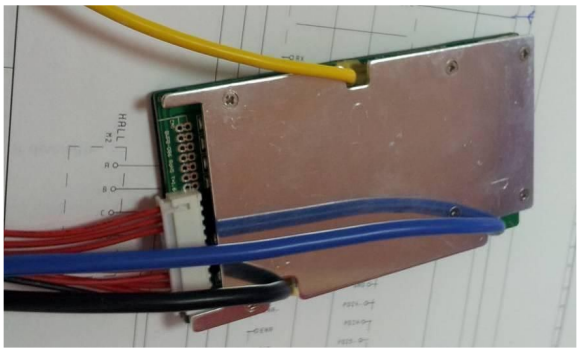


Figure 23– Protection circuit module

24V BMS 8CELLS 30A

Item	8 series balancing guard shield
Over charge protection (V)	3.95±0.025
Over charge recovery (V)	3.80±0.05
Over discharge voltage (V)	2.2±0.1
Over discharge recovery (V)	Cut load or charge
Normal working current (A)	30
Over current protection (A)	60
Internal resistance (m/ohm)	<30
Charging balancing current (mA)	60
Charging balancing voltage (V)	3.63±0.03
Over charge postpone time (mS)	1.2
Over discharge postpone time (mS)	144
Temperature protection (℃)	65℃ (option)
Temperature characteristic	±1.0mv/℃
Working temperature (℃)	-10~+60
Storage temperature (℃)	-30~+85
Power loss (uA)	<400 (Vn=3.2v normal) <200 (Vn=2.2v Under-voltage)

Table 3 – Battery pack characteristics

2.5 Charger

The Charger supplied is shown in the next picture.

The Smart Charger is designed for rapidly charge 29.2V (8 cells) LiFePO4 Battery pack.

Figure 24– LiFePo4 Smart Charger

IMPORTANT: CHECK POWER SELECTION BEFORE PLUGGING IT

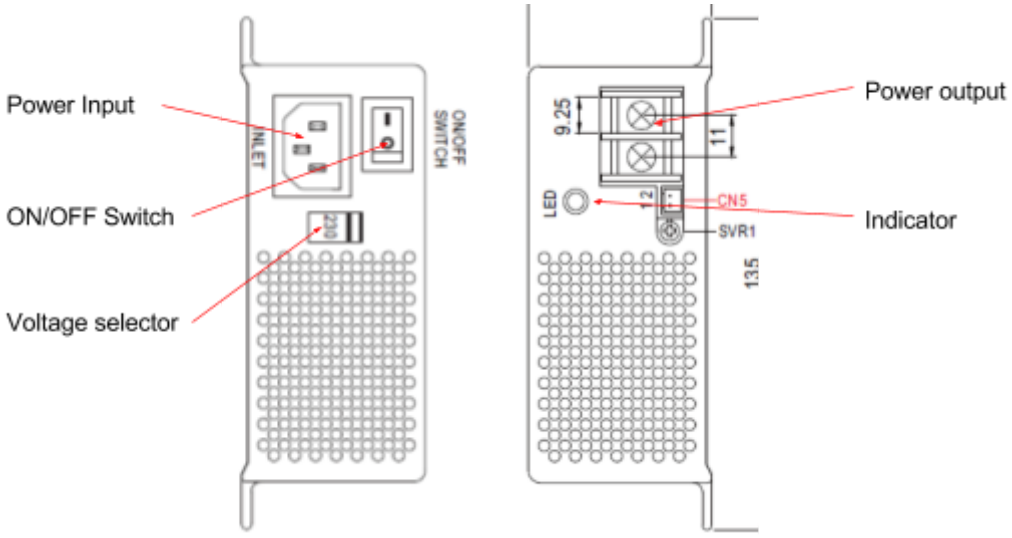


Figure 25– Charger connections

Specifications:

- INPUT
  - o Voltage range: 90 ~ 132VAC / 180 ~ 264VAC selected by switch
  - o Frequency range: 47 ~ 63Hz
- OUTPUT
  - o Boost votlage: 28.8 V
  - o Float voltage: 27.2 V

- Max output current: 10.5A
- Continous current: 6.25 A

For mor information go to:

http://www.meanwell.com/mw_search/PB-300/PB-300,360-E.pdf

LED Indicator:

- Red: Constant current & constant voltage state
- Green: Floating state

Caution:

- **The charger is designed for indoor use only.**
- **The charger should be placed horizontally and operate in well ventilated condition, avoid humidity and keep it away from inflammable explosive material.**
- **The aluminum case is a heat sink, do not cover it.**
- **Do not disassemble the charger due to high voltage inside**.

3 Accessibility

This section describes how to access to the different internal parts of the robot.

3.1 Base

To have access to the motors, orbecc camera, laser and the power and motor connectors you have to remove the covers as it's shown in the following pictures.

REMOVE FRONT AND BACK COVER:

The screws to remove are marked with a red circle.

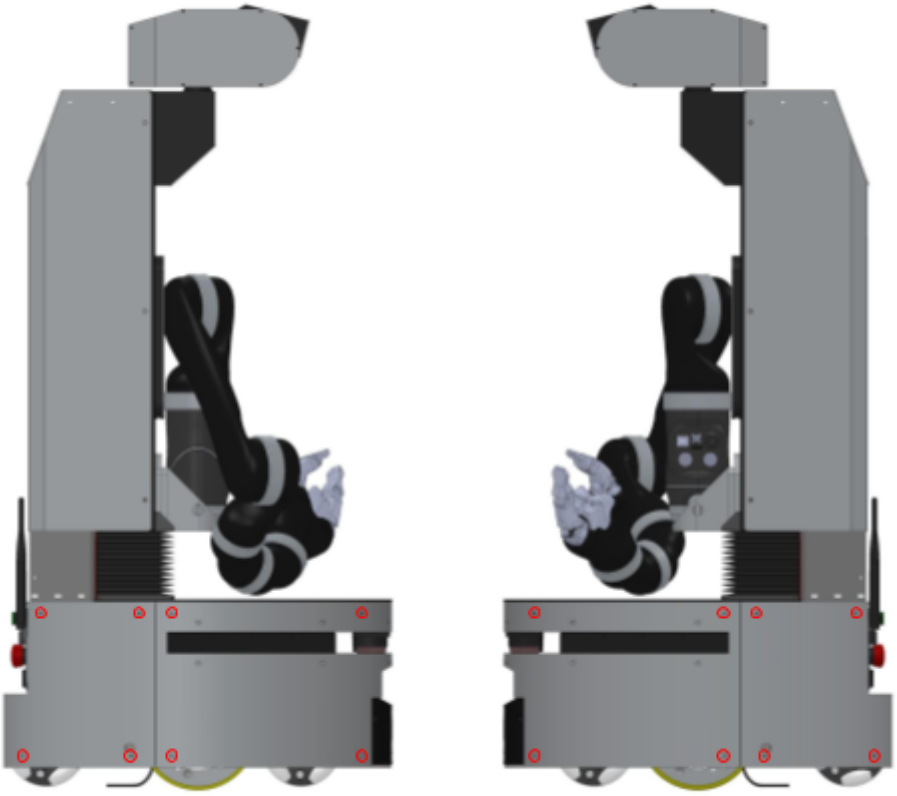


Figure 26 – Front and back cover screw removal

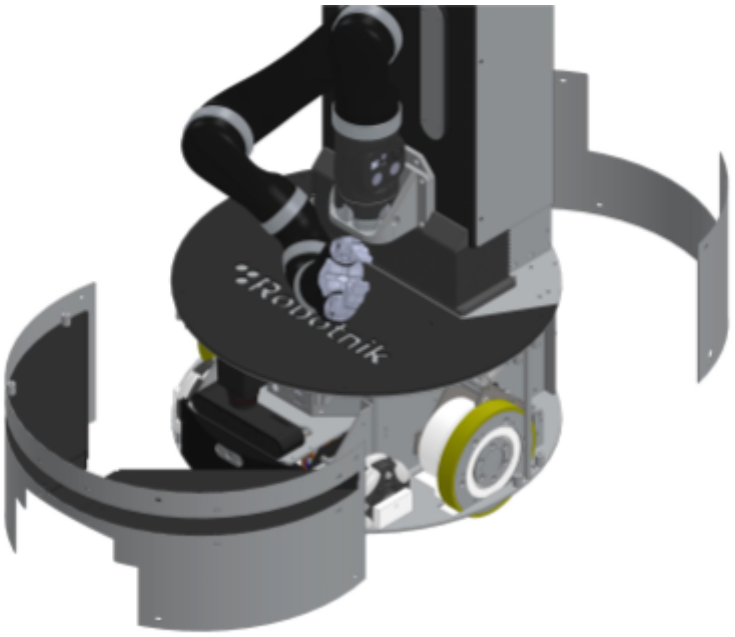


Figure 27 – Front and back cover

3.2 Electronic box

To extract the electronic box you have to remove the back and front covers of the base and later follow the instructions of the following pictures:

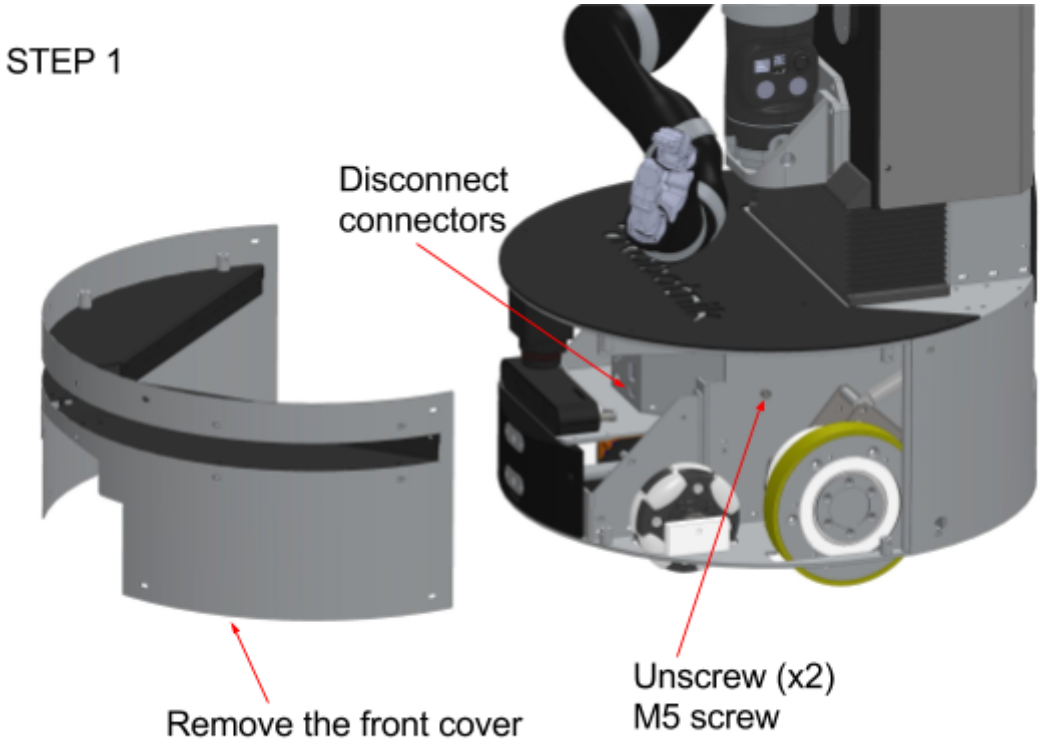


Figure 28 – Electronic box extraction - Step 1

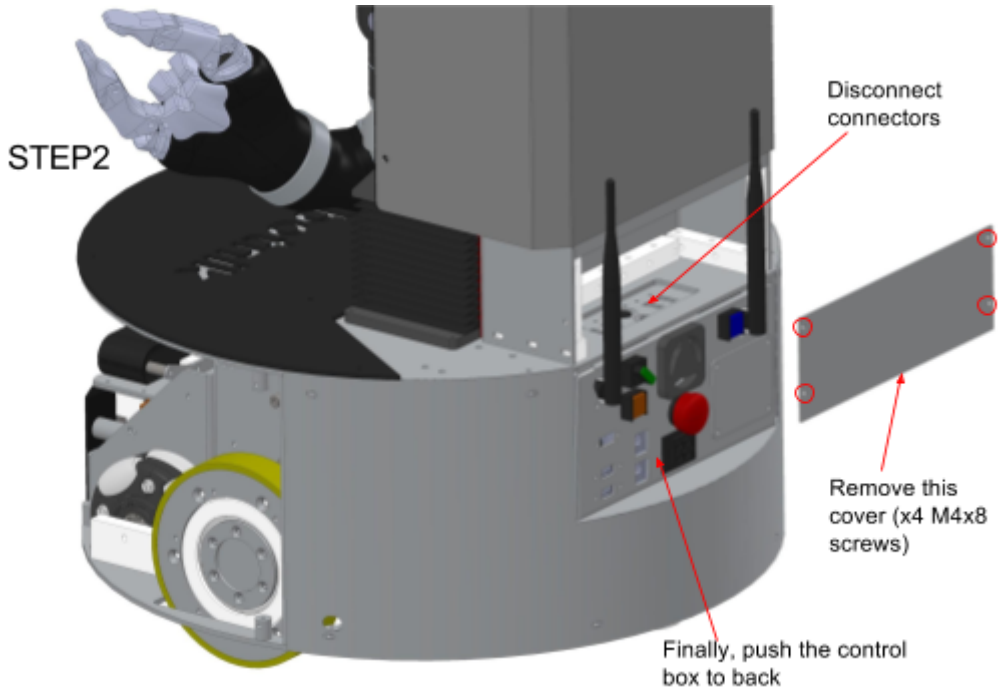


Figure 29 – Electronic box extraction - Step 2

Next picture shows the components locates inside the electronic box.

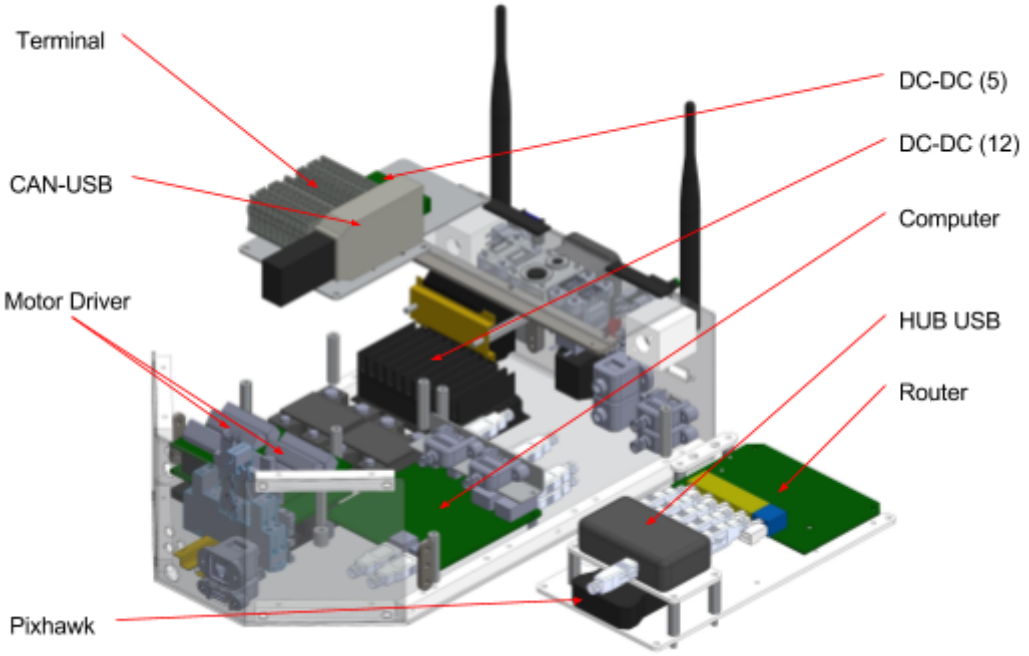
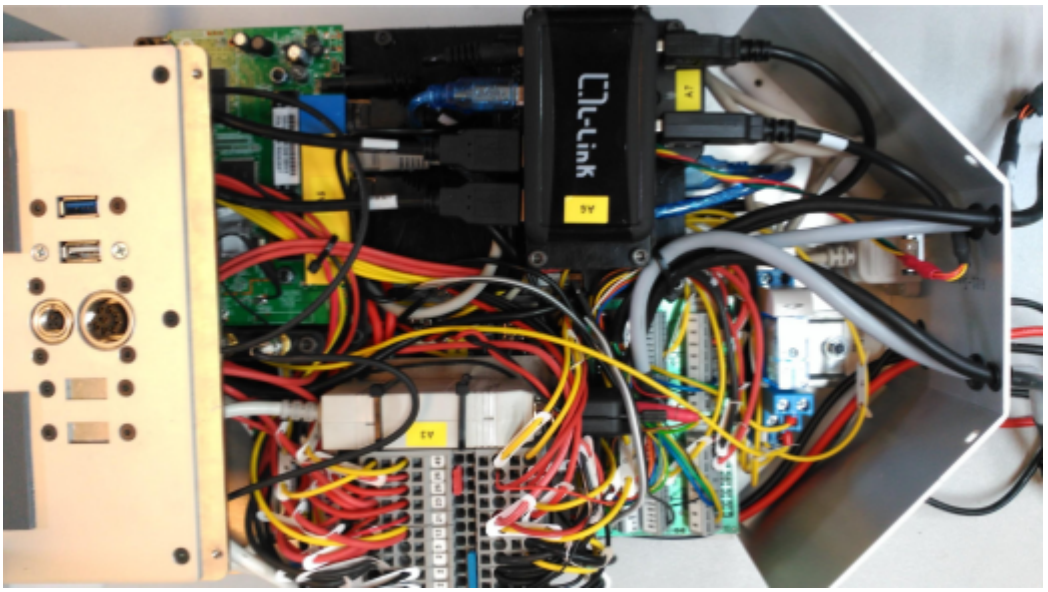


Figure 30 – Electronic box components

Last picture shows the real aspec of the interior of the box.



Figures 31 - Internal view

3.3 Torso

To have access to the electronics inside the torso you have to remove the covers as it's shown in the following pictures.

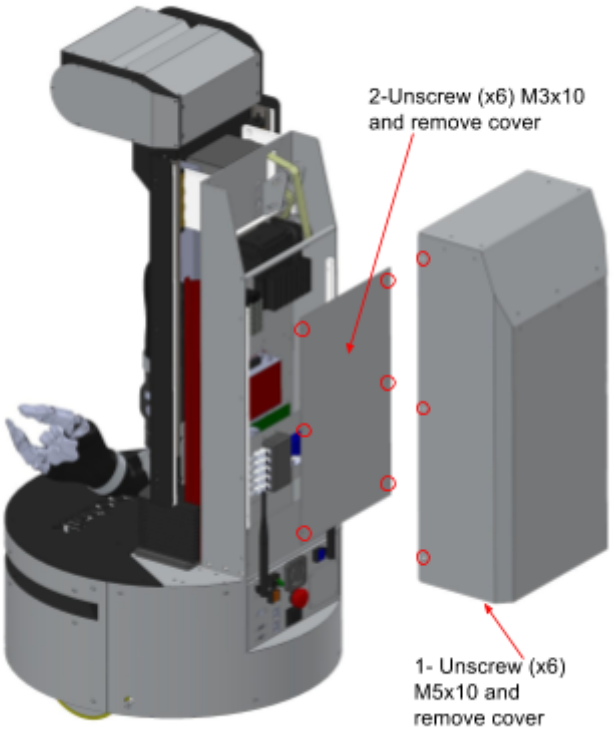


Figure 32 – Torso covers removal

Next picture shows the components locates inside the torso.

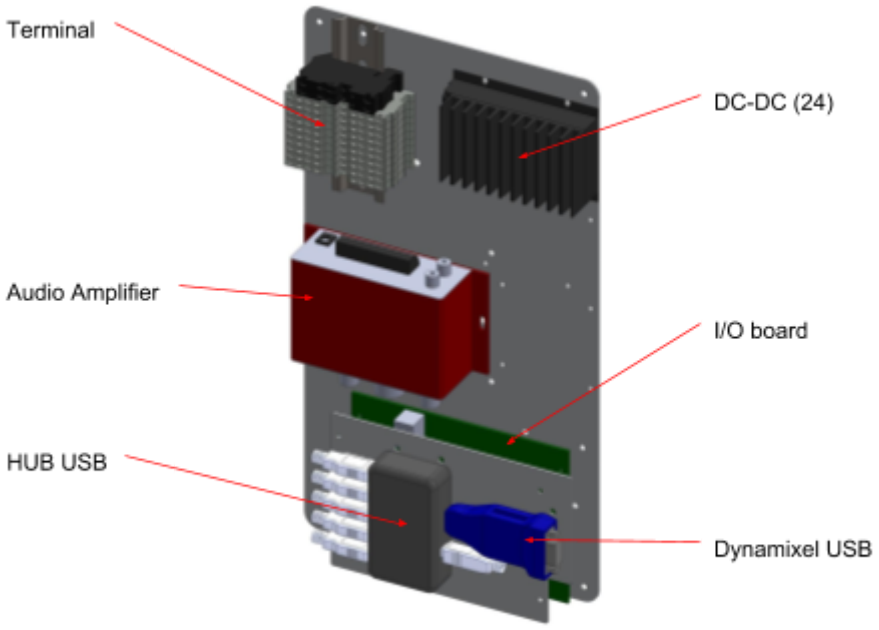


Figure 33 – Interior torso components

Last picture shows the real aspec of the interior of the torso.

Figures 34 - Internal view

3.4 Head

To have access to motors of the head you have to remove the covers as it's shown in the following pictures.

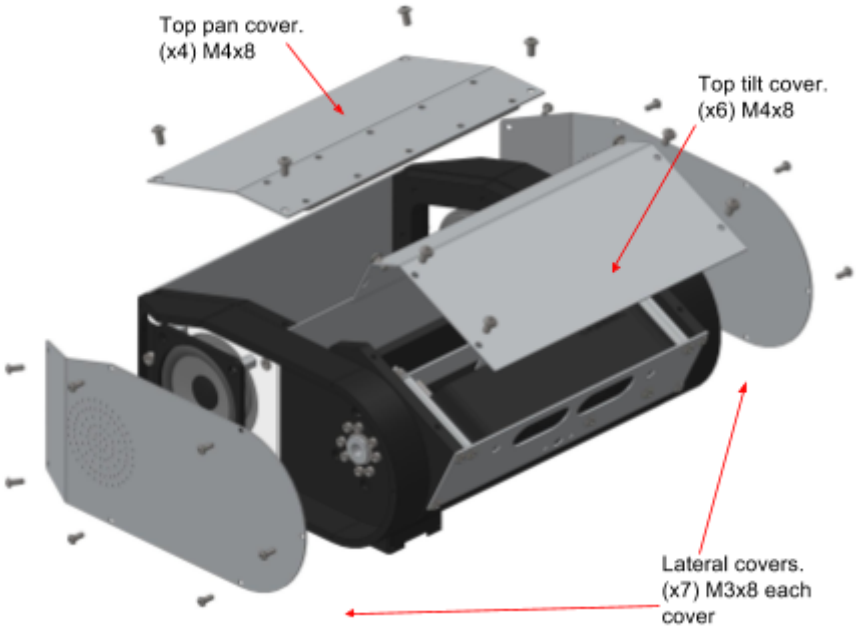


Figure 35– Head covers removal

3.5 Battery

To remove the battery pack you have to follow the followin steps.

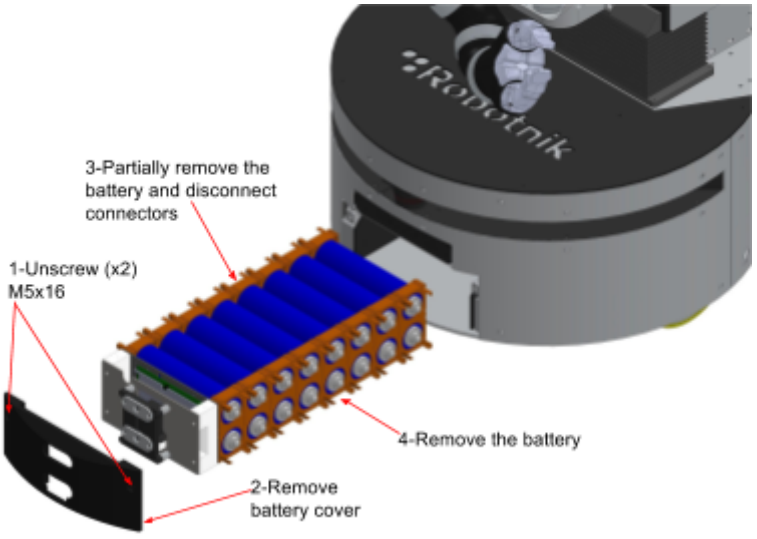


Figure 36– Battery pack removal

4 Connectivity.

This section describes the connectivity present in the robot.

4.1 Back Panel

The robot on their back panel has two USB, a HDMI port and two Ethernet ports (WAN and LAN):

Figure 37 - Control panel

4.2 Head Panels

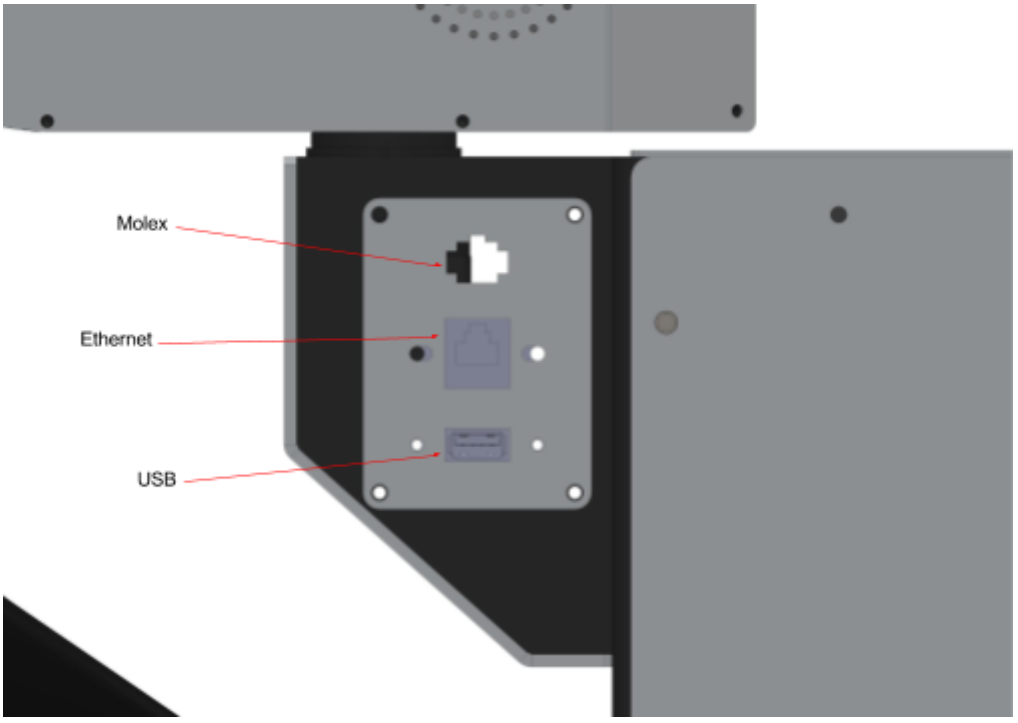


Figure 38 - Head panel

Figure 39 - Molex pinout

Pin	Voltage
1	GND
2	12VDC
3	GND
4	5VDC

Table 4 – Molex voltage pinout

5 Comunication diagram

The following figure shows the communication diagram existing inside the robot.

The functionality of the system can be further extended by using the free Ethernet ports and free USB port.

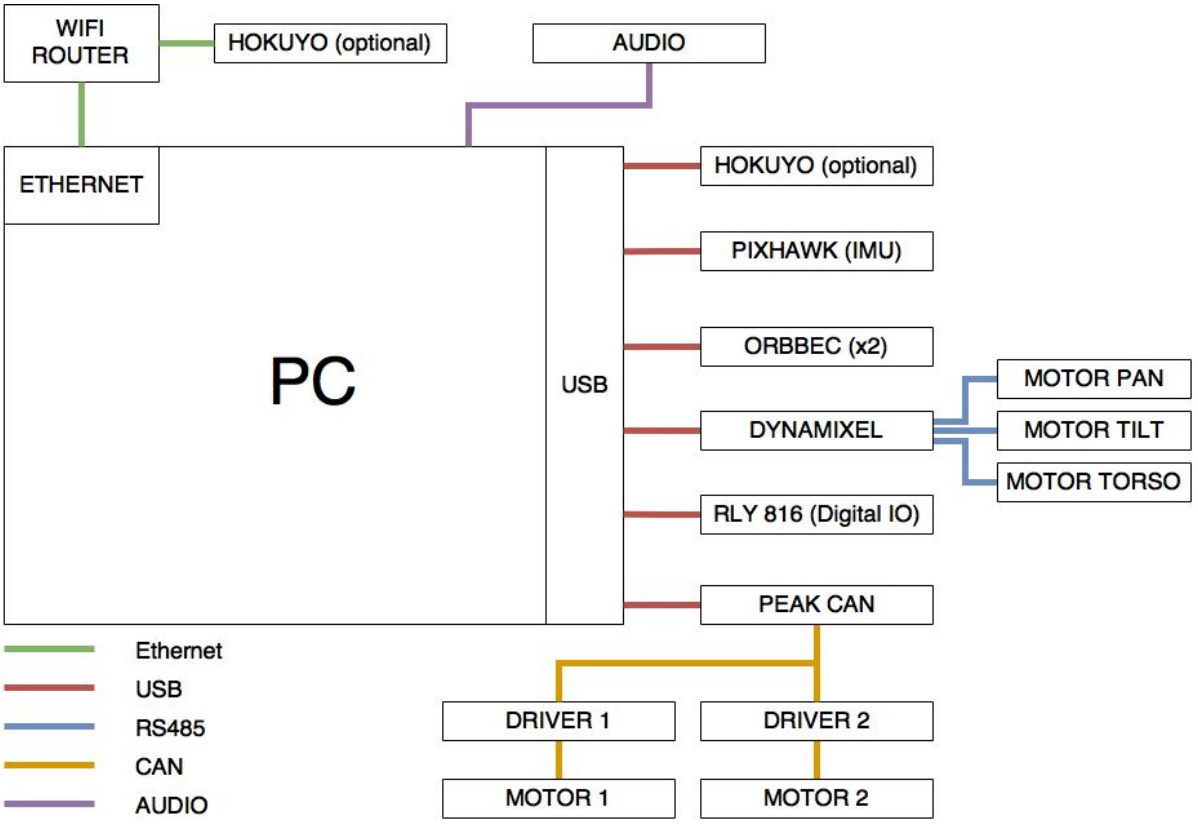


Figure 39– Communications diagram

6 Maintenance

The following table shows some elements that need maintenance and the periodicity of this maintenance.

	Often	*Every 6 month*	*Observations*
Screws	Check they are not loosen.		
Tires		Visual control of the wear rate.	Replace when needed
Outer wires		Visual control of the wear rate.	If wear appears, protect them with Shrink tube, Vulcan tape or similar.
Bearings		Control state.	If any damage appears, it is recommended its replacement by a new one.
Battery	Control Batteries Voltage, don't let the batteries get fully discharged	Check battery autonomy	Recharge ASAP if fully discharged
PC		Interior Cleaning. Visual control of the correct work of the fan (if installed).	

Table 4 – Maintenance summary

7 Basic Drawing

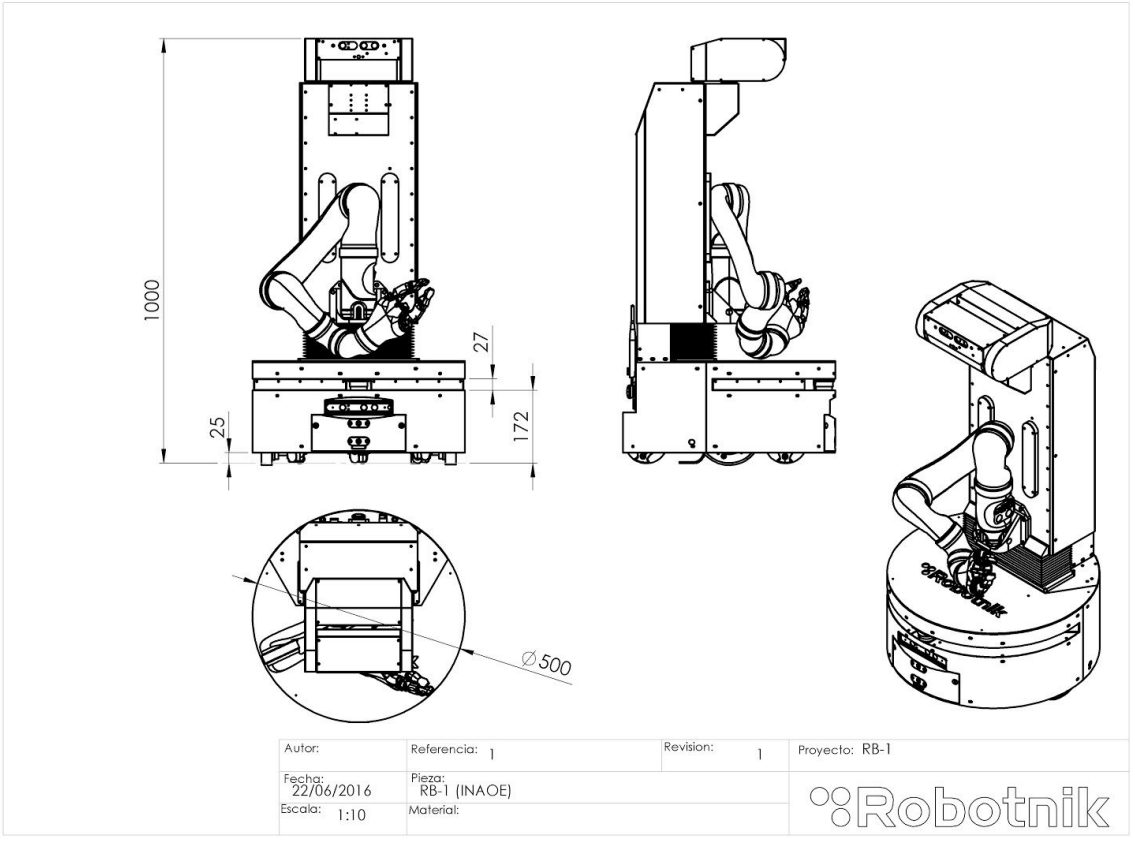


Figure 38– External robot drawings