Robotnik

SUMMIT XL STEEL

MOBILE ROBOT

HARDWARE MANUAL

Robotnik Automation,
Spain

RBTNK-DOC-SXLS0-190507AA

Contents

1. Introduction

This Manual describes the main parts of the SUMMIT XL STEEL mobile robot, as well as how are they assembled. Every main piece includes a little description of the mechanical component that composes it, emphasizing the elements that need a special periodical control and maintenance. The location and maintenance of other non mechanical components is also described below.

Finally, a summary of the basic drawings of the vehicle and the main components has been included.

2. External Elements

The next figures show the main parts of the default robot:

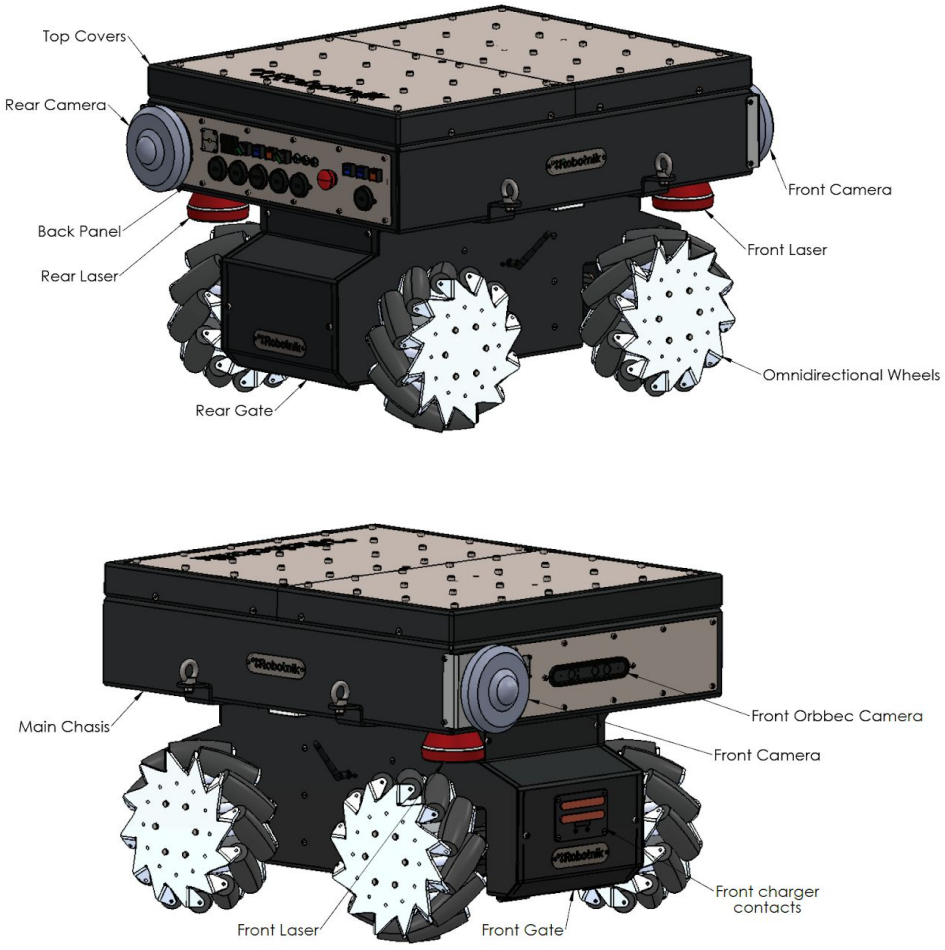

Figure 1 – Main parts of SUMMIT XL STEEL robot

The main parts that form the robot are:

- **Main chasis**: It is made of metal. The electrical components are placed inside.
- **Top Covers**: Can be removed to access to the interior of the robot where some of the control components like the control computer are placed.
- **Gates:** Can be opened to access to the robot batteries.
- **4 Motor wheels**: 500w brushless motor with Hall Effect sensor and a reduction gear box inside the aluminum wheel.
- **Battery:** 16 LiFePO4 3.2V 15Ah cells.
- **Sensors:** There are 2 S300 lasers, 2 PTZ cameras and 1 Orbbec camera.
- **Back panel:** This panel have several buttons and connectors.

2.1. Motor wheels

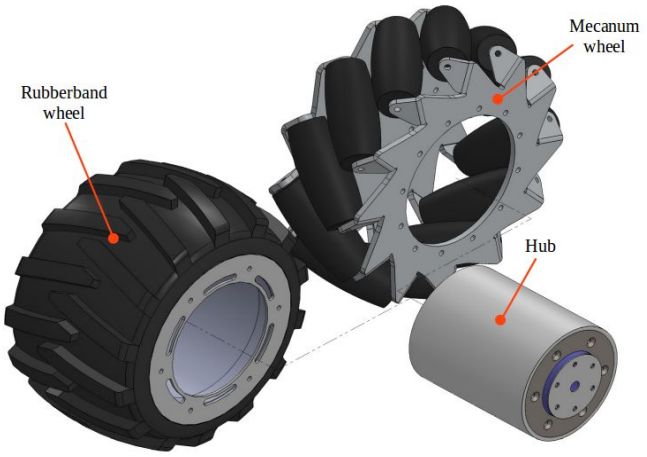

Figure 2 – Motor wheels

The robot has 4 motor wheels with the same configuration. Each wheel is composed by a motor block and a detachable wheel. The motor block has a 500w 8 poles brushless motor with Hall Effect sensor 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.

The cable must be kept in good condition, and protected if the external cover is damaged. There are three 48V power wires, two 5VDC power and three Hall Effect signals. If they are short-circuit, the motor and the driver can be damaged.

2.1.1 Tightening torque of the wheels

Wheels are attached to the hub via six hexagonal head screws. In the following table you could find the tightening torque four wheels depending the situation. These are the recomended value to avoid damages in the wheels.

Tightening torque of the wheels		
Case	One set of wheels	Various sets of wheels
Description	Your robot comes with a set of wheels rubber or mecanum.	Your robot comes with a set of rubber wheels and with a set of mecanum wheels
Tightening torque	4.5 N.m	4 N.m

Table 1 – Tightening torque for wheels

2.2. Motor Drivers

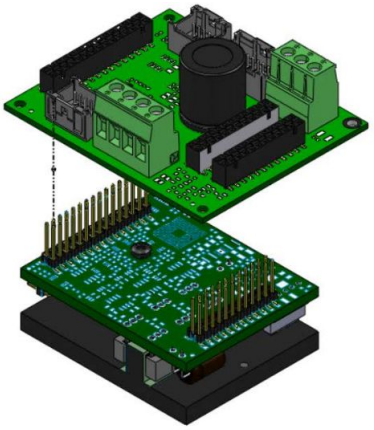

Figure 3 – Motor Driver & Connection Board

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, 2, 3 and 4). DO NOT change them from one motor to another. To reduce power consumption, if the velocity is zero, only the rear wheels brake, the front ones are free.

The computer sends CAN messages to move the robot, and they are different from the left side (1 & 2) and right side (3 & 4). Driver 1 is the only one with the Can bus resistor installed.

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

2.3. Control Panel

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

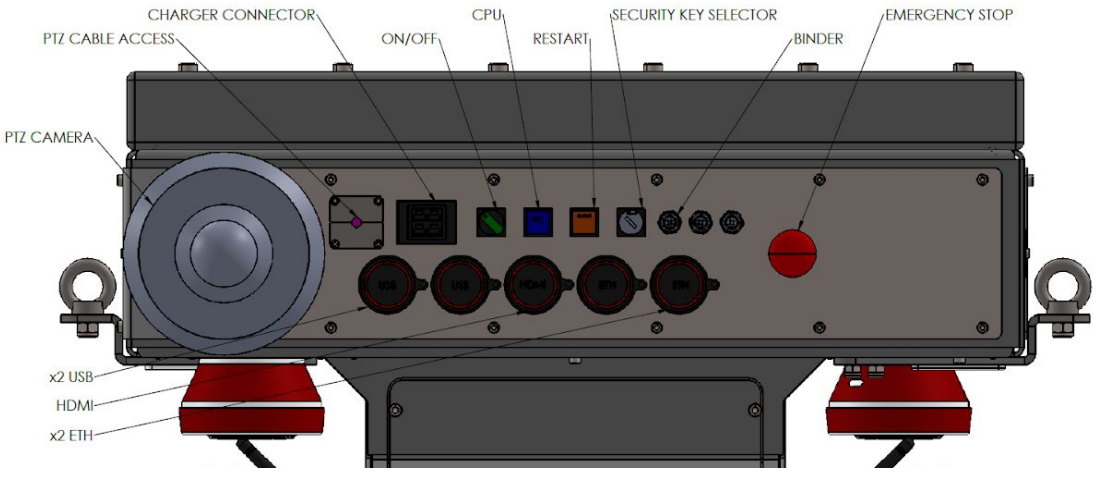

Figure 4 - Control panel

- **EMERGENCY STOP** will disable the drivers and stop the robot. CAUTION there is no rearm button, so the robot will keep moving when the Emergency Stop is released.
- General **ON/OFF** key: cuts the power of the whole robot. It has a green light indicator.
- **CPU POWER** blue indicator/switch: turns on and off the computer
- **RESTART:** orange indicator button restarts the power of robot.
- **CHARGER CONNECTOR**: to connect the provided battery charger
- Three **binder** connectors: 5,12 VDC BAT. Intended to power external devices and protected with fuse
- Two free **USB** 2.0 ports
- Two **Ethernet** ports WAN and LAN
- One **HDM**I port.

The general ON/OFF SWITCH (green) must be activated for giving energy to all the elements of the system. Then, press the CPU POWER BUTTON (blue) button to turn ON the computer, the blue button will light up. At this moment the PC (Linux) boots up and loads all the necessary programs to operate the robot.

To move the robot, the **EMERGENCY BUTTON** (red) must be pulled out.

NOTE: Remember that the robot is able to reach high speeds. Use the higher speeds only in open areas.

2.4. Hokuyo Laser Range Finder UST-10LX

The robot is equipped with UST-20LX lasers. They will be located in two corners of the base Below you can see the standard laser range finders mounted.

Emvironment: Indoor
Ambient iluminance: 15k lux
IP Protection: IP65
Wide Angle: 270º
Angular resolution: 0.25º
Scan frecuency: 40 Hz
Measuring area: 0.06 - 10 m
Accuracy: +-40 mm
Interface: Ethernet

Figure 5 – UST-20LX Laser & specifications

More info in: https://www.hokuyo-aut.jp/search/single.php?serial=167

3. Internal Elements

Following we are listing other non-mechanical components to be in consideration for maintenance tasks:

- PLATFORM CPU
- ARM CPU
- ROUTER
- FUSES AND TERMINALS
- DRIVERS
- IMU
- DC/DC
- FLEXISOFTS MODULS

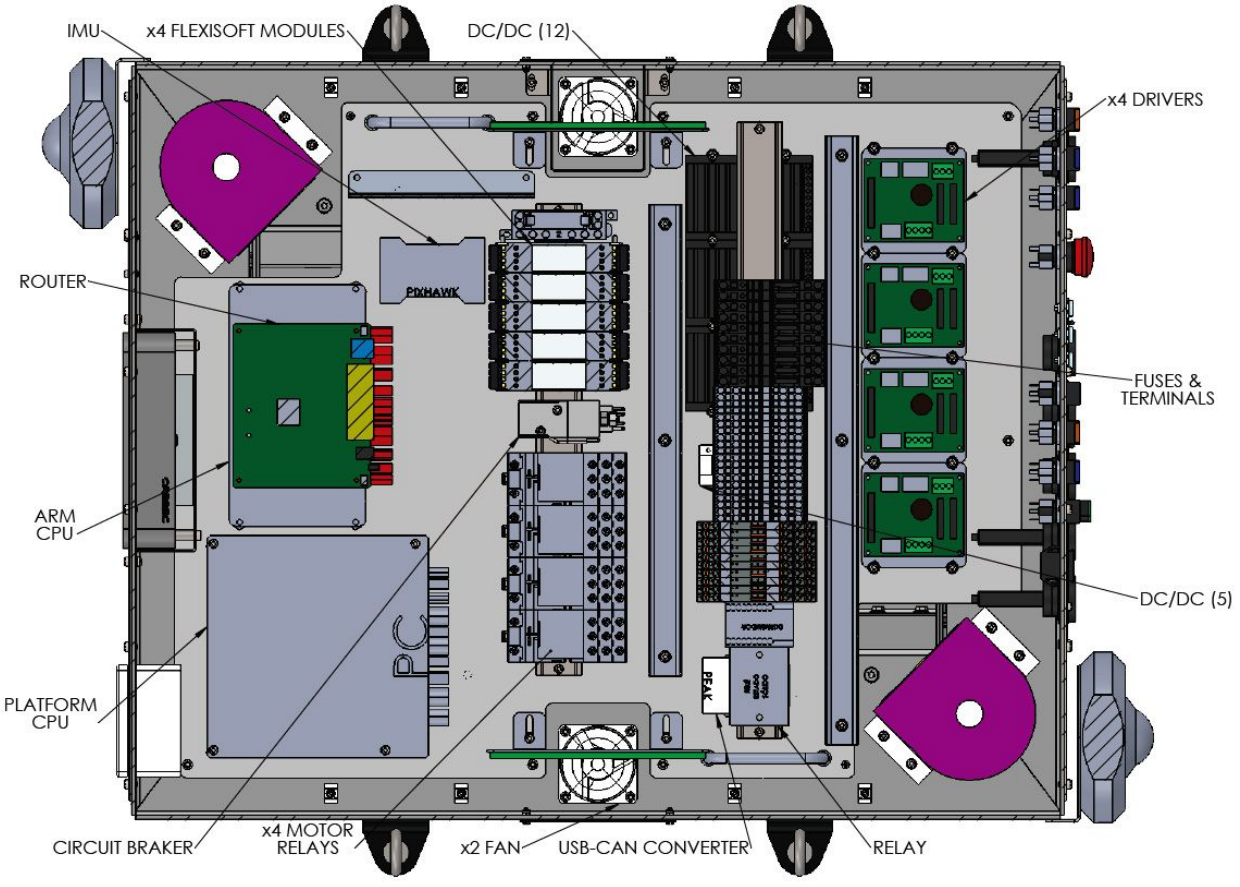

Figure 8 – Electronic board

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3.1. Embedded PC

Figure 9 – PC board

Form Factor	Mini-ITX Mainboard
Processor Chipset	Intel® Celeron™ J1900 (4x 2.42GHz) 2MB Cache, VT-x/Intel64-compatible
Memory	2x SO-DDR3L [Low Voltage, 1.35V] 1066/1333, 8GB max, Dual channel
Graphics	VGA + HDMI + LVDS + eDP
Audio	2+2 Channel HD Audio
Super I/O	FINTEK F81866A
Back Panel	- 2x USB 3.0, 2x USB2.0 - 1x LAN RJ-45 - 2x Audio - 1x HDMI - 1x VGA - 1x DC-In (10-19V)
Connectivity	- 2x SATA-II (3GB/s) - 5x USB 2.0 - 1x PCIe - 2x Mini-PCIe - Front Audio - SPDIF - 1x LPT

	- 2x RS232 - LVDS (Dual 24bit) - eDP (4-lane 24bit) - Z-U130 Flash Drive support - TPM stuffing option - Mobile SATA (SSD) support via Mini-PCIe - ExpressCard/34 support via Mini-PCIe

Table 2 –Mitac P10BI

The embedded Linux PC is located in the middle of the robot, under the wireless router. Its maintenance is equivalent to a standard PC station.

Issues could appear 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.

3.2. WIFI Router

Figure 10– Router

- Network Standard
- IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, IEEE 802.3, IEEE 802.3u, IPv4, IPv6
- Product Segment
- N300 complete networking; 300Mbps
- Data Rate
- 802.11b : 1, 2, 5.5, 11Mbps
- 802.11g : 6,9,12,18,24,36,48,54Mbps
- 802.11n : up to 300Mbps
- Antenna
- Detachable 5 dBi antenna x 2
- *Antenna type will differ according to local regulations and requirement in each country
- Operating Frequency
- 2.4GHz
- Encryption
- 64-bit WEP, 128-bit WEP, WPA2-PSK, WPA-PSK, WPA-Enterprise , WPA2-Enterprise , WPS support
- Management
- UPnP, IGMP v1/v2/v3, DNS Proxy, NTP Client, DDNS, Port Trigger, Virtual Server, DMZ
- VPN Support
- IPSec Pass-Through
- PPTP Pass-Through
- L2TP Pass-Through
- PPTP server
- Ports
- 1 x RJ45 for 10/100 BaseT for WAN, 4 x RJ45 for 10/100 BaseT for LAN
- Button
- WPS Button, Power Button
- Power Supply
- DC Output : 12 V with max. 0.5 A current

3.3. DC/DC 12VDC & 5VDC

There are Motor supply and Control supply with isolated GNDs. The motor power is taken directly from battery, but need the driver need a 5V power. The 12V DC/DC and another 5V DC/DC are isolated from motor and battery GND.

A 150W 12V DC/DC to provide a stable power supply for the electronic elements (PC, Axis camera, external power,…).

Figure 11- 12V DC/DC

There are two 5V DC/DC one to power the motor drivers and the other for logic.

Figure 12- 5V DC/DC

3.4. Terminals & Fuses

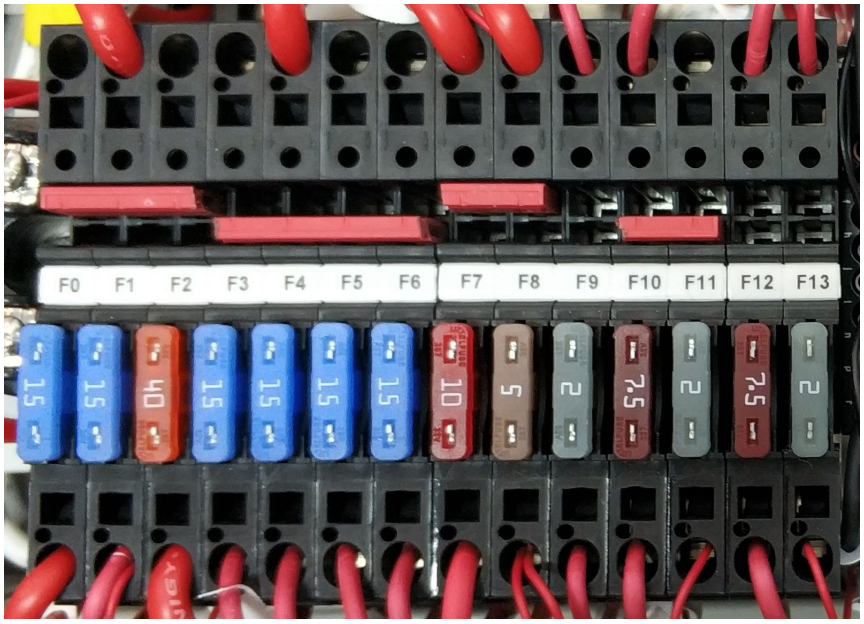


Figure 13 - Fuses

At the picture you can see the DIN rail the following fuses:

- Fuse F0: [15A] Front panel charge connector for docking station.
- Fuse F1: [15A] Back panel charge connector & switch S1.
- Fuse F2: [40A] Main fuse, connected to battery directly.
- Fuse F3: [15A] driver 1.
- Fuse F4: [15A] driver 2.
- Fuse F5: [15A] driver 3.
- Fuse F6: [15A] driver 4.
- Fuse F7: [10A] Vin for 5V, 12V and 24V DC/DCs.
- Fuse F8: [5A] Back Panel Battery OUTPUT (+BAT).
- Fuse F9: [2A] Non isolated 5V OUTPUT, for drivers.
- Fuse F10: [7.5A] 12V DC/DC converter OUTPUT (+12V).
- Fuse F11: [2A] Back panel 12V OUTPUT (+12V).
- Fuse F12 [7.5A] 24V DC/DC converter OUTPUT (+24V).
- Fuse F13 [2A] Back Panel 5V OUTPUT (+5V).

3.4.1. Initial setup of the fuses

After unpacking the robot, fuses from battery and back panel you have to insert it in the fuse holder before to turn on the robot.

Important: Electrical damage danger. Check the power ON/OFF is in OFF position before plug any fuse in the fuse holder.

Figure 14 - Power button in OFF position

- Insert fuse with number 15 in the fuse holder labelled as F1 and F2
- Insert fuse with number 40 in the fuse holder labelled as F3.

See chapter 5 for full electric drawings.

3.5. IMU: FPU Pixhawk

Pixhawk FPU is used as an IMU (Inertial Measurement Unit) to better estimate the robot position, using the Pixhawk integrated gyroscope and accelerometers.

Figure 15 - 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. The following table shows the mapping between Pixhawk TELEM2 pins and FTDI pins or wire colors.

TELEM2		FTDI	
1	+5V (red)		Not Used
2	Tx (out)	5	FTDI RX (yellow) (in)
3	Rx (in)	4	FTDI TX (orange) (out)
4	CTS (in)	6	FTDI RTS (green) (out)
5	RTS (out)	2	FTDI CTS (brown) (in)
6	GND	1	FTDI GND (black)

Table 3 - FTDI_USB-to-UART pinout

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

4. Manual Controls

The gamepad functions are fully explained in the System Start-up Manual.

4.1. DualShock game-pad

The Gamepad used for the manual movements of the robot is a Bluetooth Joystick. The receiver is located inside the robot and connected to one USB port of the computer.

The two joysticks are used for direction, traction 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 16 – DUALSHOCK controller

5. Battery and Charger

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 3 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, and also the external 12V power connector.

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. See chapter 5 for full electric drawings.

Full charging time is around 100-120 minutes for the supplied charger. Do not use other chargers without checking battery specifications.

There are three important values for the levels of the battery (if you check with a tester or via software). These values are:

- **Charging voltage:** Is the level in the robot during the charging process. Normal values are around 58.4V (16 cells per 3.65 V each cell) Note that after charging, the voltage will drop fast to "Full charge voltage" even without using the battery).
- **Full charge voltage:** Is the level in the robot with the battery full charge. Normal values are around 53.6V (16 cells per 3.35 V each cell).
- **Full discharge voltage:** Is the level in the robot with the battery empty.N Normal values are around 46.4V (16 cells per 2.9V each cell).

IMPORTANT: The cells can drop up to 2.5V, but it is not recommended. When the battery is very low, the BMS can shutdown easily if any power peak is required.

5.2. LiFePO4 battery pack

Figure 17 – LiFePo4 Battery Pack

The battery pack is composed of sixteen LiFePO4 cells and a protection circuit module.

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 bottom aluminum protection and unplugging the power supply connector (red and blue wires) and the charge connector (yellow wire).

It is recommended to have the robot upside-down to do this process. The battery weight is 8kg and will fall when the screws are removed.

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

5.2.1. LiFePO4 Cell

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

Figure 18 – LiFePo4 Cell

5.2.2. Protection circuit module

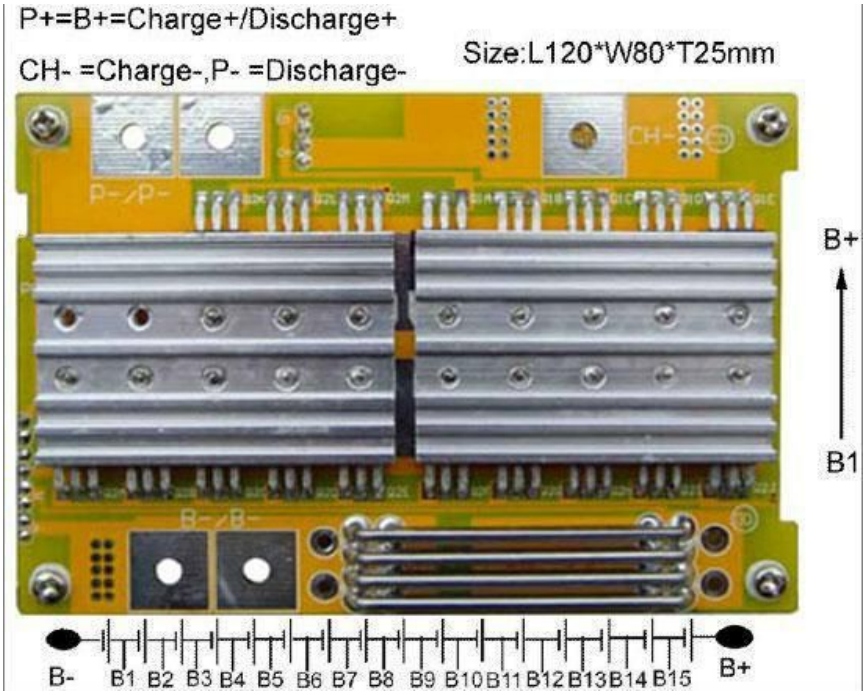


Figure 19 – Protection circuit module

Model:PCM-L16S60-563（16S）			
No.	**Test item**		**Criterion**
1	Voltage	Charging voltage	CC/CV:Li-ion/Li-polymer(4.2V/cell),LiFePO4(3.6V/cell)
		Balance voltage for single cell	Li-ion:4.20V±0.025V, Lifepo4:3.60±0.025V,
2	Current	Balance current for single cell	0-125mA (can adjust)
		Current consumption for single cell	≤20μA
		Maximal continuous charging and discharging current(continuous working current)	Charge:25A,Discharge:60A
3	Over-charge Protection	Over charge detection voltage	3.8～4.4V（can adjust）
		Over charge detection delay time	0.96~1.4S
		Over charge release voltage	3.8～4.4V（can adjust）
4	Over-discharge Protection	Over discharge detection voltage	1.9～3.1V（can adjust）
		Over discharge detection delay time	115~173mS
		Over discharge release voltage	1.9～3.1V（can adjust）
5	Over-Current Protection	Over current detection voltage	0.6V

		Over current detection current(peak current)	100-500A(optional）
		Detection delay time	7.2~11ms
		Release condition	Cut load
6	Short Protection	Detection condition	Exterior short circuit
		Detection delay time	200-500us
		Release condition	Cut load
7	Resistance	Protection circuitry（B- to P-）	≤30mΩ
8	Temperature	Operating temperature range	-40～+85℃
		Storage temperature range	-40～+125℃
9	Size		L120*W80*T25mm

Table 4 – Battery pack characteristics

5.3. LiFePO4 Charger

IMPORTANT: CHECK POWER SELECTION BEFORE PLUGGING IT

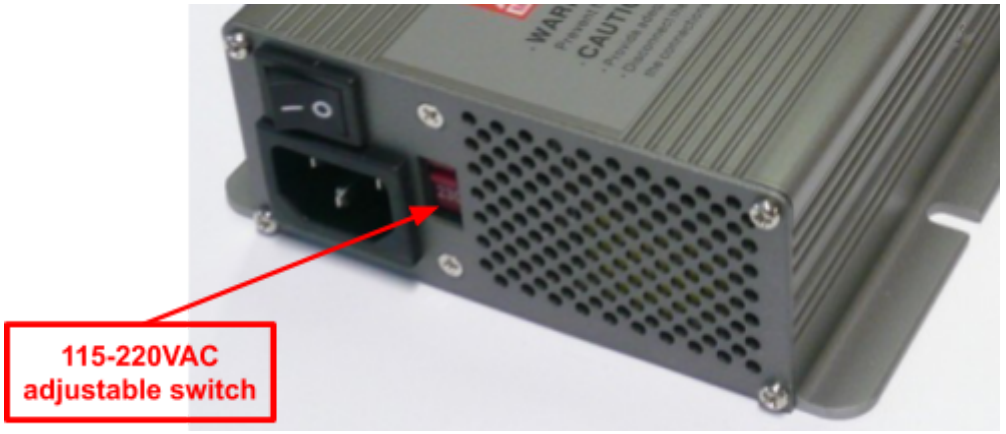


Figure 20 – LiFePo4 Smart Charger Rear view

The following two pages are part of the Mean Well datasheet.

SPECIFICATION

MODEL		PB-360□-12	PB-360□-24	PB-360□-48
OUTPUT	BOOST CHARGE VOLTAGE Vboost	14.4V	28.8V	57.6V
	FLOAT CHARGE VOLTAGE Vfloat	13.6V	27.2V	54.4V
	VOLTAGE ADJUSTABLE RANGE	13 ~ 14.7V	26 ~ 28.8V	52 ~ 58.6V
	RECOMMENDED BATTERY CAPACITY(AMP HOURS) Note 6	80 ~ 240Ah	40 ~ 125Ah	20 ~ 65Ah
	BATTERY TYPE	Open & Sealed Lead Acid		
	OUTPUT CURRENT (Typ.) Note 7	24.3A	12.5A	6.25A
INPUT	VOLTAGE RANGE	90 ~ 132VAC / 180 ~ 264VAC selected by switch 127 ~ 187VDC / 254 ~ 370VDC		
	FREQUENCY RANGE	47 ~ 63Hz		
	POWER FACTOR (Typ.)	>0.65 (with P type) at 230VAC		
	EFFICIENCY (Typ.)	85%	86%	87%
	AC CURRENT (Typ.)	7A/115VAC 3.5A/230VAC		
	INRUSH CURRENT (Typ.)	COLD START 60A		
	LEAKAGE CURRENT	<3.5mA / 240VAC		
PROTECTION	SHORT CIRCUIT	O/P Built in fuse (FS100) to protect short circuit condition, shut down o/p voltage and can not re-power on		
	REVERSE POLARITY	By internal fuse		
	OVER VOLTAGE	16 ~ 18V	31 ~ 35V	59 ~ 64V
		Protection type : Shut down o/p voltage, re-power on to recover		
	OVER TEMPERATURE	Protection type : Automatically derate charge current until zero		
FUNCTION	REMOTE CONTROL (CN5)	Open: Normal work Short: Stop Charging		
ENVIRONMENT	WORKING TEMP.	-20 ~ +60℃ (Refer to "Derating Curve")		
	WORKING HUMIDITY	20 ~ 90% RH non-condensing		
	STORAGE TEMP., HUMIDITY	-40 ~ +85℃, 10 ~ 95% RH		
	TEMP. COEFFICIENT	±0.05%/℃ (0 ~ 45℃)		
	VIBRATION	10 ~ 500Hz, 2G 10min./1cycle, 60min. each along X, Y, Z axes		
SAFETY & EMC (Note 5)	SAFETY STANDARDS	IEC60335-2-29 CB approved by TUV(except for 48V), UL60950-1 approved		
	WITHSTAND VOLTAGE	I/P-O/P:3KVAC I/P-FG:1.5KVAC O/P-FG:0.5KVAC		
	ISOLATION RESISTANCE	I/P-O/P, I/P-FG, O/P-FG:100M Ohms / 500VDC / 25℃ / 70% RH		
	EMC EMISSION	Compliance to EN55022 (CISPR22) Class B, EN61000-3-2,-3 (only P type)		
	EMC IMMUNITY	Compliance to EN61000-4-2,3,4,5,6,8,11, EN55024, light industry level, criteria A		
OTHERS	MTBF	115.8Khrs min. MIL-HDBK-217F (25℃)		
	DIMENSION	253*135*48.5mm(L*W*H)		
	PACKING	1.5Kg; 6pcs/10Kg/0.95CUFT		
NOTE	1. Modification for charger specification may be required for different battery specification. Please contact battery vendor and MEAN WELL for details. 2. All parameters NOT specially mentioned are measured at 230VAC input, rated load and 25℃ of ambient temperature. 3. Ripple & noise are measured at 20MHz of bandwidth by using a 12" twisted pair-wire terminated with a 0.1uf & 47uf parallel capacitor. 4. Tolerance : includes set up tolerance, line regulation and load regulation. 5. The power supply is considered a component which will be installed into a final equipment. The final equipment must be re-confirmed that it still meets EMC directives. 6. This is Mean Well's suggested range. Please consult your battery manufacturer for their suggestions about maximum charging current limitation. 7. Maximum charging current will be in the range of 90~110% rated output current.			

File Name:PB-360-SPEC 2015-12-15

MEAN WELL

360W Single Output Battery Charger

PB-360 series

■ Features :

- Charger for lead-acid batteries (flooded, Gel and AGM) and Li-ion batteries (lithium iron and lithium manganese) (Note.1)
- 3 stage charging
- AC 115/230VAC selected by switch
- Built-in passive PFC function compliance to EN61000-3-2 Class A (option)
- Protection: Short circuit / Reverse polarity / Over voltage / Over temperature
- 2 color LED loading indicator
- Low cost, High reliability
- FAN on/off control(Depends on charging current)
- 3 years warranty

c UL us CB (except for 48V) CE (P type only)

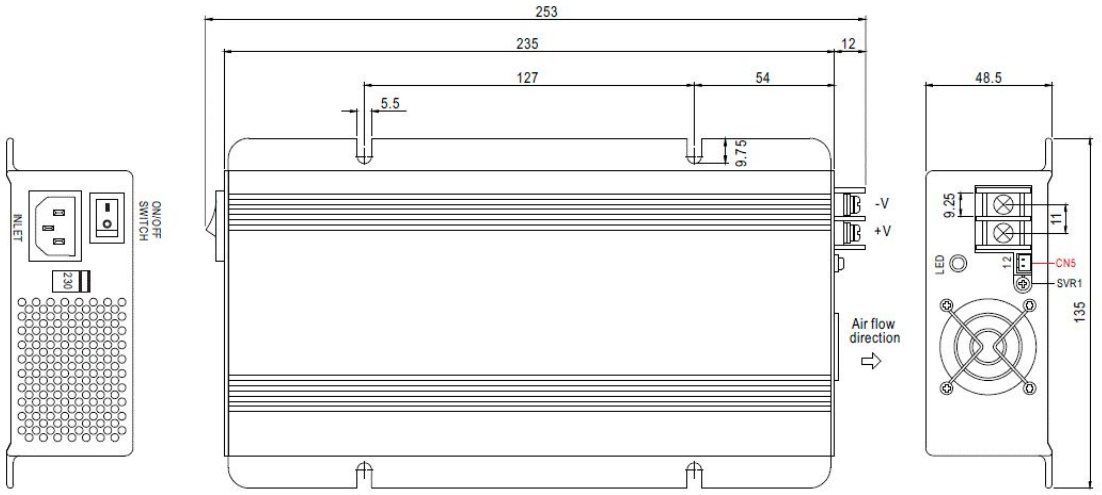
PB − 360 [P] − 12

P:With Passive PFC
N:Without Passive PFC

12:14.4V
24:28.8V
48:57.6V

■ Mechanical Specification

Case No.801A Unit:mm

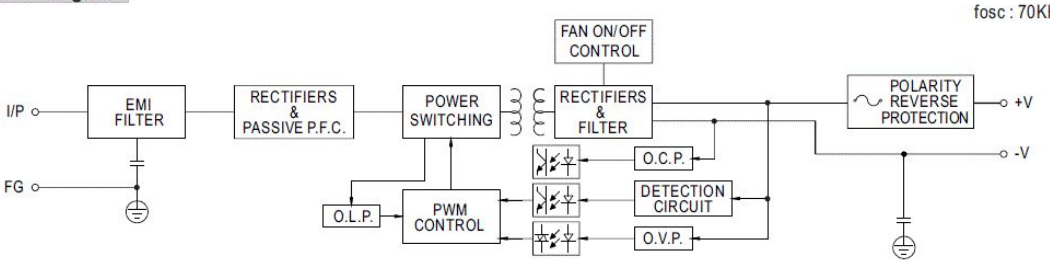


Remote Control(CN5) : JST B2B-XH or equivalent

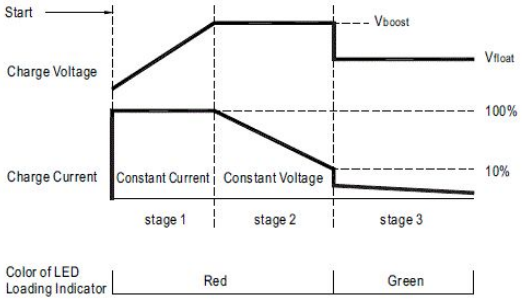
Assignment	Mating Housing	Terminal
PIN1,2 Open: Normal work	JST XHP or equivalent	JST SXH-001T-P0.6 or equivalent
PIN1,2 Short: Stop Charging		

■ Block Diagram

fosc : 70KHz



■ Charging Curve



State	PB-360-12	PB-360-24	PB-360-48
Constant Current	24.3A	12.5A	6.25A
Vboost	14.4V	28.8V	57.6V
Vfloat	13.6V	27.2V	54.4V

■ Output Load VS Temperature

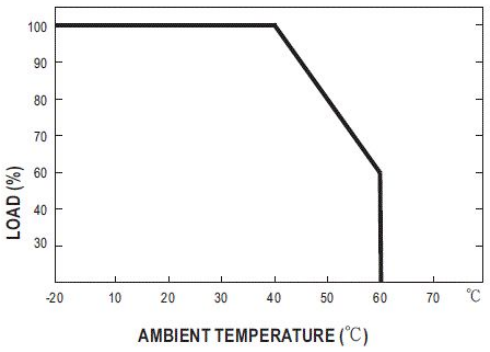


Figure 21 – Battery charguer datasheet

6. Communication 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 (inside and outside).

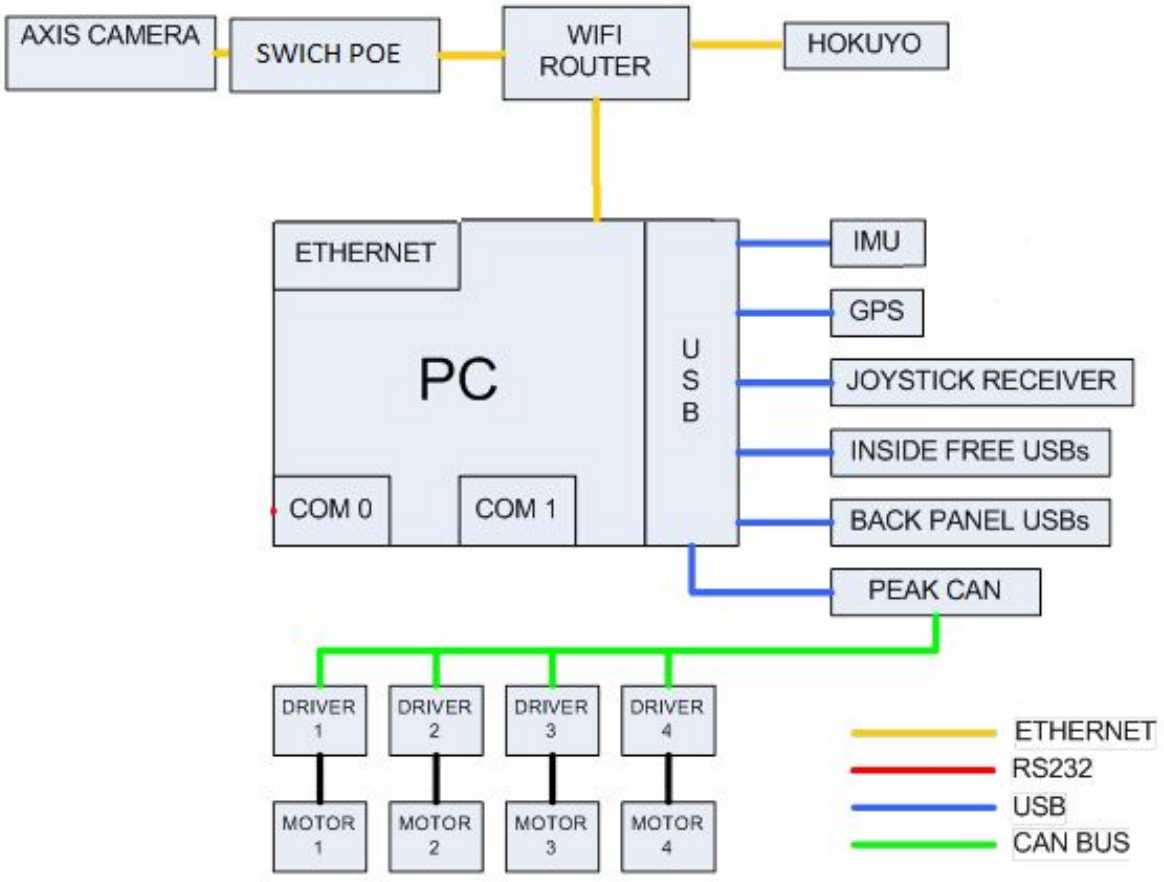


Figure 22– Communications diagram

7. Maintenance Summary

In the previous parts some main parts of the vehicle and components that need maintenance or only supervision have been mentioned. The following table summarizes all the 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 5 – Maintenance summary

8. Basic Drawings

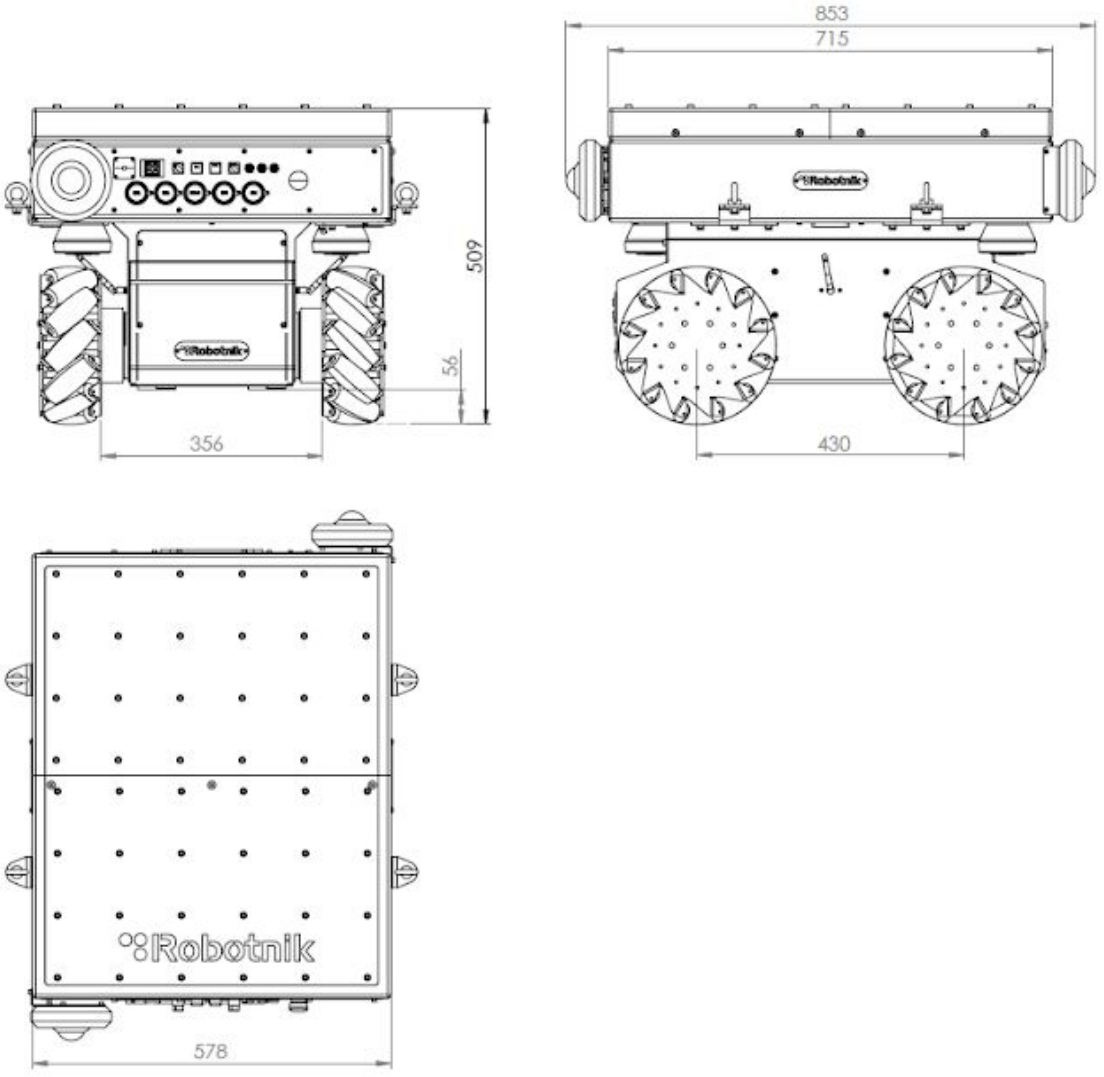


Figure 23 – Drawings