SLAMTEC

APOLLO

General Purpose Robot Platform Standard Version

User manual

Model: A2M21

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www.slamtec.com

Shanghai Slamtec.Co.,Ltd

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Introduction

Apollo is a medium-sized general purpose robot development platform developed by SLAMTEC to meet the requirement of medium-size robot application like reception robot, shop guiding robot and etc. Its build-in SLAMWARE autonomous localization and navigation module adds the function of path finding and navigation to it. And different applications can be integrated with Apollo to make it work in varies business places. Apollo is equiped with ultrasonic sensors, cliff sensors, depth cameras and etc., which help Apollo walk freely and respond well in complicated business environments. In addition, its optional version manages to self-ride an elevator and build map for multi-story buildings, which fits in more application scenarios.

Apart from the above core features, we have designed Ethernet port, power supply port and several control ports on the extended platform of Apollo to promote its related extension and development. Apollo can communicate with external world via wired or wireless network and its own battery provides power supply for itself and the extended module connected to it. And our users can control the whole Apollo and its upper extended module via varies control ports and pins.

Apollo A2M21 standard version has a complete base design, therefore, there is no need for users to make additional efforts in its external design. It works as a complete robot base waiting for upper system development right out of the box.

Basic Function

Autonomous Mapping for Localization and Navigation

The Apollo platform has the feature of autonomous map building, localization and navigation. There is no need for human assisstance during its working process. It can find the proper path to a specified place by itself and move there freely. And it also supports multi-line patrol mode like a security guard.

Autonomous Recharging

We provide open source interface for users and developpers to use it for their own upper application on Apollo, which can realize the recharging feature of Apollo, namely, the ability to go back to the charge station to charge itself when it has a very low battery.

Third Party Application Development

The Apollo has a totally free platform both in software and hardware and we offer technical support for external extended hardware. Our users can focus on the developing of business logic appplication via SLAMWARE SDK.

Optional Function

Self-riding elevator

With built-in solution for multi-story building, Apollo can work with corresponded floors seamlessly. After integration, Apollo can move into an elevator automatically, detect its current floor in rea time and move out to specified floor's destination.

Autonomous Mapping for Multi-story Building

Apollo is supported to bulid map for multi-story buildings. When getting to each floor, Apollo marks the current floor and bulid map for that floor. The multi-story building map is useful for preparing floor plans, shop navigation, evacuation plans and etc. End users can check those maps at any time.

Interior Module Block Diagram

The followig figure describes the communication between Apollo and external system, the connection of power supply and emergency stop.

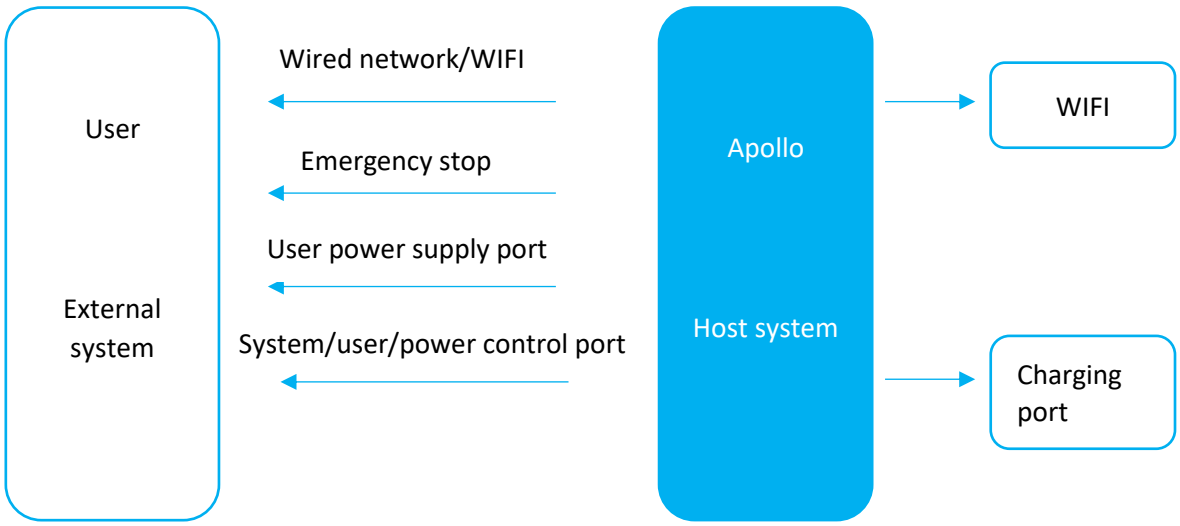


Figure 1-1 Connection between Apollo and External System

Apollo

Appearance and Structure

Apollo is a white cylinder-shaped robot base and all its edges are soft and smooth, which gives Apollo a nice and friendly outlook and feel. With lower barycenter, Apollo moves more safely and stably. Please refer to mechanical dimensions for more design details.

Sensors

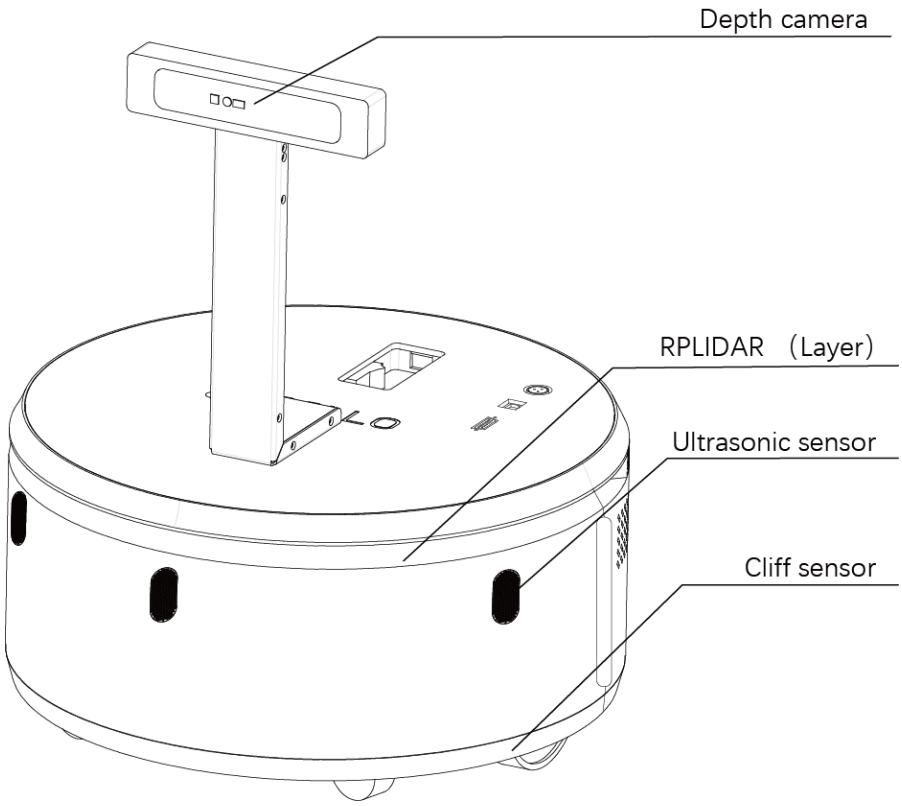


Figure 2-1 Apollo Sensor Configuration

Lidar Sensor

Apollo is equipped with a high performance Lidar with scan range more than 15 meters. Based on the map data provided by the Lidar, Apollo can build map with resolution up to 5cm and realize autonomous path finding and navigation.

Ultrasonic Sensor

Apollo has 3 ultrasonic sensors distributed in the front edge of its base. The coverage area of those sensors is 40 cm in length right ahead of Apollo. Those sensors are mainly used for detecting highly transparent obstacles to improve the performance of Apollo in mapping and obstacle avoidance.

Depth Camera

The depth camera on the top of the Apollo, with a visual angle 45°x35° and a visual range 1.3m, makes Apollo can detect the obstacles above the Lidar layer and send command out to avoid them.

Cliff Sensor

There are 3 cliff sensors in the front bottom edge of Apollo. The minimum detected depth is 5cm. When Apollo walks to an edge of a step, the cliff sensor can detect the step and send signals out to request the change of the robot direction. Therefore, the robot can avoide falling down from a higher place and move freely.

All the above sensors ensure the high perpormance of Apollo path planning, navigation and obstacle avoidance when it walking in varies complicated environments.

Charger

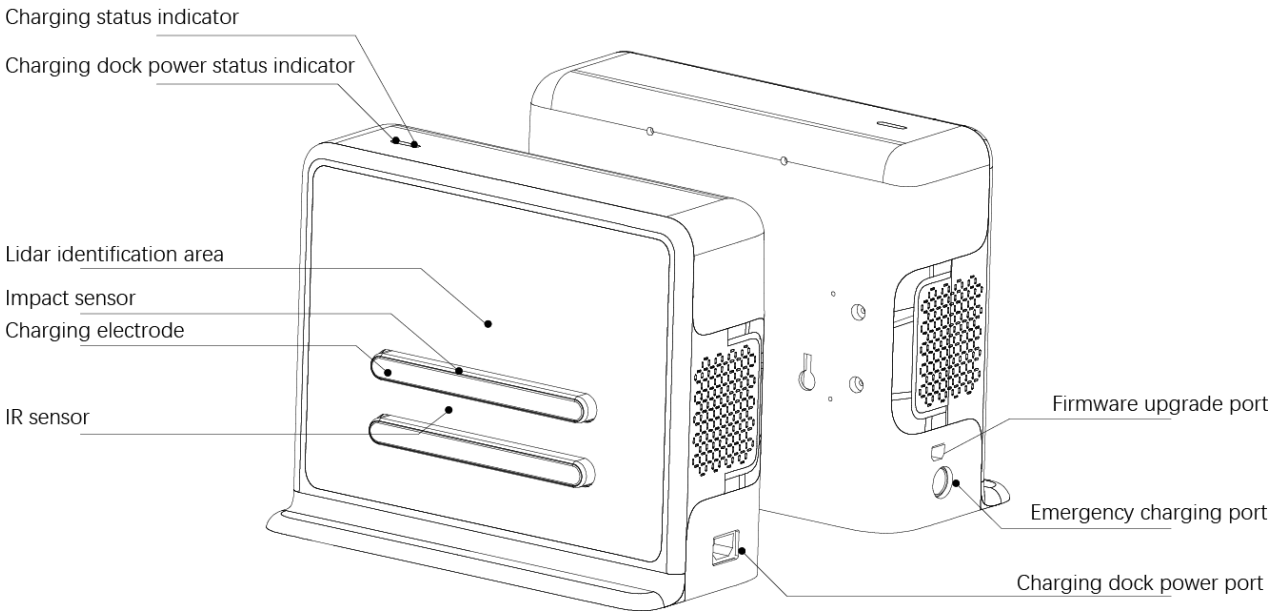


Figure 2-2 Apollo Charger

Apollo has a charger that supports autonomous recharging. After Apollo sending out a recharging command, Apollo will go back to the charger and charge itself automatically.

Charger indicators description:

Indicator	Preset Condition	Status	Description
Power Indicator (charger)	Charger power on	Red light	The charger is powered on normally.
	Charger power off	Light goes out	The charger is power off.
	Exceptions	Light flicks or goes out	There are problems in the charger.
Charging indicator (Power)	Not charging	Light goes out	The charger is not charging Apollo.
	Fully charged	Green light	Apollo is fully charged.
	Charging	Red light	Apollo is charging normally.
	Exceptions	Light flicks or goes out	There are problems in the charger.

Figure 2-3 Apollo Charger Indicators Description

Charger ports description:

Name	Parameter	Description
Charging port	220-240VAC	Provides power supply for the charger.
Charging electrode	25.2V 10A	Provides contact charging for Apollo.
Emergency charging port	25.2V 10A	Provides charging for Apollo in emergency, such as the charging electrode not working.
Firmware upgrade port	USB	Provides firmware upgrading for Apollo charger.

Figure 2-4 Apollo Charge Station Interface Description

Demo Module （Optional）

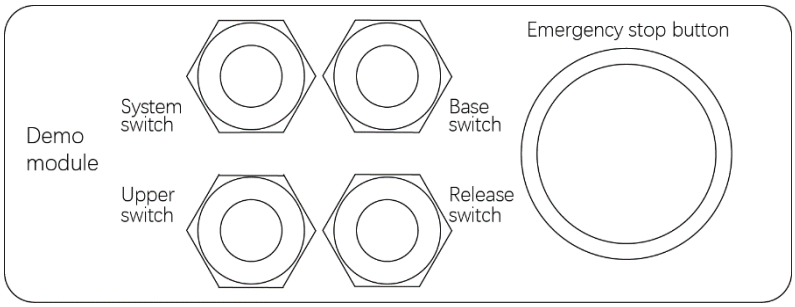


Figure 2-5 Apollo Demo Module

The demo module can monitor the control signal of upper system to simply but efffectively control the power supply and moving of Apollo.

The recommended switch to be designed and their usage are as below:

Switch Type	Description	Note
Emergency stop switch	Used for controling Apollo in emergencies. After pressing this switch, Apollo will stop moving immediately.	This switch is a must to design, or Apollo will refuse to work.
Release switch	Corresponded with the emergency stop switch, after pressing down the emergency stop switch, user need press the release switch to recover Apollo to normal status and continue other operations, like manually pushing Apollo moving.	
Apollo switch	This switch is the power switch for Apollo. Short press for power-on and long press for power-off.	
Upper switch	This switch is the control switch for the power port of upper system or upper computer. Short press for power-on and long press for power-off.	
System switch	This switch is the power switch for the whole system. Short press for power-on and long press for power-off.	Generally, user can ignore Apollo switch or upper switch, and only design this switch to replace the above two.

Figure 2-6 Apollo Demo Module Switch Description

Introduction

As shown in the following figure, the extended platform of Apollo is a rounded table with 220mm in radius. The whole top surface is all-steel and is processed by black phosphating solution. There are five M6 threaded holes regularly distributed on the table, which can meet various requirements of fixing the upper module on the Apollo. Please refer to the following figure for the specific position of threaded holes and the port dimensions.

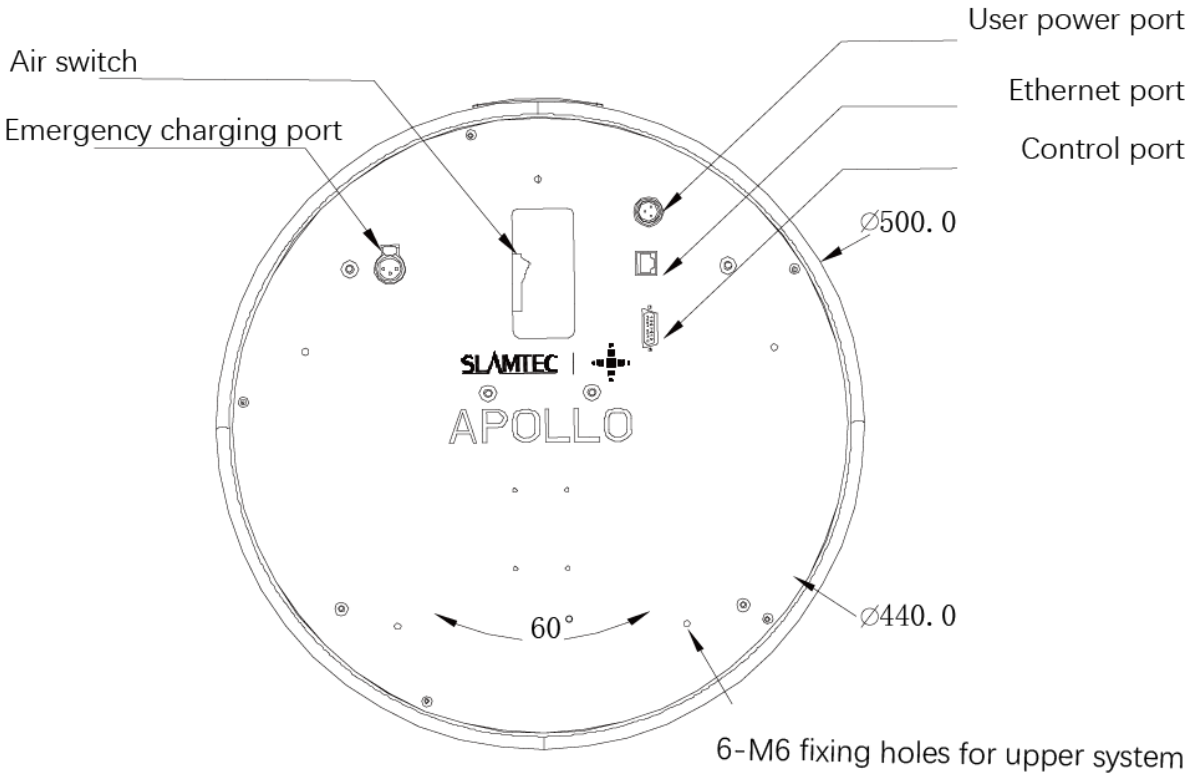
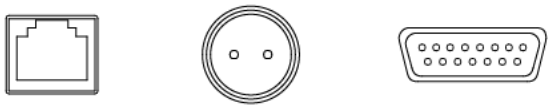


Figure 3-1 Apollo Extended Platform

Port Definition



Name	Parameter	Description	Note
Ethernet port	100/10Mbps	Used for communication between users and Apollo.	IP Address 192.168.11.1 ~ 192.168.11.100 are reserved for the bases of Apollo. Therefore, when using this Ethernet port, please ensure that the IP address of the device connected to Apollo not uses the above IP address. Or IP conflict may occur. Please refer to the SLAMWARE SDK for detailed communication protocols.
Power port	DC 18-25.2V 10A Max	Used for providing power supply for the device of users.	The end marked as 1 is positive while 2 is negative.
Control port	DB-15	Self-defined 15 pin port. User can design this port according to their own needs.	Please refer to the following figure for control port definition and pin definition, and the supported switch type for the reference design of the control port.
Emergency charging port	25.2V 10A	Used for charging Apollo under unexpected situations such as the charger electrode not working.	

Figure 3-2 Apollo Extended Platform Interface Definition

Pin Definition of Control Port

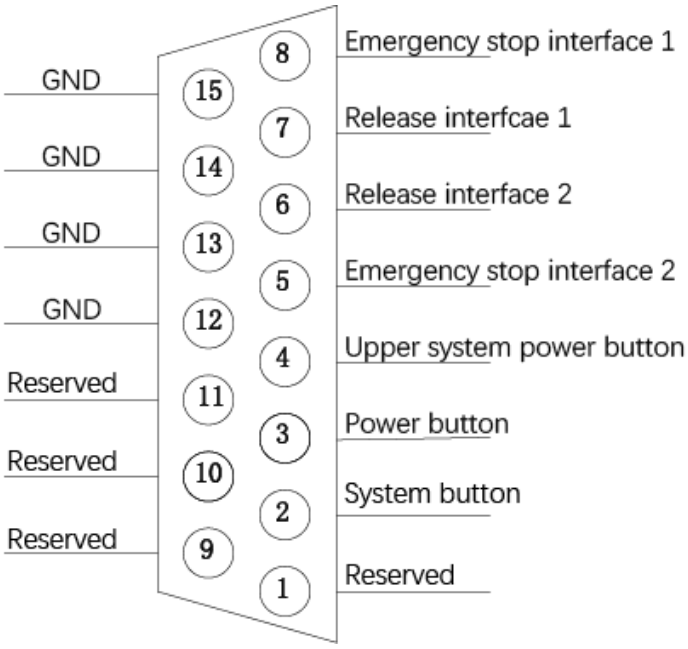


Figure 3-3 Pin Definition of Apollo Extended Platform Control Port

Supported Switch Type and Description of Control Port

Switch Name	Description	Note
Emergency stop switch (Pin5 & Pin8)	Used for controling Apollo in emergencies. Apollo will stop moving immediately after pressing this switch.	This switch is a must to design, or Apollo will refuse to work.
Release switch (Pin6 & Pin7)	Corresponded with the emergency stop switch, after pressing down the emergency stop switch, user needs to press the release switch to recover Apollo to normal status and continue other operations	Checking method Internal pull-up to check the time width of the low level. Open time: 50ms~3000ms(Typical value is 300ms, and it is invalid to repeat this operation if it has already been in open status.) Close time: 3000ms~15000ms(Typical value is 4000ms, and it is invalid to repeat this operation if it has already been in open status.)
Apollo power switch (Pin3 & Pin13)	This switch is the power switch for Apollo. Short press for power-on and long press for power-off.	
Upper system power switch (Pin4 & Pin14)	This switch is the control switch for the power port of upper system or upper computer. Short press for power-on and long press for power-off.	
System switch (Pin2 & Pin12)	This switch is the power switch for the whole system. Short press for power-on and long press for power-off.	Generally, user can ignore the Apollo switch and the upper switch, and only design this switch to replace the above two.

Figure 3-4 Supported Switch Type of Apollo Extended Platform Control Port

Apollo Deployment

1. Place Charger

With the charger, Apollo can recharge itself automaticallty. Therefore, the charger requires to be put properly to ensure its performance. When Apollo goes back to the charger, it will have a driving force, so it's better to put the charger back against a wall. And the wall should meet the following requirements.

a. The charger should fit the wall closely and there is no obstacles between them. The wall with skirting line is not recommended.

b. The wall should not be made of transparent material like mirror or glass.

c. The wall should be at least three times the width of the charger.

d. The wall should be a straight wall instead of a curved one.

The charger requires a 220V power supply and its external power supply wire is 1.5m in length. So it's better that there is a power port on the wall for the charger(the power board is not recommended since it may cause danger due to massy wires).

The ground in front of the charger should meet the following requirements:

a. Open. There is no obstacles in front of the charger (with the charger as the center and within a radius of 2 meters from the center).

b. Level. There is no slope on the ground.

c. There is no soft carpet on the ground which leads Apollo sinking into it more that 2cm.

Please always launch Apollo from the charger to ensure that it can recharge itself properly.

Note: if the charger is moved to a different place when using Apollo, user should reset the charger position accordingly when loading the map. Please refer to the detailed interfaces description in our SDK document.

2. Launch Apollo

As shown in the following figure, find the air switch and turn it on, then press the system switch on the demo module to start the system. Once succeeded, the system indicator turns red and the buzzer beeps several times. It takes one minute to start the system.

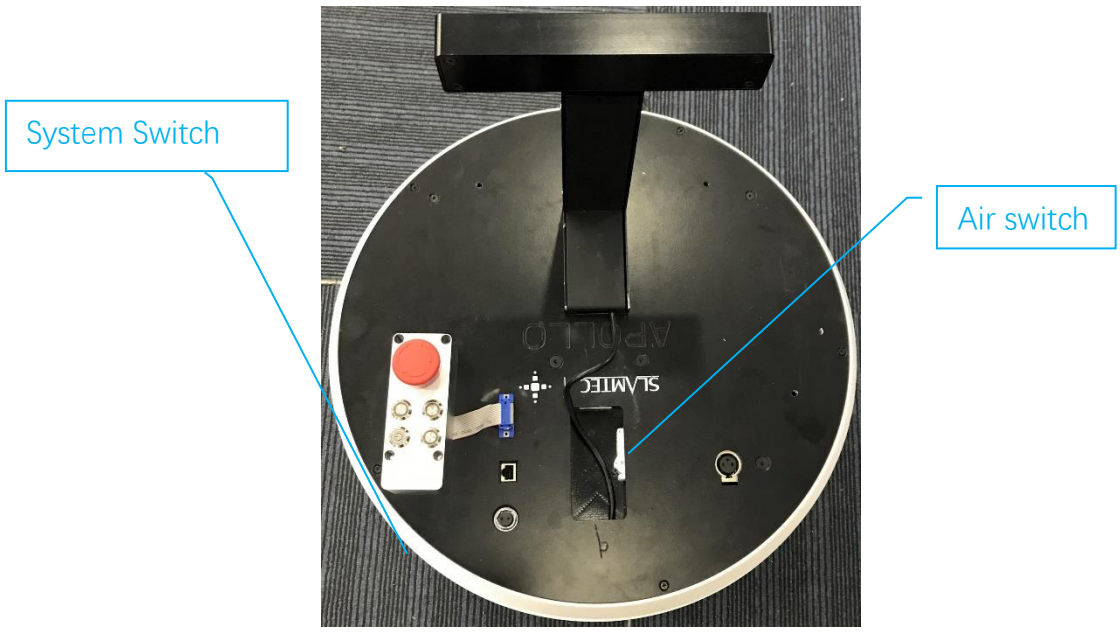


Figure 4-1 Apollo Air Switch and System Switch

3. Build and Save Map

Download and install the robot graphical tool RoboStudio from our official website http://www.slamtec.com/cn/RoboStudio. Register and login to the tool. By clicking **File**->**Robots** in the menu, user can find a docked window opened in the left side of the pane as in Figure 4-2. In this window, user can connect to or disconnect from robots.

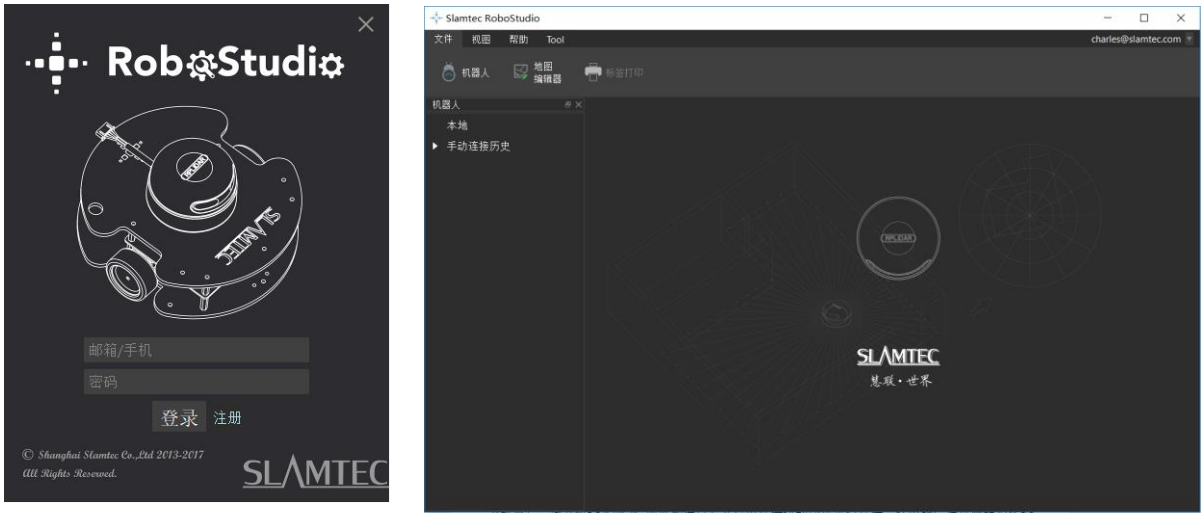


Figure 4-2 RoboStudio Robot Interface

Right click the whitespace of the robot list -> choose **manual connect robot** in the prompt dialog box, -> enter the IP address and port number in the new dialog box -> click **Connect** to connect to the robot as shown in the following screenshot. If you have already connected to the SSID obtained in step 3 via network adapter

on computer, please enter the default IP address 192.168.11.1 in the above dialog box. (The IP address of your wireless adapter network should be DHCP mode)

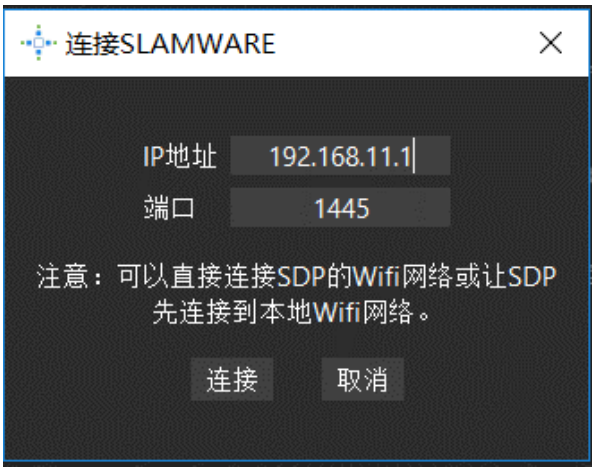


Figure 4-3 RoboStudio Robot Connection Dialog Box

Once connected successfully, the major work area will show the robot, map information and its status. The robot name will turn to green and the robot status will turn to **Connected** as below.

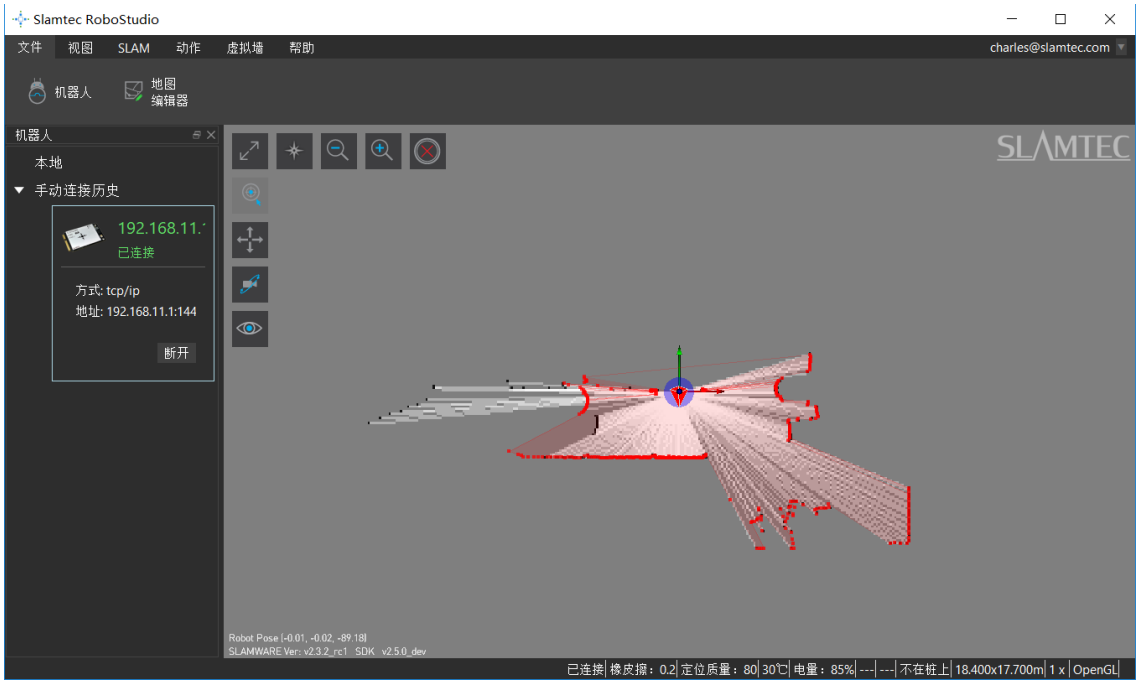


Figure 4-4 RoboStudio Robot Connection

Right click a point in the place where you want to build a map, and Apollo will follow the point to build map. After mapping, add virtual walls to the places where you want to isolate them from robot. Click **File->MapEditor** and choose saving the map file to local or uploading it to the firmware.

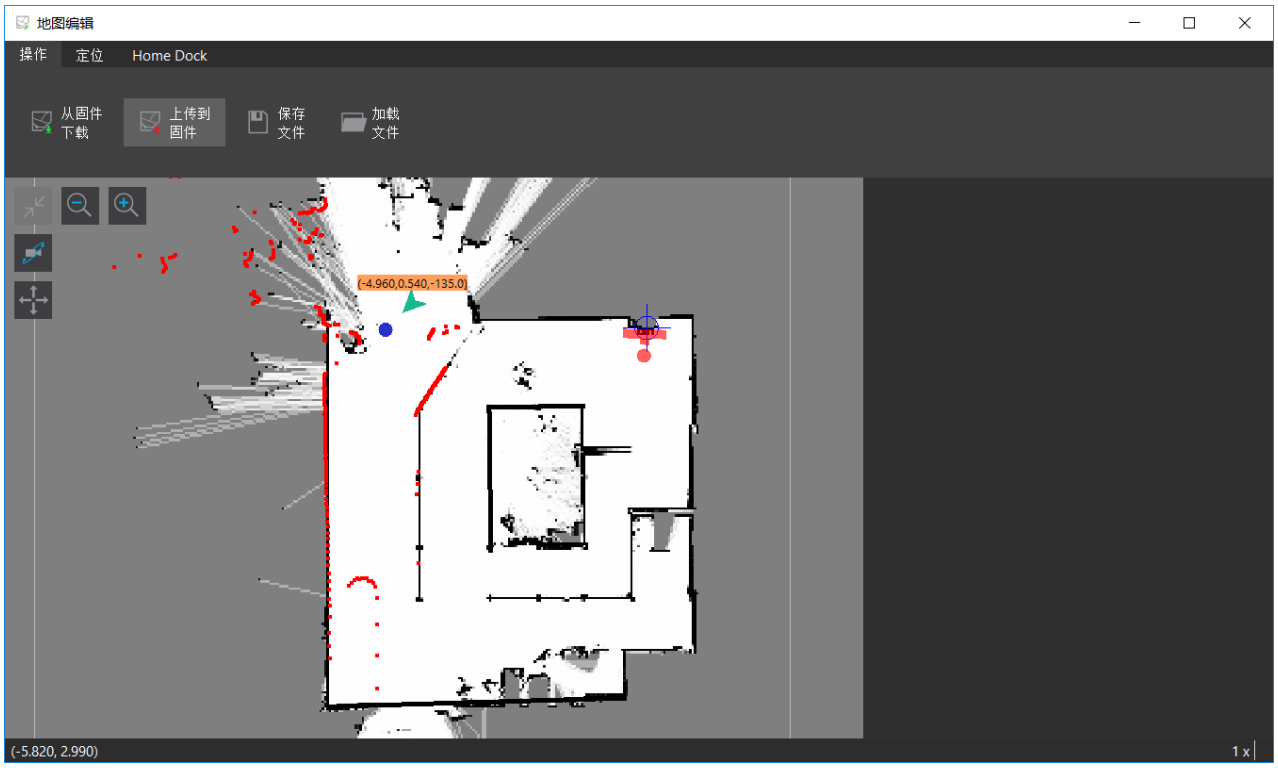


Figure 4-5 RoboStudio Robot Map Editing Window

4. Launch Host Computer and Load the Map

The following code shows how to finish loading specified map by using SDK on the upper computer.

```
/*
* upload map file to apollo
*/
#include <iostream>
#include <rpos\robot_platforms\slamware_core_platform.h>
#include <rpos\robot_platforms\objects\composite_map_reader.h>
#include <rpos\core\pose.h>

using namespace std;

int main()
{
    try
    {
        string map_path = ".\\map.stcm"; //the path of map
        string apollo_ip = "192.168.11.1"; //the ip of apollo
        int apollo_port = 1445; //the port of apollo ,default is 1445

        rpos::robot_platforms::SlamwareCorePlatform apollo =
            rpos::robot_platforms::SlamwareCorePlatform::connect(apollo_ip, apollo_port);
        //connect to the apollo
        rpos::robot_platforms::objects::CompositeMapReader cmapreader;
        //map reader
        rpos::core::Pose apollo_pose = rpos::core::Pose(rpos::core::Location(0, 0, 0));
        //the Apollo pose in map(apollo_pose should be the apollo's real pose in new map)
        //using apollo.getpose() to get the old apollo pose
        auto map = cmapreader.loadFile(map_path);
        //load map
        apollo.setCompositeMap(*map, apollo_pose);
        //set compositemap
        rpos::core::Pose home_pose = rpos::core::Pose(rpos::core::Location(0, 0, 0));
        //the home pose in map(home_pose should be the home's real pose in new map)
```

```
33.         //using apollo.gethomepose() to get the old home pose
34.         apollo.setHomePose(home_pose);
35.         //set home pose
36.     }
37.     catch (rpos::robot_platforms::ConnectionFailException &e)
38.     {
39.         cout << "connect failed on " << e.what() << endl;
40.     }
41.     catch (rpos::system::detail::ExceptionBase &e)
42.     {
43.         cout << "failed on " << e.what() << endl;
44.     }
45.
46.     return 0;
47. }
```

Please refer to our SDK reference for more movement deployment.

Connect to Computer

Wired Connection

According to the requirements from actual application development, we have designed a RJ45 Ethernet port on the extended platform of Apollo. Therefore, user can directly connect Apollo to PC via network cable for extension or further development.

Wireless Connection

To help our user test Apollo and meet the requirements in future actual application scenarios, Apollo also supports wireless connection. User can connect to the SSID of Apollo with a computer and then connect to Apollo with its default IP address 192.168.11.1. In addition, user can use our Web Portal tool to distribute a specific IP address for Apollo and use it for connection.

Debug Tools

RoboStudio

RoboStudio graphical tool is used for testing and controlling Apollo. Please download it from our official website as below:

http://www.slamtec.com/cn/RoboStudio

In the same page, we also provide a document to introduce the usage of this tool.

Web Portal Tool

During developing, testing and controlling the SLAMTEC robtots like Apollo, our users can do many things to our robot via the Web Portal tool, such as checking basic information,upgrading firmware and configuring WiFi. (Default username: *admin*. Default password: *admin111*)

Our Web Portal currently supports the following features:

1. Check the information of the robot;

2. Restart the SLAMWARE module;

3. Upgrade firmware

Slamtec provides Apollo firmware renewal and upgrade regularly. Our users can upgrade firmware via the Web Portal tool. Please ask for the latest firmware from our support engineers or sales representatives. The upgrade progress lasts for 5~10 minutes and the buzzer beeps during the upgrade process.

Apollo will restart once the upgrade finished. Before that, please ensure that Apollo has sufficient electricity.

4. WiFi configuration;

5. Start diagnosing SLAMWARE core;

6. Modify admin password;

For usage details, please refer to the following document:

https://wiki.slamtec.com/display/SD/SQ001+SLAMWARE+Web+Portal+Function+Overview

Charging and Battery

There are two ways to charge Apollo battery.

Contact Charging

Apollo has a charger supported automatically recharging. When the battery is lower than 30%(this value can be adjusted by the upper system according to actual requirements), Apollo will find the charger by itself and start recharging automatically.

Manual Charging in Emergency

In some unexpected situations, like Apollo cannot recharge itself temporarily, user can use emergency charging cable to charge Apollo The emergency charging port of Apollo is shown in the following figure. Please use the emergency charging cable to connect the emergency charging port on the charger and the charging port on Apollo

Once the fan inside the charger starts work, the charger starts charging for Apollo.

Note: there is no indicator lighting up for charging in emergency.

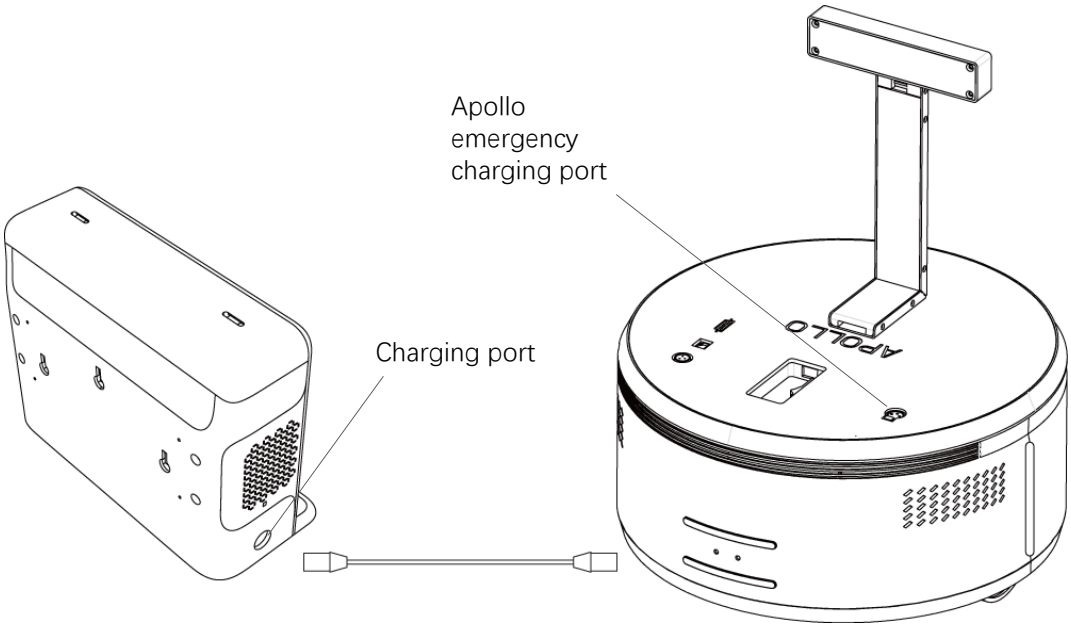


Figure 4-6 Manual Charging Connection

Battery Attention

Charging

Do not charge Apollo or its battery with non-official charging devices.

The battery should be charged within the range pf temperature specified in the products Specification. Stop charging immediately when the surface temperature of the battery is over 50℃.

Before charging, please ensure the polarities of the battery are connected properly. Reverse charging is strictly prohibited. Reverse charging cannot charge the battery. Inversely, it will induce fatal damage to the battery and even lead to battery heating, swelling, leaking, fire and explosion.

Storage

The battery should be stored in a cool and dry place. If you are intend to keep the battery for a long time (3 months or longer), it is recommended that the battery should be stored under the dry environment with temperature during 10-25℃ and without corrosive gas. And the battery should be charged at least one time every six months to ensure the voltage of the battery is between 3.6V-3.9V.

Attentional Notes

Since the battery is softly packaged with aluminum foil, it is vulnerable to sharp objects. Please do not place the battery with sharp objects.

Do not fall, hit or bend the battery or it may lead to fire.

Do not disassemble the battery in any circumstances or it may cause internal short-circuit that results in swelling and fire.

Do not directly connect the positive and negative anodes of the battery or it may lead to fatal damage to the battery and even fire.

Do not put the battery into fire or it may cause danger.

Do not put battery into liquid, such as water.

Do not charge the battery in a car.

Avoid violent vibration, shock and pressing during the transportation of the battery and handle it gently when carrying it. The battery should be packaged and protected with soft packing material.

- Handle Apollo base gently(do not kick, thrust or drag Apollo).
- Do not spill any liquid on Apollo.
- Do not use the recharging function of Apollo when it is walking on a soft carpet which can sag more than 2cm.
- Ensure that Apollo always starts on its charger.
- Do not change or replace anything in the machine without autiorization.
- Ensure that the load of Apollo meets the requirement of the specification.
- Do not use Apollo on slope.
- Do not use Apollo under environment with too many highly transparent materials.

No.	Trouble Description	Possible Cause	Solution
1	There are noisy points on the map built by Apollo (laser points appear in a place of the map that has no obstacles in the related actual place).	There are dirt on the surface of the Lidar.	Please use microfiber cloth to clean the dirt on the Lidar.
		There are obstacles near the radar, such as wires.	Please remove the obstacles.
		Other causes	Please contact SLAMTEC technical support for further help.
2	Apollo cannot start	Air switch is turned off.	Turn on the air switch on the extended plarform of Apollo.
		The battery becomes low.	Charge Apollo via emergency charging cable.
		The wire connection of build-in system switch or designed switch goes wrong.	Please check the Control Port Definition and connect related wires properly.
3	After launching Apollo, you cannot control it moving via computer application.	The red emergency switch is pressed down(You cannot push Apollo moving in this condition).	Pull up the red emergency switch.
		The release switch is pressed down(You can push Apollo moving in this condition).	Recover release switch.
		Other causes	Please contact SLAMTEC technical support for further help.
4	The range of Lidar on the map is less than its standard range and the laser light edge is in line. The range will go back to normal if uplifting the front of Apollo.	The ground is not level or flat.	Please use Apollo on a level and flat ground.
		Other causes	Please contact SLAMTEC technical support for further help.

5	The Apollo can not go back to charge itself normally.	The charger is move to a different place.	Rebuild the map and do not move the charger.
		The charger position is not set in the map.	Set the position of the charger in the map.
		The charger is disconnected to power.	Check whether the charger is properly connected to power.

Figure 6-1 Apollo Basic Problems and Solutions

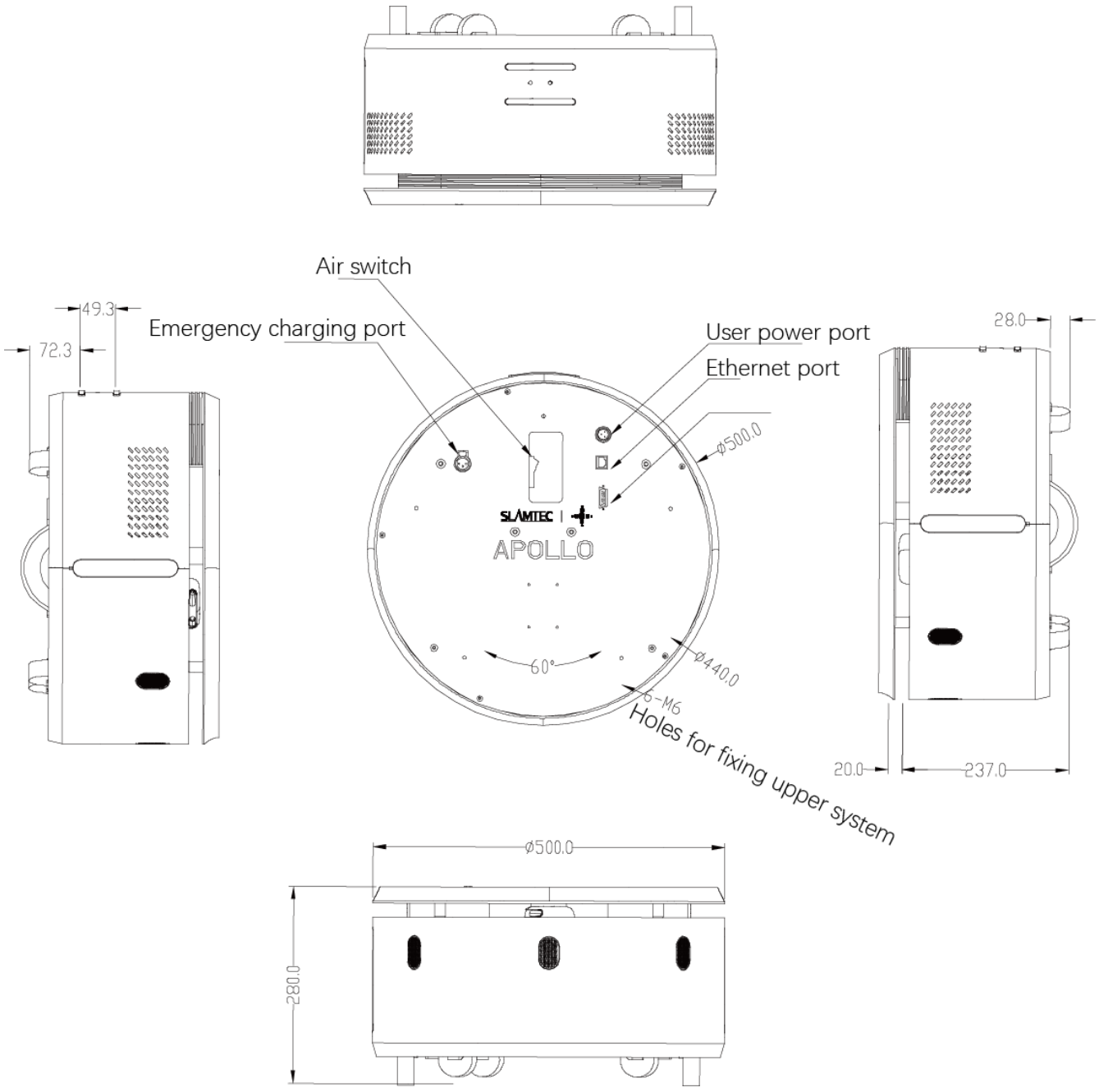


Figure 6-2 Apollo Mechanical Dimensions

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