

RoboMaster 2018 Referee System

Specification Manual

V1.4 2018.04



Disclaimer

Please read this disclaimer carefully before using this product. By using this product, you hereby signify that you have read and agree to all content herein. Please install and use this product properly and in strict accordance with the User Manual and product instructions, as well as any relevant laws, regulations, and policies. Users shall be responsible for any consequences resulting from their behavior while using this product. DJI™ Innovations (DJI™) shall not be liable for any loss incurred from using, installing, or modifying this product improperly.

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Product Usage Precautions

1. Please ensure that the monitoring device of the Referee System is installed correctly and firmly on the robot before use.
2. Please ensure that the wiring connections are correct before use.
3. Please ensure that the components are intact before use. Replace any worn or damaged components if necessary.

Reading Tips

Symbol Descriptions



Important Notes



Operation/Use Tips



Glossary & Reference

Related Documents

1. RoboMaster Referee System User Manual
2. Referee System Module Instructions

Revision Log

Date	Version	Revision Records
1/8/2018	V1.0	Release
1/10/2018	V1.1	Revised Armor Module ID setting specifications for the Engineer (pg. 22)
1/18/2018	V1.2	Revised barrel size of Speed Measurement Module (42mm projectile) (pg. 17)
2/13/2018	V1.3	Added information on installing version B of the main control module for Aerial Robots (pg. 7) Modified the Referee System interface protocol description (pg. 30)
4/13/2018	V1.4	Added "Installation Specifications for Engineer Armor Modules " (pg. 13) Added the Overheat status to "Light Bar Status Description" (pg. 26) Modified "Referee System Interface Protocol Description" (pg. 30, 33-34)

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Referee System Usage Overview

To ensure fairness, the RoboMaster 2018 competition results will be fully evaluated by the Referee System. Each team must follow all the instructions and correctly install the Referee System. In case of any violations, the team shall bear the consequences of failing the pre-match inspection.

Configuration of the Robotic Referee System

Robot Type	Number of Modules	Main Control Module (version A)	Large Armor Module	Small Armor Module	VTM Transmitter	RFID Interaction Module	Speed Measurement Module	Localization Module
Standard		1	0	4	1	1	1 (17 mm)	1
Sentry		1	2	0	0	0	1 (17 mm)	1
Hero		1	4	0	1	1	1 (17 mm) and 1 (42 mm)	1
Aerial		1 (Main Control Module version B)	0	0	1	0	1 (17 mm)	1
Engineer		1	0	4	1	1	0	1

Installation Specifications

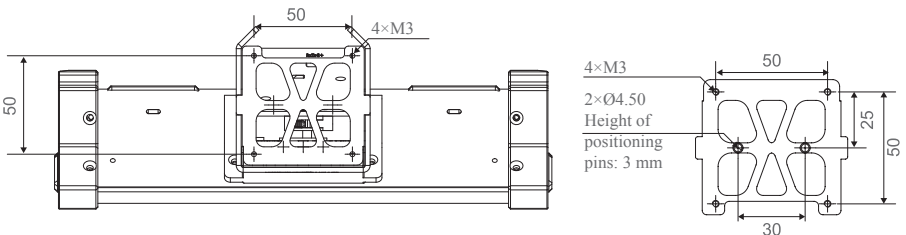
The Referee System is provided by the RMOC. This system monitors the damage status of the robot on which it is installed, including health points (HP), projectile launching speed, and chassis power, and sends the real-time data to the Operator Room computers and Referee System server to determine the outcome of the competition automatically and without bias. Teams must reserve the mechanical and electrical interfaces for installing the Referee System on their robots.

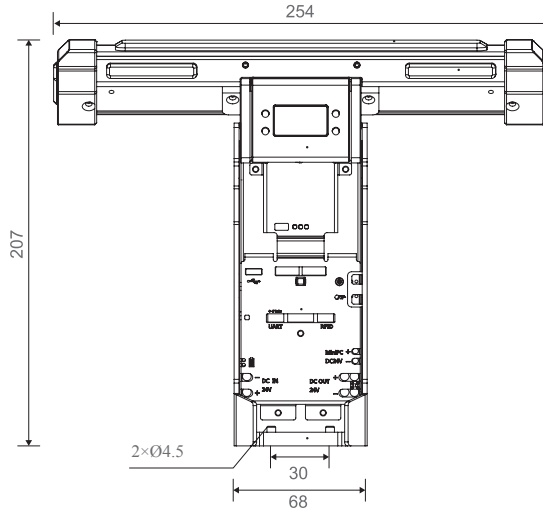
Main Control Module

Installation Procedure

Standard, Hero, and Engineer robots (Main Control Module Version A):

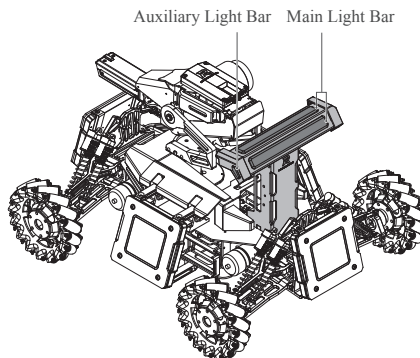
1. Refer to the size of main control module version A and reserve installation holes on the chassis. The Main Control Module holder can be flipped up or down. If needed, use the two 4.5 mm positioning pins that are 30 mm apart on one side of the module (shown in the figure below).





Unit: mm

2. Use four M3 screws to mount the Main Control Module to the chassis.
3. Ensure that an imaginary line between the two auxiliary light bars is parallel to the ground, and that the status of the main light bar is completely visible when viewing the robot from at least one direction.

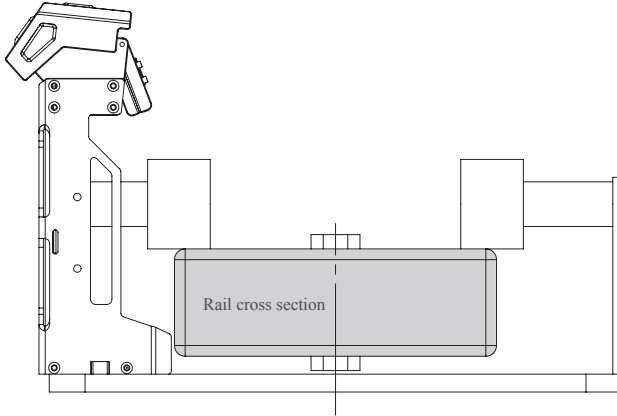


- The Main Control Module should be mounted to the Standard in such a way that the main light bar is higher than the Armor Module.

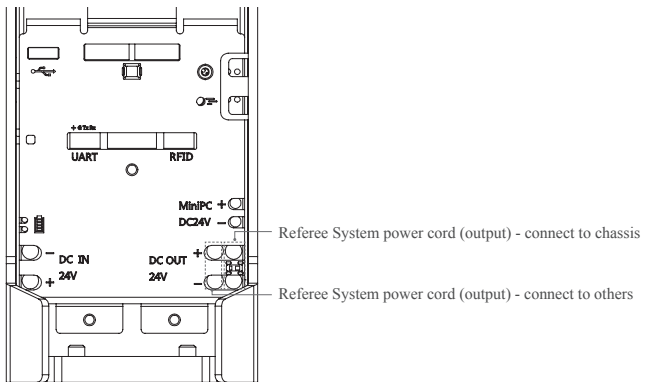
Sentry robots (Main Control Module Version A):

The mounting method is the same as that of the Standard, except that the mounting location is different.

The Sentry is mounted to the rail on which it runs. Ensure that after mounting, the Main Control Module is set on one side of the rail, and that the light bar of the Main Control Module is positioned above the top face of the rail. The light bar is not included in the overall dimension limitations.

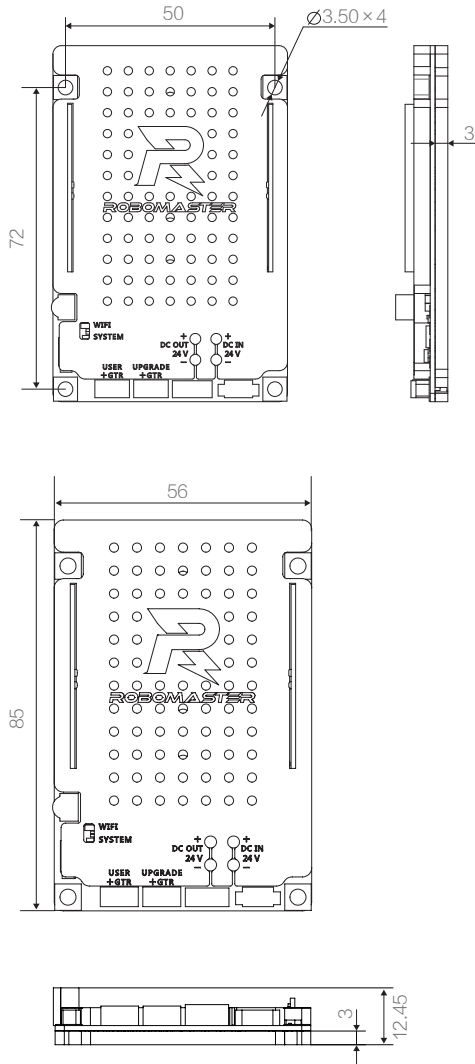


- Electronic devices with a current of higher than 10 A can be directly powered by the robot cell and controlled by a relay. The relay should be powered via the "Referee System power cord (output) - connect to others" interface so that all devices connected to the "Referee System power cord (output)" can be disconnected from the Referee System after the robot is destroyed; otherwise, it is considered cheating.

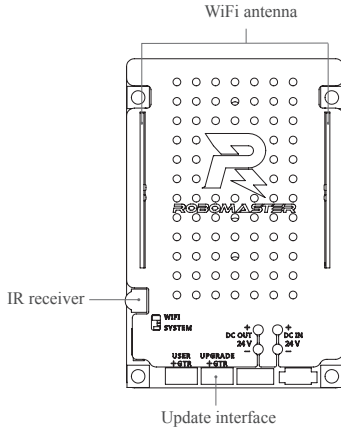


Aerial Robots (Main Control Module Version B):

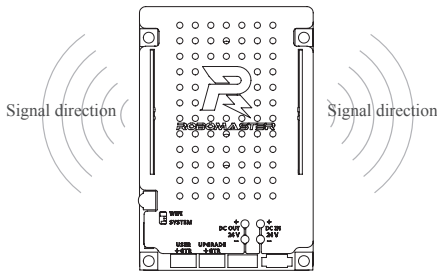
The dimensions of Main Control Module version B is different from that of version A. The size of version B is as follows:



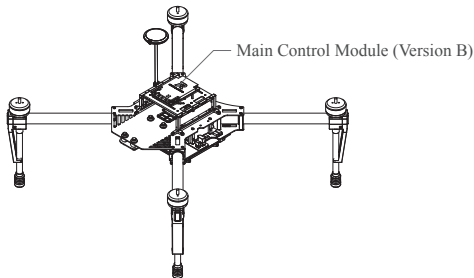
1. Refer to the size of main control module version B and reserve installation holes on the chassis.
 - a. Ensure that the IR receiver is exposed so that it can be manually connected the server during competition;
 - b. Ensure that the update interface is easily accessible to facilitate firmware updates during the check-in before the competition;



- c. Ensure that both sides of the WiFi antenna are free of signal blocking materials (such as metal and carbon plates), as shown in the following figure:



2. Use four M3 columns to secure the main control module to the top of the Aerial robot.



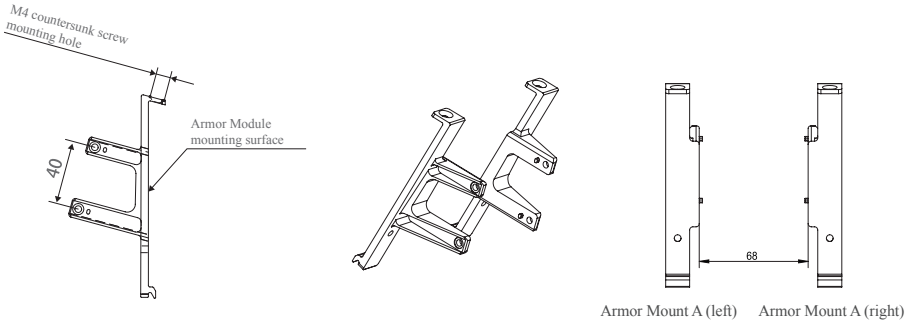
Armor Module

Description

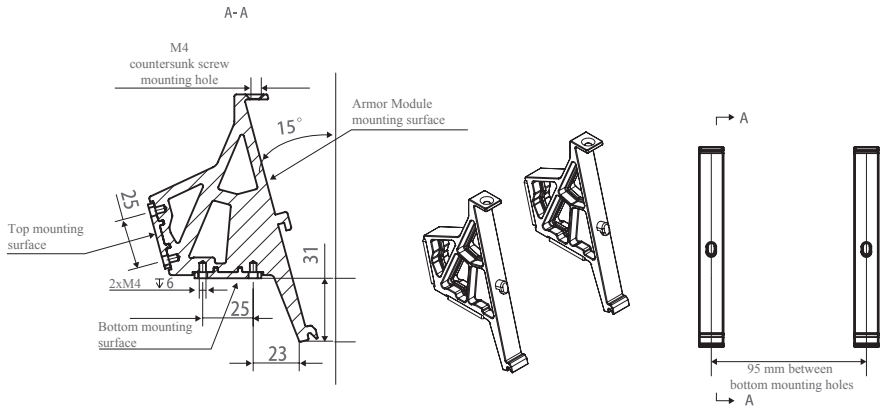
Use the armor mounts to install the Armor Module onto the robot.

There are two types of armor mounts: Mount A and Mount B.

For Armor Mount A, there is a left version and a right version (shown in the figure below):

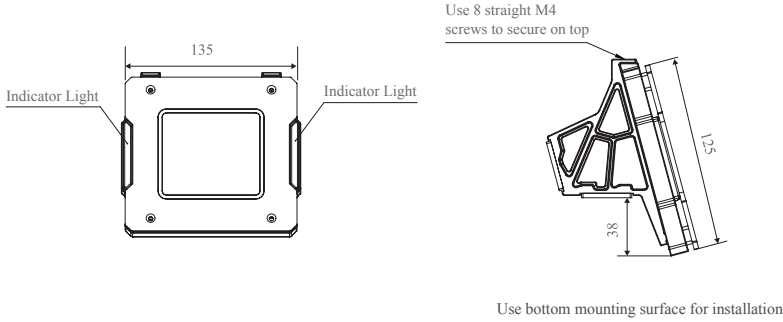


Armor Mount B is shown in the figure below:



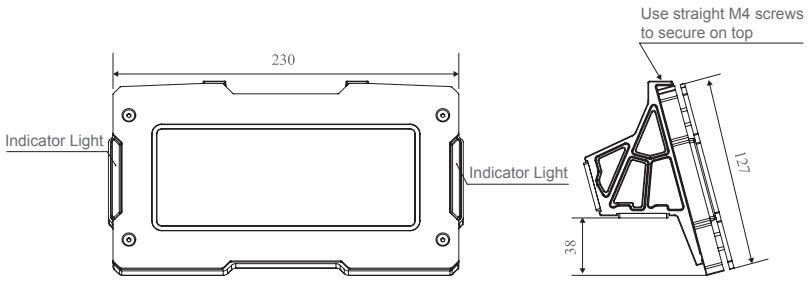
The Armor Module is composed of a Large Armor Module and a Small Armor Module, of which the former is mounted to the Hero and Sentry, and the latter is mounted to the Standard and Engineer. Armor for all robots is side-mounted.

The Small Armor Module is shown in the figure below:



Unit: mm

The Large Armor Module is shown in the figure below:



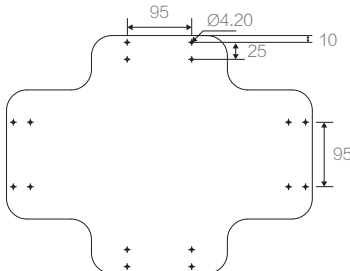
Unit: mm

The figure above uses Armor Mount B as an example. The labels in the figure apply to both Armor Mount A and Armor Mount B.

Installation Procedure

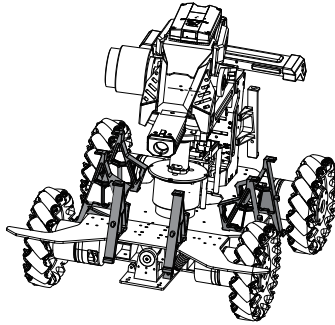
Standard, Engineer, and Hero:

- Using the dimensions shown in the figure below as a reference, reserve mounting holes on the chassis. Keep the sizes and the positions of the four mounting holes consistent.



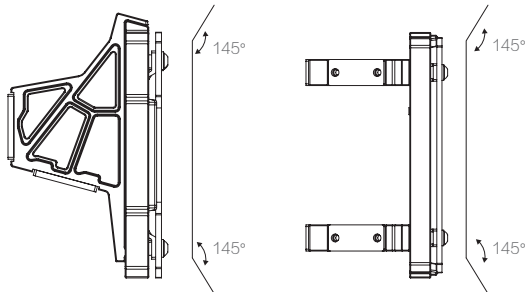
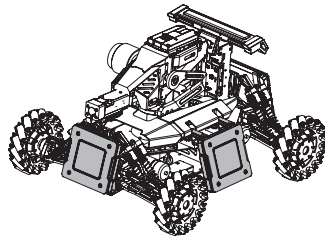
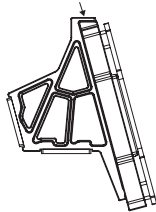
Unit: mm

2. Use M4 screws to mount Armor Mount B to three sides of the chassis as shown below.

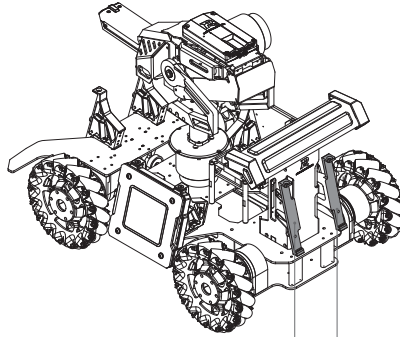


3. Install the Armor Module to Armor Mount B and secure with M4 screws. Note that when correctly installed, the threaded hole on top of the armor mount is perpendicular to the horizontal ground, not perpendicular to the top surface of the armor mount. Ensure that the front 145° of the Armor Module's exposure surface is not blocked.

Use straight M4 screws to secure on top

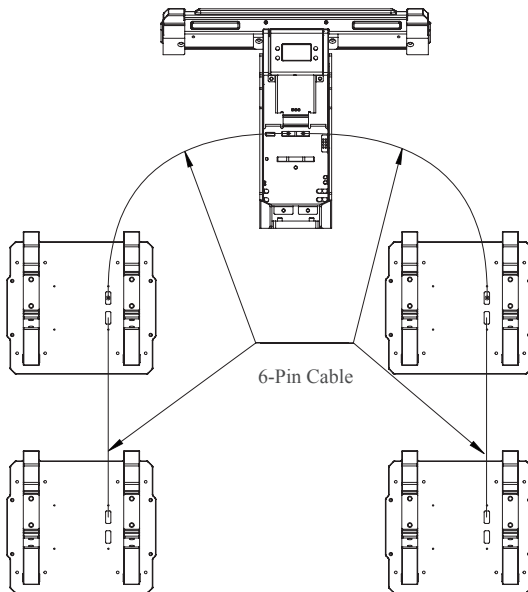


4. (Optional) Mount Armor Mount A at the rear of the robot using the M4 screw holes on the two sides of the Main Control Module. First, mount the Armor Module to Armor Mount A. Then, install Armor Mount A onto the Main Control Module. Note the difference between Armor Mount A (left) and Armor Mount A (right), and ensure that the mounting direction of the armor mount is correct for a secure installation.



Armor Mount A (left) Armor Mount A (right)

5. Use the 6-pin cable provided in the package to connect the Armor Modules in sequence to the Armor Module interface on the Main Control Panel. The two 6-pin interfaces on the Armor Module are equivalent to each other. It is recommended to split and connect the Armor Module in sequence to the two interfaces on the main control panel to balance the current load.

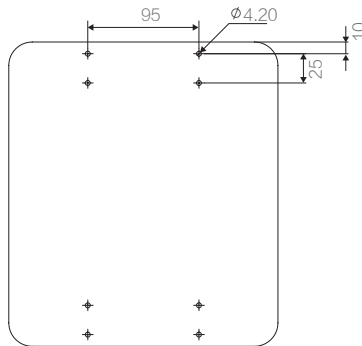




- The lower edge of the Armor Module on the side of the Standard should be 60 mm to 150 mm above the ground.
- The lower edge of the Armor Module on the side of the Engineer should be 50 mm to 400 mm above the ground. The maximum difference in distance above the ground between the lower edge of any two Armor Modules is 100 mm.
- The lower edge of the Armor Module on the side of the Hero should be 400 mm or more above the ground, and the height difference between the lower edges of any two Armor Modules in the Z-axis direction should not be more than 50 mm.

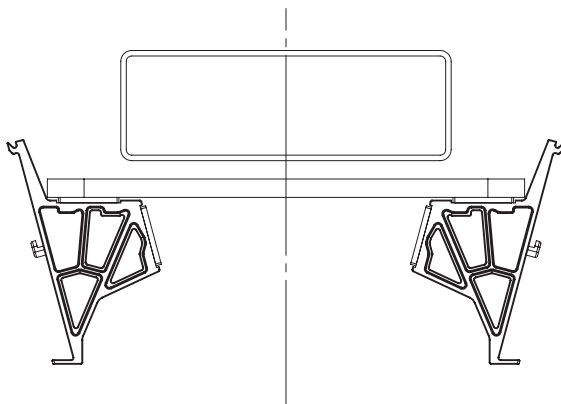
Sentry:

1. Using the dimensions shown in the figure below as a reference, reserve mounting holes on the chassis. Keep the sizes and the positions of the four mounting holes consistent.

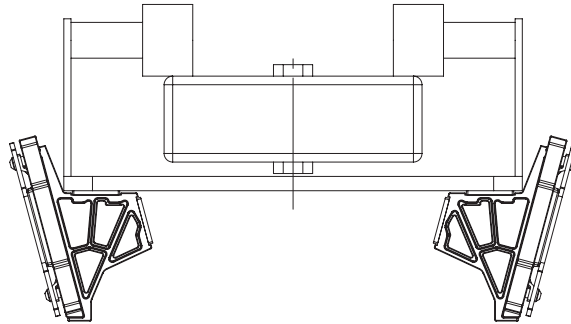


Unit: mm

2. Use M4 screws to mount Armor Mount B to the chassis. Note that the threaded hole is on the bottom.



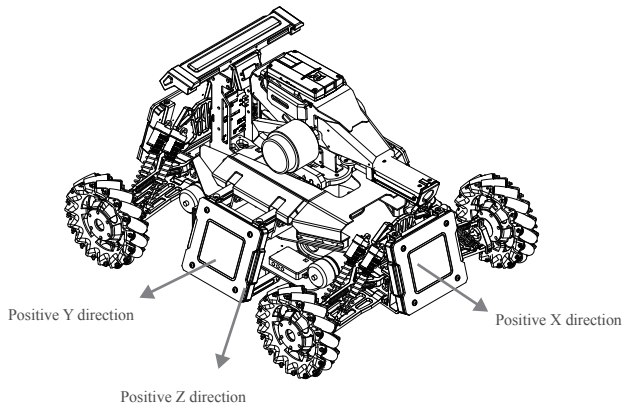
3. Install the Large Armor Module to the Armor Mount and secure with M4 screws. Note that the threaded hole on top of the armor mount is not perpendicular to the bottom surface of the armor mount. When correctly installed, the threaded hole on the bottom surface will be perpendicular to the horizontal ground. Ensure that the front 145° of the Armor Module's exposure surface is not blocked.



- The maximum size where the Sentry is positioned below the top surface of the Sentry Rail should not be more than 450 mm, and above the top surface should not be more than 150 mm (the above two-dimensional limitations are applicable for the robot at all times). When the Sentry is mounted onto the linear section of the Sentry Rail, the long edge of its large Armor Module should be parallel to the linear section of the Sentry Rail; the upper edge of the Armor Module falls into the range of ± 100 mm on the plane where the top surface of the Sentry Rail is located. The exposure surface of the Armor Module is at a 75° angle from the horizontal ground of the battlefield floor, and the normal of the Armor Module's exposure surface points at the battlefield floor.

Installation Specifications and Requirements

In the following section, the robot body coordinate system is a standard XYZ Cartesian coordinate system, with the origin being the robot's center of mass, as shown in the following figure:



The kinematics equation of the robot should be based on the Cartesian coordinate system. If the team chooses to use a non-Cartesian coordinate system, the robot's coordinate system is defined using the following guidelines: Imagine that the launching mechanism of the largest caliber of the robot in its initial state launches a projectile. Define the positive X direction as the projected vector on the XY plane of this projectile's projective direction. Establish the positive Y direction by using the positive X direction and the positive Z direction (pointed towards the ground) according to the right-hand rule, with the robot's center of mass as the origin.

Installation on the Sides

When an Armor Module is mounted on the side, its exposure surface must be firmly connected to the Armor Mount. Keep the bottom surface of the Armor Mount parallel to the XY plane, so that the acute angle between the normal vector of the Armor Module's exposure surface and the negative Z-axis is 75° . Keep the two sides without the indicator light parallel to the XY plane. The Armor Module should be firmly set after the installation. Define the directional vector of any Armor Module as the projected vector of the exposure surface's normal vector (forming an acute angle with the negative Z axis) on the XY plane. The unit vectors of the direction vectors of the 4 Armor Modules must be equal to the positive X-axis, negative X-axis, positive Y-axis, and negative Y-axis, respectively, of the robot's coordinate system. The angular error between the direction vector and the corresponding axis vector cannot exceed 5° . The kinematics equations of the robot should also be based on the Cartesian coordinate system in this case. Armor Modules must use the same reference coordinate system as the robot's own structural or kinematic characteristics. The imaginary connection line between the geometric centers of the Armor Modules mounted on the X-axis should be perpendicular to the counterparts of those mounted on the Y-axis. The two imaginary lines should also pass through the robot's geometric center. Armor Modules mounted on the X- or Y- axis can deviate by ± 50 mm from the geometric center.

Robot Transformation

In principle, after the competition starts, any Armor Module should not actively move relative to the robot body's center of mass. If a robot's shape is transformable due to its structural design, the requirements for the Armor Module are as follows:

1. At no time should any Armor Module repeatedly move back and forth quickly relative to the robot body's center of mass. The speed of any short-term movement must not exceed 0.5 m/s.
2. For the Engineer, the lower edge of the side armor before and after transformation must be 50 mm to 400 mm above the ground.
3. For the Hero, the lower edge of any Armor Module before and after transformation should be 400 mm or more above the ground. The geometric center of the four side-mounted Armor Module bodies and the relative location between the horizontal ground where the central axis of the launching tube is located when any one of the launching mechanisms is on a level ground must remain unchanged throughout the competition.
4. For the Sentry, the upper edge of any Armor Module before and after transformation must be within 100 mm above or below the plane where the top surface of the Sentry Rail is located. The height of the armor plate relative to the rail plane should not be changed; horizontal movement relative to the structure used to mount the robot to the rail is also not allowed.



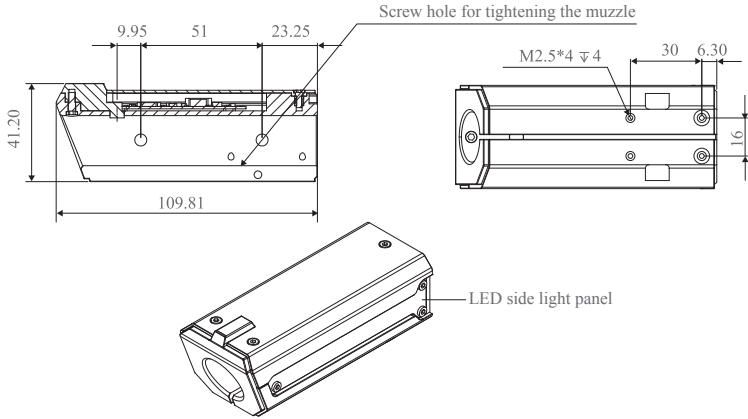
- Self-designed protective armor cannot have any contact with the Armor Modules provided by the RMOc.
 - Do not change or decorate the Armor Modules provided by the RMOc.
 - Connect the wires to the robot appropriately depending on the situation. Ensure that wires are firmly connected and protected from damage.
-

Speed Measurement Module

Description

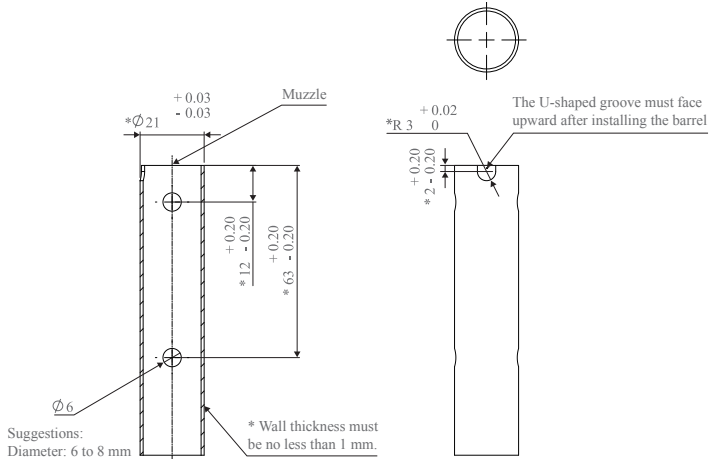
There are two versions of the Speed Measurement Module: 17 mm and 42 mm.

17 mm Speed Measurement Module:



Unit: mm

17 mm barrel size restrictions:

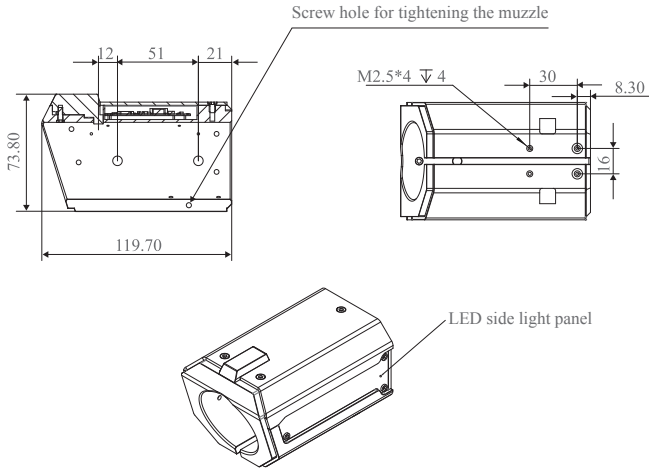


Unit: mm

17 mm barrel requirements:

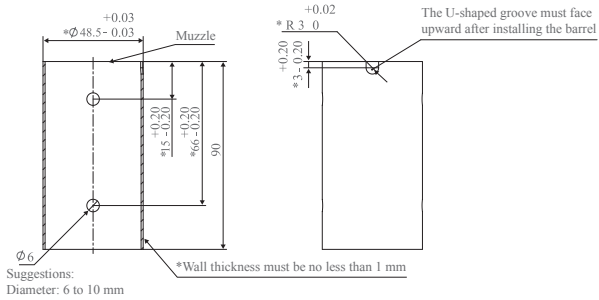
1. The barrel length must be greater than 90 mm.
2. Pay special attention to maintaining dimensions marked with the * sign.
3. Ensure that the Through Beam Photoelectric Sensors are not blocked.
4. Transparent materials are not allowed.

42 mm Speed Measurement Module:



Unit: mm

42 mm barrel size restrictions:



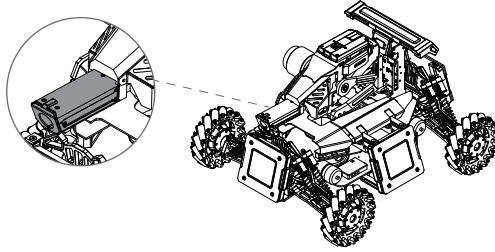
Unit: mm

42 mm barrel requirements:

1. The barrel length must be greater than 90 mm.
2. Pay special attention to maintaining dimensions marked with the * sign.
3. Ensure that the Infrared LEDs are not blocked.
4. Transparent materials are not allowed.

Installation Steps (the 17 mm Speed Measurement Module is used as an example)

1. Set the Speed Measurement Module on the barrel with its cable pointing at the Main Control Module and the cylindrical step aligning with the U-shaped groove on the barrel.
2. Use M3 screws to tighten the barrel through the screw holes in the rear of the Speed Measurement Module.
3. Connect the Speed Measurement Module to the aviation plug on the Main Control Panel's Speed Measurement interface. The completed installation is shown in the figure below:

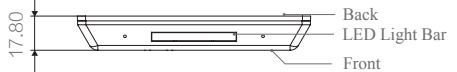
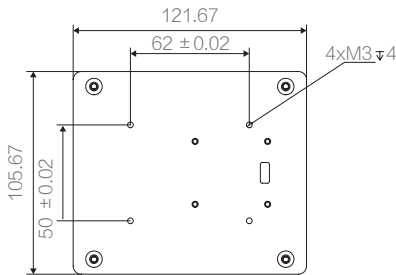


- 4 M2.5 threaded holes are provided to install an RM laser sight or your own laser. Your own laser should not exceed 35 mW of power and the laser color must be red.
- Do not look directly at the laser without eye protection. Safety goggles are recommended during operation.
- Do not block the mounting holes for the Infrared LEDs. Otherwise, the Speed Measurement Module will be unable to initialize.
- Ensure that the Speed Measurement Module is firmly secured to avoid relative displacement between the barrel and the module.

RFID Interaction Module

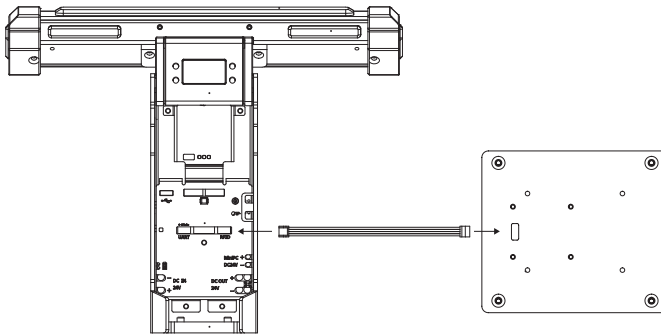
Installation Procedure

1. Using the dimensions and interfaces of the RFID Interaction Module as a reference, reserve mounting holes on the chassis.

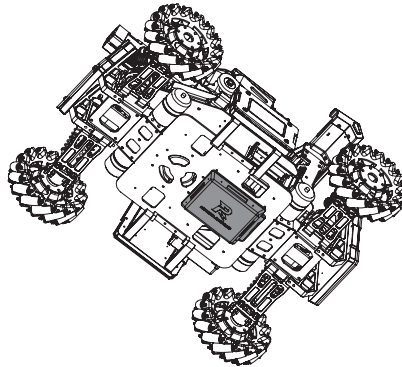


Unit: mm

2. Use the 4-pin cable provided in the package to connect the RFID Interaction Module to the RFID interface on the Main Control Panel of the Referee System's Main Control Module.



3. Use M3 screws to mount the RFID Interaction Module to the chassis. Do not press or bend the cable during installation, and choose an installation location away from the ground.

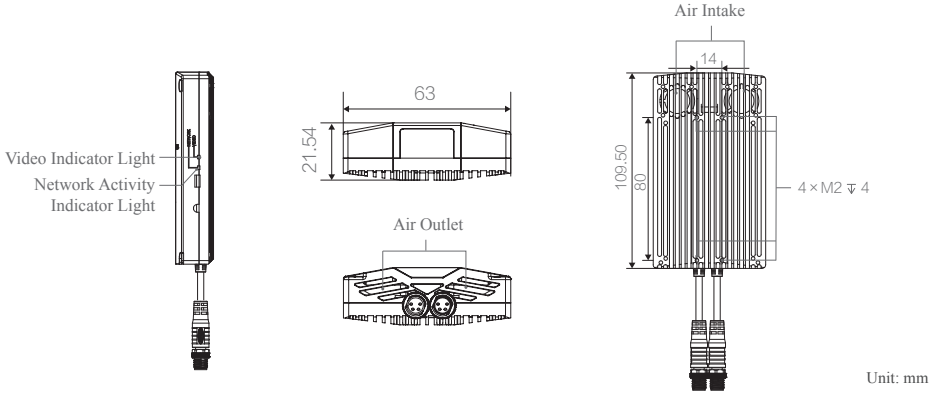


- Ensure that the logo side of the RFID Interaction Module is not blocked by any metal objects, and that the side without a logo is free of current interference (such as a motor wire or RM center plate). Test the effective detection distance of the module. If it decreases, check whether the module is installed properly.
- The Engineer uses a Robot Regeneration Card, both sides of which should not be blocked by any metal objects. Being blocked by a metal object will reduce the effective detection distance of the RFID Interaction Module and may result in detection failure.
- The supplied IC card is the Robot Regeneration Card.

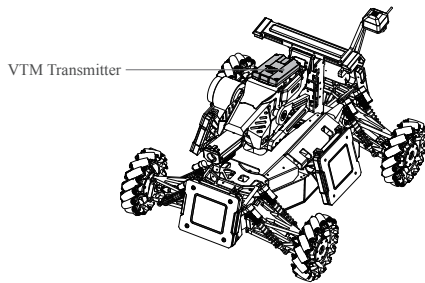
Camera Transmission Module

Installation of the VTM Transmitter

1. Using the dimensions and interfaces of the VTM Transmitter as a reference, reserve mounting holes in the desired location.



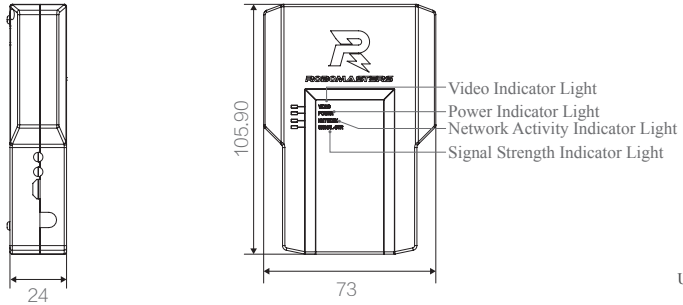
Use four M2 screws to mount the VTM Transmitter to an appropriate location. To ensure that the VTM Transmitter works properly, keep its air intake and outlet free of blockage. Also make sure that no metal components are blocking the top of the module, where its antenna is located.



2. Connect the aviation plug of the VTM Transmitter to the plug on the Main Control Panel's camera transmission interface.

Installation of the VTM Receiver

Use the supplied mounting clip to mount the VTM Receiver on the monitor or any other support. Ensure that the mounting location is at least 1 m above the ground and is not blocked by any metal objects. Check the quality of the receiving image to find the most suitable mounting location. The VTM Receiver is shown in the figure below:

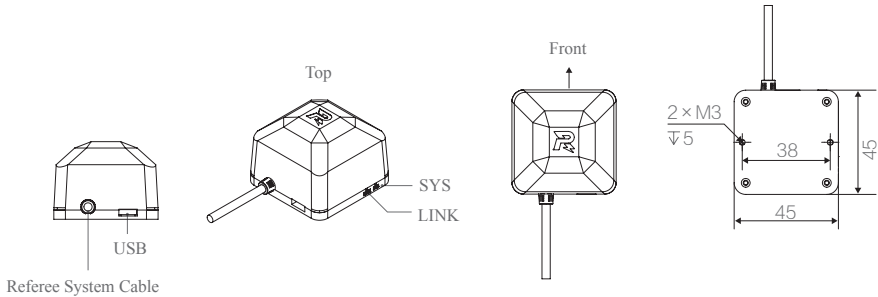


Unit: mm

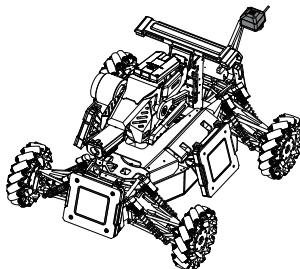
Localization Module

Installation Procedure

1. Using the dimensions of the Localization Module as a reference, reserve mounting holes in the specified locations.



2. Use two M3 screws to mount the Localization Module to the specified location. The front of the Localization Module must be in line with the front of the robot, horizontally installed with the top facing up.



3. Use the aviation plug extension cords in the package to connect the Localization Module to the aviation plug of the Camera Transmission Module.



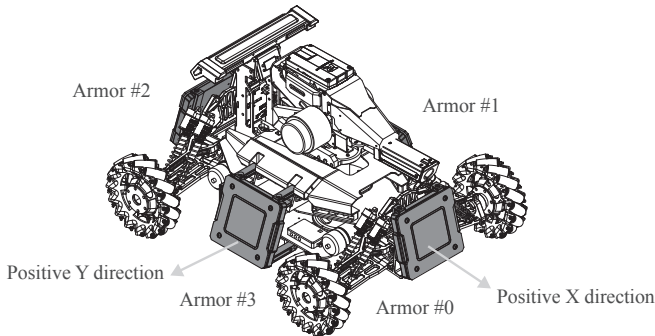
- The aviation plugs on the VTM Transmitter, the Speed Measurement Module, the Localization Module, and the Main Control Module are all equivalent interfaces.
- The localization base stations are fixed at the top of the fence around the site. While the robot is moving, ensure that the straight-line connection between the Localization Module and each base station is not blocked by the robot itself. It is recommended to install the Localization Module at the highest point on the robot.
- It is recommended to maintain a distance of greater than 20 cm between the installation location of the Localization Module and the motor, the Camera Transmission Module, and any components that have or can generate a strong magnetic field in motion. If not possible, the distance should be no less than 10 cm.
- The Localization Module of the Sentry is not included in the overall dimension limitations.

Functions and Usage Rules

Armor Module ID Setting Specifications

The modules of the Referee System communicate using a CAN network, so they need unique IDs to ensure smooth communication. During production, each Armor Module is assigned a default ID. Therefore, you need to set sequenced IDs the first time you install multiple Armor Modules and each time you replace them. The ID setting procedure is as follows:

1. On the Referee System interactive main page, press and hold the "Confirm" button to enter the "Function" page.
2. On the "Function" page, press the up and down buttons to select "System Setup" and enter the "System Setup" page.
3. On the "System Setup" page, select "Armor ID Setup". Then, press the "Confirm" button to enter the armor ID setting page. Select "Armor ID Reset" to reset the armor ID. In this process, the armor indicator light will flash at a certain frequency (The red light flashes if the robot ID is on the red team, and the blue light flashes if the ID is on the blue team).
4. Strike each Armor Module in succession at a certain strength. If the armor light stops flashing, the armor ID has been set successfully. The ID number of the Armor Module that was hit first is 0, and the ID number is sequentially incremented according to the order in which they were struck. After completing the above operations, check whether the armor ID has been set successfully by looking up the version number of the Armor Modules. If the read number of effective Armor Modules is the same as the number of Armor Modules installed, the procedure is complete. Armor Module ID numbers have a strict sequential requirement, as shown in the figure below:



Standard, Hero and Engineer:

Referring to the Armor Module installation specifications, based on the requirements established for the robot coordinate system, set the Armor Module IDs in the positive X direction, negative Y direction, negative X direction, and positive Y direction are to 0, 1, 2 and 3, respectively. That is, in the Armor ID setting mode, tap the Armor Modules in the positive X direction, negative Y direction, negative X direction and positive Y direction in turn to set all robot Armor Module IDs. (Standard ID setting of the side-mounted Armor Module; mainly displays direction information about the exposure surface of the robot on the contestant's operation page. In addition, the "real-time HP change information" output from the Referee System also uses this data as a reference)

Sentry:

The Sentry has armor only on the left and right. Set the Armor ID on the side facing the base to 0 and set the other Armor ID to 1.



- Please set the Armor Module IDs in advance of the competition. If an ID is set incorrectly, the Referee System will not be able to detect it during initialization, and will automatically deduct HP from the robot during the competition as the Armor Module is considered to be offline.

Power Monitoring

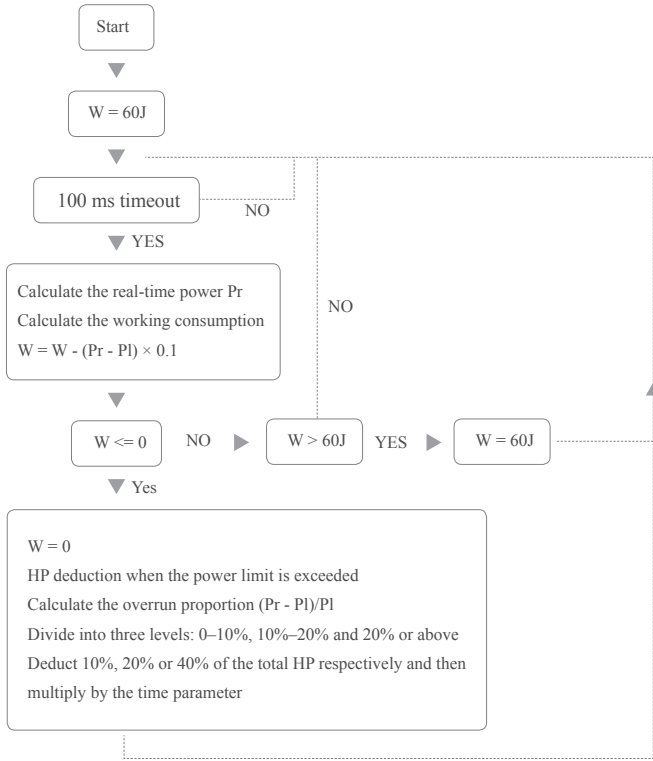
The part where a robot power system and its attachments are loaded and installed is the robot chassis, which can make the robot move horizontally. The chassis power of the robot will be continuously monitored by the Referee System. The system will trigger the punishment mechanism of deducting HP from the robot if it exceeds the allowed power range. The chassis power refers to the power of the power system that makes the robot move horizontally, excluding the power of the power system used for special tasks, such as functional movements that include moving the upper mechanical structure.

According to the competition rules of RoboMaster 2018, the limitations on chassis power output for each robot type are as follows:

Robot type	Upper power limit
Standard	80
Sentry	Unlimited
Hero	120
Aerial	Unlimited
Engineer	Unlimited

When a robot exceeds the chassis power limit, the HP deducted depends on the degree to which the limit is exceeded. This degree is calculated using the formula $(Pr - PI)/PI$, in which Pr is the instantaneous chassis power output and PI is the power limit specified by the RoboMaster competition. For details, refer to the table above. If the chassis power is not more than 10% below the threshold, then up to 10% of HP is deducted from the robot. If the chassis power is more than 10% but not more than 20% above the threshold, then up to 20% of HP is deducted from the robot; if the chassis power is more than 20% above the threshold, then up to 40% of HP is deducted from the robot.

Taking into account the difficulty in controlling the instantaneous output power while the robot is moving, the RMOC has defined a cushioning capacity W of 60 joules for the software. The frequency of the Referee System when detecting the chassis power is 10 Hz. The figure below shows the whole detection process and the logic of deducting the HP from the robot:



The 80 W power limit of the Standard is used as an example here. If the robot has the continuous power output of 140 W, 60 J of energy will be consumed after 1 second. In the next 100 ms detection cycle, the calculated overrun proportion is $(140 - 80)/80 = 75\%$, which is more than 20% above the power limit; therefore, the HP to deduct is $1500 \times 40\% \times 0.1 = 60$.

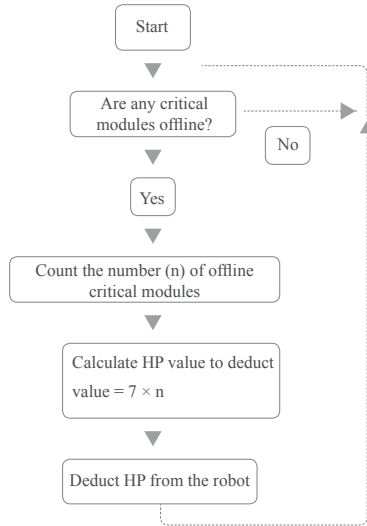
Module Status Monitoring

To ensure fair competition, it is important that all of the Referee System modules are working properly. Therefore, the Referee System initializes each module after powering up. Depending on the amount of impact each module has on the competition, it is classified into one of the following categories: critical modules or general modules.

Critical modules: Armor Module, Speed Monitor Module, Main Control Module, Wi-Fi Module and Positioning Module

General modules: RFID Interaction Module and Video Transmission Module

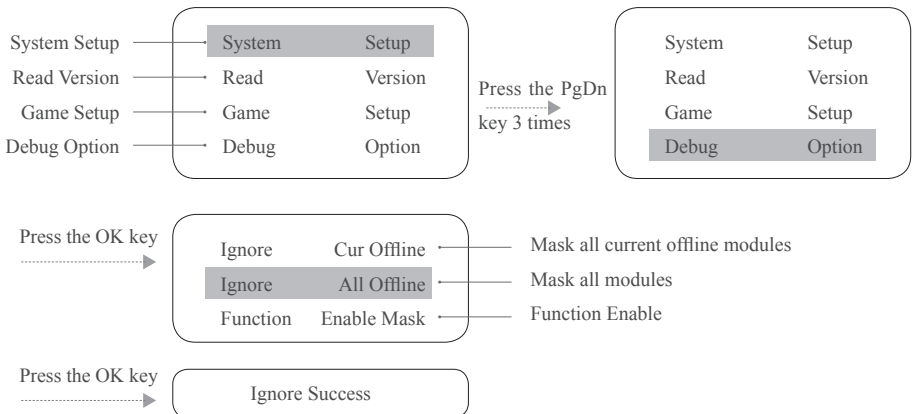
Critical modules affect the fairness of the competition. For example, a malfunctioning Armor Module will not detect enemy attacks. In the official competition, the Referee System checks each module's connection at a frequency of 2 Hz. If a critical module is detected as offline, the Referee System will automatically deduct HP from the robot. The HP deduction mechanism is shown in the following flowchart:



Offline general modules will be detrimental to the team’s performance. Therefore, the Referee System will not deduct any HP, but instead will flash the yellow auxiliary light to inform the team of the situation.

Taking into account the importance of various modules of the Referee System in the competition, the RMOC fully tests the Referee System and assures that each module cannot be damaged easily. Contestants should not disassemble or modify any parts of the Referee System without authorization.

For the self-test masking method of the Referee System, refer to the example below:



- The module-masking function is available only during routine debugging. In the pre-match inspection, match-specific Referee System firmware that cannot mask these features will be burned into the robot by officials.
- To ensure fair competition, contestants are entitled to ask the RMOC to repair or change a damaged Referee System module in the inspection process. After the inspection process, the functionality of the Referee System is the responsibility of the contestants.

Light Bar Status Description

Status	Main Light Bar of Main Control Module	Auxiliary Light Bar in front of Main Control Module	Auxiliary Light Bar on the sides of the Main Control Module	RFID light	Armor light	17 mm/42 mm Speed Measurement Module light
Default status	Display HP	Display robot color (red/blue)	Level: periodic flashing N times (N represents robot level) No level: red/blue light steadily lit	Red/blue light steadily lit	Red/blue light steadily lit	Display heat
Module upgrade	Display the progress bar in green			/	/	/
Search command	All HP bars flash in green			/	/	/
Not competing; critical module offline	Yellow light steadily lit	Yellow light steadily lit	Yellow light steadily lit	/	/	/
Not competing; general module offline	/	Yellow light flashes	Yellow light flashes	/	/	/
Competing; critical module offline	/	Yellow light steadily lit	/	/	/	/
Powering-on self-test	Red/blue self-test progress bar	/	/	/	/	/
Revive	The colored light moves from the center to both sides	/	/	/	/	/
Regenerate	The green cell moves from the left to the right	/	/	/	/	/
Heat/Defense Buff	/	/	/	Green light steadily lit	/	/
Attack buff	/	White light flashes	White light flashes	"Class 1: yellow light steadily lit Class 2: green light steadily lit"	/	/
Hit by a 17 mm projectile	/	/	/	/	The related armor flashes	/
Hit by a 42 mm projectile	Green light flashes	Flash	Flash	/	The related armor flashes	/
Destroyed	Off	Red/blue light steadily lit	Red/blue light steadily lit	White light steadily lit	Off	Light red/light blue steadily lit
Send off	Off	Off	Off	White light steadily lit	Off	White light steadily lit
Overheat	/	/	/	/	/	Purple light fades in and out
Speed exceeded	/	/	/	/	/	Red/blue light flashes once

20-Second System Initialization Period

After the three-minute preparation phase preceding the competition, there is a 20-second Referee System Initialization Period. After the system initialization, the competition officially starts. During the initialization, the competition server automatically detects the client connection status, robot wireless connection status, robot module status, and the status of the battlefield elements. If the status cannot support the game's proper initialization (e.g., a client, robot, or element is offline), the system initialization countdown will be suspended. After all faults are cleared, the referee will manually restart the system initialization and the countdown continues. Upon entering the 20-second System Initialization Period, the competition server restores all robots' HP completely. During this period, operators (except for Aerial operators who must stay in the Aerial Operator Room) must stay in the Operator Room where they can check whether the mice and the keyboards for the competition are functioning properly.

Competition Information Interface

To help contestants better implement automation and obtain real-time statuses during the competition, the Referee System includes a UART input and output interface. This system outputs some data from the robots and the battlefield during the competition. It can also transmit data customized by the users and display it on the contestants' UI. The output information includes the remaining competition time, the robot's HP, the real-time current and voltage output of the chassis, etc. The open uplink data interface has three floating-point data and one unsigned character data reserved. You can implement according to the Referee System Interface Protocol Description. The uplink data will be presented on the corresponding operator page, where the floating-point data will display a specific value and the six-bit unsigned character data will appear as six indicator lights.

Battlefield Geo-Fence

Purpose

Preventing robots not involved in the competition from connecting with the game system, which will interfere with the normal operation of the competition.

Introduction to the Operating Principle

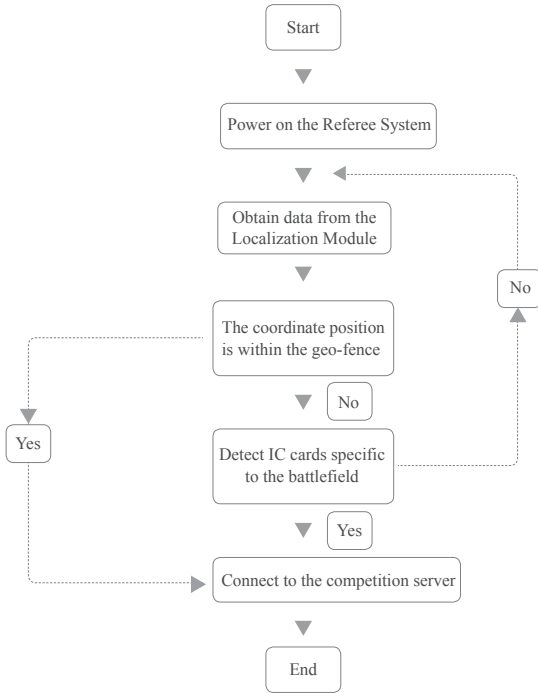
The geo-fence defines the battlefield. A robot can be connected to the competition server only within the geo-fence. Both the Localization Module and RFID Interaction Module of the Referee System are used to check whether a robot works within the geo-fence.

1. Localization Module identification of the geo-fence zone

According to the descriptions about the Localization Module in the "Mounting of the Referee System" section, the Localization Module mounted to a robot communicates with a Localization Module base station installed around the battlefield and can thus calculate the relative location of the robot in the battlefield. This location information can be a basis for accurately judging whether the robot is located inside or outside the geo-fence. If it is located inside the geo-fence, the Referee System mounted to the robot will automatically connect to the competition server. Note that the Localization Module should be installed in accordance with the installation instructions to ensure accuracy when calculating the location relative to a robot.

2. RFID Interaction Module identification of the geo-fence zone

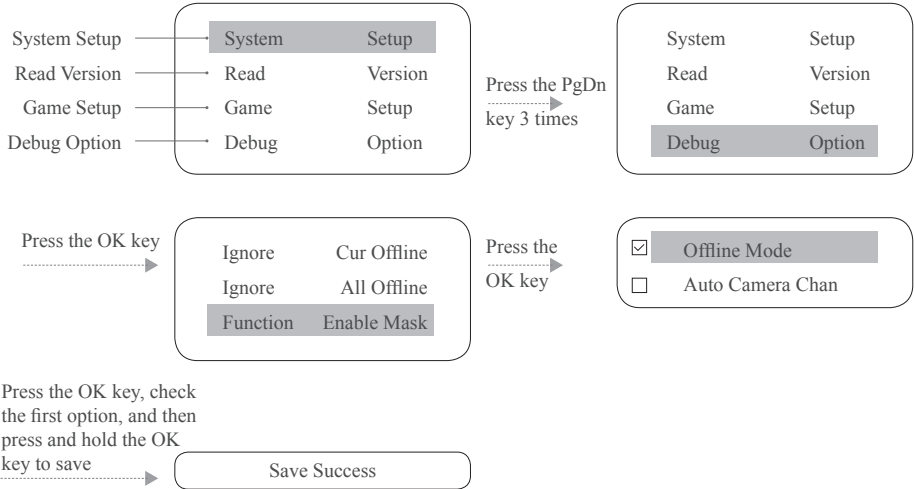
For this function, a series of IC cards specific to the battlefield is produced. The battlefield-specific IC cards contain geo-fence-related data. If the RFID Interaction Module detects this data, the Referee System mounted to the robot will automatically connect to the competition server. This method can be used only before the competition, within the three-minute preparation phase or the 20-second Referee System Initialization Period preceding the competition. During this time, if any robots inside the battlefield are not connected to the competition server, referees will use battlefield-specific IC cards to make these robots properly connect to the competition server. The following chart shows the workflow of how the Referee System uses the geo-fence feature to connect to the competition server:



• The geo-fence feature is dependent on the Localization Module. If a robot's Localization Module is not properly installed, the robot will unexpectedly lose power and restart during the competition. If the robot reconnects to the competition system within 15 seconds, the robot's HP will be restored to its most recent value and the competition will continue. If the Localization Module cannot generate accurate positioning data for more than 15 seconds, the robot will fail to connect to the competition system. At the end of the competition, the remaining HP of the robot will be judged as 0.

Offline Mode

The Referee System is divided into offline mode and online mode. Offline mode refers to when the Referee System is not connected to the server. Offline mode allows users to debug and use the Referee System regardless of its connection status. In offline mode, the Referee System can automatically detect the attack damage of a projectile and monitor the robot chassis power, barrel heat, and launch speed limit. However, updates and competition data are not available for a robot in offline mode.



Online Mode

Online mode refers to when the Referee System is connected to the server. Online mode is used during the formal competition. In online mode, a robot will be subject to competition mechanisms. The system can automatically switch between online mode and offline mode.

Appendix

Referee System Interface Protocol Description

Communication Protocol Format

FrameHeader(5-Byte)	CmdID(2-Byte)	Data(n-Byte)	FrameTail (2-byte, CRC16, entire package verification)
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Frame Header Format

Domain	Offset position	Size (byte)	Description
SOF	0	1	The FrameHeader is fixed at 0xA5
DataLength	1	2	Data segment length
Seq	3	1	Sequence number
CRC8	4	1	Frame header CRC8

Command Code IDs

Summary

Command Code	Data segment length (Byte)	Function Description
0x0001	8	Robot status, transmitted periodically at a frequency of 10 Hz
0x0002	1	Damage data, transmitted when the robot is hit
0x0003	6	Real-time launch data, transmitted when a projectile is launched
0x0004	20	Real-time power and heat data, transmitted periodically at a frequency of 50 Hz
0x0005	2	Real-time RFID interaction data; transmitted periodically at a frequency of 10 Hz when the RFID card is detected
0x0006	1	Match results data is sent at the end of the match
0x0007	2	Buff status, sent when the status of any Buff changes
0x0008	16	Robot position and barrel orientation information are sent periodically at a 50Hz frequency
0x0100	13	Team custom data displayed in the operating interface is limited to a frequency of 10Hz

Details

Robot's status in the competition (0x0001)

Byte offset	Size	Description
0	2	Remaining time in the current round (seconds)
2	1	Current stage 0: pre-competition stage 1: preparation stage 2: initialization stage 3: 5-second countdown 4: in combat 5: calculating competition results
3	1	Robot's current grade
4	2	Robot's current HP
6	2	Robot's maximum HP

Structure Definition:

```
typedef __packed struct
{
    uint16_t stageRemianTime;
    uint8_t gameProgress;
    uint8_t robotLevel;
    uint16_t remainHP;
    uint16_t maxHP;
}extGameRobotState_t;
```

Damage data (0x0002)

Byte offset	Size	Description
0	1	Bits 0-3: indicate the armor ID if the type of change is armor damage 0x0: armor #0 (front) 0x1: armor #1 (left) 0x2: armor #2 (rear) 0x3: armor #3 (right) 0x4: armor #4 (up 1) 0x5: armor #5 (up 2) Other bits reserved Bits 4-7: Type of HP changes 0x0: armor damage (attack received) 0x1: module offline

Structure Definition:

```
typedef __packed struct
{
    uint8_t armorType : 4;
    uint8_t hurtType : 4;
}extRobotHurt_t;
```

Real-time launching data (0x0003)

Byte offset	Size	Description
0	1	Projectile type 1: 17 mm projectile 2: 42 mm projectile
1	1	Projectile launching rate (rounds/s)
2	4	Projectile velocity (m/s)

Structure Definition:

```
typedef __packed struct
{
    uint8_t bulletType;
    uint8_t bulletFreq;
    float bulletSpeed;
}extShootData_t;
```

Real-time power & heat data (0x0004)

Byte offset	Size	Description
0	4	Chassis output voltage (V)
4	4	Chassis output current (A)
8	4	Chassis output power (W)
12	4	Chassis power buffer (W)
16	2	17 mm barrel heat
18	2	42 mm barrel heat

Structure Definition:

```
typedef __packed struct
{
    float  chassisVolt;
    float  chassisCurrent;
    float  chassisPower;
    float  chassisPowerBuffer;
    uint16_t shooterHeat0;
    uint16_t shooterHeat1;
}extPowerHeatData_t;
```

RFID interaction data (0x0005)

Byte offset	Size	Description
0	1	Card type 0: Attack buff card 1: Defense buff card 2: Red team health card 3: Blue team health card 4: Red team (HP)Regeneration Card 5: Blue team (HP)Regeneration Card 6: Red team cooling card 7: Blue team cooling card 8: Bunker card 9: Reserved 10: Resource Island card 11: ICRA large Power Rune attack points card
1	1	Card index number; used to distinguish different sections

Structure Definition:

```
typedef __packed struct
{
    uint8_t cardType;
    uint8_t cardIdx;
}extRfidDetect_t;
```

Competition result data (0x0006)

Byte offset	Size	Description
0	1	Competition result 0: Draw 1: Red team wins 2: Blue team wins

Structure Definition:
typedef __packed struct
{
 uint8_t winner;
}extGameResult_t;

Buff obtained data (0x0007)

Byte offset	Size	Description
0	2	Buff type (1 = active) bit0: Regeneration via Regeneration Point bit1: Regeneration via Engineer bit2: Regeneration via (HP)Regeneration Card bit3: Resource Island defense bit4: Team member has activated a large Power Rune bit5: Enemy has activated a large Power Rune bit6: Team member has activated a small Power Rune bit7: Enemy has activated a small Power Rune bit8: Accelerate cooling bit9: Bunker defense bit10: Defense 100% bit11: No Sentry Base defense bit12: Sentry Base defense available

Structure Definition:
Typedef __packed struct
{
 Uin16_t buffMusk;
}exBuffMusk_t;

Robot's positioning and orientation information (0x0008)

Byte offset	Size	Description
0	4	Positioning on the x-coordinate (m)
4	4	Positioning on the y-coordinate (m)
8	4	Positioning on the z-coordinate (m)
12	4	Barrel orientation (degrees)

Structure Definition:

```
typedef __packed struct
{
    float x;
    float y;
    float z;
    float yaw;
}extGameRobotPos_t;
```

Team-customizable data (0x0100)

Byte offset	Size	Description
0	4	Customized data 1
4	4	Customized data 2
8	4	Customized data 3
12	1	Customized data 4

Structure Definition:

```
typedef __packed struct
{
    float data1;
    float data2;
    float data3;
    uint8_t mask;
}extShowData_t;
```

CRC Example Code

```
//crc8 generator polynomial:G(x)=x8+x5+x4+1
const unsigned char CRC8_INIT = 0xff;
const unsigned char CRC8_TAB[256] =
{
0x00, 0x5e, 0xbc, 0xe2, 0x61, 0x3f, 0xdd, 0x83, 0xc2, 0x9c, 0x7e, 0x20, 0xa3, 0xfd, 0x1f, 0x41,
0x9d, 0xc3, 0x21, 0x7f, 0xfc, 0xa2, 0x40, 0x1e, 0x5f, 0x01, 0xe3, 0xbd, 0x3e, 0x60, 0x82, 0xdc, 0x23, 0x7d, 0x9f,
0xc1, 0x42, 0x1c, 0xfe, 0xa0, 0xe1, 0xbf, 0x5d, 0x03, 0x80, 0xde, 0x3c, 0x62, 0xbe, 0xe0, 0x02, 0x5c, 0xdf, 0x81,
0x63, 0x3d, 0x7c, 0x22, 0xc0, 0x9e, 0x1d, 0x43, 0xa1, 0xff, 0x46, 0x18, 0xfa, 0xa4, 0x27, 0x79, 0x9b, 0xc5, 0x84,
0xda, 0x38, 0x66, 0xe5, 0xbb, 0x59, 0x07, 0xdb, 0x85, 0x67, 0x39, 0xba, 0xe4, 0x06, 0x58, 0x19, 0x47, 0xa5, 0xfb,
0x78, 0x26, 0xc4, 0x9a, 0x65, 0x3b, 0xd9, 0x87, 0x04, 0x5a, 0xb8, 0xe6, 0xa7, 0xf9, 0x1b, 0x45, 0xc6, 0x98, 0x7a,
0x24, 0xf8, 0xa6, 0x44, 0x1a, 0x99, 0xc7, 0x25, 0x7b, 0x3a, 0x64, 0x86, 0xd8, 0x5b, 0x05, 0xe7, 0xb9,
0x8c, 0xd2, 0x30, 0x6e, 0xed, 0xb3, 0x51, 0x0f, 0x4e, 0x10, 0xf2, 0xac, 0x2f, 0x71, 0x93, 0xcd, 0x11, 0x4f, 0xad,
0xf3, 0x70, 0x2e, 0xcc, 0x92, 0xd3, 0x8d, 0x6f, 0x31, 0xb2, 0xec, 0x0e, 0x50, 0xaf, 0xf1, 0x13, 0x4d, 0xce, 0x90,
0x72, 0x2c, 0x6d, 0x33, 0xd1, 0x8f, 0x0c, 0x52, 0xb0, 0xee, 0x32, 0x6c, 0x8e, 0xd0, 0x53, 0x0d, 0xef, 0xb1, 0xf0,
0xae, 0x4c, 0x12, 0x91, 0xcf, 0x2d, 0x73, 0xca, 0x94, 0x76, 0x28, 0xab, 0xf5, 0x17, 0x49, 0x08, 0x56, 0xb4, 0xea,
0x69, 0x37, 0xd5, 0x8b, 0x57, 0x09, 0xeb, 0xb5, 0x36, 0x68, 0x8a, 0xd4, 0x95, 0xcb, 0x29, 0x77, 0xf4, 0xaa, 0x48,
0x16, 0xe9, 0xb7, 0x55, 0x0b, 0x88, 0xd6, 0x34, 0x6a, 0x2b, 0x75, 0x97, 0xc9, 0x4a, 0x14, 0xf6, 0xa8,
0x74, 0x2a, 0xc8, 0x96, 0x15, 0x4b, 0xa9, 0xf7, 0xb6, 0xe8, 0x0a, 0x54, 0xd7, 0x89, 0x6b, 0x35,
};
unsigned char Get_CRC8_Check_Sum(unsigned char *pchMessage,unsigned int dwLength,unsigned char ucCRC8)
{
unsigned char ucIndex;
while (dwLength--)
{
ucIndex = ucCRC8^(*pchMessage++);
ucCRC8 = CRC8_TAB[ucIndex];
}
return(ucCRC8);
}
/*
** Descriptions: CRC8 Verify function
** Input: Data to Verify,Stream length = Data + checksum
** Output: True or False (CRC Verify Result)
*/
unsigned int Verify_CRC8_Check_Sum(unsigned char *pchMessage, unsigned int dwLength)
{
unsigned char ucExpected = 0;
if ((pchMessage == 0) || (dwLength <= 2)) return 0;
ucExpected = Get_CRC8_Check_Sum (pchMessage, dwLength-1, CRC8_INIT);
return ( ucExpected == pchMessage[dwLength-1] );
}

```

```

/*
** Descriptions: append CRC8 to the end of data
** Input: Data to CRC and append,Stream length = Data + checksum
** Output: True or False (CRC Verify Result)
*/
void Append_CRC8_Check_Sum(unsigned char *pchMessage, unsigned int dwLength)
{
    unsigned char ucCRC = 0;
    if((pchMessage == 0) || (dwLength <= 2)) return;
    ucCRC = Get_CRC8_Check_Sum ( (unsigned char *)pchMessage, dwLength-1, CRC8_INIT);
    pchMessage[dwLength-1] = ucCRC;
}

```

```

uint16_t CRC_INIT = 0xffff;
const uint16_t wCRC_Table[256] =
{
    0x0000, 0x1189, 0x2312, 0x329b, 0x4624, 0x57ad, 0x6536, 0x74bf,
    0x8c48, 0x9dc1, 0xaf5a, 0xbded, 0xca6c, 0xdbe5, 0xe97e, 0xf8f7,
    0x1081, 0x0108, 0x3393, 0x221a, 0x56a5, 0x472c, 0x75b7, 0x643e,
    0x9cc9, 0x8d40, 0xbfdb, 0xae52, 0xdaed, 0xcb64, 0xf9ff, 0xe876,
    0x2102, 0x308b, 0x0210, 0x1399, 0x6726, 0x76af, 0x4434, 0x55bd,
    0xad4a, 0xbcc3, 0x8e58, 0x9fd1, 0xeb6e, 0xfae7, 0xc87c, 0xd9f5,
    0x3183, 0x200a, 0x1291, 0x0318, 0x77a7, 0x662e, 0x54b5, 0x453c,
    0xbdc6, 0xac42, 0x9ed9, 0x8f50, 0xfbef, 0xea66, 0xd8fd, 0xc974,
    0x4204, 0x538d, 0x6116, 0x709f, 0x0420, 0x15a9, 0x2732, 0x36bb,
    0xce4c, 0xdfc5, 0xed5e, 0xfcd7, 0x8868, 0x99e1, 0xab7a, 0xbaf3,
    0x5285, 0x430c, 0x7197, 0x601e, 0x14a1, 0x0528, 0x37b3, 0x263a,
    0xdced, 0xcf44, 0xfddf, 0xec56, 0x98e9, 0x8960, 0xbbfb, 0xaa72,
    0x6306, 0x728f, 0x4014, 0x519d, 0x2522, 0x34ab, 0x0630, 0x17b9,
    0xef4e, 0xfec7, 0xcc5c, 0xdd5, 0xa96a, 0xb8e3, 0x8a78, 0x9bf1,
    0x7387, 0x620e, 0x5095, 0x411c, 0x35a3, 0x242a, 0x16b1, 0x0738,
    0xffcf, 0xee46, 0xdcdd, 0xcd54, 0xb9eb, 0xa862, 0x9af9, 0x8b70,
    0x8408, 0x9581, 0xa71a, 0xb693, 0xc22c, 0xd3a5, 0xe13e, 0xf0b7,
    0x0840, 0x19c9, 0x2b52, 0x3adb, 0x4e64, 0x5fed, 0x6d76, 0x7eff,
    0x9489, 0x8500, 0xb79b, 0xa612, 0xd2ad, 0xc324, 0xf1bf, 0xe036,
    0x18c1, 0x0948, 0x3bd3, 0x2a5a, 0x5ee5, 0x4f6c, 0x7df7, 0x6c7e,
    0xa50a, 0xb483, 0x8618, 0x9791, 0xe32e, 0xf2a7, 0xc03c, 0xd1b5,
    0x2942, 0x38cb, 0x0a50, 0x1bd9, 0x6f66, 0x7eef, 0x4c74, 0x5dfd,
    0xb58b, 0xa402, 0x9699, 0x8710, 0xf3af, 0xe226, 0xd0bd, 0xc134,
    0x39c3, 0x284a, 0x1ad1, 0x0b58, 0x7fe7, 0x6e6e, 0x5cf5, 0x4d7c,
    0xc60c, 0xd785, 0xe51e, 0xf497, 0x8028, 0x91a1, 0xa33a, 0xb2b3,
    0x4a44, 0x5bcd, 0x6956, 0x78df, 0x0c60, 0x1de9, 0x2f72, 0x3efb,

```

```

0xd68d, 0xc704, 0xf59f, 0xe416, 0x90a9, 0x8120, 0xb3bb, 0xa232,
0x5ac5, 0x4b4c, 0x79d7, 0x685e, 0x1ce1, 0x0d68, 0x3f3, 0x2e7a,
0xc70e, 0xf687, 0xc41c, 0xd595, 0xa12a, 0xb0a3, 0x8238, 0x93b1,
0x6b46, 0x7acf, 0x4854, 0x59dd, 0x2d62, 0x3ceb, 0x0e70, 0x1ff9,
0xf78f, 0xe606, 0xd49d, 0xc514, 0xb1ab, 0xa022, 0x92b9, 0x8330,
0x7bc7, 0x6a4e, 0x58d5, 0x495c, 0x3de3, 0x2c6a, 0x1ef1, 0x0f78
};
/*
** Descriptions: CRC16 checksum function
** Input: Data to check,Stream length, initialized checksum
** Output: CRC checksum
*/
uint16_t Get_CRC16_Check_Sum(uint8_t *pchMessage,uint32_t dwLength,uint16_t wCRC)
{
    Uint8_t chData;
    if (pchMessage == NULL)
    {
        return 0xFFFF;
    }
    while(dwLength--)
    {
        chData = *pchMessage++;
        (wCRC) = ((uint16_t)(wCRC) >> 8) ^ wCRC_Table[((uint16_t)(wCRC) ^ (uint16_t)(chData)) & 0x00ff];
    }
    return wCRC;
}

/*
** Descriptions: CRC16 Verify function
** Input: Data to Verify,Stream length = Data + checksum
** Output: True or False (CRC Verify Result)
*/
uint32_t Verify_CRC16_Check_Sum(uint8_t *pchMessage, uint32_t dwLength)
{
    uint16_t wExpected = 0;
    if ((pchMessage == NULL) || (dwLength <= 2))
    {
        return __FALSE;
    }
    wExpected = Get_CRC16_Check_Sum ( pchMessage, dwLength - 2, CRC_INIT);
    return ((wExpected & 0xff) == pchMessage[dwLength - 2] && ((wExpected >> 8) & 0xff) ==
    pchMessage[dwLength - 1]);
}

```

```
}  
}  
  
/*  
** Descriptions: append CRC16 to the end of data  
** Input: Data to CRC and append,Stream length = Data + checksum  
** Output: True or False (CRC Verify Result)  
*/  
void Append_CRC16_Check_Sum(uint8_t * pchMessage,uint32_t dwLength)  
{  
    uint16_t wCRC = 0;  
    if((pchMessage == NULL) || (dwLength <= 2))  
    {  
        return;  
    }  
    wCRC = Get_CRC16_Check_Sum ( (U8 *)pchMessage, dwLength-2, CRC_INIT );  
    pchMessage[dwLength-2] = (U8)(wCRC & 0x00ff);  
    pchMessage[dwLength-1] = (U8)((wCRC >> 8)& 0x00ff);
```



• UART communication configuration, baud rate 115200, data bit 8, stop bit 1, parity bit none, flow control none.



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