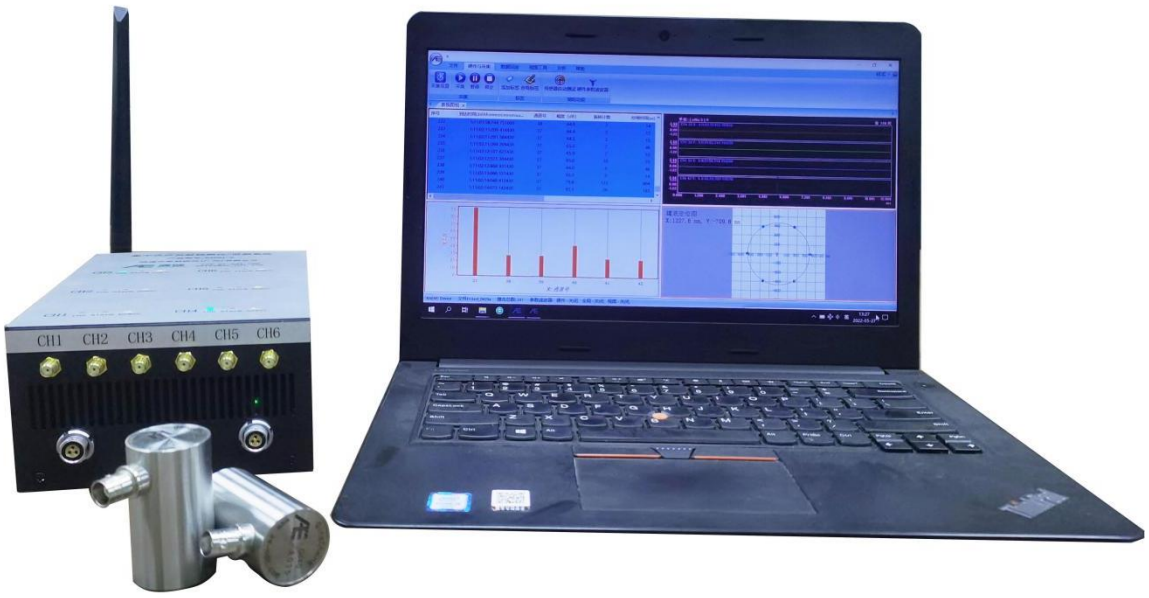
RAEM1-6 USER'S MANUAL
Operation Guide



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1. Technical Background

1.1 Acoustic Emission Technology Introduction

Acoustic emission (AE) is the phenomenon of transient elastic waves generated by the rapid release of energy from local sources in materials, sometimes also known as stress wave emission. The acoustic emission testing technology is the acoustic detection method by receiving and analyzing the acoustic emission signals to evaluate the material performances or structural integrity. The deformation and crack propagation of materials under stress are important mechanisms of structural failure. The source directly related to deformation and fracture mechanism is called acoustic emission source.

The principle of acoustic emission detection is shown in Figure 1-1. The elastic waves emitted from the acoustic emission source finally propagate to the surface of the material, causing the surface displacement that can be detected by the acoustic emission sensor. The sensor converts the mechanical vibration of the material into an electrical signal, which is then amplified, processed, and recorded. By analyzing and inferring the recorded acoustic emission signals, the mechanism of the acoustic emission of the material is understood.

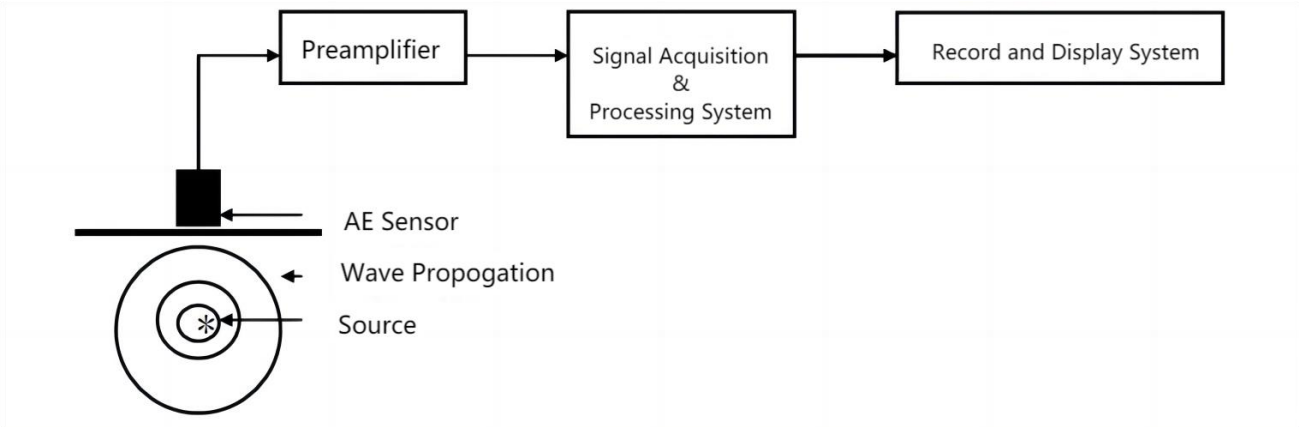


Fig. 1-1 Block diagram of acoustic emission testing principle

1.2 Main Purpose of Acoustic Emission Testing

- Locate the acoustic emission source
- Analyze the properties of the acoustic emission source

- Determine the time and load of the AE occurrence
- Assess the severity of the acoustic emission source

1.3 Characteristics of Acoustic Emission Testing

The discovery of each acoustic emission source indicates the application of AE system. The AE testing method is different from other conventional NDT methods in many aspects:

- It is a dynamic detection method. The detected energy comes from the object itself, not from the detection instrument;
- It is sensitive to linear defects and can detect the movement of the defects under external structural stress;
- It can detect and evaluate the state of the defects in the whole structure;
- The system can provide real-time or continuous information of the defects changing with the external variables, such as load;
- The requirement of approaching the detected objects is not high;
- It can be used for inspection of pressure vessels in service;
- When used in pressure tests of pressure vessels, it can prevent catastrophic failure of the inspected object caused by unknown discontinuous defects and limit its maximum working pressure;
- It is suitable for object detection with complex geometry.

By finding the hidden defects, even in some unreachable parts of the structure, the spread of the damages can be prevented. That is the main purpose of the AE detection/monitoring.

1.4 Applications of Acoustic Emission Technology

Currently acoustic emission technology has been applied in many fields, including the following aspects:

- The petrochemical industry
- The power industry
- Material test

- Civil Engineering
- The aerospace and aviation industry
- Metal Process
- The transportation industry

1.5 Key Terms of Acoustic Emission Technology

(1) **Starting point of AE signal:** the starting point of an AE signal recognized by the system processor, is usually when the amplitude begins to exceed the threshold;

(2) **End point of AE signal:** the end point of the AE signal, which is usually defined as the last time that the signal amplitude crosses the threshold;

(3) **Duration:** the time interval between the beginning and the end of the acoustic emission signal;

(4) **Rise time:** the time interval between the starting point of AE signal and the peak of the AE signal;

(5) **Sensor array:** a combination of two or more sensors placed on a component to detect and determine the position of the source in the array;

(6) **Attenuation:** the decrease of the AE amplitude per unit distance, usually expressed in dB per unit distance;

(7) **Average Signal Level (ASL):** the time average logarithmic value of the acoustic emission signal after rectification. The amplitude of the acoustic emission signal is measured in logarithmic scale, in unit of dB. At the input of the pre-amplifiers, 0dB = 1μV;

(8) **RMS**: Root mean square. The effective average value of the signal amplitude, in unit of V;

(9) **Channel:** a complete acoustic emission channel consists of a sensor, a pre-amplifier or an impedance matching transformer, a filter, a secondary amplifier, a connection cable and a signal detector or processor;

(10) **Counts:** also known as ring-down counts. In the selected detection interval, the number of times the AE signal crosses the present threshold;

(11) **Event:** a local material change giving rise to acoustic emission;

(12) **Event count:** the number of events that can be detected by the AE instrument.

(13) **Couplant:** the material filled between the contact surface of the sensor and test structure, which can

improve the ability of sound energy passing through the interface in the process of acoustic emission monitoring;

(14) **Decibel (dB):** logarithmic measurement value of AE signal amplitude referring to 1μV, dB = 20lg(A/1μV), where A is the amplitude voltage value of the measured AE signal;

(15) **Dynamic range:** the decibel difference between the overload level and the minimum signal level (usually determined by one or more factors in the noise level, low-level distortion, interference or resolution level) in a system or sensor;

(16) **Effective sound velocity:** the sound velocity calculated on the basis of arrival time and distance determined by the artificial acoustic emission signal, for the use of source location;

(17) **Burst acoustic emission:** the qualitative description of the discrete signals related to an independent acoustic emission event in the material;

(18) **Continuous acoustic emission:** the qualitative description of the continuous signal level produced by the rapid occurrence of acoustic emission events;

(19) **Energy:** elastic energy released by acoustic emission events;

(20) **Threshold:** the threshold value for monitoring the triggered AE signal;

(21) **Monitoring area:** part of the structure monitored by AE sensors;

(22) **Detection range:** the part of the test object evaluated by acoustic emission technology;

(23) **Felicity effect:** the presence of AE at stress levels below the maximum previously experienced;

(24) **Felicity ratio:** the ratio of the stress at presence to the maximum stress applied last time;

(25) **Floating threshold:** a dynamic threshold established by the time average of the amplitude of the input signal;

(26) **Hit:** any signal that exceeds the threshold and causes a system channel to collect data;

(27) **Kaiser effect:** under a fixed sensitivity, there is no detectable AE signal before the stress level is exceeded.

1.6 Key Terms in RAEM1-6 System

(1) **Channel:** a channel through which the acoustic emission signal enters the acquisition card through sensors, amplifiers and data cables for independent processing;

(2) **Sampling rate:** also known as sampling speed, the number of sampling points per second of analog voltage signal acquired by the ADC module; for example, 10MSPS, means 10M (=10^6) points per second;

(3) **Sampling accuracy:** the sampling accuracy determines the minimum resolution of the signal within the input voltage range. For example, in the 20Vpp input range, the 16-bit sampling accuracy means that the voltage of 20V is divided into 2^{16} units, i.e. the step is about 0.305 mV. The higher the accuracy, the higher the resolution of the signal;

(4) **TCP/IP:** also known as network communication protocol, a data transmission protocol widely used by computers;

(5) **AST:** automatic sensor testing, which refers to the technology that the sensor transmits a mechanical pulse signal under a voltage excitation and it is received by the adjacent sensors to evaluate the sensitivity of adjacent sensors;

(6) **ADC:** analog to digital conversion, i.e. analog voltage signal is converted into digital signal;

(7) **Analog filter:** filter applied in the analog circuit. The product uses 4th order Butterworth analog filter before ADC;

(8) **Pre-amplifier:** amplifies the weak voltage signal output from the sensor and applies impedance transformation, in order to adapt to the electronic amplification circuit for long-distance signal transmission, and outputs analog signals;

(9) **Coaxial cable:** the signal cable that transmits the pre-amplifier output signal to the acquisition host. The inner layer is a single core wire, and the outer layer is a shielding coating layer. Generally, the impedance is 75 ohm;

(10) **IoT:** Internet of Things;

(11) **Hit extract sample mode:** also known as "envelop collection". It uses the threshold, HDT, HLT and so on to recognize or define a hit AE signal, including its start and end and length;

(12) **Time parameter sample mode**: the mode collects each AE hits by the set threshold and the sample length;

(13) **System rating**: users set the system rating rules by the parameters intensity (how big the parameter is) and activity (how many times it appears). If the sampled parameters exceed one rating level, it will be rate at that level.

(14) **EET**: enforced end time, in unit of micro-second (us). It ranges from 1 ~ 50000us. When the AE hit is

continuously higher than the threshold value, and the set HDT cannot define the end of the AE signal, the EET takes effect which means it is the duration of the current hit and other related AE feature parameters are calculated based on this duration. EET is effective only in Hit Extract sample mode, not in Time parameter sample mode;

(15) **HDT**: Hit definition time, also known as the envelop definition time, in unit of micro-second (us). the setting range is 100 ~ 50000μs (positive integer), can be directly input in the text box. It refers to the waiting time interval of a hit signal in order to correctly determine the end point of that hit signal. When the set HDT value is greater than the time interval T between two adjacent wave packets that exceed the threshold, the two wave packets will be classified as one acoustic emission hit signal; if the set HDT value is less than the time interval T when the two wave packets cross the threshold, the two wave packets are divided into two acoustic emission hit signals. For the same signal, the greater the HDT is, the fewer the AE parameters are extracted, while the smaller the HDT is, the more AE parameters are extracted.

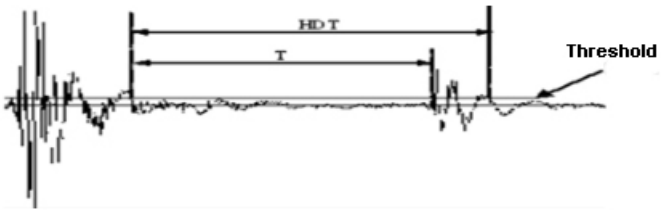


Fig. 1-2 HDT definition diagram

(16) **HLT**: Hit lock time, in unit of micro-second (μs). The setting range is 1 ~ + ∞ (positive integer), can be directly input in the text box. In order to avoid receiving the reflected waves or late waves, HLT is the set time window for closing the measurement circuit. At the end of the current acoustic emission event after a HDT time, there is a period of time (HLT) that the signal will be ignored. This window is called hit lock time. The value is affected by the signal attenuation, structure size, etc. If the setting value is too big, the subsequent AE signal will be missed. As shown in the figure below, the next AE signal T period has passed the threshold, but the HLT has not finished, so the signal in T period will not be collected.

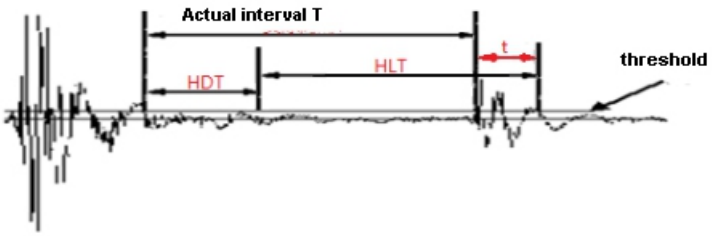


Fig. 1-3 HLT definition diagram

(17) **U3H:** When it says U3H, it may refer to the U3H format for data files, i.e. PRA and AED format. Sometimes, it may also refer to the SWAE software server (because previously it only connects to U3H instruments).

2. Product Introduction

RAEM1-6 Remote Acoustic Emission system adopts ZYNQ approach with AD4001 chip as the base layer and 4G/Wi-Fi/Ethernet built-in, and supports IoT operations, such as cloud data storage and cloud data reporting.

The up-to-date firmware version is V1.0.56_20220530, and the configuration software version is 2.14.2.35.

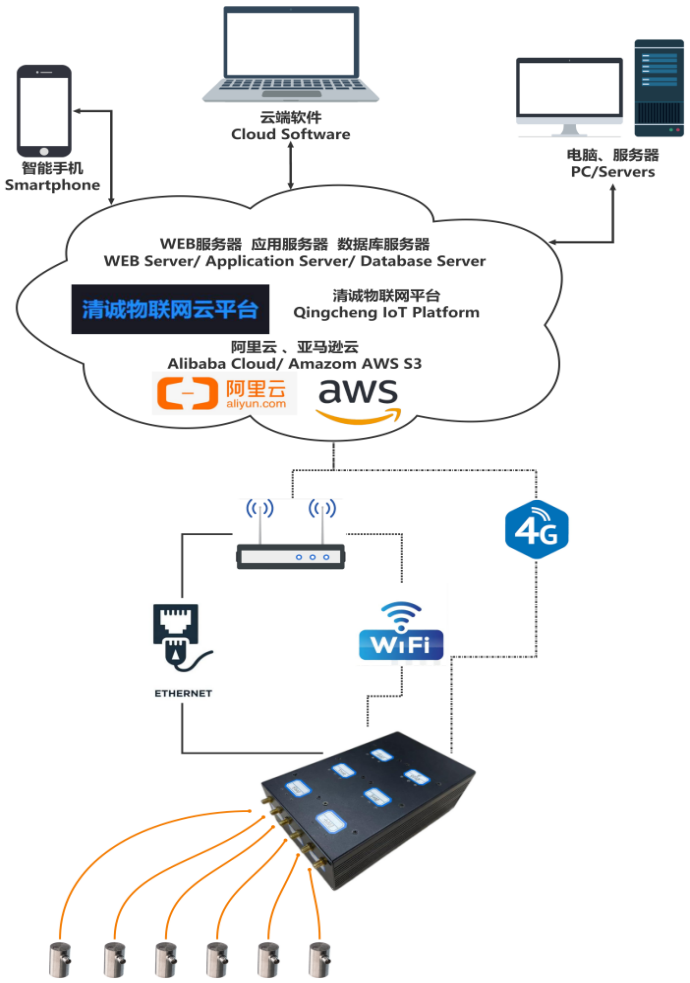


Fig. 2-1 RAEM1-6 IoT AE system

2.1 RAEM1-6 Introduction

RAEM1-6 remote acoustic emission system consists of three parts:

- RAEM1-6 (AE sensor, signal acquisition, communication)
- Platform (cloud server, LAN, PC, phones)
- Client end (phones, PC, screens)

RAEM1-6 is an intelligent IoT acoustic emission system integrating AE signal acquisition control, analysis, storage with communication. RAEM1-6 host is a rectangular box with aluminum alloy shell with PCB boards inside and a magnet bottom. Each RAEM1-6 includes 2-6 acoustic emission channel. RAEM1-6 includes pre-amplifier power supply, signal conditioning, filtering, ADC and digital signal processing, data output interfaces, data storage and remote communication modules. Acoustic emission sensors and built-in power supply. Multiple data communication methods (Wi-Fi/ 4G/ Ethernet/ RS485 etc.) can be selected based on the user's demands. There is SD storage card built-in to prevent stored data loss when the power is lost.

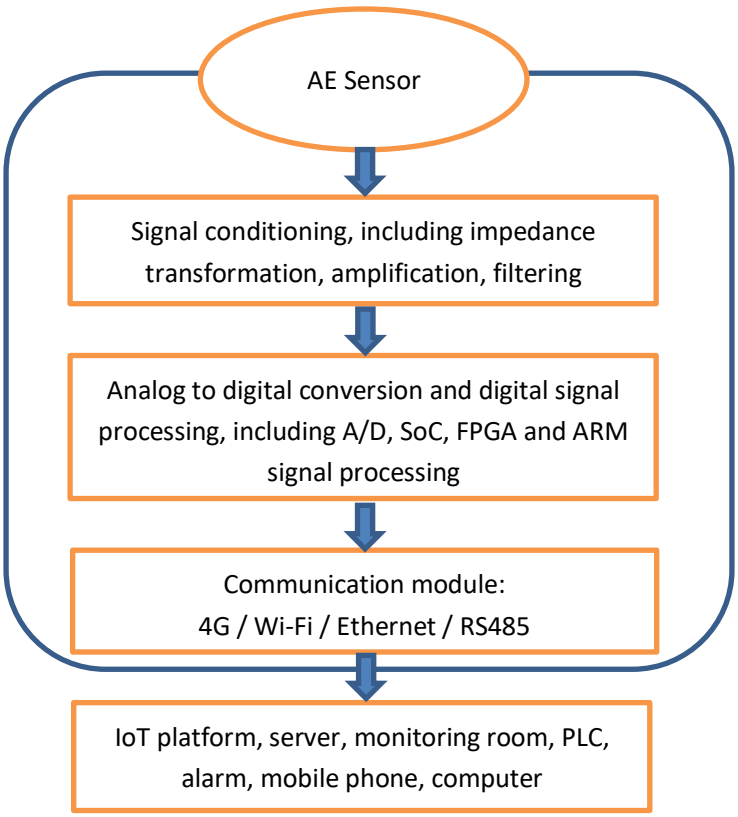


Fig. 2-2 RAEM1 Functional modules flow diagram

Output data types are AE parameters, waveform, and parameter ratings. Anyone to all three data types can be selected to stored and output. Data can be uploaded to the cloud IoT platform for display (e.g., Qingcheng Alibaba Cloud or Qingcheng IoT Cloud), or be downloaded to the client computers for post analysis using Qingcheng professional AE signal analysis software. It can also be sent to Qingcheng SWAE software directly for real-time analysis.

This user's manual will introduce the regular version of RAEM1-6 system and its connection, configuration and usage. It starts with product parts and connection, followed by system communication and configuration.

2.2 Hardware Introduction

RAEM1-6 system is a six-channel AE system with external sensors connected to the aluminum cuboid box, 12V DC power supply adapter, equipped with a variety of communication modes, including Ethernet and Wi-Fi, 4G network communication.

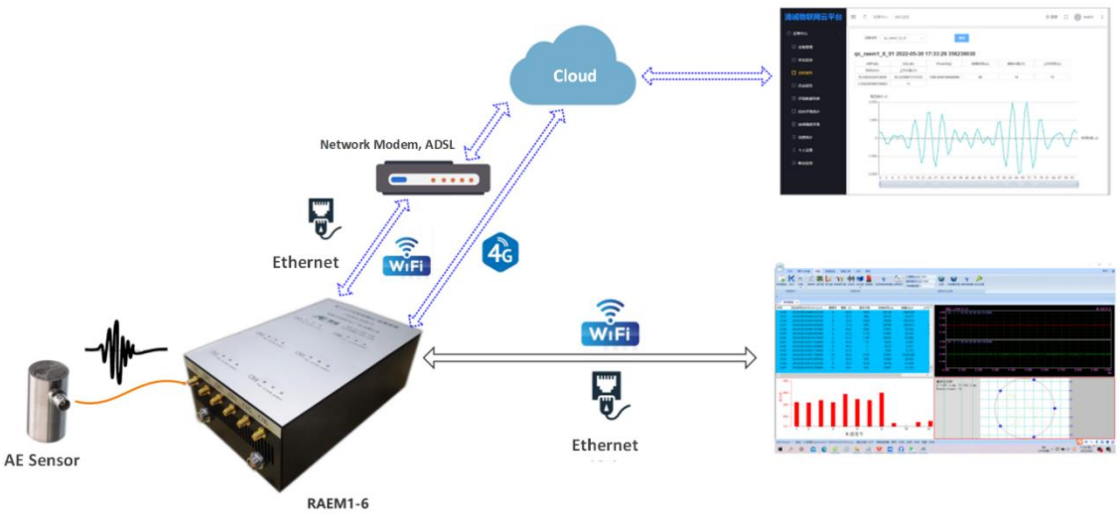


Fig. 2-3 RAEM1-6 Various connection modes

Figure 2-4 shows the RAEM1-6 hardware package, which consists of a RAEM1-6 aluminum alloy square box, an integral preamp sensor (and sensor magnetic clamp), a 4G external antenna, a sensor cable, a 12V power adapter, a network cable, and a cascaded cable.

The RAEM1-6 panel is shown in Figure 2-5:

- **(State) indicator light:**

- POWER: power indicator (yellow), showing power on and off. It should be steady on after the power supply is connected.
- RUN: Running indicator (green): indicates the running status of the device. During normal operation, the running light flashes, about once every second;
- ALARM: Alarm light (red), impact indicator/warning light. Every time there is an impact, the alarm lights up. **(Under development, function to be determined)**

- Sensor interface: connect the external sensors, sensor is commonly preamplifier built-in series;
- Clock synchronization interfaces: on-line interface, two interface did not distinguish between higher and lower;
- Antenna interface: connect 4 g antenna;
- Power switch: opening and closing of the control device;
- Electrical socket: connect the 12 v, 5 a power adapter.
- Network port: connection cables;
- IoT SIM card slot, you can insert the Internet of things.

 RAEM1-6	 Sensor	 Coaxial Cable
 Power adapter	 4G antenna	 Synchronous cascade cable

Fig. 2-1 RAEM1-6 hardware package

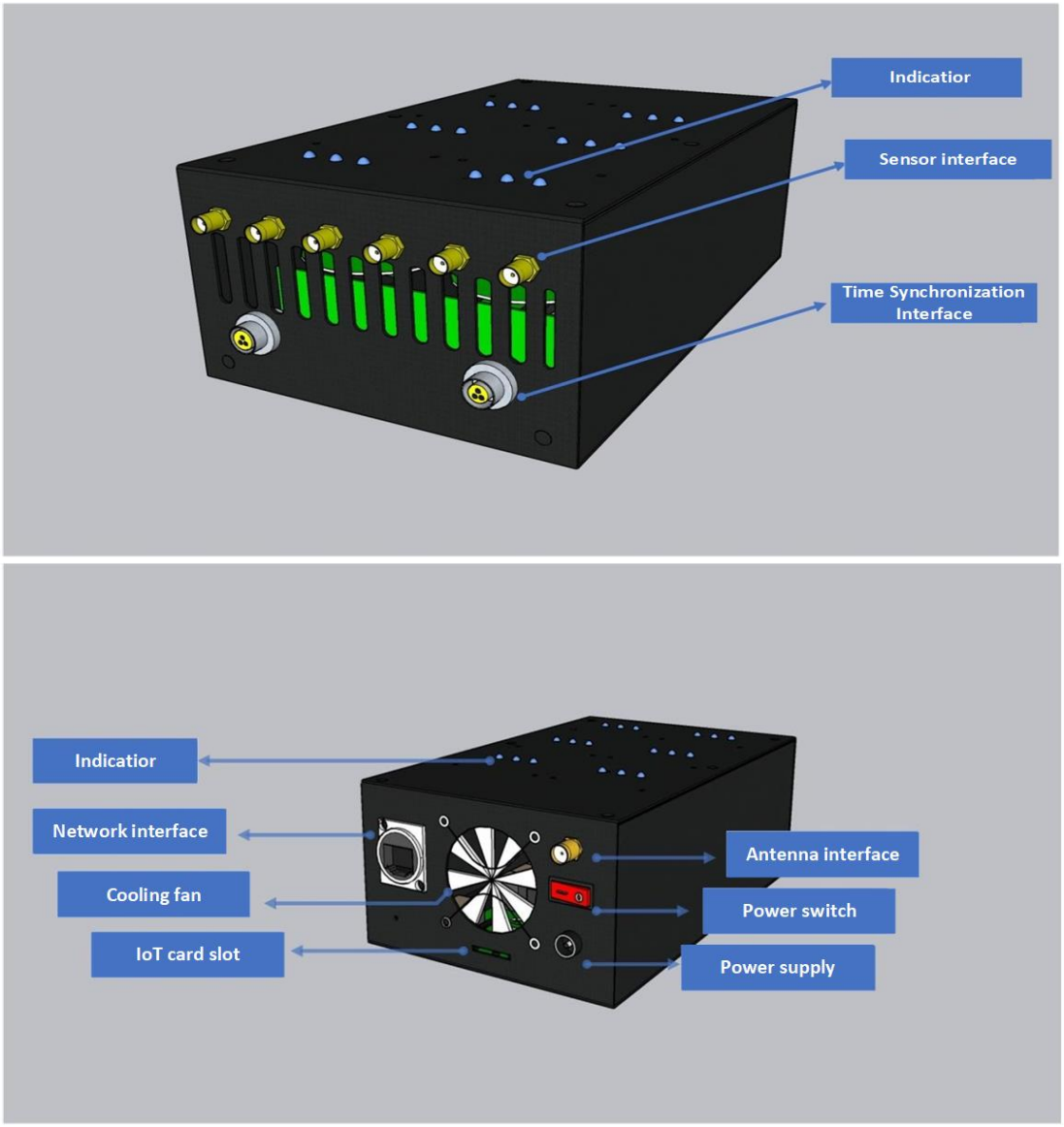


Fig. 2-5 Front and back panels of the RAEM1-6

2.3 Technical Specifications

- Multi-channel AE input, can be cascaded to 38 channels;
- Sampling rate 2MHz, sampling accuracy 16-bits per channel;
- Signal input bandwidth 10K-1000KHz;
- The dynamic range is 70dB;
- Compatible sensors: integral preamp series of sensors;
- Sensor preamp supply voltage and gain: 12V34dB, 28V40dB, 5V26dB;
- **Signal trigger** and **time trigger** to collect data, flexible system sampling cycle and collection time

settings (cycle days, collection time in one day, start and stop time of collection);

- The sampling length, the number of times and the intervals of time trigger can be set;
- The system noise ASL is better than 30dB;
- Output data types: waveform, parameters, parameter ratings; Optionally set any 1-3 types of data storage and output;
- Digital filter: 0 KHZ to 1000 KHZ frequency range any value set straight, high-pass, low-pass, band-pass (a combination of analog filter use);
- Original waveform or filtered waveform data;
- Acoustic emission HIT parameters, including arrival time, amplitude, ring-down count, energy, rise time, duration, RMS, ASL;
- Parameter ratings, based on the national and international AE monitoring standards, can automatically generate intensity ratings, activity ratings, and intensity activity ratings.
- Clock synchronization: can a serial port (cable) channel the UN general assembly, 38 channel synchronous clock precision of 10 μs or less;
- Built-in SD card 64G of memory, may store the above three kinds of data, can be extended to 512G;
- Optional communication methods: 4G, Wi-Fi, Ethernet, RS485;
- External power supply, power adaptor outputs 12V DC;
- Operational temperature：LAN：-20℃~60℃； Wi-Fi：0℃~60℃
- Dimensions: length x width x height：22mm x 13mm x 8mm
- Weight：1.6kg

2.4 Quick Start of RAEM1-6

RAEM1-6 can be used as two different systems, one is as a **IoT remote unattended acoustic emission monitoring system**, and the other can be used as a **desktop type acoustic emission detector.** The following describes the connection modes, networking modes, and adaptive software systems of the two modes. Regardless of the communication mode, the hardware connection procedure is as follows:

1) Connect the power adapter to the power port of RAEM1-6. The other end of the power adapter is

connected to the electric supply.

2) Connect the sensor and the sensor connector of RAEM1-6 with coaxial cable. The sensor is recommended to be integral preamp model. If no integral preamp sensor is selected, connect the sensor to the external preamp, and then connect the preamp to the sensor port of RAEM1-6. Also, ensure that the power supply voltage of the preamp is consistent with the output voltage of RAEM1-6. Check the label on the side of the device to determine the sensor frequency and preamp voltage. For example:

Sensor：5V/40kHz
Host model：1-6
Wi-Fi：RAEM1-5V-1
Wi-Fi/IP：192.168.0.1

3) Turn on the RAEM1-6 power switch and wait until the power light is steady on and the RUN light flashes.

4) Users can further connect and use the software according to the test purpose and communication method.

Fig. 2-6 RAEM1-6 Hardware connections

Fig. 2-7 Hardware connection of RAEM1-6 - Rear

2.5 Configuration Tool and Software and Cloud Introduction

After the RAEM1-6 device is started, it automatically starts signal collection and communication connection according to the existing configuration and hardware connection. You can open the existing configuration of RAEM1-6 through the provided communication mode and modify and update the configuration. Some communication modes support real-time parameter viewing and analysis, or online waveform and parameter viewing and analysis.

The factory Settings of RAEM1-6 are recommended and have passed factory tests. You are advised to use the default settings. If you need to change the configuration, you are advised to save the original factory configuration file to the computer and then change the configuration

RAEM1-6 automatically starts collecting data after startup. When there is one or more hits, RAEM1-6 packs all hits within 5 seconds and generates a compressed packet. If there is no bump, no packet is generated. It is stored on a local SD card or uploaded to the cloud center according to different communication methods. After the collection is complete, you can view and download the collected data packets through the cloud or directly visit RAEM1-6.

There are three ways to configure RAEM1s. One way is through the "**RAEM1 Configuration Software**" tool developed by Qingcheng company for this specific purpose. Another way is through **Qingcheng IoT Cloud Platform** for remote configuration. The third method is the online debug function

on the **Qingcheng Alibaba Cloud Platform**.

There are many ways to view and download RAEM1-6 data. Users can view the real-time parameters and parameter ratings online through **Qingcheng Alibaba Cloud** (currently not available for data downloads yet). Or users can use **Qingcheng IoT Cloud** to view real-time parameter and waveform, configure RAEM1 and download the data from the cloud. Users can also choose to upload the data to the **AWS S3** storage buckets. Another method is to connect RAEM1 directly to Qingcheng **SWAE** software for real-time AE signal acquisition, data view analysis and parameters and waveform data storage.

- **RAEM1 Configuration Software:** is a Windows executable software specified for RAEM1 configuration developed by Qingcheng company. It requires RAEM1-6 to connect to the computer, via cable connection using Ethernet or wireless connection through Wi-Fi. Using the RAEM1 Configuration Tool software, it can access and modify the RAEM1-6 device information, acquisition settings, data storage, communication settings, system settings and file view for data downloads. See Chapter 3.3 for specific instructions and use.

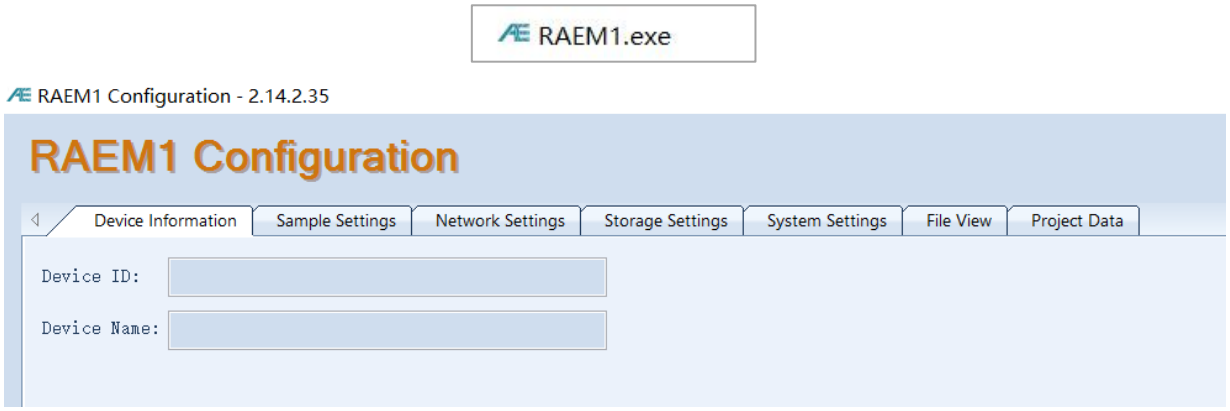


Fig. 2-8 Screenshot of RAEM1 configuration software

- **Qingcheng IoT Cloud Platform:** is Qingcheng's own IoT cloud platform specified for Qingcheng's IoT products. It requires wireless communication modules in RAEM1-6, such as 4G network or Wi-Fi. After logging into Qingcheng IoT Cloud, users can view real-time parameters, waveform and ratings, and modify RAEM1 configurations remotely, as well as downloading AE data from the cloud servers which are uploaded by RAEM1 remotely. Please see Section 4.3 for more detail.
- **Qingcheng Alibaba Cloud:** is the cloud platform setup by Qingcheng based on the Alibaba IoT

platform. It also requires wireless modules in RAEM1, such as 4G network or Wi-Fi. After logging into the Qingcheng Alibaba account, it allows users to view real-time parameters and parameter ratings. It also supports online debug functions to control and configure RAEM1s. Please see Section 4.4 for detail usages.

- **U3H（RAEM1）:** SWAE software is a professional AE software developed by Qingcheng company to support the use of the Qingcheng AE equipment, including U3H and RAEM series. It allows users to view real-time AE feature parameters and waveform collected and sent by RAEM1. Please see Section 3.4 for more detail.
- **AWS S3**: RAEM1-6 also supports to upload data to AWS S3 bucket. Please see Section 5.3.2 for more information.

3. RAEM1-6 Desk Type Detector Operation guide

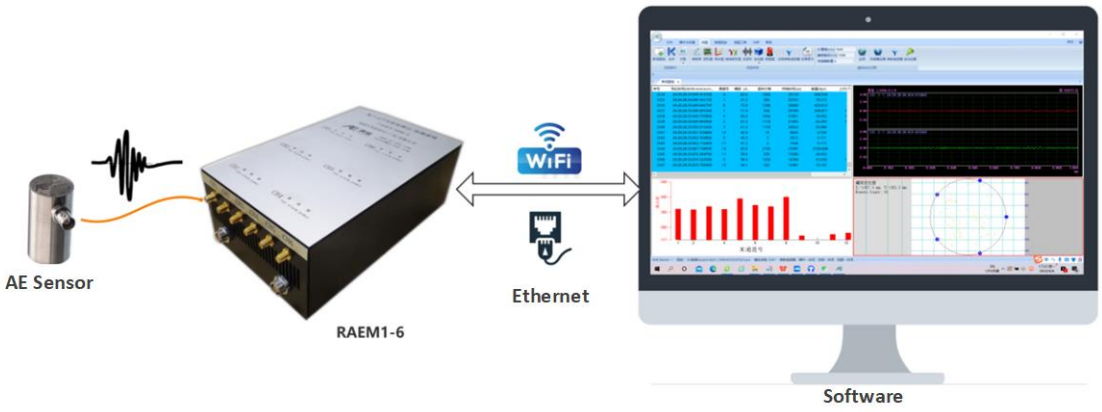


Fig. 3-1 Connection diagram of RAEM1-6 desktop detector

The RAEM1-6 sound wave (acoustic emission) can be used as a bench detector. That is, RAEM1-6 does not connect to the Internet or the cloud, but only connects locally through the LAN. The LAN connection can be a network cable limited connection or a wireless LAN local connection through a Wi-Fi router. The following describes the Ethernet or Wi-Fi connection and networking mode.

When RAEM1-6 is used as a bench detector, RAEM1-6 should be used with Qingcheng SWAE software. The configuration is done through RAEM1 configuration software, and the real-time display and analysis of the data is done through SWAE. Chapters 3.3 and 3.4 describe the software used for the desktop detector.

3.1 Ethernet Connection

3.1.1 Single RAEM1-6 Ethernet connection

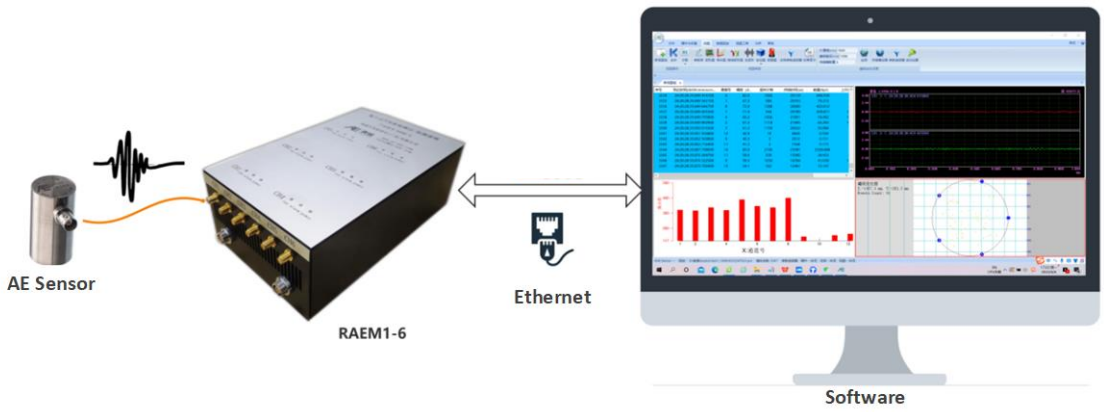


Fig. 3-2 Connecting a network cable to a RAEM1-6 desktop detector

RAEM1-6 can be directly connected to a PC for configuration and data collection using Ethernet. For a single RAEM1-6, connect the network port at the back of the RAEM1-6 to the computer network port using a network cable.

If this is the first time for the computer to connect to the device, you need to set the Ethernet configuration item for the computer. Refer to Chapter 3.1.3.

3.1.2 Multiple RAEM1-6 Ethernet connection

Fig. 3-3 Network connection of a RAEM1-6 desktop monitor

If multiple RAEM1-6 networks need to be connected at the same time, RAEM1-6 networking is required. Connect these RAEM1-6 to a switch with a network cable, and then connect the switch to the computer with a network cable.

If this is the first time for the computer to connect to the device, you need to set the Ethernet configuration item for the computer. Refer to Chapter 3.1.3.

Multiple RAEM1-6 networks also require clock synchronization by connecting multiple RAEM1-6 in series with cascade cable. Each RAEM1-6 has two clock synchronization interfaces. Connect one end of the cascading cable to any clock synchronization interface of RAEM1-6, and connect the other end of the

cascading cable to any clock synchronization interface of another RAEM1-6 to cascade the two RAEM1-6. If so, cascade all required RAEM1-6 in series.

Before delivery, the master/slave mode of the channel is set for clock time synchronization. Users do not need to perform operations. Generally, only one channel of each RAEM1-6 is set as the host, and the others are slave. **If multiple RAEM1-6 are cascaded, only one channel (which can be any channel) is kept as the host, and all the other channels are changed to the slave.** If you do need to perform this operation by yourself, refer to Section 3.3.3.3 for details.

3.1.3 Computer Ethernet properties configuration

If this is the first time for the computer to connect to the device, you need to set the Ethernet configuration item for the computer.

RAEM1-6 Ethernet IP address of each channel is **192.168.0.XXX.** For example, 192.168.0.101 goes up to 192.168.0.106. Therefore, it is necessary to configure the Ethernet of the computer into the corresponding network segment and appropriate mode. You can configure Ethernet attributes in the following ways:

- **Configuration 100M Ethernet full-duplex mode:** open the computer control panel > > network and Internet > > network connections, double-click the Ethernet, the following window pop up. Click "Configuration" >> "Advanced", find "Speed and Duplex" in "Properties", then select "100 Mbps full duplex". Click OK.
- **IPV4 addresses to configure Ethernet 192.168.0. XX segment:** in the "Ethernet properties" window, double-click the "Internet protocol version 4 (TCP/IPV4)", and then in the pop-up window, click on the "use the following IP address:". Then enter the IP address "192.168.0. XX" (XX indicates that it can be any number). The subnet mask is 255.255.255.0. The default gateway is 192.168.0.1. Click OK.

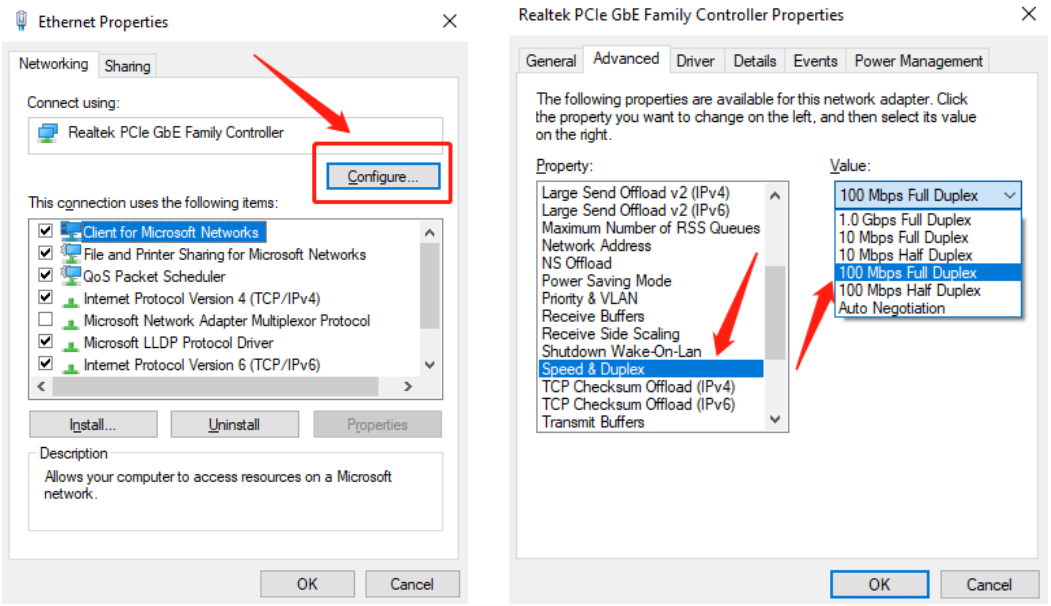


Fig. 3-4 Setting the Ethernet full-duplex mode

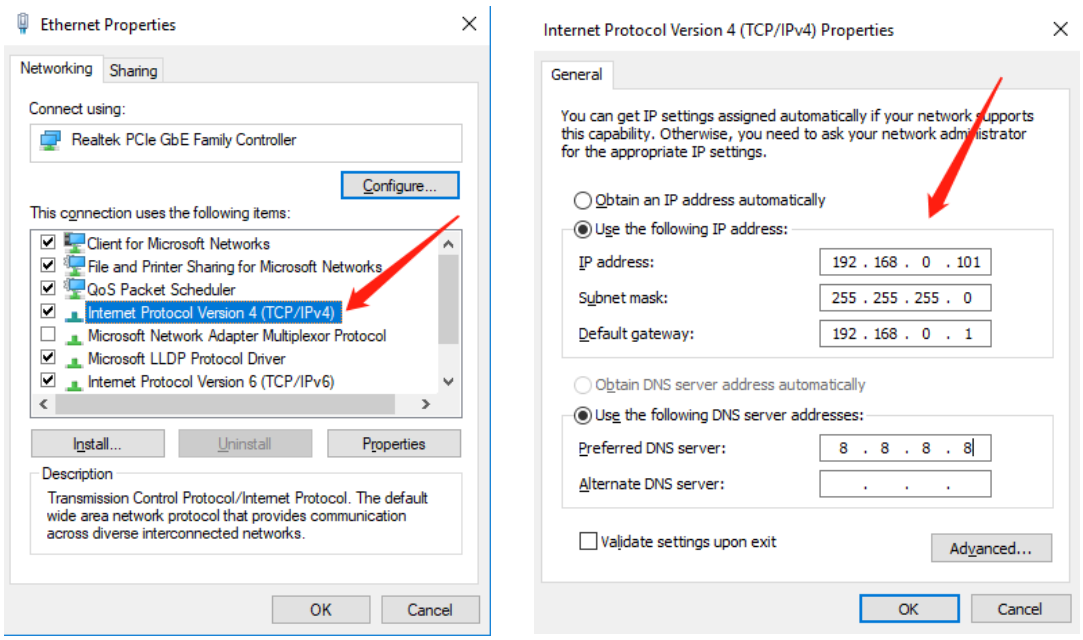


Fig. 3-5 Setting the Ethernet network segment

3.2 Wi-Fi connection

3.2.1 Single RAEM1-6 Wi-Fi connection

Fig. 3-6 Wi-Fi connection for a single RAEM1-6 desktop monitor

RAEM1-6 can be directly connected to a PC through its built-in Wi-Fi signal. You are advised to use it only for parameter setting. Open the Wi-Fi list of your computer, and find the Wi-Fi with the same name as the Wi-Fi on the side TAB of RAEM1-6 to connect.

After the connection is successful, all channels of RAEM1-6 are displayed on the configuration software. If the connection fails, try moving the computer closer to RAEM1-6.

Fig. 3-7 Wi-Fi network of RAEM1-6 desktop detector

3.2.2 Multiple RAEM1-6 Wi-Fi connections

Fig. 3-8 Wi-Fi networking for RAEM1-6 desktop monitor

If you need to connect multiple RAEM1-6 using Wi-Fi, you need to use RAEM1-6 networking. Connect the RAEM1-6 to a Wi-Fi router with a network cable, and then connect the computer to the router over Wi-Fi.

The Wi-Fi router also needs to be configured. The router must be configured as network segment 0, that is, 192.168.0.xxx, and the router must be set to automatically assign IP addresses to devices. After the connection is successful, all the channels connected to the router can be seen on the configuration software.

Multiple RAEM1-6 networks also require clock synchronization by connecting multiple RAEM1-6 in series with cascades. Each RAEM1-6 has two clock synchronization interfaces. Connect one end of the cascading cable to any clock synchronization interface of RAEM1-6, and connect the other end of the

cascading cable to any clock synchronization interface of another RAEM1-6 to cascade the two RAEM1-6. If so, cascade all required RAEM1-6 in series.

Before delivery, the master/slave mode of the channel is set for clock time synchronization. Users do not need to perform operations. Generally, only one channel of each RAEM1-6 is set as the host, and the others are slave. If multiple RAEM1-6 are cascaded, only one channel (which can be any channel) is kept as the host, and all the other channels are changed to the slave. If you do need to perform this operation by yourself, refer to Section 3.3.3.3 for details.

3.3 RAEM1 Configuration Software

3.3.1 Introduction to RAEM1 Configuration Software

RAEM1 Configuration Software is a Windows executive program developed by Qingcheng Company for RAEM1 configuration purpose exclusively. Users can use the software to configure RAEM1-6 when RAEM1-6 is operating.

For the first time use, it usually requires to configure the RAEM1 wireless settings or the terminal servers etc. To do that, it needs to connect RAEM1 to the computer through the **Ethernet cable** and use this configuration software to start configuring.

To use RAEM1 Configuration software, **the firewall function and the WLAN function on the computer must be turned off.** The following is to turn off the firewall.

① Open "Windows Defender Firewall with Advanced Security";

② Click "Windows Defender Firewall Properties";

③ In the "Domain Profile" tab, change the "Firewall state" from "On" to "Off".

④ Change the "Firewall state" to "Off" in the "Private Profile" and "Public Profile" tabs as well. Then click "OK" to take effect.

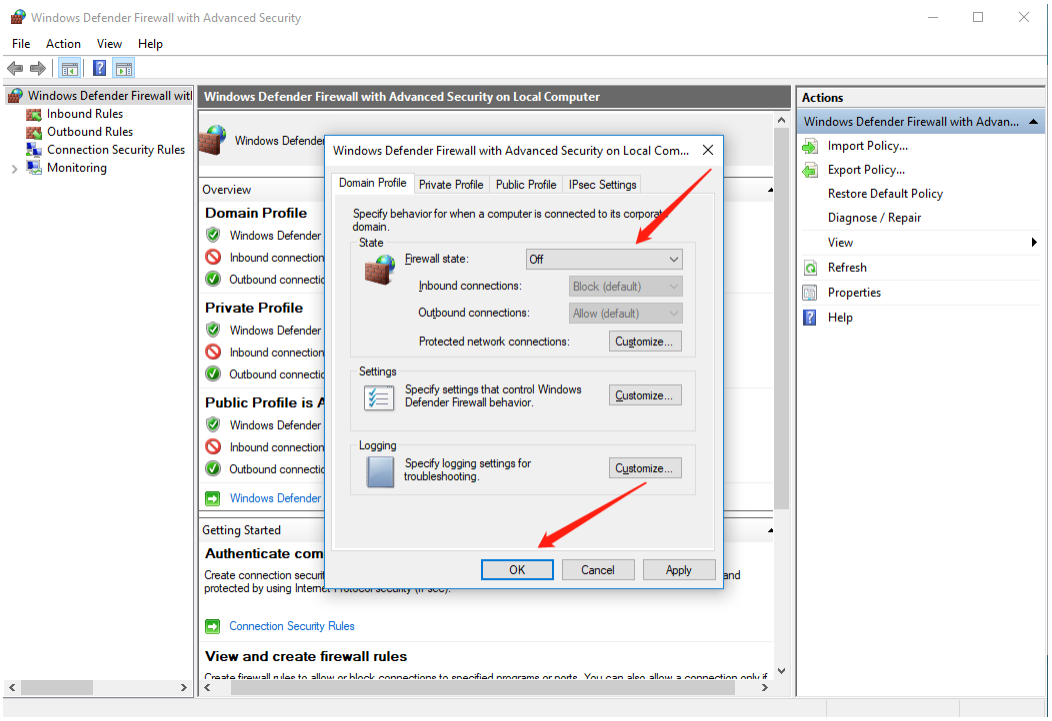


Figure 3-9 Disabling the firewall.

Decompress and open the compressed RAEM1 Configuration software package. Double click to run the "**RAEM1.exe**" under the "**RAEM1 Configuration x_x_x_x**" folder, for example. There are 32-bit and 64-bit software (labeled with "-x64") available. Choose one that works on your environment.

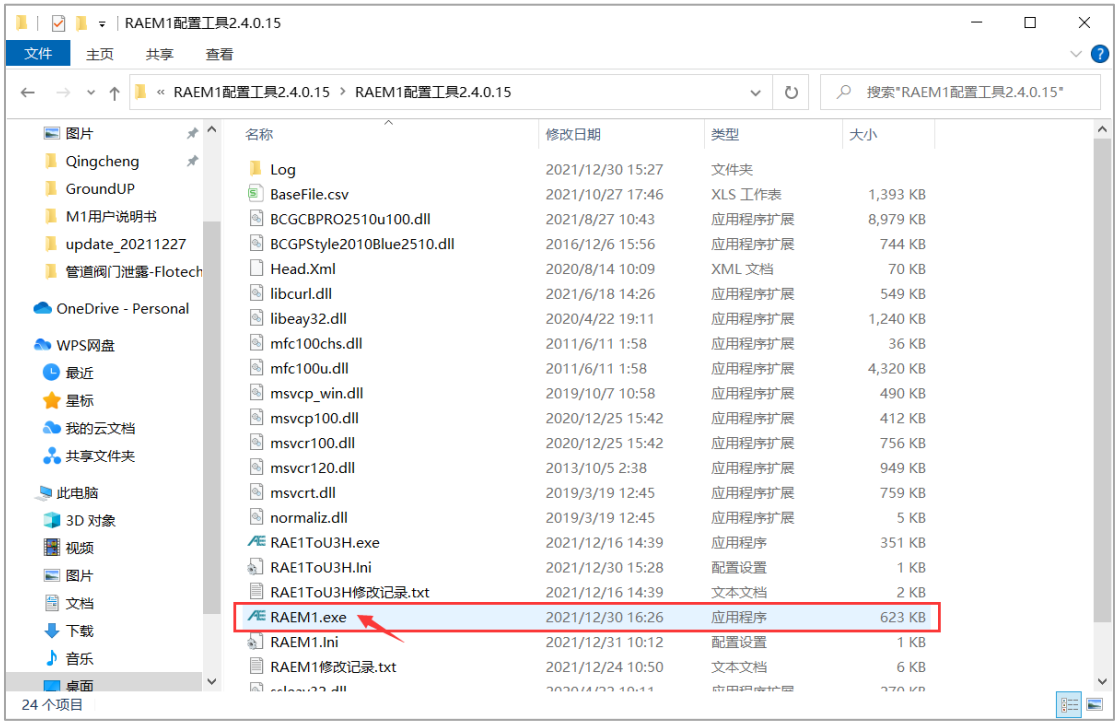


Fig. 3-10 RAEM1 Parameter configuration software executable file

The operation steps of RAEM1 Configuration software are:

① Also, when the first time running, it might pop up a firewall warning window. It must check both the private and the public network options and then click "Allow access".

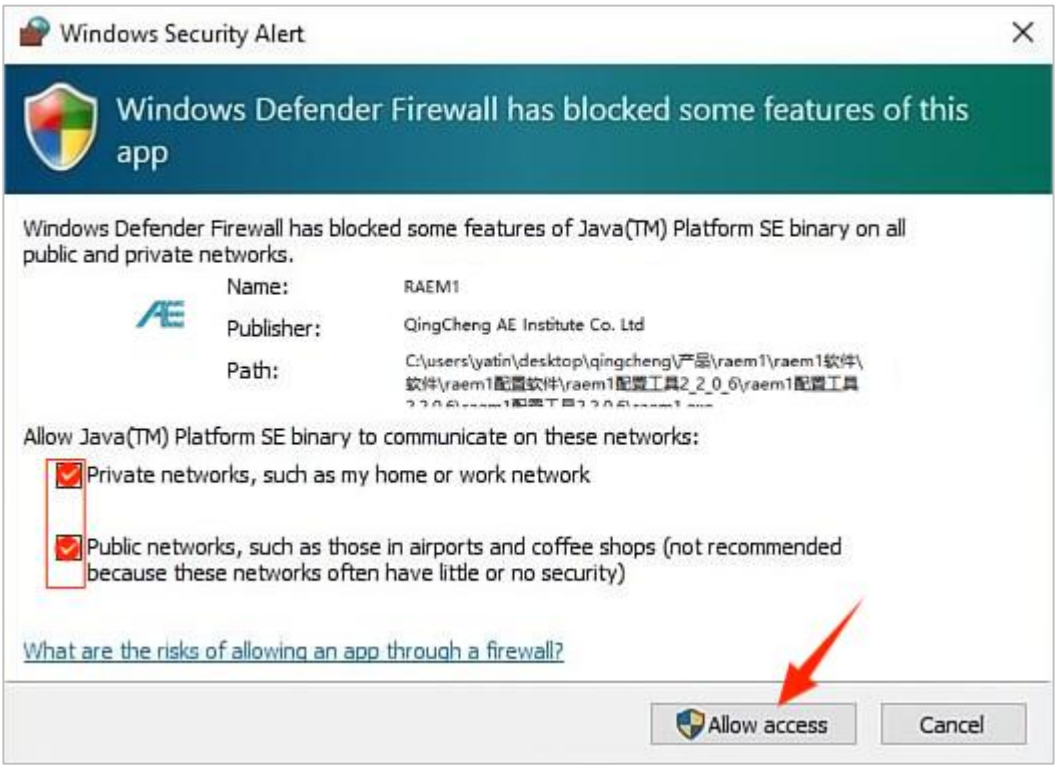


Fig. 3-11 Firewall Security Alert

② The RAEM1 Configuration software main interface is as shown in Figure 4-4. It mainly consists of two big parts, the **Device Configuration Information** on the left window and the **Device List** including all the connectable devices on the right. The tabs of different pages are on top of the device configuration information window. Click on the tabs to switch to different pages. On top of the device list on the right shows the current selected device IP. All the device information on the left window is from this current IP device. The "**Set Device**" button on the top right corner is to send the configuration information to the selected devices. Normally once the configurations are sent to the devices, it will take effects immediately, except for some settings with the "**Modify**" buttons next to them. On the bottom left corner there are two buttons, "**File Convert**" and "**Other**". In the "**Device Information**" page, it shows the device firmware version and the sampling status on the bottom left corner of the device information window.

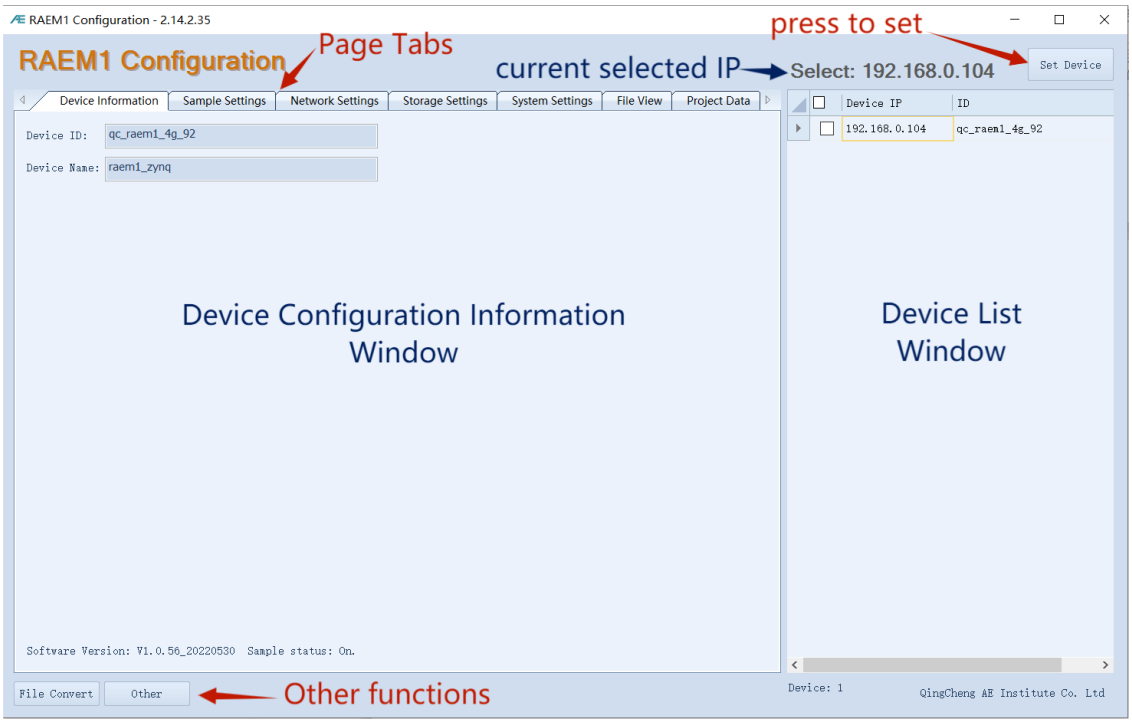


Fig. 3-12 RAEM1 Configuration Main Interface

③ The software should automatically list all the connectable RAEM1 devices in the device list on the right window (**including Wi-Fi and Ethernet connections**) under the current connected network. If the device IP and ID are shown in red on the device list, it means the device is offline and it losses connection to the software currently. Follow the steps below to debug some common situations:

a. If a desired RAEM1 is not on the list, please check whether the "RUN" light of RAEM1 is flashing every second.

b. If the connection is through Ethernet cable, make sure the Ethernet cable connection and the PC configurations are correct, see Section 3.1.

c. If other connection methods are used, such as Wi-Fi Hotspot or Router mode, please check and debug the problems based on the connection methods mentioned in Section 3.2.

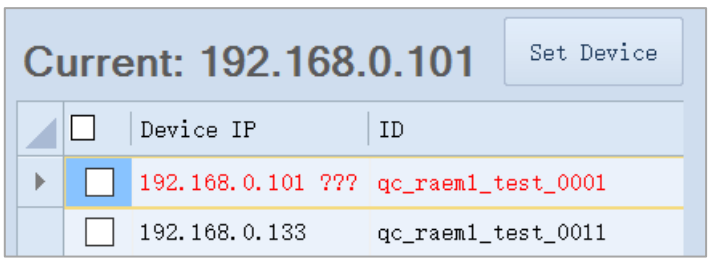


Fig. 3-13 RAEM1 Configuration Tool Device Offline

④ If you want to change the configuration settings, please first check the checkbox of the devices you want to update before modifying the settings in the left window. Click "**Set Device**" after modifications. Then the configuration settings will be updated to the checked RAEM1s and take effects immediately. When multiple RAEM1s are selected, all the configuration settings in the left window (except for the **Device Information** page, **System Settings** page and part of the **Network Settings** page) are updated to the selected devices for batch operations.

⑤ The buttons in the "**System Setting**" page (see the red rectangle below) only take effects on the current selected device (see the "Current" IP on the top right corner), no matter it is checked in the checkbox or not. If you want the batch operation of those button functions to multiple RAEM1s, you can right click on the device list to select the batch function in the context menu after selecting multiple RAEM1s to be updated.

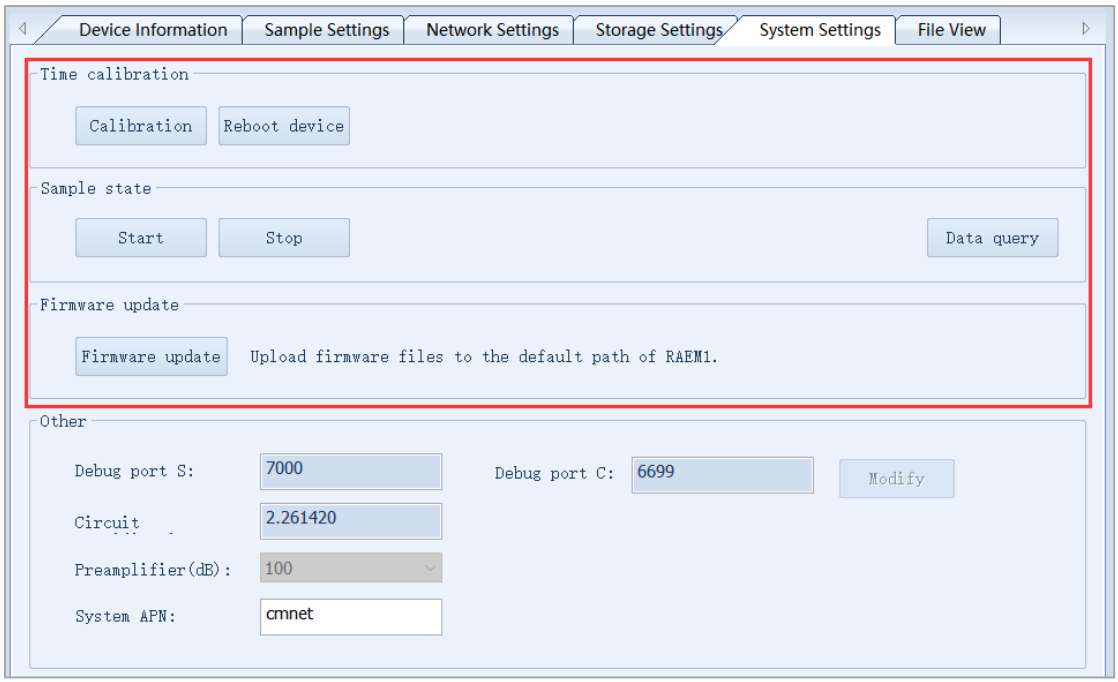


Fig. 3-14 RAEM1 Configuration Software System setting buttons

⑥ In the device list, right click to show the context menu. The context menu is only effective on the selected devices in the list.

- **Start sampling**: send command to the device to require the device to start collecting;
- **Stop sampling**: send command to the device to stop it from collecting data;
- **Calibrate device time**: apply the current PC time to the device;

- **Reread device info**: read the device settings information again, whether it is checked or not;
- **Reboot device**: make the device restart;
- **Firmware file upload**: used to update the device firmware. It can choose one or multiple files at the same time (maximum 20 files at a time).
- **AST check**: this function is exclusive for certain type of RAEM1. It requires two sensors for Auto Sensor Test (AST) check. The device sends out the excitation signal to the transmitter sensor to generate the acoustic waves and the receiver sensor collects the acoustic signals. Based on the receiving signals, it can test out how the sensor sensitivity and coupling status.
- **Enter sleep mode**: by enabling the sleep mode, it stops acquisition, transmission and communication to save power. But be careful with this function because it may require some efforts to wake up the device.

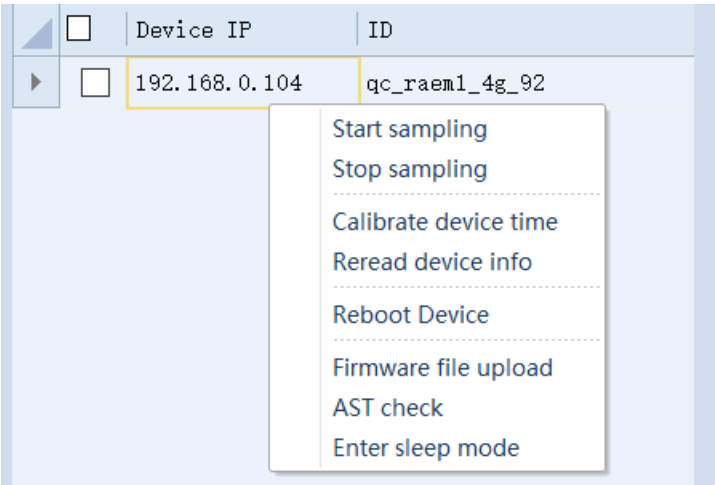


Fig. 3-15 RAEM1 Configuration Software context menu

⑦ In the "**Network Settings**" page, the "**Modify**" button is only to modify the current selected RAEM1's configurations, for example **Ethernet IP address**, and **Master/Slave** settings. After changing the values in those frames, click "**Modify**" buttons to pop out the window as Figure 4-9. Click the "**Setup**" button to send the device. No need to click "**Set Device**" button after.

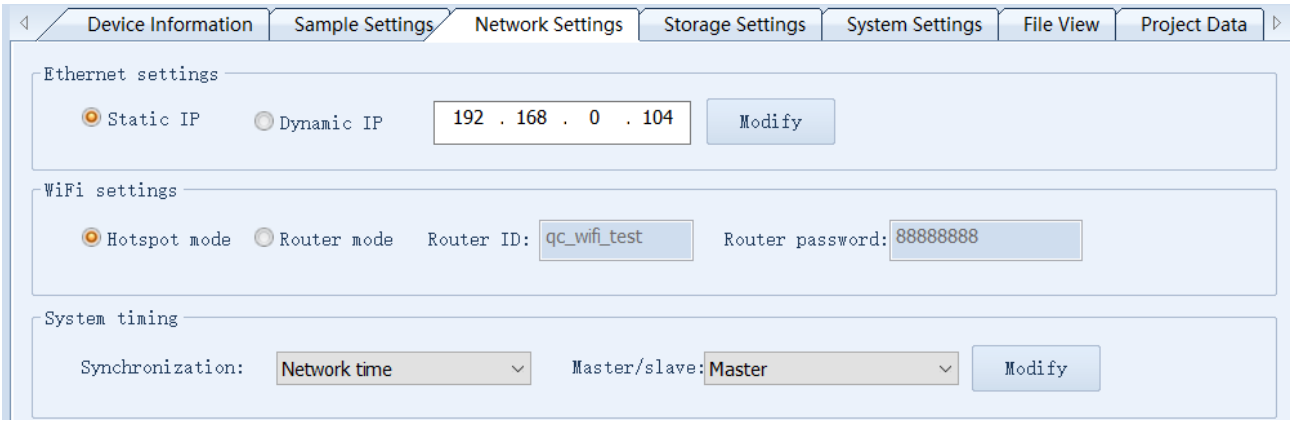


Fig. 3-16 RAEM1 Configuration Software "Modify" button

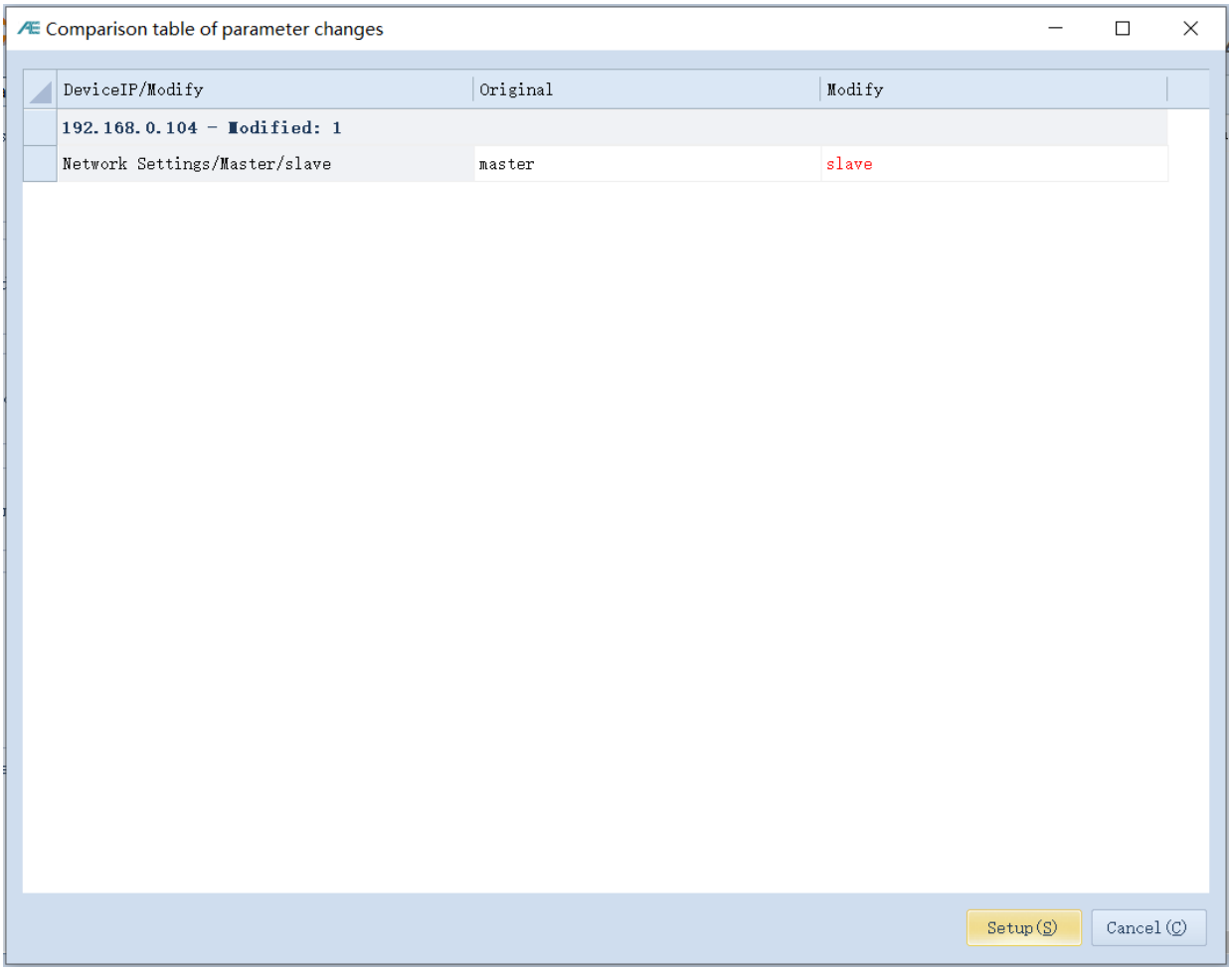


Fig. 3-17 RAEM1 Configuration Software "Modify" Confirmation window

⑧ There are two buttons on the bottom left corner of the interface:

✧ **File Convert**: opens the "**RAE1ToU3H.exe**" program which converts the downloaded RAEM1 data packages to U3H format (. pra &. aed) or CSV format. Please see Section 9 for more detail;

✧ **Other**: there are a few options, one is to save the configurations as a file in the PC; the other option is to read the configuration file from the PC. It also can change the display languages, between Chinese and English. After selecting the language, it needs to click the "**Reboot**" button at the bottom to take effect. The software will restart and update the display language.

The following is the introduction of RAEM1 Configuration software functions.

3.3.2 Sample Settings

3.3.2.1 Sample Mode

There are 2 sample modes, Hit Extract mode and Time Parameters mode. The default mode is Hit Extract mode.

- **Hit Extract mode:** also known as Envelop Extract mode. An effective AE hit event is defined by threshold, HDT, HLT and EET and the shape of the hit signal is like the envelop. The HIT event is extracted and sampled based on the set threshold, EET, HDT and HLT.

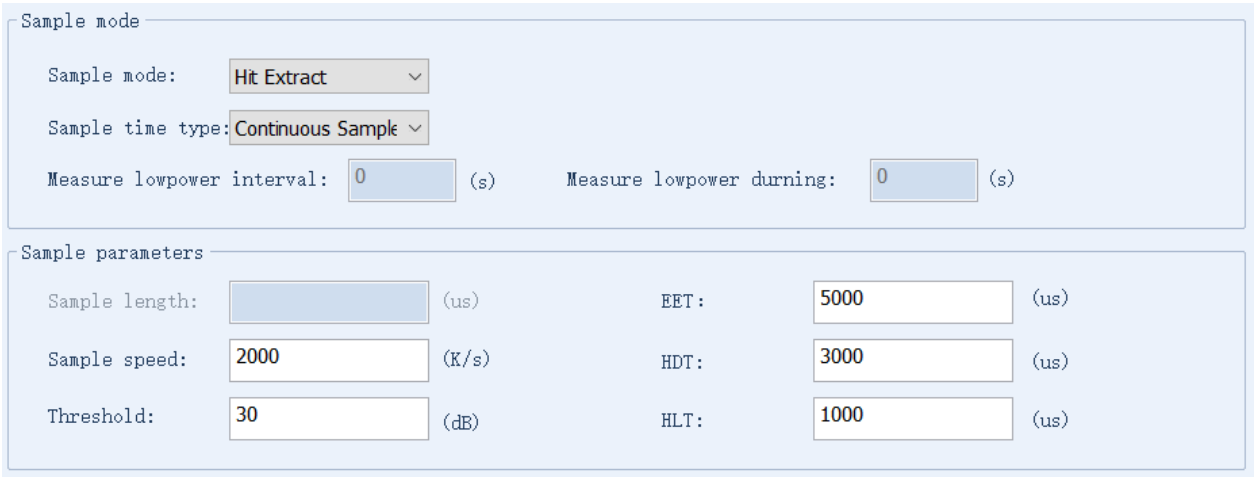


Fig. 3-18 Sample Mode - Hit Extract Mode

- **Time Parameters Mode:** The AE signals are continuously over the threshold or it is the continuous AE signals. Then the Time Parameter mode defines each AE hit event and calculates the AE parameter values based on the sample length (in unit of us), sample times and the sample intervals.

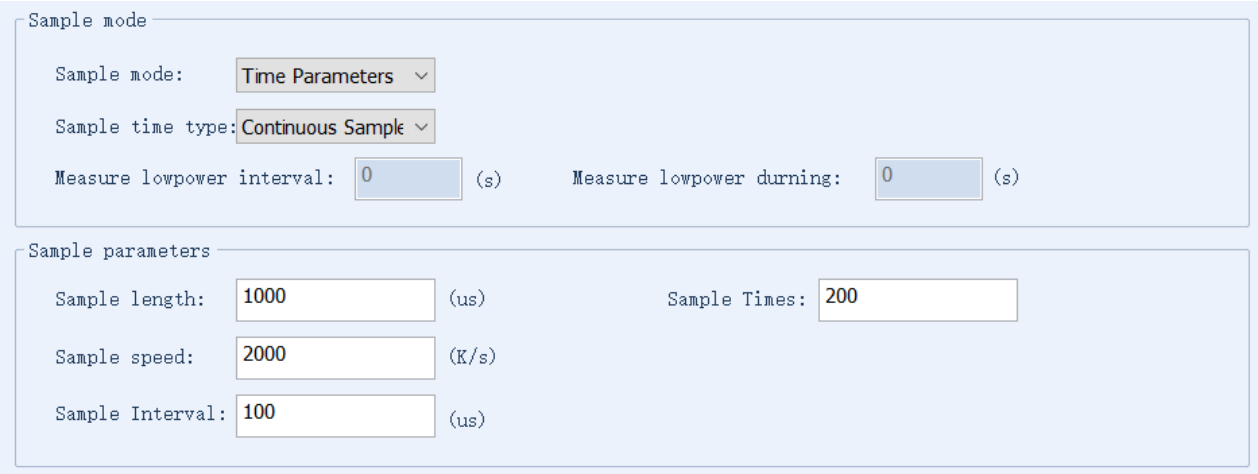


Fig. 3-19 Sample Mode - Time Parameters Mode

There are also 3 types of sample time modes, **continuous sampling**, **timing sampling** and **interval sampling**, respectively. The sample time mode decides when it starts sampling and how long it lasts for. The default timing mode is continuous sampling time.

- **Continuous Sample**: when there is a trigger signal inputs, it will start to sample since;
- **Timing Sample**: it can be set to sample data for a certain period of time in a specific date, accurate to the seconds. The interface is shown below.

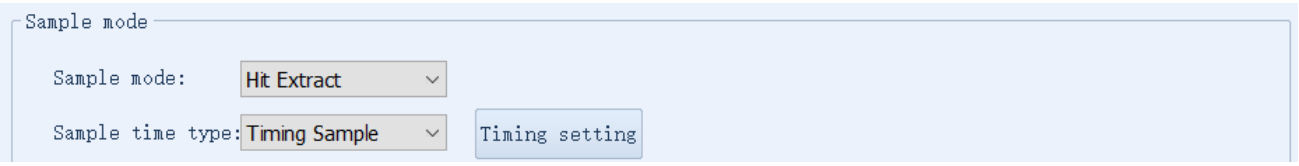


Fig. 3-20 Hit Extract Mode - Timing Sample

Click "Timing setting" to add acquisition time periods:

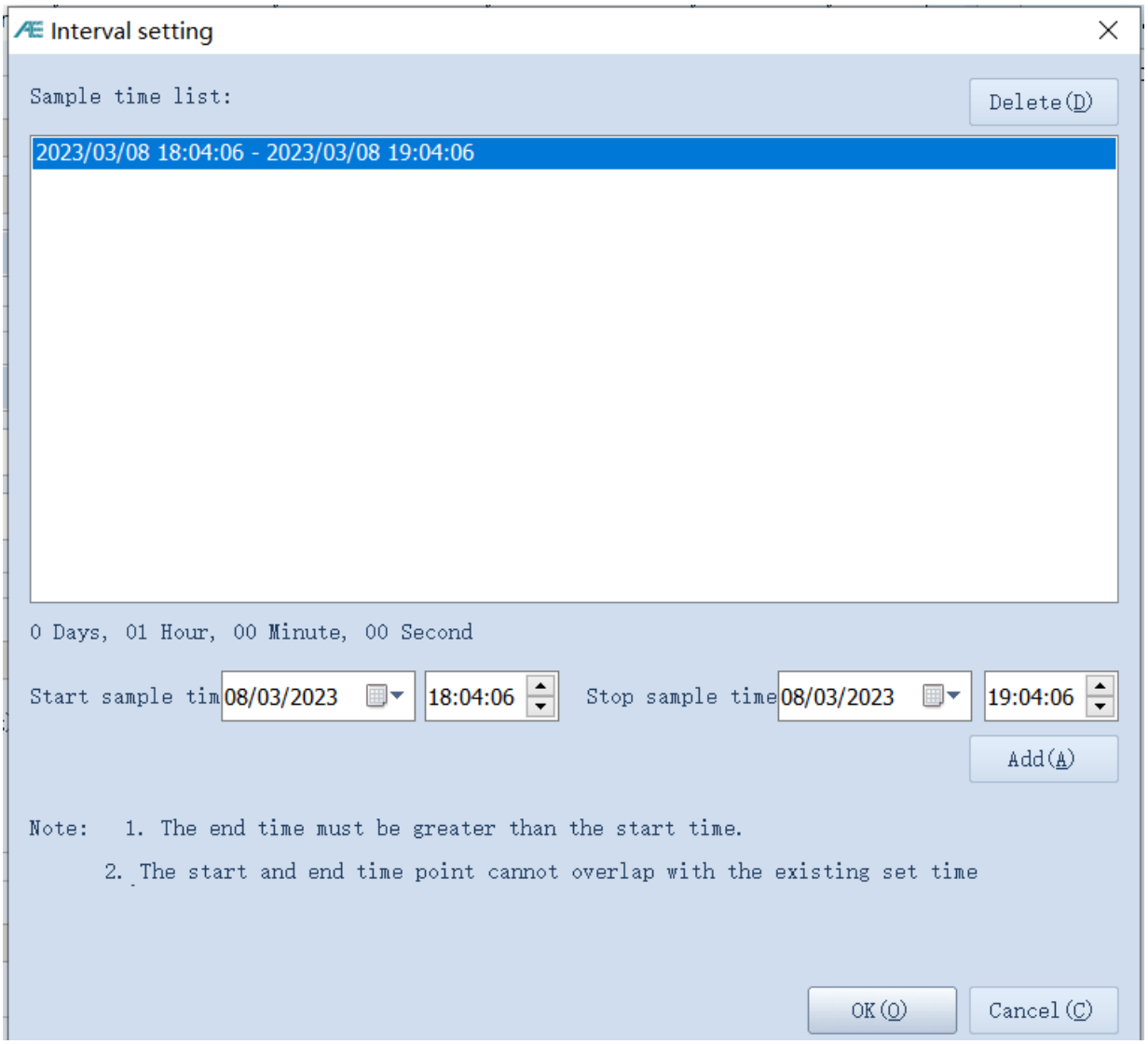


Fig. 3-21 Timing Sample settings page

- **Interval Sample**: it can set the sample intervals and the sample period duration.

Fig. 3-22 Interval Sample settings

- Sample duration: how long each sampling period lasts for, in unit of seconds. The minimum duration is 5 seconds, no upper limit.
- Interval duration: how long the intervals are between the sampling periods, in units of seconds. The minimum duration is 5 seconds, no upper limit.

3.3.2.2 Sample Parameters Settings

- **Sample length**: the length of each sample, in unit of points. It means the length of each waveform that can be recorded and stored. For example, if it is set to 4000, that means each waveform only records and stores the first 4000 points. This setting is only effective to "Time Parameters" mode, not for "Hit Extract" mode.
- **Sample speed**: maximum speed is 2000K/s. The value means the maximum collectable points per second in the current channel during the AE signal collection. The higher the set value is, the higher the sample resolution is, but also the bigger the data size is. The recommended value is about 10 times the upper limit of the concerned frequency domain. For example, if it is set to 1000, it means it can sample 1000k points per second at its maximum.
- **Threshold**: system signal triggered threshold, in unit of dB. It is suitable for the burst AE signal acquisition. It is the voltage level that determines when the AE waveform signal should start to be recorded. When the channel is in standby state and the voltage level exceeds the set value, it triggers to start recording. If it is in "Time Parameters" mode, its end time is decided by the "Sample length". But if it is in "Hit Extract" mode, its end time is decided by "HDT". According to the AE system application environment settings, it is normally a few dB higher than the background noise. The set range is 1~100dB (integer). 40dB is the normal threshold in engineering.

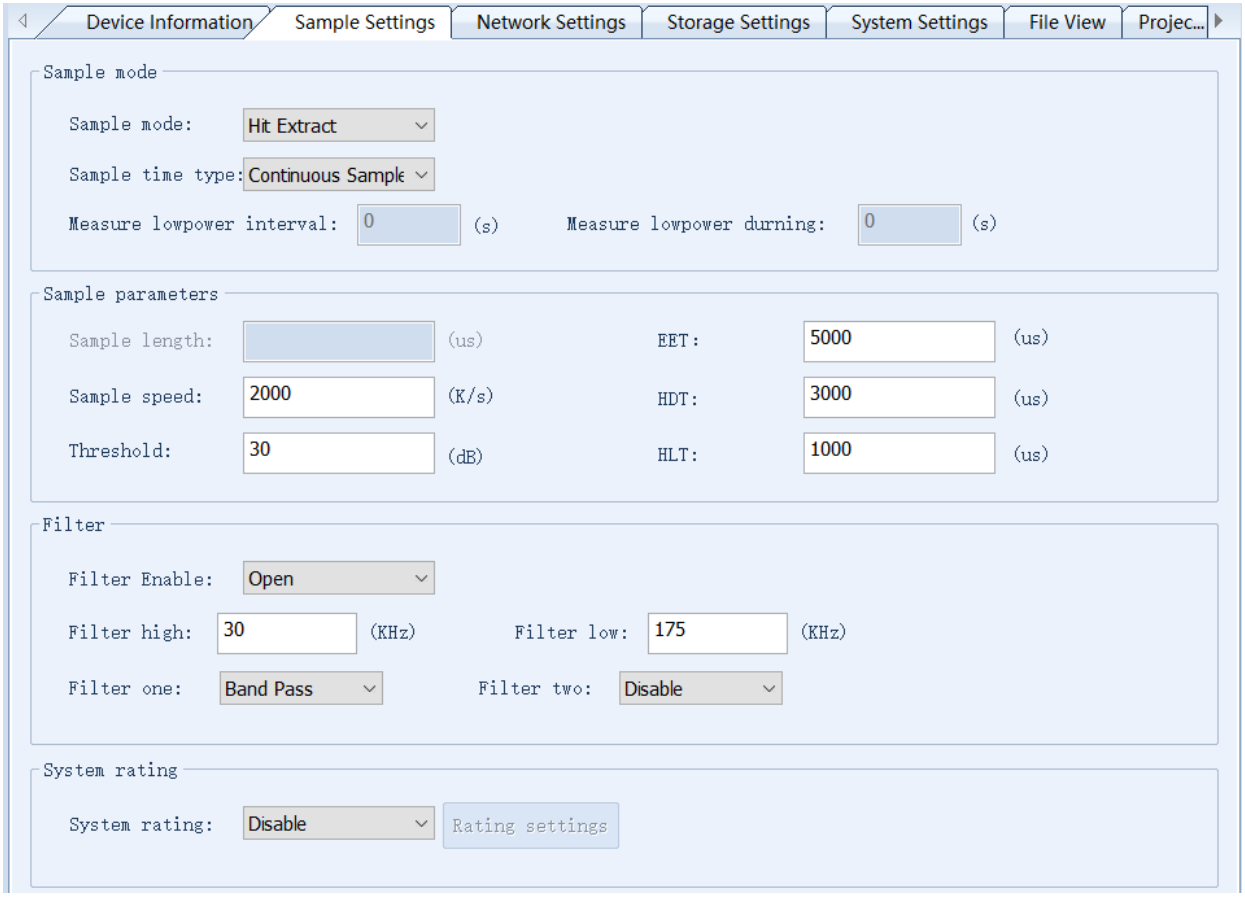


Fig. 3-23 RAEM1 Configuration software Sample Settings page

- **EET**: enforced end time, in unit of micro-second (μs). It ranges from 1 ~ 50000μs. When the AE hit is continuously higher than the threshold value, and the set HDT cannot define the end of the AE signal, the EET takes effect which means it is the duration of the current hit and other related AE feature parameters are calculated based on this duration. EET is effective only in Hit Extract sample mode, not in Time parameter sample mode;
- **HDT**: Hit definition time, also known as the envelop definition time, in unit of micro-second (μs). the setting range is 100 ~ 50000μs (positive integer), can be directly input in the text box. It refers to the waiting time interval of a hit signal in order to correctly determine the end point of that hit signal. When the set HDT value is greater than the time interval T between two adjacent wave packets that exceed the threshold, the two wave packets will be classified as one acoustic emission hit signal; if the set HDT value is less than the time interval T when the two wave packets cross the threshold, the two wave packets are divided into two acoustic emission hit signals. For the same signal, the greater the HDT is, the fewer the AE parameters are extracted, while the smaller the HDT is, the more AE

parameters are extracted. HDT is only effective in "Hit Extract" mode, but not "Time Parameters" mode.

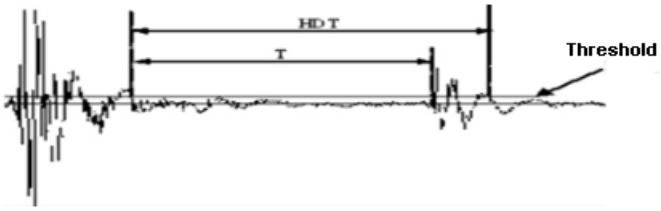


Fig. 3-24 HDT definition diagram

- **HLT**: Hit lock time, in unit of micro-second (μs). The setting range is 1 ~ +∞ (positive integer), can be directly input in the text box. In order to avoid receiving the reflected waves or late waves, HLT is the set time window for closing the measurement circuit. At the end of the current acoustic emission event after a HDT time, there is a period of time (HLT) that the signal will be ignored. This window is called hit lock time. The value is affected by the signal attenuation, structure size, etc. If the setting value is too big, the subsequent AE signal will be missed. As shown in the figure below, the next AE signal T period has passed the threshold, but the HLT has not finished, so the signal in T period will not be collected. HLT is only effective in "Hit Extract" mode, but not "Time Parameters" mode.

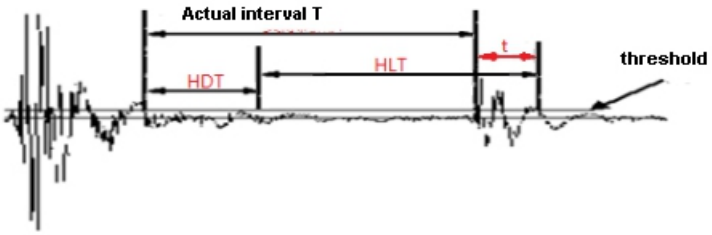


Fig. 3-25 HLT definition diagram

3.3.2.3 Filter

The filters in the software are the digital filters. There are two filters available. Filter One will be applied first before applying Filter Two (Filter Two will be available to set in the future). The filter frequency bandwidth is set by the "Filter high(pass)" frequency and the "Filter low(pass)" frequency. But first select the filter type for Filter One. For example, the "Band Pass" tyoe needs to set both high-pass and low-pass frequencies. The "Low Pass" only use "Filter low(pass)" frequency and the "High Pass" only use "Filter high(pass)" frequency.

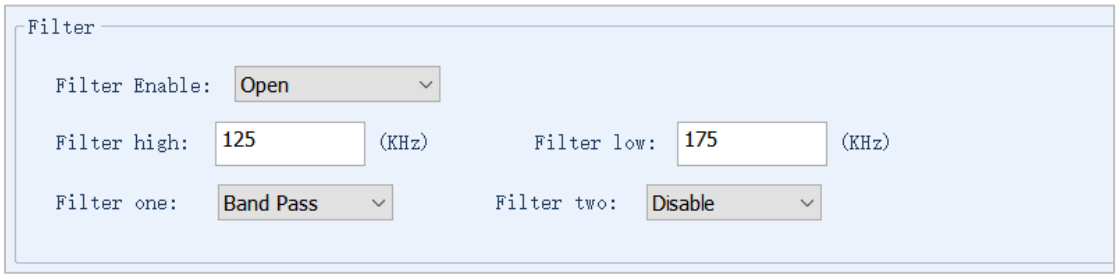


Fig. 3-26 Filer settings

3.3.2.4 System Ratings

Rating is to evaluate the overall performance levels of the current acoustic emission events according to the defined rating rules, so as to make alarms or action measures in response to different rating results. Select some parameters and set their values as different intensity levels, and specify the activity levels by the number of times that intensity levels report within a certain period. During the specified acquisition period, if any of the collected parameters exceeds a specified intensity or activity level threshold, it will be assessed and rated to a certain level of intensity or activity. Users can set the intensity or activity level for alarm reporting, or they can push alarm information according to the comprehensive rating levels.

The comprehensive rating level combines both the intensity and activity levels over a period of time and obtains the highest level of the comprehensive rating. The comprehensive rating level meets the NBT47013.9-2015 standard. It is important to note that the intensity level of the comprehensive rating cannot exceed 3 levels and the activity level cannot exceed 4 levels. Otherwise, a comprehensive rating cannot be obtained.

Comprehensive Rating Level		Activity Level			
		4	3	2	1
Intensity Level	3	4	4	3	2
	2	4	3	2	1
	1	3	3	2	1

Table 3-1 Rating level standards

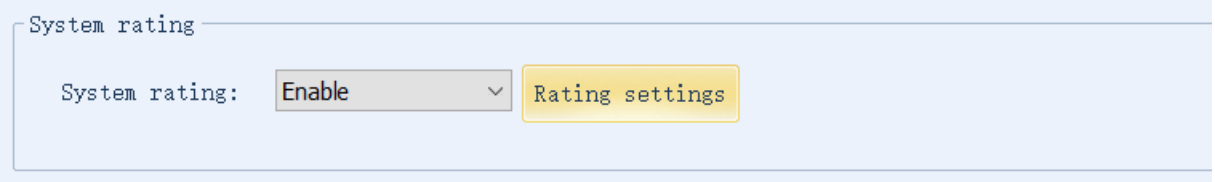
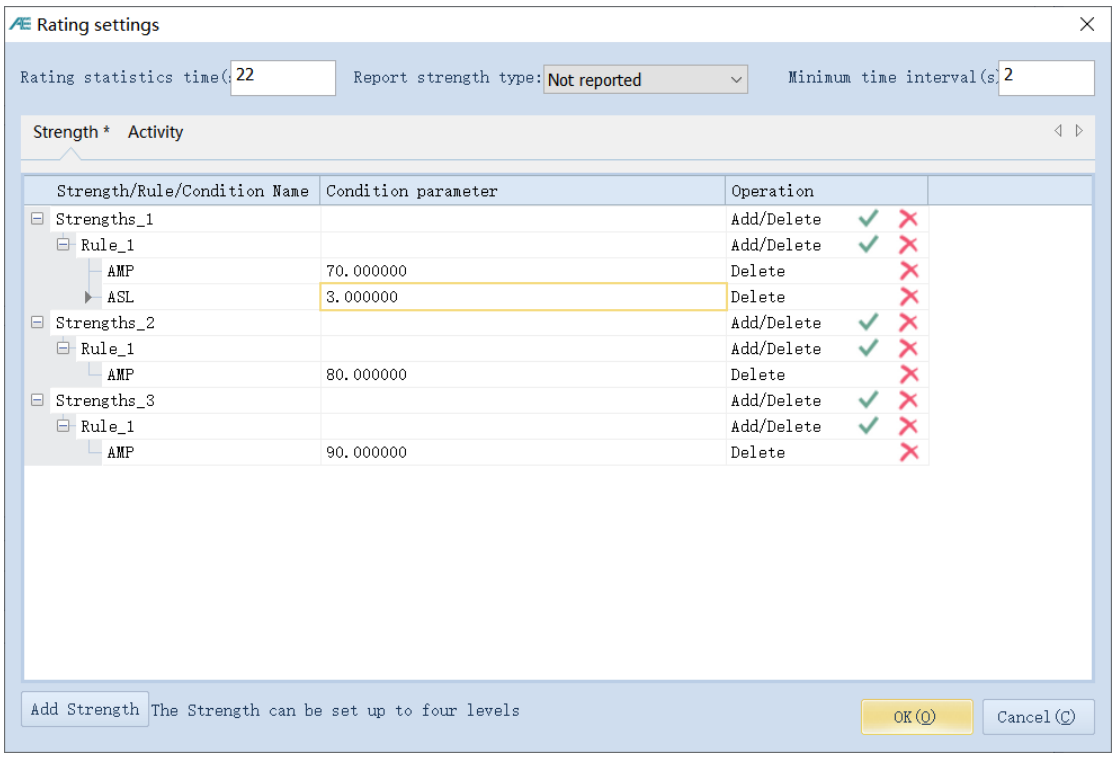


Fig. 3-27 System Rating function

In the "Sample Settings >> System rating", enable the function and press "Rating settings". At the bottom left corner of the Rating Settings window, press "Add Strength" or "Add Activity" to create rating levels. Each rating level can have one or multiple rules. Any one rule under that rating level reaches, that rating level will trigger and report. Each rule can also have one or more parameters as thresholds. It requires all the parameters in the rule reach the set values to make it conform the rule.



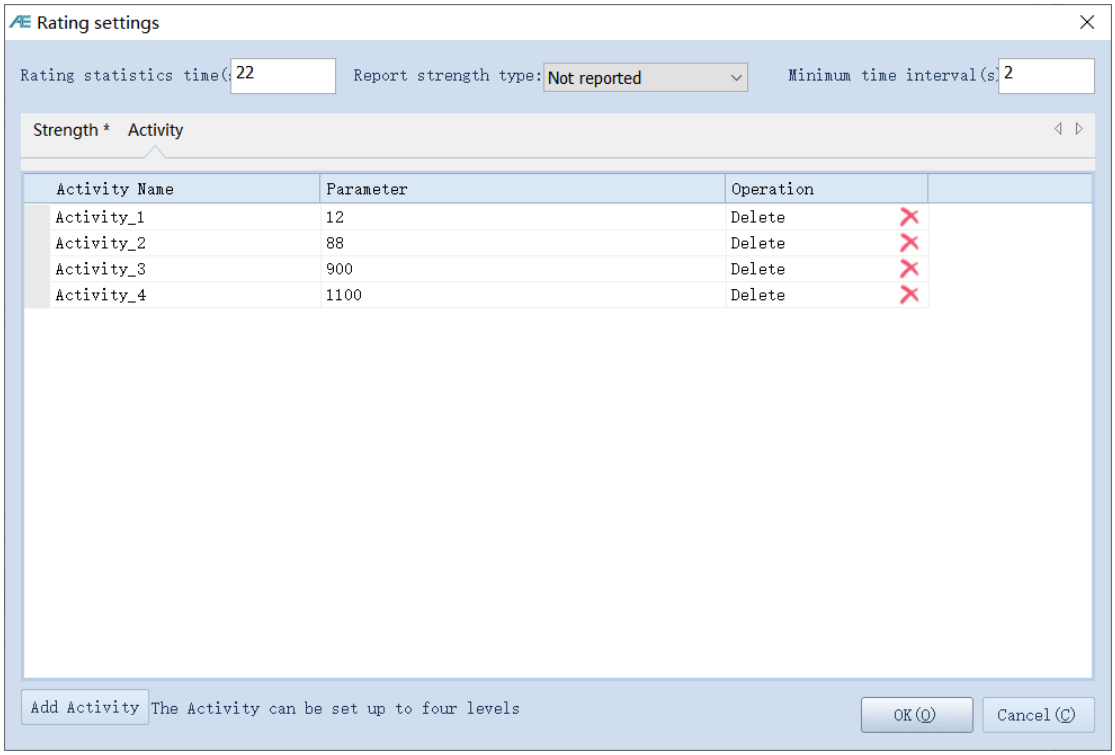


Fig. 3-28 System rating setting page

3.3.3 Network Settings

The default factory device IP addresses for different connection are:

Ethernet	192.168.0.101
Wi-Fi Hotspot mode	192.168.100.1

Table 3-2 RAEM1 device IP list

3.3.3.1 Ethernet Settings

The Ethernet can be set as static IP or dynamic IP. It can be achieved by using the RAEM1 Configuration software.

- **Static IP**: the IP address in the text-box will be used as the device Ethernet target IP address.

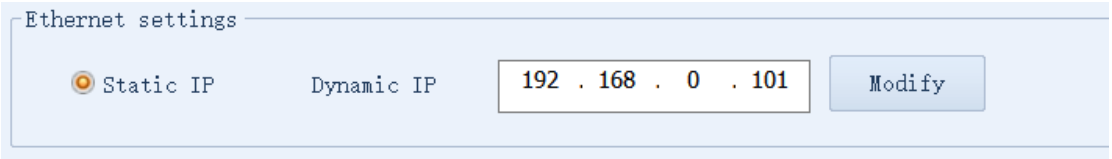


Fig. 3-29 Ethernet IP settings

The default setting is static IP, 192.168.0.101. That means when the computer is set at 192.168.0.xxx, for example 192.168.0.20, it can connect to the device.

- **Dynamic IP**: it will get the IP address dynamically from the router. In the device scan list window of RAEM1 Configuration software, it lists all the connectable RAEM1s that connects to the desired routers and other connection methods. If the device IP has changed, it will appear in the device list with a new device IP and it can be found by identifying the device ID in the scan list.

3.3.3.2 Wi-Fi Settings

The default Wi-Fi mode of RAEM1 is Hotspot mode. RAEM1 releases a Hotspot for connection. The Hotspot ID is for example "qc_raem1_WiFi_0001" and the default password is 88888888. When the computer searches for RAEM1 Hotspot, it can configure the RAEM1 after connecting to the RAEM1 Hotspot.

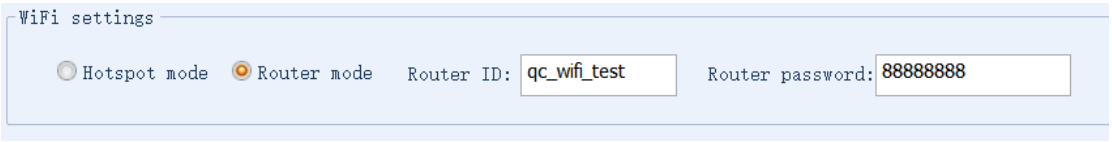


Fig. 3-30 Router mode settings

RAEM1 can also switch to the router mode for multiple connection or router Internet access. But before connecting to the router, **please make sure the subnet of the router address is NOT zero**. It means the router network address 192.168.Y.XXX and Y must not be zero because the 192.168.0.XXX is reserved for Ethernet connection.

When it is changed to the router mode:

① it needs to enter the router ID and password in the text-box in the software;

② Then reboot the device;

③ Connect the computer to the router network.

After rebooting, it will automatically connect to the software with the new device IP in the device list. If the router has access to the Internet, RAEM1 can get the dynamic IP and communicate with the serve. Through the Internet function in the router, it can access the cloud server to configure RAEM1 and download data remotely. If the router doesn't have Internet function, it can access data and configuration settings through local network and software, same as Ethernet and Hotspot mode access.

3.3.3.3 System Timing

System timing means the RAEM1 clock synchronization method. It depends on the device hardware connection and communication methods.

- **Network time**: means to synchronize the clock with the network base time.
- **Local wired time sync.**: includes Ethernet, RS485 and TTL to RS485. Local timing is that among the connected RAEM1s in the local network, one RAEM1 is chosen to be the master and others are the slaves to be synchronized with the master clock.
- **Wireless time sync.**: it is exclusive to the RAEM1 with wireless sync. Module built-in.
- **Master/Slave**: choose to be the master or slave of the clock.

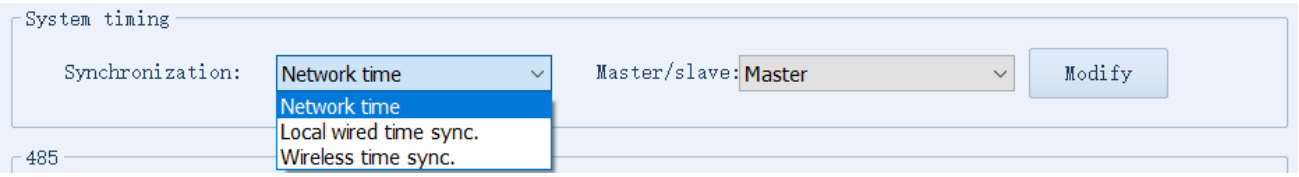


Fig. 3-31 System timing

3.3.3.4 485

When the RAEM1 has RS485 communication, it can use the 485-protocol defined by Qingcheng for data and control commands transmission. The related 485 protocol is introduced in Section 10. Please contact Qingcheng company for latest 485 protocol in detail.

3.3.3.5 AWS Param

RAEM1 supports data upload to AWS S3 server. AWS S3 is Amazon Cloud storage, ideal for data

storage. The AWS S3 setup instructions are introduced in Section 8.2.2.

3.3.4 Storage Settings

- **Data storage**:
  - **Save Wave**: whether to save the waveform to the local storage card or not. If disabled, it will not save the waveform data. It is disabled by default;
  - **Save Param**: whether to save the parameters to the local storage card or not. If disabled, it will not save the parameters. It is disabled by default;

Note:

1) The data storage mentioned above only means to the local memory card storage. When it is disabled, the data can still be uploaded to the Alibaba Cloud server/ TCP server/ SWAE software. It is just NOT stored in the local SD card, as well as NOT uploading to the Qingcheng IoT Cloud or AWS.

2) The data will be packed as a zip file every 5 seconds when there are HITs. But no data packs if there is no HITs during the time.

  - **Upload original data**: whether to send the original data (waveform and parameters) to the **Qingcheng IoT Cloud** server. If disabled, it will not send data to server to save the streaming data. It is disabled by default.

- **U3H Server**:
  - **Send U3H**: whether to send the real-time data to the SWAE software. It is disabled by default;
  - **Send Wave**: whether to send the waveform to the SWAE software. It is disabled by default;
  - **Send Param**: whether to send the parameters to the SWAE software. It is disabled by default;
  - **Address type**: the target PC address type. It can be auto or user defined ("Use IP"). "Auto" type is the factory setup for testing. It means the PC address is already setup for factory settings and requires no manual input. But **it is suggested to choose "Use IP" always**. Find the IP address of the PC that uses SWAE software and enter the IP address to the address text-box.
  - **Address**: If "Use IP" is selected, it needs to enter the target PC address here;
  - **Port**: can be configured. The default is 18883.

3.3.5 System Settings

3.3.5.1 Time Calibration

If the time stamp of the data package is incorrect, you can click "**System Settings**" page >> "**Time Calibration**" >> "**Calibration**" button to calibrate the selected RAEM1's clock with the system clock of the computer. After calibration, the device may stop sampling data. In that case, click "Start" button below to restart sampling.

" **Reboot device**" button reboots the selected RAEM1. **Rebooting takes some time and it must NOT be interrupted or turned off during the rebooting. After reboots, it cannot be connected and controlled until the RAEM1 restarts completely and the "RUN" light flashes again.**

3.3.5.2 Sample State

- **Start**: sends start acquisition command to the selected device and the device starts data acquisition immediately after clicking this button. By default, the device starts acquisition automatically after powering up;
- **Stop**: requests the device to stop data acquisition;
- **Data query**: click to enter the "Real time data" page where there are data reported in every second. Please note that the data is logged in every second randomly to test if the connection is normal. Please check all the original data in the desired location (local storage or cloud server).

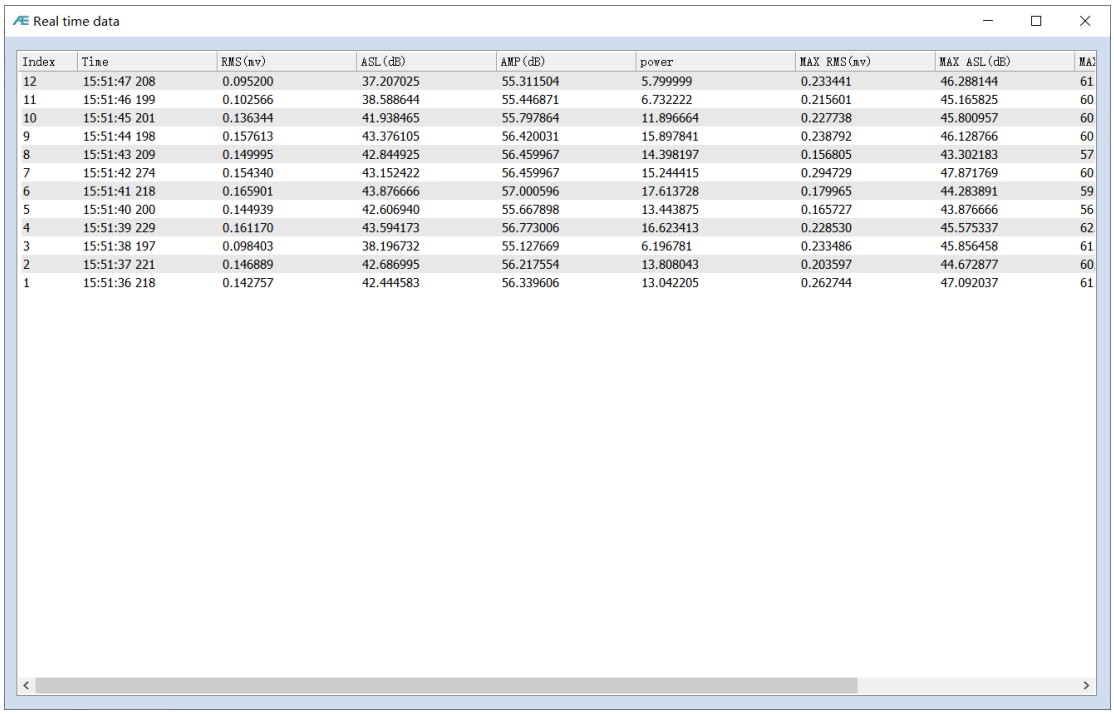


Fig. 3-32 Real time data page

3.3.5.3 Firmware Update

There are two files to update the firmware:

- update.zip
- md5sum.txt

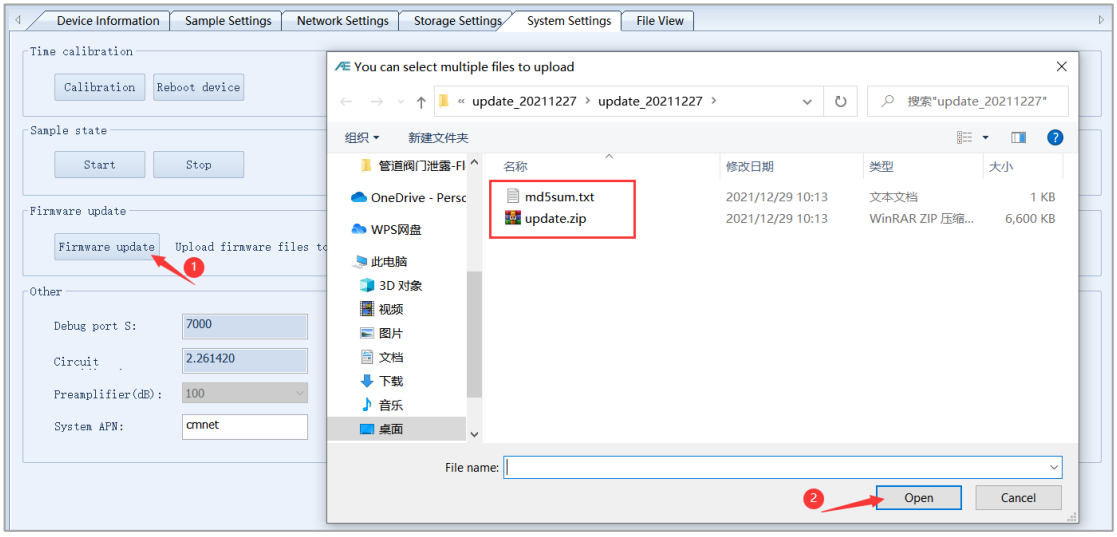


Fig. 3-33 Firmware update

Click "Firmware update" button to upload "update.zip" and "md5sum.txt" files in order. **After uploading**

the files, the system will update automatically followed by rebooting. Please don't interrupt the process by disconnecting the power or manual restart during the process. It also supports multiple files for uploading. You can choose both files to upload at the same time.

3.3.5.4 Other

There are other information including: debug ports, circuit magnification, preamplifier and system APN. Except for network APN, the others settings cannot be configured because they are for internal debugging and factory settings.

3.3.6 File View

Click "File View" tab to view the selected device's data packages stored in local storage card.

The files in the list can be downloaded, deleted, converted to CSV or U3H format, by clicking the right button of the mouse. The functions are:

- **Download selected files**: download the selected files. If the files are not selected, it will not be downloaded;
- **Download all files**: download all the files in the list;
- **Delete selected files**: delete the selected files. It would not delete the files if they are not selected;
- **Delete all files**: delete all the files in the list;
- **Covert to CSV format**: convert the selected files into CSV format. Each zip file converts into one CSV file. But if the data number is more than 830,000, it will be saved as multiple CSV files;
- **Merge multiple files and convert to CSV format**: merge and convert multiple selected files into one CSV file if it is possible. But if the number of data is more than 830,000, it will be saved into multiple CSV files;
- **Convert to U3H forma**t: convert the selected files into U3H format (. pra &. aed). Each file is converted and saved as one U3H format file. If multiple files are selected, there are multiple U3H format files;
- **Merge multiple files and convert to U3H format**: convert the multiple selected files into one U3H format file. If all the files are wanted to be converted, press "Ctrl + A" to select all files and then select this function;
- **U3H conversion settings**: set the sample rate and sample length. Please note that the sample length means the waveform length of U3H format after conversion, which is different from the sample length of RAEM1. The value should be equal to or greater than 1000, equal to or less than 100000.

- **Refresh file list**: If the file list is refreshing, the functions mentioned above will not be available.

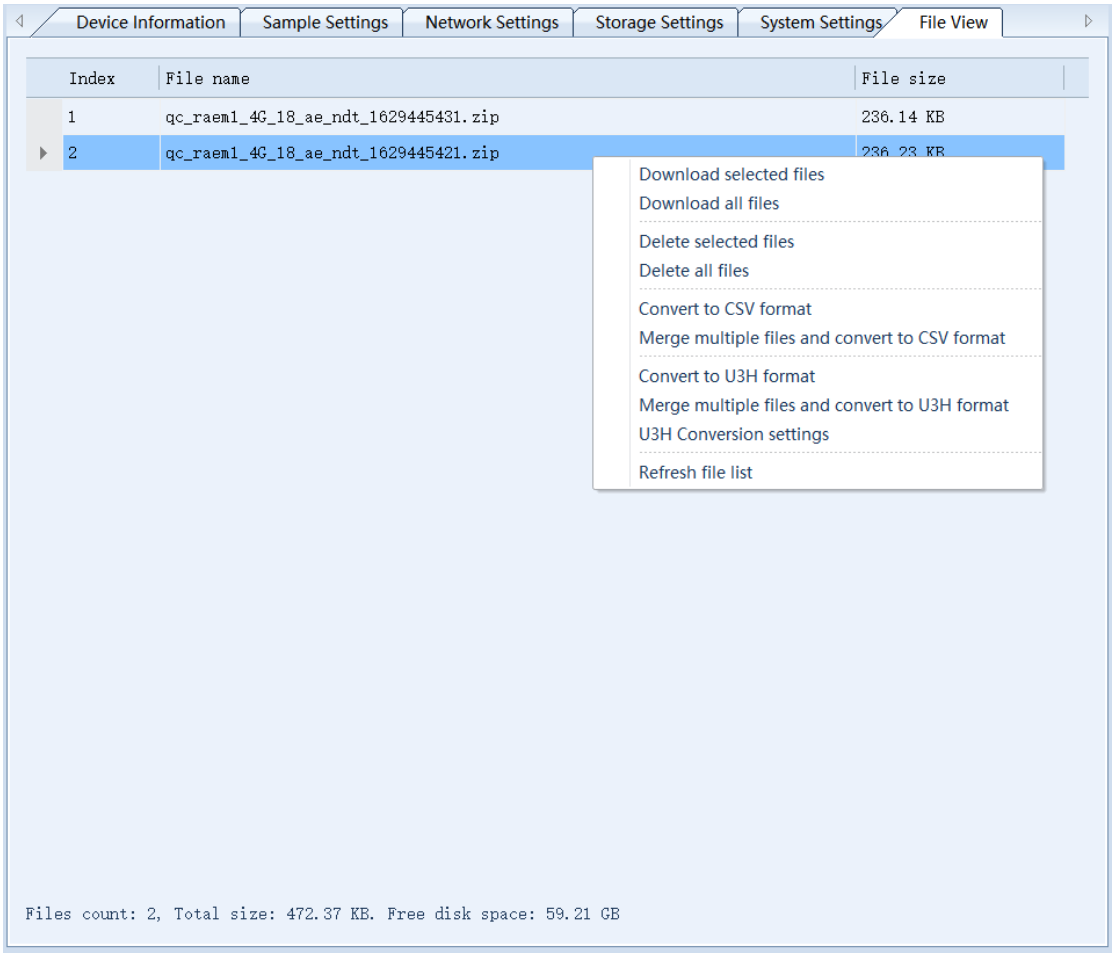


Fig. 3-34 File View

Press "Ctrl + A" to select all files. When using the mouse to drag and select multiple files, please make sure the mouse is in the file name column, not the empty column of the list.

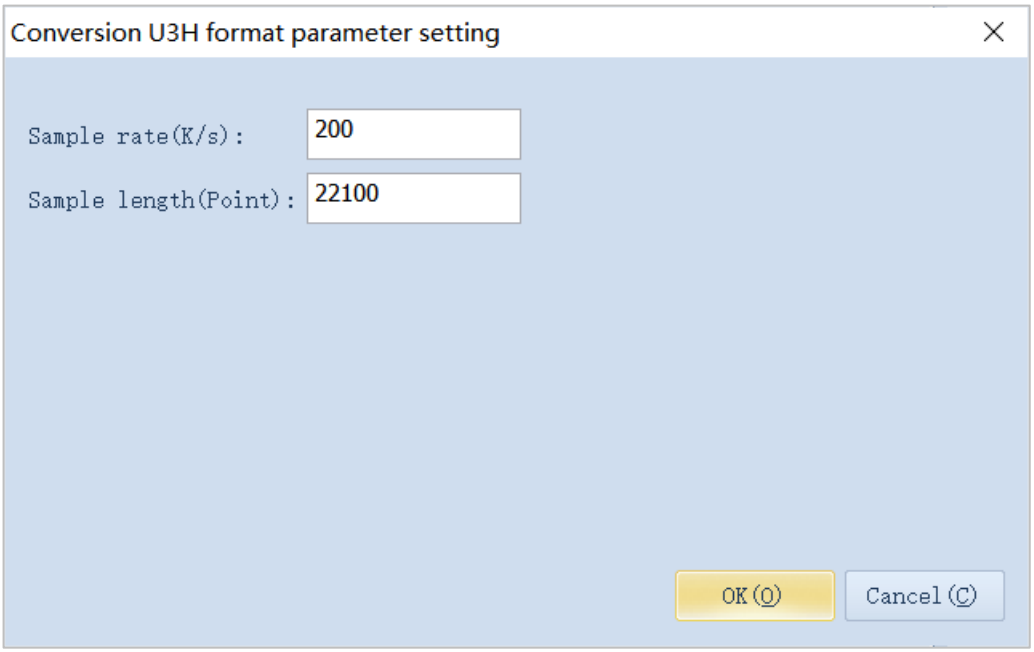


Fig. 3-35 U3H format conversion settings

3.3.7 Project Data

This section is designed for special projects in terms of the special data transmission methods or prototypes. There are TCP modes, QC Aliyun mode (Alibaba Cloud transmission) and other specific projects. Only TCP modes and Aliyun mode are introduced below.

- **Data reporting mode**: There are a few types of data reporting modes to servers, such as TCP mode, TCP mode v2, QC Aliyun mode and other specific server modes (specific server modes will not be introduced in the manual because they are designed just for the certain projects). Based on the selected report modes, it shows the server IP address and port, or the Aliyun key and Aliyun secret below.
- **Report interval**: the time interval between the two data reporting time. During this interval, it chooses the group of data with the maximum amplitude to report. The default report interval is 1000ms, i.e. 1s. The minimum interval is 200ms.

3.3.7.1 QC Aliyun (Alibaba Cloud) Mode

QC Aliyun mode is used to set the RAEM1 to be able to communication to the Alibaba Cloud server. In this mode, users can view the RAEM1 in the QC Alibaba Cloud platform for its real-time AE parameters, parameter ratings and configurations. But the waveform is not yet supported to be viewed or download

currently. It requires the devices to have Internet function in this mode. The following 3 types of devices can access Internet:

1	4G devices. It can use Ethernet or QC IoT platform to connect and configure. The device IP address is 192.168.0.101.
2	Wi-Fi devices. It needs to be router mode and connects to the router that accesses the Internet.
3	Ethernet devices. It connects to the router that has access to the Internet.

Table 3-3 QC Aliyun Mode network setup

When the Aliyun Key and the Aliyun secrete are configured and sent to the device, RAEM1 will automatically connect to Alibaba Cloud and start uploading data. Qingcheng Aliyun information is set at factory settings and can be used directly. Please see Section 6 for detail steps.

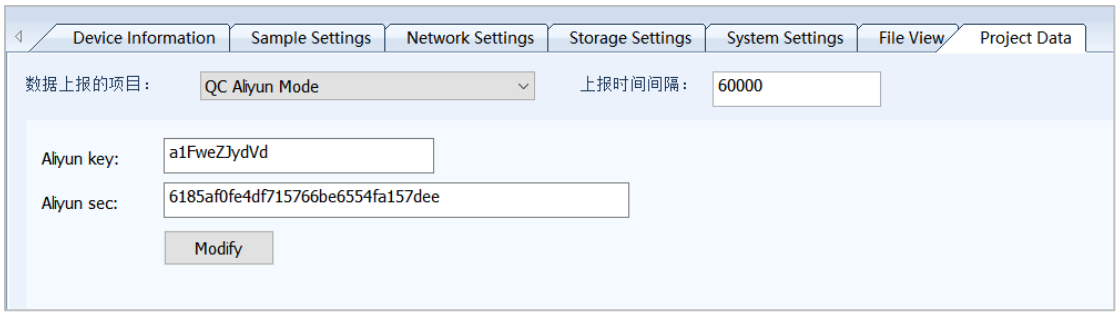


Fig. 3-36 QC Aliyun mode setup

3.3.7.2 TCP Mode and TCP Mode V2

The TCP modes in the "Project Data" are defined TCP protocols by Qingcheng. The reported data stream is reporting with time intervals. For example, the reporting interval is 60000 ms by default. It means every 60 seconds; the device will report one stream of data to the server using the TCP protocol and the data is the AE parameters of a single AE Hit with the maximum amplitude. All the other AE hits during that time are not reported. If all the AE hits data are wanted, please refer to Section 7 using the SWAE software or Section 8.

When it is configured to be TCP mode or TCP mode v2, it needs to configure the server address and the server port. The reporting interval is in unit of ms. The minimum of the reporting interval is 200.

TCP mode v2 is an additional version based on the TCP mode with more parameter types for communication supported. In order to be compatible with the older version of TCP mode, "v2" is added as the new TCP mode name.

Protocol	Qty.	Parameters
TCP mode	4	Amplitude, ASL, power, RMS
TCP mode v2	9	Arrival time, AMP, Power, RMS, ASL, Rise time, Rise ring-down counts, Duration, Ring-down counts

Table 3-4 TCP Mode setup

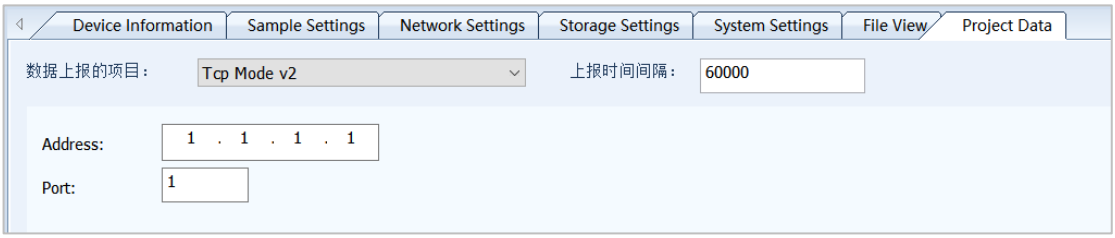


Fig. 3-37 TCP Mode setup

The related TCP protocol is introduced in Section 10. Please contact Qingcheng company for more detail about the latest TCP protocol.

Under the TCP mode, if the server has background program, it can receive the corresponding data. The simple server test code can be:

```
#!/usr/bin/python
import socket
import commands
import time
# import redis
HOST='0.0.0.0'
PORT=18883
s= socket.socket(socket.AF_INET,socket.SOCK_STREAM)
s.setsockopt(socket.SOL_SOCKET,socket.SO_REUSEADDR,1)
s.bind((HOST,PORT))
s.listen(1)
while 1:
        conn,addr=s.accept()
        print'Connected by',addr
        while 1:
                data=conn.recv(1024)
                time_stamp = time.time()
                listData = data + ',' + str(int(time_stamp))
                print(data)
conn.close()
```

Fig. 3-38 TCP mode test code

The context that the server receives is:

```
qc_raem1_test_0001,36.390879,192.656167,4611614559298.000000,26844156.844411,162217050397547
qc_raem1_test_0001,43.579539,192.658916,4611679381904.000000,26844345.509581,1622170503113346
```

Fig. 3-39 TCP mode server receiving data

TCP Mode (not TCP Mode v2) outputs 4 AE characteristic parameters, including amplitude, ASL, Power and RMS. The format of the output data is: device ID + amplitude + ASL + Power + RMS + timestamp, separated by comma.

3.4 Online collection by U3H (RAEM1) software

SWAEU3H (RAEM1) (hereinafter referred to as "U3H") is a professional AE control, processing and analysis software developed by Qingcheng Company. It has RAEM1-6 to collect and process AE data, and then the data is sent to SWAE software of the computer through the LAN for real-time analysis and display. The data display includes parameter table, waveform chart and position chart and so on. Because of the high precision synchronous clock, the arrival time of each parameter is high precision, using U3H software with high precision time difference sound source location algorithm can get a variety of high precision AE source location.

Our U3H (RAEM1) software can be used to connect RAEM1 for online collection, including real-time display of parameters and waveform. Install the U3H (RAEM1) software package and install the software. Connect RAEM1-6 to the PC and configure the PC, hardware, and software Settings. When Raem1-6 is running the collection, the real-time collection can be started.

- support online transmission mode: Ethernet connection (single or networking), Wi-Fi network connection
- RAEM1 configuration software version: V2.9.0.27
- U3H (RAEM1) software version (Windows) :

Setup_x64 v4.4.19.45 U3H(RAEM1_20220616)-v28.exe

Remarks: attention when using U3H online acquisition, it is necessary to close the firewall:

- ① **Open Windows Defender Firewall with Advanced Security.**
- ② **Open "Windows Defender Firewall Properties";**
- ③ **In the domain profile, change Firewall status to Off.**
- ④ **Repeat Step 3 under Private Profile and Public Profile.**
- ⑤ **Click "OK".**

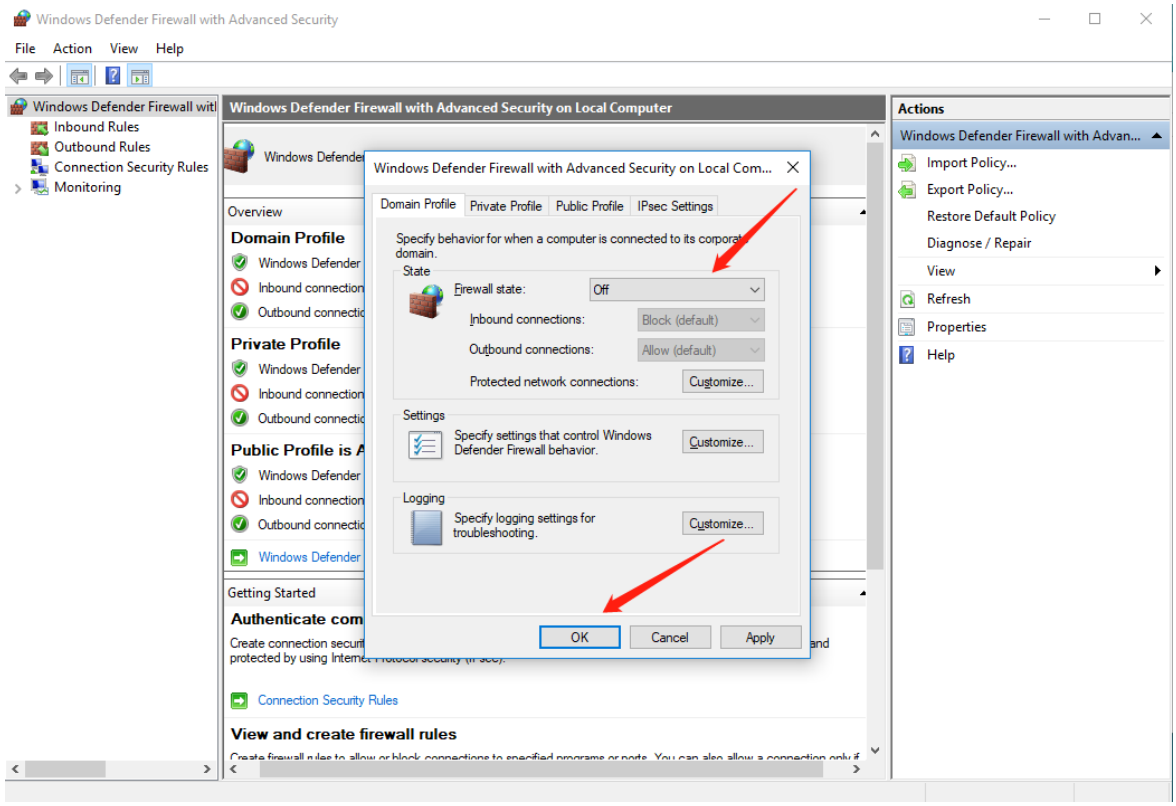


Fig. 3-40 Disabling the firewall

Follow these steps to connect RAEM1-6 to the software for use:

(1) Connect RAEM1-6 devices according to the Ethernet connection method described in Chapter 3.1 or Wi-Fi connection method described in Chapter 3.2. You can choose single direct connection or multi-device networking. However, please note that for the Wi-Fi direct connection of a single RAEM1-6, due to the transmission rate and stability, it is recommended that this mode only be used with the parameter configuration software.

(2) By default, RAEM1-6 supports U3H online transmission on one network segment, that is, 192.168.0.xxx. If they are already connected via a network cable or Wi-Fi router, Windows users can tap the network button at the bottom right of the screen and view the network properties of the

connection. Check whether the IP address of the connected computer is on the target network segment 192.168.0.xxx, and note down xxx.

(3) RAEM1-6 needs to be set in RAEM1 configuration software to send data to the specified computer. In the device list, select the channel that you want to send data to the U3H software. On the **Storage Settings** page, disable **Save Waveform**, **Save Parameters**, and **Upload original data**. **Send U3H software** "Enable and enable" **send waveform** "and" **send parameter** "data. IP Address type "Select" **Enter IP** ", and then enter the computer IP address found in the previous step into "**PC address**", so that RAEM1-6 will send the data to the specified computer. Caution Ensure that the IP address of RAEM1-6 and the target IP address of the PC are on the same network segment. Fill in the port number truthfully. Then click the "Settings" button in the upper right corner of the configuration software to send the above changed Settings to the selected channel of RAEM1-6. Close the configuration software.

Note: Turn off local waveform and parameter saving because local SD card saving may slow down sending data to U3H and cause data loss. As long as the waveforms and parameters sent to the U3H are enabled, all the original data will be sent to the U3H, and then saved in the U3H format.

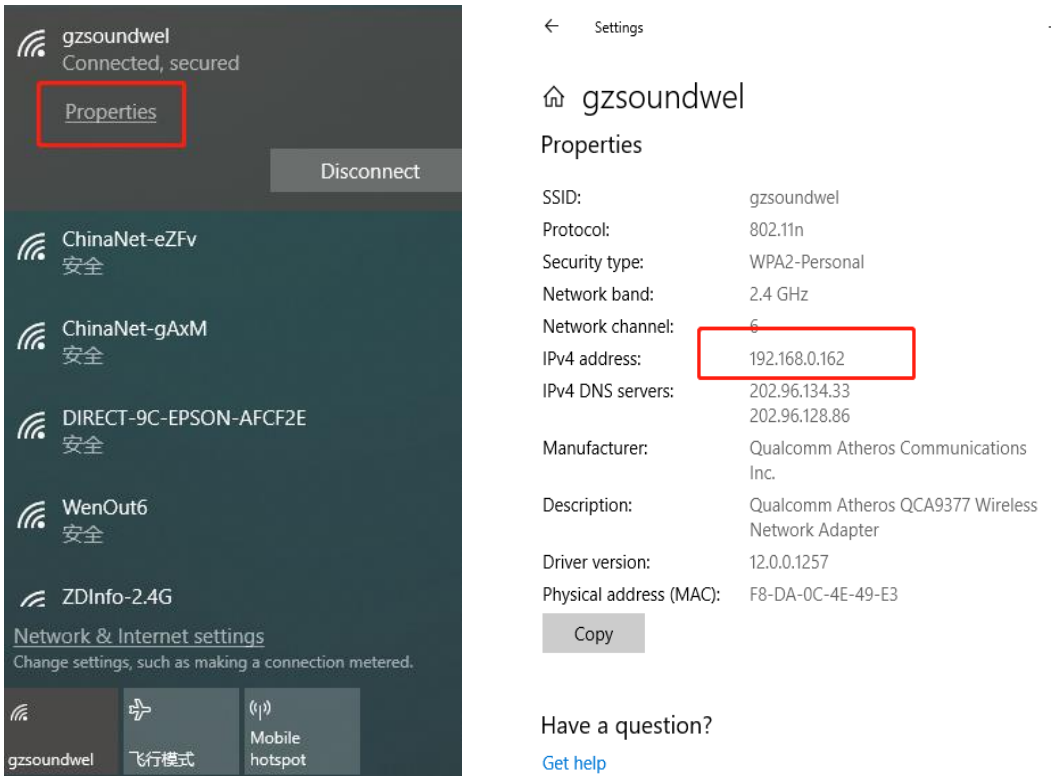


Fig. 3-41 Viewing the connected network address

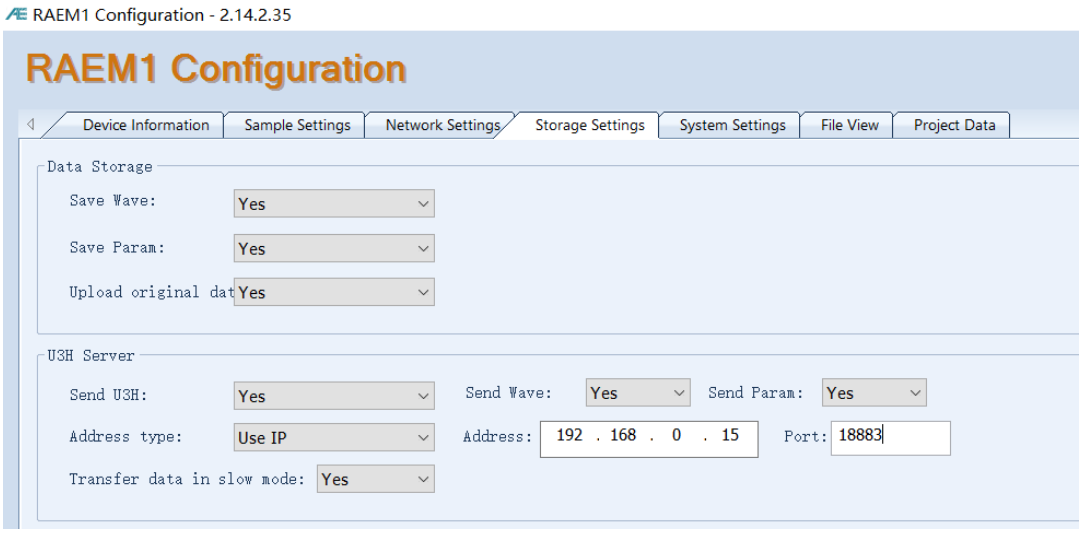


Fig.3-42 Setting the target IP address of the PC in RAEM1 Configuration software

(4) The U3H (RAEM1) software needs to be installed. If the computer has a regular version of the U3H software, you need to completely uninstall the regular version of the U3H software before installing the U3H (RAEM1) software. After the software is installed, start the software, click "**Hardware and Sample**", and click "**Sample Settings**".

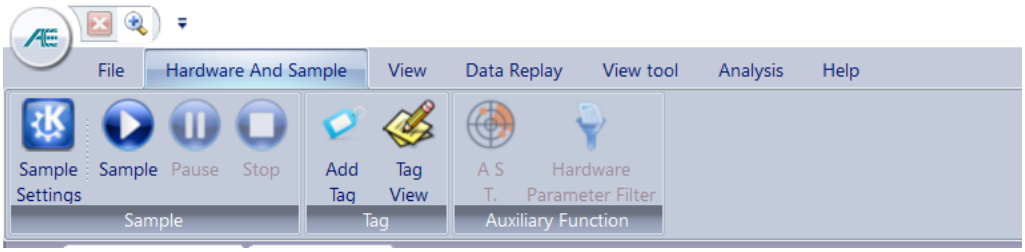


Fig. 3-43 U3H software sample Settings

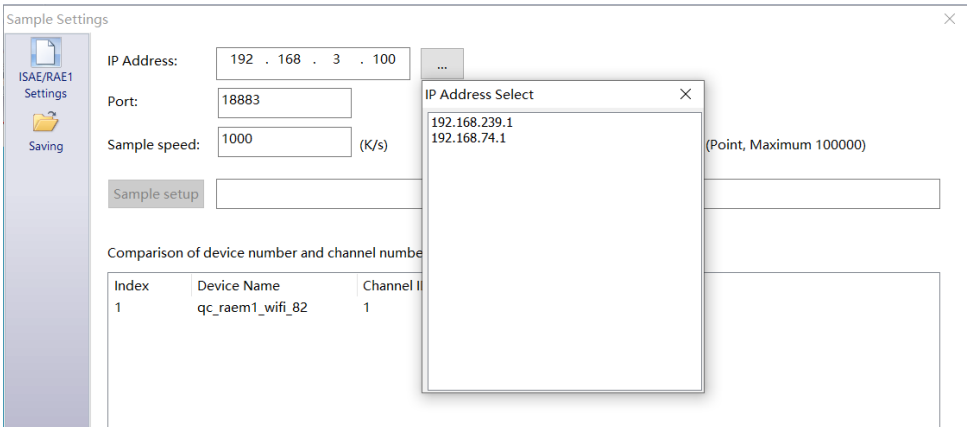


Fig. 3-44 Change Add collection Settings

① IP Address: specifies the IP address of the target PC. This parameter is the same as IP address in Send U3H Server in the previous step. You can also click "... "on the right. Get the current computer IP address.

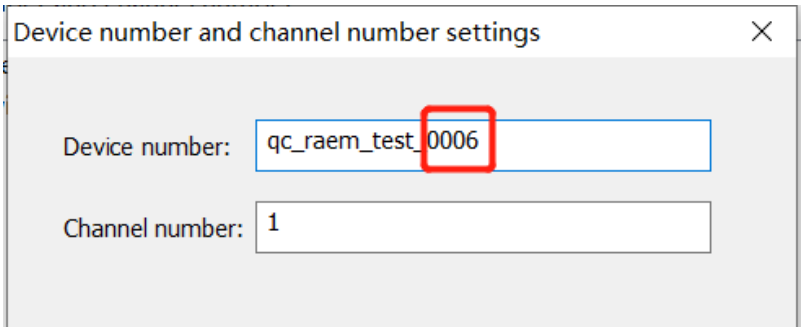
② Port number: The port number is the same as that set in "Send U3H Server" in RAEM1-6.

③ Sampling speed: consistent with the sampling speed set by RAEM1-6

④ Sampling length: only related to the display in U3H, it is recommended to set the value equal to RAEM1-6 sampling rate multiplied by EET

⑤ Click the "Add" button, and the pop-up window will set the device number and channel number

Device number: Enter the last four digits of the RAEM1 device number as follows



Channel number: Manually define the channel number, which is defined as 1 in ascending order

(5) Click "Save" and click "Sample" button:

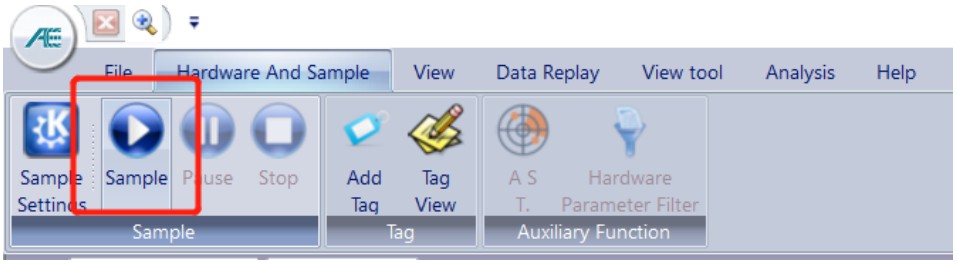


Fig. 3-45 Click and Collect

(6) Define the data saving path: save the data sent by RAEM1-6 into U3H software format (. pra and. aed)

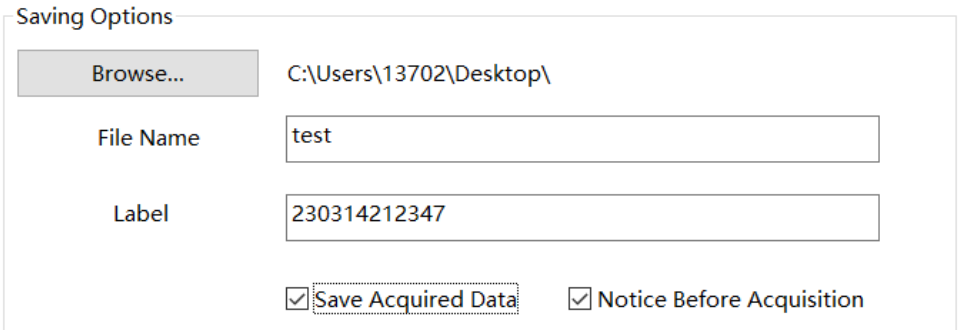


Fig. 3-46 Save path for the collection file

(7) Starting Sample will have a network matching process ranging from 1-30s, and parameters and waveforms can be observed to be sent online. Generally, the waveform will appear first, and then wait 3 seconds for the parameters to appear.

序号	到达时间(dd:hh:mm:ss:m...	通道号	幅度（d...	振铃计数	持续时间(us)	能量(KpJ)	上升计数
10	6:23:39:33:036 117264	1	92.6	36	1286	15178.333	2
11	6:23:39:34:967 814200	1	91.1	43	1388	7583.171	0
12	6:23:39:34:987 101200	1	61.4	9	101	19.678	0
13	6:23:39:34:988 562200	1	64.8	231	2817	17.981	45
14	6:23:39:34:992 500200	1	61.0	276	2597	11.811	149
15	6:23:39:34:996 556200	1	60.9	270	2476	11.150	16
16	6:23:39:35:001 832200	1	60.9	174	1530	14.816	101
17	6:23:39:35:006 523200	1	59.8	35	453	15.425	0
18	6:23:39:35:015 525264	1	62.4	301	2937	12.925	166
19	6:23:39:35:737 080200	1	95.1	440	5820	7158.272	1
20	6:23:39:35:747 022200	1	58.7	0	12	57.212	0
21	6:23:39:36:293 766200	1	95.5	22	1439	52041.584	1
22	6:23:39:37:473 177200	1	95.5	234	4238	15530.599	1
23	6:23:39:37:478 485264	1	64.0	283	3675	21.464	4

Fig. 3-47 Parameter table data

(8) When the mouse scrolls over the waveform view, the channel number will be changed:

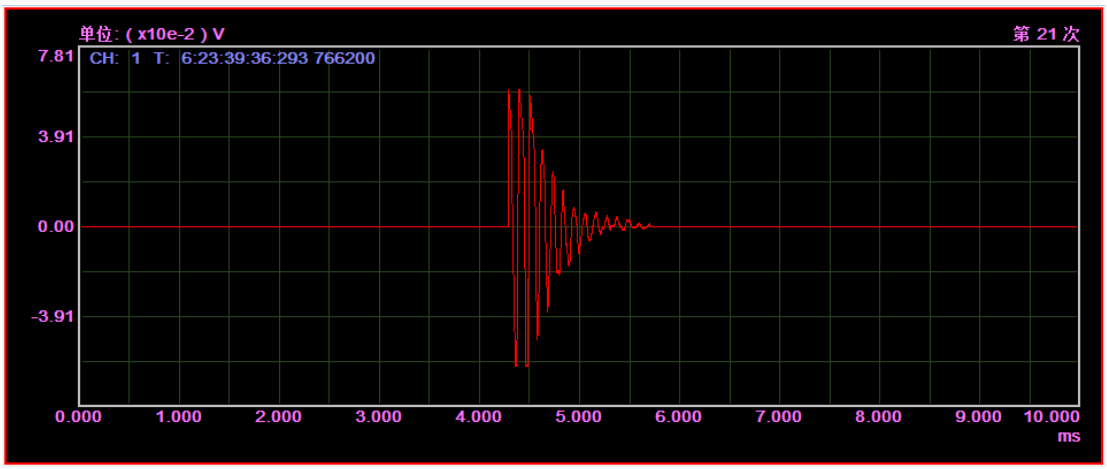


Fig. 3-48 Waveform view

4. RAEM1-6 IoT Monitoring System Operation Guide

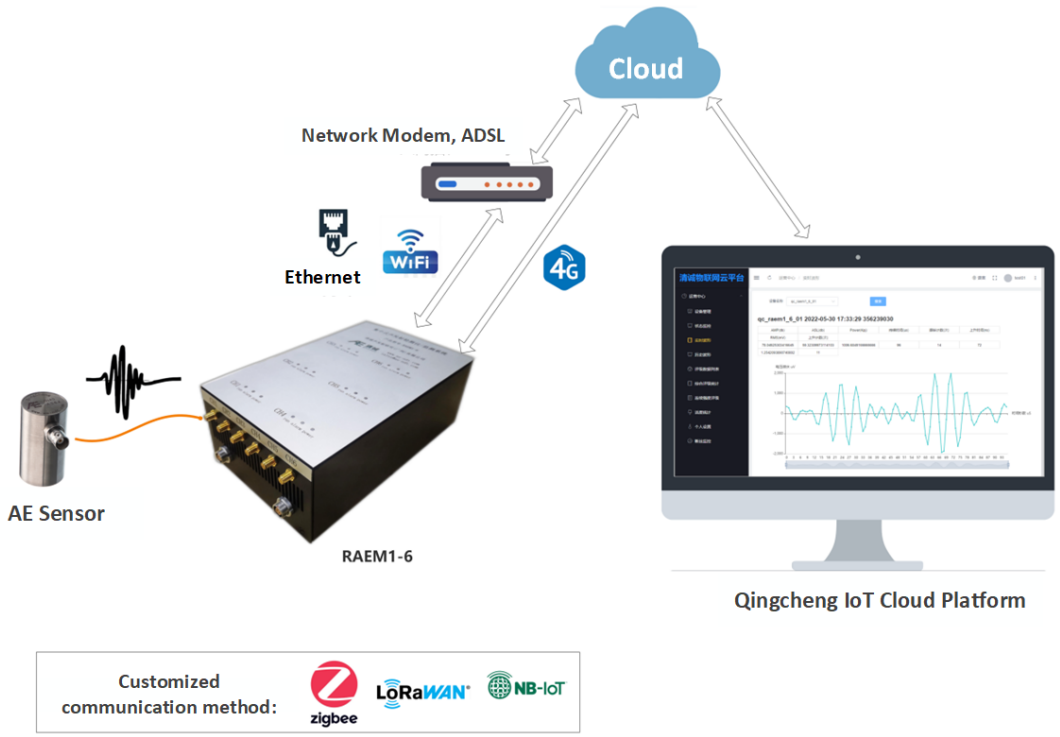


Figure 4-1 Connecting the RAEM1-6 monitoring system

In addition to the function of detector, RAEM1-6 can also be used as monitoring equipment, namely, RAEM1-6 sound wave (acoustic emission) monitoring system. Data can be uploaded to various cloud platforms through existing Ethernet and Wi-Fi communication or upgrading 4G or other communication methods to realize long-term unattended monitoring of monitoring/detection objects in the Internet of Things. Provide flexible alarm threshold Settings, can actively push the alarm information to the client mobile phone.

Now connect the hardware as required. After completion, start RAEM1-6, and you can start the operation after logging in to the QingCheng IoT could platform.

The Internet of Things cloud can be the Qingcheng Internet of Things cloud platform independently developed by Qingcheng, or it can be Ali Cloud, or Amazon AWS, or users can put forward other client cloud requirements. This manual mainly describes how to use Qingcheng IoT cloud platform and Ali Cloud platform.

4.1 4G network connection

RAEM1-6 can use 4G Internet of Things network card to connect to cloud server directly through mobile Internet for parameter configuration, data transmission, display analysis and other purposes.

A single RAEM1-6 can directly connect to the cloud through its built-in 4G module. You need to connect a 4G antenna and plug in an Internet of Things card. After the hardware connection is complete, start RAEM1-6 to log in to the cloud server and start operations.

Fig. 4-2 RAEM1-6 Connecting to the cloud over 4G

The IoT card slot is on the back of the RAEM1-6. Generally, the factory does not provide IoT card. Customers need to buy their own IoT cards can be wireless mobile cards of any carrier, 2G, 3G, 4G, 5G networks, standard (Mini-SIM) SIM card size. The Internet of Things network card can be inserted to use. Note that the metal chip is inserted face down. Because the slot is relatively inward, a thin pen or other similar object is needed to insert or remove it. To insert, push the IoT card in until the card is locked in the slot. To remove, push the card inward with the pen, and the card will be ejected.

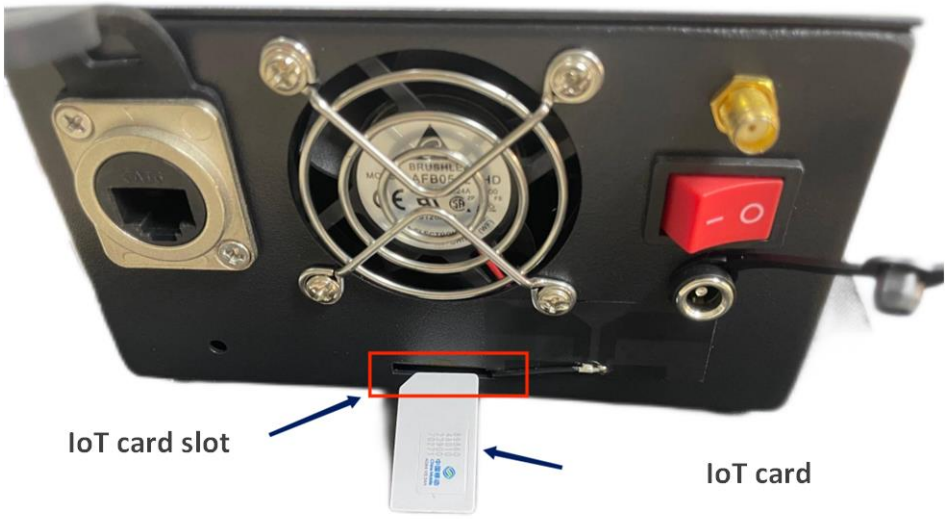


Fig. 4-3 RAEM1-6 Network adapter and card slot for the Internet of Things

If multiple RAEM1-6 are used and connected to the cloud via 4G networks, clock synchronization is also required. It is only necessary to connect all RAEM1-6 in series with a cascade cable. Each RAEM1-6 has two clock synchronization interfaces. Connect one end of the cascading cable to any clock synchronization interface of RAEM1-6, and connect the other end of the cascading cable to any clock synchronization interface of another RAEM1-6 to cascade the two RAEM1-6. If so, cascade all required RAEM1-6 in series.

Before delivery, the master/slave mode of the channel is set for clock synchronization. Users do not need to perform operations. Generally, only one channel of each RAEM1-6 is set as the master, and the others are slave. **If multiple RAEM1-6 are cascaded, only one channel (which can be any channel) is kept as the master, and all the other channels are changed to the slave.** If you really need to operate by yourself, you need to use network cables to connect RAEM1-6 to the computer and operate with "RAEM1 Configuration software". For details, see Section 3.3.

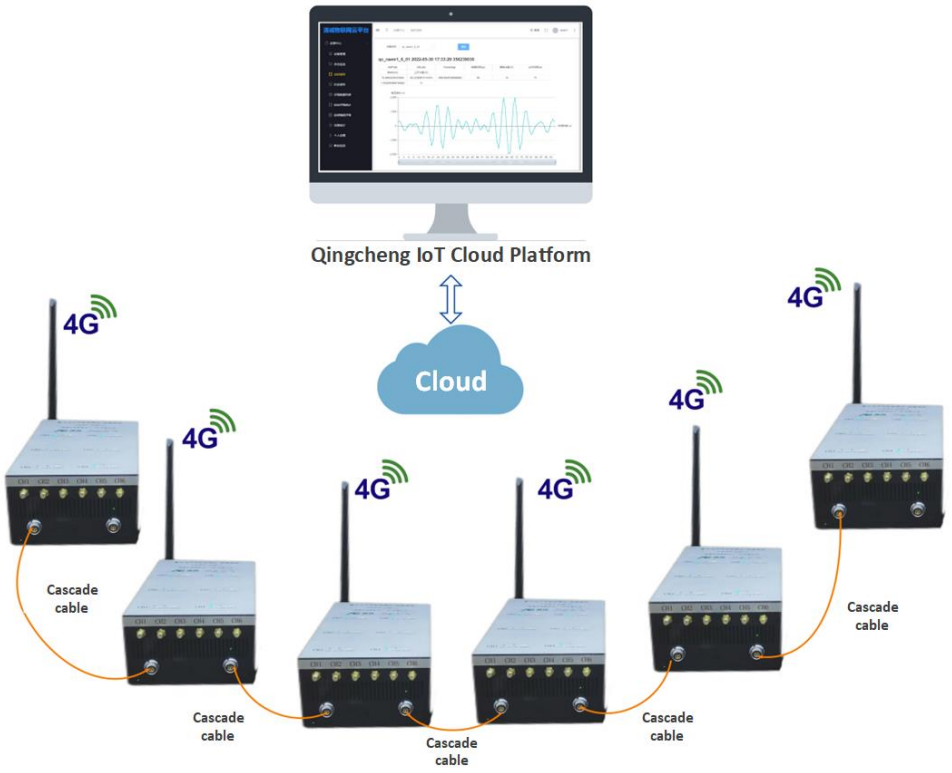


Fig. 4-4 RAEM1-6 on the 4G network

4.2 Wi-Fi Network connection

RAEM1-6 can also use a wireless network gateway to connect to the cloud server for parameter configuration, data transmission, display and analysis, such as Wi-Fi router. The following example uses a Wi-Fi router as an example.

A single RAEM1-6 as a monitoring system can be connected to the Internet through a router. Connect RAEM1-6 to the Wi-Fi router with network cable first. Then the router connects to the Internet. Log in the IoT cloud platform. In this case, the Wi-Fi router also needs to be configured. **The router must be configured as network segment 0, that is, 192.168.0.xxx, and the router must be set to automatically assign IP addresses to devices.** After the connection is successful, you can directly access the Internet to view devices and start operations on the cloud platform of the Internet of Things. If your computer is on the same Wi-Fi router as RAEM1-6, you can also use the RAEM1 Configuration Software (see Section 3.3) for local configuration and simple debugging.

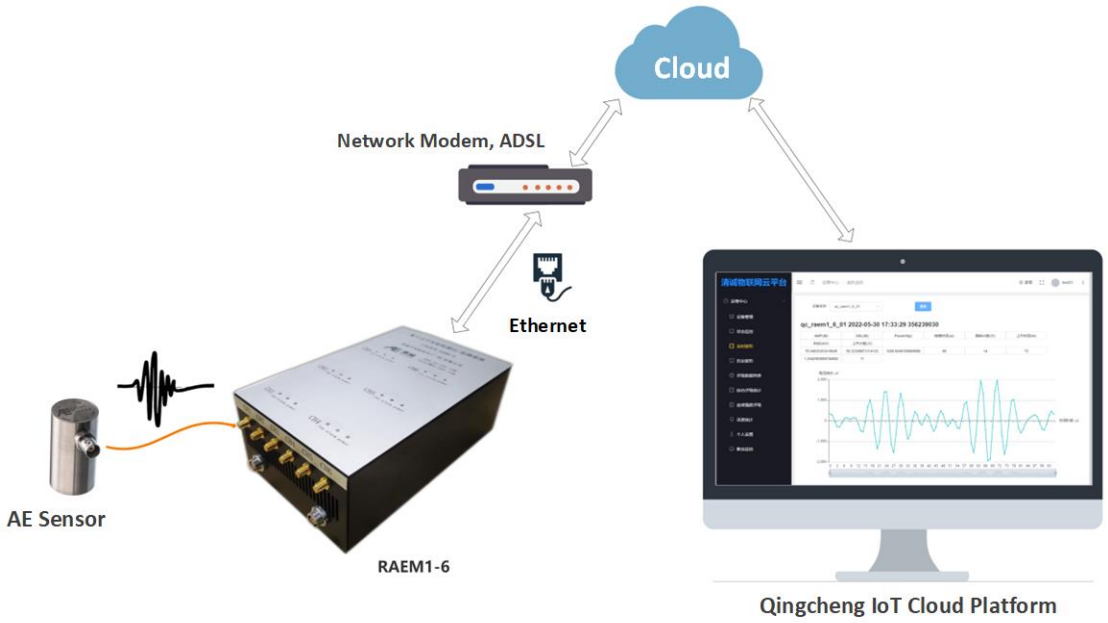


Fig. 4-5 RAEM1-6 Connecting to the cloud center through the gateway

If multiple RAEM1-6 networks are required to be used as monitoring systems, first connect these RAEM1-6 to Wi-Fi routers with network cables, and then connect the routers to the Internet. Log in the IoT cloud platform. The Wi-Fi router also needs to be configured. **The router must be configured as network segment 0, that is, 192.168.0.xxx, and the router must be set to automatically assign IP addresses to devices.** After the connection is successful, you can directly access the Internet to view devices and start operations on the cloud platform of the Internet of Things. If your computer is on the same Wi-Fi router as RAEM1-6, you can also use the RAEM1 Configuration software (see Section 3.3) for local batch multiple configurations and simple debugging.

Multiple RAEM1-6 networks also require clock synchronization by connecting multiple RAEM1-6 in series with cascade cable. Each RAEM1-6 has two clock synchronization interfaces. Connect one end of the cascading cable to any clock synchronization interface of RAEM1-6, and connect the other end of the cascading cable to any clock synchronization interface of another RAEM1-6 to cascade the two RAEM1-6. If so, cascade all required RAEM1-6 in series.

Before delivery, the master/slave mode of the channel is set for clock synchronization. Users do not need to perform operations. Generally, only one channel of each RAEM1-6 is set as the host, and the others are slave. If multiple RAEM1-6 are cascaded, only one channel (which can be any channel) is kept as the host, and all the other channels are changed to the slave. If you do need to perform this operation

by yourself, refer to Section 3.3 for details.

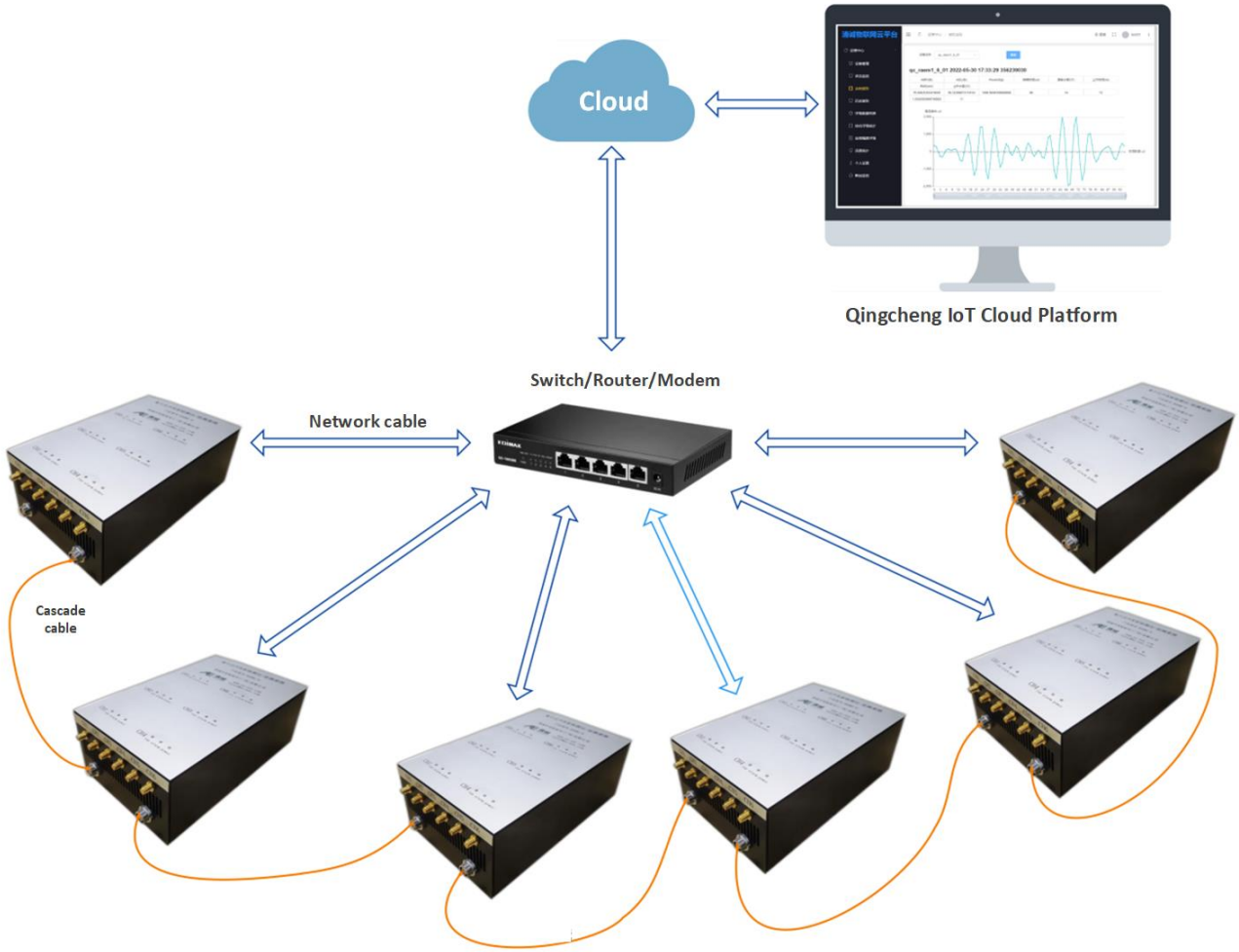


Fig. 4-6 Networking of RAEM1-6 through the gateway

4.3 Qingcheng IoT Cloud Platform

Qingcheng Internet of Things Cloud Platform is a cloud platform developed by Qingcheng AE Institute for our own Internet of Things acoustic emission products. Customers can log in to the platform to remotely check and modify the device configurations in real time, as well as real-time display of AE waveform, parameters, and the rating levels, alarms and reports, etc.

Log in to the Qingcheng IoT cloud platform (https://www.iot.ae-ndt.com/) and enter the user's name and password. At present, the cloud platform does not support users to register their own accounts. All account registration needs to be operated through Qingcheng Company. Please contact us for user registration and login information.

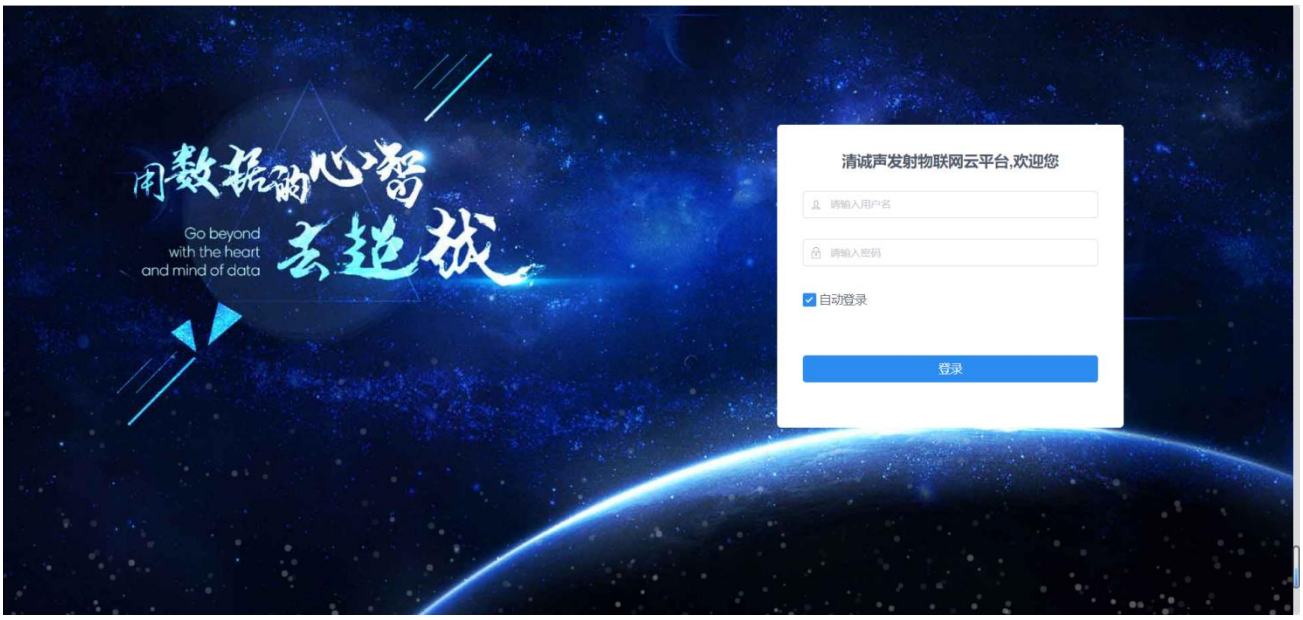


Fig. 4-7 Qingcheng Internet of Things cloud platform login

After the login, the **AE Device** >> **Device Management** page is displayed by default. At the upper left corner of the platform page, there are languages (Chinese/English) conversion and user interface and password settings available.

4.3.1 Device Management

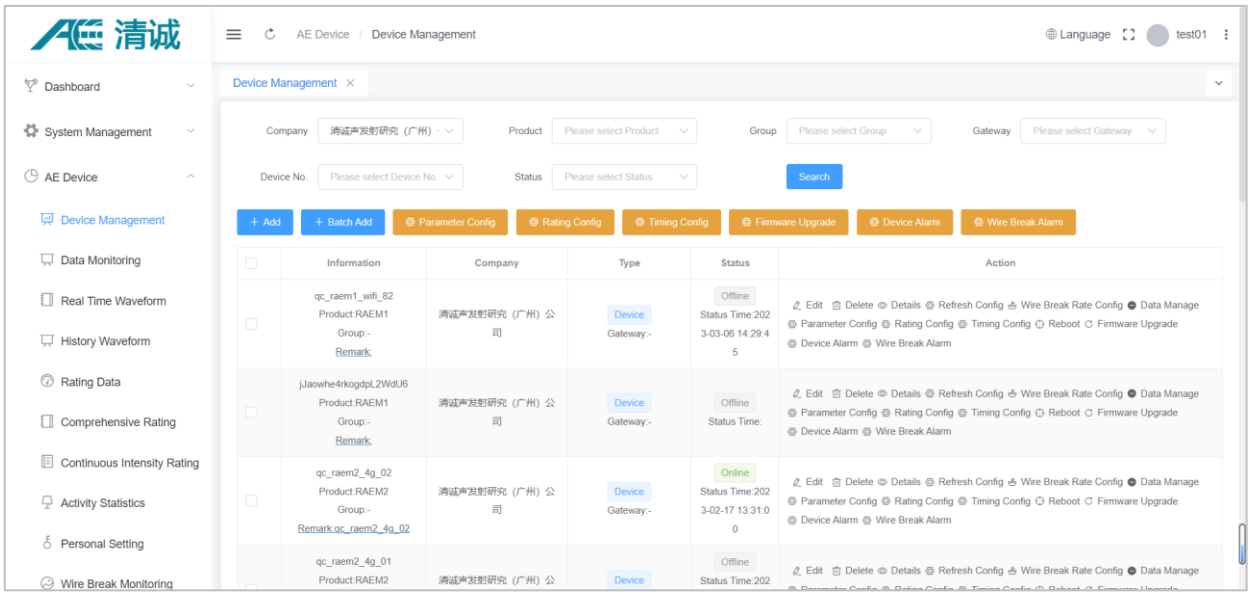


Fig. 4-8 Device management of Qingcheng IoT cloud platform

The **Device Management** page lists all the IoT AE devices under this account. Users can search for desired devices through different search items, such as **Company**, **Product**, **Group**, **Gateway**, **Device No.** or **Status** to start filtering searches. The following table lists all devices on the current platform. From left to right, **Information**, **Company**, **Type**, **Status**, and **Action** columns are displayed.

The orange configuration buttons below the search bar and above the table are bulk operation buttons. First, select several devices you want to configure in the leftmost column of the table, and then click the desired orange button. The corresponding configuration options will appear in the pop-up window. Double check the selected devices and set the configuration settings and click **Submit** button at the bottom. At this time, the new configuration is sent to several selected devices at the same time and takes effect immediately.

Action in the rightmost column of the device list can be used to open some pages related to the device:

- **Edit**: edit the device's remarks, product type, company, group, connect server, type and other basic information.
- **Delete**: remove the device with all related information.
- **Details:** check the current state of the data of the device, which is "**Data monitoring**" under the

"**Device management**" bar on the left section. The chart shows the correlation diagram of the selected attributes (i.e., **parameter,** by default **AMP** is selected) and the time.

- **Refresh Config**: reread the current configurations of the device.
- **Wire Break Rate Config**: configure the settings for the bridge suspension cable rope wire break rate monitored by the device. (Enable it when the device monitors the bridge cable rope wire breaks)
- **Data Manage**: to delete a time period of data. Each account has a specific storage capacity, and no more data can be stored if the capacity is full.
- **Parameter Config**: view and modify the configurations of the device. After submission, the new configurations will be sent to the device in real time and it takes effect immediately.
- **Rating Config:** view and modify the rating functions and configurations. After submission, the configurations will be sent to the device in real time and it takes effect immediately.
- **Timing Config**: set the timing sampling configurations of the device. After submission, the configurations will be sent to the device in real time and it takes effect immediately.
- **Reboot**: reboot the device remotely.
- **Firmware Upgrade**: by clicking on this button, the device will automatically download and upgrade to the most up-to-date firmware available online. After the upgrade is completed, the device automatically restarts. Please wait until the device completes the whole reboot process before performing any further operations.
- **Device Alarm**: set the alarm trigger criteria and alarm reporting methods.
- **Wire Break Alarm**: set the bridge wire break alarm reporting method and frequency. (Used when the device monitors the bridge wire break rate).

Several important functions are described in detail below.

4.3.1.1 Parameter Configuration

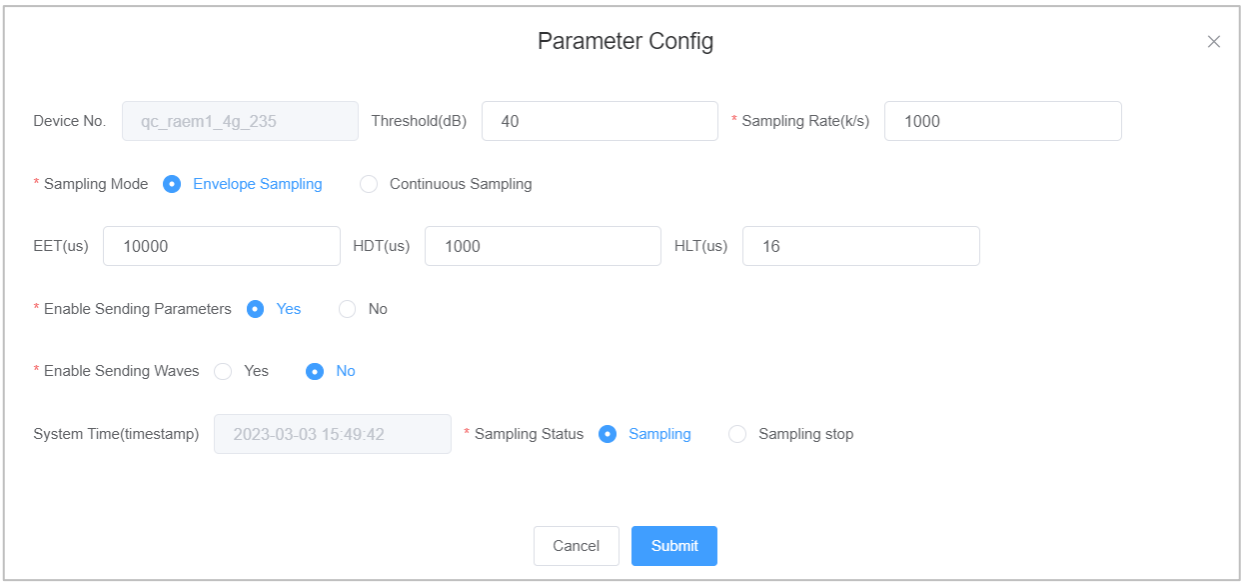


Fig. 4-9 Parameter Config. of Qingcheng IoT cloud platform

- **Threshold**

Preset trigger threshold, in unit of dB When the amplitude of the sampling signal exceeds this threshold, the starting point of the AE signal is identified by the AE processor. Only valid for the envelope sampling mode, not for the continuous (parameter) sampling mode.

- **Sampling rate**

Sampling rate is the number of points of the analog voltage signal sampled by the analog-to-digital chip every second. The unit is k/s, indicating that N thousand points per second. For example, 1000k/s, that is, one million points per second (1MHz).

- **Sampling mode**

According to the selected mode, the start and end of the received acoustic emission signals are identified, in order to generate the corresponding AE feature parameter data. There are two modes available, **envelope sampling** and **continuous sampling**:

  - **Envelope sampling**

    The start and end points of a hit signal (envelope shape) are defined and identified according to the set threshold, HDT, HLT and EET parameters, in order to generate the corresponding AE feature parameter data.

  - **Continuous sampling**

    According to the sampling length, sampling times and sampling interval, the acoustic emission signal that exceeds the threshold is intercepted and analyzed, in order to generate the corresponding AE feature parameter data.

- **Enforced End Time (EET)**

The EET ranges from 1μs to 50,000 μs. When the acoustic emission signal amplitude is consistently

higher than the threshold value, and the set hit definition time (HDT) cannot determine the intercepted acoustic emission parameters, the EET takes effect. The system breaks up the continuous signal by using EET as the "duration" of the current generated parameter, and other characteristic parameters is calculated based on this duration of waveform signal. EET is valid only for envelope sampling mode, but not for continuous (parameter) sampling mode.

- **Hit defined time (HDT)**

Envelope definition time (or **hit definition time**), unit: microsecond (μs), abbreviated to HDT, ranging from 100μs to 50,000μs (a positive integer). It means the waiting interval of a hit signal for the correct determination of the end point of a hit signal. When the set HDT value is more than the time interval (T) between the threshold exceeding time of two adjacent signal envelopes, the two signal envelopes will be classified as an acoustic emission hit signal. If the HDT value set is less than the time interval (T) between two signal envelopes' threshold exceeding time, the two signal envelopes are divided into two acoustic emission hit signals. For the same signal, the larger the HDT value is, the fewer AE parameters will be extracted; the smaller the HDT value is, the more AE parameters will be extracted. HDT is only effective for envelope sampling mode, but not for continuous parameter sampling mode.

- **Hit lock time (HLT)**

Hit lock time, unit: microsecond (μs), abbreviated to HLT. The value ranges from 1 to +∞ (positive integer). To avoid receiving the reflected or post waves, the time window for turning off the measurement circuit is set. After the end of the current acoustic emission event, a signal for a period of time (HLT) after the HDT is ignored. This window is called the hit lock time, and the value set is affected by signal attenuation and structure size. If the setting value is too large, the subsequent acoustic emission signal will be missed. The next acoustic emission signal period exceeds the threshold, but the HLT has not ended. So the signal will not be collected at the period. HLT is only effective for envelope sampling mode, but not for continuous parameter sampling mode.

- **Sampling length**

The length of each sample, in unit of microseconds (μs), is a signal for a set length collected each time. It is only valid for continuous (parameter) sampling mode, but not for envelope sampling mode.

- **Sampling times**

The number of times a fixed-length signal is collected in continuous sampling mode. It is only valid for continuous parameter sampling mode, but not for envelope sampling mode.

- **Sampling interval**

In continuous sampling mode, the interval stopping time after each sampling of a fixed-length signal, in unit of microseconds (μs). After the time is up, the fixed-length signal is collected again. It is only valid for continuous (parameter) sampling mode, but not for envelope sampling mode.

- **Enable sending parameters**

Whether to send parameters to the Qingcheng IoT cloud platform. Enabled by default.

- **Enable sending waves**

Whether to send waveform to the Qingcheng IoT cloud platform. Disabled by default.

- **System time**

System clock, in seconds. The display format is yyyy-mm-dd hh:mm:ss.

- **Sampling status**

Select **Sampling** or **sampling Stop**, which indicates the current collection status of the device.

4.3.1.2 Rating Configuration

Rating is to evaluate the overall performance levels of the current acoustic emission events according to the defined rating rules, so as to make alarms or action measures in response to different rating results. Select some parameters and set their values as different intensity levels, and specify the activity levels by the number of times that intensity levels report within a certain period. During the specified acquisition period, if any of the collected parameters exceeds a specified intensity or activity level threshold, it will be assessed and rated to a certain level of intensity or activity. Users can set the intensity or activity level for alarm reporting, or they can push alarm information according to the comprehensive rating levels.

The comprehensive rating level combines both the intensity and activity levels over a period of time and obtains the highest level of the comprehensive rating. The comprehensive rating level meets the NBT47013.9-2015 standard. It is important to note that the intensity level of the comprehensive rating cannot exceed 3 levels and the activity level cannot exceed 4 levels. Otherwise, a comprehensive rating cannot be obtained.

Comprehensive Rating Level		Activity Level			
		4	3	2	1
Intensity Level	3	4	4	3	2
	2	4	3	2	1
	1	3	3	2	1

Table 4-1 Rating level standards

- **Enable rating**

Whether the rating function is enabled.

- **Intensity config**

If a comprehensive rating is required, the intensity should not exceed 3 levels. Click "**Add intensity**" to add an intensity level. Under the same intensity level, you can add multiple rules. The relationship

between different rules of the same intensity level is "OR" condition. That is, if one of the rules is met, the intensity of this level is reached. In the same rule, add one or more parameters as the intensity level conditions. The relation of all these parameters under the same rule is "AND" condition. That is, the rule can be considered as reached only when every parameter condition in this rule is met. For example, the intensity level 1 has two rules. Rule 1 is when the amplitude (AMP) exceeds 70dB and also the energy exceeds 500 KpJ at the same time. Rule 2 is when ASL exceeds 65dB. The intensity level 1 is considered reach if either rule is met. For Rule 1, both conditions are required to meet so that Rule 1 is met.

- **Activity config**

If a comprehensive rating is required, activity cannot exceed 4 levels. Every time when an intensity is greater than or equal to level 1, one activity is counted.

- **Rating Interval**

The data collected within this period are counted, and the rating results are given according to the intensity and activity rules. The unit is second. The default value is 20 seconds.

- **Rating report criteria**

Select **no report** or select to report a level of intensity. If you choose to report level 1 intensity, it will alarm when the intensity is equal to or greater than level 1.

- **Intensity reporting min. interval**

No more intensity alarm of the same level will be reported within this period of time after the first alarm is reported. However, if an intensity higher than this level occurs within that period of time, the system will also report an alarm. The default value is 10 seconds.

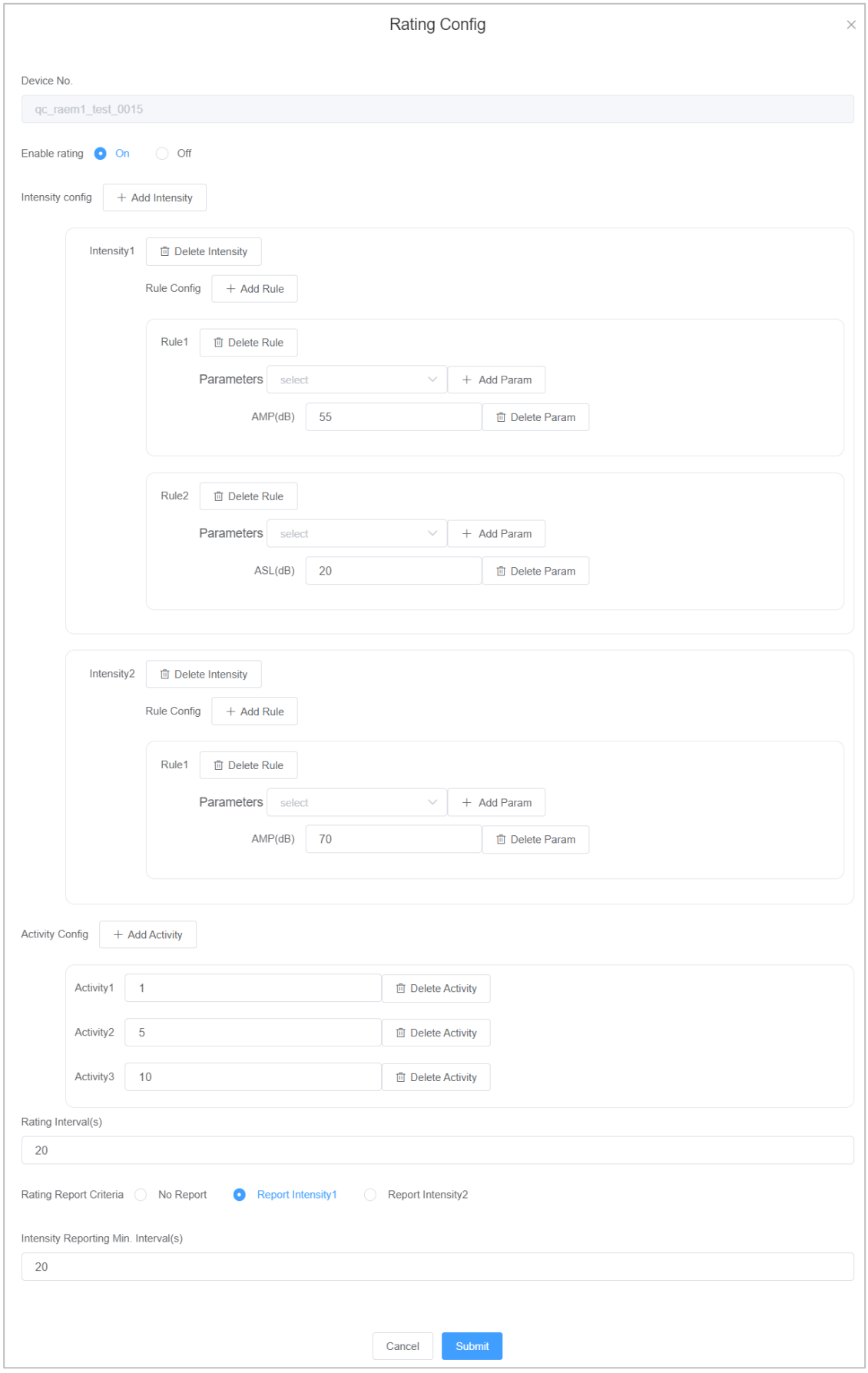


Fig. 4-10 Rating Config. of Qingcheng IoT cloud platform

4.3.1.3 Timing Configuration

You can configure to be timing sampling mode. By default, the sampling mode is **continuous sampling mode**. The other option is **interval sampling mode**. That is, after sampling for a period of time, stop sampling for a period of time, and then restart sampling for a period of time, and the cycle repeats. If you select the interval sampling mode, you need to set the duration for each "**Timing Sampling Time**" (unit: second) and the duration for each "**Sleep Time"** (unit: second).

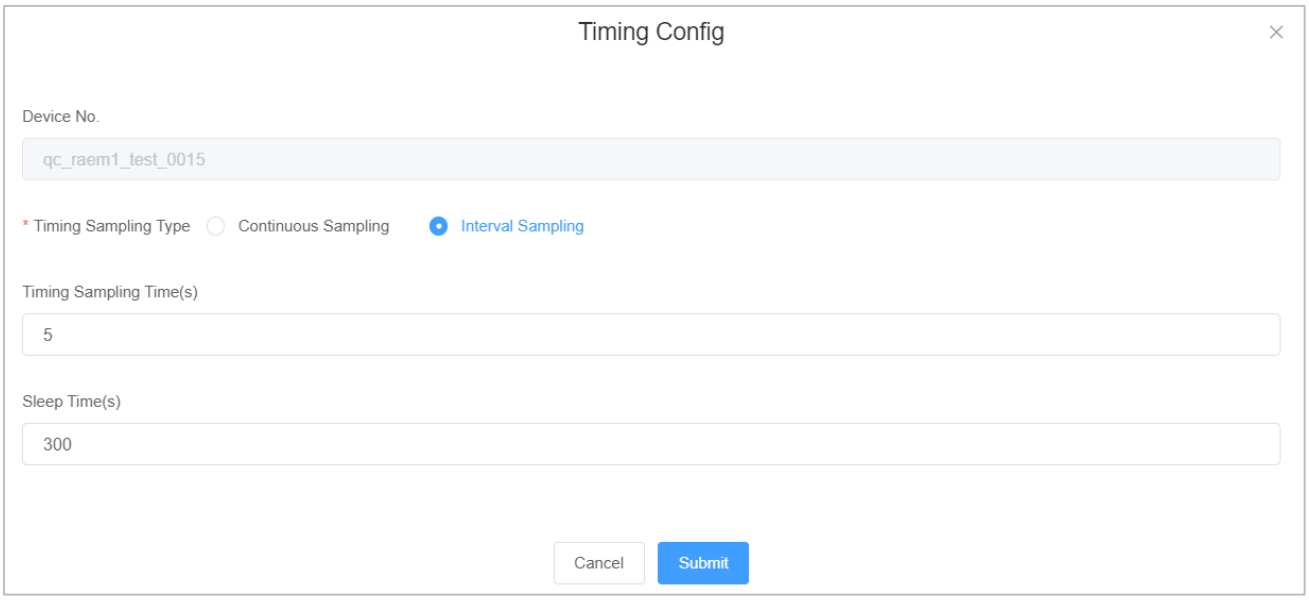


Fig. 4-11 Timing Configuration Page

4.3.1.4 Wire Break Rate Configuration

Wire break rate configuration is the setting of the calculation and determination function of wire break rate. "**Wire Amount**" is the total number of wires measured by the device, which affects the calculation of wire break rate. Select the intensity level as the "**Wire Break Criteria**", indicating that if the intensity level is equal to or higher than this level, it is considered that the wire break happens.

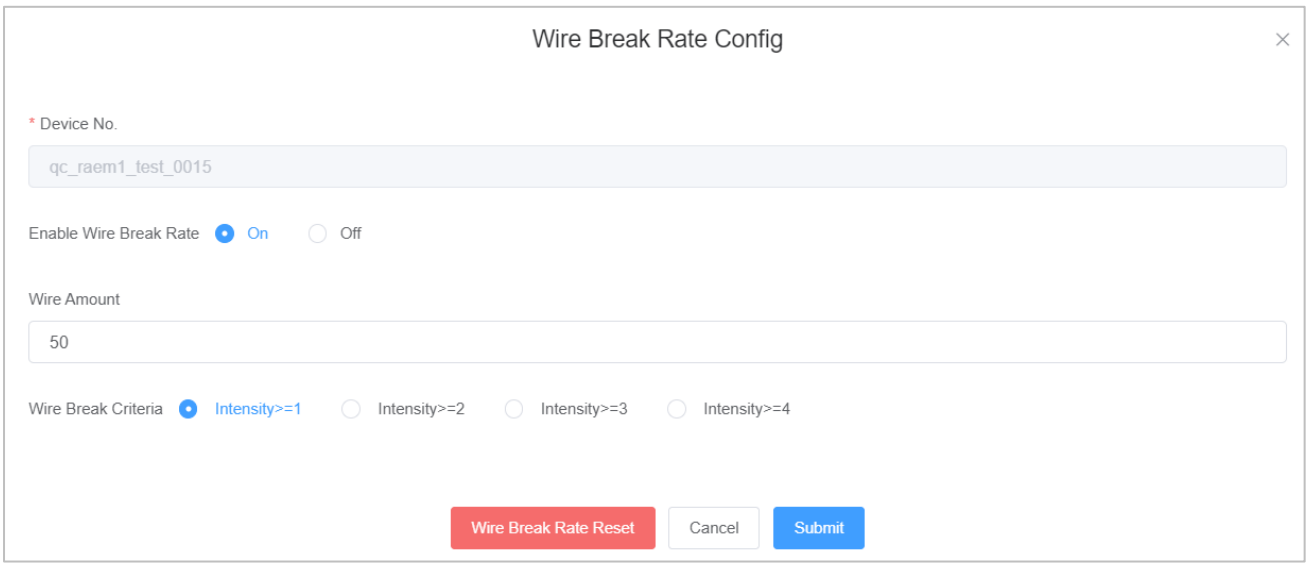


Fig. 4-12 Wire Break Rate Configuration Page

4.3.1.5 Data Manage

"**Data Manage**" page can remove some data on the cloud platform to free up more spaces for data storage. Select the time period of the data to be deleted. Click "**Remove Data**" button to remove the selected period of data.

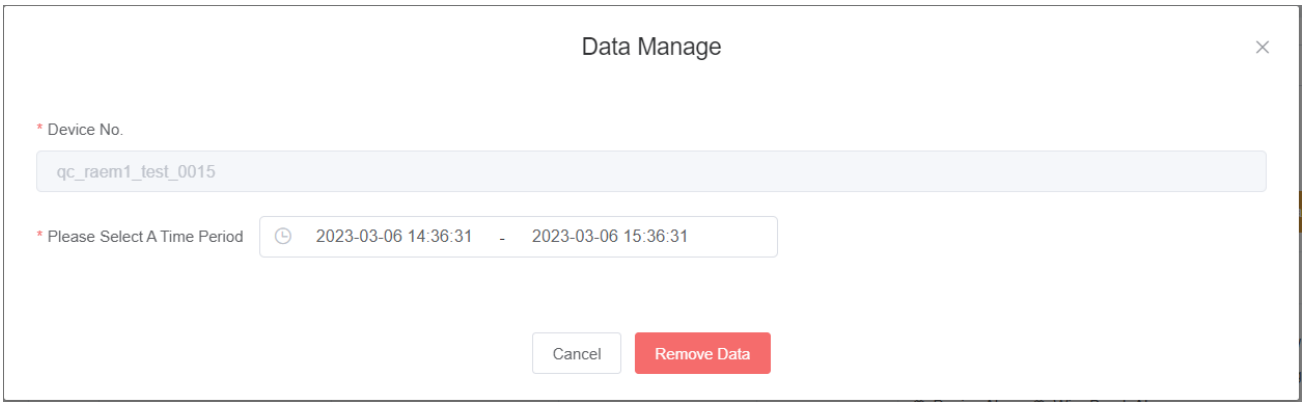


Fig. 4-13 Data Manage Window

4.3.1.6 Firmware Upgrade

The current firmware version and status is shown in the window. To upgrade the firmware, press "Submit" button to send the upgrade request to the device. After the device receives the upgrade request, it will use FTP to download the latest firmware from the cloud and upgrade automatically.

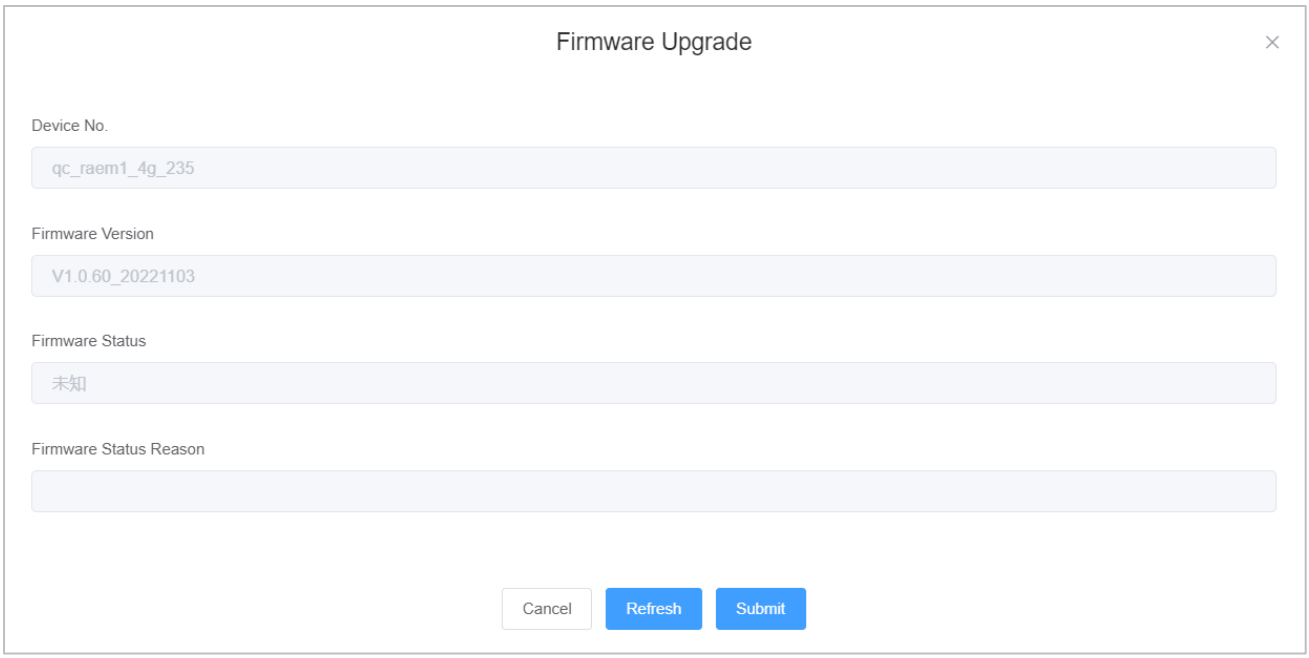


Fig. 4-14 Firmware Upgrade Window

4.3.1.7 Device Alarm

The "**Device Alarm**" is to set the rating alarm information, including alarm noticing methods (**Notice Type**), alarm **frequency** (every 5 minutes) and the **trigger** rating levels. For example, if the "Intensity1" is selected for Intensity Alarm Trigger, when the real-time intensity level is equal to 1 or higher than 1, the intensity alarm will be triggered. The same applies to the Comprehensive Rating Alarm and the Activity Level Alarm.

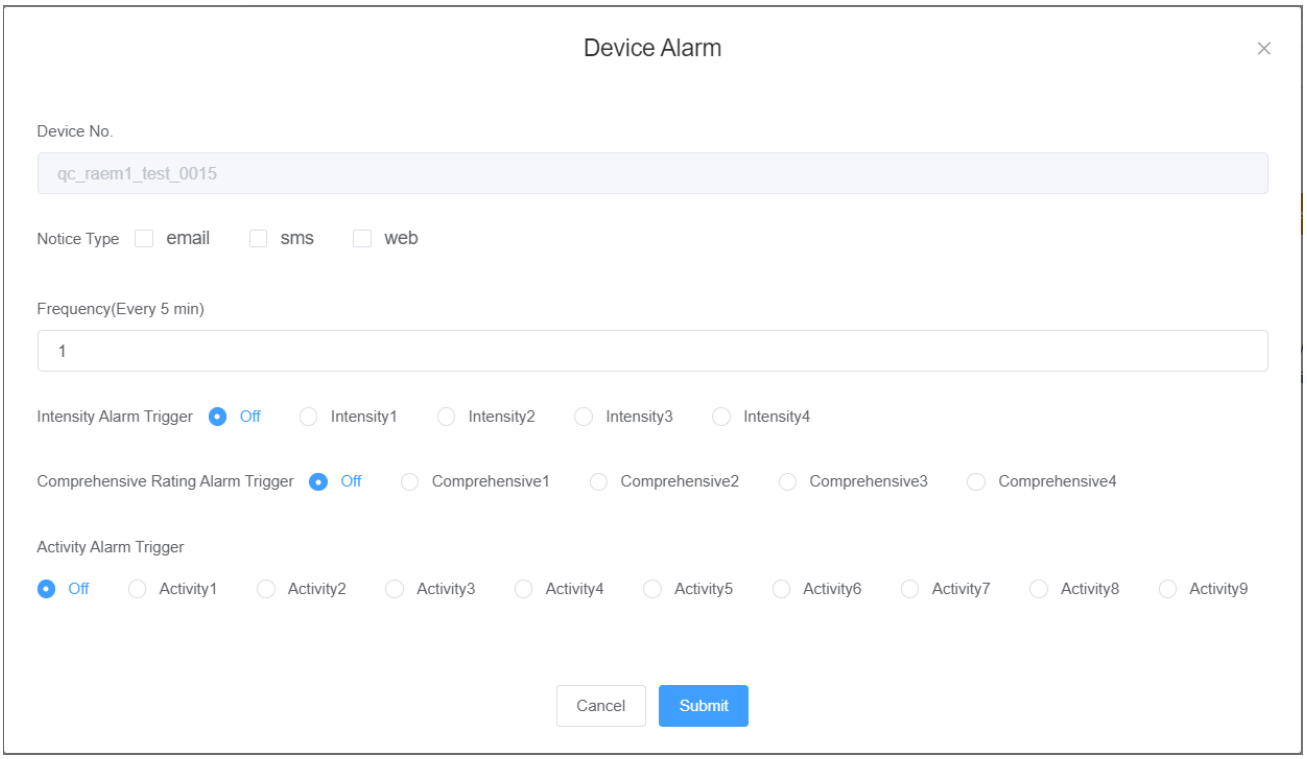


Fig. 4-15 Device Alarm Window

4.3.1.8 Wire Break Rate Alarm

The **Wire Break Rate Alarm** sets the alarming information when the wire break rate is triggered, including the alarm noticing type and the alarm frequency for every 5 minutes.

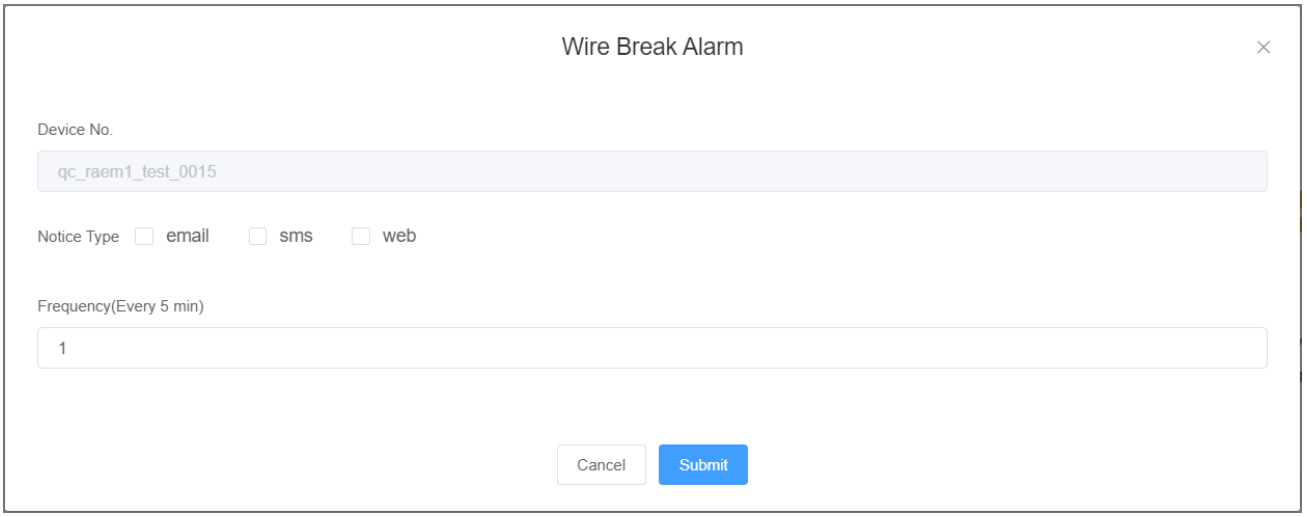


Fig. 4-16 Wire Break Alarm Window

4.3.2 Data Monitoring

The **Data Monitoring** page displays the correlation graph of the selected parameters changes of the devices over time. You can click "**Data Monitoring**" on the left menu bar of the platform or click "**Details**" under the "Action" column to enter the "**Data Monitoring**" page. The default is a correlation graph of AMP (amplitude parameter) and time.

- **Company**: the company that the device belongs to.
- **Group**: the group that the device belongs to.
- **Device No.**: the serial number of the devices., no more than four devices at one time.
- **Parameters:** select one or multiple parameters to display. It only allows one device when multiple parameters are selected to display.
- **Create time**: you can choose a time slot for display, such as today, yesterday, the last ten minutes, last hour, last week, last month, three months or last year or any set amount period.
- **Points:** the maximum display point number within the chosen time interval. It can be 100, 500, 1000, 2000, or 5000 points.
- **Order:** the data points can be displayed in ascending or descending order.

After modifying the above settings, click "**Search**" to update the graph display. When the mouse moves on the graph, the detail parameter value and the time coordinates of the closest data point with the cursor are displayed. If the parameter points in the selected time is more than the specified maximum number of observation points, the graph will be displayed in multiple pages. Click the "**Previous**" or "**Next**" below to go through the pages.

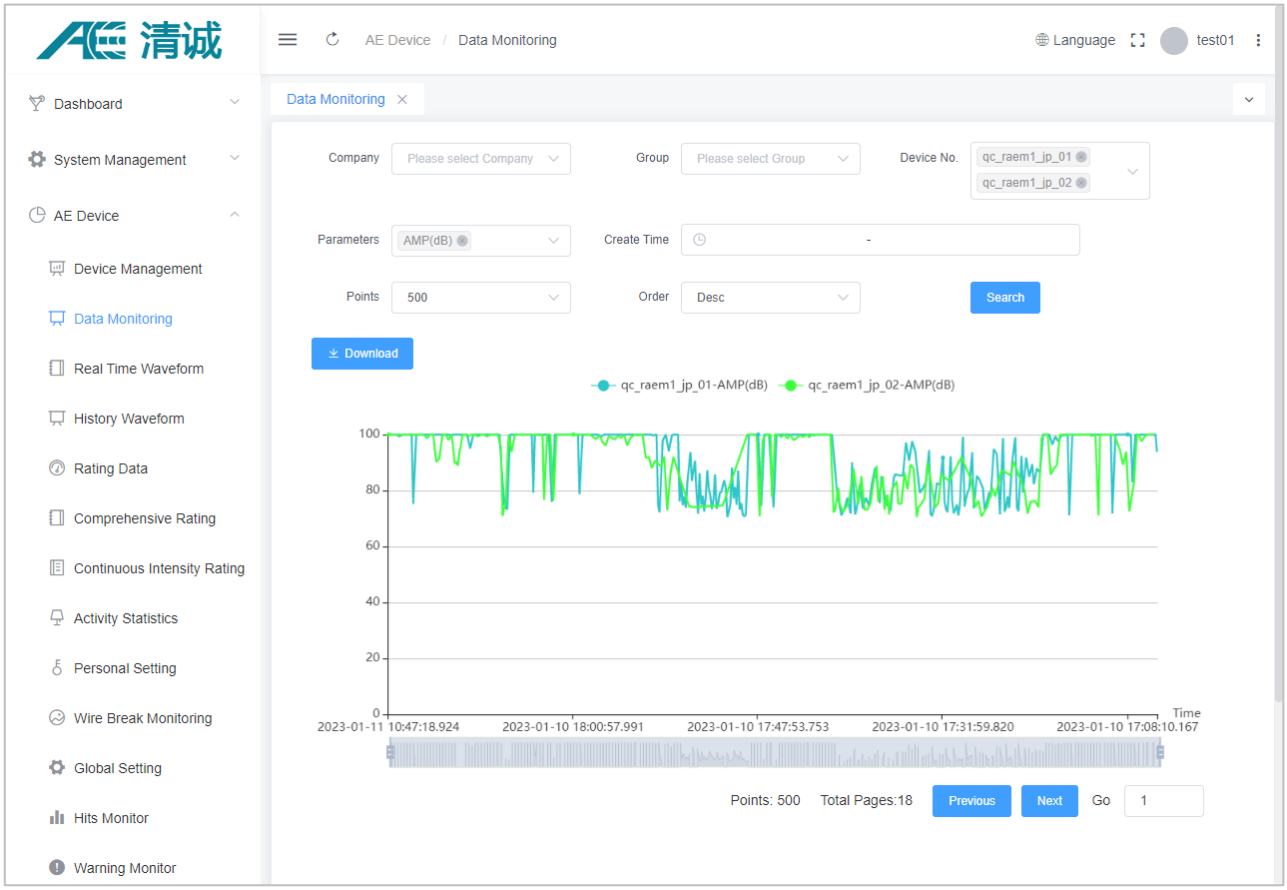


Fig. 4-17 Data monitoring page

Double-click on any coordinate point, the pop-up window displays a waveform corresponding to that coordinate point (parameter). However, if "**Enable sending waves**" function is not enabled in **Parameter Config**, no waveform is uploaded and displayed here. On the top of the pop-up "Wave" window, the waveform arrival time and its other 8 parameters extracted from this waveform are displayed. When the mouse cursor moves over the waveform, its voltage value and the time coordinate at each closest data point will be displayed correspondingly. Click "**Previous**" or "**Next**" to display the adjacent waveform diagrams.

Fig. 4-18 Waveform page from the Data monitoring

4.3.3 Real-time Waveform

The **Real-Time Waveform** page displays real-time waveform of the device. However, if "**Enable sending wave**" function is not enabled in **Parameter Config**, no waveform is displayed. Select a device by **Group** and **Device No.,** If the device is offline, its last uploaded waveform is displayed. If the device is online, the waveform will be continuously updated in real time as the waveform is continuously uploaded to the cloud platform. When the AE signal is detected, it will be uploaded to the cloud platform through the wireless network by the device. However, according to the effectiveness and stability of the actual network and the actual transmission delay, the data uploaded to the cloud platform will have a certain delay. The waveform arrival time and the other eight parameter values corresponding to the waveform are displayed

on the page. When the mouse moves over the waveform, the voltage value and time coordinates will be shown correspondingly. User cannot check the previous waveform in this page because this page is based on the actual received signal which changes dynamically in real time. To view all waveform, go to the **History Waveform** page.

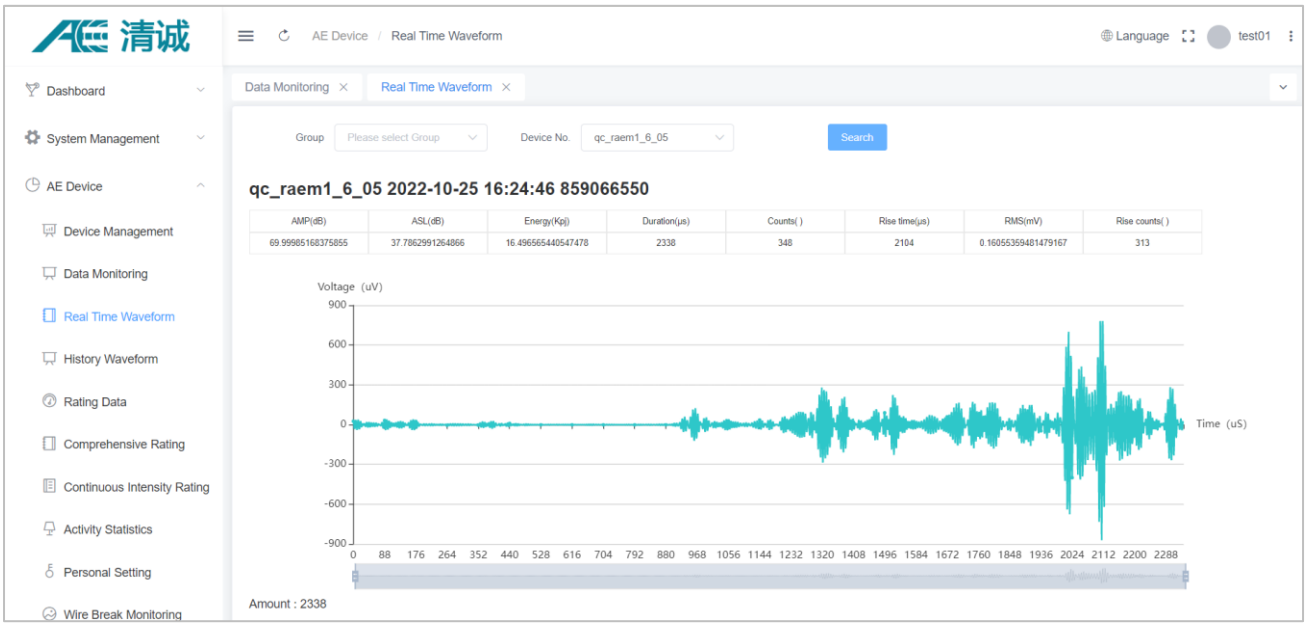


Fig. 4-19 Real-Time waveform page

4.3.4 History Waveform

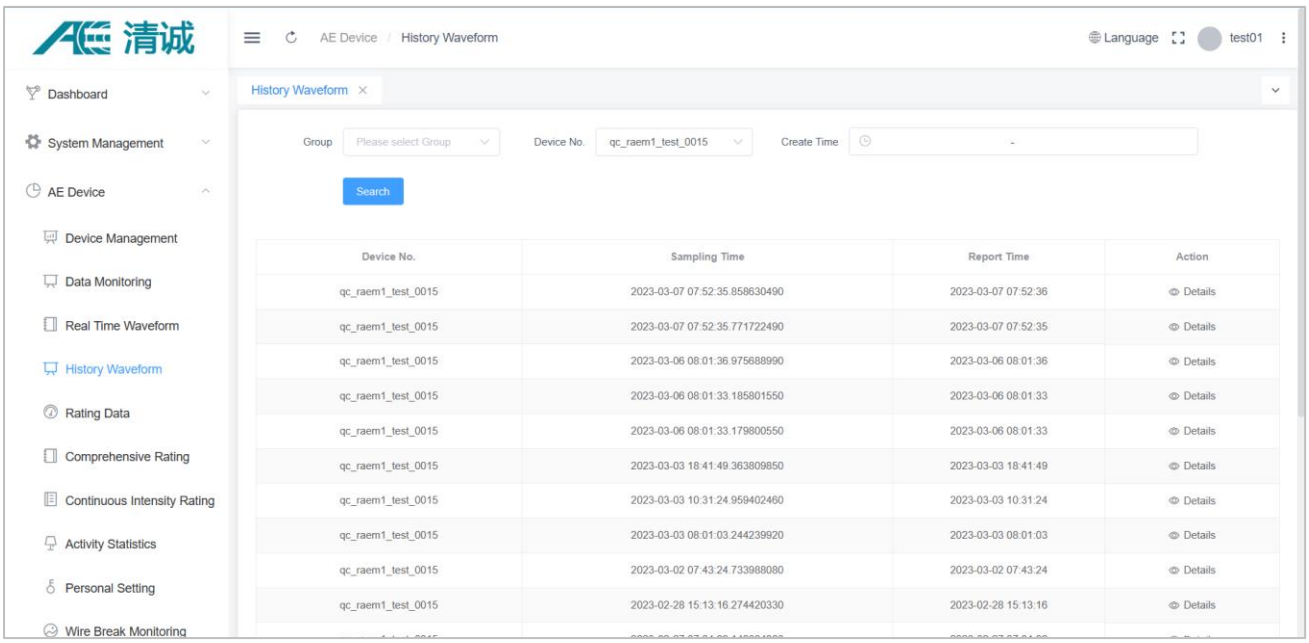


Fig. 4-20 History waveform page

The **History Waveform** page displays all historic waveform of the device. Use the **Group** and **Device**

Number options to select a device to view its historic waveform. You can select **Create Time** to filter all waveform in a specific time frame. Click "**Search**" to update the table display. The table lists the sampling time and report time of each waveform. The sampling time is the time when waveform is generated and collected, and the report time is the time when waveform data is uploaded to the cloud platform. The "Create Time" filter above is based on the sampling time. Click the "**Details**" button on the right column to display each waveform and its corresponding parameter data.

4.3.5 Rating

Rating is to evaluate the overall performance levels of the current acoustic emission events according to the defined rating rules, so as to make alarms or action measures in response to different rating results. Select some parameters and set their values as different intensity levels, and specify the activity levels by the number of times that intensity levels report within a certain period. During the specified acquisition period, if any of the collected parameters exceeds a specified intensity or activity level threshold, it will be assessed and rated to a certain level of intensity or activity. Users can set the intensity or activity level for alarm reporting, or they can push alarm information according to the comprehensive rating levels.

The comprehensive rating level combines both the intensity and activity levels over a period of time and obtains the highest level of the comprehensive rating. The comprehensive rating level meets the NBT47013.9-2015 standard. It is important to note that the intensity level of the comprehensive rating cannot exceed 3 levels and the activity level cannot exceed 4 levels. Otherwise, a comprehensive rating cannot be obtained.

Comprehensive rating level		Activity level			
		4	3	2	1
Intensity level	3	4	4	3	2
	2	4	3	2	1
	1	3	3	2	1

Table 4-2 Rating level standards

Users need to choose **Device Management** > **Rating Configuration** to enable the rating function and set rating rules and levels. The device will get the rating results after the set time period, and the data is displayed in the rating related pages.

4.3.5.1 Rating Data

Rating data displays the intensity or comprehensive rating level of the device in a table list. Select the **Group** and **Device number** that you want to view and set **Type** as Intensity or Comprehensive (level). You can select the **Create time** to filter the rating levels data based on the report time.

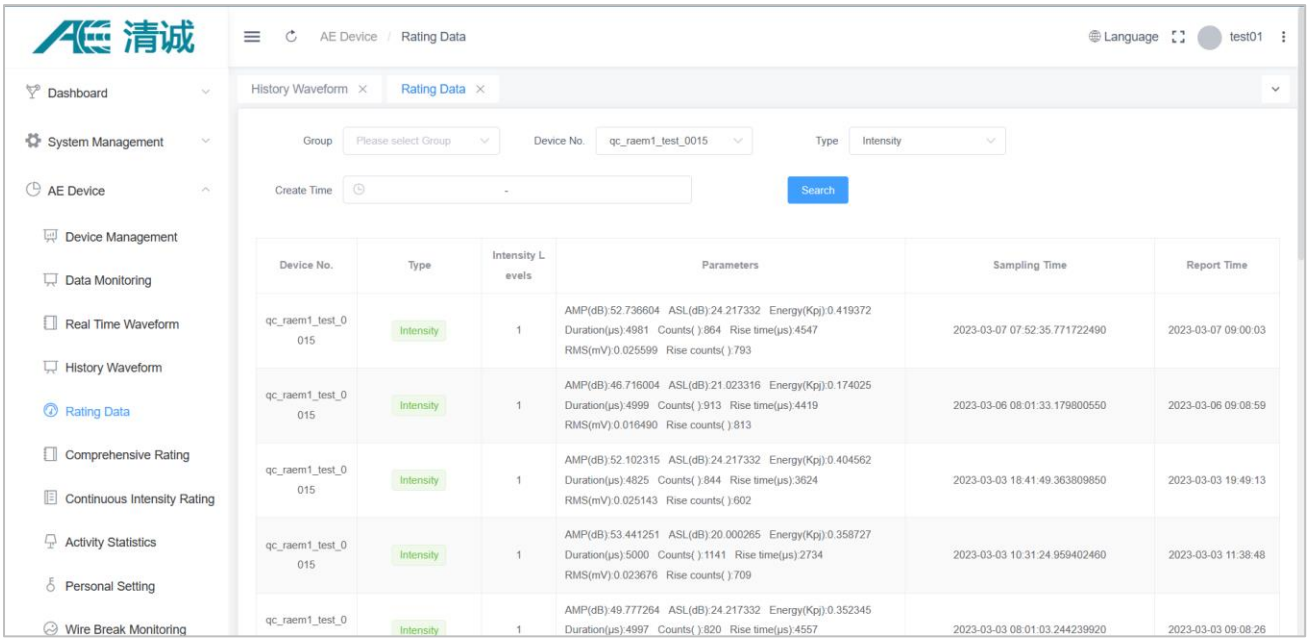


Fig. 4-21 Rating data - Intensity page

The intensity level table illustrates the intensity level information of all the signals that trigger the intensity level alarms, including the trigger intensity level, corresponding parameters, sampling time, and data report time.

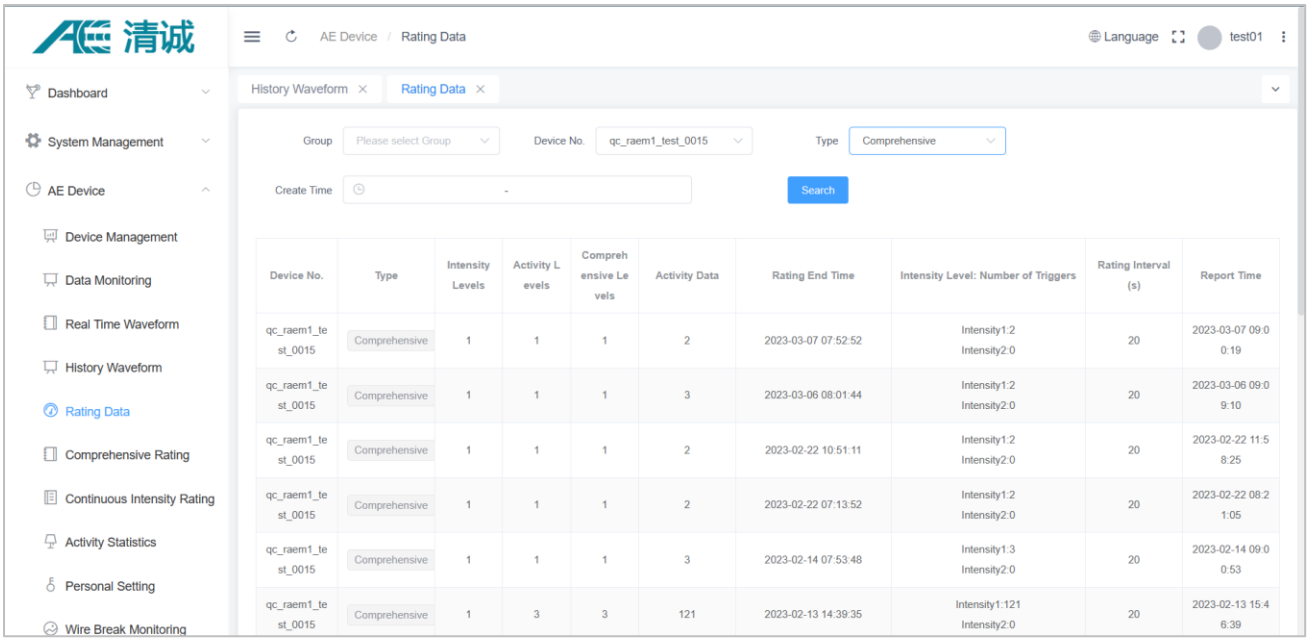


Fig. 4-22 Rating data - Comprehensive rating page

The comprehensive rating level table illustrates the reported comprehensive rating levels. Within the specified rating interval (20 seconds by default), the system will conduct a comprehensive rating by summarizing the intensity, activity levels to obtain the comprehensive rating level for this period of time. If there is no intensity or activity reported during the period, the system will not output the comprehensive rating level. Only when there are intensity level and activity level reported during the rating interval, the comprehensive rating level will be conducted.

The comprehensive rating data list includes the (highest) intensity level, (highest) activity level, corresponding comprehensive rating level, total amount of activity number, each intensity level triggered number, rating end time, rating interval and the report time for the period.

4.3.5.2 Comprehensive Rating

The **Comprehensive Rating** page displays the comprehensive rating history of the device in time domain in the form of line diagram. When the mouse cursor moves over the chart, the comprehensive rating level and the rating end time coordinates will be displayed correspondingly. The **Rating end time**, **Points** and **Order** can be configured freely. If the number of points in the selected period is more than the selected point number of observation points, the whole data will be displayed in multiple pages. Click the "**Previous**" or "**Next**" below to go through the pages. The bar chart below shows the amount of different

comprehensive levels for the time period.

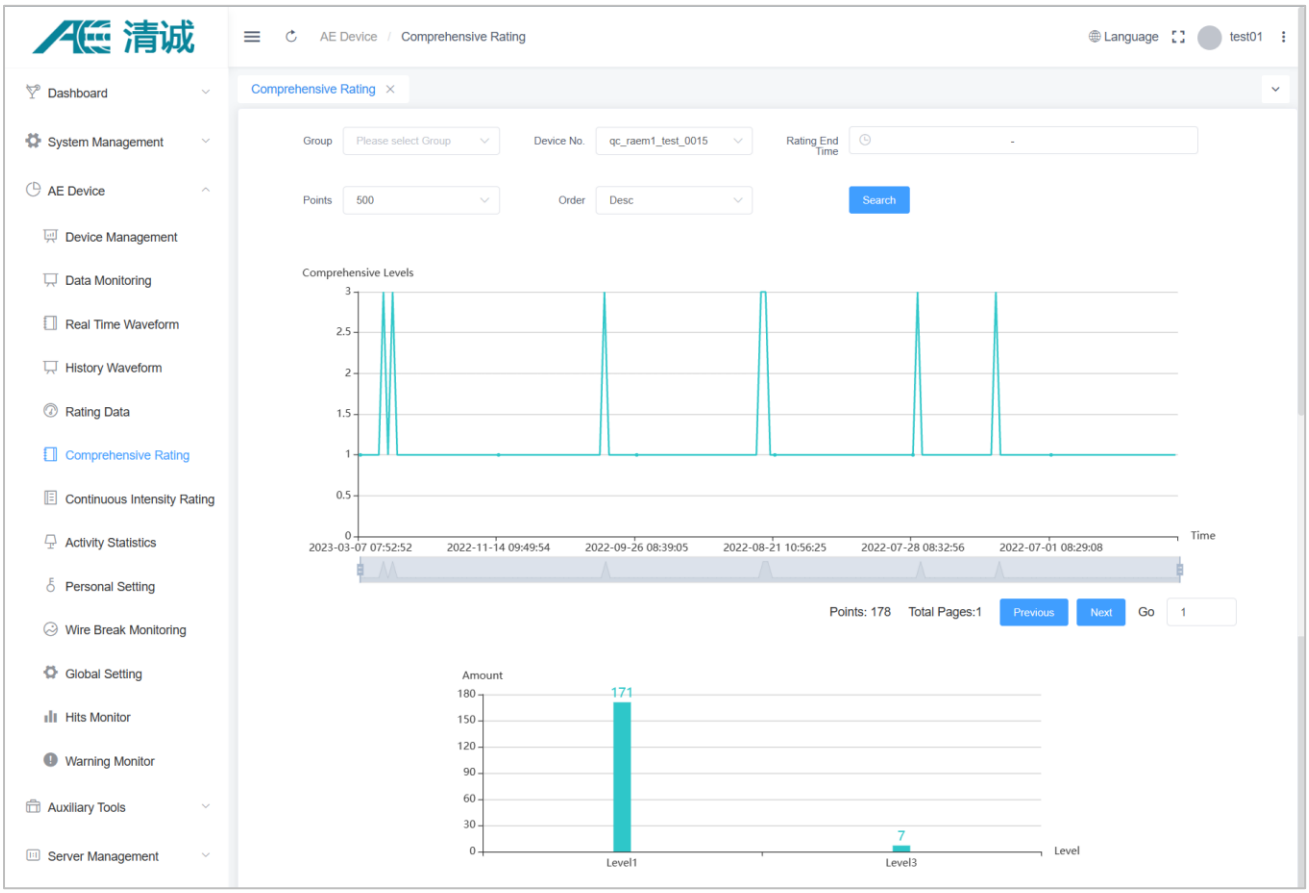


Fig. 4-23 Comprehensive rating page

4.3.5.3 Continuous Intensity Rating

The **Continuous Intensity Rating** page is a chart showing the trend of the intensity rating levels of the device in time domain in the form of line diagram. When the mouse cursor moves over the chart, the intensity level and rating end time coordinates will be displayed correspondingly. The **Rating end time**, **Points** and **Order** can be configured freely. If the number of points in the selected period is more than the selected point number of observation points, the whole data will be displayed in multiple pages. Click the "**Previous**" or "**Next**" below to go through pages. The bar chart below shows the amount of different intensity levels for the time period.

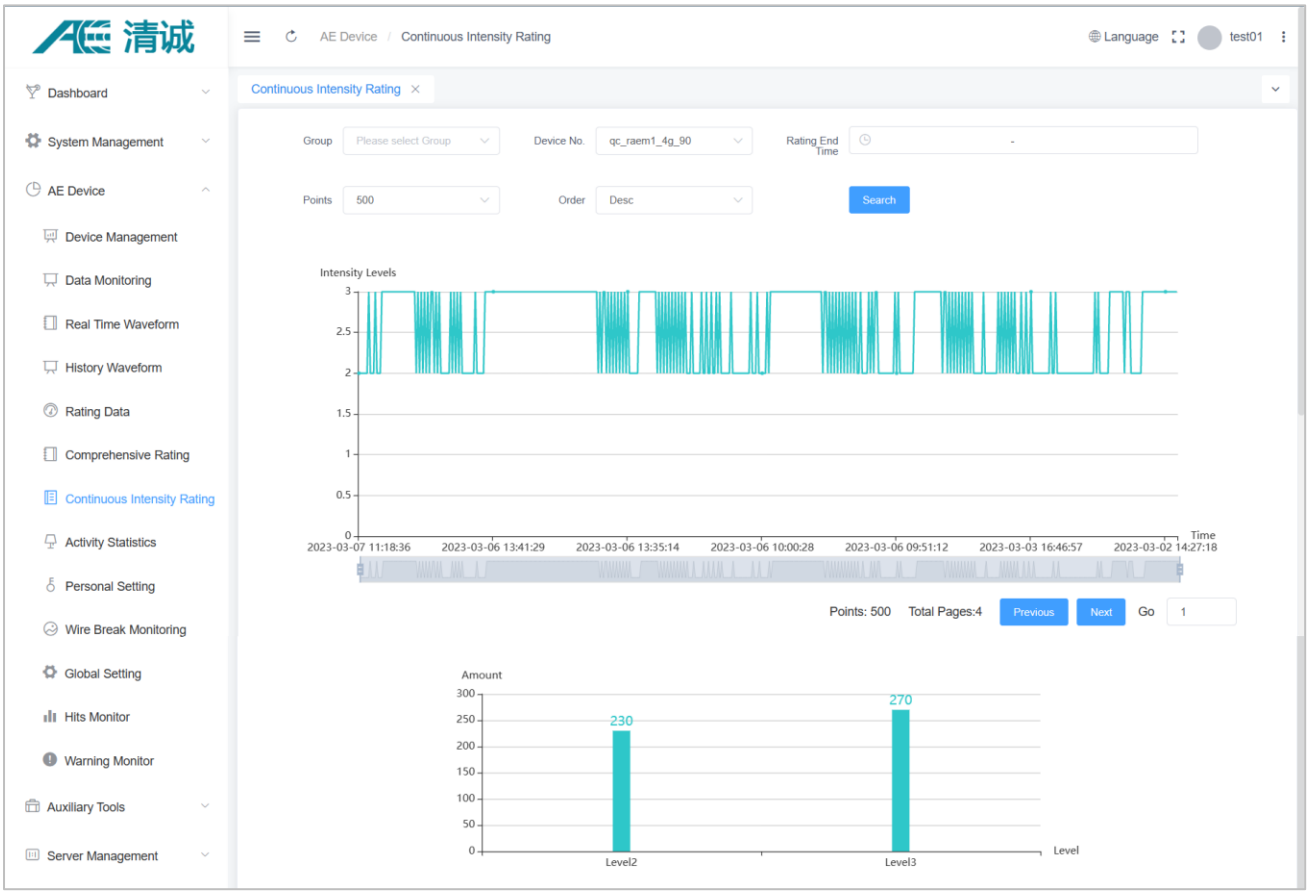


Fig. 4-24 Continuous intensity rating page

4.3.5.4 Activity Statistics

The **activity statistics** page displays a chart showing the trend of the activity levels of the device in time domain in the form of line diagram. When the mouse cursor moves over the chart, the activity level and rating end time coordinates will be displayed correspondingly. The **Rating end time**, **Points** and **Order** can be configured freely. If the number of points in the selected period is more than the selected point number of observation points, the whole data will be displayed in multiple pages. Click the "**Previous**" or "**Next**" below to go through pages. The bar chart below shows the activity number for the time period.

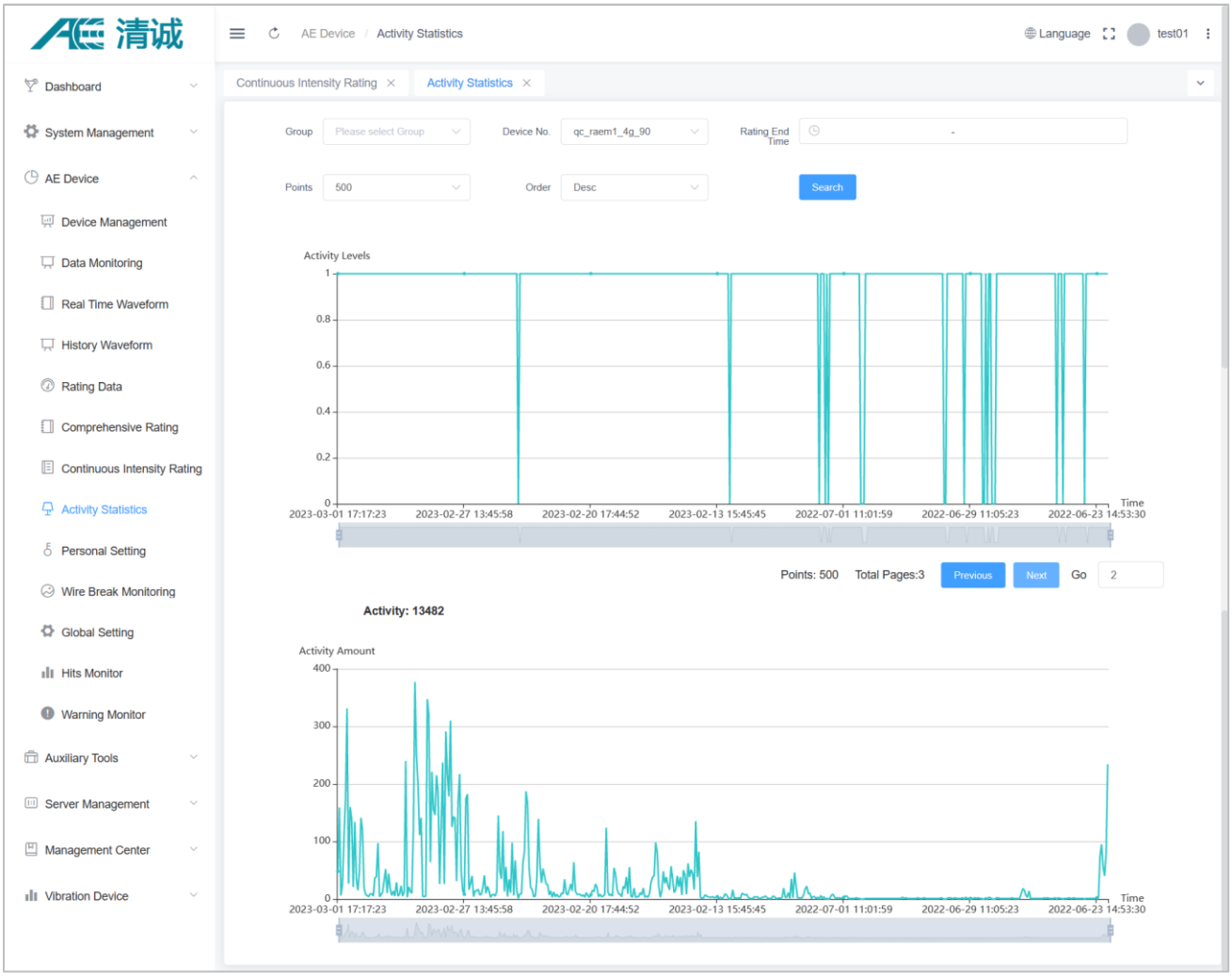


Fig. 4-25 Activity statistics page

4.3.6 Personal Setting

Personal Setting page is used to set personal information and device alarms and wire break alarms, including:

- **Info Setting**: set up a nickname, mobile phone number and email address.
- **Device alarm:** review or enable the devices to report the alarms. The detail alarm settings of each device is in its "Device Alarm" setting in the "Device Monitoring" page.
- **Wire Break Alarm:** review or enable the devices to report the wire break alarms. The alarm settings of each device is in its "Wire Break Alarm" setting in the "Device Monitoring" page.

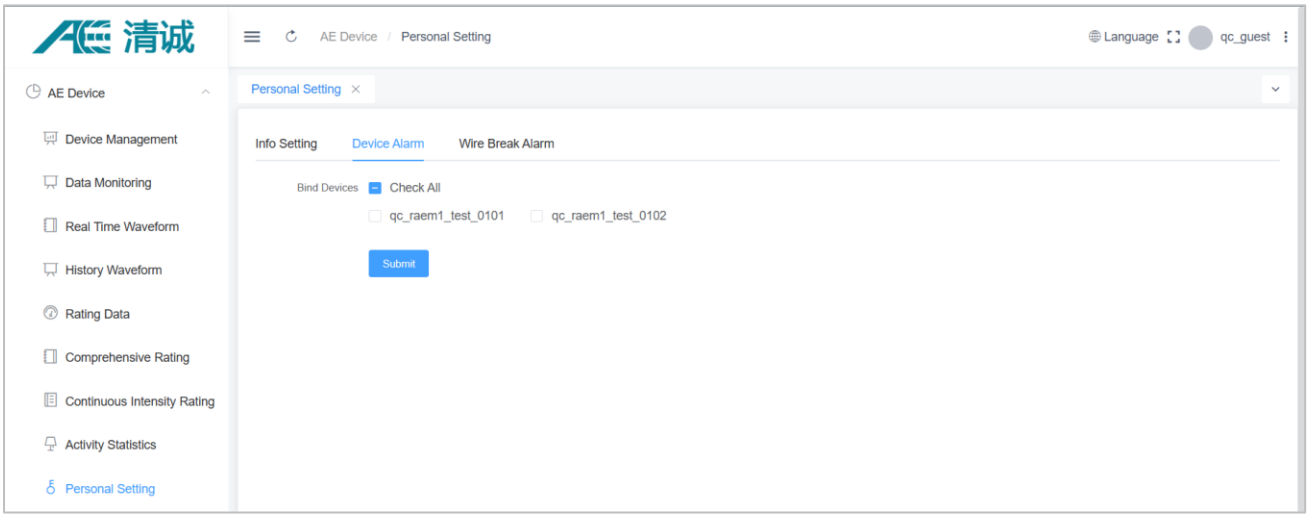


Fig. 4-26 Personal Settings-device alarm page

4.3.7 Wire Break Monitoring

Wire break monitoring is specially designed for wire break result display and wire breaking rate monitoring. It can be used for wire breaks monitoring of bridge suspension cables.

Choose **Device management** >> **Action** >> **Wire Break Rate Config** to set the wire break rate configurations. "**Wire amount**" is the total number of wires measured by the device, which affects the calculation of wire breaking rate. Select the intensity level of "**Wire Break Criteria**", indicating that if the intensity is equal to or greater than this level, it is considered that the wire break has happened.

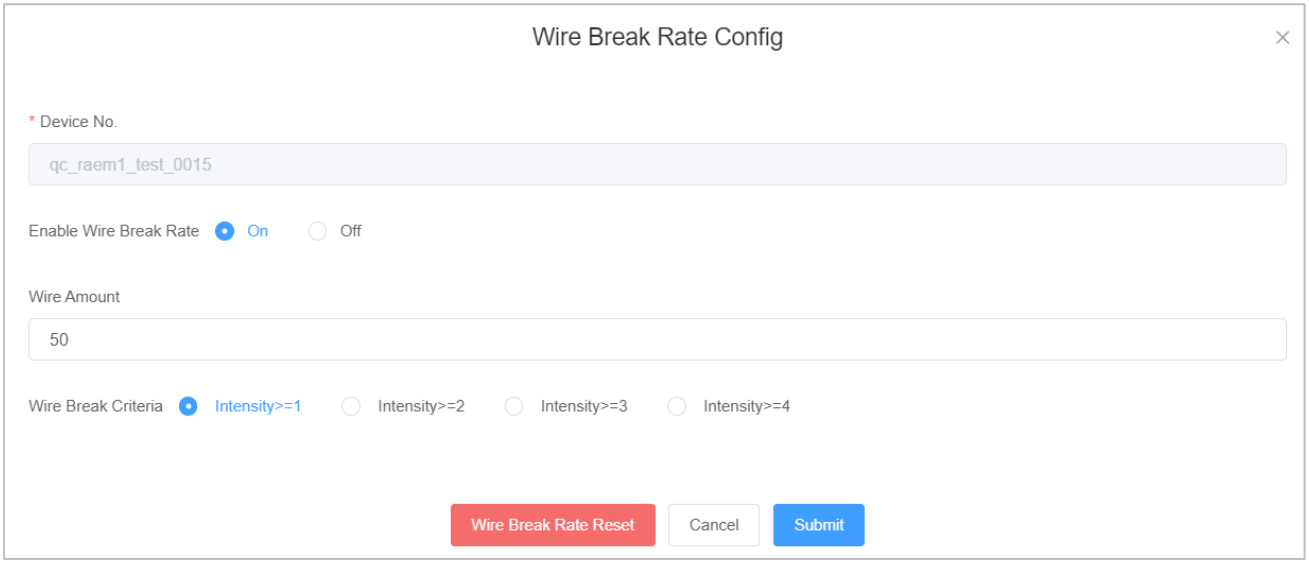


Fig. 4-27 Wire break rate config page

The wire break monitoring page displays the changing trend of the wire break rate and the number of

wires breaking in a certain period of time in the form of line charts. When the mouse moves to the chart, the wire break rate (or wire breaking amount) and the corresponding time coordinates will be displayed. If the **Point** in the selected period is too large, the chart will be displayed on multiple pages. Click "**Previous**" or "**Next**" below to convert the page. The number of wire break is determined according to the intensity and activity of the setting.

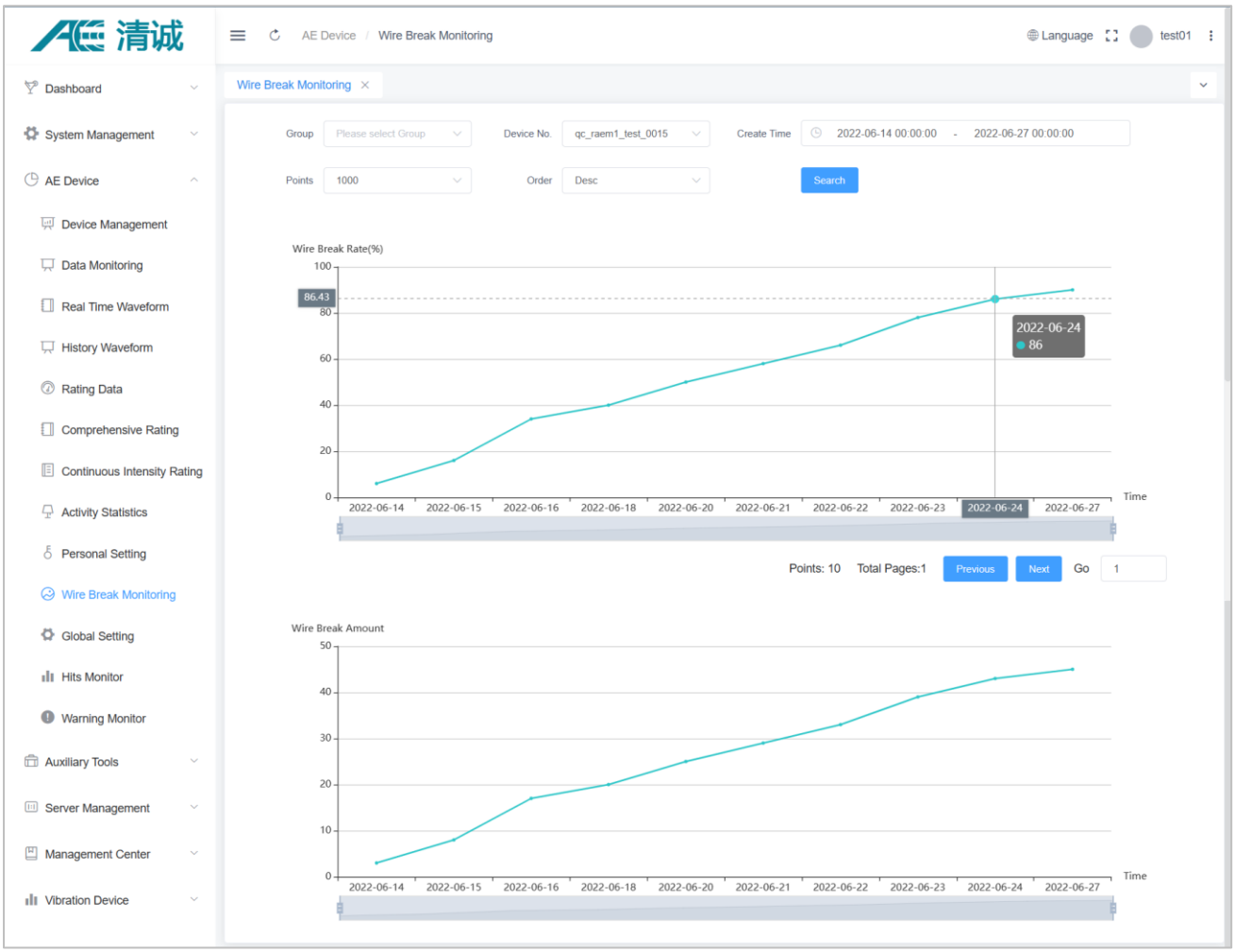


Fig. 4-28 Wire breaks monitoring page

4.3.8 Global Setting

AST test: Perform an AST test on the selected monitoring device.

- **AST**: enable or disable the AST test.
- **Time interval:** set AST detection time interval, in unit of seconds.
- **Device number**: choose the desired devices.

Click "Submit" to upload the settings to devices and the AST function will turn on automatically. The

results will be returned to the platform and displayed in the table below with the device number, time and the amplitudes.

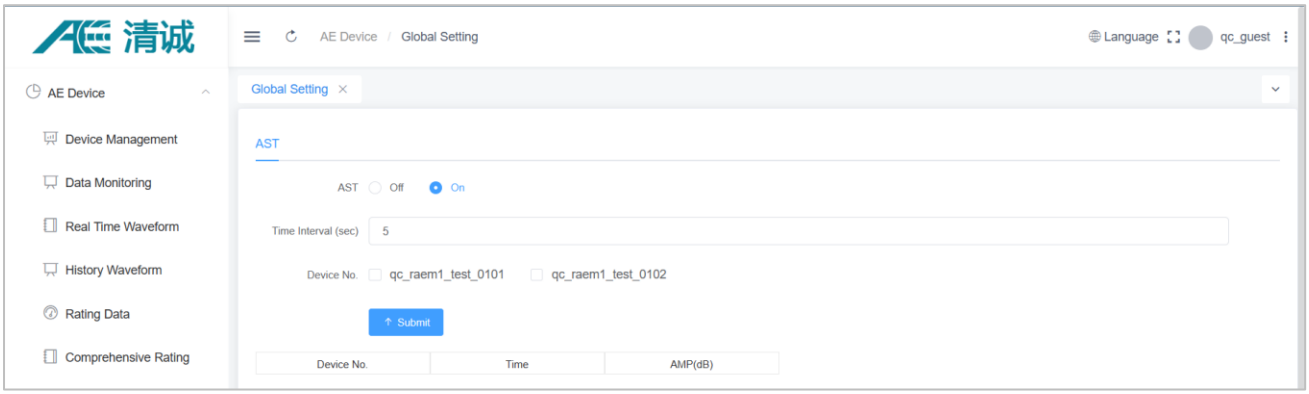


Fig. 4-29 Global Setting Page

4.3.9 Hit Monitor & Warning Monitor

The Hit Monitor page shows the AE hits number of one or multiple devices.

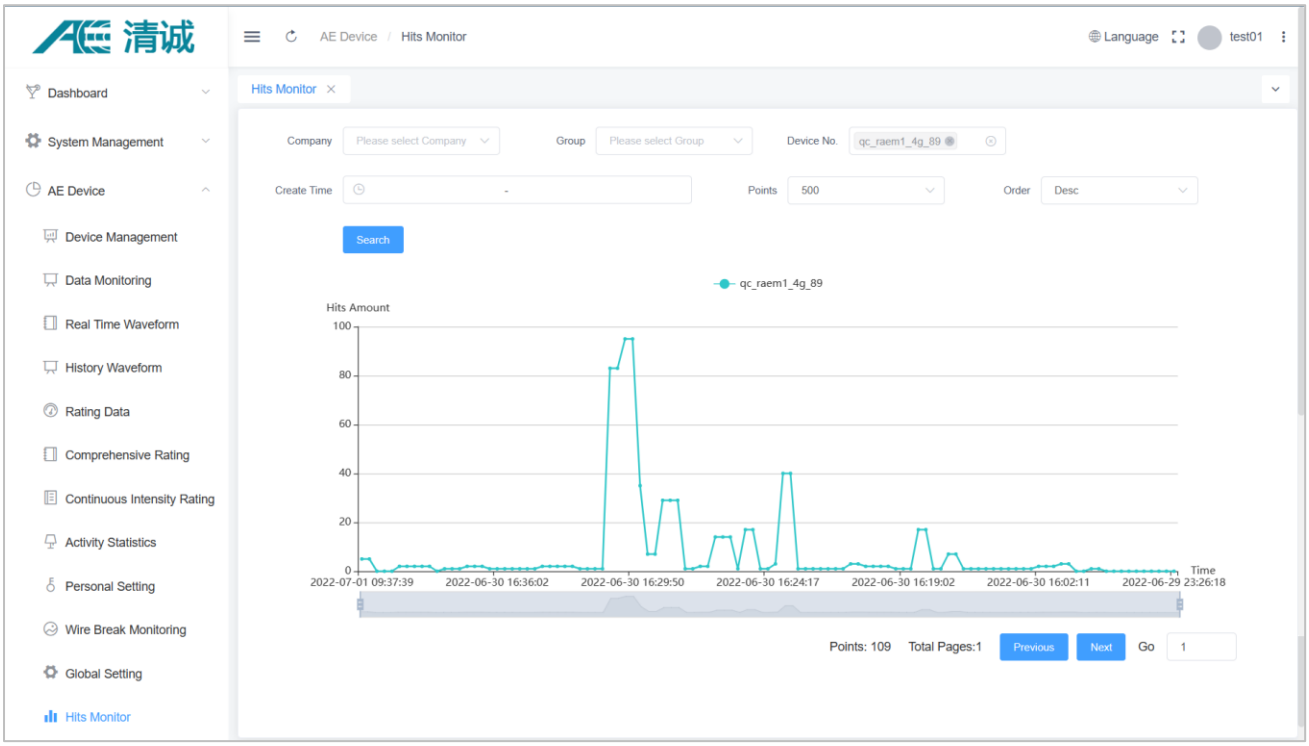


Fig. 4-30 Hit Monitor Page

The Warning Monitor page is the device alarm triggering summary page. Users need to choose **Device Management >> Device Alarm** configuration to enable the alarm functions and set different alarm trigger levels. The device will send out alarms to the users when the alarm threshold is triggered. The triggered alarm information is displayed in the line chart. It displays the rating result alarms in the form of

line charts. Users can select one of the three ratings (intensity, activity or the comprehensive rating alarms) to display in the time domain with the warning line showing in the chart.

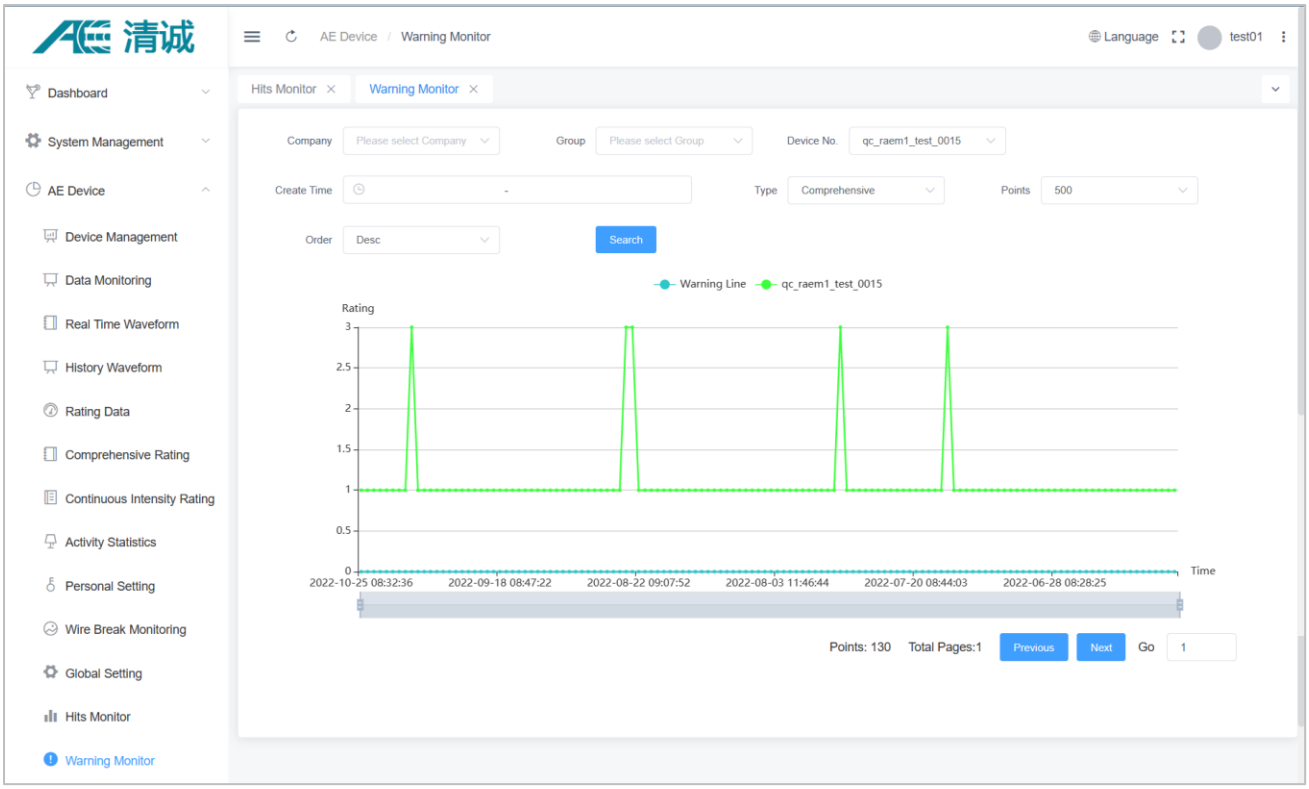


Fig. 4-31 Warning Monitor Page

4.3.10 Auxiliary Tools

The "**Auxiliary Tools**" includes the **Downloads** function, which can package and download the uploaded data packets of the device on the cloud platform. Users need to enable the data upload function to the cloud and specify the uploading data types in order to receive desired data on the cloud. Configure the data uploading setting in **Device Management >> Parameter Config. >> "Enable Sending Parameters"** and **"Enable Sending Waves"**. Only when the data is uploaded to the cloud, you can download the data on the Downloads page.

Before downloading, first it needs to package the device's data in a zip file. Select the device name and data time range. Click "**Search**" to find if there is existing data packs. If not, click "**+Zip**" to create a new data package. Once the data is packaged and completed, the data packs will be shown in the table of the Downloads page. The table shows the device number, file name, file size, the time labels of the package, status and the operation buttons.

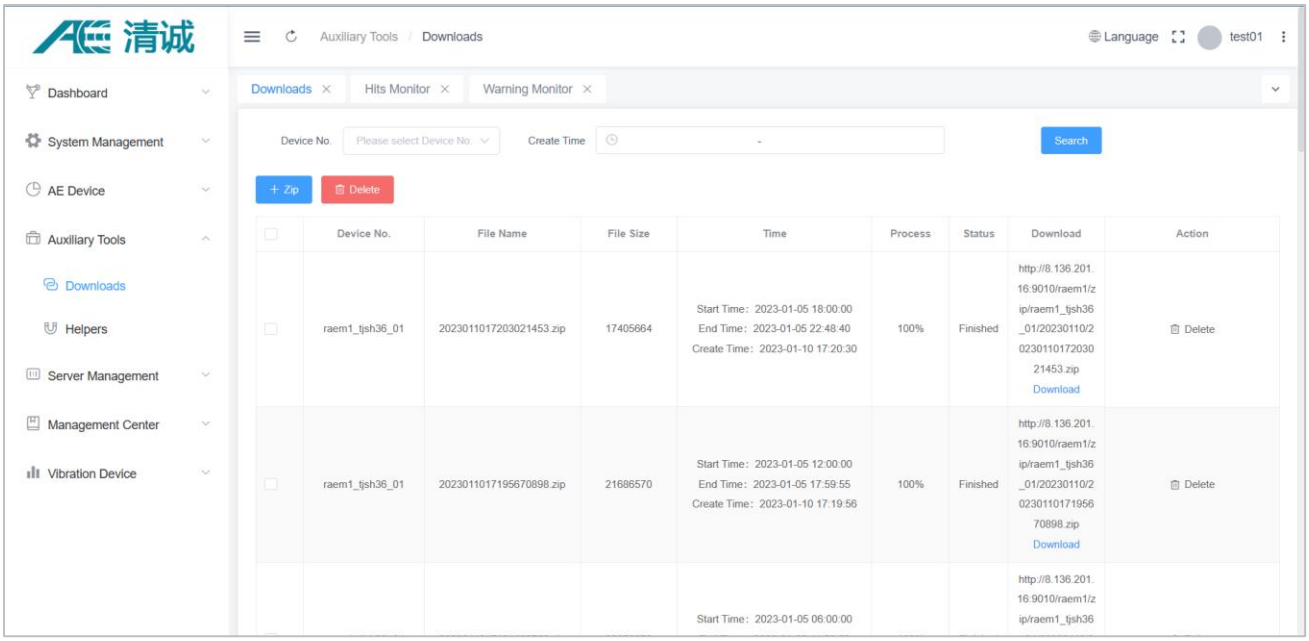


Fig. 4-32 Cloud platform data downloads

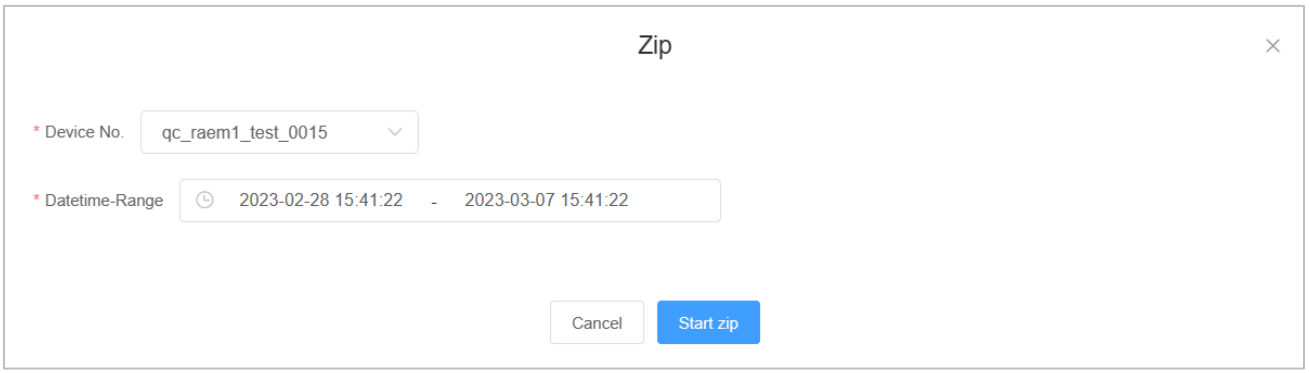


Fig. 4-33 Cloud platform data packaging Settings

*If you are interested in other functions that are not introduced, please contact us for details.

4.4 Qingcheng Alibaba Cloud Platform

Qingcheng IoT AE devices can upload data to Alibaba Cloud IoT platform. Qingcheng Alibaba Cloud platform supports real-time parameters and parameter ratings view, as well as online debugging RAEM1 function. (The waveform and data downloading functions are not yet supported but will be available in the future).

To use the Qingcheng Alibaba Cloud, it requires the devices to have Internet function. The three types of devices below can access Internet:

1	4G devices. Use Ethernet or Qingcheng IoT Cloud for configuration. Device IP: 192.168.0.101
2	Wi-Fi devices. It needs to configure as Router mode and connect to the router to access Internet.
3	Ethernet devices. It needs to connect to a router that can access Internet.

Table 4-3 Qingcheng Alibaba Cloud Devices Internet Configuration

Users need to register their own Alibaba account to access Alibaba Cloud IoT platform. Qingcheng can provide technical supports to help users to connect the AE devices and to use Alibaba Cloud. If there are further requirements, please contact us for solutions.

4.4.1 Register

Step 1: Open the link in the browser https://www.alibabacloud.com/

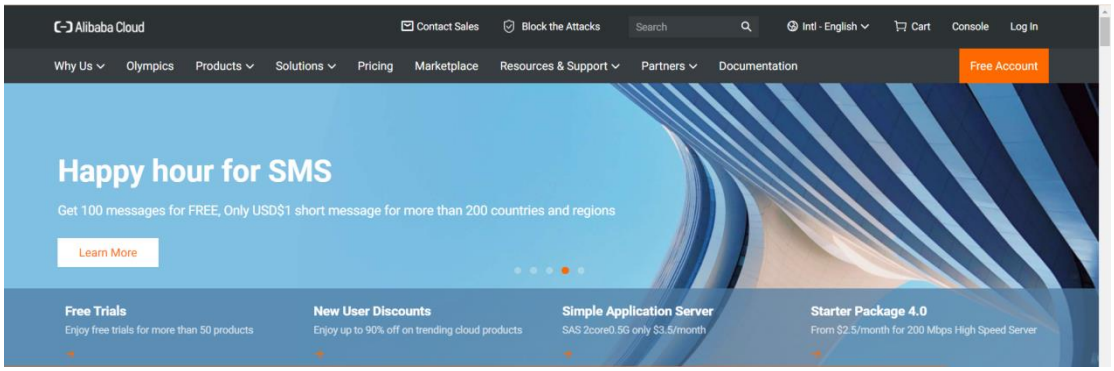


Fig. 4-34 Qingcheng Alibaba Cloud Registration

Step 2: Click "**Free Account**" in the upper right corner.

Step 3: Choose "Business Account" or "Individual Account".

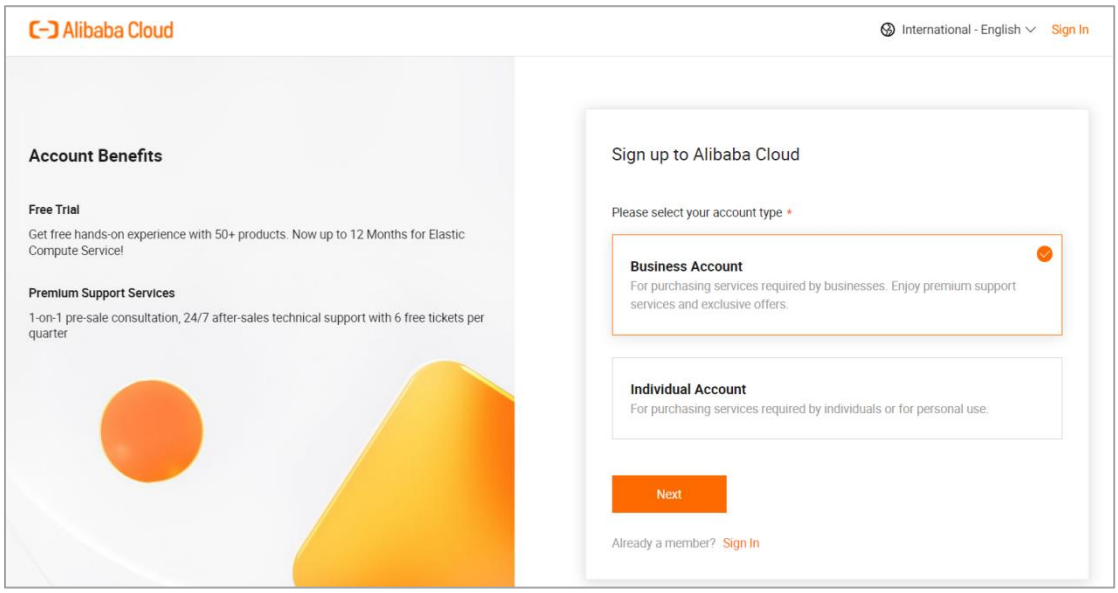


Fig. 4-35 Qingcheng Alibaba Cloud -Business Account

For "Individual Account":

① enter email address;

② enter password (it needs to include 8-20 characters; contains only letters, numbers and symbols; contains at least three of the following: uppercase letters, lowercase letters, numbers, symbols);

③ confirm password;

④ click "Sign Up (Step 1 of 2)";

⑤ choose verification methods, either "By Phone" or "By Email";

⑥ select country/region, enter verification information and also check the agreements below;

⑦ Click "Sign Up (Step 2 of 2)".

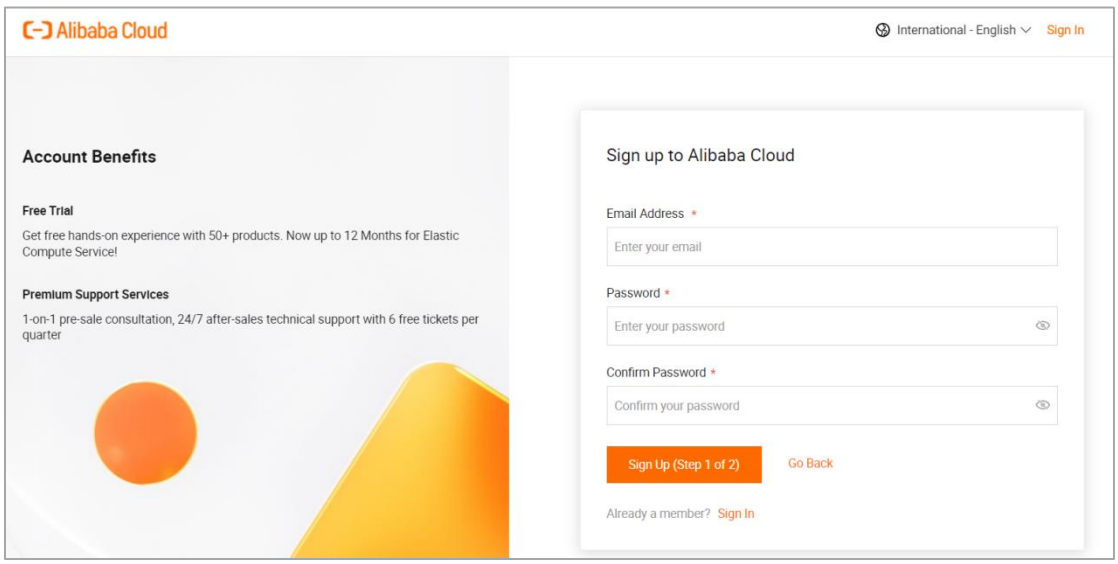


Fig. 4-16 Qingcheng Alibaba Cloud Account Info

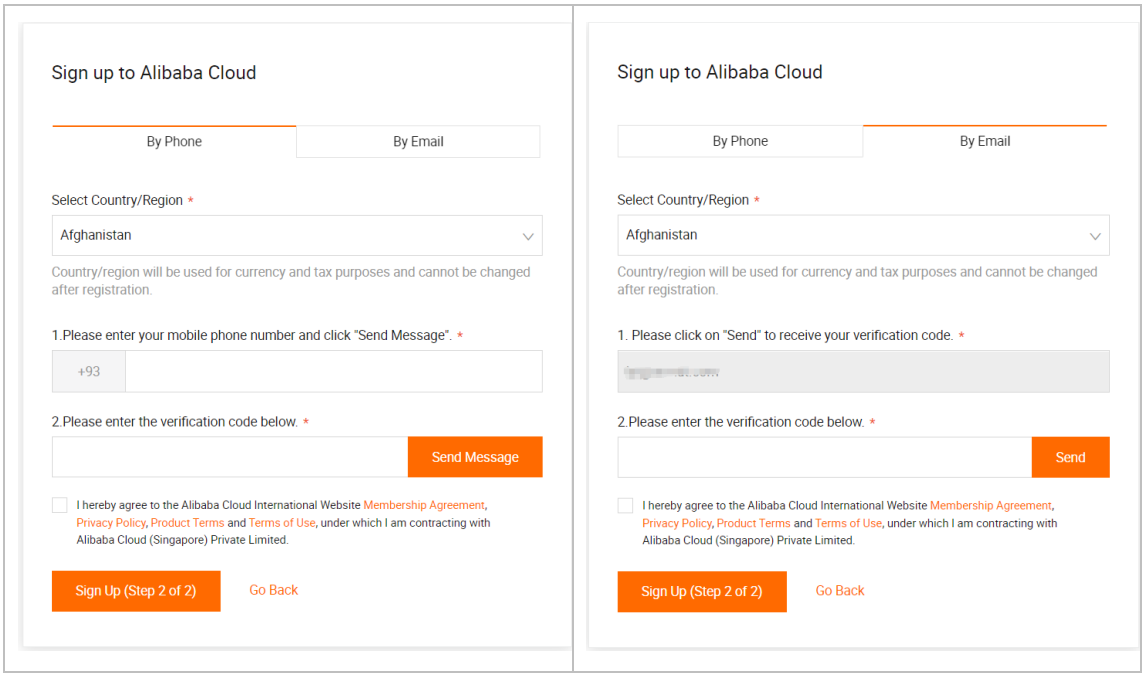


Fig. 4-37 Qingcheng Alibaba Cloud Registration Method

Step 4: When this page is shown, your account is successfully created.

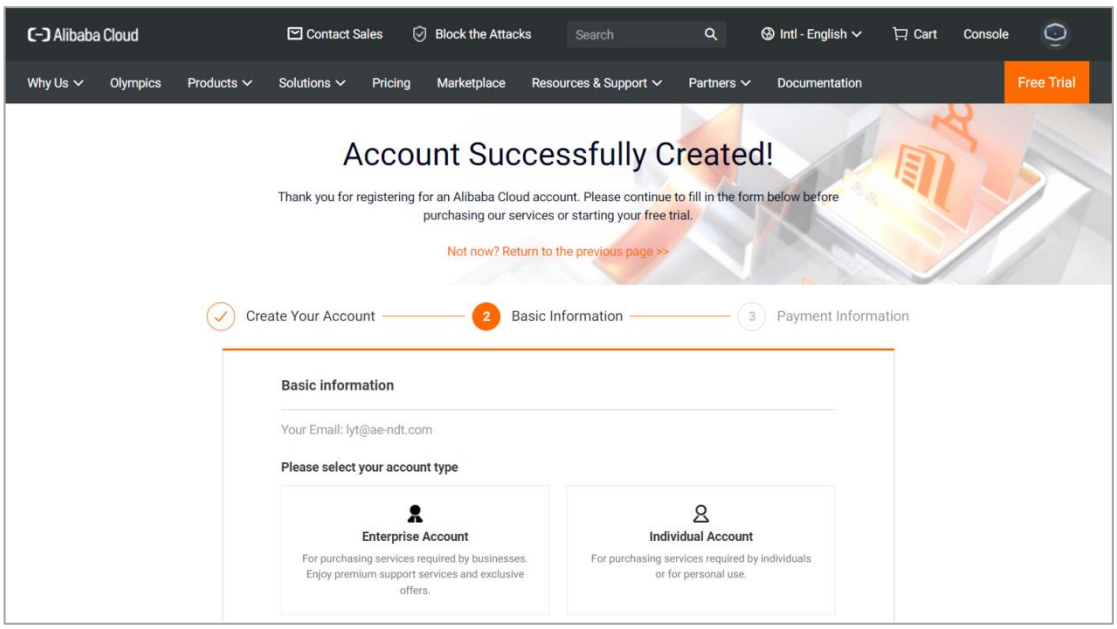


Fig. 4-38 Qingcheng Alibaba Cloud Account Created

Step 5: Click the "**Console**" at the upper right corner, next to your account icon to get into the console interface.

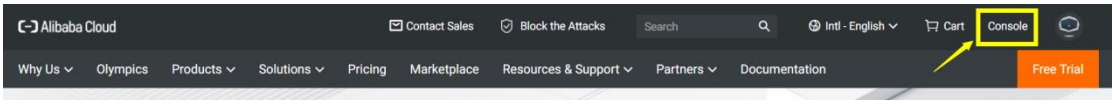


Fig. 4-39 Qingcheng Alibaba Cloud Select Console

Step 6: Click the "三" icon at the upper left corner.

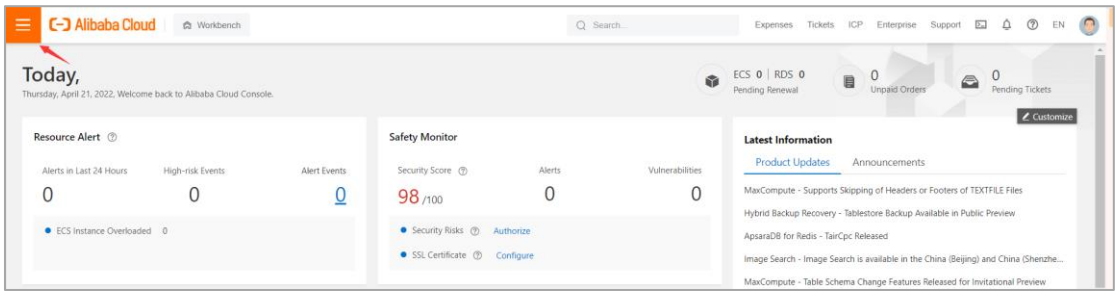


Fig. 4-40 Qingcheng Alibaba Cloud Menu Icon

Step 7: Search for "**IoT platform**" in the search bar. Select the "**IoT Platform**" in the result.

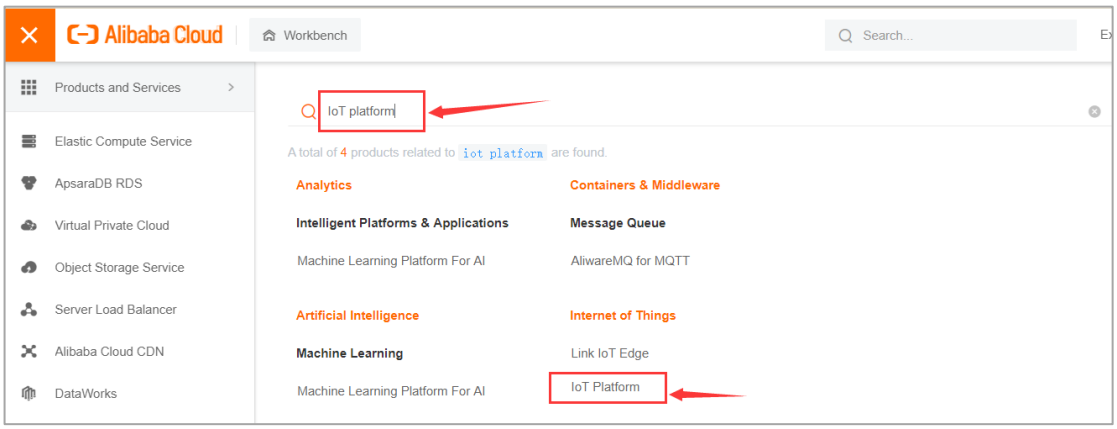


Fig. 4-41 Qingcheng Alibaba Cloud Search IoT Platform

Step 8: "Activate Now".

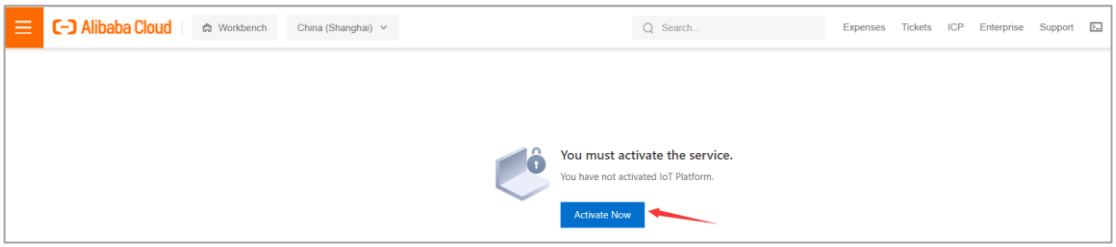


Fig. 4-42 Qingcheng Alibaba Cloud Activate IoT Platform

Step 9: Check the terms of service and click "**Activate Now**" at the bottom. If you haven't completed the billing information, the "Activate Now" button is not available. You will need to complete the billing information to activate the IoT platform service.

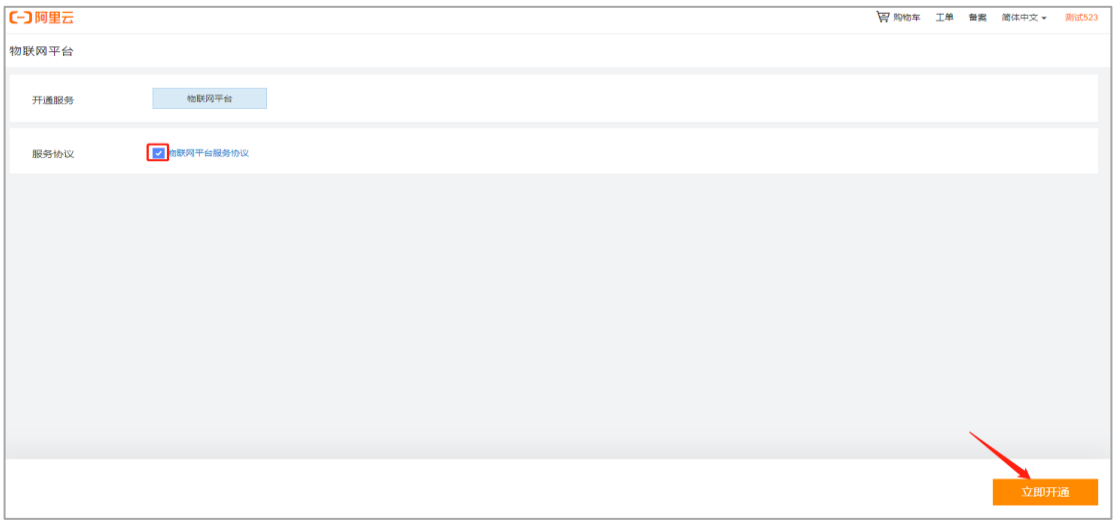


Fig. 4-43 Qingcheng Alibaba Cloud Activate Now

Step 10: After successfully activated, click "**Management Console**". It takes about 2 minutes to activate "Public Instance".

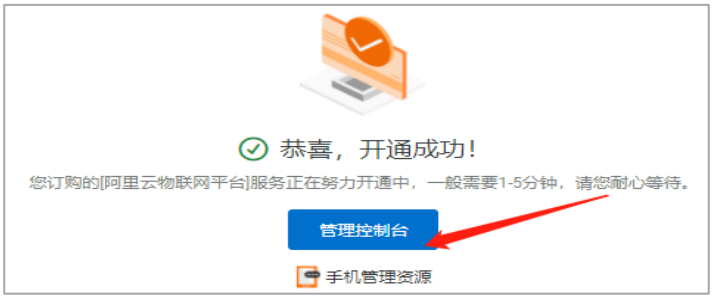


Fig. 4-44 Qingcheng Alibaba Cloud Activate Succeed

4.4.2 Create Product and Devices

Step 11: A product is a collection of devices with the same features. In the "**Products**" page, click "**Create Product**".

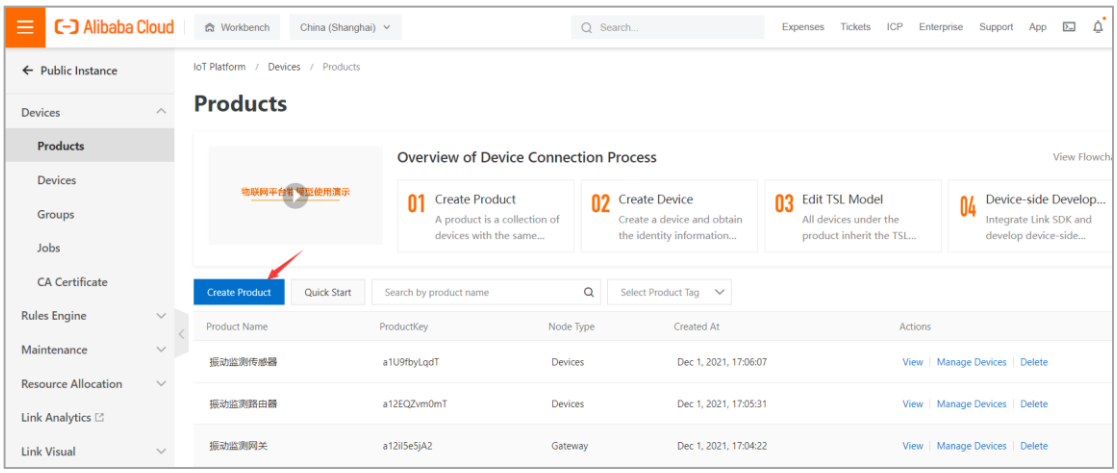


Fig. 4-45 Qingcheng Alibaba Cloud Create Product

Step 12: Enter the product information as below and then click "OK" to create product: Name >> Category: Custom Category >> Node Type: Directly connected device >> Network: Cellular (2G/ 3G/ 4G/ 5G) >> Data type: ICA standard >> verification: Weak >> Authentication Mode: Device Secret.

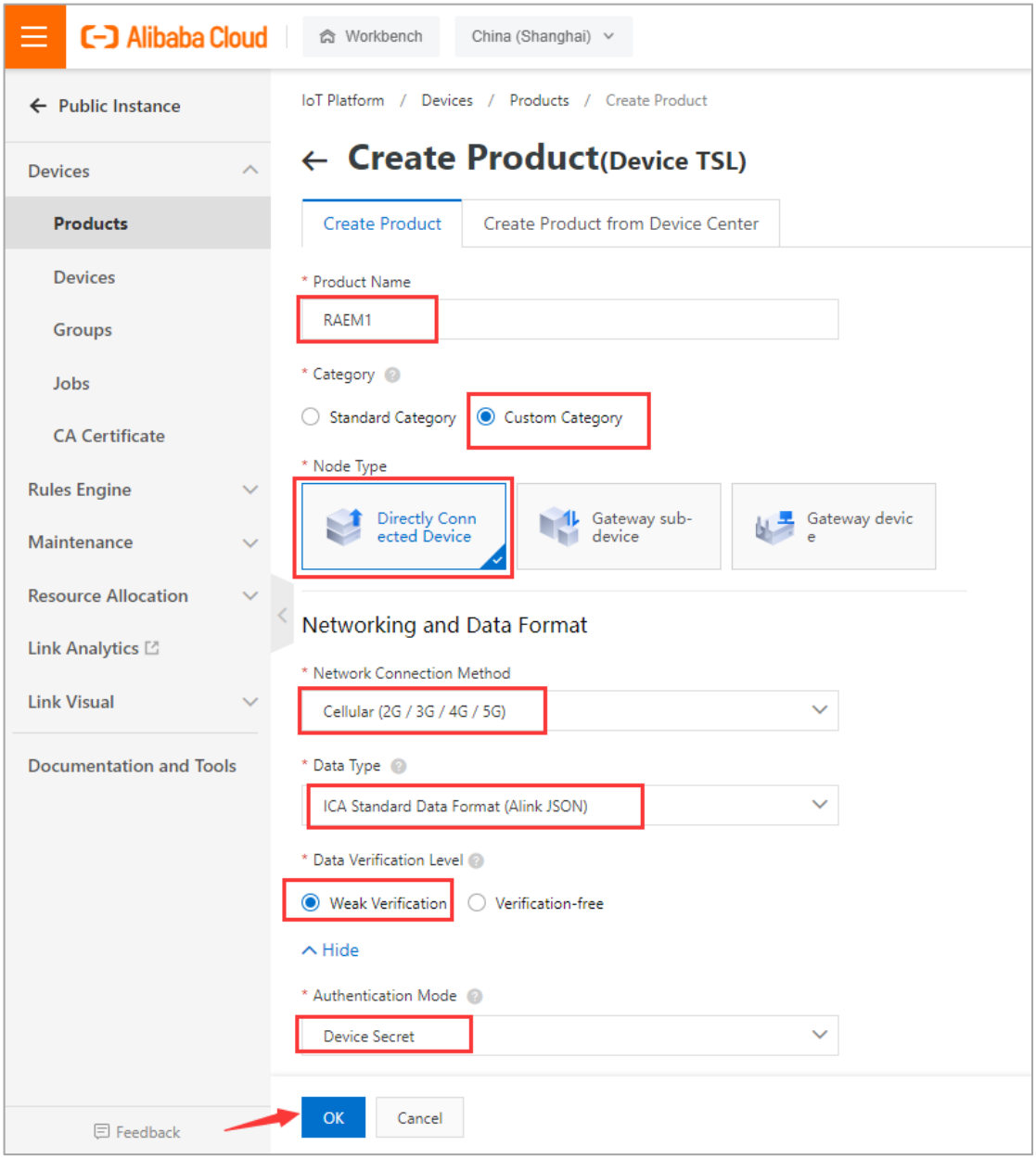


Fig. 4-46 Qingcheng Alibaba Cloud Create Product Info

Step 13: In the "Devices" page, click "Add Device".

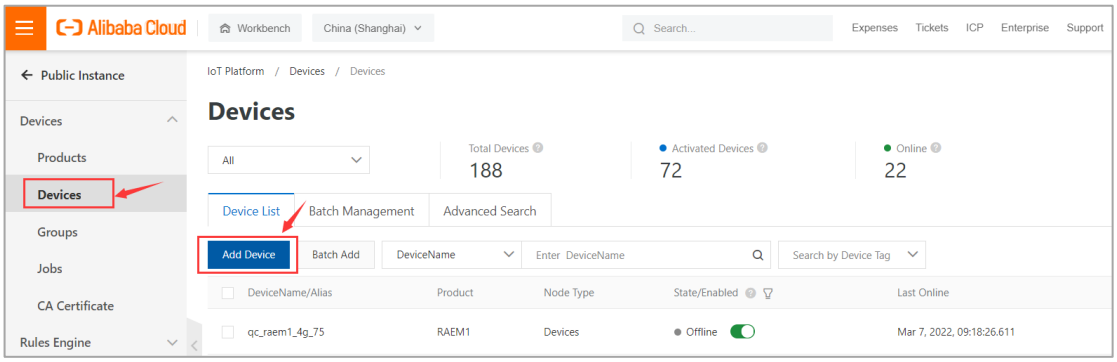


Fig. 4-47 Qingcheng Alibaba Cloud Add Device

Step 14: Choose the product type, and enter the device name, then click "OK".

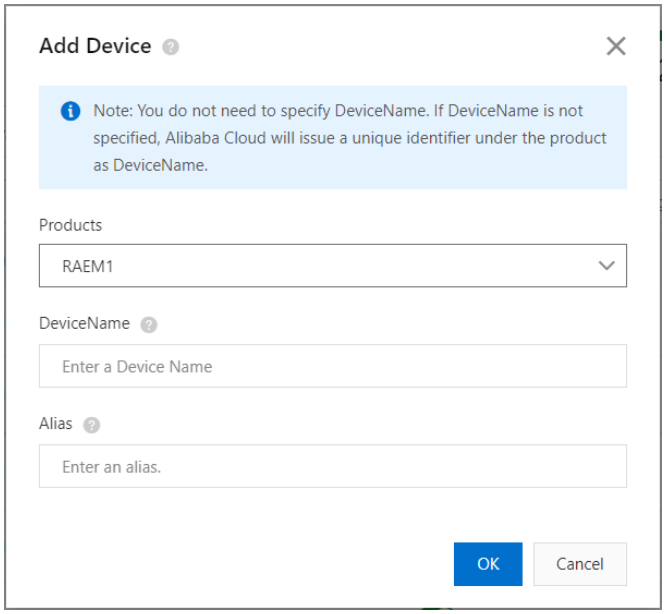


Fig. 4-48 Qingcheng Alibaba Cloud Device Info

4.4.3 Edit TSL Model

Step 15: All the devices under the product inherit the TSL model of the product. Under "Product", click "View" in the desired product name. Select "Define features" tab and click "Edit draft" in the blue notice bar.

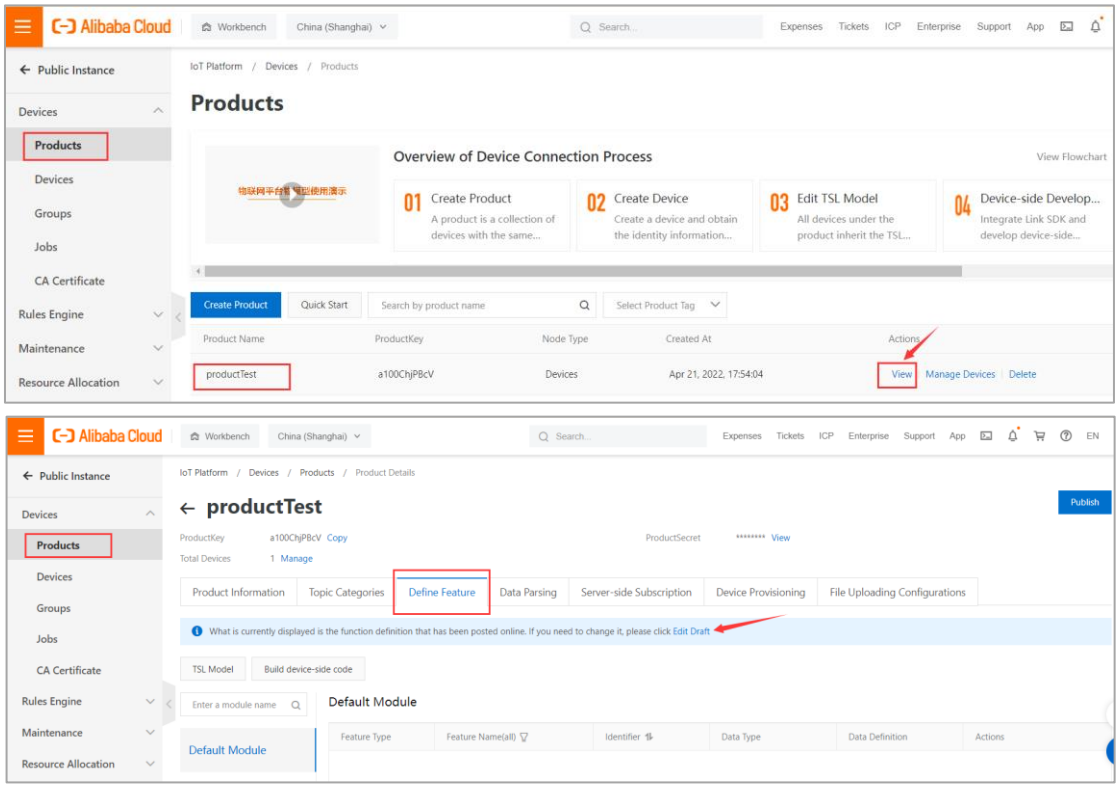


Fig. 4-49 Qingcheng Alibaba Cloud Edit Product Draft

Step 16: Click "**Import**" and upload the **"model.zip"** package provided by Qingcheng company. Contact

us for the package. After uploading, click "**Release online**" button at the bottom of the "Edit Draft" page.

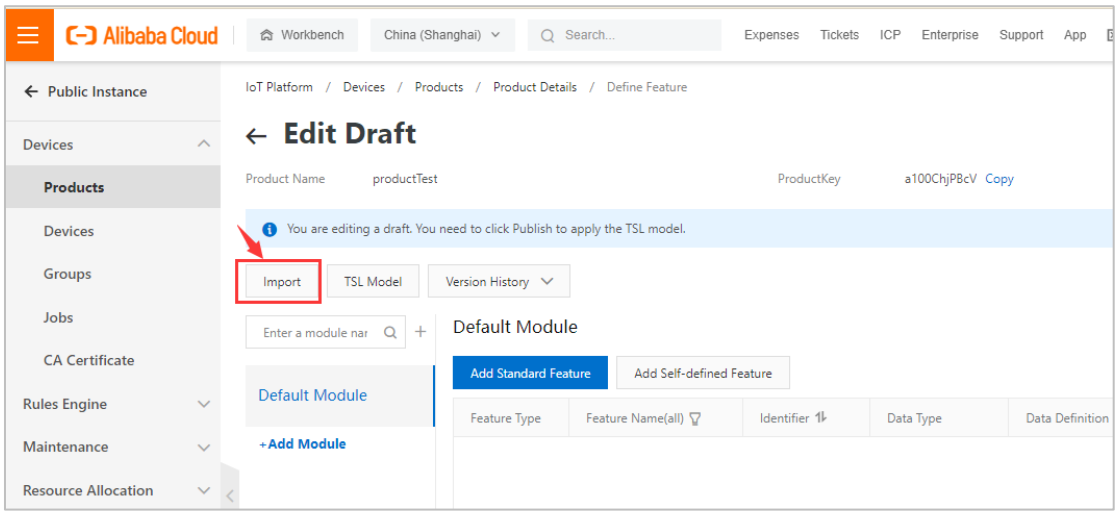


Fig. 4-50 Qingcheng Alibaba Cloud Import Model Draft

4.4.4 Activate Devices

Step 17: After adding new products, it needs to activate new devices. In the product list, click "Manage Devices" in the desired product row.

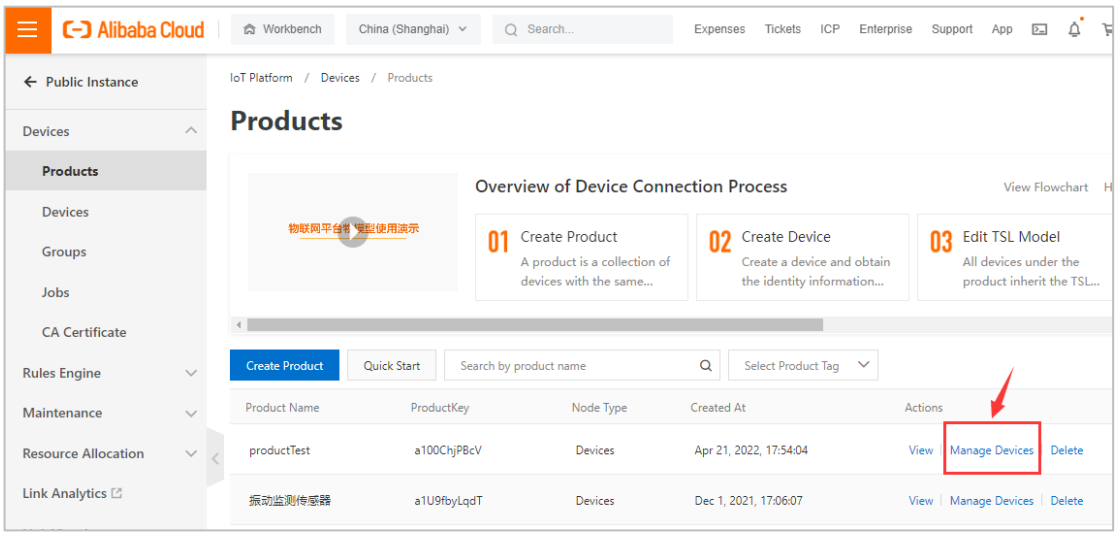


Fig. 4-51 Qingcheng Alibaba Cloud Manage Device

Step 18: All the devices under this product catalog are listed here. Click "View" of each device. Then click to view the device secret.

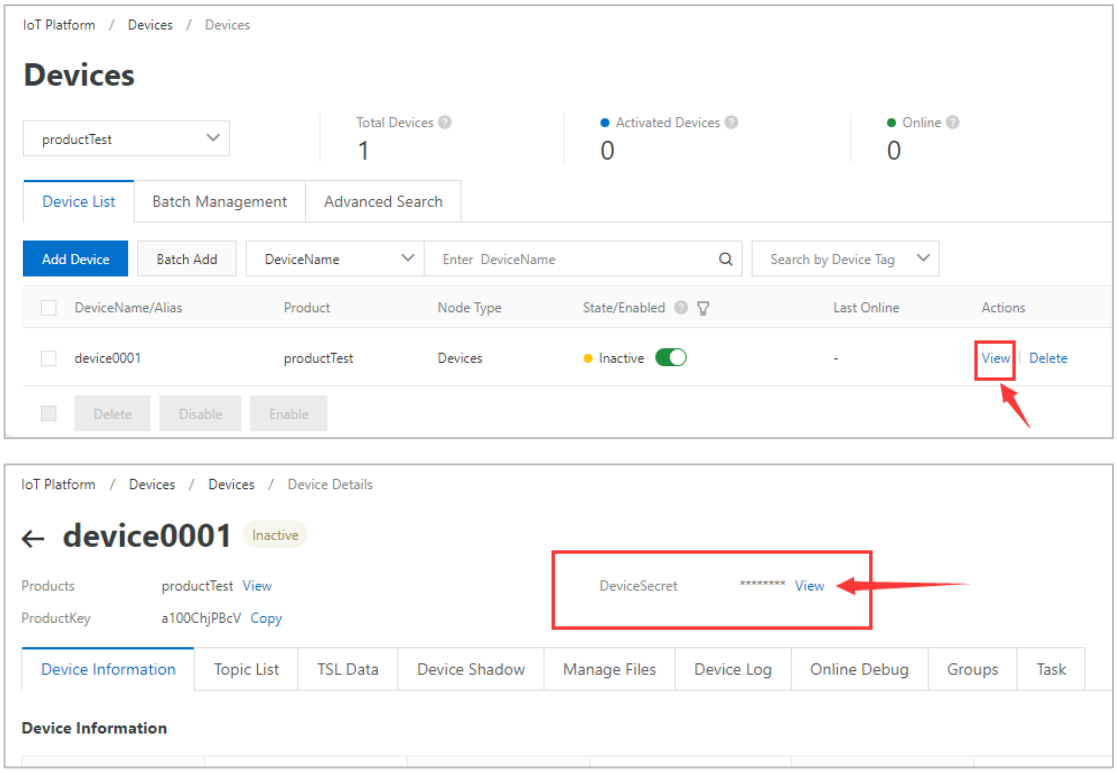


Fig. 4-52 Qingcheng Alibaba Cloud View Device Secret

Step 19: Copy the product key and device secret.

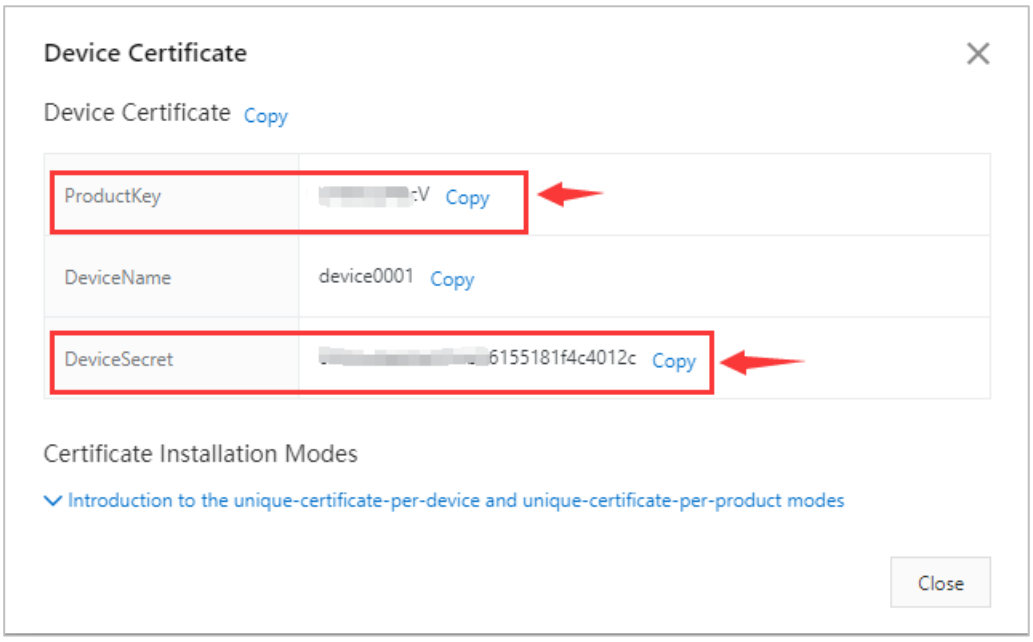


Fig. 4-53 Qingcheng Alibaba Cloud Copy Key and Secret

Step 20: Paste the key and the device secret to the configurations of the device. It can be done by the RAEM1 configuration software (Section 4) or the Qingcheng IoT Cloud (Section 5). For example, after connecting the RAEM1 to the Qingcheng IoT Cloud, open the configuration and find the network settings. Paste the Alikey and AliSecret to it. Then click "Send Config". After sending successfully, click "Reboot"

and let the hardware reboot without interruption.

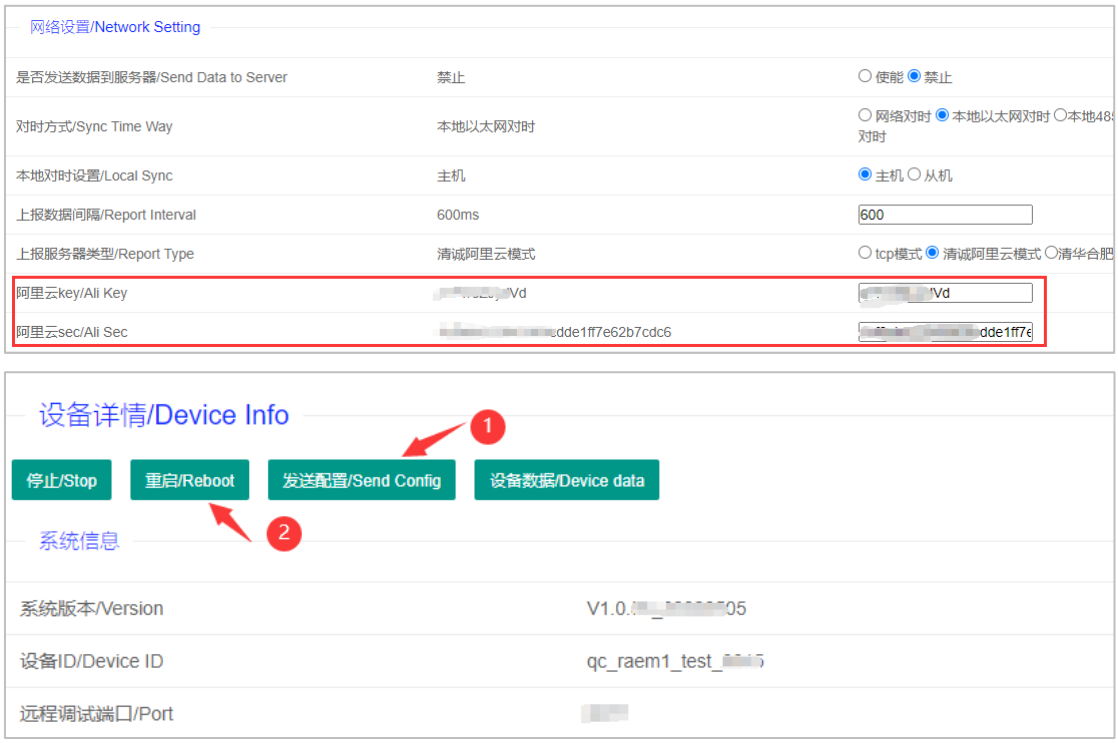


Fig. 4-54 Qingcheng Alibaba Cloud Configure Ali Key and Secret

Step 21: When the device state becomes "active", it means it is successfully activated.

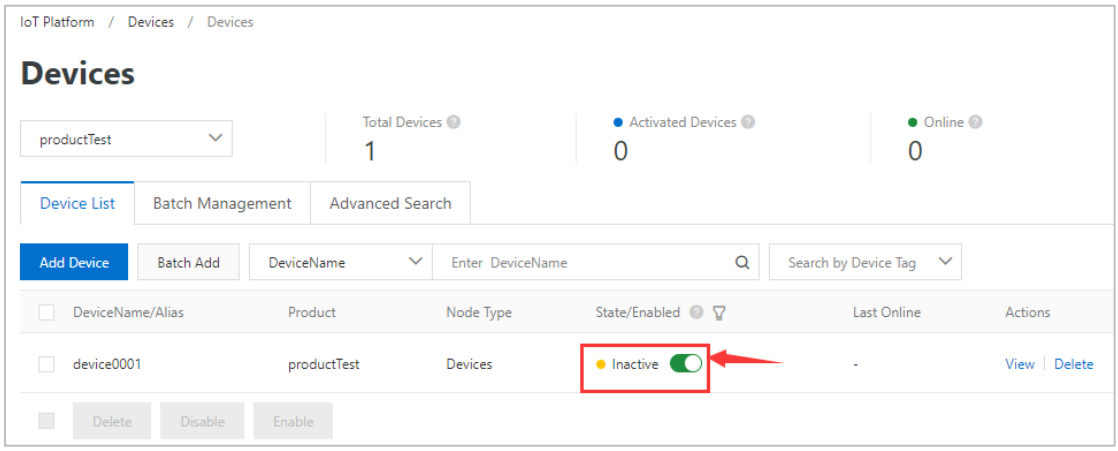


Fig. 4-55 Qingcheng Alibaba Cloud activate device

4.4.5 View Devices

(1) Choose "Public Instance". (See Figure 4-57).

(2) Select "Devices" >> "Devices" in the left column (Figure 4-57). There are all devices listed below. Choose the device type" RAEM1" below the "Devices" to search for only RAEM1s. Click on the desired device name.

(3) Choose the "TSL Data" tab and there are three modules under the "Default Module" on the left, device configuration, device Information and device data respectively. All the data are real-time display. (Figure 4-58)

Note *that currently only parameters, system ratings and configurations are uploaded to the Alibaba Cloud, no waveform data available yet. Every 200ms one group of data with the maximum amplitude is uploaded to the cloud server, not every single group data. If all the original data are wanted, please use Qingcheng IoT Cloud or contact us to configure Alibaba Cloud to receive all original data.*

(4) There is a "View Data" button on the upper right corner of each parameter block. Click on the button to view the parameter history chart or form. (Figure 4-59)

(5) Click "Online Debug" tab or under the "Maintenance" on the left menu to enter the online debugging page. Select online devices and start debugging and configurations. To modify the configurations, enter the new configuration values in the text-box on the left column and click "Debugging" >> "Set" to send the configurations to the devices. Click "Get" to read the current settings. (Figure 4-60)

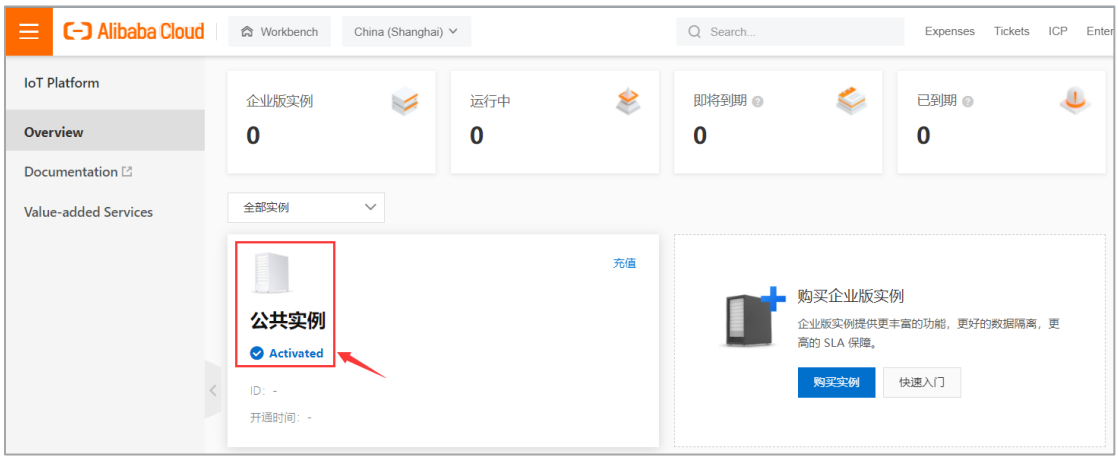


Fig. 4-56 Qingcheng Alibaba Cloud

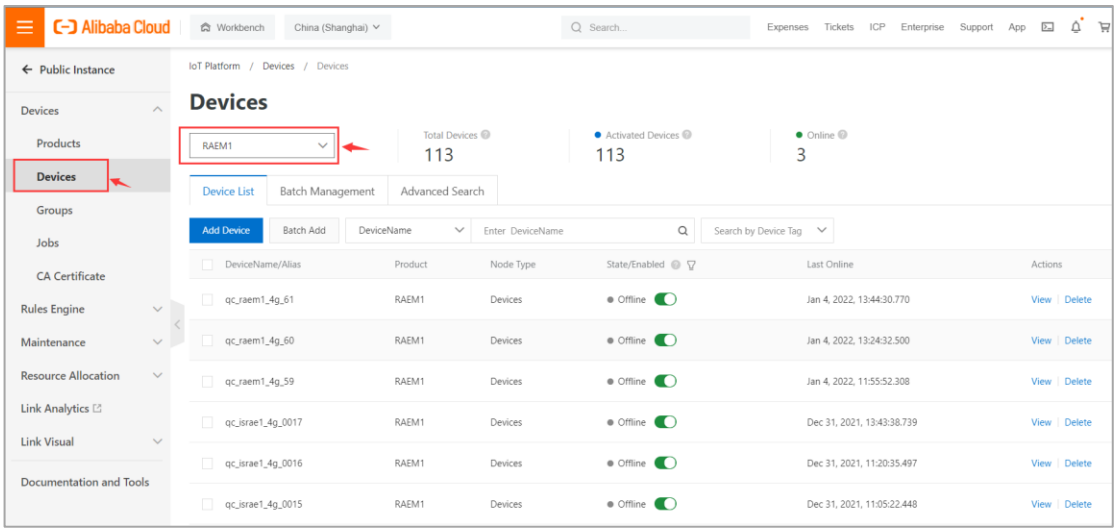


Fig. 4-57 Qingcheng Alibaba Cloud

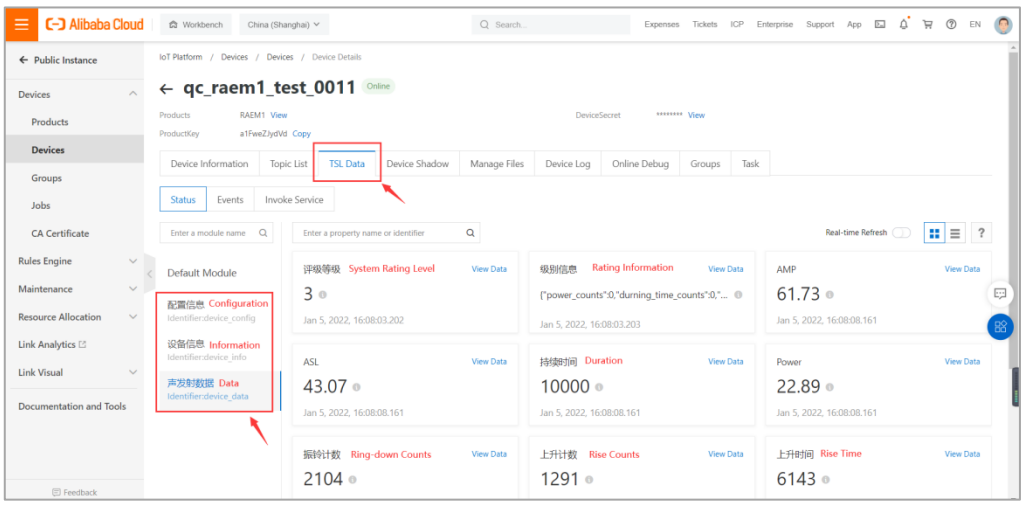


Fig. 4-58 Qingcheng Alibaba Cloud

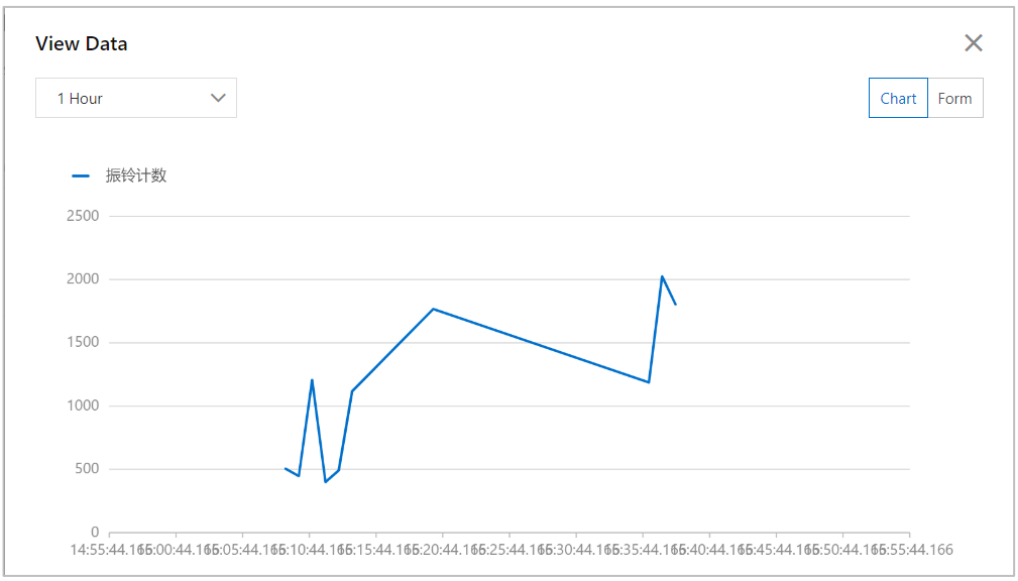


Fig. 4-59 Qingcheng Alibaba Cloud

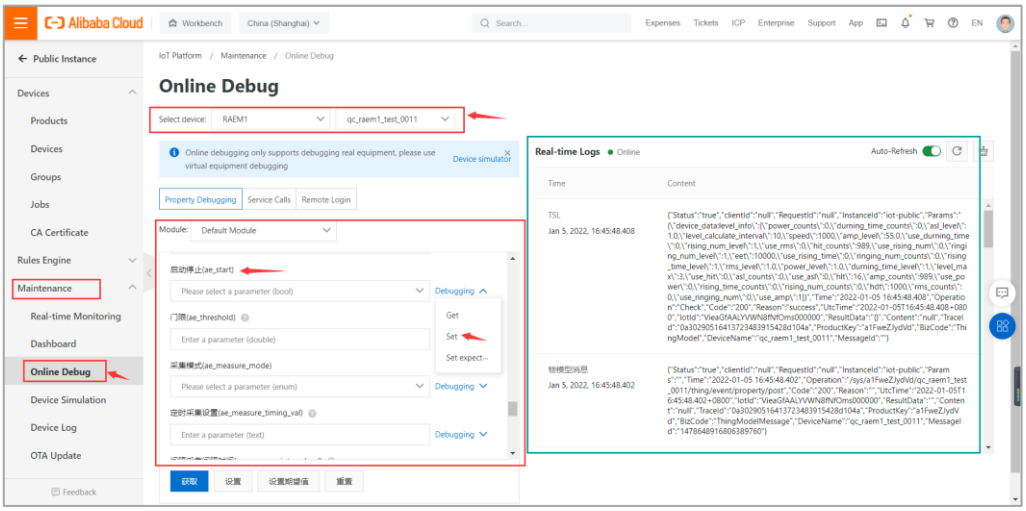


Fig. 4-60 Qingcheng Alibaba Cloud

5. Data Access

There are 3 ways to access data from RAEM1-6: RAEM1 configuration software, SWAE software and Qingcheng IoT cloud platform.

5.1 RAEM1 Configuration Software Access

The **file view** function of the RAEM1 configuration software can obtain the data stored locally by RAEM1-6. It also supports downloading and format conversion. See Chapter 3.3 for details.

5.2 U3H (RAEM1) software access

See Chapter 3.4 for details.

5.3 Cloud server access

RAEM1-6 supports the upload, storage and download of data packages from two cloud servers, namely Qingcheng IoT cloud platform and Amazon AWS S3 cloud service.

5.3.1 Qingcheng IoT Cloud Access

See Chapter 4.3 for details.

5.3.2 AWS S3 Setup and access

Amazon Simple Storage Service (Amazon S3) is an object storage service that offers industry-leading scalability, data availability, security, and performance. RAEM1 supports uploading data to AWS S3 server. Users need to register for their own AWS account and follow the steps below to setup RAEM1. Before using AWS, please make sure the firmware version is v1.0.53 and above.

- **AWS S3 Setup**

1) Sign up a Root user account in AWS.

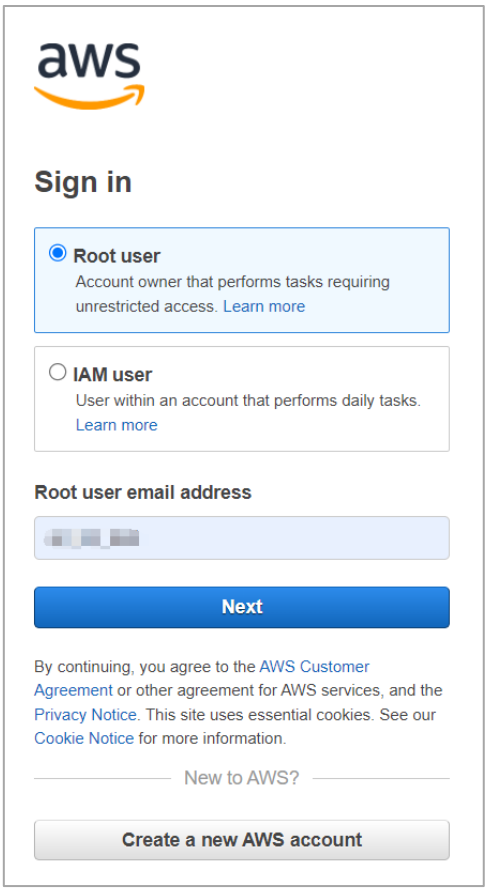


Fig. 5-1 Sign up for AWS Root account

2) Create new accounts in AWS

- Go to IAM service

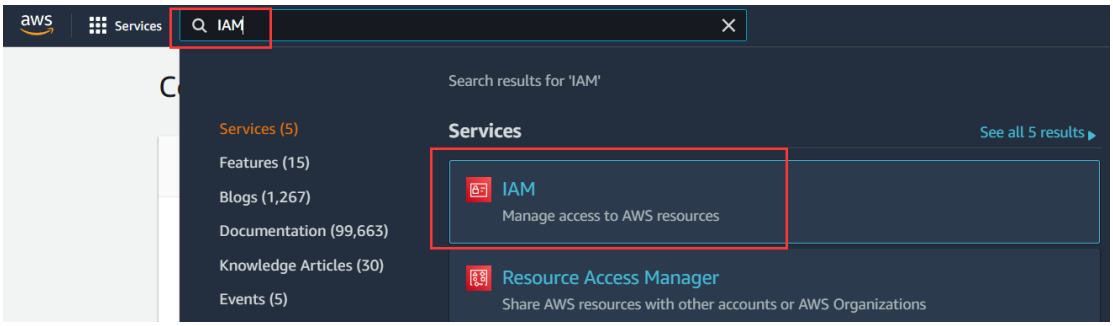


Fig. 5-2 Search for IAM

- Add users

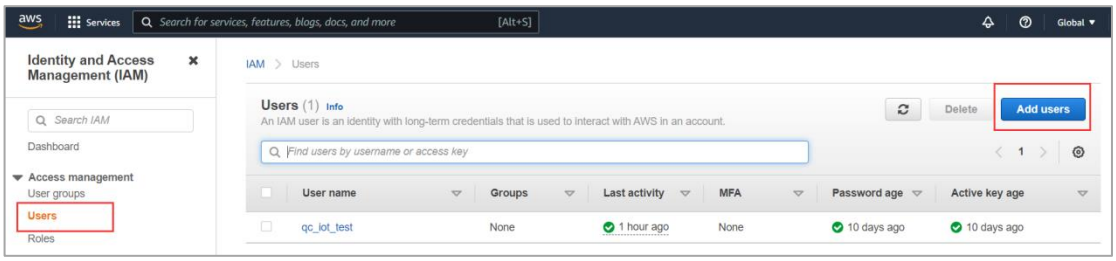


Fig. 5-3 Add users

➢ Step 1: enter the user's name and check the "Access key" and "password";

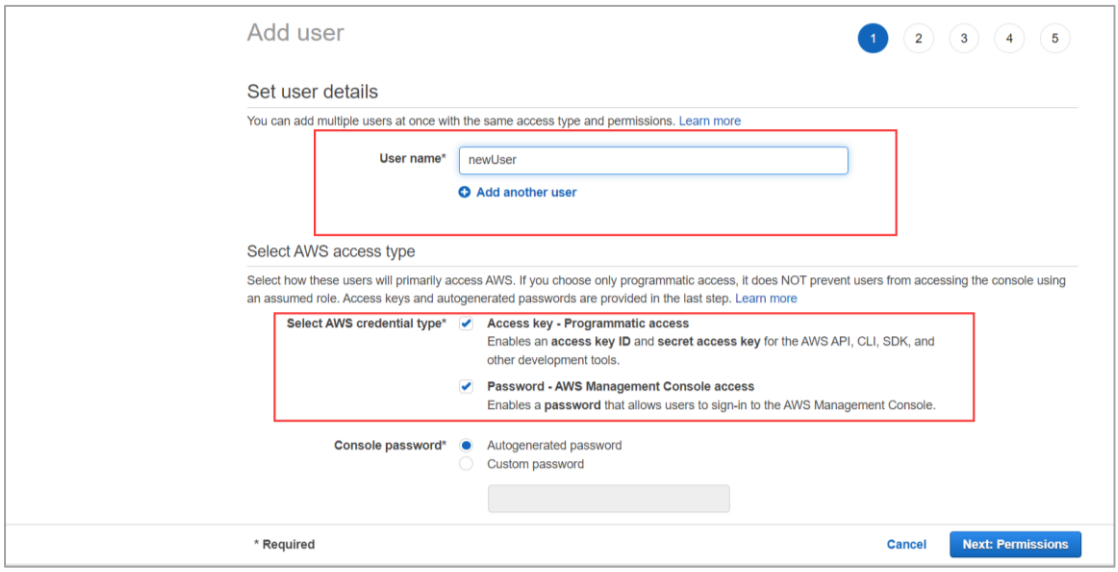


Fig. 5-4 User adding step 1

➢ Step 2: select "attaching existing policies directly" and search for "S3", check "AmazonS3FullAccess";

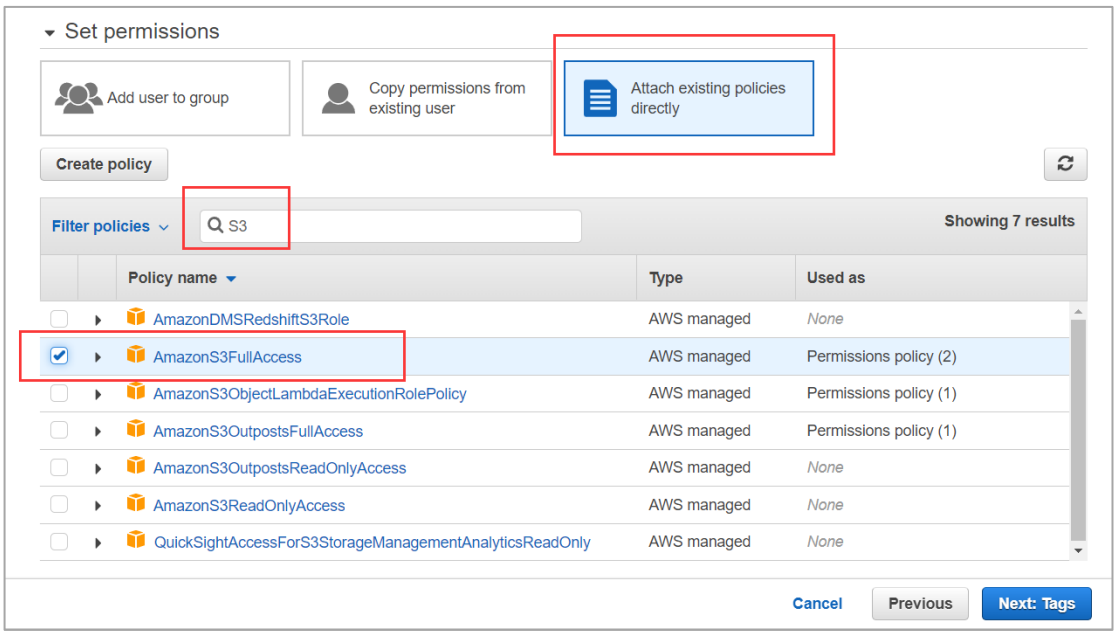


Fig. 5-5 User adding Step 2

➢ Then "Next" and "Next" again to get to Step 4. In Step 4, click "Create user".

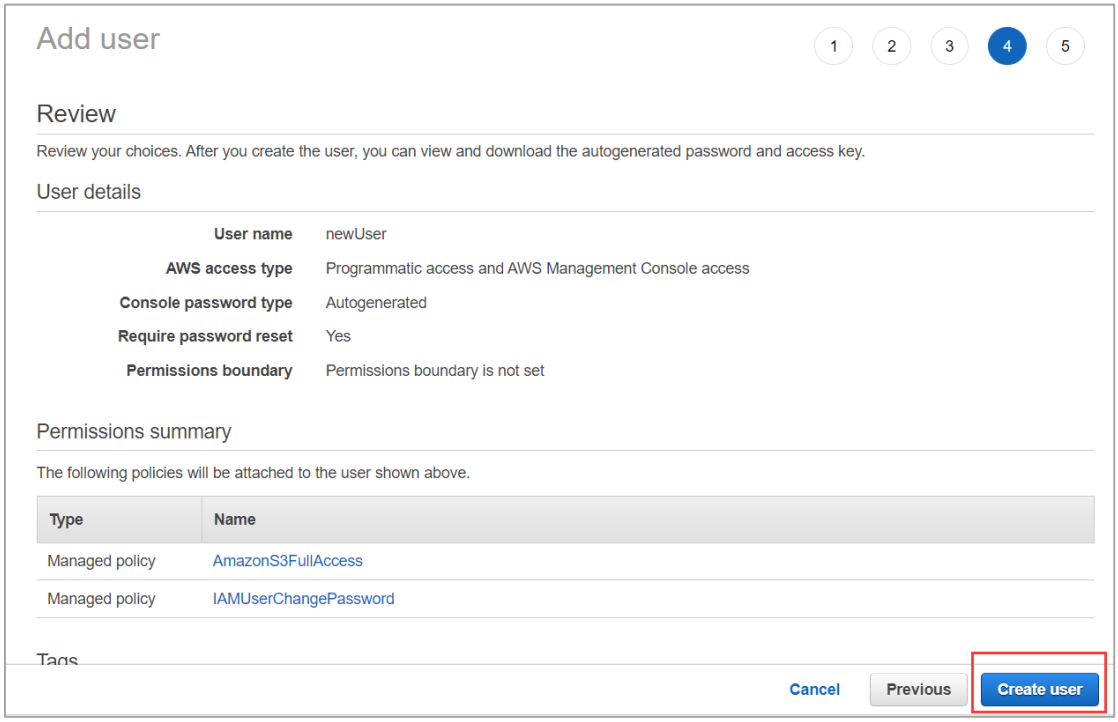


Fig. 5-6 User adding Step 4

➢ Download the CSV file to get the Access key and secret for the RAEM1 configuration.

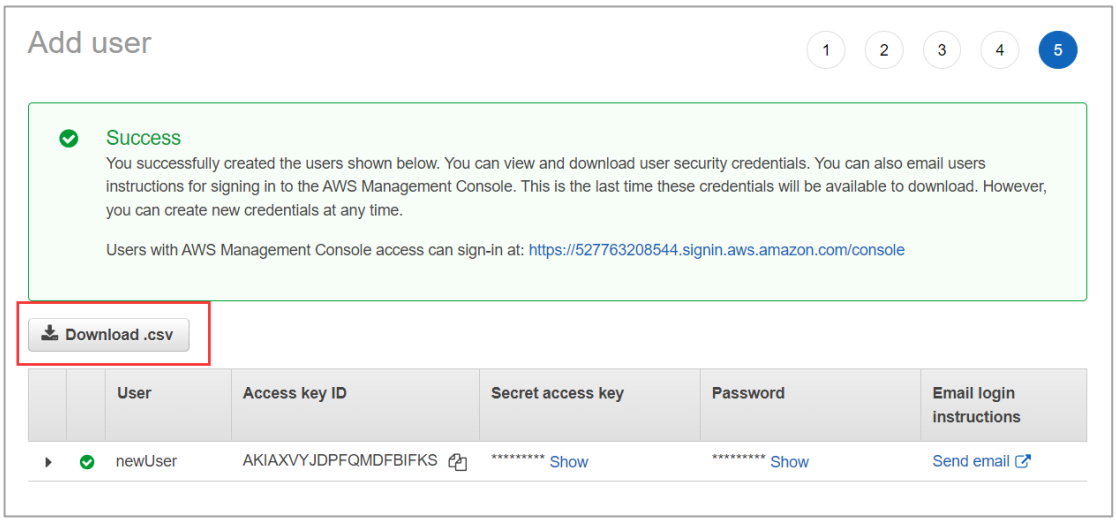
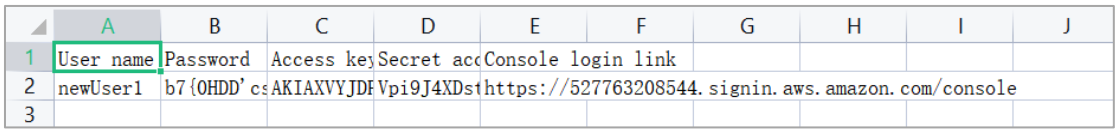


Fig. 5-7 User adding Step 5



	A	B	C	D	E	F	G	H	I	J
1	User name	Password	Access key	Secret acc	Console login link					
2	newUser1	b7{0HDD'cs	AKIAXVYJDF	Vpi9J4XDst	https://527763208544.signin.aws.amazon.com/console					
3										

Fig. 5-8 Access key and secrete

3) Create the S3 Bucket using the AWS IAM user account

➢ Open the downloaded CSV file. Open the Console login link it provides and enter user name and password. It will ask you to create a new password afterwards.

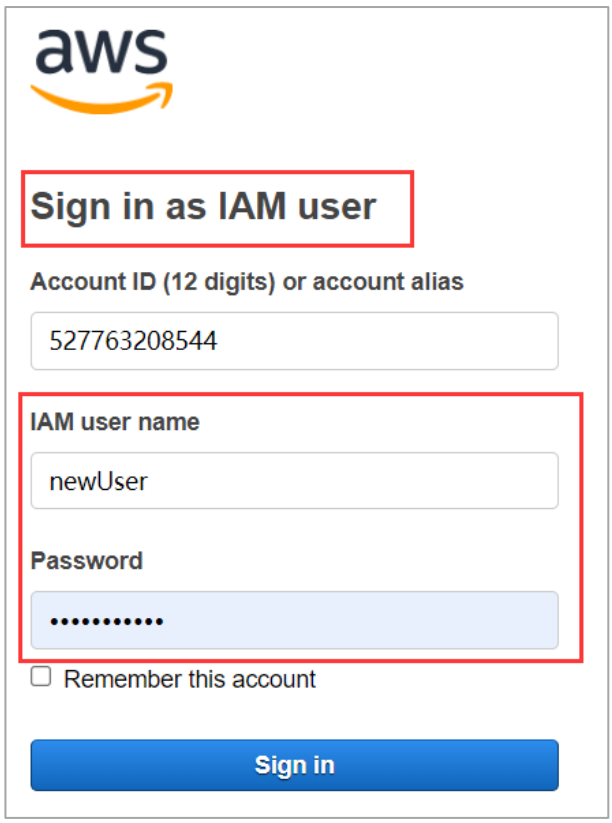


Fig. 5-9 Console Login Link

➢ Search for S3

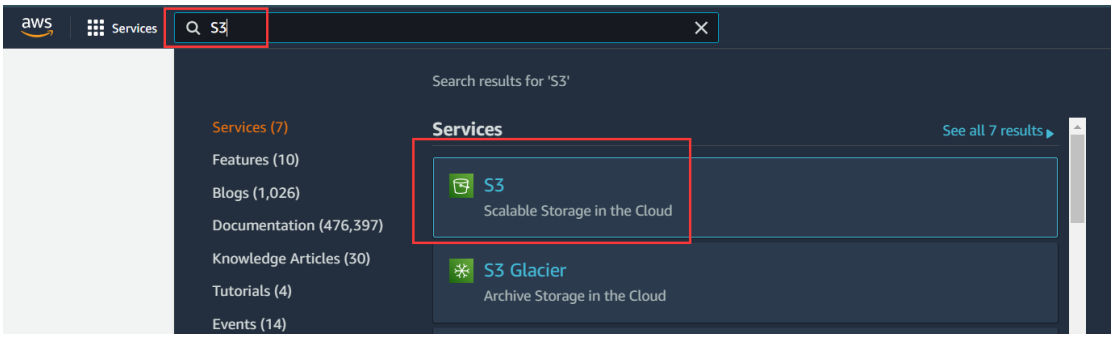


Fig. 5-10 Search for S3

➢ Create bucket

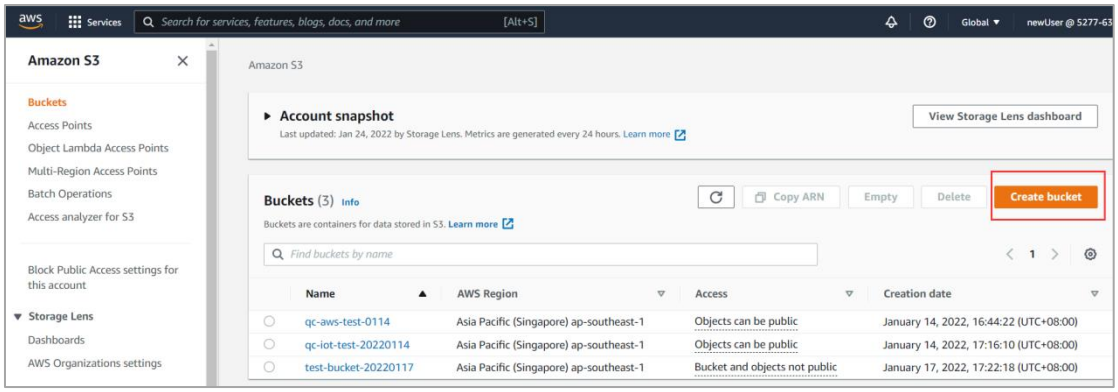


Fig. 5-11 Create bucket

➢ Enter bucket name and AWS region. Press "Create bucket" at the bottom.

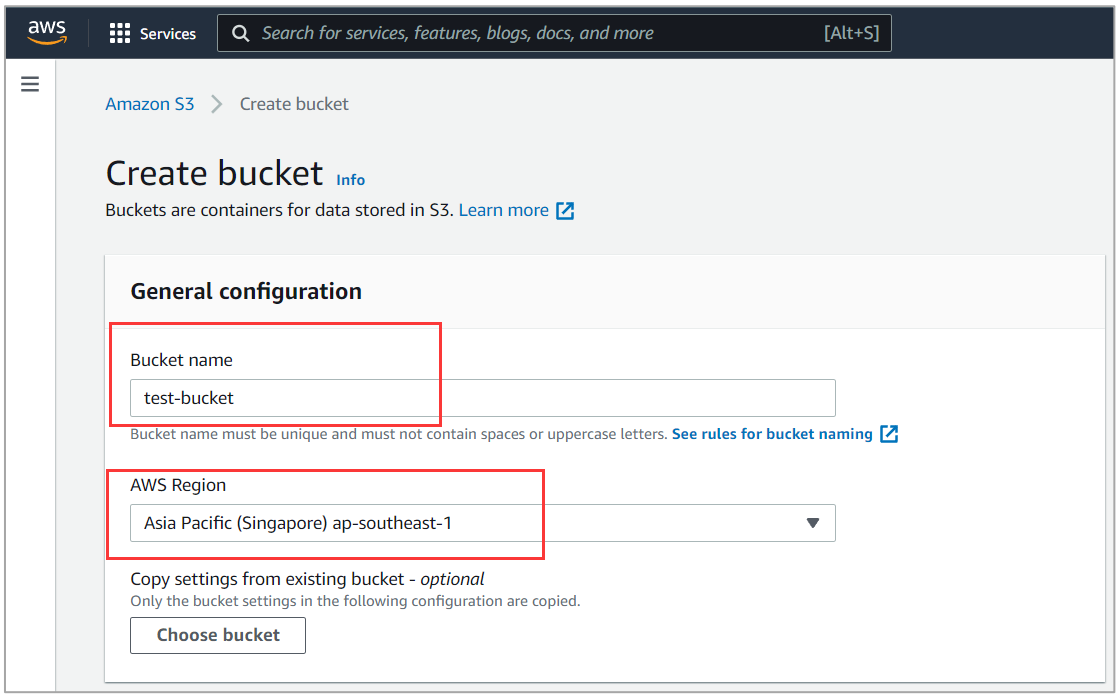
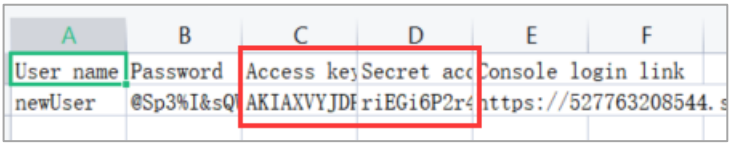


Fig. 5-12 Enter bucket information

4) Configure RAEM1 AWS

➢ Get the AWS key, Secret, Bucket Name and region information from the above steps.



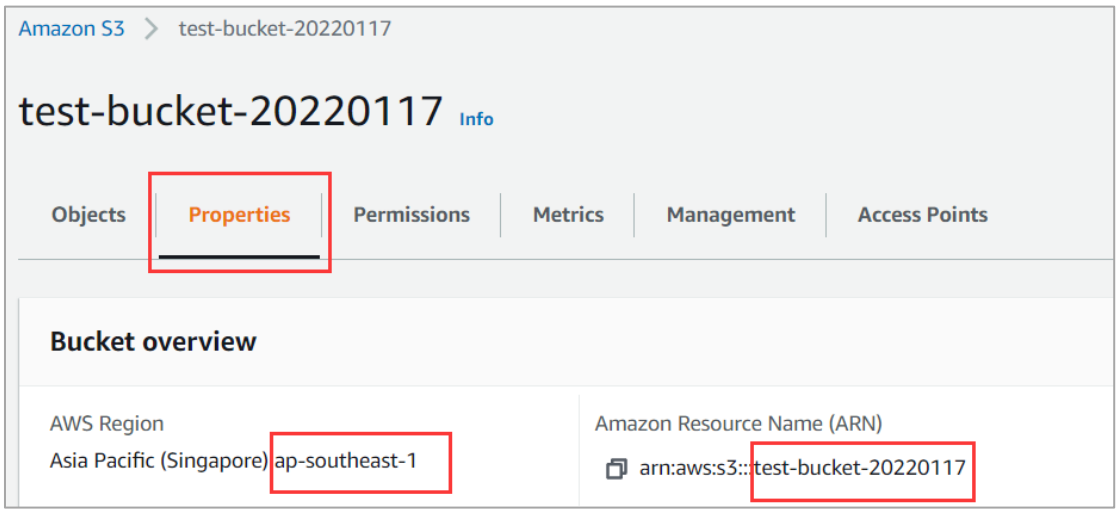


Fig. 5-13 Get AWS S3 Information

➢ Enter the information in the RAEM1 Configuration software AWS section.

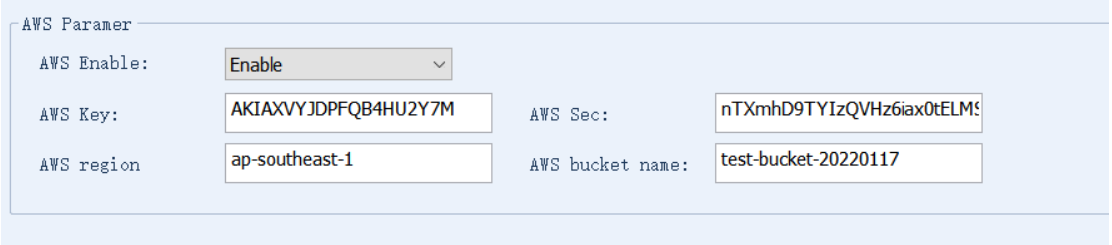


Fig. 5-14 Enter AWS configuration

➢ Also configure the RAEM1 data storage settings. Make sure to enable "Save Wave" and "Save Param", but disable "Upload original data". Because that means to upload data to Qingcheng IoT Cloud.

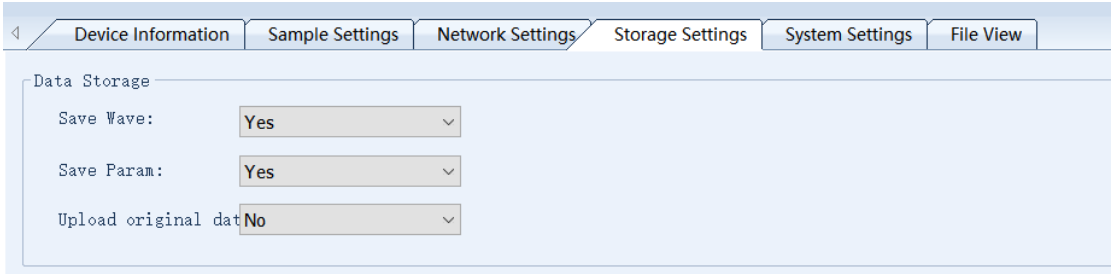


Fig. 5-15 Data Storage settings for AWS

➢ After successfully send the AWS setup information to the RAEM1, it needs to reboot the device to take effects. Right click on the device name in the device list and select "Reboot Device". The device will automatically reboot and reconnects. Please do not interrupt the reboot process in any way.

◆ **Data Access**

➢ When there are HITs, RAEM1 will pack the data every 5 seconds and then store in the local

storage first. If there is no data, there will be no data packs. Then based on the network availability, it will start upload the data packs to the specified AWS S3 bucket. If the network connection stops when it is uploading. It will stop and retry when the connection is back. Once the data packs are uploaded to the cloud server successfully, the local storage copies will be deleted. To access and download the data packs in AWS S3:

- Log in to your AWS account and go to S3 server. In the bucket list, choose the bucket that is set to store the RAEM1 data.

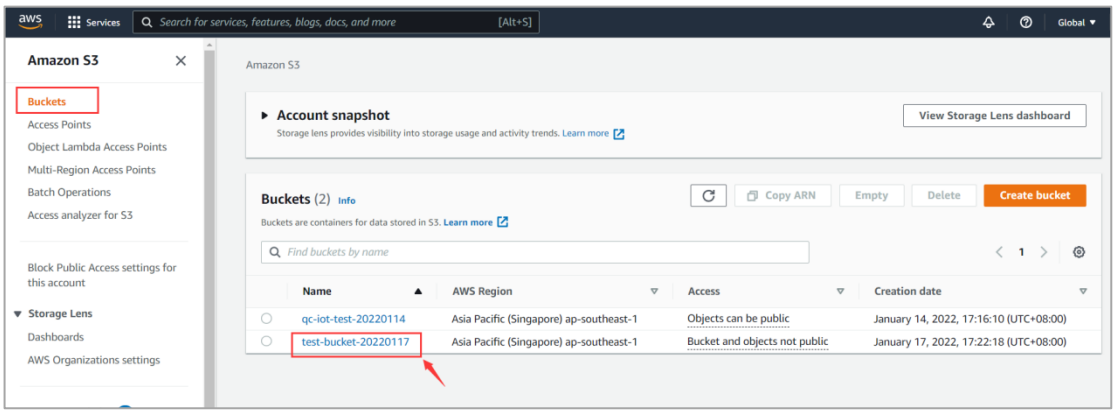


Fig. 5-16 Select bucket

- Choose "tmp/" folder

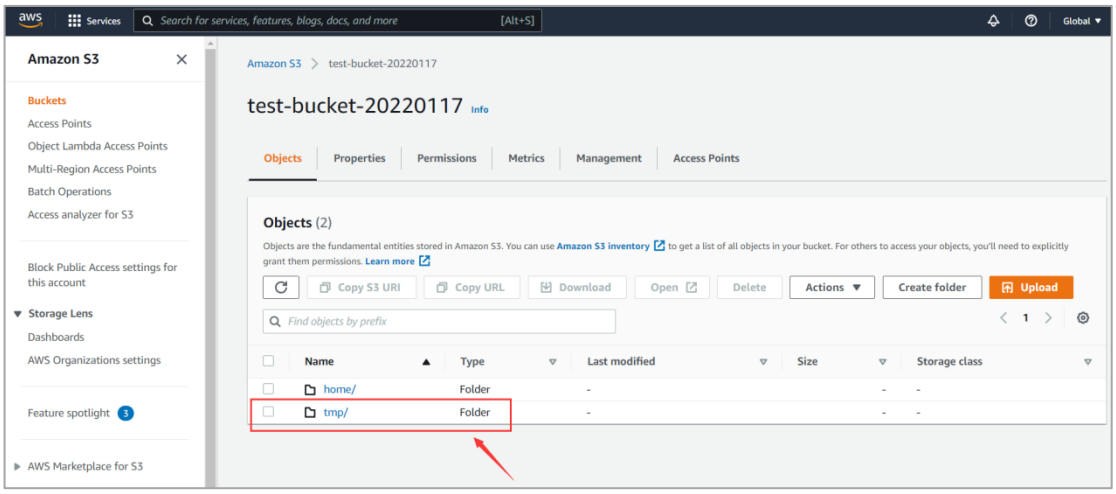


Fig. 5-17 Open "tmp/" folder

- Choose "aws_data/" folder. Inside the folder, the RAEM1 data packs are all listed. Click on the name to start further operations.

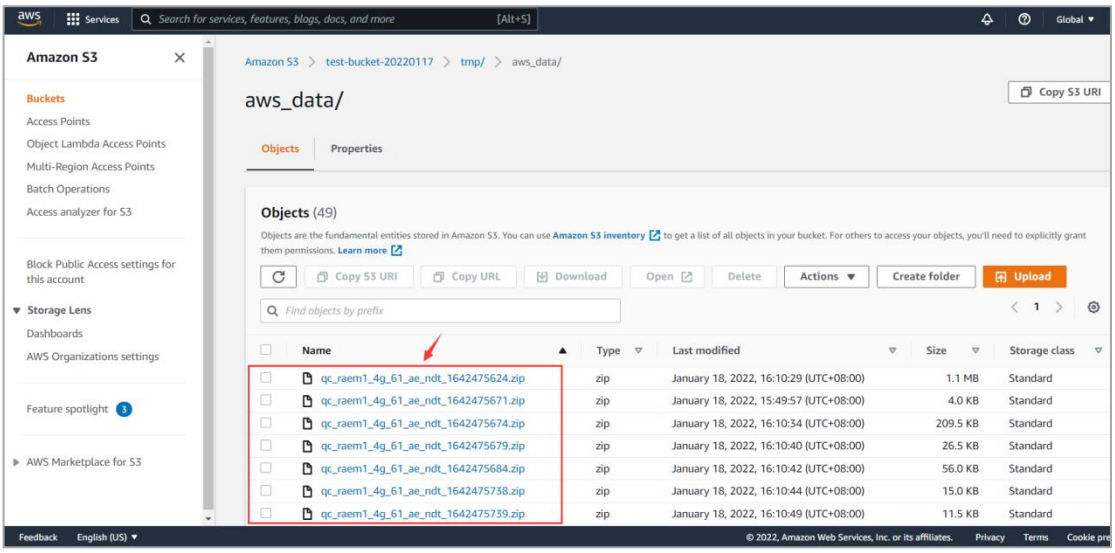


Fig. 5-181 Data packs in the bucket

6. Data Format Conversion

The format of RAEM1-6 data needs to be converted before in-depth data analysis can be carried out on Qingcheng U3H software or other third-party data analysis software. Currently, there is no software for direct analysis and display of RAEM1-6 data.

The data generated by RAEM1-6 can be converted using our format conversion software "**RAE1toU3H**" (you can also open the software through the "File Conversion" button in the lower left corner of RAEM1 configuration tool software). The "**File View**" page of the RAEM1 configuration tool allows you to download data and convert formats at the same time, as detailed in Chapter 3.3

The converted files (. pra and. aed) can be opened and analyzed in U3H software. For details about how to use 3H software, please contact our company to obtain the U3H software manual. It can also be converted to CSV format for third-party software analysis. Conversion software supports multi-channel conversion.

The conversion steps using "**RAE1toU3H**" software are as follows:

1) Download RAEM1 data. The downloaded data is a single ZIP package, and multiple ZIP packets can be converted together. Store all the downloaded ZIP packages in a folder. If multiple RAEM1 are converted to multiple channels, place the ZIP package for each RAEM1 in a separate folder.

2） Open the conversion tool, "**RAE1toU3H.exe**". It can also be opened using the "File Convert" button in the lower left corner of the RAEM1 configuration software.

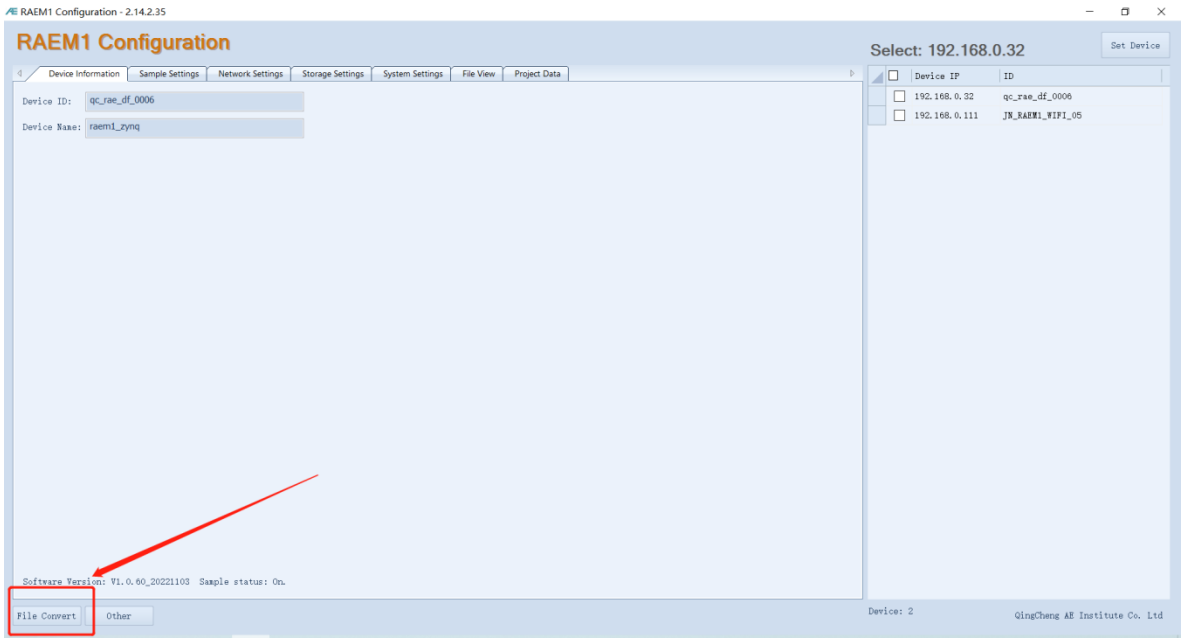


Fig. 6-1 RAEM1 Configuring the file conversion function of the software

3） Click "Add Directory" and select the directory corresponding to the ZIP package. Each directory will act as a channel. The channel number can be changed by left-clicking. Right-click the menu to delete the current or all added directories. Check the ZIP package option. Select the directory address to save. The sampling rate should be consistent with that of RAEM1. Click "Convert U3H":

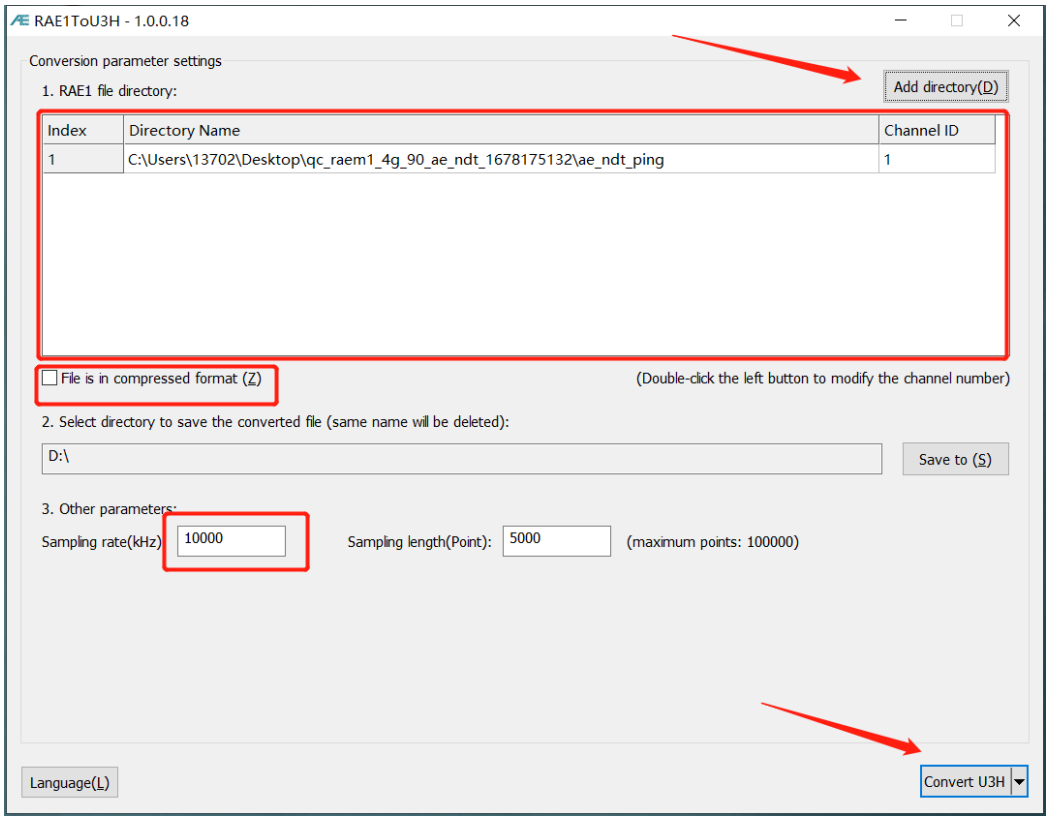


Fig. 6-2 RAE1ToU3H main screen

4） Pop-up window appears to display the process and progress of data conversion. When the data conversion is complete, there will be a prompt completion window.

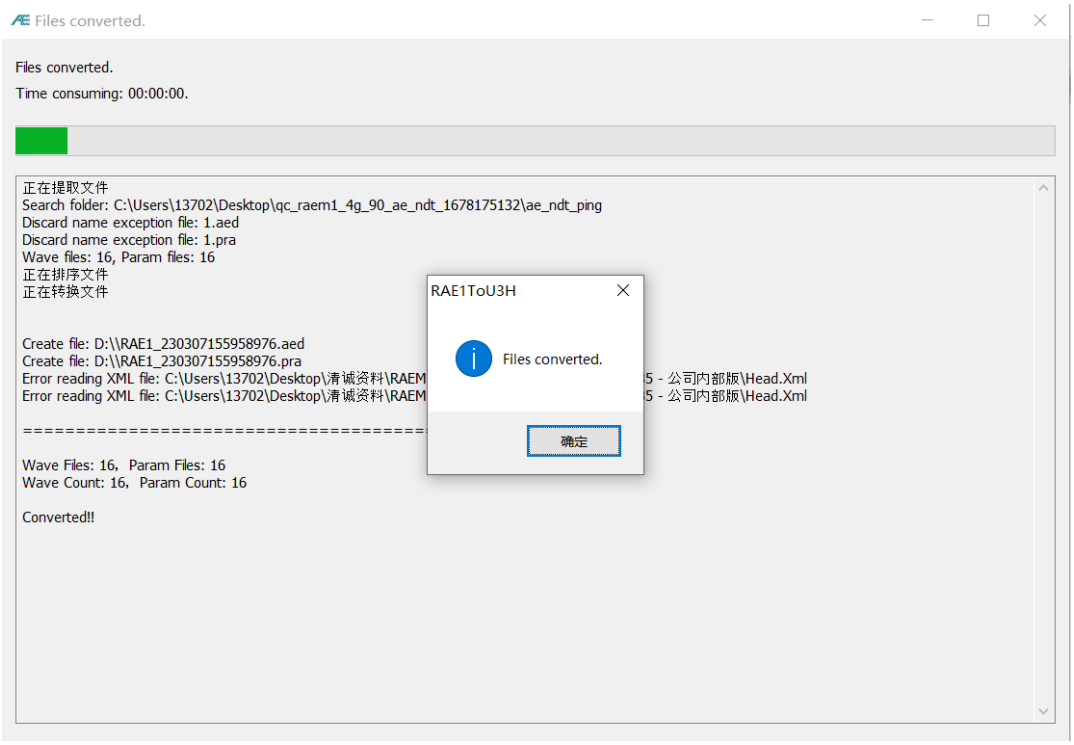


Fig. 6-3 RAE1ToU3H conversion screen

5) After the conversion is complete, the corresponding U3H files (. pra and. aed), which can be imported into our SWAE host computer for analysis:

Fig. 6-4 3 hours of data generated after conversion

6) If you want to convert to CSV format, click "▼" next to "Convert U3H" and click "**Convert CSV file**." After the conversion is complete, you can view the corresponding CSV file in the corresponding directory. The generated CSV file has the prefix RAE1. The first column of the CSV file is the time and the second column is the waveform (the voltage value at each collection point). When the generated CSV file exceeds about 800,000 lines, another new CSV file is automatically generated.

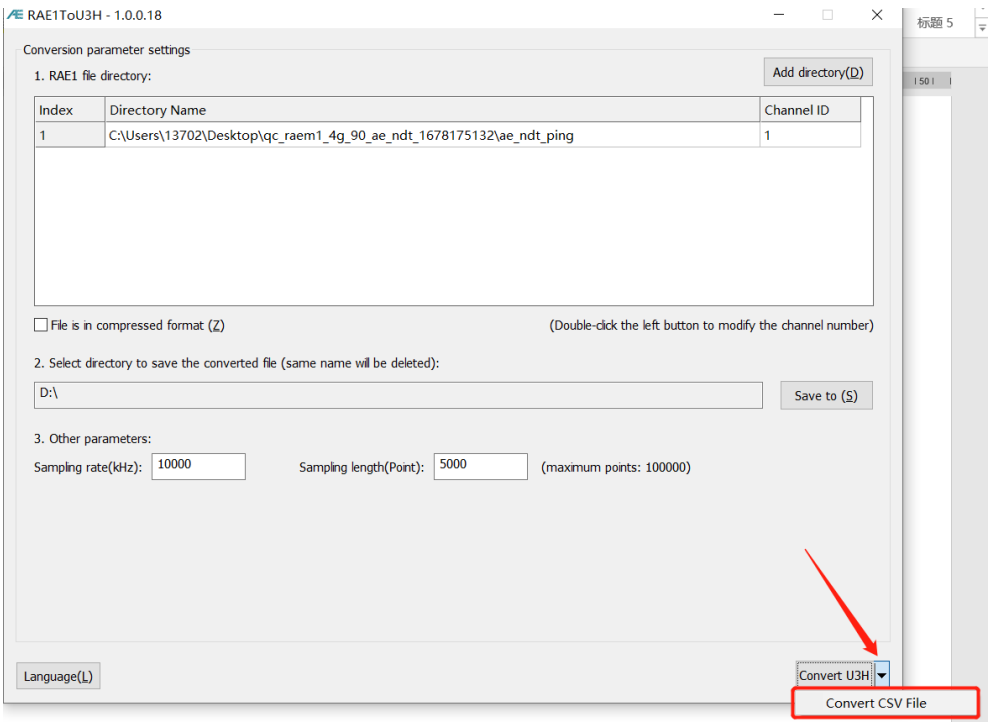
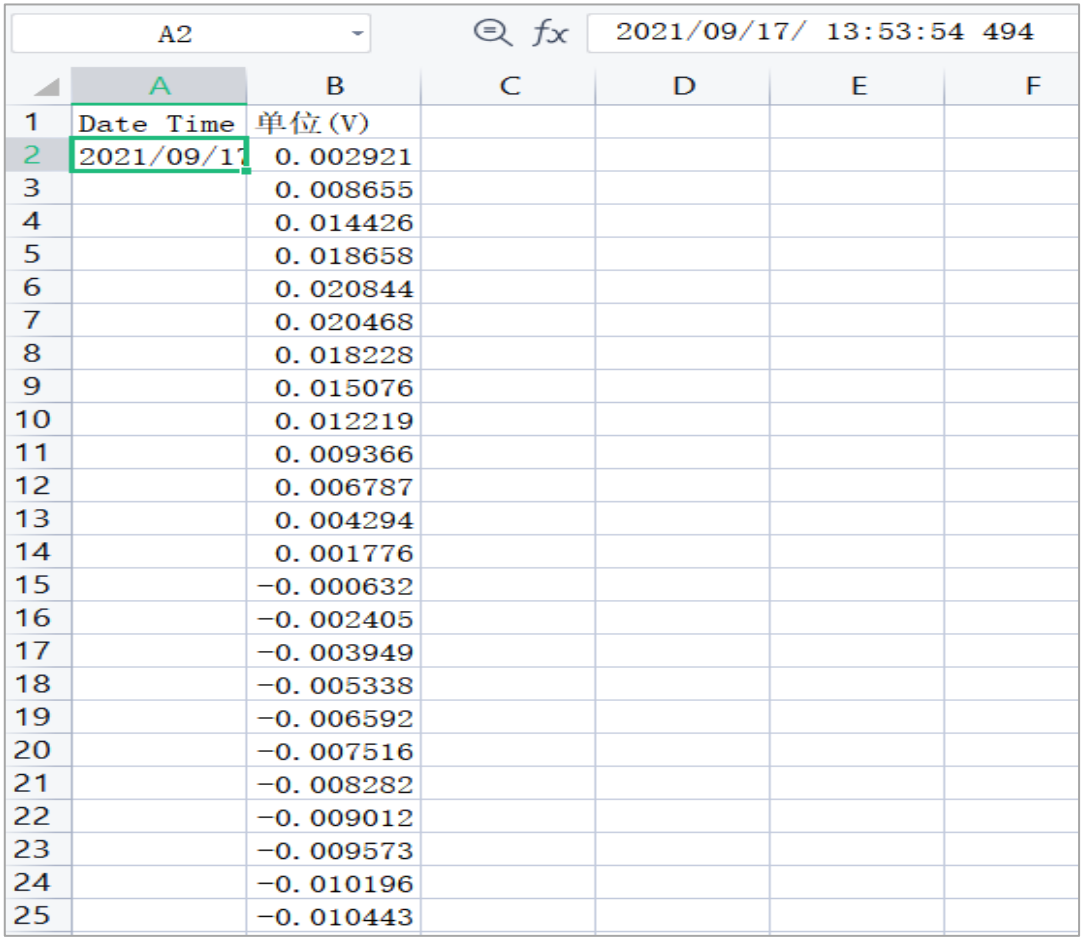


Fig. 6-5 Converting RAE1ToU3H to CSV button

名称	修改日期	类型	大小
qc_raem1_test_06_ae_ndt_16318580...	2021/9/17 14:01	WinRAR ZIP 压缩...	995 KB
qc_raem1_test_06_ae_ndt_16318581...	2021/9/17 14:01	WinRAR ZIP 压缩...	2,057 KB
qc_raem1_test_06_ae_ndt_16318581...	2021/9/17 14:01	WinRAR ZIP 压缩...	2,053 KB
qc_raem1_test_06_ae_ndt_16318582...	2021/9/17 14:01	WinRAR ZIP 压缩...	2,053 KB
qc_raem1_test_06_ae_ndt_16318582...	2021/9/17 14:01	WinRAR ZIP 压缩...	2,052 KB
RAE1_210917135354494.csv	2021/10/13 17:39	XLS 工作表	49,993 KB

Fig. 6-6 CSV file generated after conversion



A2 fx 2021/09/17/ 13:53:54 494

	A	B	C	D	E	F
1	Date Time	单位(V)				
2	2021/09/17	0.002921				
3		0.008655				
4		0.014426				
5		0.018658				
6		0.020844				
7		0.020468				
8		0.018228				
9		0.015076				
10		0.012219				
11		0.009366				
12		0.006787				
13		0.004294				
14		0.001776				
15		-0.000632				
16		-0.002405				
17		-0.003949				
18		-0.005338				
19		-0.006592				
20		-0.007516				
21		-0.008282				
22		-0.009012				
23		-0.009573				
24		-0.010196				
25		-0.010443				

Fig. 6-7 CSV file format

7. Transmission Protocols for Third Party Development

RAEM1 devices can provide local TCP and RS485 interfaces for third party development. Some protocol details are shown below:

7.1 TCP Integration Protocol

The TCP protocol outputs all AE Hit parameters and waveforms.

7.1.1 TCP Mode v2 Network Attributes

- Address: configurable, choose "Use IP" and enter the server IP address and port.
- Port: configurable.
- Communication Protocol: TCP
- Endianness: Little Endian

7.1.2 TCP Mode v2 Parameter Transmission

The TCP mode v2 supports parameter transmission. It needs to turn on the "Send Param" to SWAE server function in the RAEM1 Configuration software.

Fig. 7-1 RAEM1 Configuration software "TCP v2 Send Param" function

The structure of the sent protocol is as follows:

Device ID
amplitude, in dB
Power，in Kpj

RMS，in mV
ASL，in dB
Rise time，in μs
Rise counts
Duration，in μs
Count
Time

7.1.3 U3H Mode Parameter Transmission

The device supports parameter transmission. It needs to turn on the "Send Param" to U3H server function in the RAEM1 Configuration software.

Fig. 7-2 RAEM1 Configuration software "Send Param" function

The protocol format is:

Protocol Header	Device ID	Data Type	Data Length	Data

- Protocol Header: 4 bytes, fixed, 0xA5A5A5
- Device ID: 4 bytes, the last 4 digits of the device ID
- Data Type: 4 bytes, 0x00000000 is parameter data
- Data Length: 4 bytes, length of the data content
- Data Content: parameters

The parameters data format is as followed:

Version	4 bytes
Arrival time (second)	unsigned int, 4 bytes
Arrival time (micro-second)	unsigned int, 4 bytes
AMP (dB)	Double, 8 bytes
Power (kJ)	Double, 8 bytes
RMS (mV)	Double, 8 bytes
ASL (dB)	Double, 8 bytes

Rise time (μs)	unsigned int, 4 bytes
Rise Ring-down counts	unsigned int, 4 bytes
Duration (μs)	unsigned int, 4 bytes
Ring-down counts	unsigned int, 4 bytes

7.1.4 U3H Mode Waveform Transmission

The device supports waveform transmission. It needs to turn on the "Send Wave" to U3H server function in the RAEM1 Configuration software.

Fig. 7-3 RAEM1 Configuration software "Send Wave" function.

The protocol format is:

Protocol Header	Device ID	Data Type	Data Length	Data

- Protocol Header: 4 bytes, fixed, 0xA5A5A5
- Device ID: 4 bytes, the last 4 digits of the device ID
- Data Type: 4 bytes, 0x00000001 is waveform data
- Data Length: 4 bytes, length of the data content
- Data Content: waveform

The waveform data contents format is:

Arrival time (second)	unsigned int, 4 bytes
Arrival time (micro-second)	unsigned int, 4 bytes
Version	4 bytes
Waveform points	unsigned int, 4 bytes
Sample speed (K/S)	unsigned int, 4 bytes
Gain, preamplifier, in unit of times	unsigned int, 4 bytes
Enlarge, circuit magnification, in unit of times	Double, 8 bytes
N numbers of waveform data	Each waveform has 2 bytes, i.e., there are 2N numbers of waveform data with

	2N bytes of data size.

7.2 485 Integration Protocol

7.2.1 485 Interface Attributes

- Baud rate: 57600
- Bits: 8
- Stop bit: 1
- Verification: none
- Flow control: none
- Endianness: Little Endian

7.2.2 485 Master Mode

As the 485 Master to send data, it needs to turn on the "485 Send Param" function in the RAEM1 Configuration software:

Fig. 7-4 RAEM1 Configuration software "485 Send Param" function

The protocol format is:

Protocol Header	Protocol Content	CRC Verification	Protocol End

- Protocol Header: 4 bytes, 0xA5A5A5A5
- Protocol Content: depends on the detail protocol. See the end of the protocol. The device generates parameters data.
- CRC verification: 2 bytes, the CRC value is specified for this protocol content. Refer to the verification program at the end of this protocol.
- Protocol End: 4 bytes, 0xFCFCFCFC

7.2.3 485 Slave Mode

As the 485 Master to send data, it needs to turn on the "485 Control" function in the RAEM1 Configuration software:

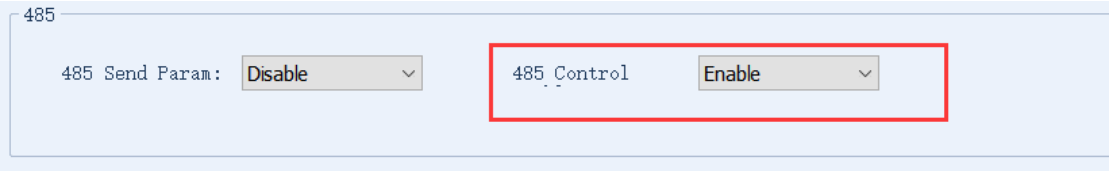


Fig. 7-5 RAEM1 Configuration software "485 Send Param" function

The protocol format is:

Protocol Header	Protocol Content	CRC Verification	Protocol End

- Protocol Header: 4 bytes, 0xA5A5A5A5
- Protocol Content: depends on the detail protocol. See the end of the protocol. The device controls data messages.
- CRC verification: 2 bytes, the CRC value is specified for this protocol content. Refer to the verification program at the end of this protocol.
- Protocol End: 4 bytes, 0xFCFCFCFC

7.2.4 485 Master Slave Mode

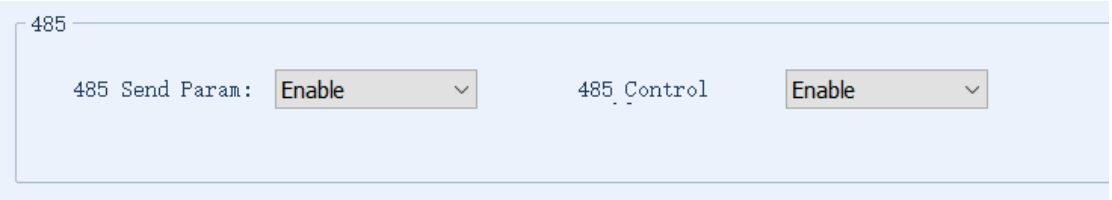


Fig. 7-6 RAEM1 Configuration software 485 functions

When enable the parameter sending and 485 control functions at the same time, the device will enter the Master/Slave mode, which it switches in between these two modes automatically. The communication process in this mode is:

1) it runs in Master mode by default, which means it keeps sending parameter data out;

2) for every 5 seconds, it sends out a switch mode command to inform that it is going to switch to the slave mode for control command transmissions. Once the slave receives the control command, it needs to send out the control command in 1 second, which means the master wait time is for only 1 second.

Please see the mode switching commands at the end of the protocol;

3) After finishing one slave mode reception, it switches back to master mode and starts to send out data again.

7.2.5 485 Wire Connection

4-core Wire	Signals
Red	+12V
Black	Ground
Yellow	485A
Green	485B

We made a test program to test the 485 communications before the shipment.

1) Make sure the 485 is enabled in the configuration software:

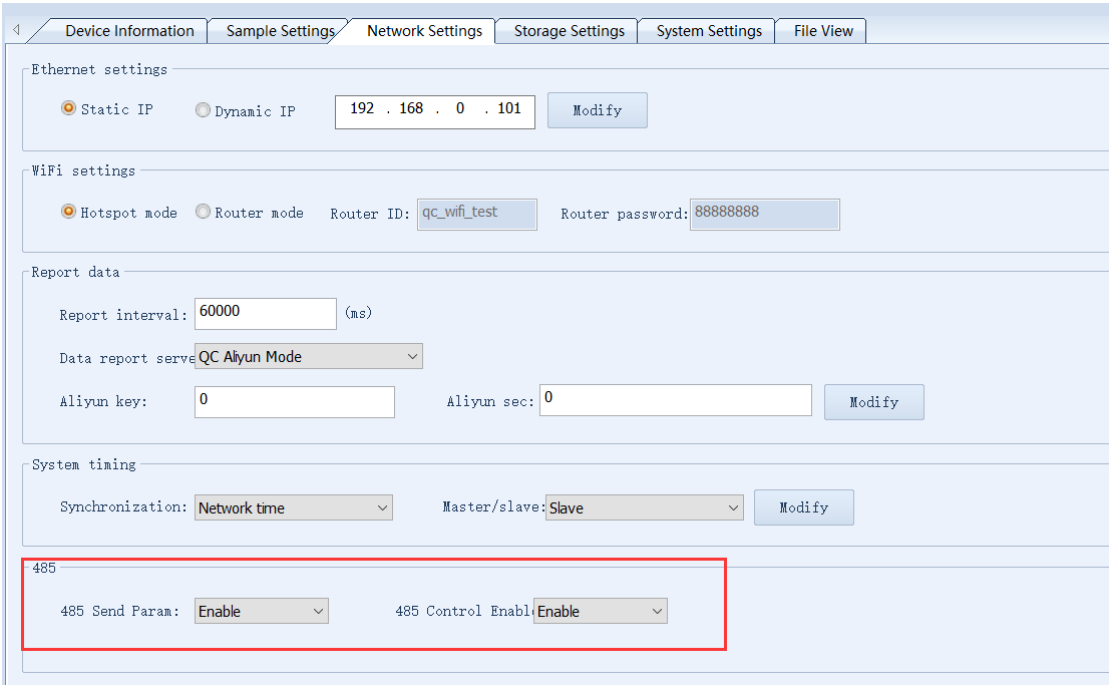


Fig. 7-7 RAEM1 Configuration software for 485

2) After hardware connection and turning on the RAEM1, it will automatically send in the data.

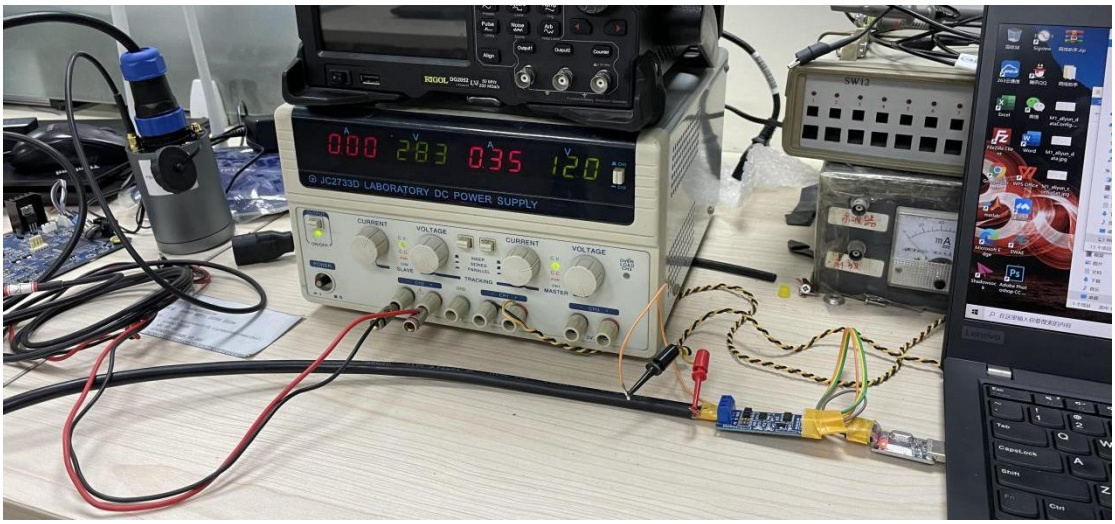


Fig. 7-8 RAEM1 485 hardware test setup

3) In our test program, the data were interpreted and displayed in the window:

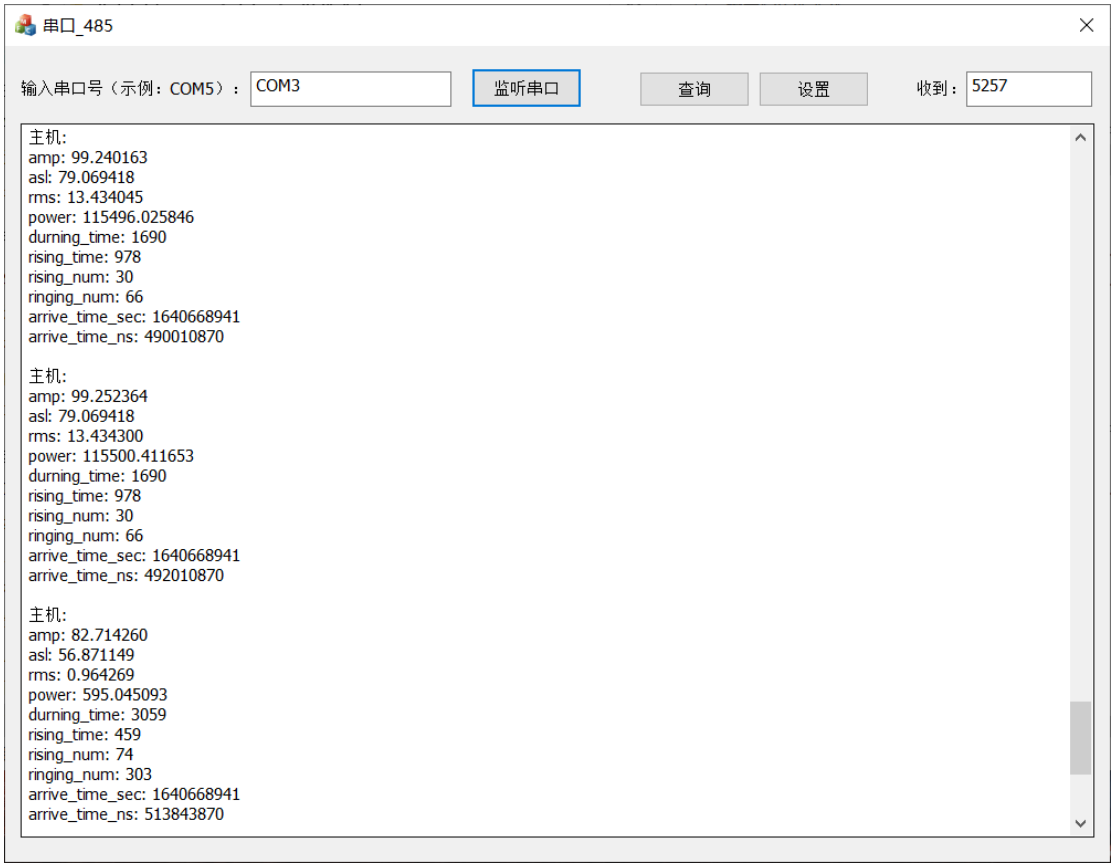


Fig. 7-9 RAEM1 485 serial test software example as Master

4) When we requested to read the configurations, it returned the configuration setups:

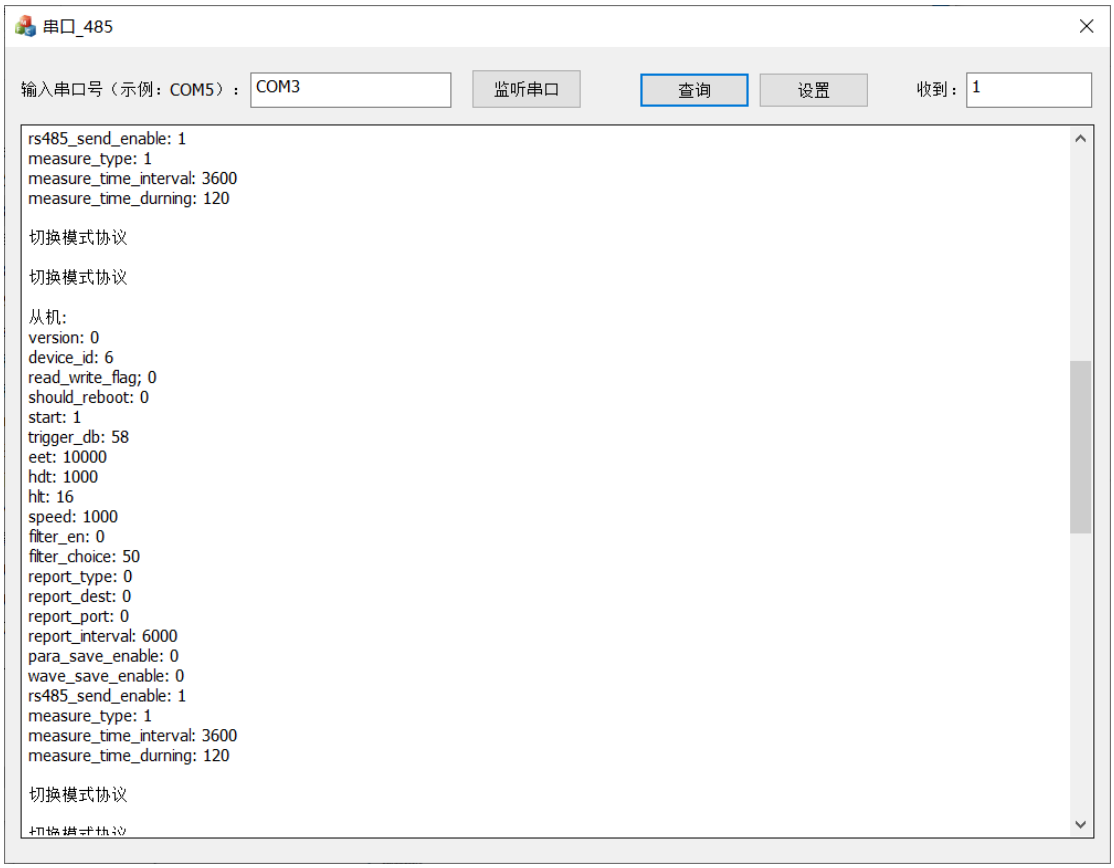


Fig. 7-10 RAEM1 485 serial test software example as Slave

5) The baud rate of RS485 protocol in REAM1 is 57600 bps. Theoretically, there are maximum 100 groups of data per second. During our tests, we sent 500 pulses per second for 10 seconds and it received all 5000 groups of data but it took more than 10 seconds to receive. So if there are more 100 groups of data per second, it would take extra time to receive data after the pulses are sent and it might loss some data over time if there are too many data sending for a long period.

Please contact Qingcheng company for up-to-date detail protocols.