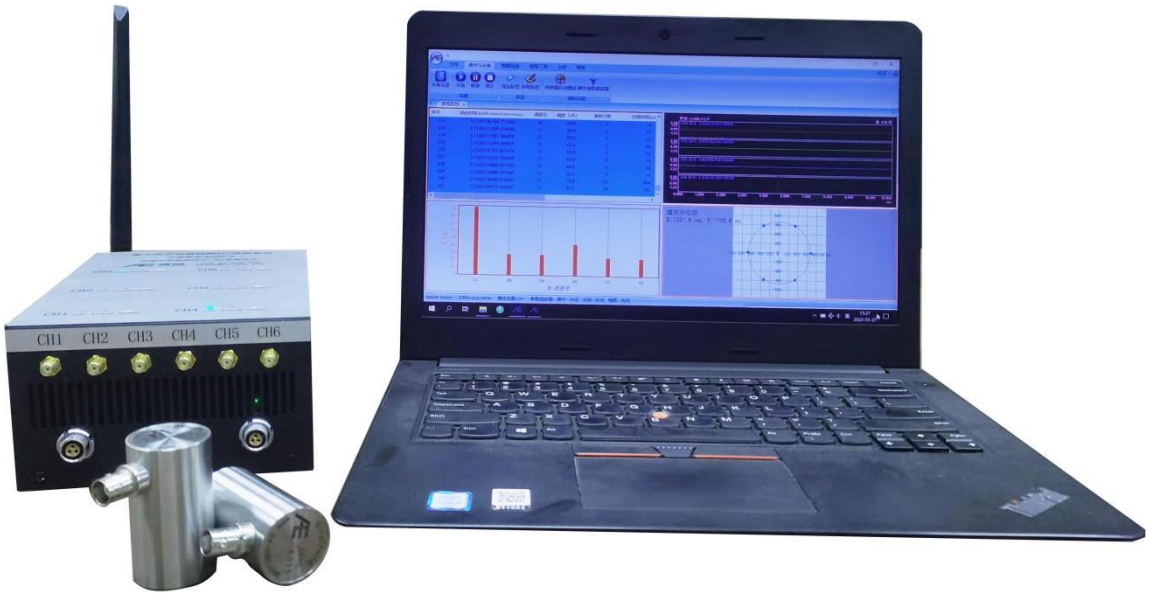
RAEM1-6 USER'S MANUAL

Operation Guide



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QAWRUMS (QingCheng AE Institute)
www.aendt.com
E-mail：sales2@ae-ndt.com
WeChat: 19128609186
Tel：(+86)19128609186
Contact: Jessica Jia
Skype: jessicajia

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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.

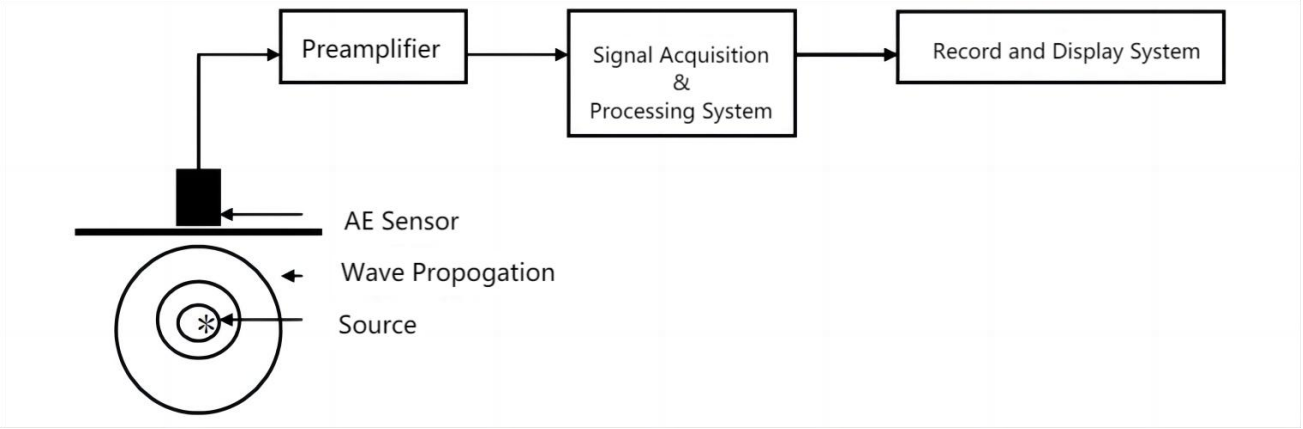


Fig. 1-1 Block diagram of acoustic emission testing principle

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.

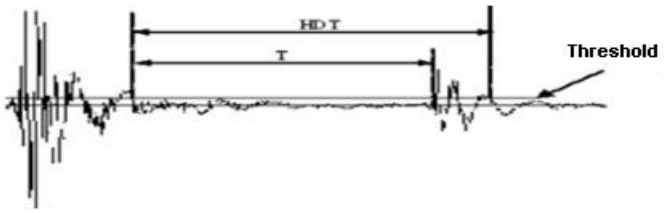


Fig. 1-2 HDT definition diagram

(16) **HLT**: Hit lock time, in unit of micro-second (μs). The setting range is 1 ~ 20,000,000 (positive integer) in the software, and 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.

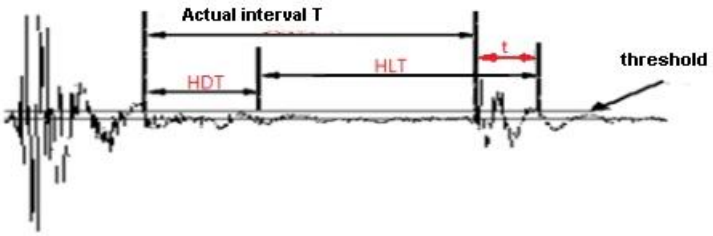


Fig. 1-3 HLT definition diagram

(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 4G/Wi-Fi/Ethernet built-in, and supports IoT operations, such as cloud data storage and cloud data reporting.

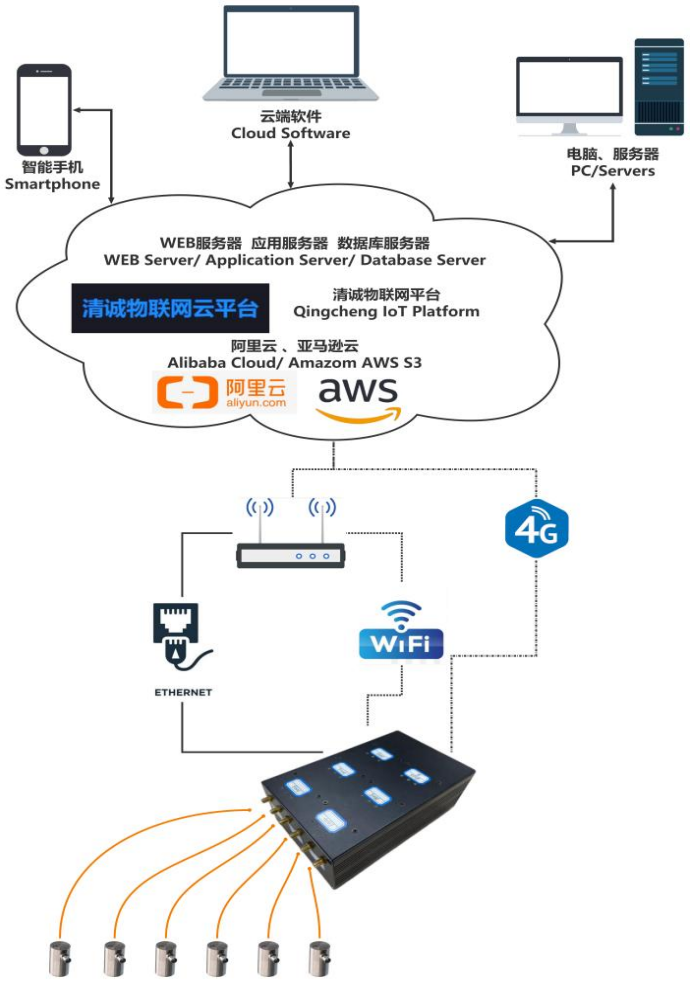


Fig. 2-1 RAEM1-6 IoT AE system

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) 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.

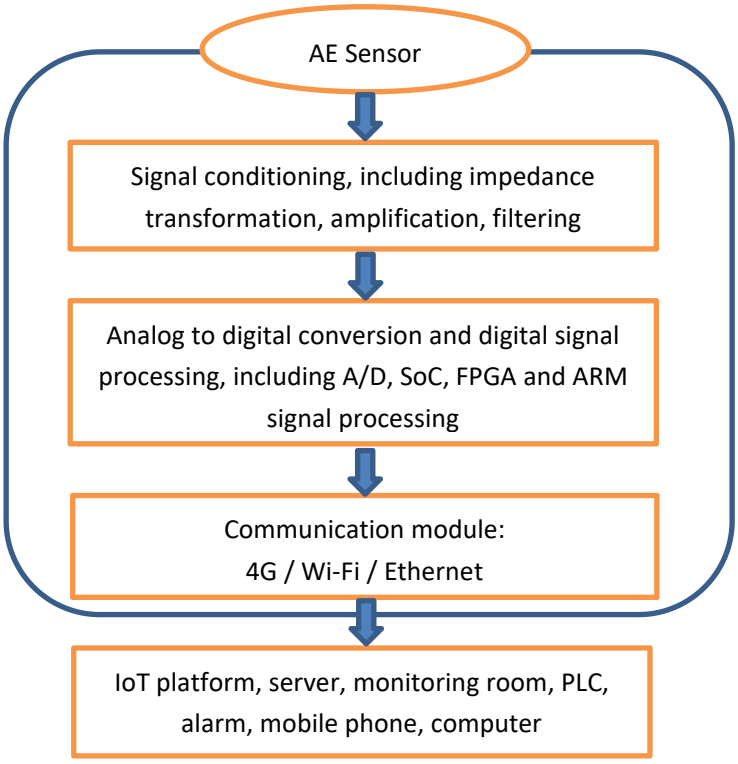


Fig. 2-2 RAEM1 Functional modules flow diagram

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.

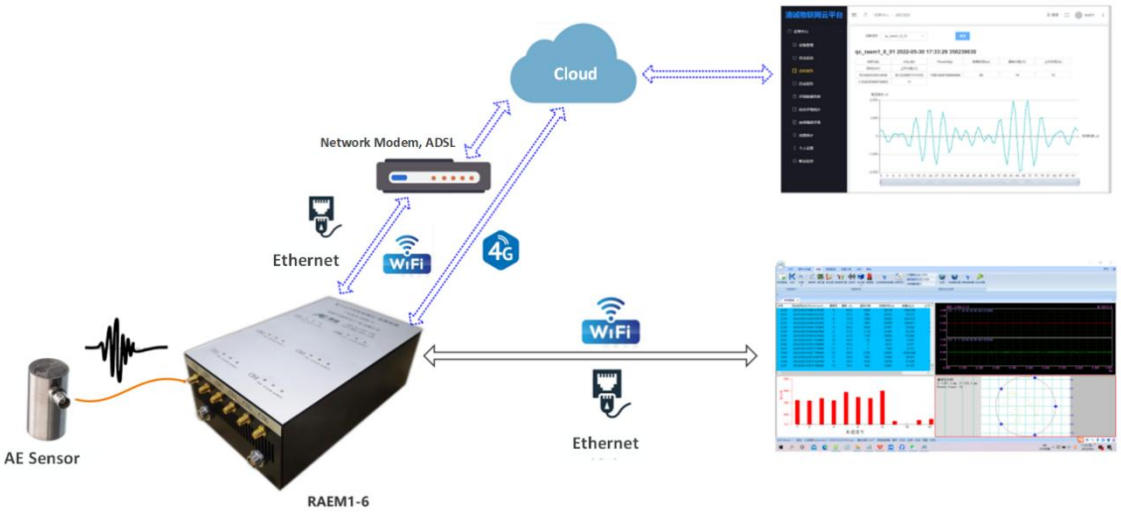


Fig. 2-3 RAEM1-6 Various connection modes

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.

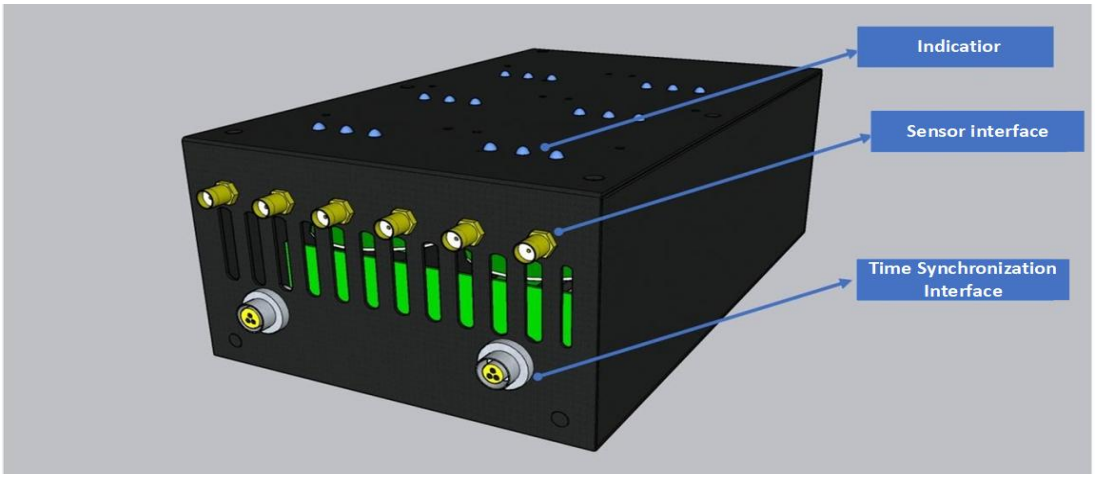
The RAEM1-6 panel is shown in Figure 2-5:

- **(State) indicator lights:**
  - 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: interfaces for cascade connection, the two interfaces don't have connection orders;

- Antenna interface: connect to the 4G antenna;
- Power switch: turning on and off the device;
- Electrical socket: connect the 12V/ 5A power adapter.
- Network port: connection Ethernet cables;
- IoT SIM card slot: you can insert the IoT 4G SIM card.

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

Fig. 2-4 RAEM1-6 hardware package



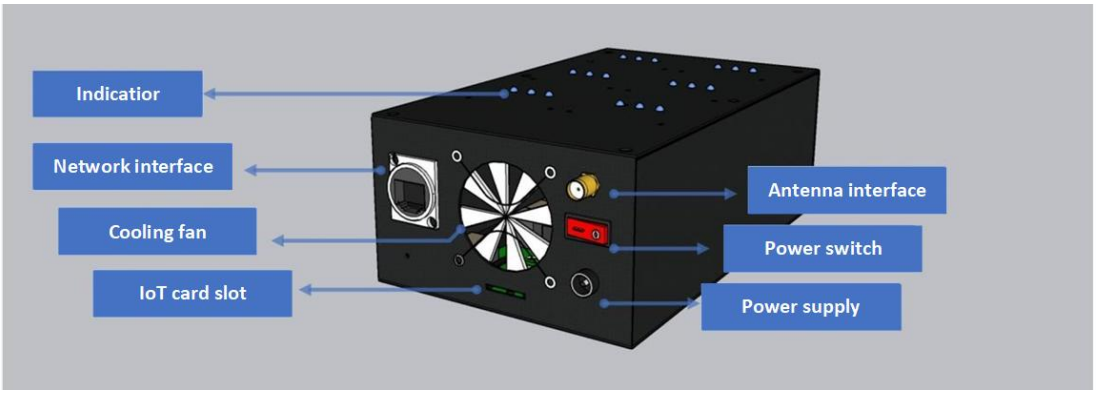


Fig. 2-5 Front and back panels of the RAEM1-6

2.3 Technical Specifications

- Multi-channel AE input, can be cascaded to many channels;
- Sampling rate max at 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: 0KHz to 1000KHz frequency range any value set pass-through, high-pass, low-pass, band-pass (a combination of analog filter use);
- Original waveform or filtered waveform data;
- Acoustic emission characteristic parameters, including the arrival time, amplitude, counts, energy, rise time, rise counts, duration, RMS, ASL, peak frequency, centroid frequency and five partial power spectrum;
- 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 series cascade connect to a large system; 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;
- External power supply, power adaptor outputs 12V DC;
- Operational temperature: LAN: -20℃~60℃; Wi-Fi: 0℃~60℃
- Dimensions: length x width x height: 22cm x 13cm x 8cm
- Weight: 1.6kg

2.4 Quick Start of RAEM1-6

RAEM1-6 can be used as two different systems, one is as an **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) Read the RAEM1-6 label on the side of the case to figure out the matching power adaptor, preamp and sensor specs. For example the RAEM1-6 with the side label below is suitable to connect to the sensors at around 40kHz resonant frequency and the preamp voltage at 5V. There are six channels, from 1 to 6. The WiFi Hotspot name is RAEM1-5V-1 and the WiFi Hotspot IP address is 192.168.0.1.

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

Note: The input power supply to the RAEM1-6 should be 12V/5A so check the power adaptor output. The sensor type is normally the integral sensor with built-in preamplifier. The RAEM1-6 supplies power voltages to the preamplifier and it can be 5V, 12V or 28V. Therefore check the preamp voltage before connecting to RAEM1-6 to avoid over voltage burning the preamp in the sensor. The analog filters in

RAEM1-6 also require the sensor frequency range to match. So check the sensor frequency range before connection. Please pay attention to the case side label.

2) Connect the power adapter to the power port of RAEM1-6. The other end of the power adapter is connected to the electric supply.

3) Connect the sensor and the sensor connector of RAEM1-6 with a coaxial cable. The sensor is recommended to be the 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 confirm the connected sensor frequency and preamp voltage.

4) Turn on the RAEM1-6 power switch and wait until the **POWER** light (yellow LED) is steady on and the **RUN** light (green LED) flashes.

5) Users can connect to and use the software or the cloud platform according to the test purpose and the 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 the signal collection and the communication connection according to the existing configuration and hardware connection. You can open the configuration software of RAEM1-6 through the provided communication mode and modify and update the configurations. Some communication modes support the real-time parameter viewing and analysis, or the 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 configurations, you are advised to save the original factory configuration file to the computer and then change the configurations.

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 hits, no packet is generated. The data is stored on a local SD card or is 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.

- **SWAE:** 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

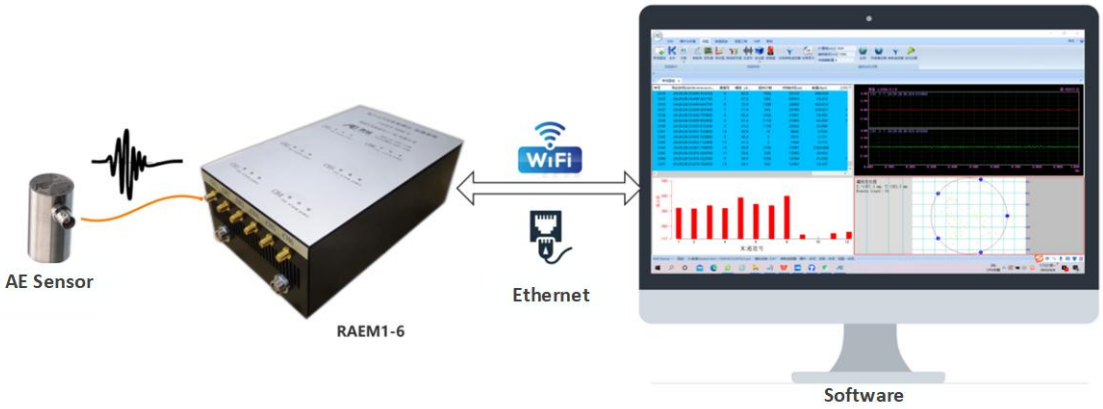


Fig. 3-1 Connection diagram of RAEM1-6 desktop detector

The RAEM1-6 sound wave (acoustic emission) can be used as a bench detector. That is, RAEM1-6 does not directly 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 the "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

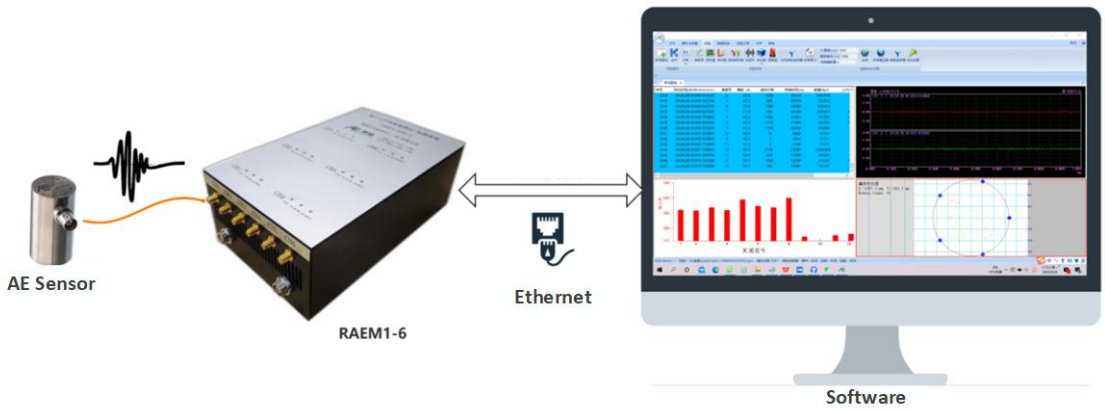


Fig. 3-2 Connecting a network cable to a RAEM1-6 desktop detector

RAEM1-6 can be directly connected to a PC for configurations 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

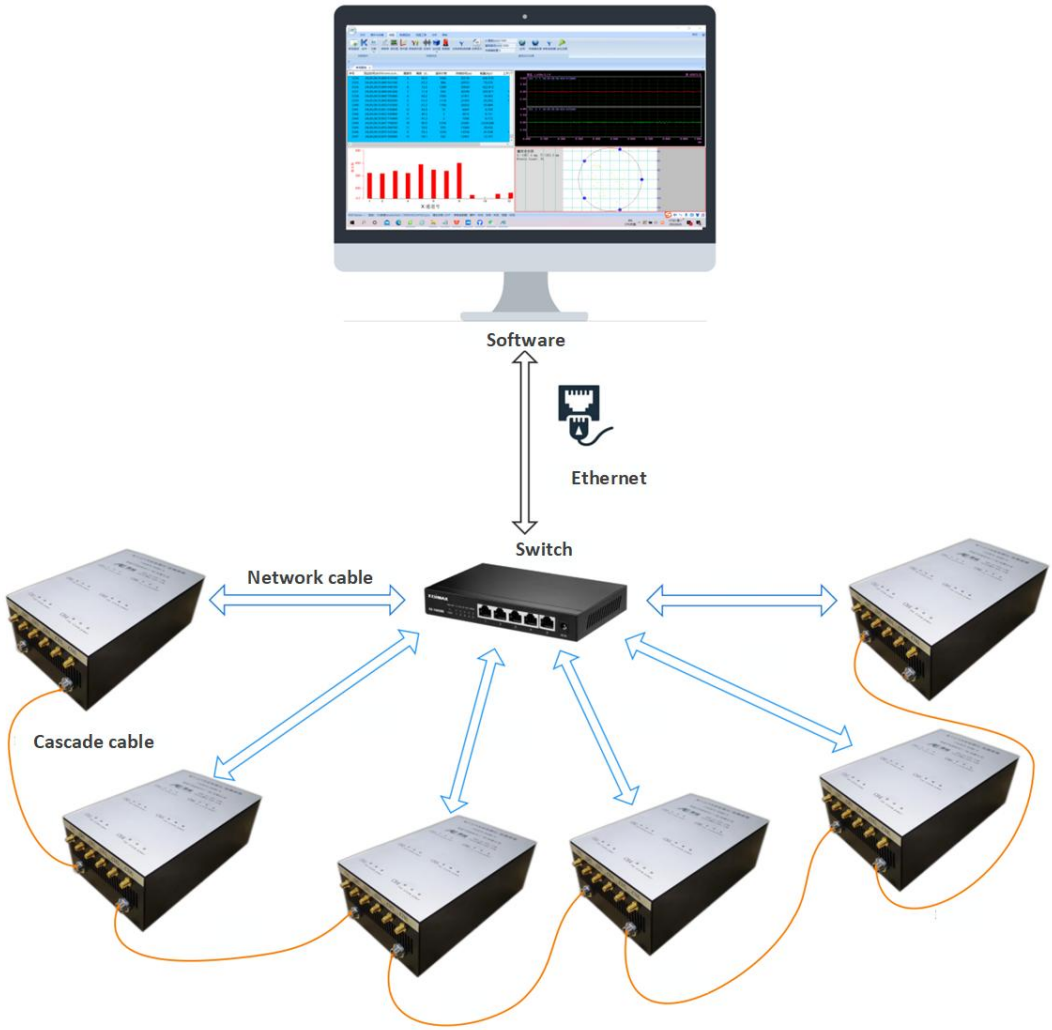


Fig. 3-3 Network connection of a RAEM1-6 desktop monitor

If multiple RAEM1-6 networks need to be connected at the same time, RAEM1-6 networking is required. Connect each of these RAEM1-6 to the switch with Ethernet 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 the clock synchronization by connecting multiple RAEM1-6 in series with cascade cables. Each RAEM1-6 has two clock synchronization interfaces. Connect one end of the cascading cable to any one of the clock synchronization interfaces of RAEM1-6, and connect the

other end of the cascading cable to one clock synchronization interface of another RAEM1-6 to cascade the two RAEM1-6. Cascade all required RAEM1-6 in series.

Before delivery, the master/slave mode of the channel is set for the clock time synchronization. Users do not need to perform such 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 configurations of the computer.

Each channel of the RAEM1-6 has an Ethernet static IP Address, which should look like **192.168.0.xxx**, For example, the IP should be 192.168.0.101 goes up to 192.168.0.106. Each static Ethernet IP address is the unique address to find each channel. So it is not recommended to change the Ethernet static IP addresses of the RAEM1-6.

To communication the RAEM1-6 with the computer, it is necessary to configure the computer to be at the same communication segment with RAEM1-6. You can configure Ethernet attributes of the computer 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.
- **TCP/IPv4 addresses configure to 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". Note that "XX" can be any number but NEVER can be the same as any channel IP address of RAEM1-6 because it will cause communication conflicts. So for instance, you can enter "192.168.0.20". The subnet mask is "255.255.255.0". The default gateway is "192.168.0.1". Click "OK".

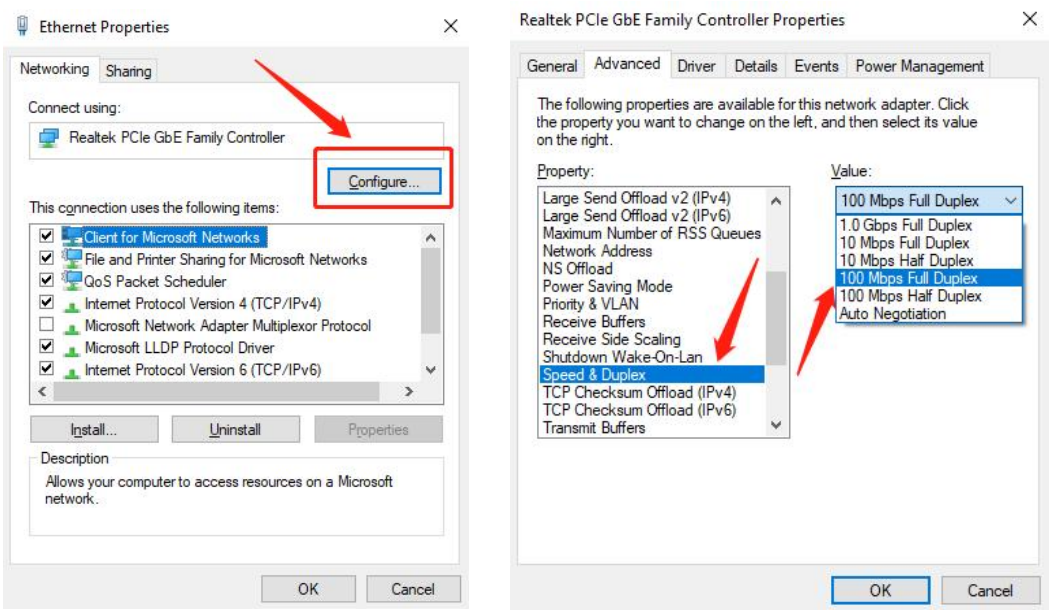


Fig. 3-4 Setting the Ethernet full-duplex mode

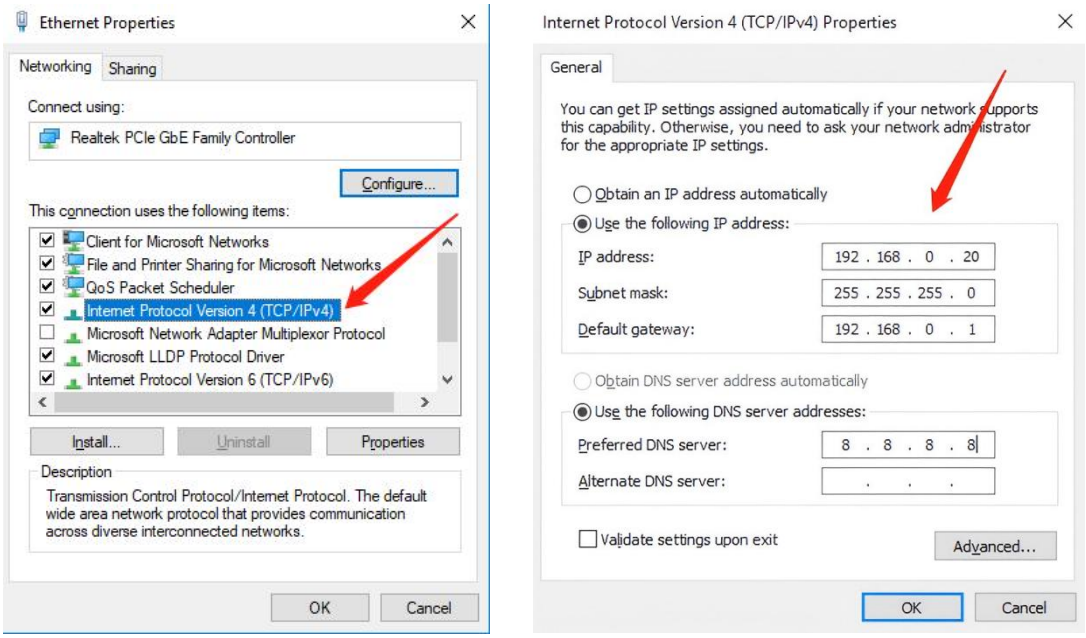


Fig. 3-5 Setting the Ethernet network segment

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 Hotspot signal. You are advised to use Hotspot connection only for settings. Open the Wi-Fi list of your computer, and find the Wi-Fi name with the same name as "the Wi-Fi" on the side label of RAEM1-6 to connect. The default password is 88888888.

After the connection is successful, all channels of RAEM1-6 should be 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

RAEM1-6 doesn't support wirelessly connecting to the WiFi router. So the WiFi "Router" mode is not available in RAEM1-6.

If you want to use WiFi to transmit data, use the Ethernet cable to connect RAEM1-6 to the WiFi router, then the data can be transmitted from the router to the computer or server via WiFi.

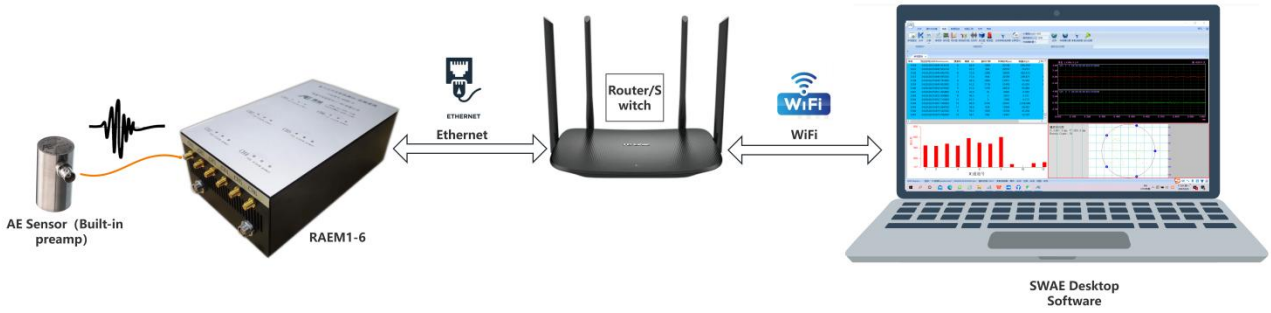


Fig. 3-8 RAEM1-6 router connection diagram

3.2.2 Multiple RAEM1-6 Wi-Fi connections

Fig. 3-9 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 or the Ethernet cable.

The Wi-Fi router also needs to be configured. There are two methods to make the router configurations.

	RAEM1-6	WiFi Router	Computer
1	Static IP: 192.168.0.101 to 106	Use a fixed IP: e.g. 192.168.0.50	Use a fixed IP: e.g. 192.168.0.20
2	Change the static IP to dynamic IP and obtain IP from the router	Automatically assign IP address to devices	Obtain IP automatically from the router

Table 3-1 RAEM1-6 Networking IP Configuration Methods

Method 1 means the router must be configured to the network segment "0" same as the RAEM1-6 static Ethernet IP, which should be 192.168.0.xxx. But "xxx" cannot be the same the IP as RAEM1-6 channels. So it is recommended to be 192.168.0.50 to avoid conflicts. The computer Ethernet IPv4 address also should be a fixed IP, for example 192.168.0.20.

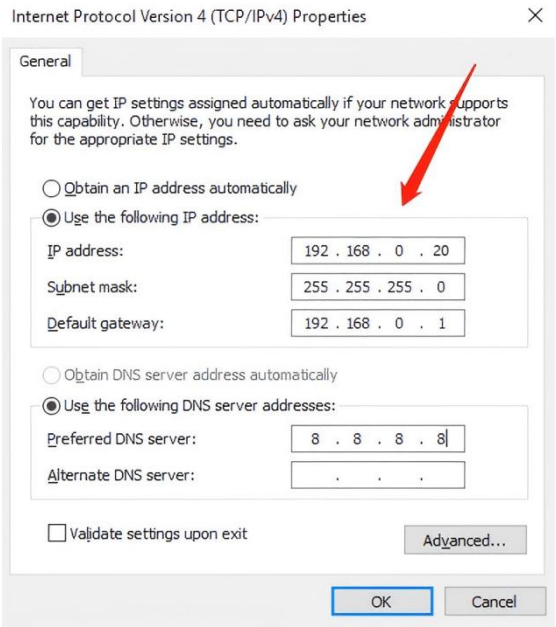


Fig. 3-10 Computer IPv4 modification

For method 2, the router can set to automatically assign IP addresses to devices. In that case, RAEM1-6 Ethernet IP should be changed to "Dynamic" IP instead of static. And the computer should also

be changed to obtain IP automatically. One problem with Method 2 is if in some case, the RAEM1-6 needs to directly connect to computer through Ethernet cable afterwards, RAEM1-6 and the computer should both change the IP addresses to static IP again using the router before the direct connection.

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 RAEM1-6 wireless settings or the terminal servers etc. To do that, it needs to connect RAEM1-6 to the computer through the **Ethernet cable** and use this configuration software to start configuring.

⚠ To use "RAEM1 Configuration" software, **the firewall 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.

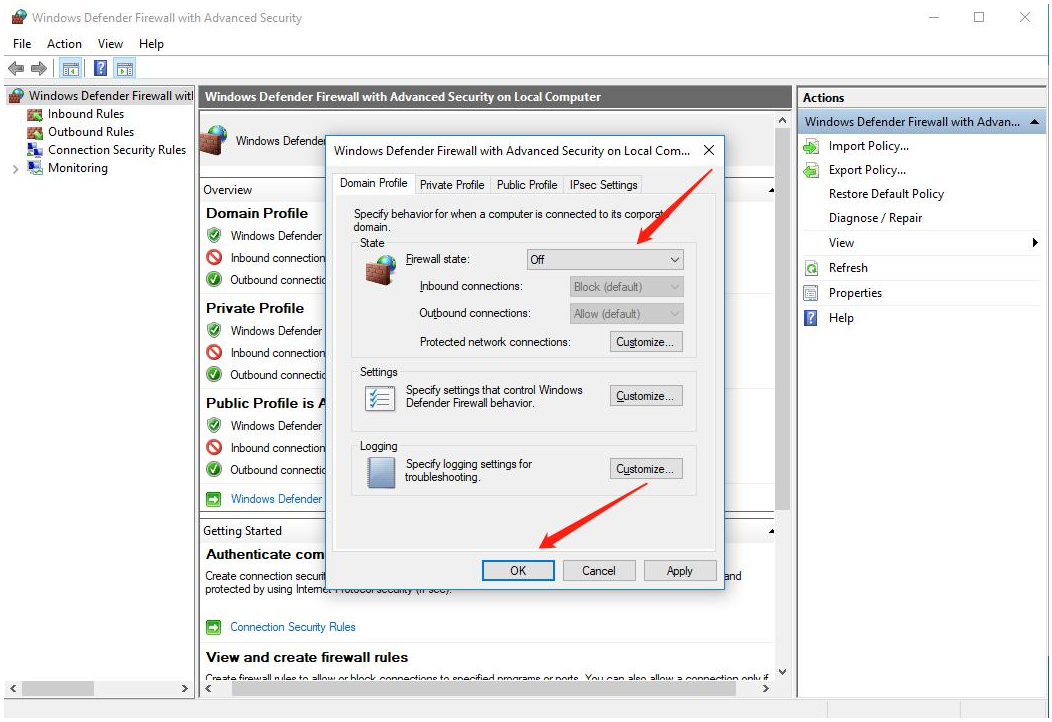


Fig. 3-11 Disabling the firewall.

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.

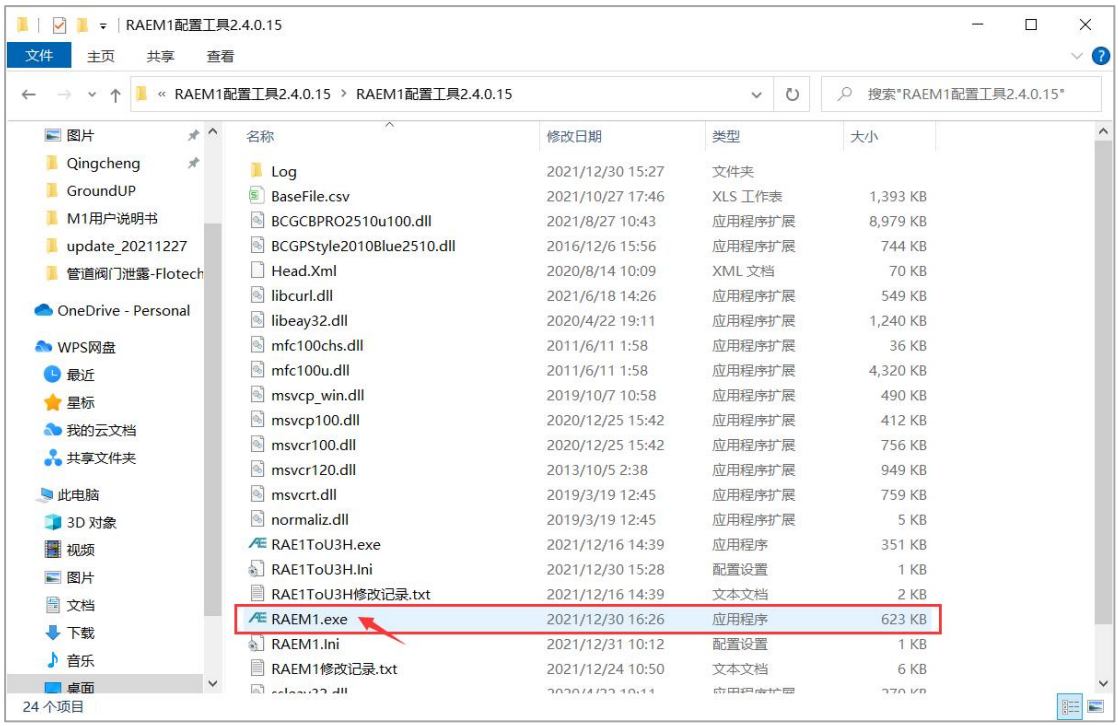


Fig. 3-12 RAEM1 Parameter configuration software executable file

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".

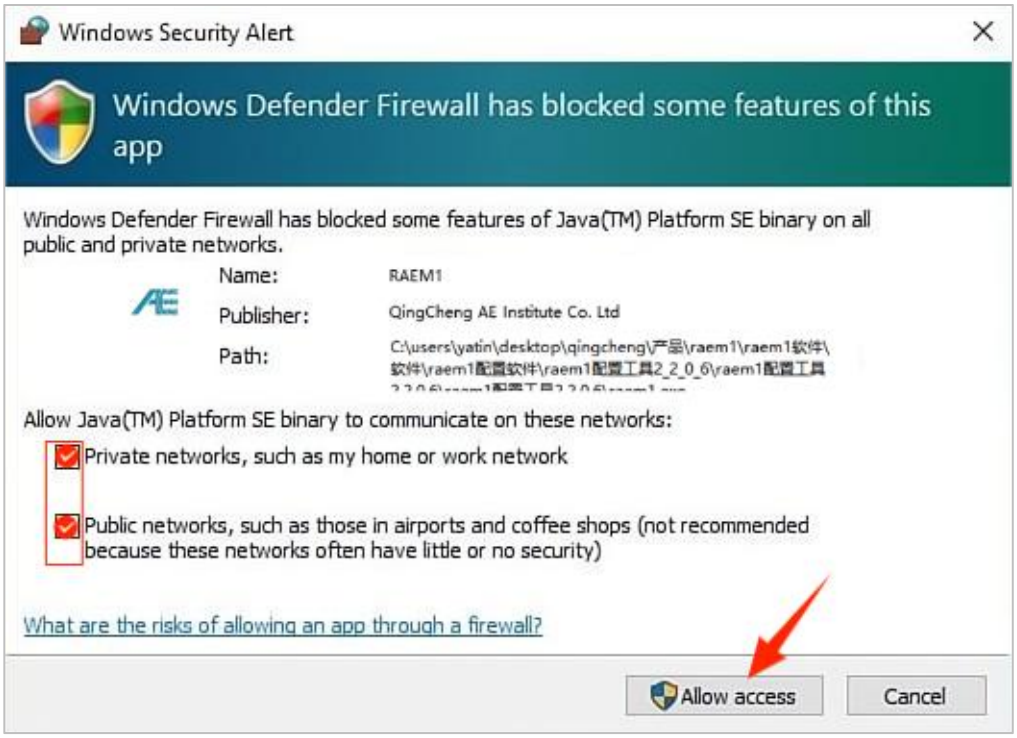


Fig. 3-13 Firewall Security Alert

② The "RAEM1 Configuration" software main interface is as shown in the figure below. 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.

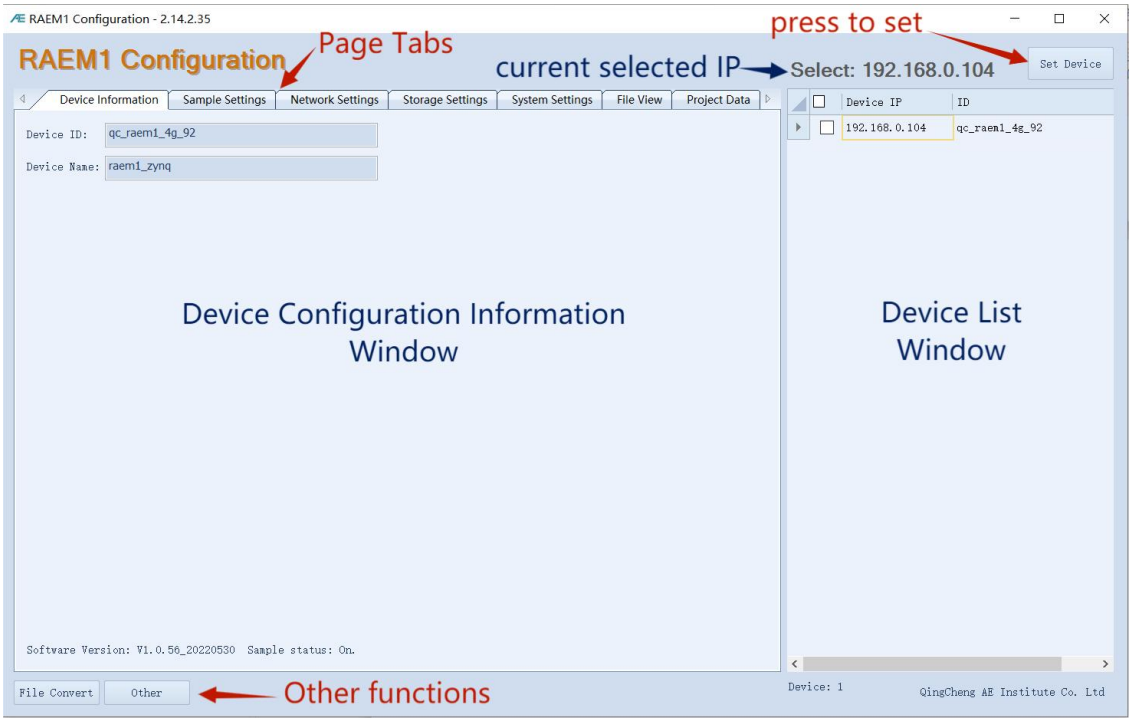


Fig. 3-14 RAEM1 Configuration Main Interface

③ The software should automatically list all the connectable RAEM1-6 channels 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 channel is offline and it losses connection to the software currently. Follow the steps below to debug some common situations:

a. If a desired RAEM1-6 channel is not on the list, please check whether the "RUN" light of the channel 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, please check and debug the problems based on the connection methods mentioned in Section 3.2.

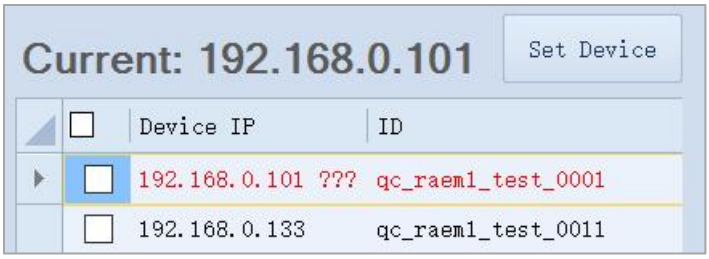


Fig. 3-15 RAEM1 Configuration Tool Device Offline

④ If you want to change the configuration settings, please first check the checkbox of the channels

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 channels and take effects immediately. When multiple channels 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 channels for batch operations.

⑤ The buttons in the "**System Setting**" page (see the red rectangle below) only take effects on the current selected channel (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 channels, you can right click on the device list to select the batch function in the context menu after selecting multiple channels to be updated.

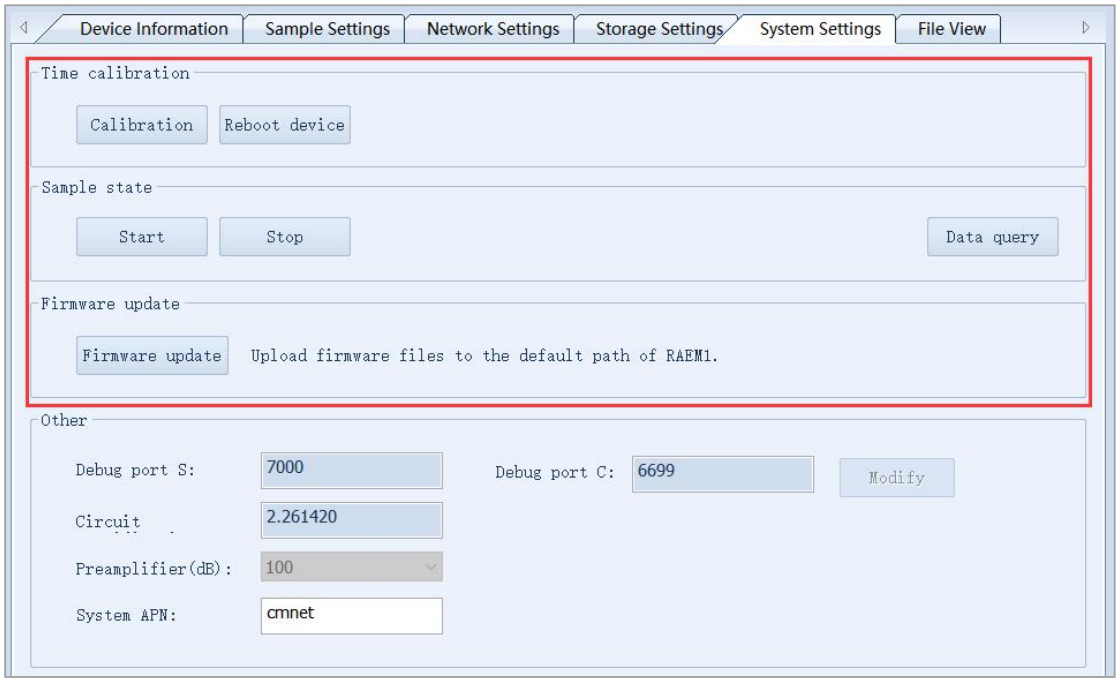


Fig. 3-16 RAEM1 Configuration Software System setting buttons

⑥ In the device list, right click to show the context menu. The context menu is only effective on the selected channels 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 (with a transmitter sensor). 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.

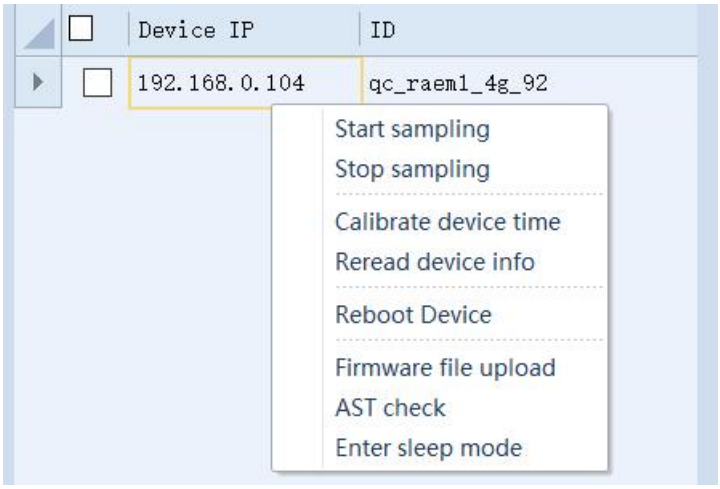


Fig. 3-17 RAEM1 Configuration Software context menu

⑦ In the "**Network Settings**" page, the "**Modify**" button is only able to modify the current selected channel 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 shown below. Click the "**Setup**" button to send the channel. No need to click "**Set Device**" button after.

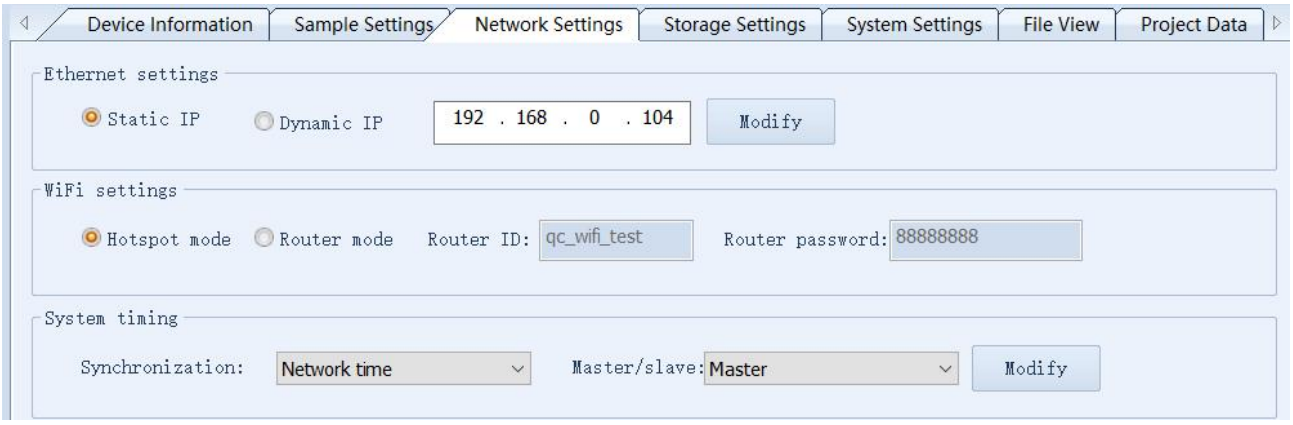


Fig. 3-18 RAEM1 Configuration Software "Modify" button

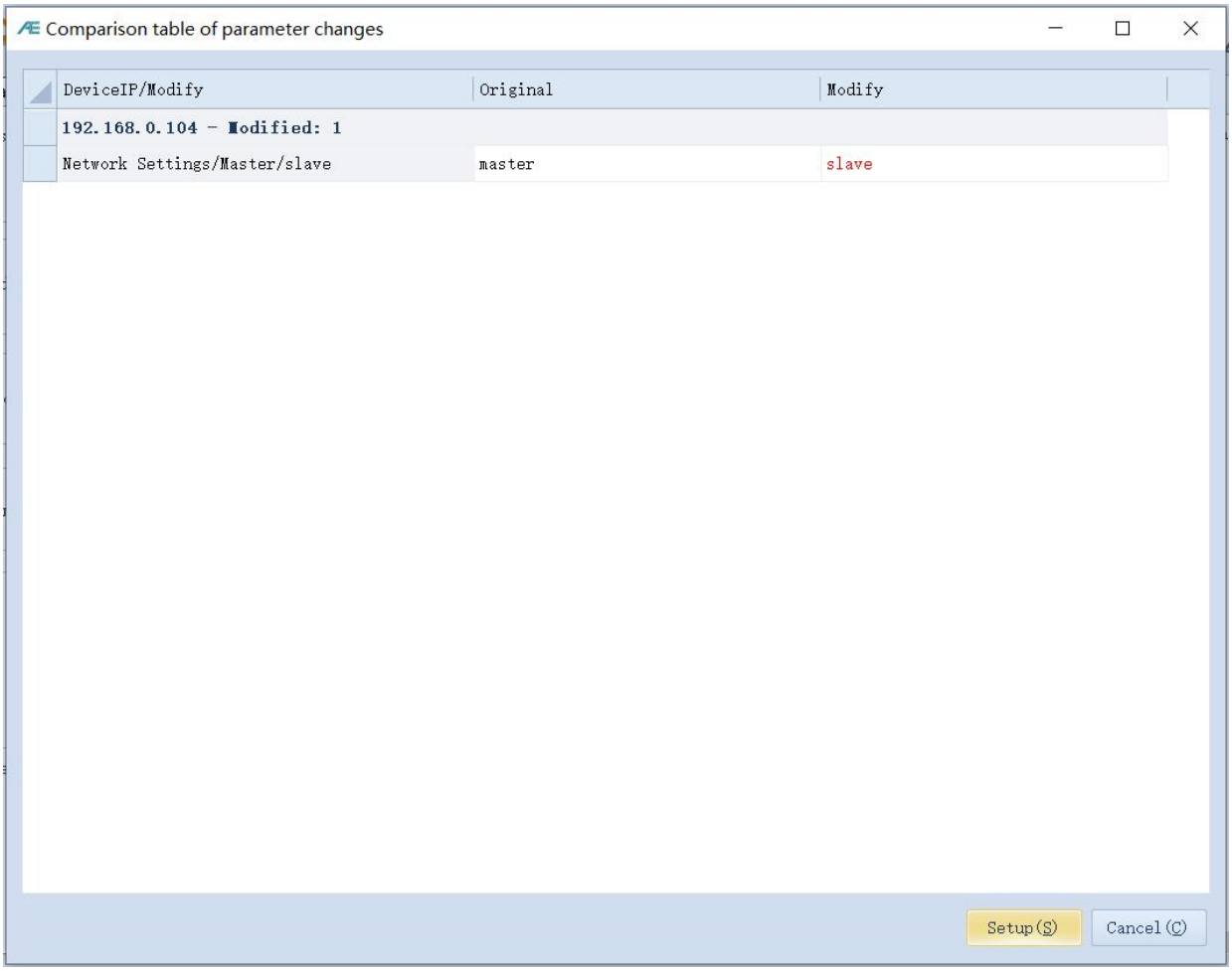


Fig. 3-19 RAEM1 Configuration Software "Modify" Confirmation window

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 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 (unit of K/s), 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.

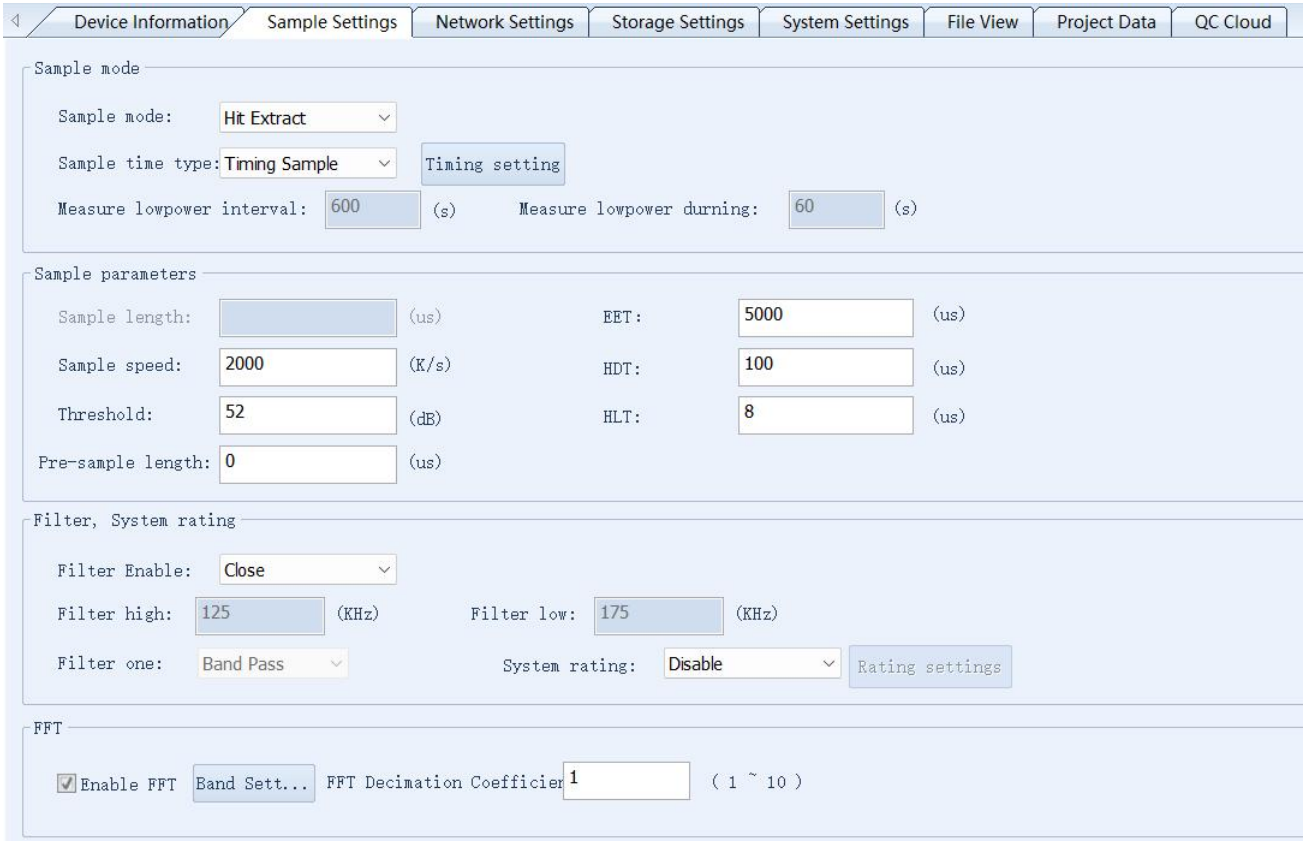


Fig. 3-20 RAEM1 Configuration software Sample Settings page

- **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.

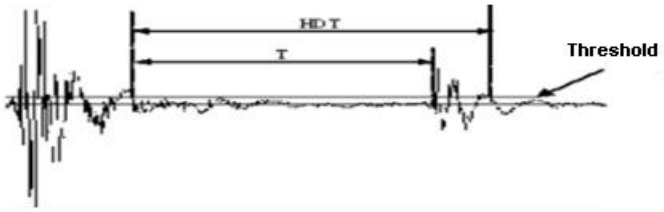


Fig. 3-21 HDT definition diagram

- **HLT**: Hit lock time, in unit of micro-second (μs). The setting range is 1 ~ 20,000,000 (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.

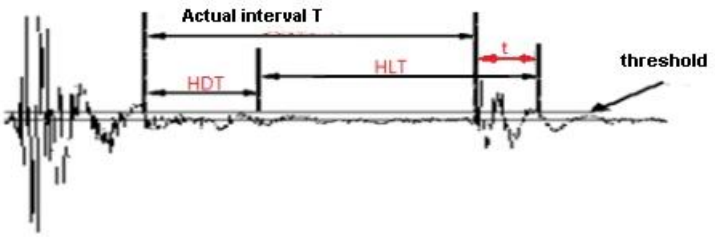


Fig. 3-22 HLT definition diagram

- **Pre-sample Length (us)**: collect a segment of data before the acoustic emission signal crosses the threshold, with the data length unit in microseconds. This setting is only effective for generating waveforms and does not affect parameter generation.

3.3.2.2 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.

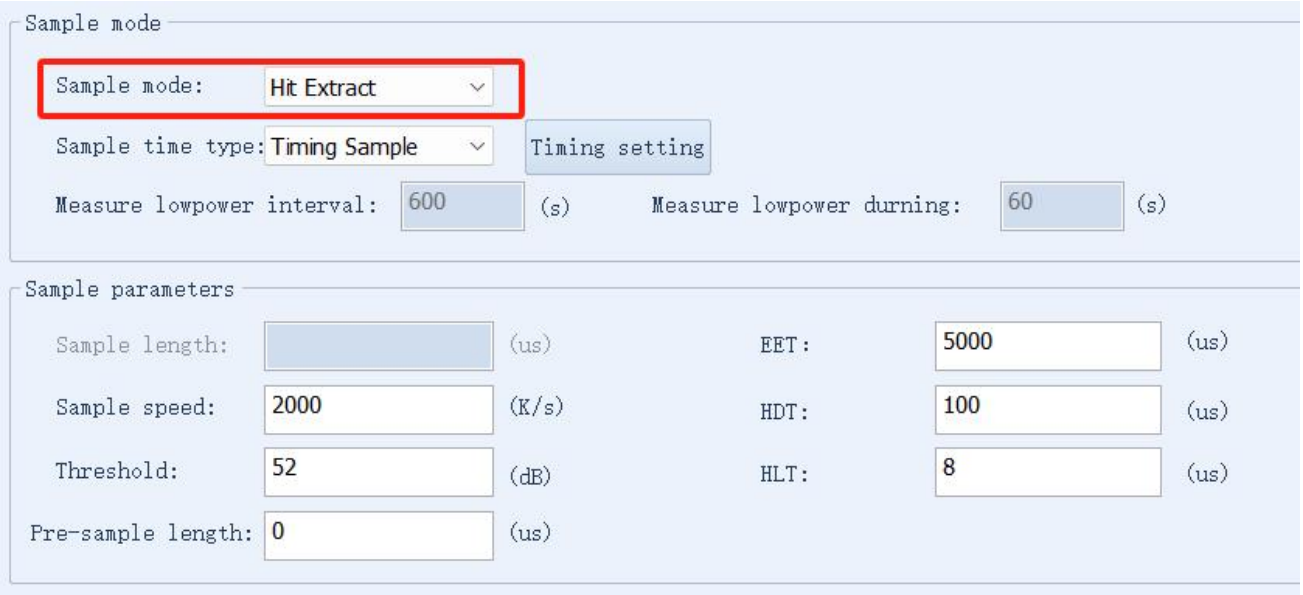


Fig. 3-23 Sample Mode - Hit Extract Mode

- **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.

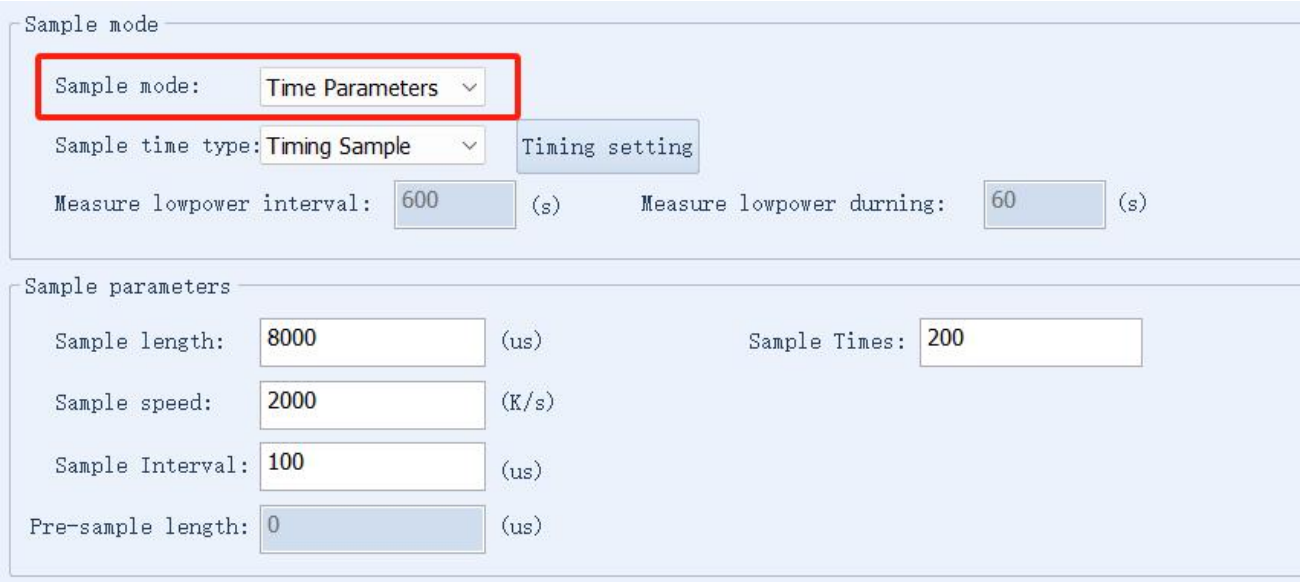


Fig. 3-24 Sample Mode - Time Parameters Mode

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. 3-25 Hit Extract Mode - Timing Sample

Click "Timing setting" to add acquisition time periods:

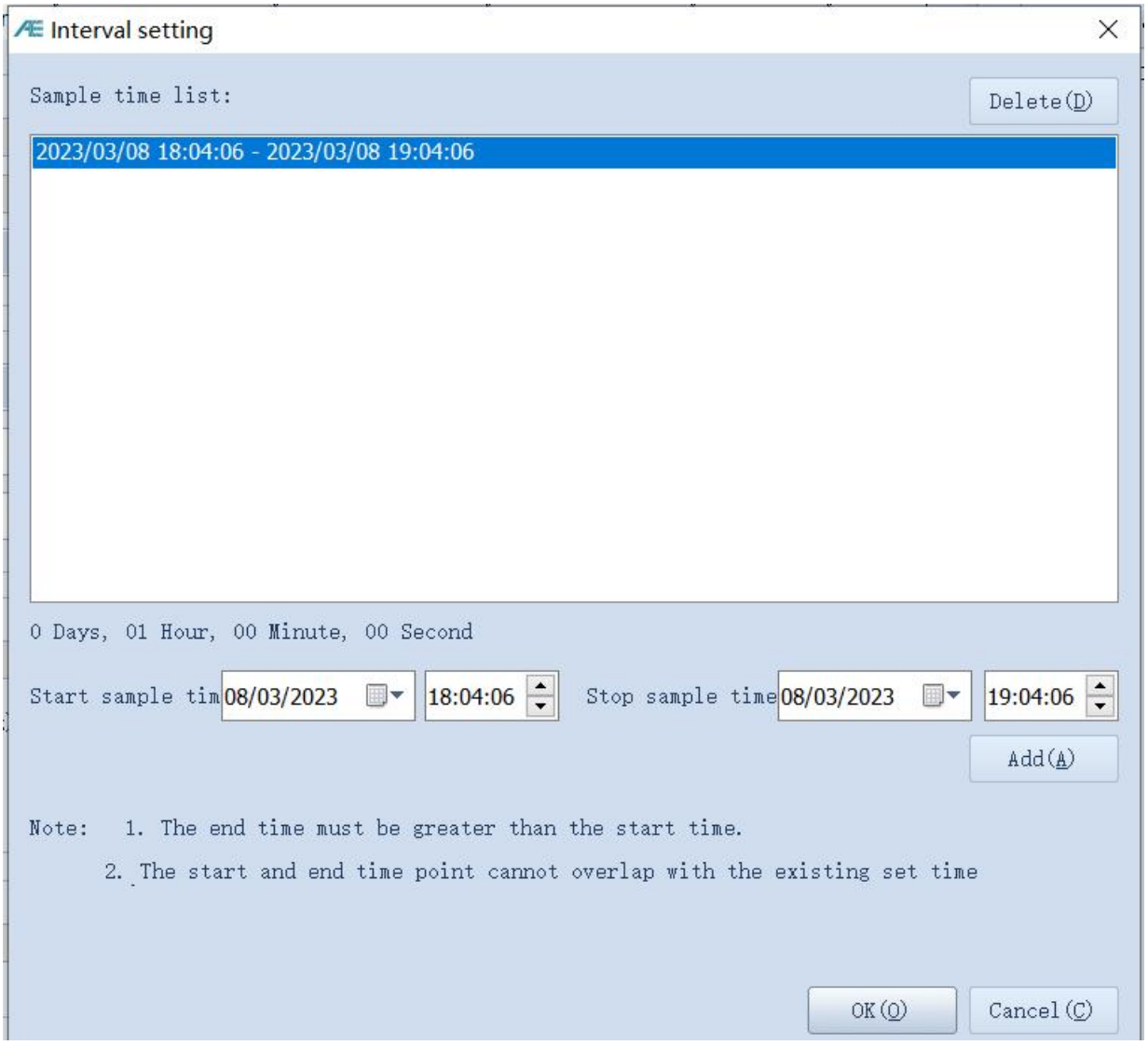


Fig. 3-26 Timing Sample settings page

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

Fig. 3-27 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.

3.3.2.3 Filter

The filters in the software are the digital filters.

- Filter Enable: whether to turn on the digital filter function.
- Filter One: There are three options: low pass, band pass, high pass, or choose not to use a digital filter.
- Filter high (KHz): Refers to the high pass frequency of the frequency domain. The frequencies does not pass when the signal frequency is below this frequency.
- Filter Low (KHz): Refers to the low pass frequency of the frequency domain. The frequencies cannot pass when the signal frequency is higher than this frequency.

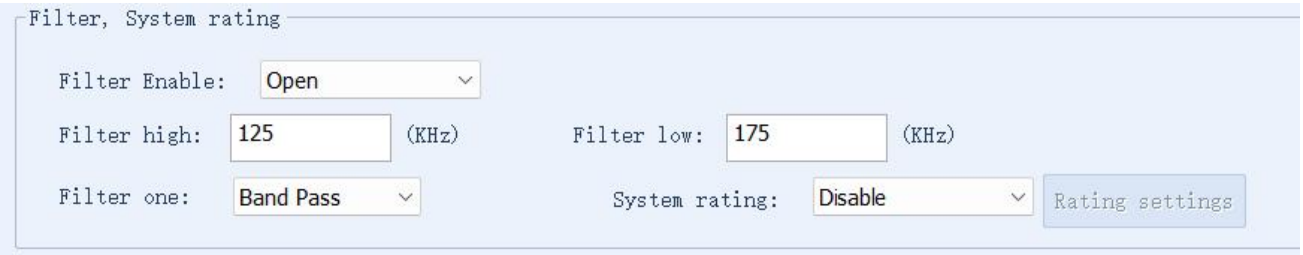


Fig. 3-28 Filer settings

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 3-2 Rating level standards

Fig. 3-29 System Rating function

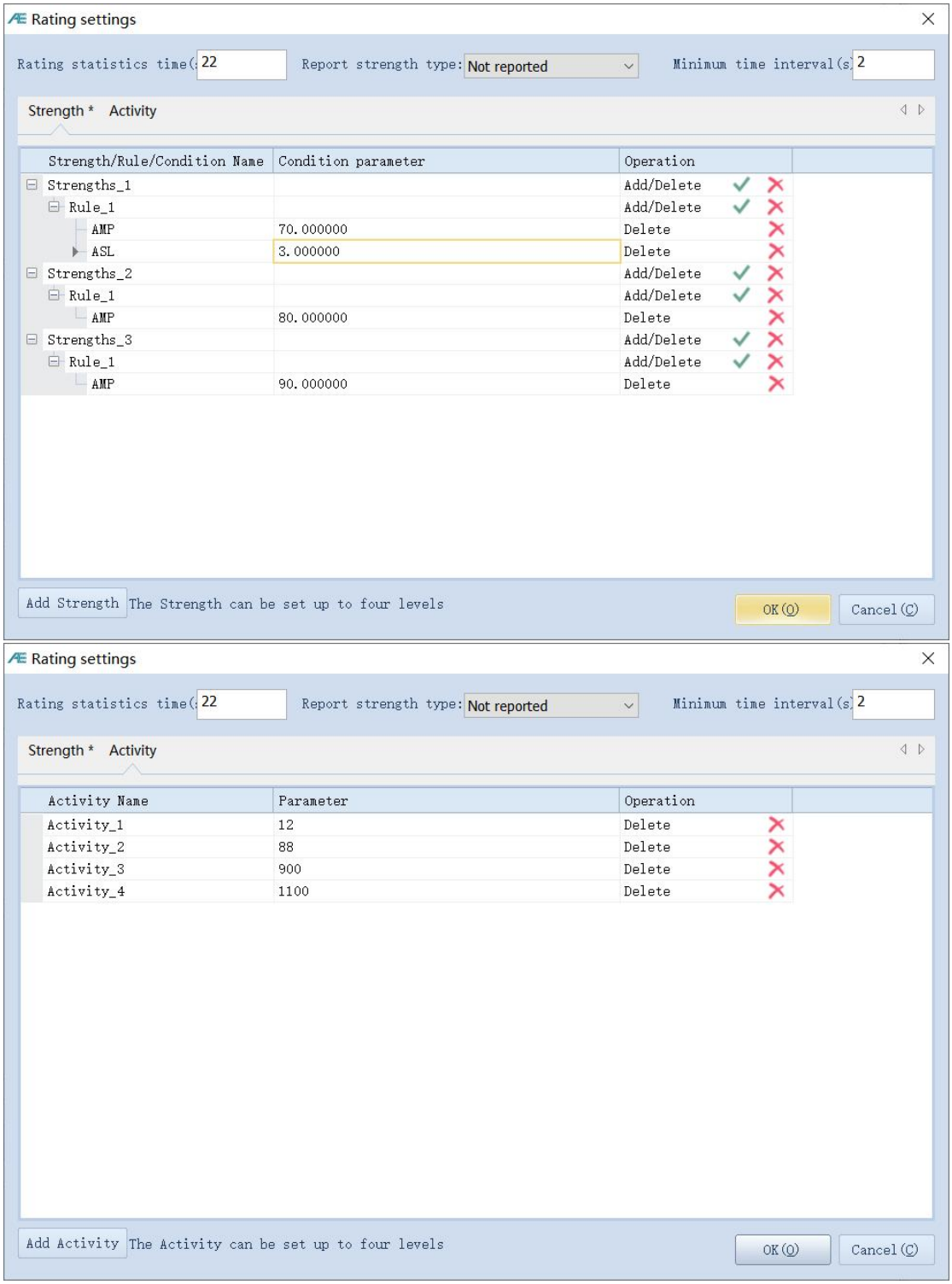


Fig. 3-30 System rating setting page

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.

3.3.2.5 System Ratings

- FFT extraction coefficient: The value can be selected from 1 to 10, which means that one of the original sampling points (sampling rate of waveform sampling) is extracted for FFT calculation on average.
- Start frequency (KHz): The starting frequency of the power spectrum band.
- End frequency (KHz): The ending frequency of the power spectrum band. After checking the enabled parameter, press "Auto Allocate" to proportionally allocate the frequency band range set here.
- Parameter 1 to Parameter 5: " √ " Select the "Enable" checkbox after the parameter name to enable the current parameter. You can check as needed, up to 5 can be set. After selecting a parameter, set its upper and lower limits of the frequency band. Just enter a positive integer in kHz.
- Auto Allocate: The set value range will be automatically divided according to the number of selected local power spectrum parameters. The value after automatic distribution allows the user to modify it again.

3.3.3 Network Settings

3.3.3.1 Ethernet Settings

When using the Ethernet to connect RAEM1-6 to the computer or routers, it should configure the Ethernet IP addresses for all terminals. The Ethernet IP of RAEM1-6 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 as shown below is the channel Ethernet IP address.

Fig. 3-31 Ethernet IP settings

The default Ethernet IP of RAEM1-6 is the static IP, from 192.168.0.101 to 192.168.0.106 for the six

channels of RAEM1-6. Therefore when the computer and/or router is connected, the Ethenet IP address of the computer/router should be set to the same network segment "0" but using a different ID 192.168.0.xxx, for example 192.168.0.20. Using the same IP address will cause transmission conflicts.

- **Dynamic IP**: it is normally used when the RAEM1-6 is connected to a router through Ethernet cable. RAEM1-6 will get the IP addresses dynamically from the router. If the channels of RAEM1-6 are changed to the dynamic IP, follow the steps: select the channel, then choose "Dynamic IP"; click the "Modify" button on the right, and click "OK" in the pop-up dialog box. The newly modified configuration will be sent to the selected channel, and the channel will automatically reboot (if not, please manually reboot to take effect). This channel will appear in the device list with a new device IP address after restart (but the device ID remains unchanged and can be identified by the device ID).

One thing to remember is that if RAEM1-6 has changed to using dynamic IP addresses and later the RAEM1-6 is directly connected to the computer through an Ethernet cable, RAEM1-6 cannot be recognized because the computer can only read static IP address, instead of assigning the dynamic IP like the router. So when using "Dynamic IP" and switching connection from the router to a computer, please remember and make sure to change RAEM1-6 back to "Static IP" mode before switching.

3.3.3.2 Wi-Fi Settings

The default Wi-Fi mode of RAEM1-6 is Hotspot mode. RAEM1-6 releases a Hotspot for connection. The Hotspot ID is for example "RAEM1-5V-1" and the default password is 88888888. You are advised to use Hotspot connection only for settings. Open the Wi-Fi list of your computer, and find the Wi-Fi name with the same name as "the Wi-Fi" on the side label of RAEM1-6 to connect.

The "Router" mode of RAEM1-6 is not available. Because RAEM1-6 cannot wirelessly connect to a WiFi router by design. Please refer to the Ethernet connection for data transmission.

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.

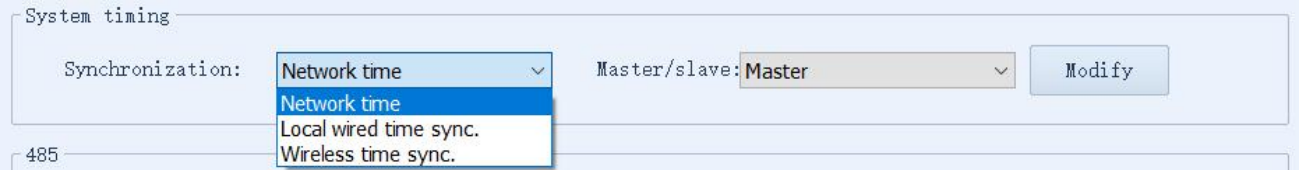


Fig. 3-32 System timing

RAEM1-6 selects 'Local wired time sync. (synchronization)'. Then ensure that within the same local area network (Ethernet or WiFi router connection network), there is only one channel that is the master, and all other channels are slaves.

After setting the master-slave mode, the device needs to be restarted for clock synchronization to take effect. In the device list, check the channels that have been modified for both the master and slave devices (multiple channels can be checked together), and then right-click and select "Reboot Device" from the menu. Please be patient and wait for the device to restart. During the restart process, the device's indicator light will turn off and the IP address of the channel on the software will also turn red. But don't interfere with the restart process. After the restart is completed, the channel indicator light will return to normal, and the device list of the software will also turn black.

3.3.3.4 AWS Param

RAEM1-6 supports data upload to AWS S3 server. But the function is disabled by default. AWS S3 is Amazon Cloud storage, ideal for data storage. Contact us if you are interested in using AWS.

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**: [AKA "SWAE software"]

- **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 computer 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 computer 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 computer address here;
- **Port**: can be configured. The default is 18883.

3.3.5 System Settings

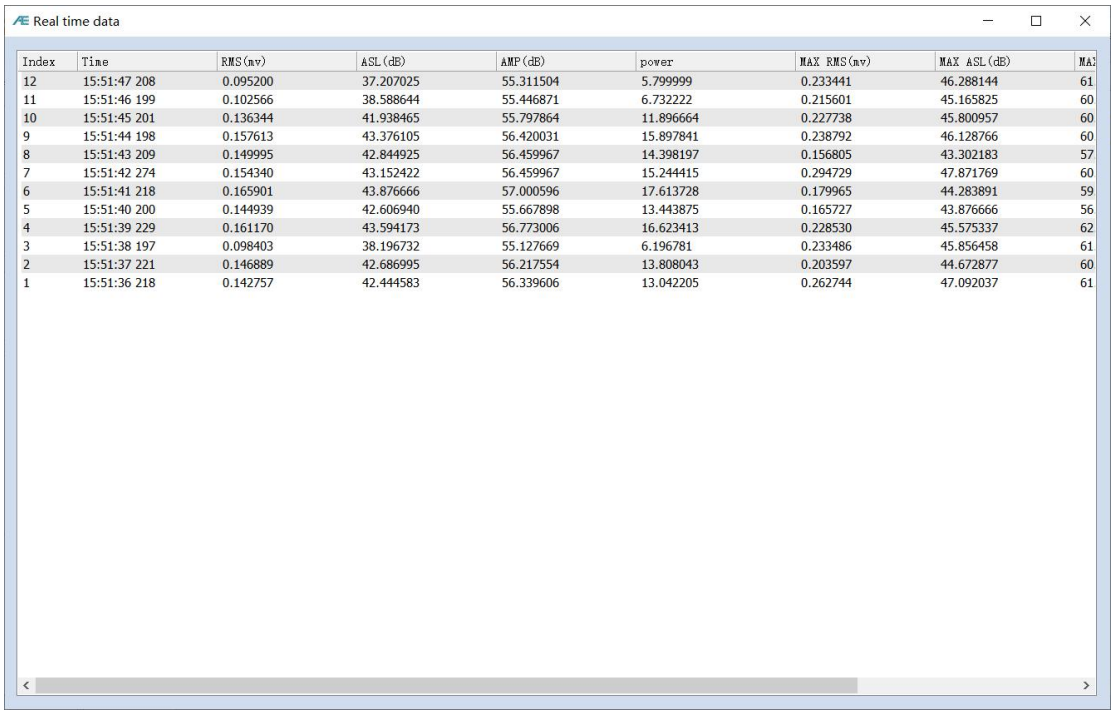
3.3.5.1 Time Calibration

If the time stamp of the data package is incorrect, you can click "**System Settings**" page >> "**Time Calibration**" >> "**Calibration**" button to calibrate the selected RAEM1-6 channel'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 RAEM1-6 channels. **Rebooting takes some time and it must NOT be interrupted or turned off during the rebooting. After rebooting, it cannot be connected and controlled until the RAEM1-6 channel 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).



Index	Time	RMS(mv)	ASL(dB)	AMP(dB)	power	MAX RMS(mv)	MAX ASL(dB)	MA
12	15:51:47 208	0.095200	37.207025	55.311504	5.799999	0.233441	46.288144	61
11	15:51:46 199	0.102566	38.588644	55.446871	6.732222	0.215601	45.165825	60
10	15:51:45 201	0.136344	41.938465	55.797864	11.896664	0.227738	45.800957	60
9	15:51:44 198	0.157613	43.376105	56.420031	15.897841	0.238792	46.128766	60
8	15:51:43 209	0.149995	42.844925	56.459967	14.398197	0.156805	43.302183	57
7	15:51:42 274	0.154340	43.152422	56.459967	15.244415	0.294729	47.871769	60
6	15:51:41 218	0.165901	43.876666	57.000596	17.613728	0.179965	44.283891	59
5	15:51:40 200	0.144939	42.606940	55.667898	13.443875	0.165727	43.876666	56
4	15:51:39 229	0.161170	43.594173	56.773006	16.623413	0.228530	45.575337	62
3	15:51:38 197	0.098403	38.196732	55.127669	6.196781	0.233486	45.856458	61
2	15:51:37 221	0.146889	42.686995	56.217554	13.808043	0.203597	44.672877	60
1	15:51:36 218	0.142757	42.444583	56.339606	13.042205	0.262744	47.092037	61

Fig. 3-33 Real time data page

3.3.5.3 Firmware Update

There are two files to update the firmware:

- update.zip
- md5sum.txt

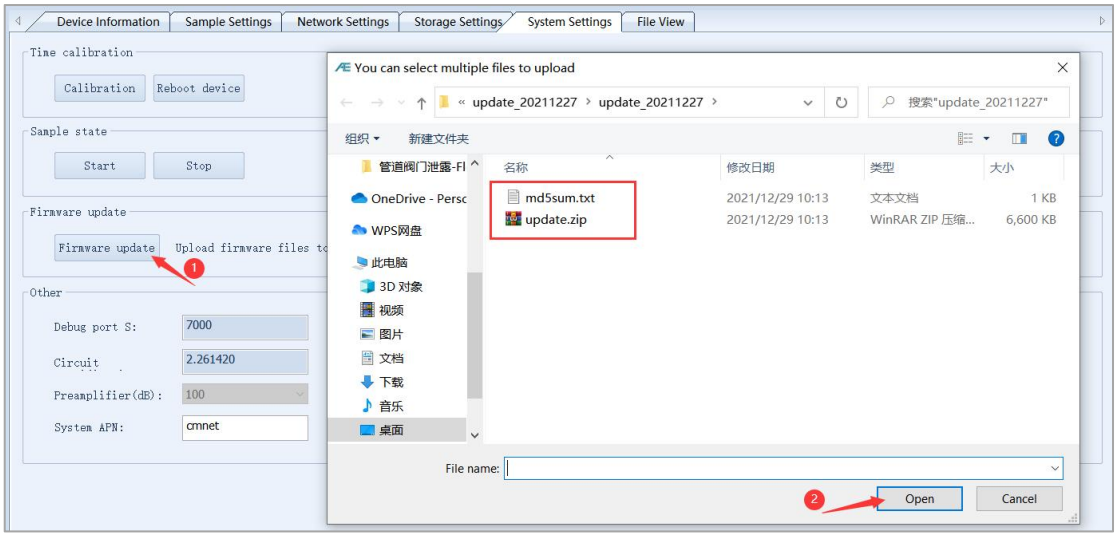


Fig. 3-34 Firmware update

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 automatically rebooting. Please don't interrupt the process by disconnecting the power or manual restart during the process. Please patiently wait for the reboot until the channels start working and connection resumes.

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 RAEM1-6. 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. Right click and select this function to refresh the list.

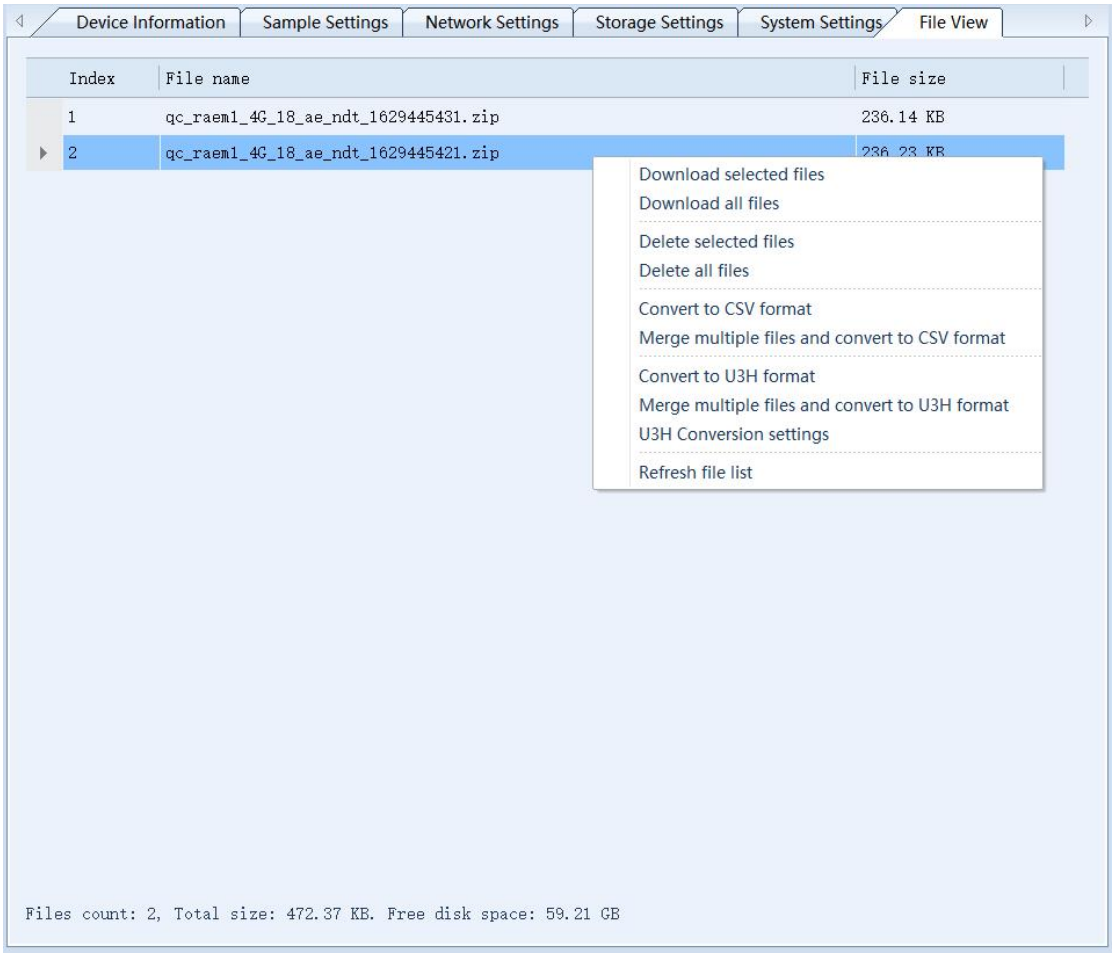


Fig. 3-35 File View

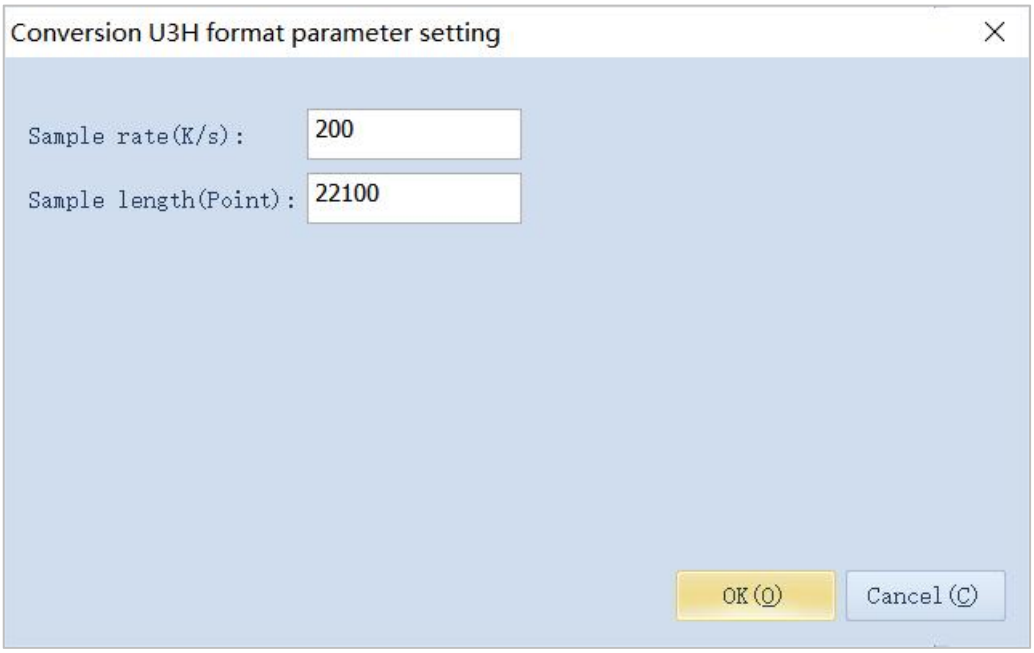


Fig. 3-36 U3H format conversion settings

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. (Note: after changing the mode, it will only take effects after rebooting)
- **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 RAEM1-6 to be able to communication to the Alibaba Cloud server. In this mode, users can view the RAEM1-6 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.

When the Aliyun Key and the Aliyun secrete are configured and sent to the channels, RAEM1-6 channels 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 4.4 for detail steps.

Fig. 3-37 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 QAWRUMS. 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 7.1.

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	Amplitude, ASL, Power, RMS, Rise time, Rise ring-down counts, Ring-down counts, Duration, report time

Table 3-4 TCP Mode setup

Fig. 3-38 TCP Mode setup

The related TCP protocol is introduced in Section 7.1. Please contact us for more details 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:

```
import socket
import datetime
HOST = '192.168.0.30'
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:
    print("get IP",datetime.datetime.now())
    (conn,addr) = s.accept()
    print('Connected by',addr)
    while 1:
        print("get Data",datetime.datetime.now())
        data = conn.recv(2048)
        print(data)
        print("\n")
conn.close()
```

Fig. 3-39 TCP mode test code

The context that the server receives is:

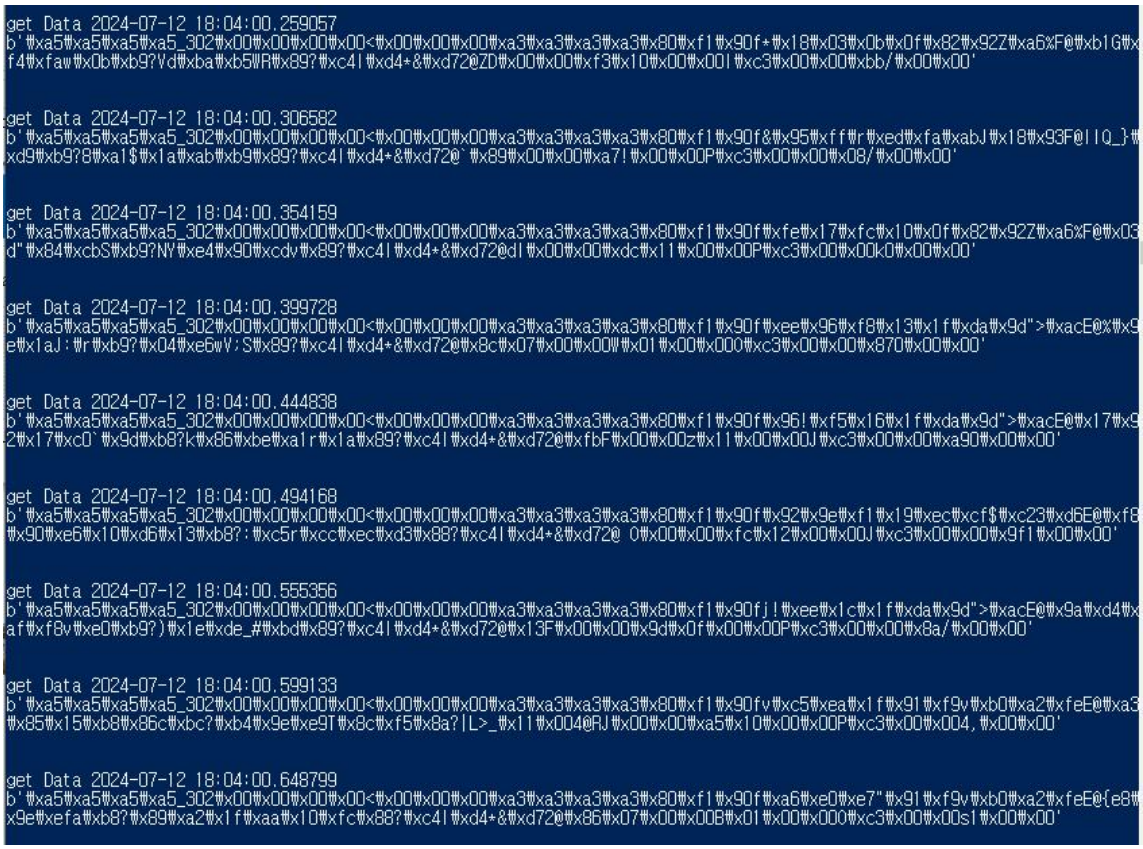


Fig. 3-40 TCP mode server receiving data

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.

```
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
```

"TCP Mode v2" outputs 9 AE characteristic parameters, including amplitude, ASL, Power, RMS, Rise time, Rise ring-down counts, Ring-down counts, Duration, report time. The format of the output data is: device ID + amplitude + ASL + Power + RMS + Rise time + Rise ring-down counts + Ring-down counts + Duration + report time, separated by comma.

```
qc_raem1_4g_89,38.740266,17.501490,0.067384,0.025052,125,10,10,125,1694746199.984745
qc_raem1_4g_89,39.300841,15.917865,0.057709,0.023184,502,86,106,654,1694746201.99322
```

Note: When choosing "TCP v2" mode, the server IP address cannot be the same as the IP address of the computer/server for SWAE software.

3.4 Online Collection by SWAE software

SWAEU3H (RAEM1) (hereinafter referred to as "***SWAE***") is a professional AE control, processing and analysis software developed by Qingcheng/QAWRUMS Company. It supports data transmitted from RAEM1-6 on the 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 SWAE software with high precision time difference sound source location algorithm can get a variety of high precision AE source location.

SWAE software can be used to connect RAEM1 and RAEM-6 for online collection, including real-time display of parameters and waveform. Install the SWAE software package and install the software. Connect RAEM1-6 to the computer and configure the computer, 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

⚠ **Remarks: attention when using the software, 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".**

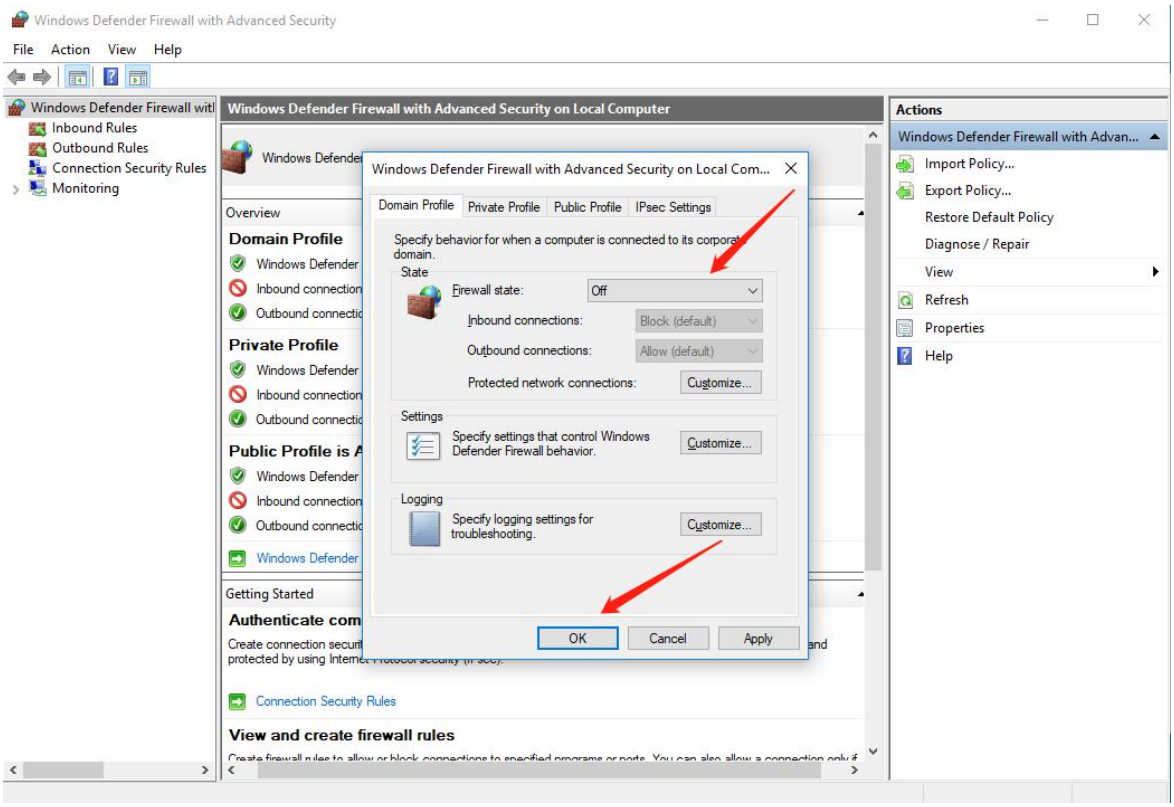


Fig. 3-41 Disabling the firewall

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

(1) Connect the 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) To send the data to SWAE software, the RAEM1-6 and the computer should be under the same network segment, i.e. 192.168.0.xxx (but different IPs). 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 write down xxx.

(3) RAEM1-6 also needs to be set up in "RAEM1 configuration" software to be able to send data to the specified computer. In the device list, select the channels that you want to send data to the SWAE software. On the **"Storage Settings"** page, disable the **"Save Waveform", "Save Parameters",** and **"Upload original data"** functions. Enable **"Send U3H software"** and enable **"send waveform"**

and **"send parameter"** data. The IP Address type select **"Enter IP"**, and then enter the computer's IPv4 address which can be marked down in Step (2). 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. 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 computer are on the same network segment, but cannot the same IP.

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

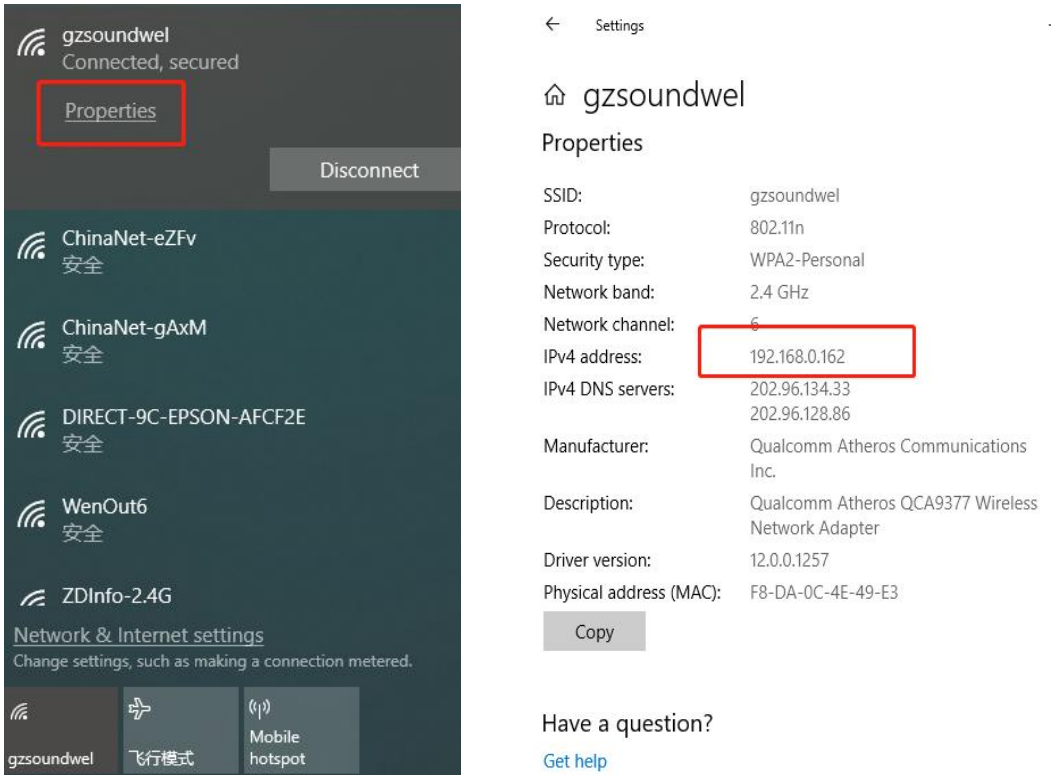


Fig. 3-42 Viewing the WiFi router connected computer network address

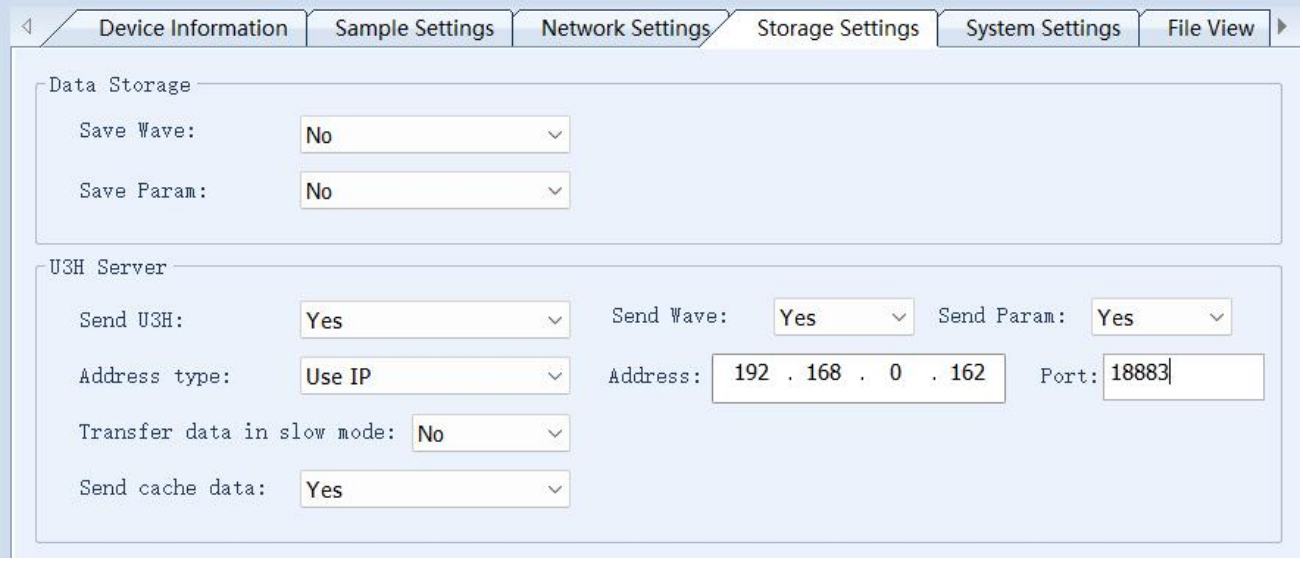


Fig. 3-43 Setting the target IP address of the PC in RAEM1 Configuration software

(4) The SWAE software needs to be installed. After the software is installed, start the software, click "**Hardware and Sample**", and click "**Sample Settings**".

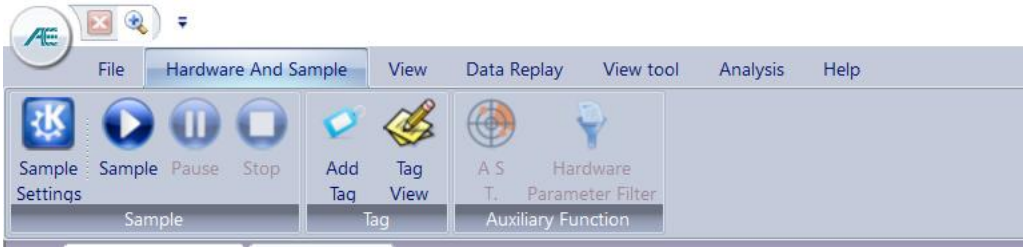


Fig. 3-44 Software sample Settings

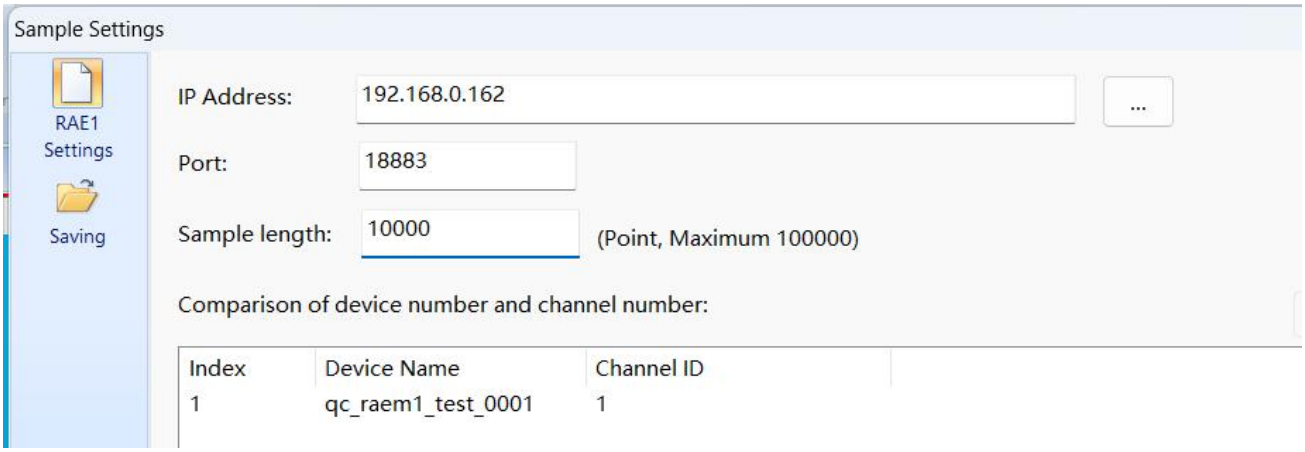


Fig. 3-45 Change Address in the Settings

① IP Address: specifies the IP address of the target PC. This parameter is the same as IP address in Step (4) above. You can also click "... "on the right. Get the current computer IP address.

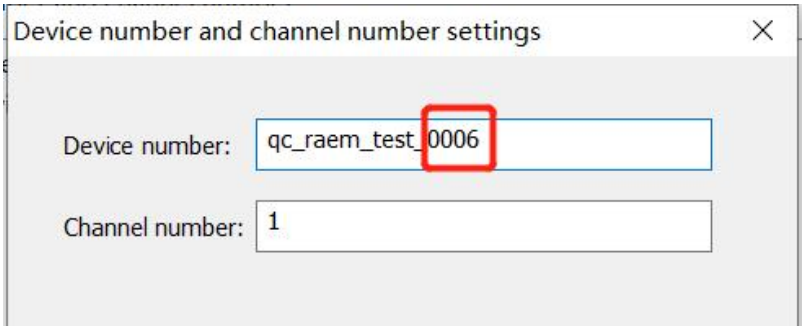
② Port number: The port number is the same as that set in "RAEM1 Configuration" software.

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

④ Sampling length: only related to the waveform window display in SWAE. It is recommended to set the value equal to RAEM1-6 sampling rate multiplied by EET (or the "sample length in unit of microseconds in the configuration software").

⑤ Click the "Add" button to add channels. The pop-up window will allow to set the device number and channel number. If you don't define the channels here, the software will assign the channel numbers based on the arrival orders of different channels. For example, if Channel 0003 data arrives first, Channel 0003 will be assigned as channel #1 in the software.

- Device number: Enter the last four digits of the channel ID as follows:
- Channel number: Manually define the channel number, which is defined as 1 in ascending order.



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

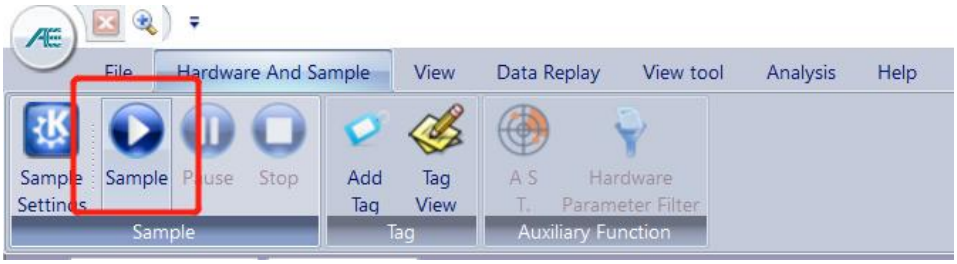


Fig. 3-46 Click and Collect

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

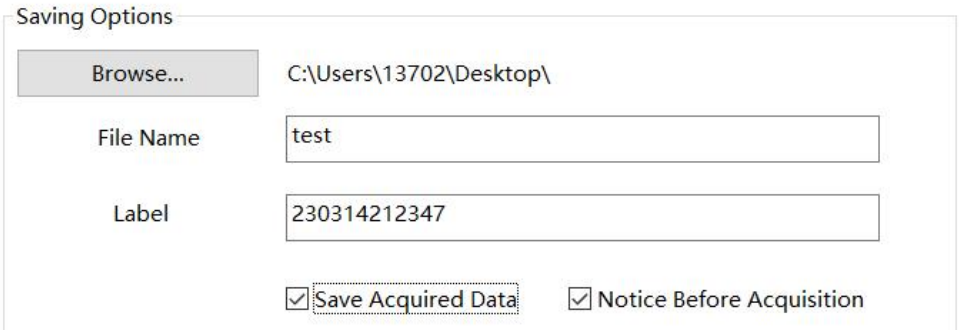


Fig. 3-47 Save path for the collection file

(7) Starting sampling will have a network matching process for a few seconds, and parameters and waveform 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. 3-48 Parameter table data

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

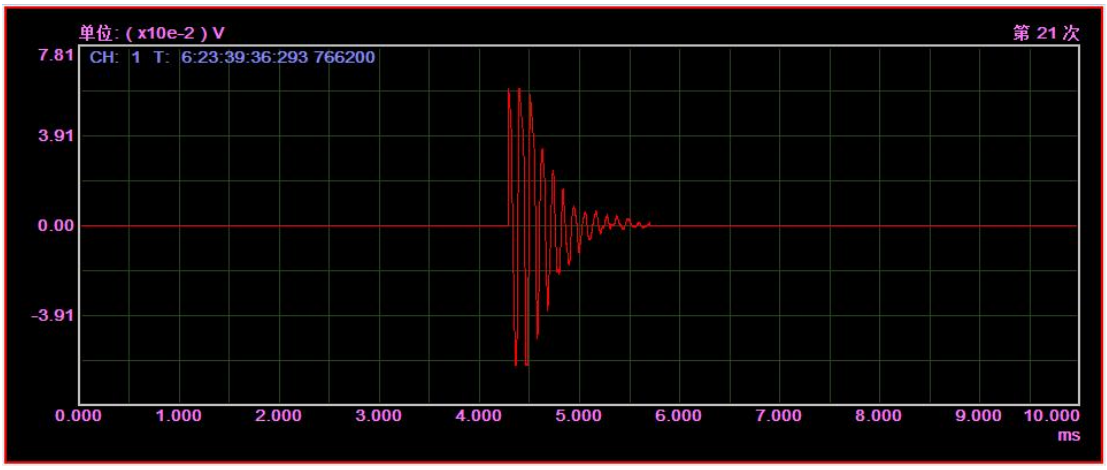


Fig. 3-49 Waveform view

4. RAEM1-6 IoT Monitoring System Operation Guide

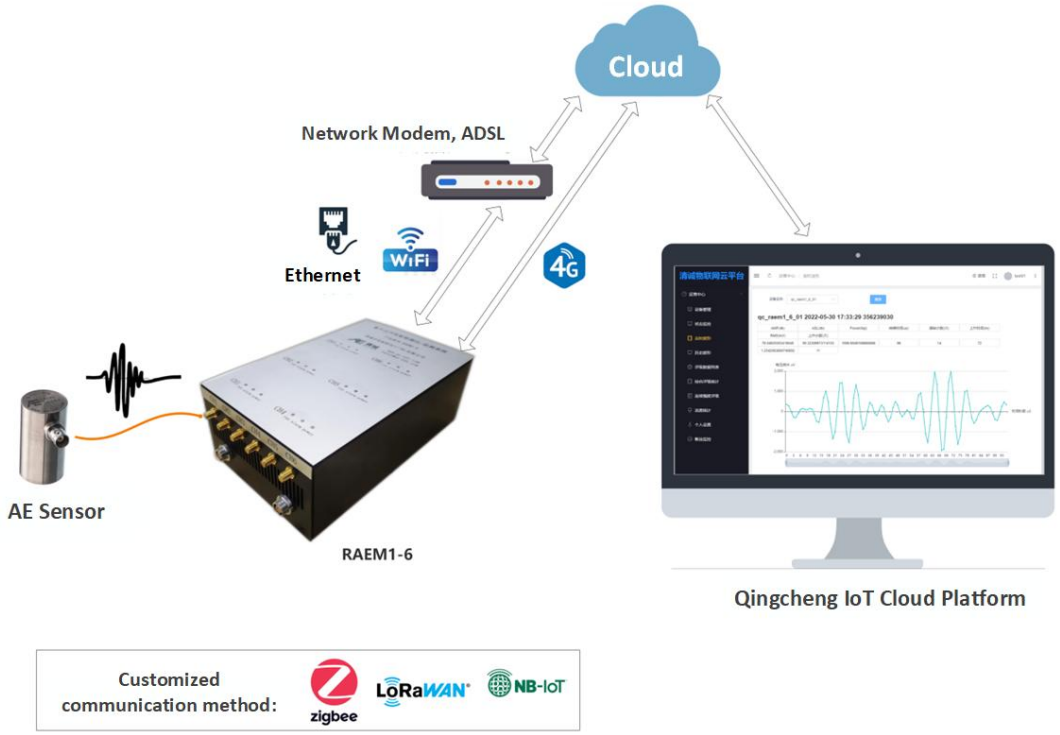


Fig. 4-1 Connecting the RAEM1-6 monitoring system

In addition to the function of detection, 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 objects in the Internet of Things. By 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 Alibaba 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 Alibaba Cloud platform.

4.1 4G network connection

RAEM1-6 can use 4G SIM card (Internet of Things network card) to connect to the 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 a 4G SIM 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 a 4G IoT card. Customers need to buy their own IoT cards, which 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.

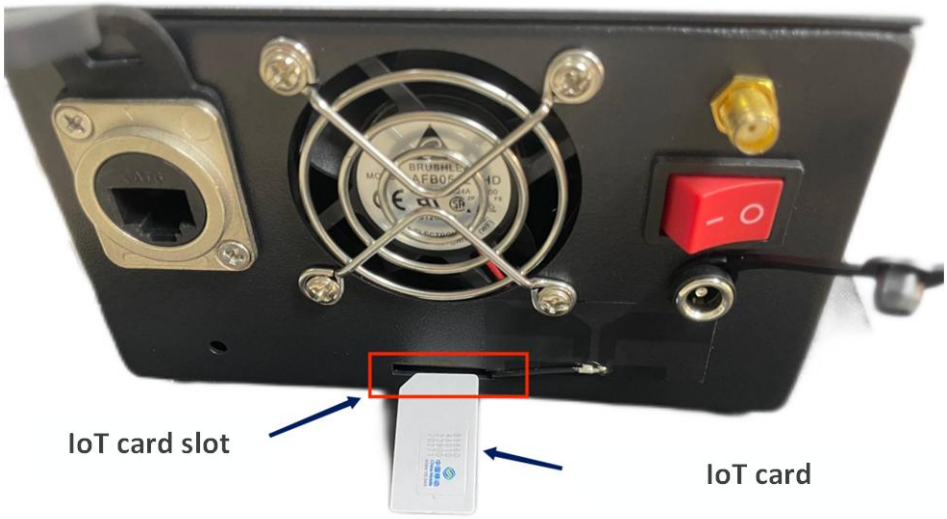


Fig. 4-3 RAEM1-6 Network adapter and card slot for the Internet of Things

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.

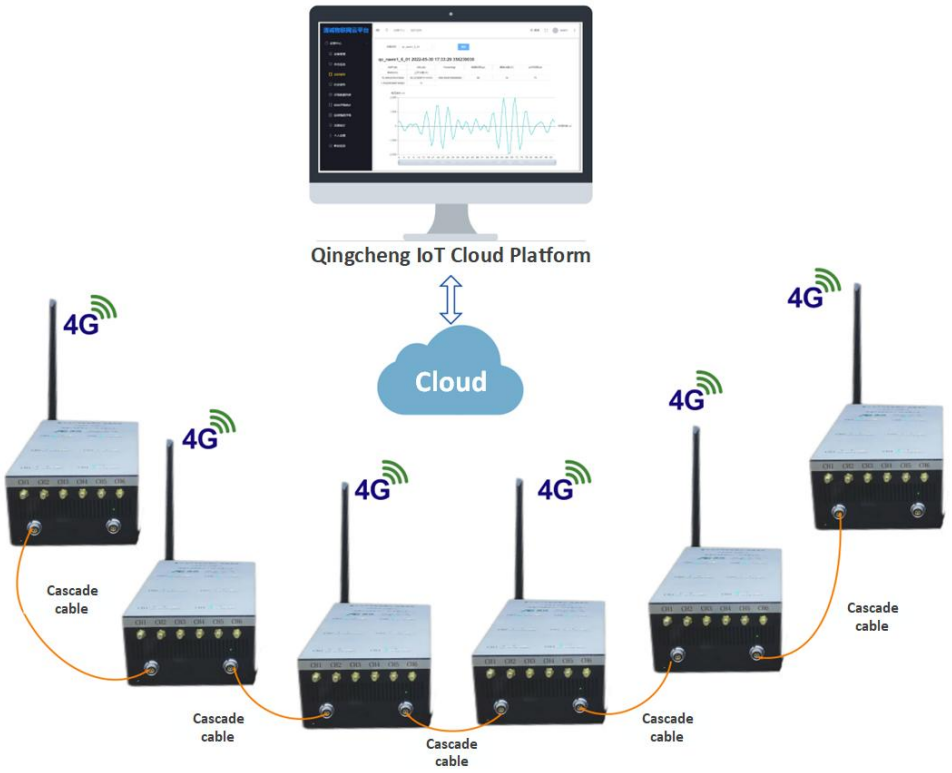


Fig. 4-4 RAEM1-6 on the 4G network

4.2 Wi-Fi Network Connection

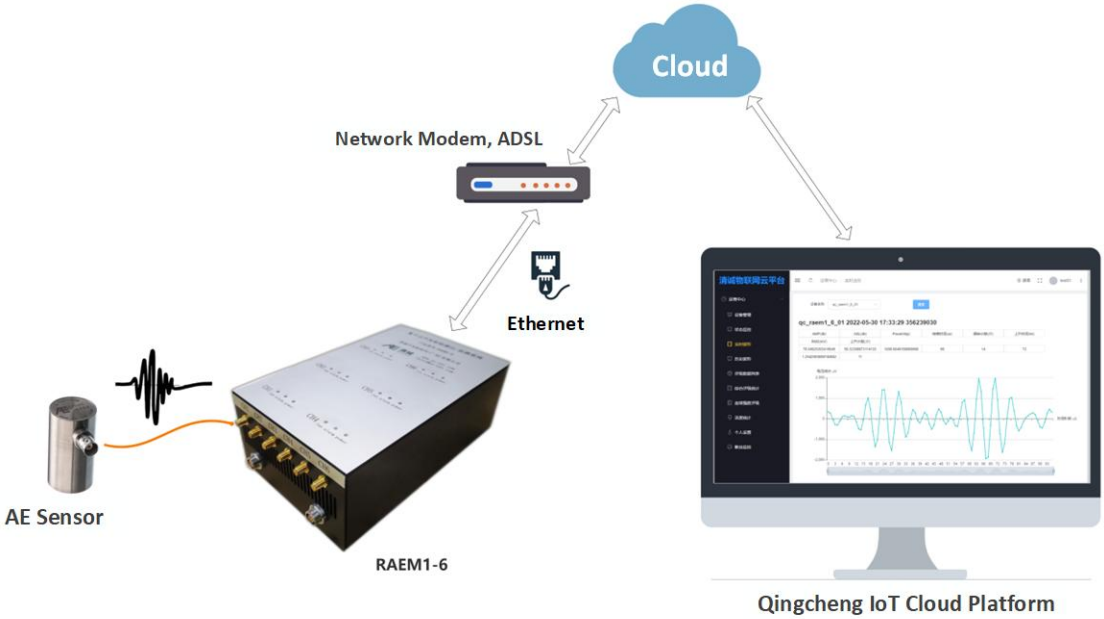


Fig. 4-5 RAEM1-6 Connecting to the cloud center through the gateway

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 an Ethernet cable first. Then the router connects to the Internet. Log in the IoT cloud platform to view data.

The Wi-Fi router also needs to be configured. There are two methods to make the router configurations.

	RAEM1-6	WiFi Router
1	Static IP: 192.168.0.101 to 106	Use a fixed IP: e.g. 192.168.0.50
2	Change the static IP to dynamic IP and obtain IP from the router	Automatically assign IP address to devices

Table 4-1 RAEM1-6 Networking IP Configuration Methods

Method 1 means the router must be configured to the network segment "0" same as the RAEM1-6 static Ethernet IP, which should be 192.168.0.xxx. But "xxx" cannot be the same the IP as RAEM1-6 channels. So it is recommended to be 192.168.0.50 to avoid conflicts.

For method 2, the router can set to automatically assign IP addresses to devices. In that case, RAEM1-6 Ethernet IP should be changed to "Dynamic" IP instead of static. One problem with Method 2 is if in some case, the RAEM1-6 needs to directly connect to computer through Ethernet cable afterwards, RAEM1-6 and the computer should both change the IP addresses to static IP again using the router before the direct connection.

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 connected to 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.

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. Follow the same method of single RAEM1-6

configuration via WiFi to the Internet mentioned above. 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.

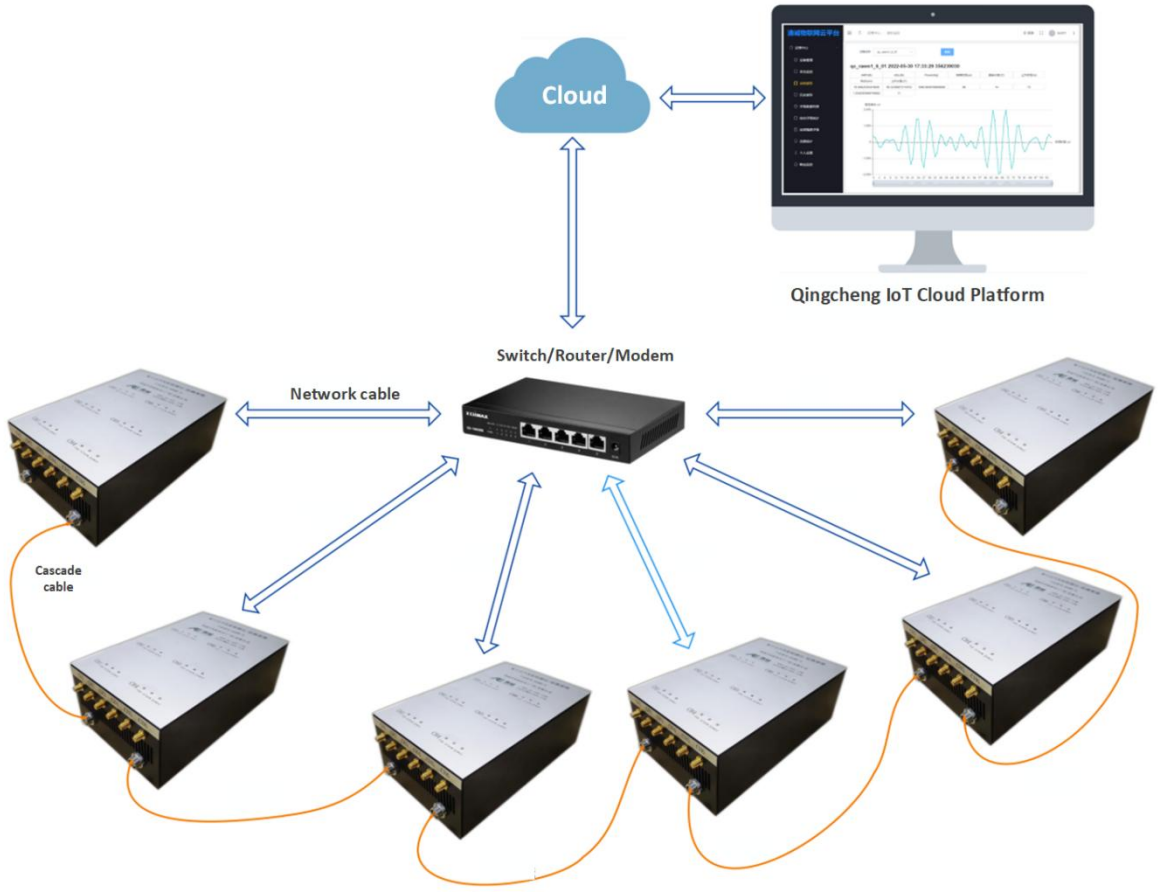


Fig. 4-6 Networking of RAEM1-6 through the gateway

4.3 Qingcheng IoT Cloud Platform

Qingcheng Internet of Things (IoT) 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** (http://cloud.ae-ndt.com) and enter the account 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.

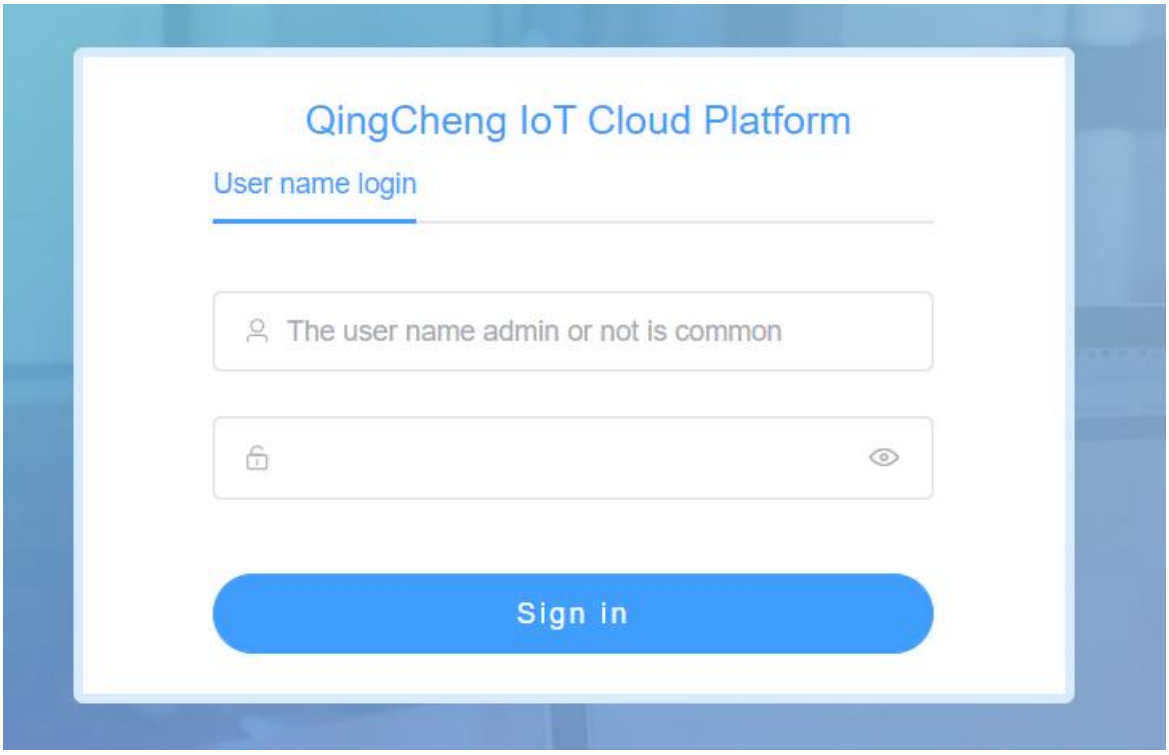


Fig. 4-7 Qingcheng Internet of Things cloud platform login

After the login, at the upper right menu bar of the platform page, there are languages (Chinese/English) conversion and user interface and password settings available.

Fig. 4-8 Basic Profile Menu Example

4.3.1 IoT Products

4.3.1.1 Device Groups

Group the devices to facilitate subsequent management of the devices. You can add groups through the device groups page to manage devices in groups.

The operation is as follows: click [Add], fill in the "Name", "Parent", and "Department" information (Note: When creating a new parent, the "Parent" column does not need to be filled in). “Purpose” can be “Default” or “AE Location Analysis”. Choose “Default” in general.

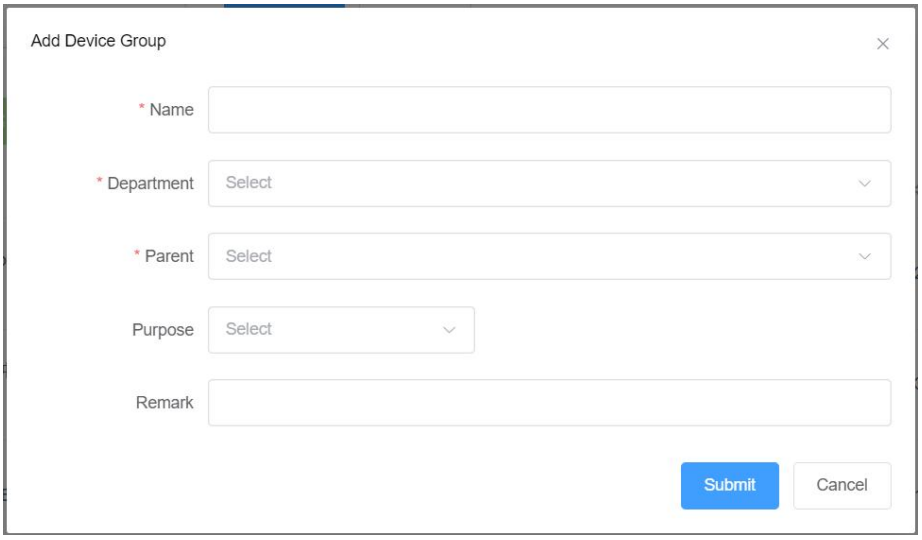


Fig. 4-9 Device Group “Add” window

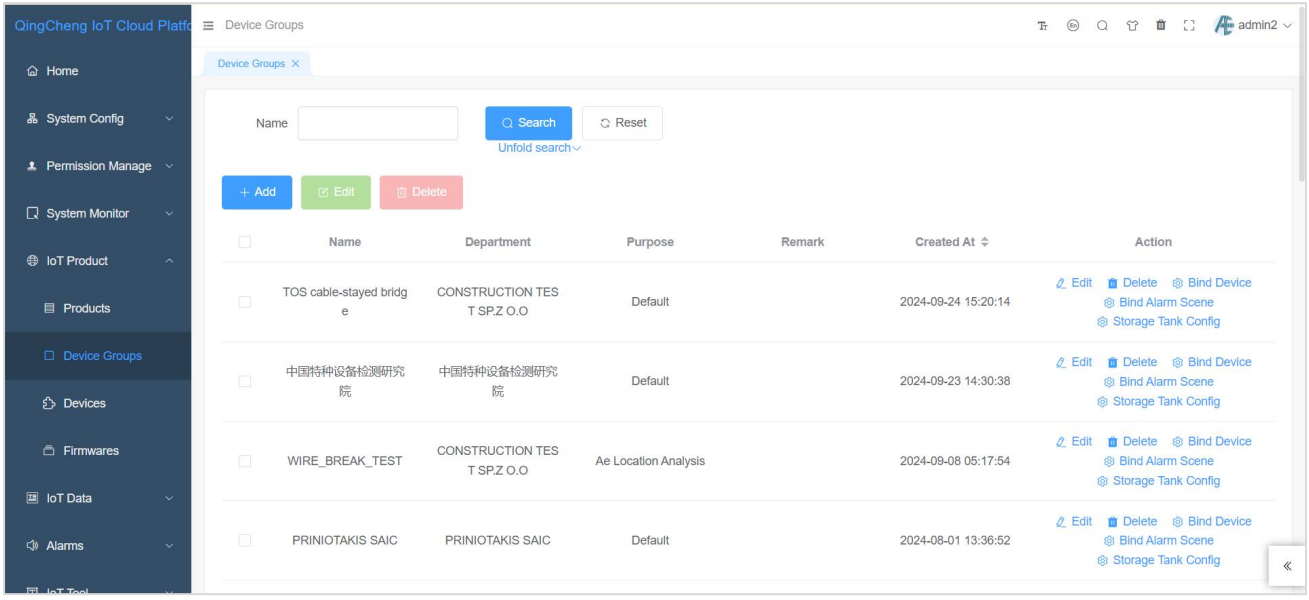


Fig. 4-10 Device Group page of Qingcheng IoT cloud platform

- **Bind Device**: Binding devices into this group for group managements.
- **Bind Alarm scene:** After grouping devices and binding alarm scenarios, users can receive alarm information for the grouped devices in this alarm scenario.
- **Storage Tank Config**: generally used for detecting the bottom plate of atmospheric storage tanks. After filling the information, a detection report can be automatically generated by clicking the **[Report]** button at the bottom right corner;

  ■ **Basic Information**

  Fill in the relevant basic information based on the on-site inspection environment, and scroll down the page and click **[Submit]** on the bottom left corner after filling it out.

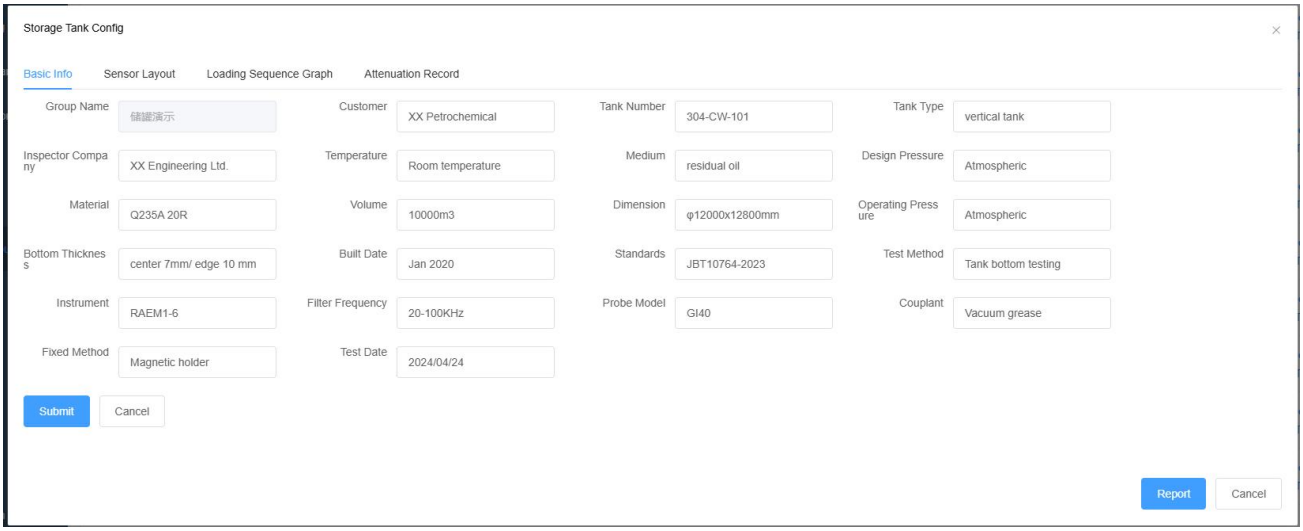


Fig. 4-11 Storage tank configuration - basic information

■ **Sensor Layout**

- ◆ **Tank Diameter (mm)**: the diameter and length of the tank bottom plate;
- ◆ **Channel No.**: Click to select the device number, then click to add it;
- ◆ **Add:** After selecting the device number in the channel number column, the device is added as a channel in the tank bottom location map;
- ◆ **Delete:** After selecting the device number in the channel number column, the channel can be deleted from the map;
- ◆ **Clear:** Clear all sensors from the map;
- ◆ **Generate Graph**: save and generate the current location map on the left into the final report. If "Generate Graph" button is not clicked, the location map on the left will not be saved to the report.

- **Move Left**: After selecting one of the channels above, the device can be moved left by one channel number;
- **Move Right**: After selecting one of the channels above, the device can be moved to the right by one channel number;
- **Submit:** Save the sensor layout plan.

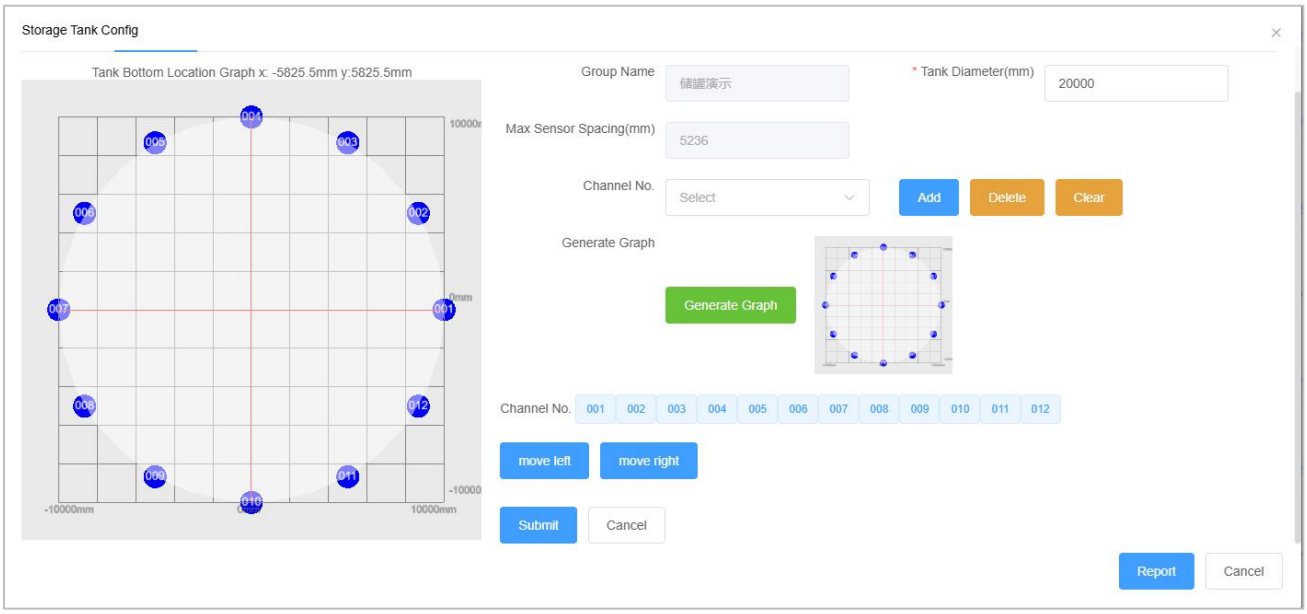


Fig. 4-12 Storage tank configuration - Sensor layout

- **Loading Sequence**
  - **Add:** to add a new load into the sequence.
  - **Duration (min):** Loading or load hold time;
  - **Height(m):** represents the loads;
  - **Refresh:** after filling the duration and height, refresh to update the loading sequence on the left;
  - **Delete:** delete one of the load sequence;
  - **Generate Graph**: save and generate the current loading sequence on the left into the final report. If the "Generate Graph" button is not clicked, the loading sequence on the left will not be saved to the report.
  - **Submit:** Save the loading sequence.
- **Attenuation Record**
  - **Measurement Probe:** to specify one channel to do the attenuation test;
  - **Add:** to add a recording point of the test.

- **Distance (m):** the distance from the probe to the simulation point location.
- **Amplitude (dB):** the amplitude of the received signal from the simulation point.
- **Delete:** delete one of the recording points;
- **Submit:** Save the record.

■ **Report**: Based on the information, the cloud will generate a storage tank test report which can be downloaded and saved.

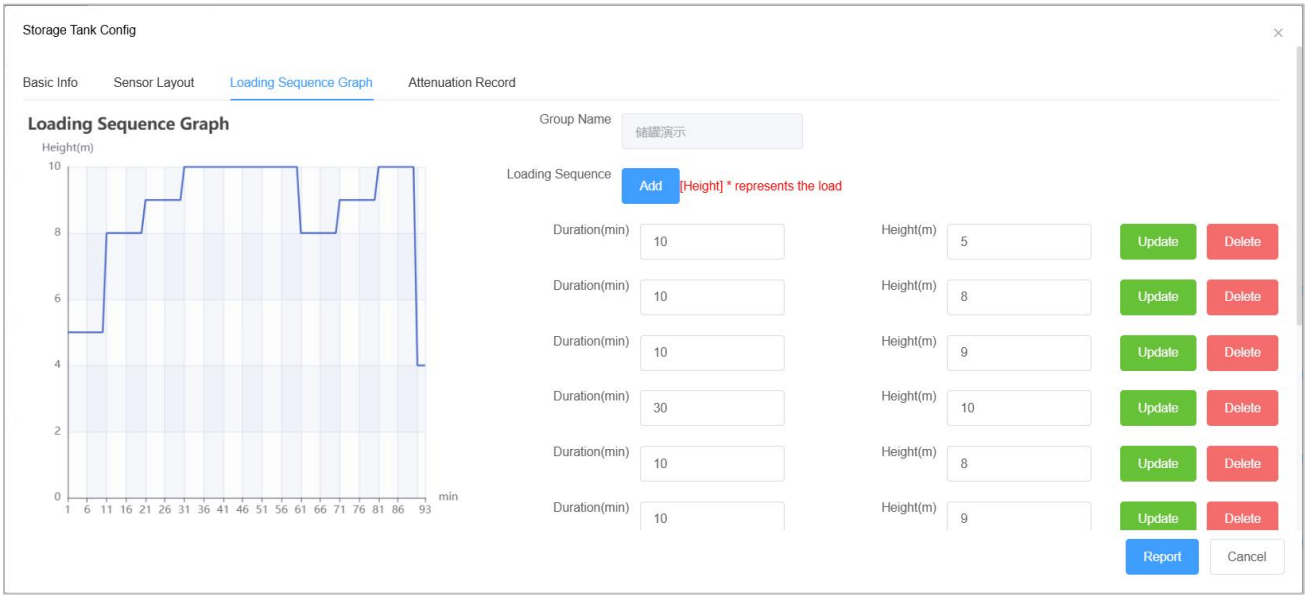


Fig. 4-13 Storage tank configuration - loading sequence

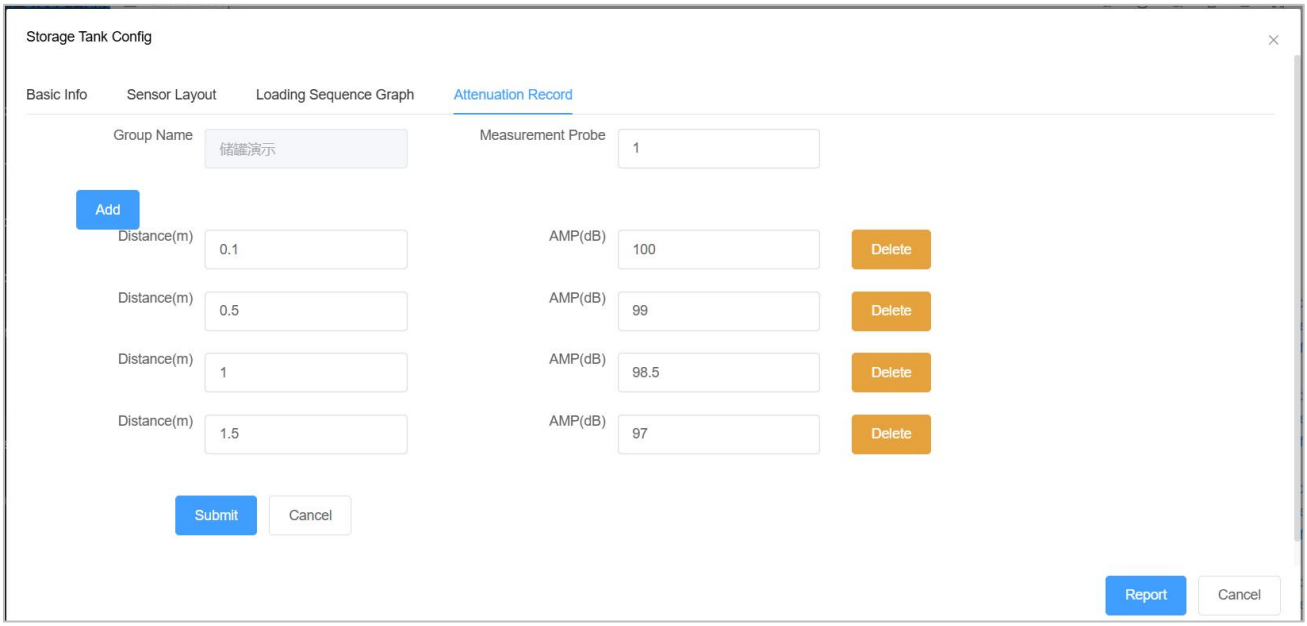


Fig. 4-14 Storage tank configuration - Attenuation record

4.3.1.2 Devices

The "Devices" page lists all IoT AE devices under the current account. Users can search for the desired devices by different search items, such as searching by device name and number, product, device group, status or product type. Users can also add new devices.

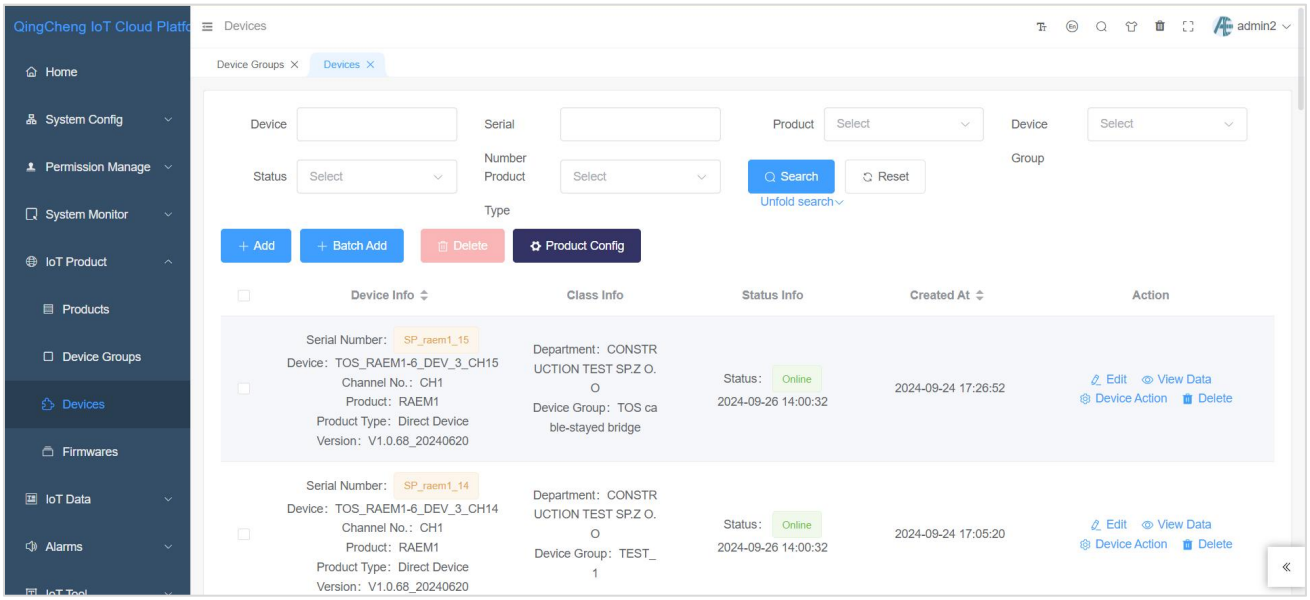


Fig. 4-15 Device Manage page

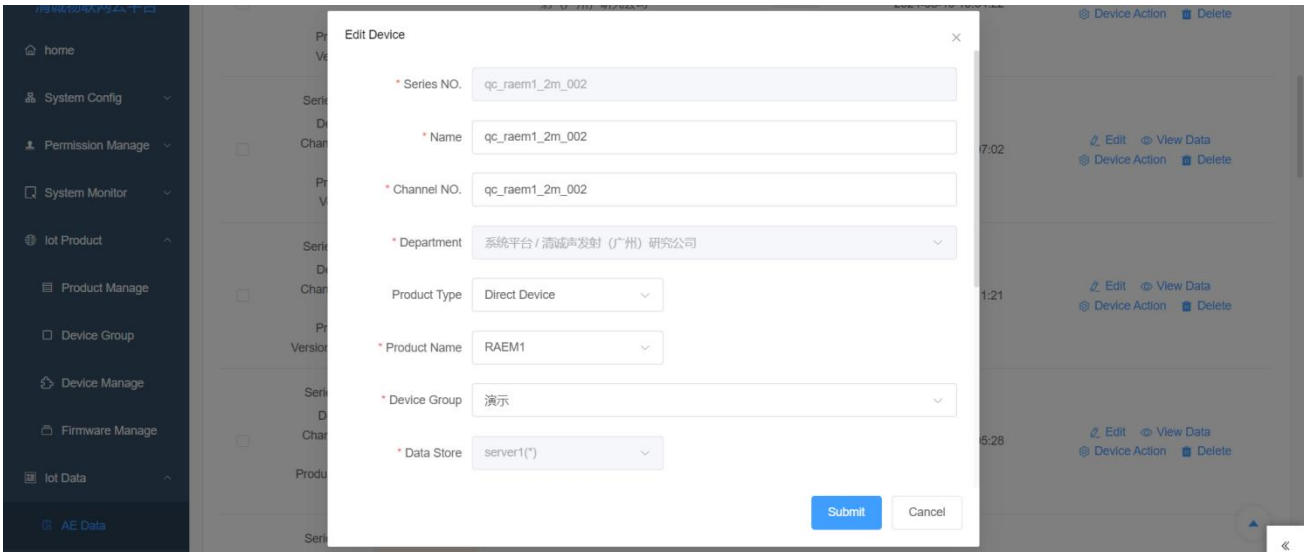


Fig. 4-16 Device Manage "Edit" or "Add" Window

[+Add]: You can add new devices or edit the existing devices.

- Serial Number: Fill in the device number on the product label (required)
- Name: User-defined (required)

- Channel number: User-defined (required)
- Department: Select the department to which the device belongs (required)
- Product Type/Name: Select the corresponding product (required)
- Device group: The group to which the newly added device belongs (required)
- Data store: Select the server for data storage (required)
- Server connection: select the server to connect the device to. (required)

After a new device creation, it will show up a new row for the created device. Under the "**Action**" column on the right, click "**Edit**" to modify the device information above.

4.3.1.2.1 Device Configuration

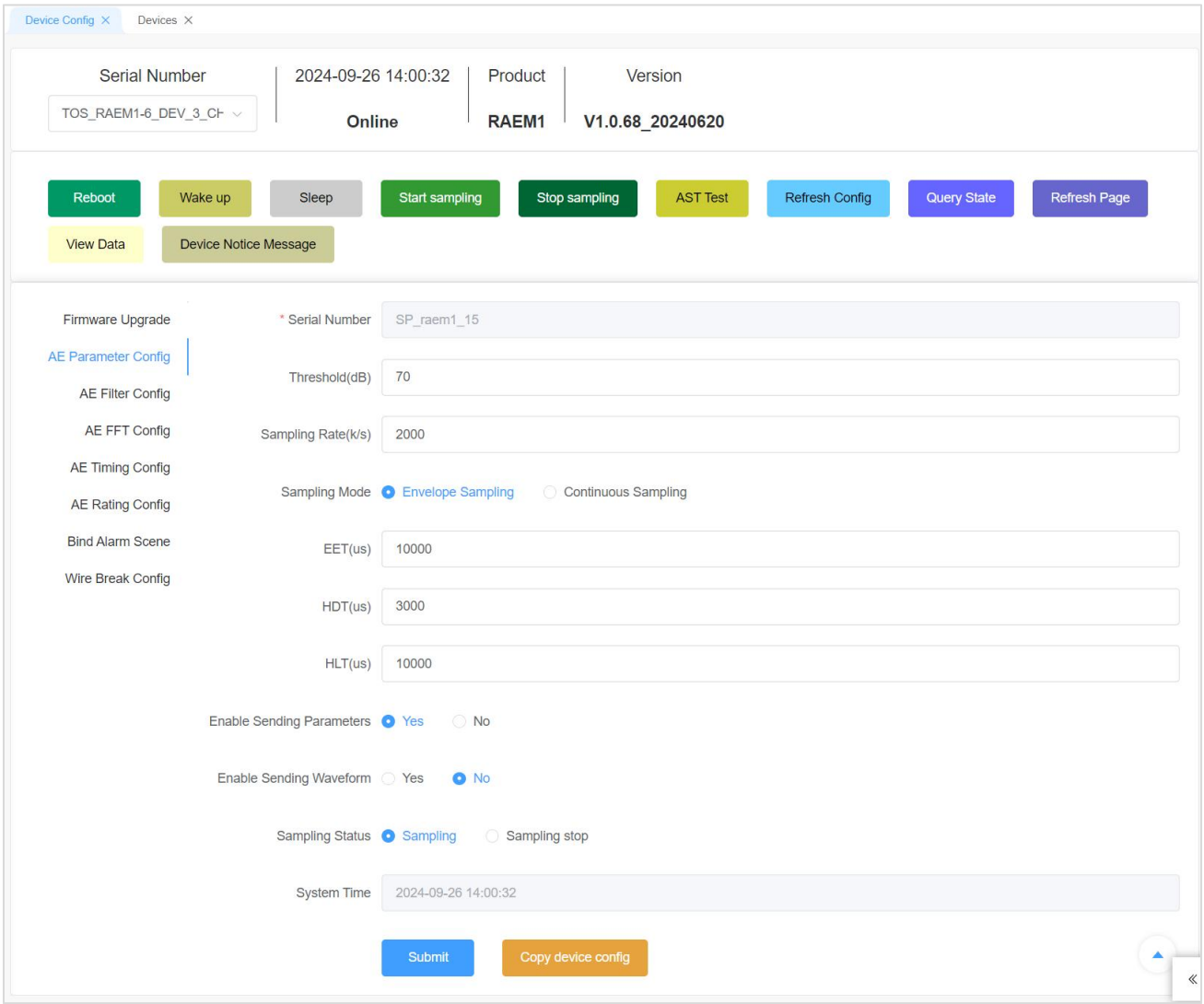


Fig. 4-17 Device Manage > Device Configuration page

Click "**Device Action"** to enter the device configuration page. In the device action page, you can see the colored button with **Reboot, Wake up, Sleep, Start sampling, Stop Sampling, AST test, Refresh Config, Query status, refresh page and View data** functions. And you can configure the device with **Firmware upgrade, Parameter config, Filter config, FFT config, Timing config, Rating config, Bind alarm scene, Wire break config.**

There are some device configuration page buttons description below:

- **Reboot**: Restart the device;
- **Wake up**: to wake up the device in sleep mode (currently only available in RAEM2);
- **Sleep**: to command the device to immediately enter sleep mode (currently only available in RAEM2);
- **Start Sampling**: to command the device to begin acquisitions;
- **Stop Sampling**: to command the device to stop acquisitions;
- **AST test:** Press to perform an AST test once (currently only available in RAEM2);
- **Refresh Config:** Read the latest device configuration and refresh the page;
- **Query state:** to obtain the device current status;
- **Refresh Page**: Refresh the current web page;
- **View data**: Go to the **'AE Data'** page to view the data;
- **Device Notification**: Click to obtain the notification messages of the device.

(1) **Firmware Upgrade**:

To upgrade the firmware, select the target device and click **[Device Action]** on the right. In the pop-up window, click **[Upgrade]** to upload the firmware package. Contact us for the firmware package. After the device receives the upgrade request, it will upgrade automatically and automatically reboot to take effect. Please don't interrupt the process until the device finishes rebooting and is back online again.

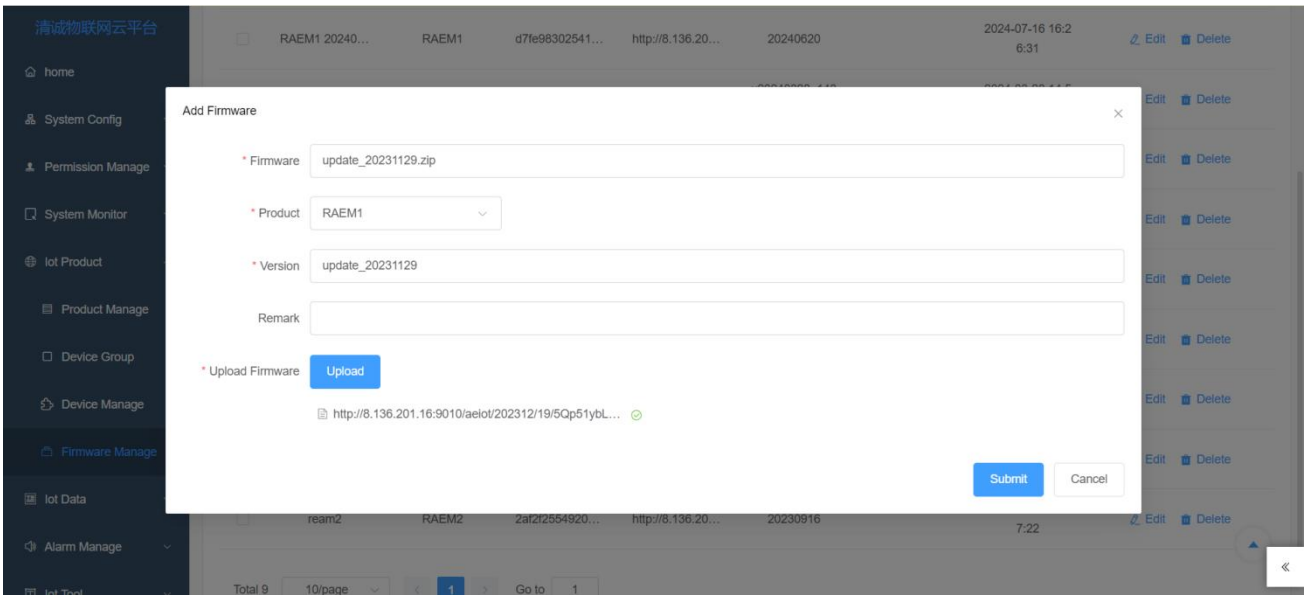


Fig. 4-18 Firmware Upgrade Window

(2) In the [**AE Parameter Config]** tab:

- **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.

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 20,000,000 (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.

- **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.

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 waveform**

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

- **Sampling status**

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

- **System time**

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

After completing the settings, click **[Submit]**. If you see "OK" returned at the top of the page and the page parameters have been modified, it means the modification is successful.

Copy Device Config: Click and pop up a window to select the devices of the same group to have all the copied configurations. After submitting, the selected device will be updated synchronously.

(3) In the **[AE Filter Config]** tab:

- **Enable Filter**

Whether to enable the digital filter in the device or not.

- **High-pass Filter:** it means the lower limit of the frequency band. When the signal frequency is lower than this frequency, the signal will not pass. Unit of KHz.
- **Low-pass Filter:** it means the upper limit of the frequency band. When the signal frequency is higher than this frequency, the signal will not pass. Unit of KHz.

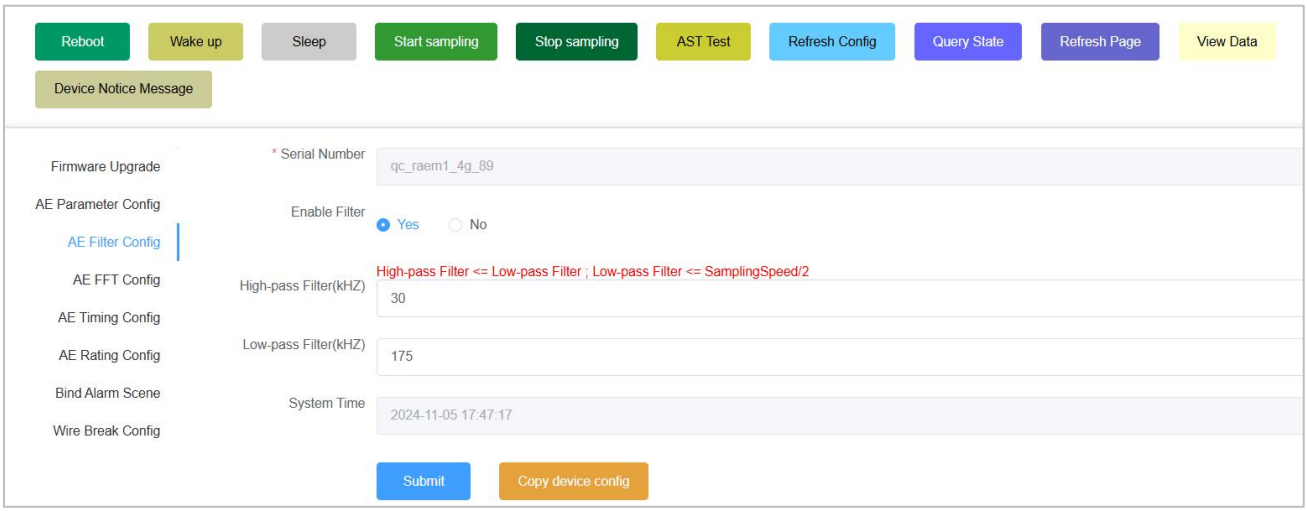


Fig. 4-19 AE Filter Config

(4) In the **[AE FFT Config]** tab:

- **Enable FFT:** Whether to enable the FFT function or not.
- **Decimation Factor [1-10]:** choose an integer from 1 to 10 to decimate the signal by M. It means it keeps only every M^{th} sample to perform the FFT function.
- **Start Frequency**: The start frequency of the partial power spectrum segment.
- **End Frequency**: The end frequency of the partial power spectrum segment.

After filling, press "**Auto Spacing**" to auto proportionally allocate the frequency range set here.

- **Partial Power Segment 1 to 5**: check-box the **[Enable]** ☑ after the segment to enable the current frequency segment. Any segment can be selected as needed. After selecting a segment, set its frequency band upper and lower limits. Simply enter a positive integer in unit of "kHz";

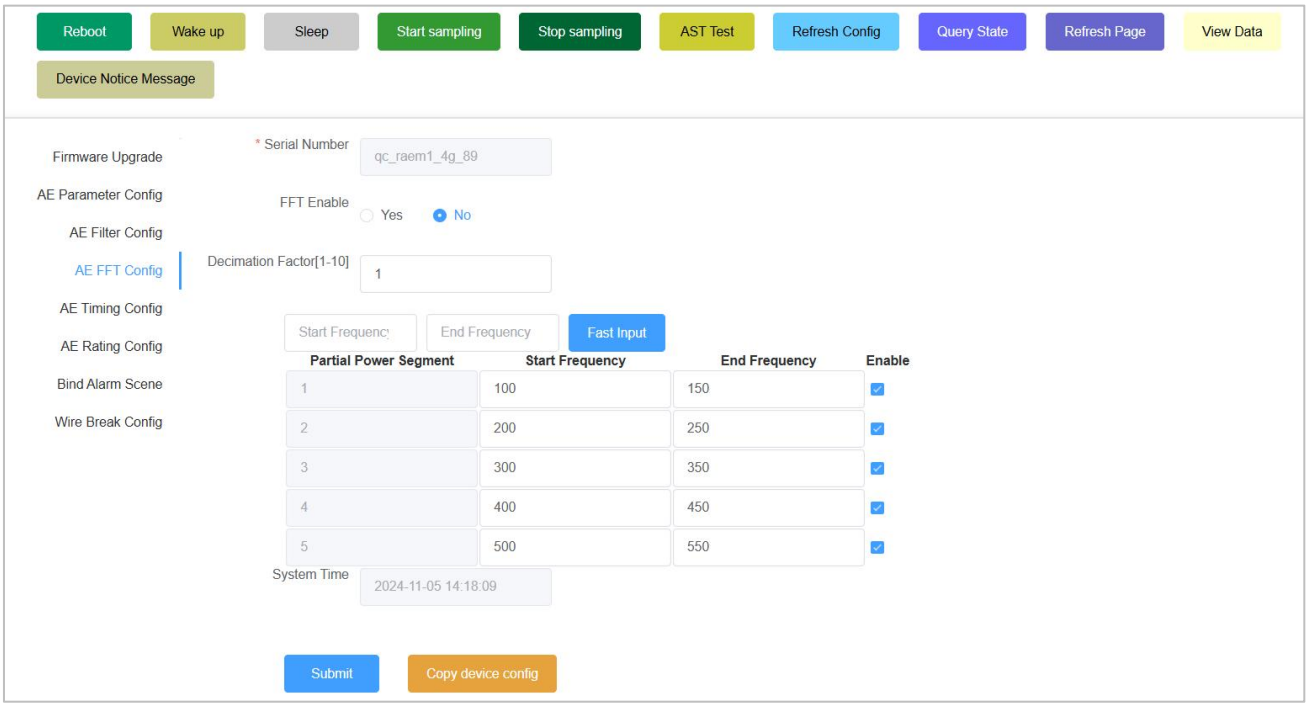


Fig. 4-20 AE FFT Config

(5) In the **[AE Timing Config]** tab:

You can choose to collect signals at regular intervals. The default is the **"Continuous Sampling"** mode, which means that the acquisition is continuous and uninterrupted. Another type is the **"Interval Sampling"** mode, which means that after collecting signals for a period of time, the collection is paused for a period of time, and then restarted for a period of time, repeating the cycle. If you choose the Interval Sampling mode, you need to set the duration of each collection (in seconds) and the duration of stopping (in seconds). The **"Scheduled Sampling"** mode, which means only start to collect data when the start

time is up, and stopping the collection when the end time is up. Its minimum unit is days.

Operations:

Click **[Device Action] >> [AE Timing Config.]** button on the right menu bar of the desired device to open the "Device Configuration".

After completing the settings, click **[Submit]**. If you see "OK" returned at the top of the page and the page parameters have been modified, it means the modification is successful.

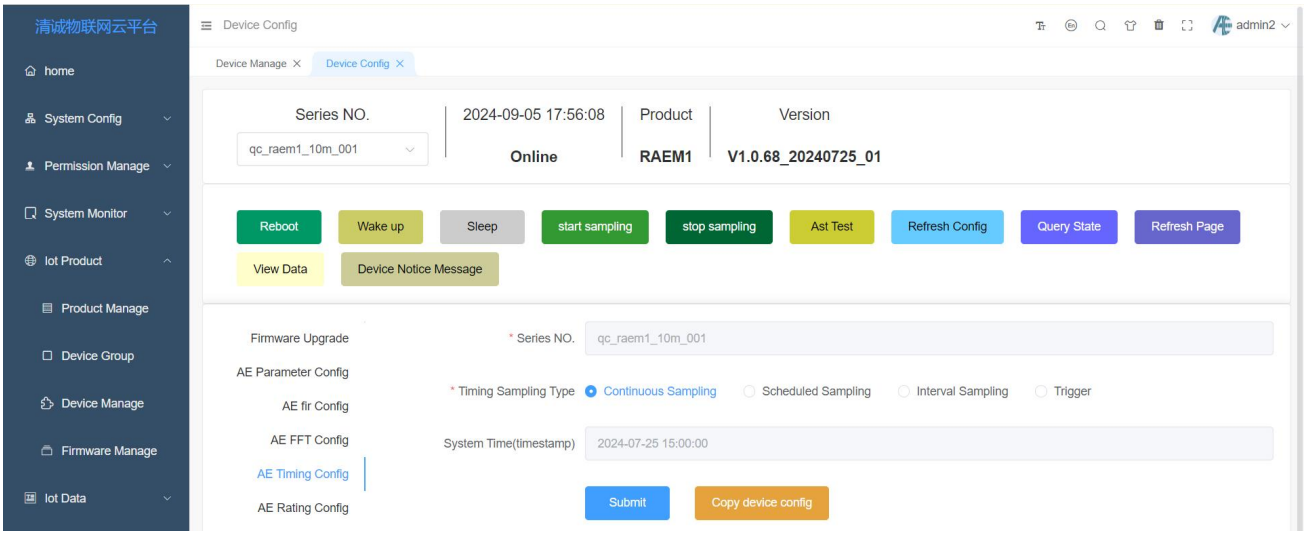


Fig. 4-21 Timing Configuration Page

(6) In the **[AE Rating Config]** tab:

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

- **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.

Operations:

Click **[Device Action] >> [AE Rating Config.]** button on the right menu bar of the desired device to open the "Device Configuration".

After completing the settings, click **[submit]**. If you see "OK" returned at the top of the page and the page parameters have been modified, it means the modification is successful.

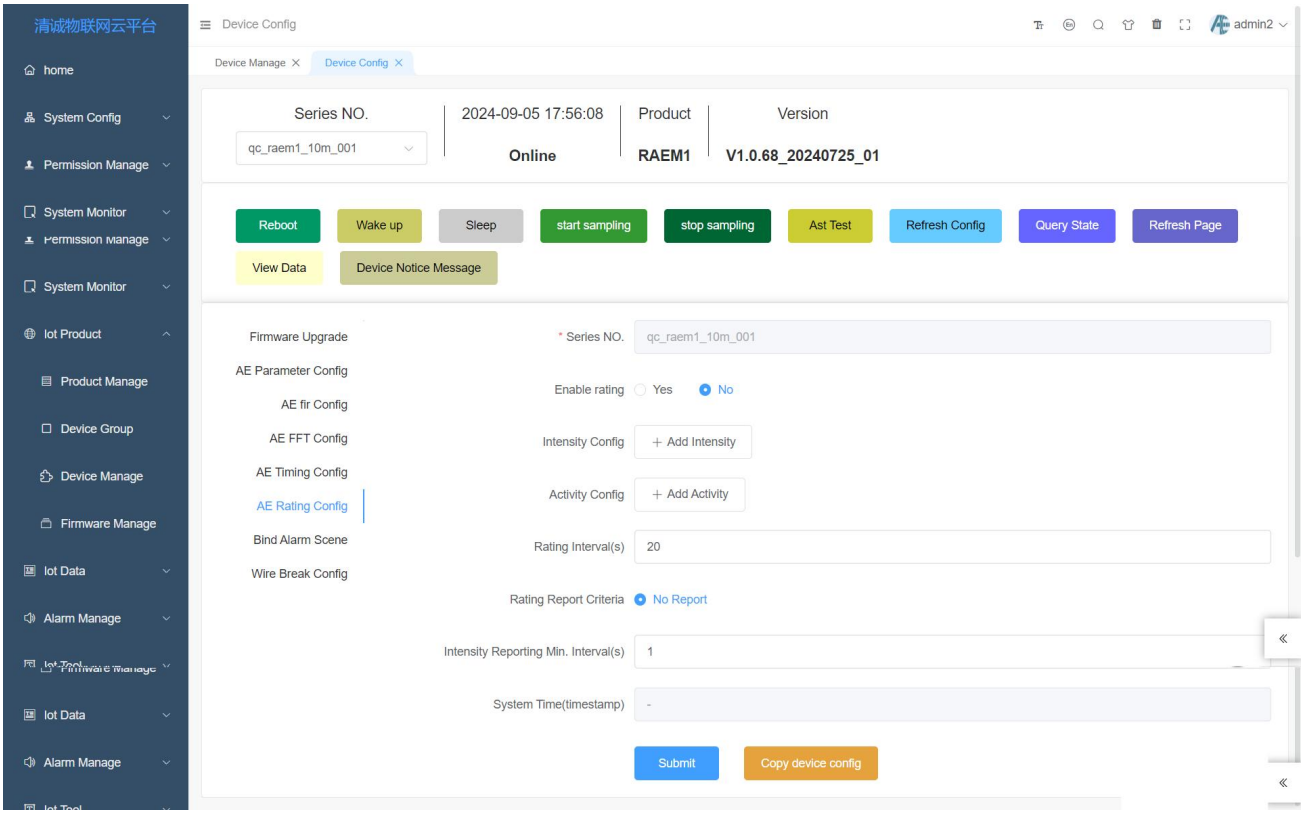


Fig. 4-22 Device Manage > AE Rating Configuration page

(7) In the **[Wire Break Config]** tab:

Wire break configuration is the setting of the calculation and determination function of wire break rate.

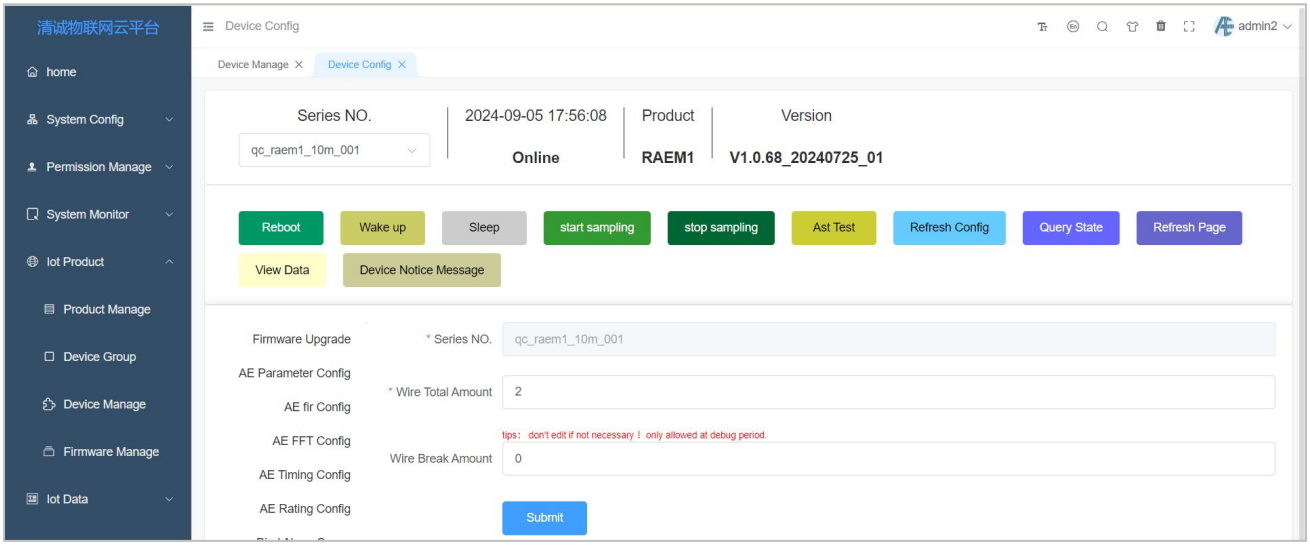


Fig. 4-23 Wire Break Configuration Page

4.3.2 IoT Data

4.3.2.1 AE Data

The **[AE Data]** page displays the time diagrams of the change of a few parameters of one or a few devices. You can click **[IoT Data]** → **[AE Data]** in the menu bar on the left side of the platform to enter. Or click the **[View Data]** button on the right side of the **[Device Manage]** page to enter the **[AE Data]** page of the device. The default is the correlation diagram of all parameters with time.

- **Product:** select the product type of the device.
- **Device:** Enter or select the device number. There can be more than one device.
- **Parameter:** View the relationship between the selected parameter and time. The optional parameters are: AMP (amplitude [dB]), ASL (average signal level [dB]), Power (energy [KpJ=10^3 pJ]), duration [μs], counts, rise time [μs], RMS (root mean square [mV]), rise counts.
- **Creation At:** You can choose the length of the time axis to be displayed, such as the last 10 minutes, one hour, one day, one week, etc. or set any time period.

(1) Viewing Data

Select "RAEM1" for **[Product]**, select the actual equipment ID number for **[Device]**, and select **[Created At]** according to your needs. After setting, click **[Search]** to update the chart display. When the mouse moves over on the charts, the reading and time of the parameter corresponding to the horizontal

and vertical coordinate points will be displayed.

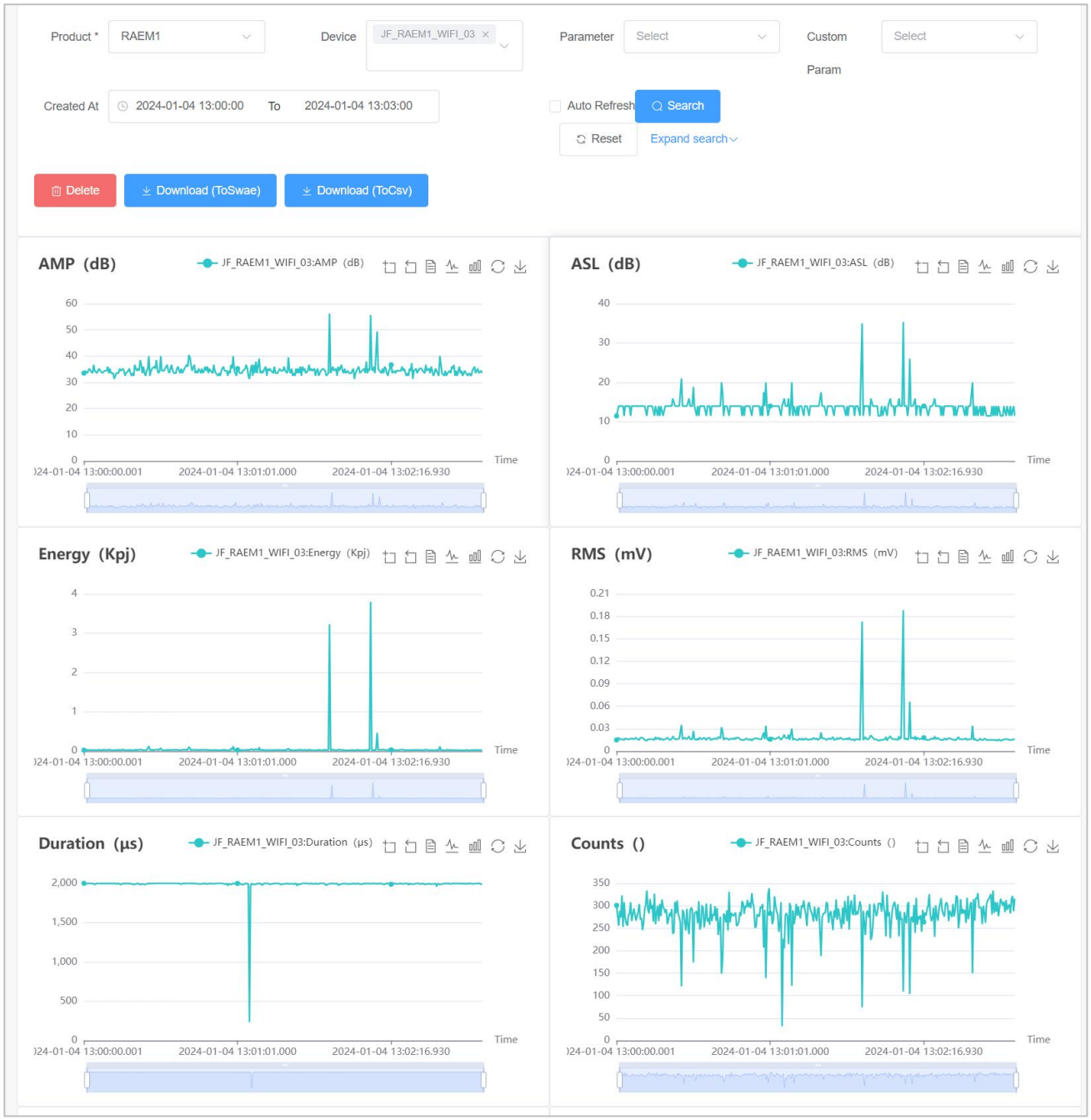


Fig. 4-24 Data monitoring page

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.

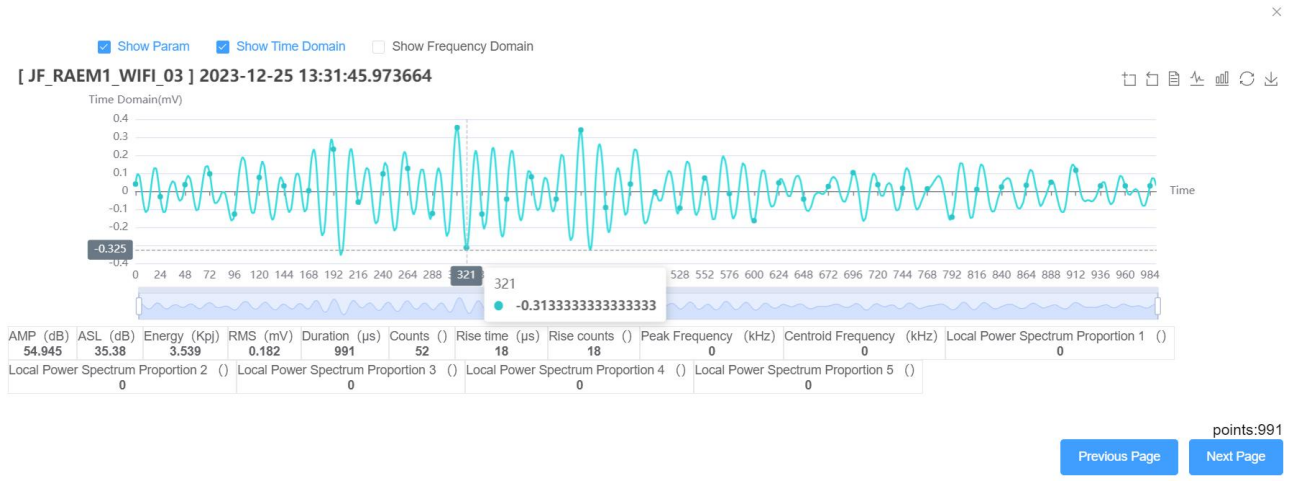


Fig. 4-25 Waveform page from the AE Data

The buttons in the upper right corner are: Regional Zoom In, Regional Zoom Out, Data View, Switch to Line Chart, Switch to Bar Chart, Restore, and Save as Image.

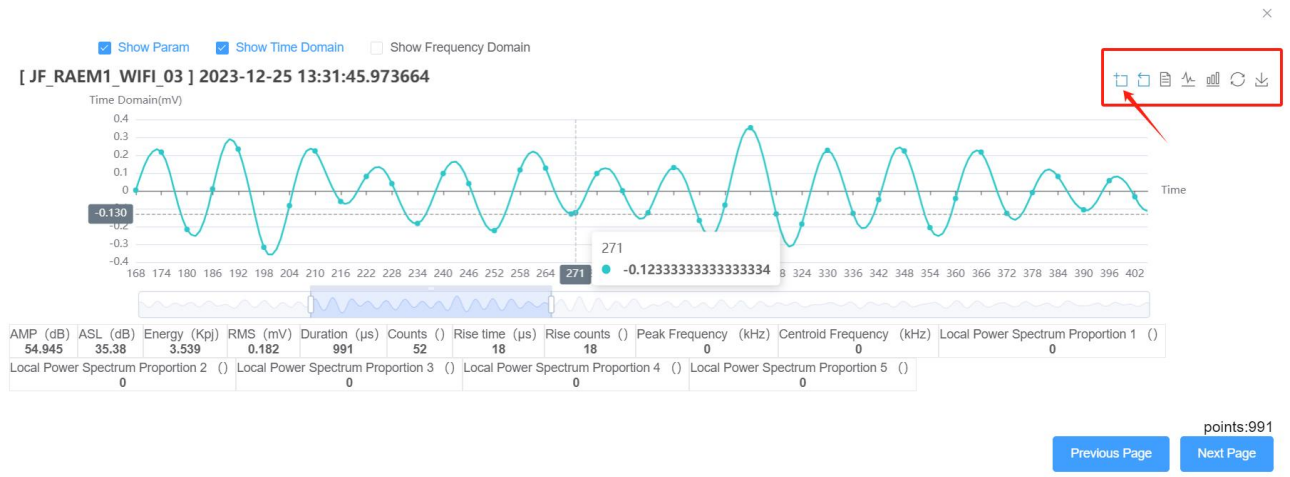


Fig. 4-26 Expand Waveform page from

- **Regional Zoom In**: Click "Regional Zoom-in" button, then use the mouse to pressure down and drag a rectangle area in the graph. Once releasing the mouse, only the selected area (in time domain) of the graph will be displayed.
- **Regional Zoom Out**: Click "Regional Zoom-out" button, the graph will restored to the previous zooming stage.
- **Data Table**: list all the data points in table list.
- **Switch to line chart**: display data in line chart.
- **Switch to bar chart**: display data in bar chart.

- **Restore:** Restore to default state.
- **Save as Image:** You can save the image to your computer.

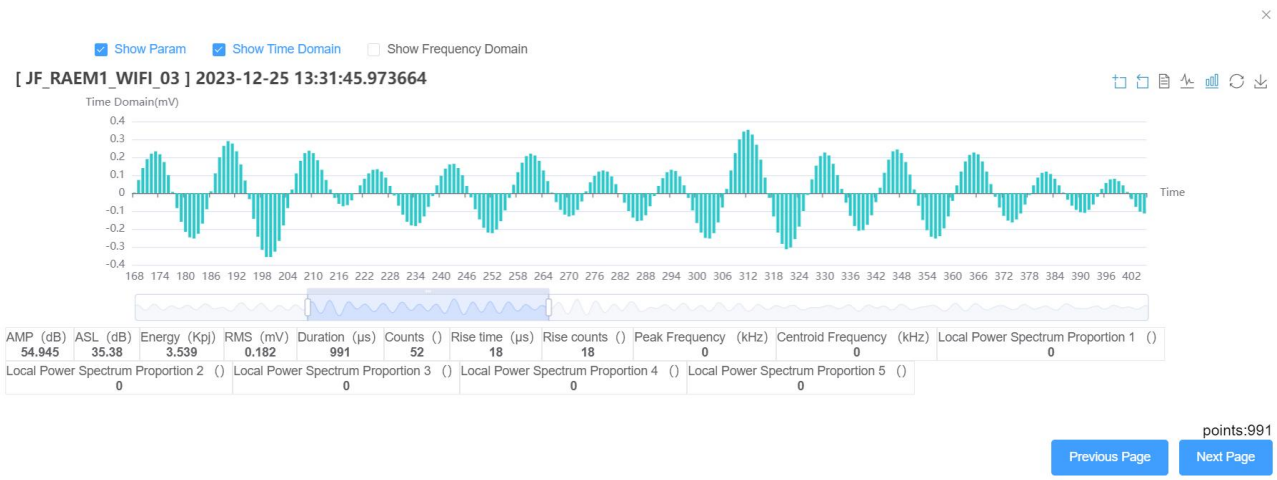


Fig. 4-27 Expand Waveform page from in bar diagram

(2) Data Download

- **Download (To CSV)**: Download the AE data locally in CSV format.

Steps: **[Product]** Select **"RAEM1"**, **[Device]** Select the device number that needs to download data, **[Creation Time]** select the creation time of the data that needs to be downloaded, and click **[Download (To CSV)]**. In the pop-up window, click "**OK**" to start the download of data. Once finished, it will show up as a CSV file with all parameters from the selected time frame of the device.

- **Download (To SWAE)**: Download the AE data locally in the format of SWAE software can read, which is .PRA and .AED format.

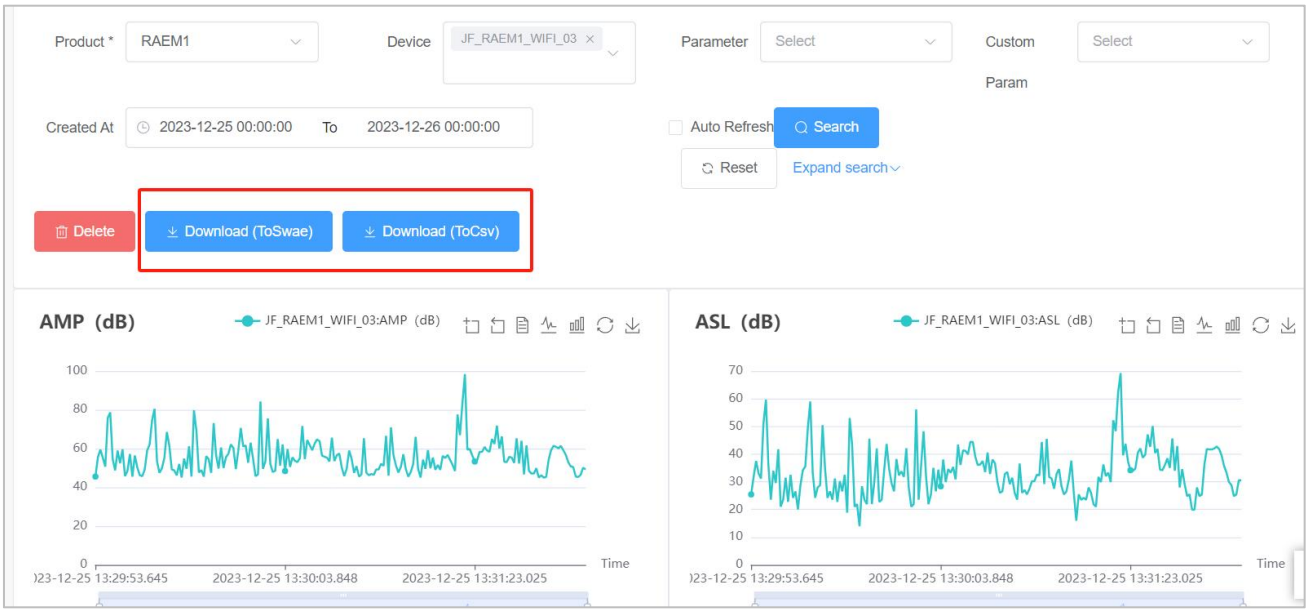


Fig. 4-28 Download Data

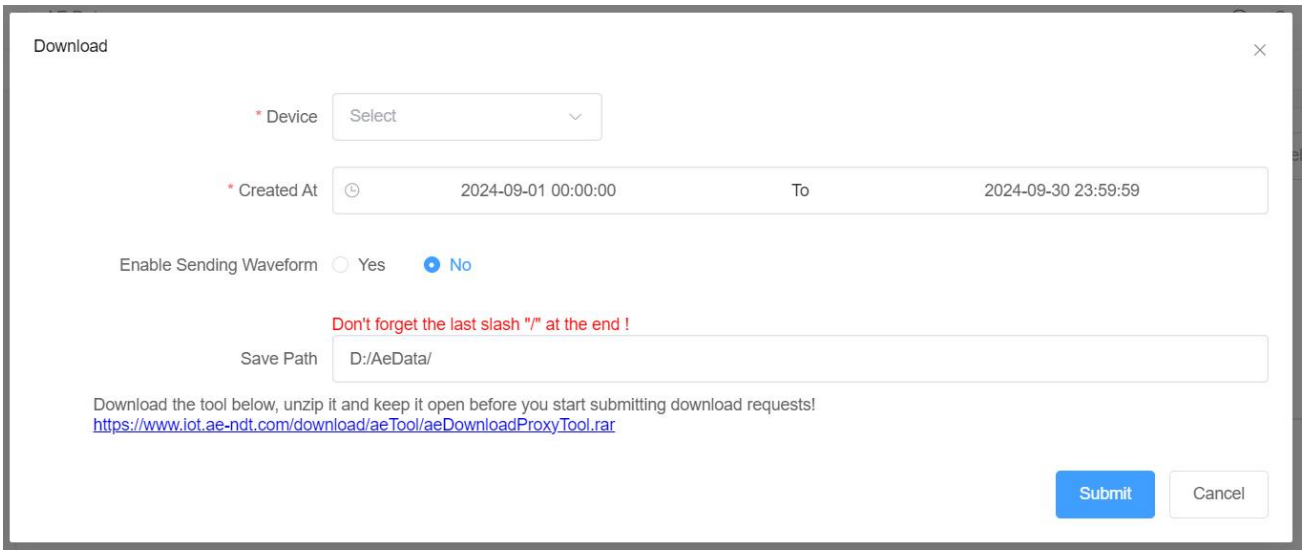


Fig. 4-29 Download to SWAE window

If **[Download To SWAE]** is selected, first download the "aeDownloadProxyTool.rar" by clicking the link at the bottom of the pop-up window and decompress the compressed file, run the "Tools". Select "Device" and "Creation Time". If you also need to download the waveform data, select "Enabling Sending Waves" and click "Submit" after completing the settings.

After submission, when the running 'Tools' page displays '**download finish!!!**', it indicates that the data download is complete.

Fig. 4-30 Finishing Download the AE tool

After downloading, you can see the downloaded data in the save directory.

Note: The saved directory is "D:/AeData/" (the file save path can be modified). The data will be stored

in a subfolders under this directory, named after the time when the data was downloaded.

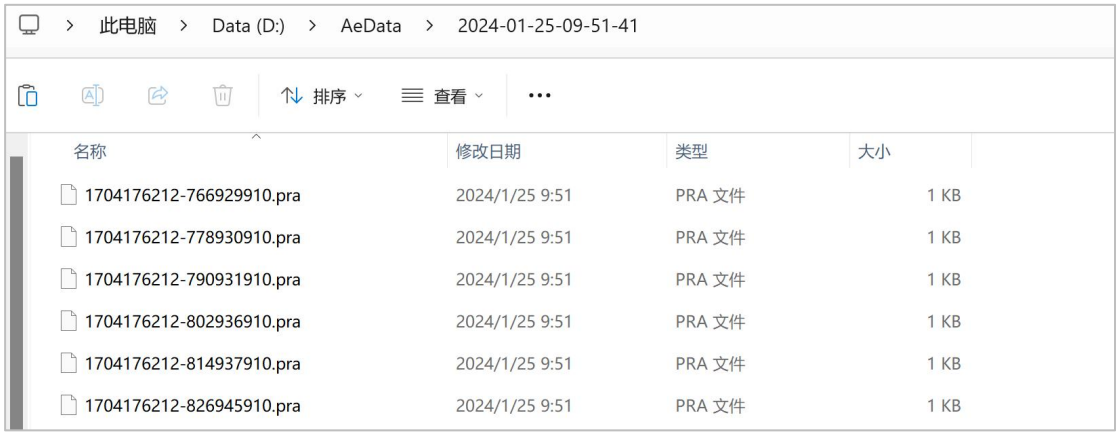


Fig. 4-31 Downloaded data in PRA format

Data format conversion operation:

Please refer to Chapter 9 for specific steps on data format conversion for the "RAE1toU3H" software conversion.

Data Replay operation:

Open the "SWAE software" and first confirm whether the devices supported by the software are RAEM1 devices.

Click on '**Data Replay**', then click on '**Replay Settings**'. In the pop-up file selection window, select the data file to be played back. The data files mainly include waveform files with a suffix of .aed and parameter files with a suffix of .pra.

Steps:

① By default, select '**Parameters'** and **'Waveform'**, and choose the type of data playback as needed. When both are selected, both parameter files and waveform files will be played back simultaneously;

Note: If "**waveform to parameters**" is selected, a new parameter file will be automatically generated when replaying the waveform;

② Set playback speed (FPS) to a maximum of 100000; Set 200 here, click **[OK]** after setting is complete

③ Click on **[Replay]**.

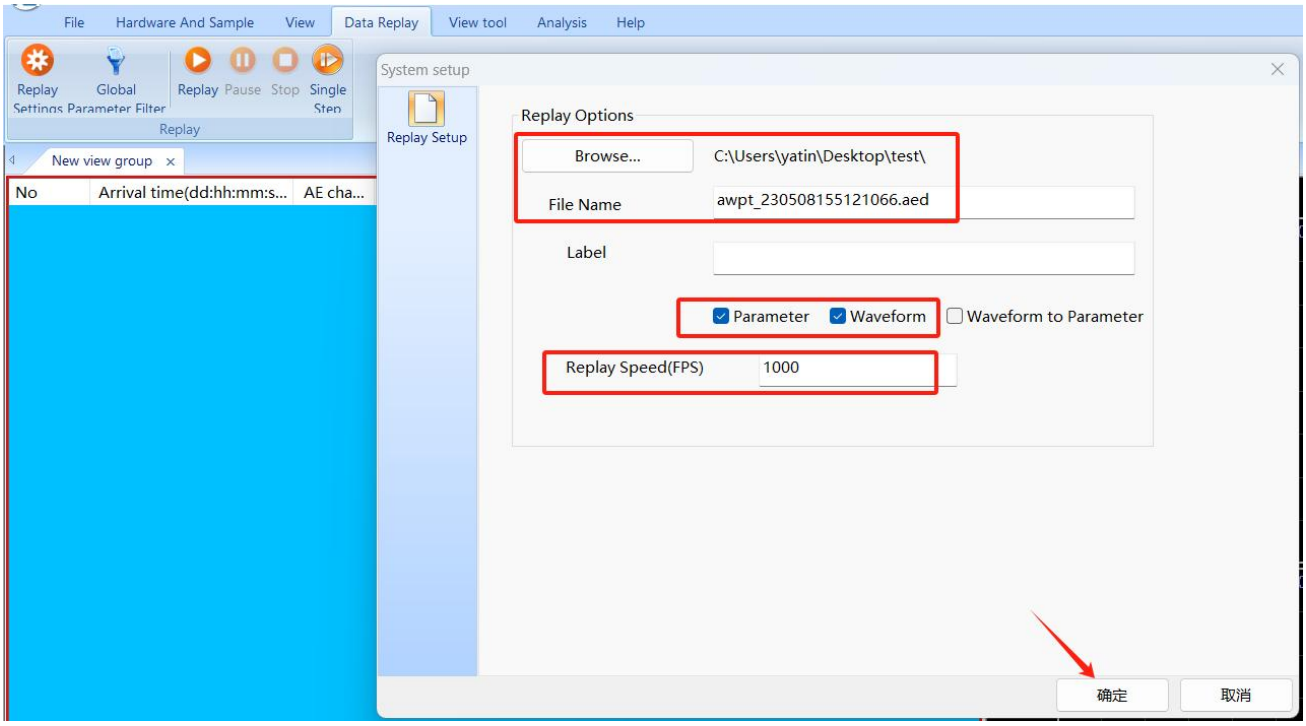


Fig. 4-32 Data Replay

(3) Data Delete

Delete: Delete the sound emission data.

Click on '**AE Data**', select the **product, device, creation time**, then click '**Delete**' to delete the data of the selected device during this period. (Note: After selecting the parameters, click Delete to delete the data within the selected time period).

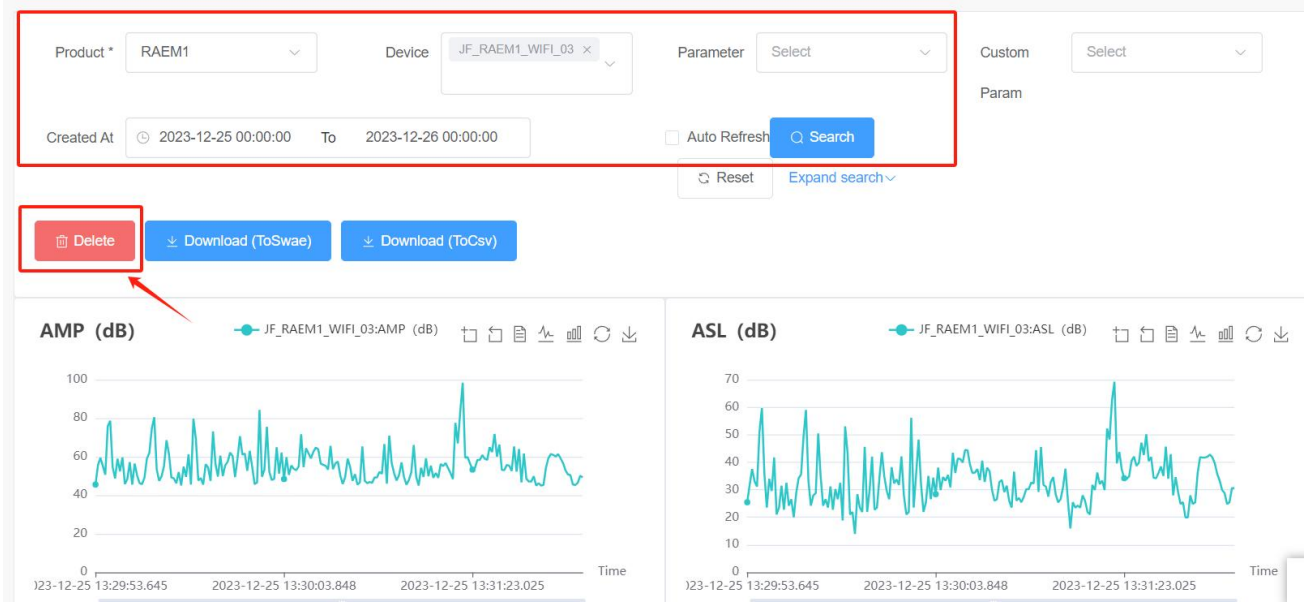


Fig. 4-33 Delete Data

4.3.2.2 AE Rating Data

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 4-3 Rating level standards

Users need to choose **[IoT Product] > [Devices]**, select a device and click the **[Device Action]** to open the **[Device Config]** tab. In the **[Device Config] > [AE Rating Config]** 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.

Rating result viewing operation:

In the **[IoT Data] > [AE Rating Data]**, select the device that needs to view the rating results. The rating types are optional: intensity, comprehensive, and activity. Click on **[Search]**.

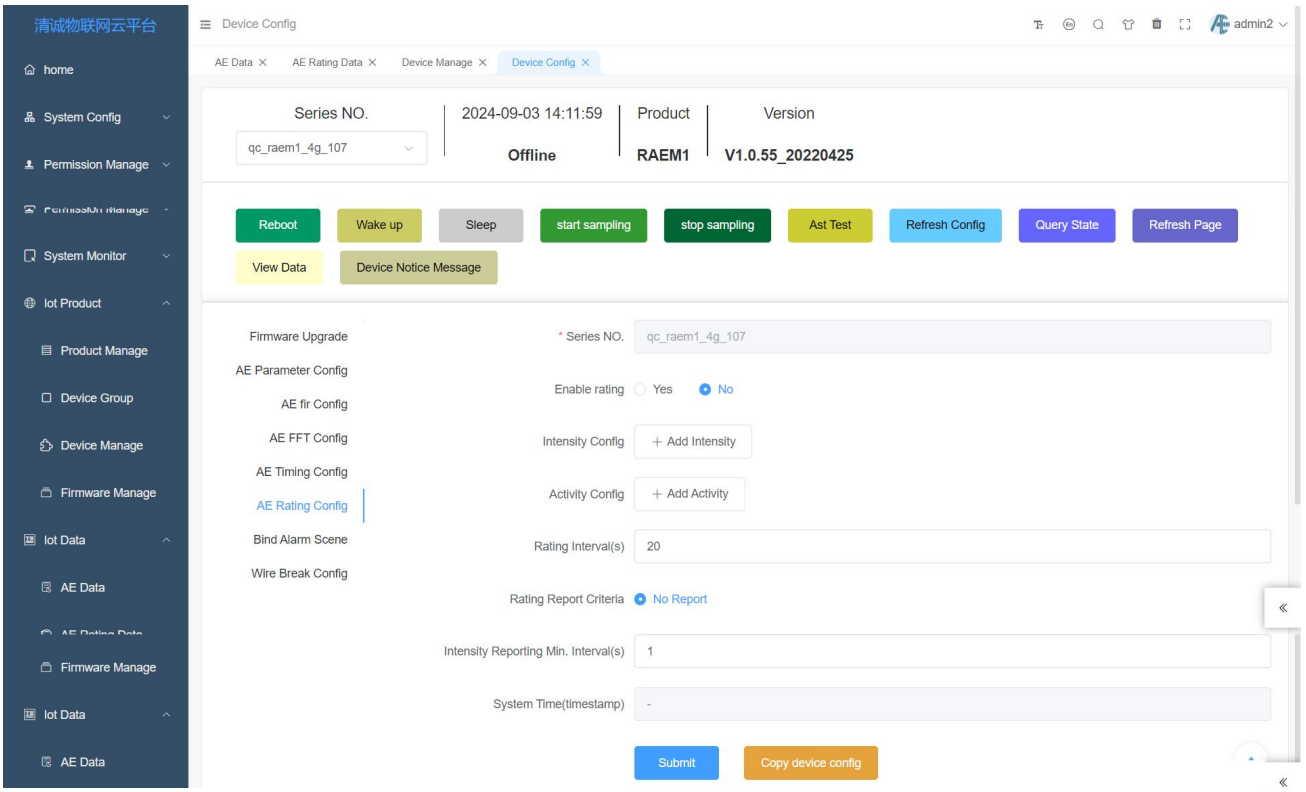


Fig. 4-34 Setup AE rating settings

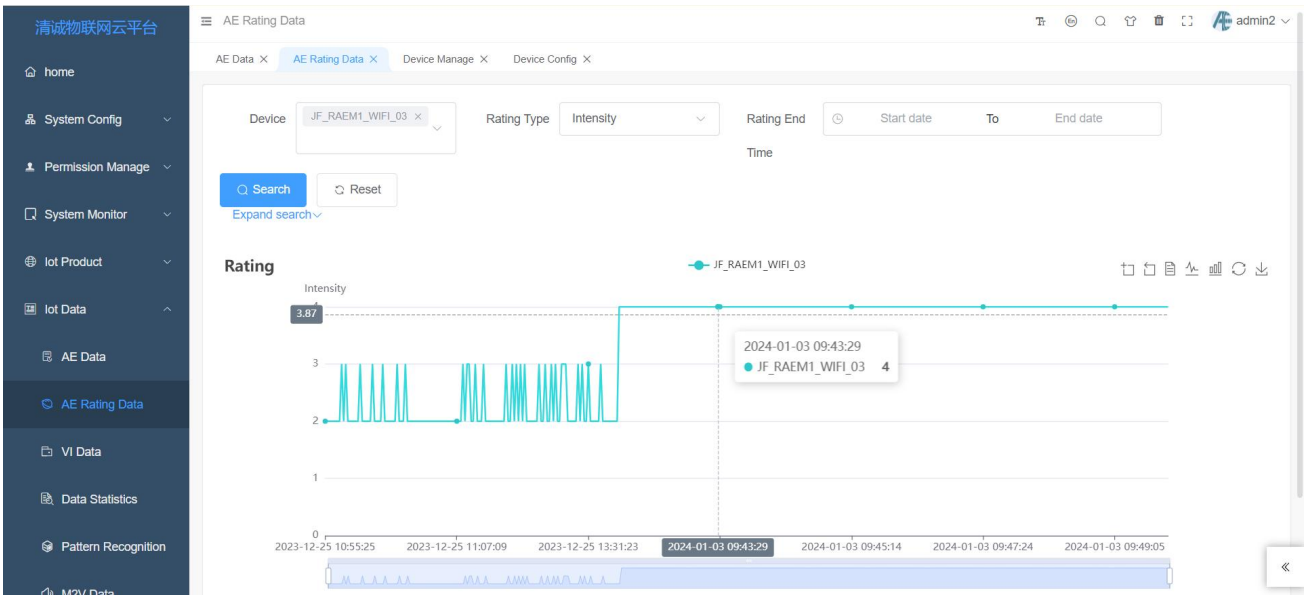


Fig. 4-35 AE Rating result view

4.3.2.3 Correlogram

Correlation graph refers to a type of relationship graph that uses two or more acoustic emission parameters as horizontal and vertical coordinates to draw correlation curves, distribution graphs, line

graphs, etc., to characterize acoustic emission signals. It is a major application tool for analyzing parameter data.

- **Add Graph**: Add a new AE correlation graph;
- **Save Settings**: Save existing settings;
- **Restore Settings**: Restore the settings of the last saved sound emission related image;
- **Points**: The number of points in the relevant chart can be selected from 100, 200, 500, 1000, 2000, 5000, 10000, and 20000;
- **Statistical mode**: There are two statistical methods to choose from: maximum value and average value;
- **Display mode**: includes three display modes: line chart, bar chart, and scatter chart;
- **[X] axis**: The X-axis parameters include arrival time, amplitude (dB), ASL (dB), energy (KpJ), RMS (mV), duration (us), counts, rise time (us), rise counts, peak frequency (KHz), frequency centroid (KHz), and 5 partial power spectrum segments;
- **[X] Range**: the range of X axis.
  - **[X] Auto**: The coordinate display range of the relevant graph will be automatically adjusted according to the data distribution situation;
  - **[X] Custom**: Filter out values that are not within this range based on the maximum and minimum values entered by the user;
- **[Y] axis**: The Y-axis parameters include arrival time, amplitude (dB), ASL (dB), energy (KpJ), RMS (mV), duration (us), counts, rise time (us), rise counts, peak frequency (KHz), frequency centroid (KHz), and 5 partial power spectrum segments;
- **[Y] Range**: The range of Y axis:
  - **[Y] Auto**: The coordinate display range of the relevant graph will be automatically adjusted according to the data distribution.
  - **[Y] Custom**: Filter out values that are not within this range based on the maximum and minimum values entered by the user.

Operation steps:

Select **[Device]** ->Select the time to be counted **[Create At]** ->Select **[Points]** ->Select **[Statistics Mode]** according to specific needs. Here, select the maximum value ->Select **[Display Mode]** ->**[X] axis**

parameter selection. Here, select the arrival time ->**[X Range]**. Here, select automatic ->select the **[Y] axis** parameter ->**[Y Range]**. Here, select automatic ->After setting, click **[Start]**.

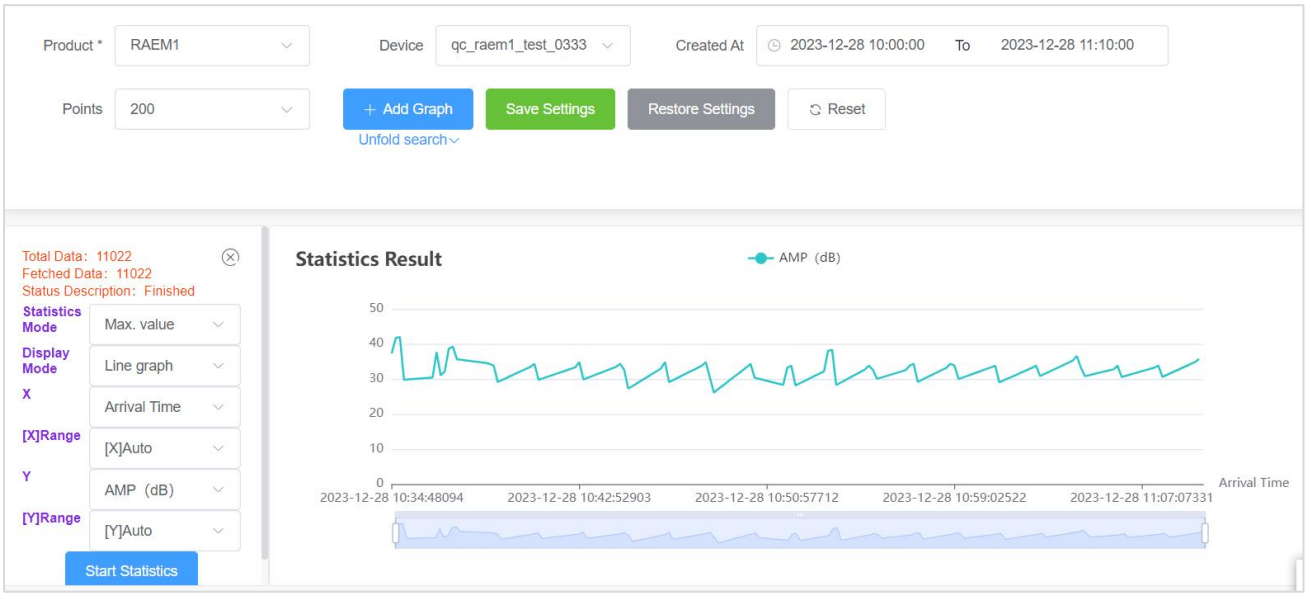


Fig. 4-36 Add a correlation graph

4.3.3 Alarms

4.3.3.1 Alarm Users

Alarm users are used to set alarm information output settings, and when an alarm is triggered, a message will be sent to the set phone or email.

Click on **[Alarms] > [Alarm Users]** to enter the alarm user page, click on **[Add]** to add a new user, and fill in the information.

- **Contact** (required): Alarm user name
- **Department** (required): Select the department user who needs to receive alarm information
- **Language**: Available in Chinese or English
- **Phone** (required): The phone number to receive alarms
- **Email**: Email for receiving alarm information
- **Receive Frequency(min)** (required) (Note: The receiving frequency depends on the frequency in the alarm scenario and the receiving frequency of the alarm user, with the maximum value being the frequency at which the user receives alarm information).

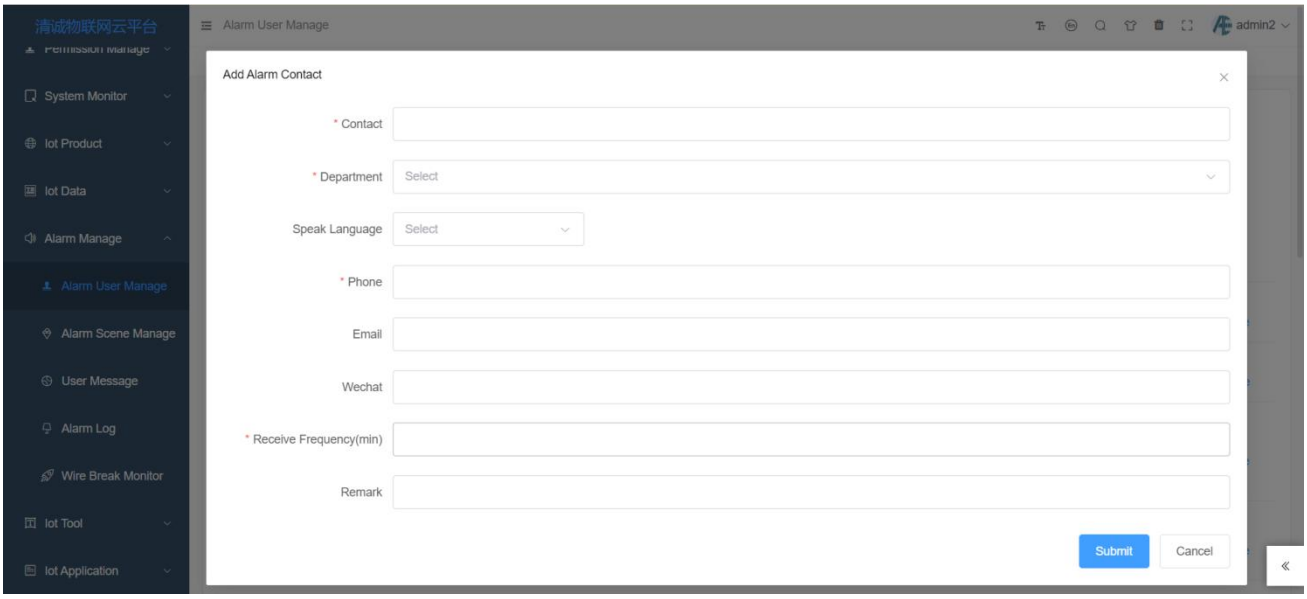


Fig. 4-37 Add alarm contact

Click on **[Alarms] > [Alarm Users]** to enter the alarm user page, click on **[Bind Alarm Scene]** on the right of the existing users to bind certain testing scenes to the user.

Fig. 4-38 Bind Alarm Scene

4.3.3.2 Alarm Scenario

Alarm Scenario: This page is used for users to customize alarm scenarios, such as in the application of bridge wire rope breakage monitoring, which can be customized as breakage monitoring.

Click on **[Alarms] > [Alarm Scenario]** to set up alarm scenarios. **[Add]** button can add alarm scenarios.

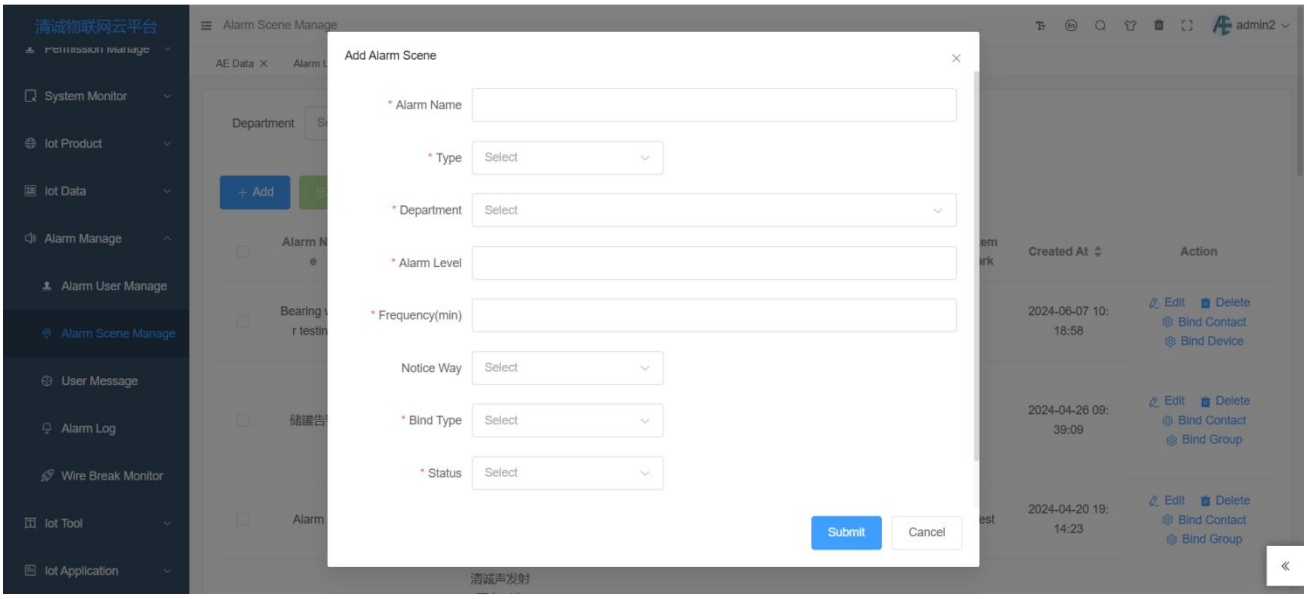


Fig. 4-39 Add Alarm Scene

Alarm Name (Required): Enter the name of the new alarm.

Type (Required): Options include Intensity, Activity, Comprehensive, Wire Break and Tank Report.

Department (Required): Select the department where the alarm scene needs to be added. Once selected, the alarm scene will only be added within that department.

Alarm Level (Required): Select based on the chosen type.

- **Intensity and Comprehensive**: Alarm levels range from 1 to 4.
- **Activity**: Alarm levels range from 1 to 3.
- **Wire Break**: The rating depends on the intensity rating.

Frequency (Required): The frequency at which the platform sends notifications, with a minimum of 1 minute.

Binding type (Required): You can choose to bind to a single device or to bind to devices within the entire device group;

Status (Required): Enable or disable alarm;

Return to the **[Alarm Scenario]** page, under the **[Action]** column:

- **Bind Contact**: select the users which are bonded to this alarm scene.
- **Bind Device**: select the devices which are bonded to this alarm scene.

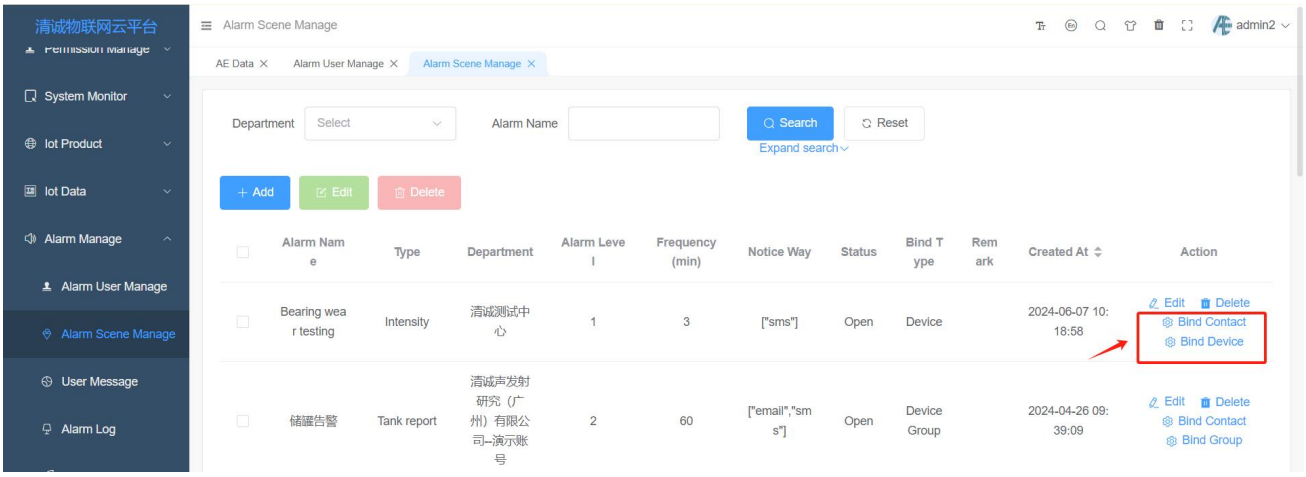


Fig. 4-40 Bind contacts or devices buttons

4.3.3.3 User Messages & Alarm Log

Click on **[Alarms] > [User Messages]** to view the user messages.

Click **[View]** under the **[Action]**, to open the **[Alarm Log]** tab.

In the **[Alarm Log]**, click **[Edit]** to mark the actions taken for that alarm notice.

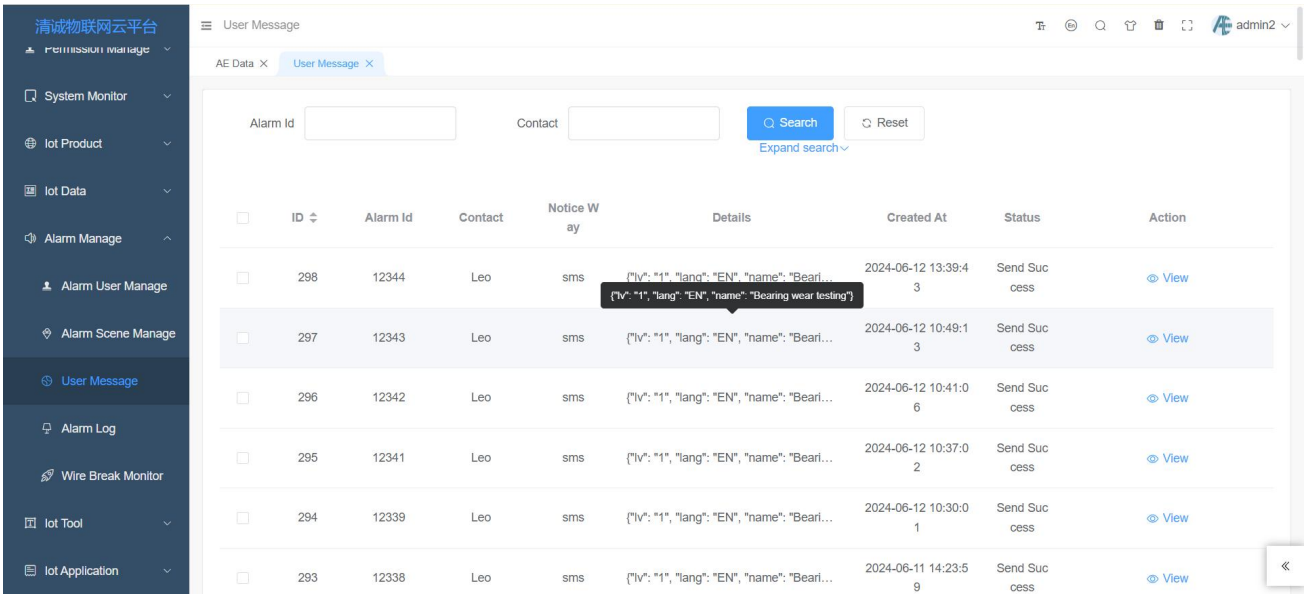


Fig. 4-41 User Messages

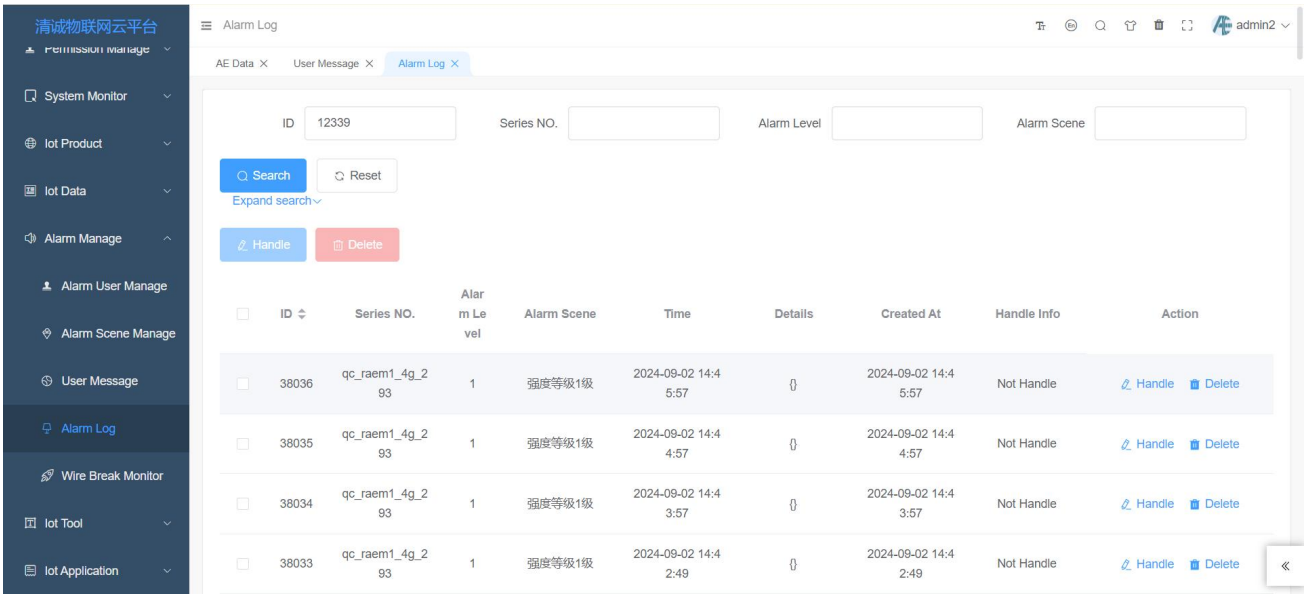


Fig. 4-42 Alarm Log

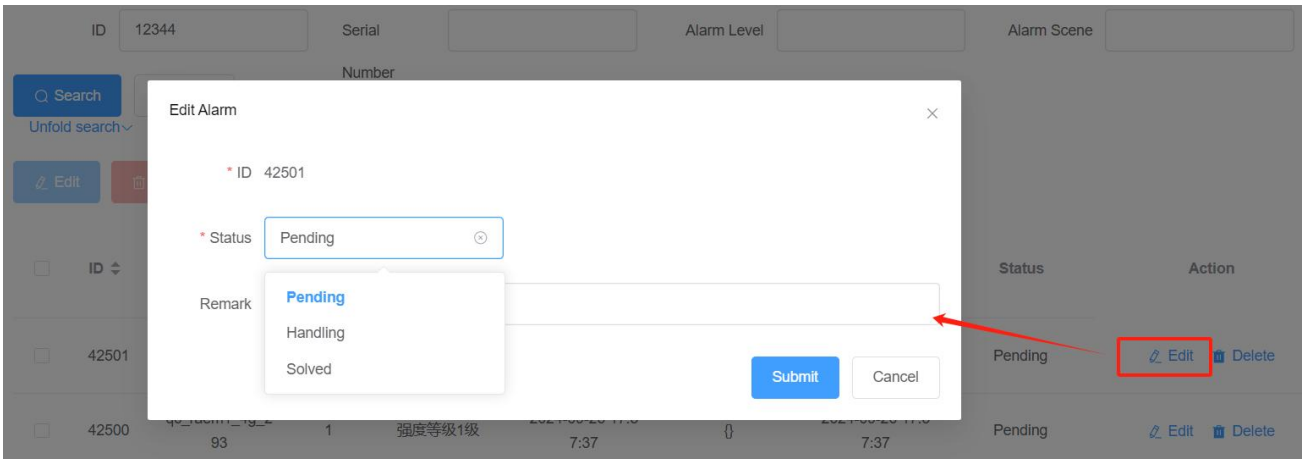


Fig. 4-43 Alarm Status Edit

4.3.4 IoT Tool

4.3.4.1 AST Test

Click on **[IoT Tool]** → **[AST Test]**. Select the device that need to be tested, after clicking **[Submit]**, please wait a moment to get the test results. But please note that AST test only works when the device has an AST sensor built-in, such as RAEM2, BWM2 series.

- **Get Result**: The most recent AST test results can be obtained.
- **Time interval (s)**: How many seconds should the AST test be sent once.

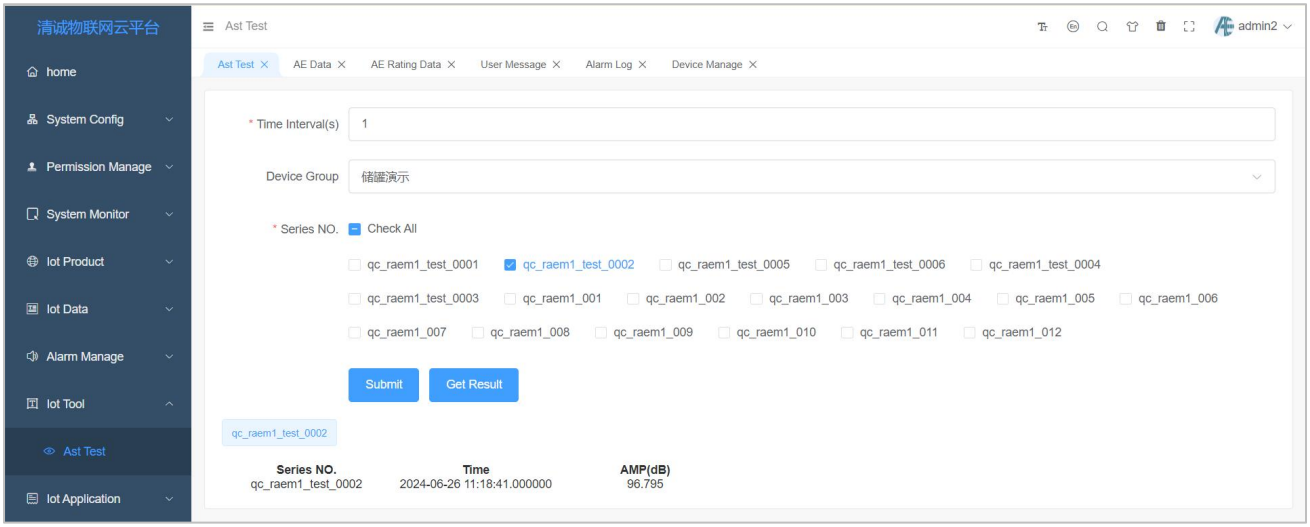


Fig. 4-44 AST Test

4.3.5 IoT Application

4.3.5.1 Storage Tank

4.3.5.1.1 Storage Tank Report

[IoT Application] → **[Storage Tank]** → **[Storage Tank Report]** to enter the tank inspection report page to set the scheduled inspection time and view the downloaded report.

- **Classifications**: Users set recommended values for acoustic emission source classifications based on the standard *"JB10764-2023 Non destructive Testing Atmospheric Pressure Metal Storage Tank Acoustic Emission Testing and Evaluation Method"*;
- **Add**: Newly added equipment for regular tank inspection, with automatic report output upon completion of the inspection;
  - **Add**: Add scheduled inspection time for storage tanks;
  - **Start Time**: Set the start time for tank detection;
  - **End Time**: Set the end time for tank detection;
  - **Delete:** Delete the scheduled detection time for storage tanks;
  - **Confirm**: Save settings.
- **Report status**: There are three optional statuses: incomplete, pending, and verified;
- **View Report**: Click to view and download this report;

- **Verify**: Review and verify newly issued reports (status as incomplete);
- **Status**: It is divided into two states: verified and pending. Newly issued reports (i.e. with a status of "incomplete") need to modify their status, otherwise they will be deleted by the system..

Operation steps:

1. **[IoT Product]** → **[Device Groups]** → **[Add]** to add a new group

2. In the new group, click **[Storage Tank Config]** and fill in basic information, sensor layout, loading sequence, and attenuation records. For specific operation steps, refer to 4.3.1.1 Device Groups;

3. **[IoT Application]** → **[Storage Tank]** → **[Storage Tank Report]** → **[Classifications]** Set the recommended values of acoustic emission source classification levels according to the standard JB10764-2023 Non destructive Testing Atmospheric Pressure Metal Tank Acoustic Emission Testing and Evaluation Method (click "Fill in Recommended Values" to directly fill in the standard recommended values). After setting, click **[Submit]**;

4. **[Add]** Select department, device group, and select device → **[Add]** Add tank inspection start time and end time → **[Submit]**;

5. Wait for the tank inspection to be completed;

6. Return to the tank report page, click on **[Search] ->** Find Report **-> [View Report] -> [Verify]** to change the report status to "Verified" or "Pending".

4.3.5.1.2 Storage Tank Data

[IoT Application] → **[Storage Tank]** → **[Storage Tank Data]** to enter the tank data page to view the rating results.

Users can select a device group to view the tank bottom plate rating results for that group.

**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	Ethernet devices. It needs to connect to a router that can access Internet.

Table 4-4 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/

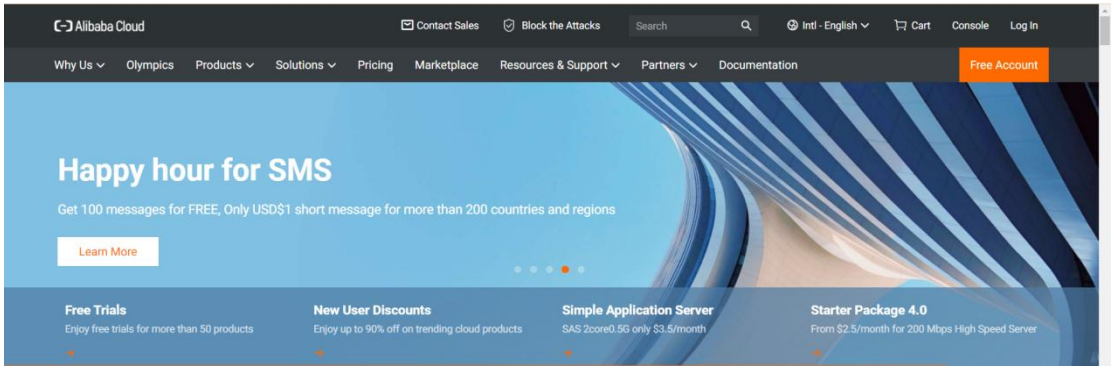


Fig. 4-45 Qingcheng Alibaba Cloud Registration

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

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

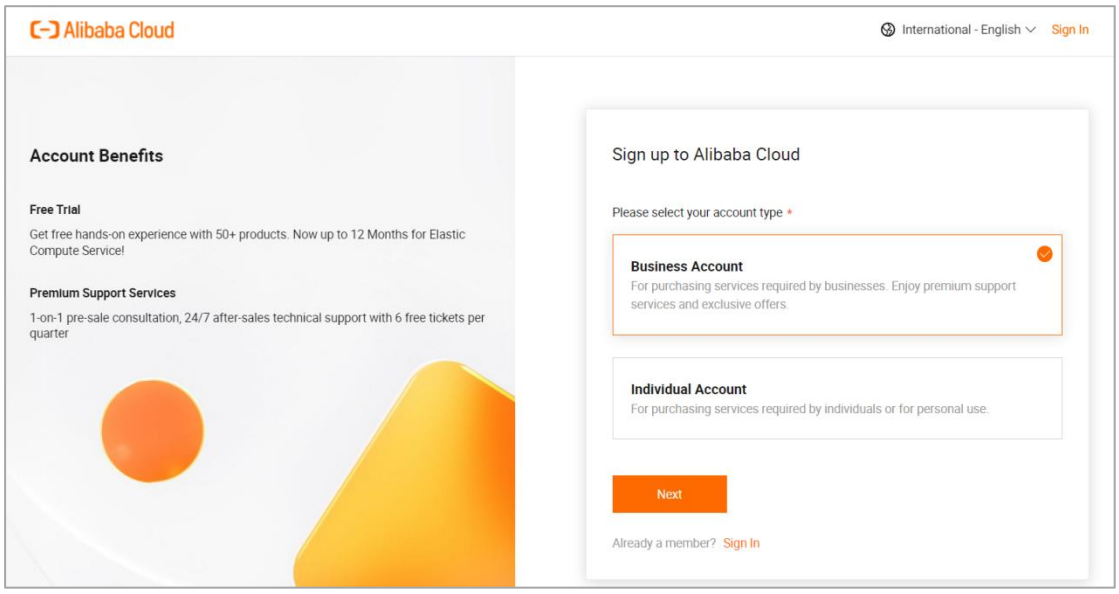


Fig. 4-46 Qingcheng Alibaba Cloud -Business Account

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)".

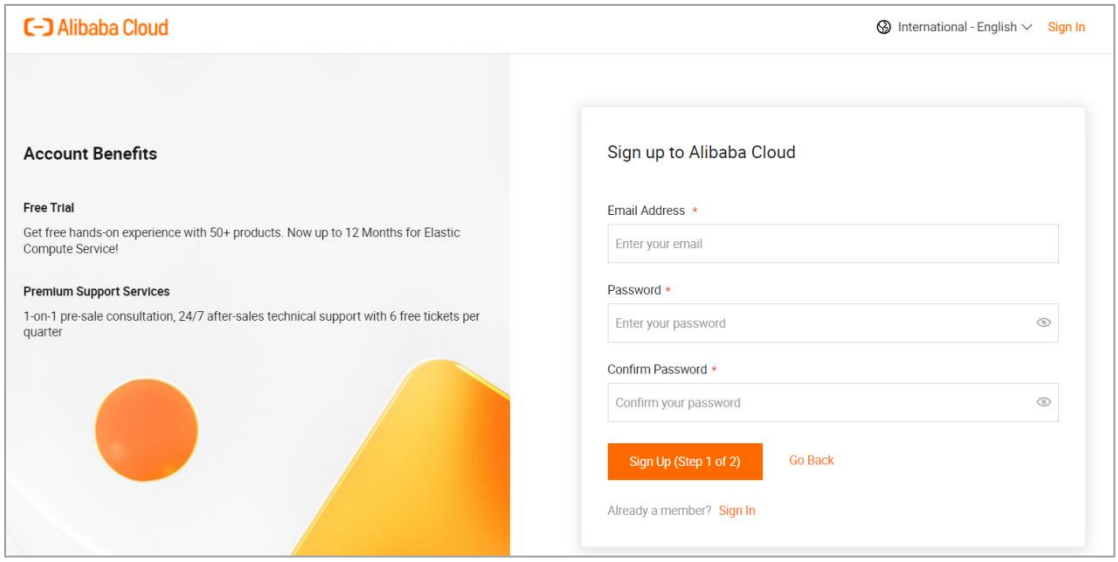


Fig. 4-47 Qingcheng Alibaba Cloud Account Info

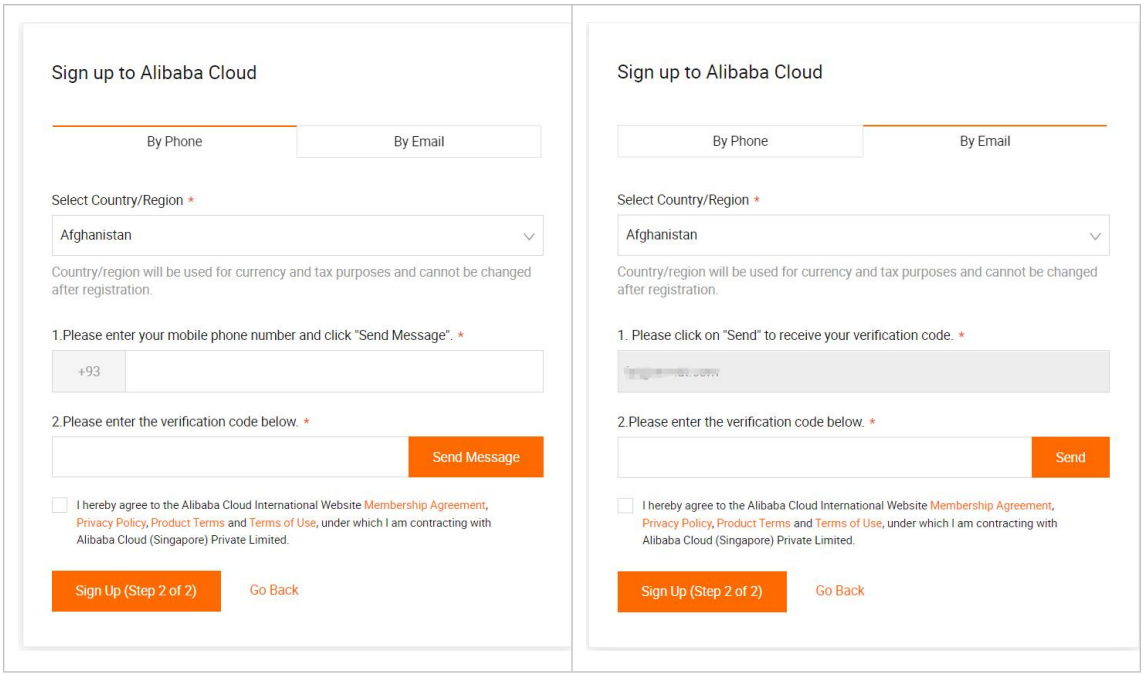


Fig. 4-48 Qingcheng Alibaba Cloud Registration Method

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

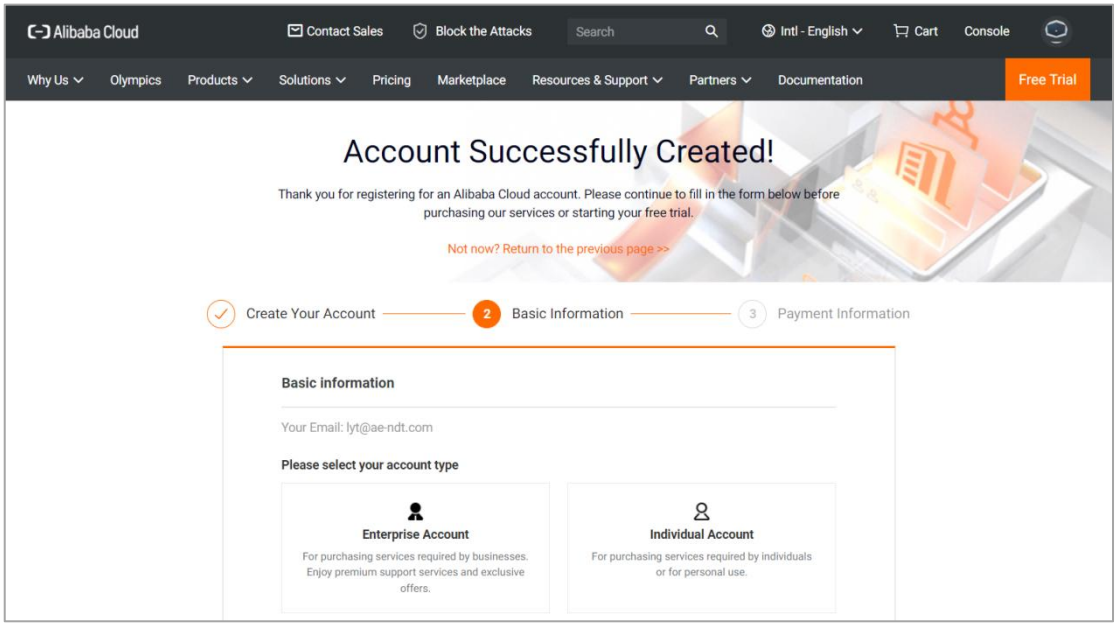


Fig. 4-49 Qingcheng Alibaba Cloud Account Created

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

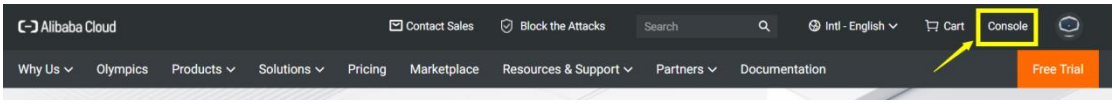


Fig. 4-50 Qingcheng Alibaba Cloud Select Console

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

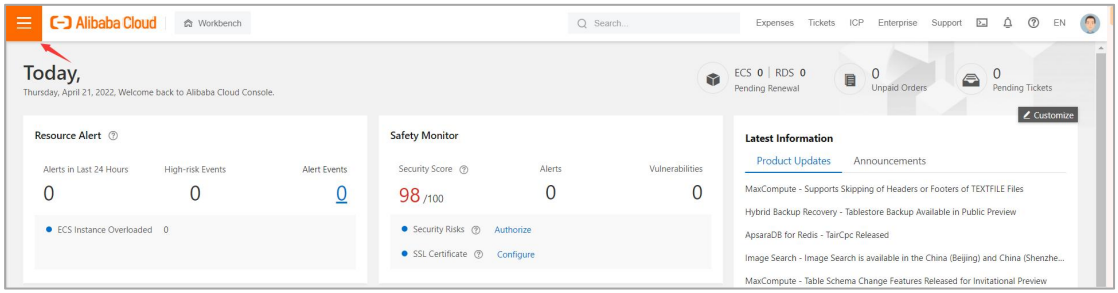


Fig. 4-51 Qingcheng Alibaba Cloud Menu Icon

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

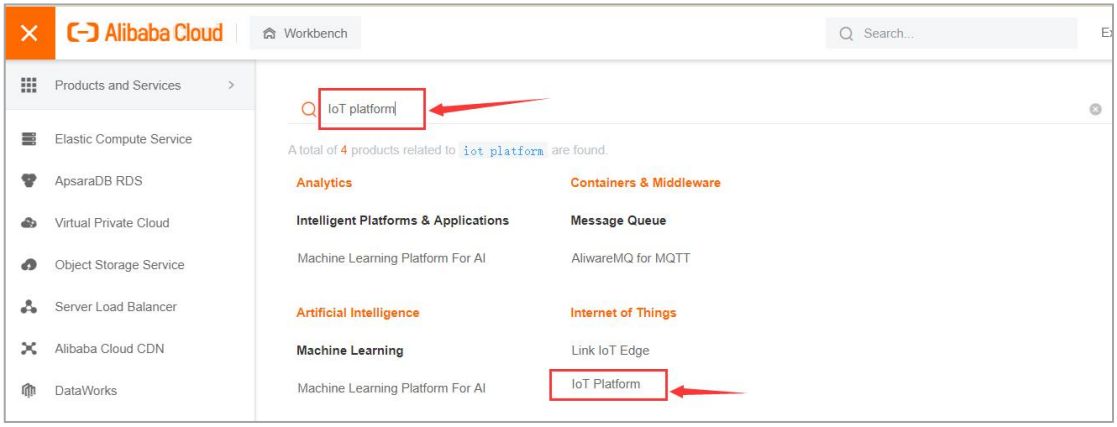


Fig. 4-52 Qingcheng Alibaba Cloud Search IoT Platform

Step 8: "Activate Now".

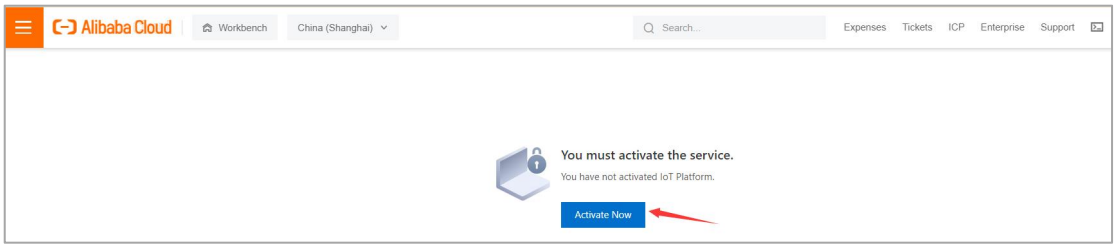


Fig. 4-53 Qingcheng Alibaba Cloud Activate IoT Platform

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.

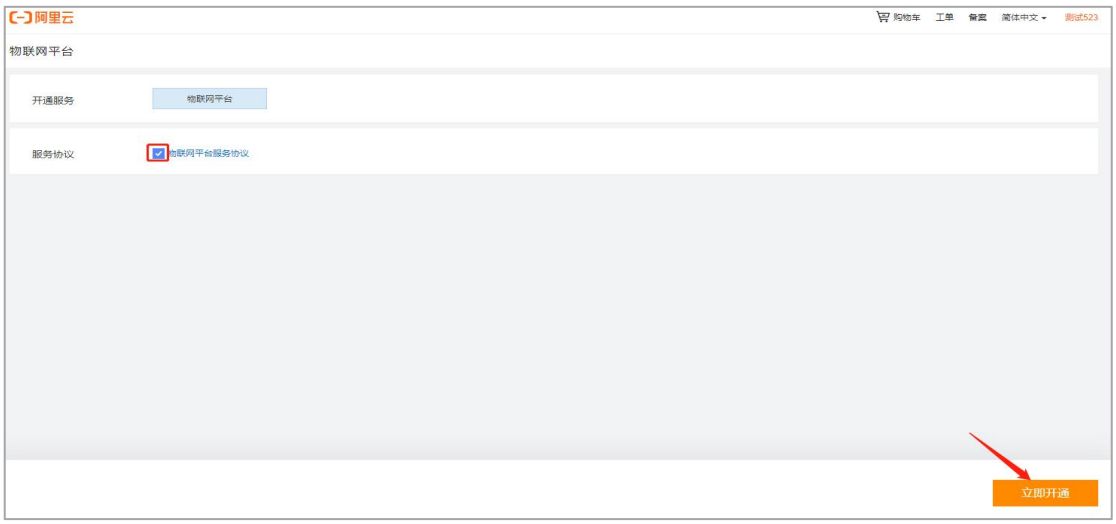


Fig. 4-54 Qingcheng Alibaba Cloud Activate Now

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

Fig. 4-55 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**".

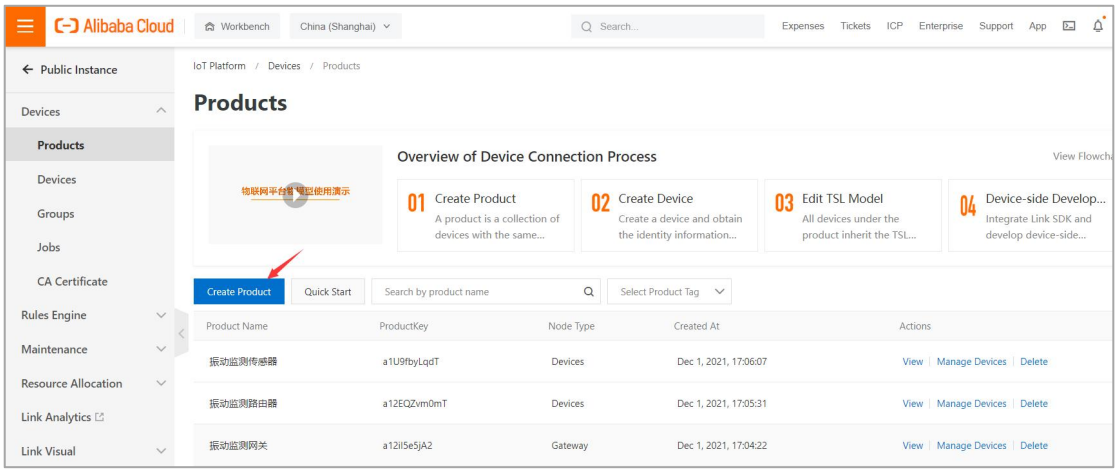


Fig. 4-56 Qingcheng Alibaba Cloud Create Product

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.

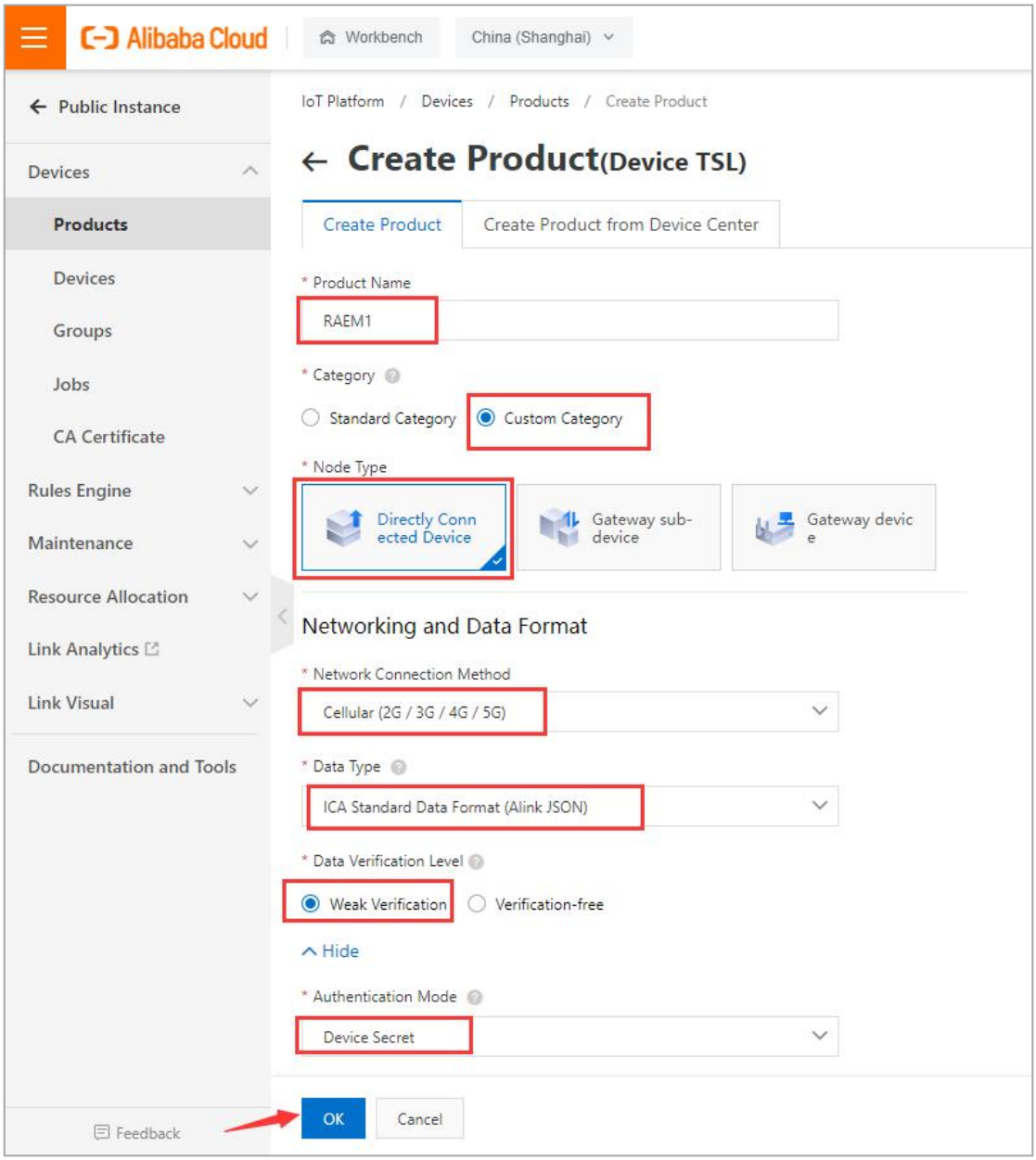


Fig. 4-57 Qingcheng Alibaba Cloud Create Product Info

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

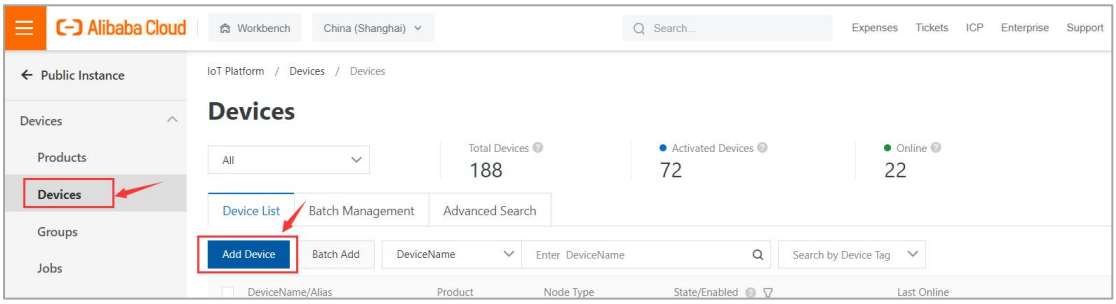


Fig. 4-58 Qingcheng Alibaba Cloud Add Device

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

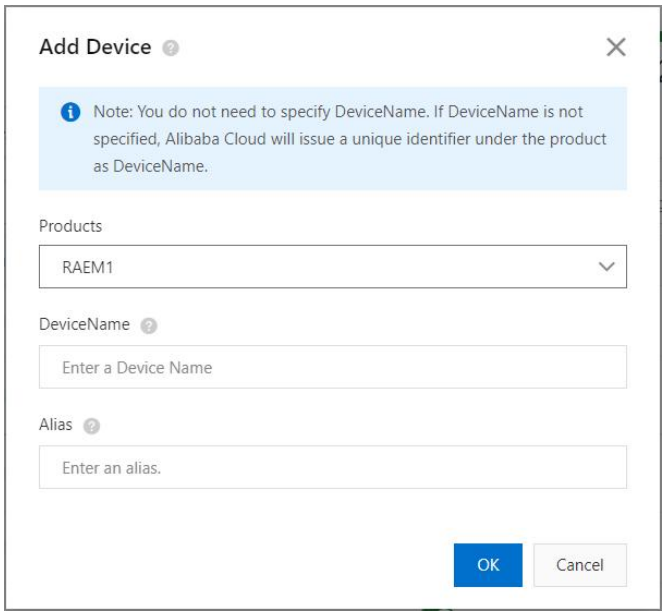


Fig. 4-59 Qingcheng Alibaba Cloud Device Info

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.

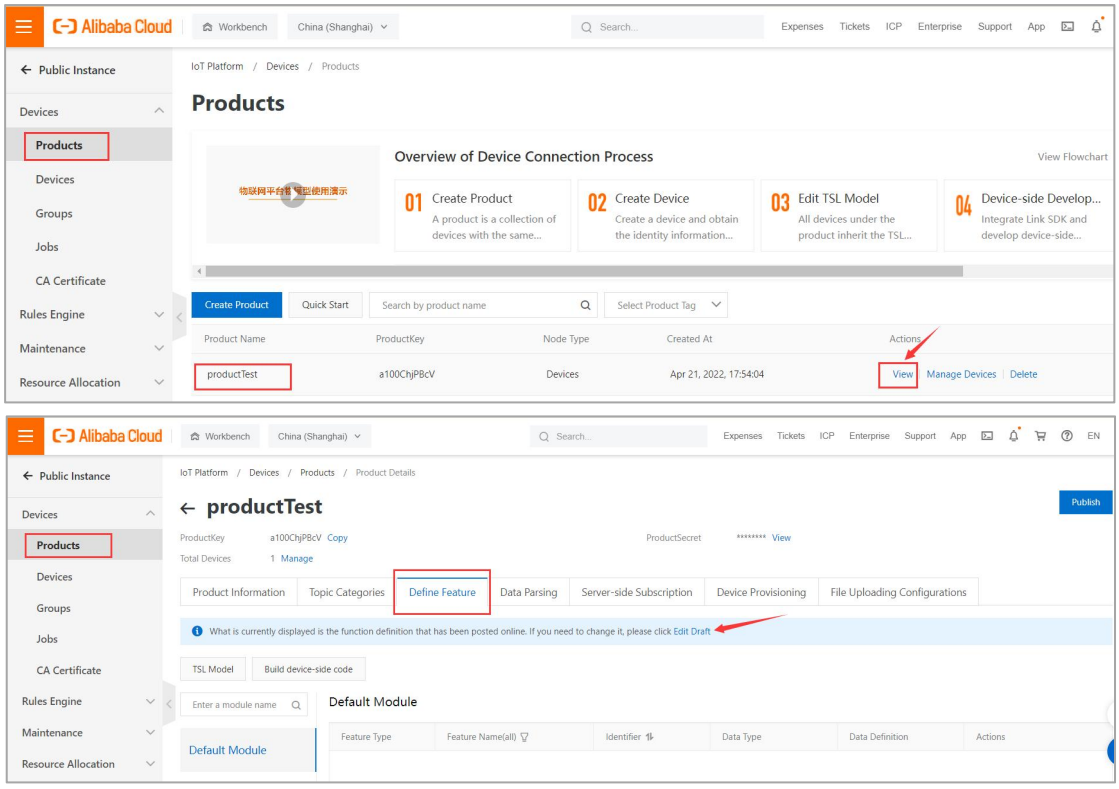


Fig. 4-60 Qingcheng Alibaba Cloud Edit Product Draft

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.

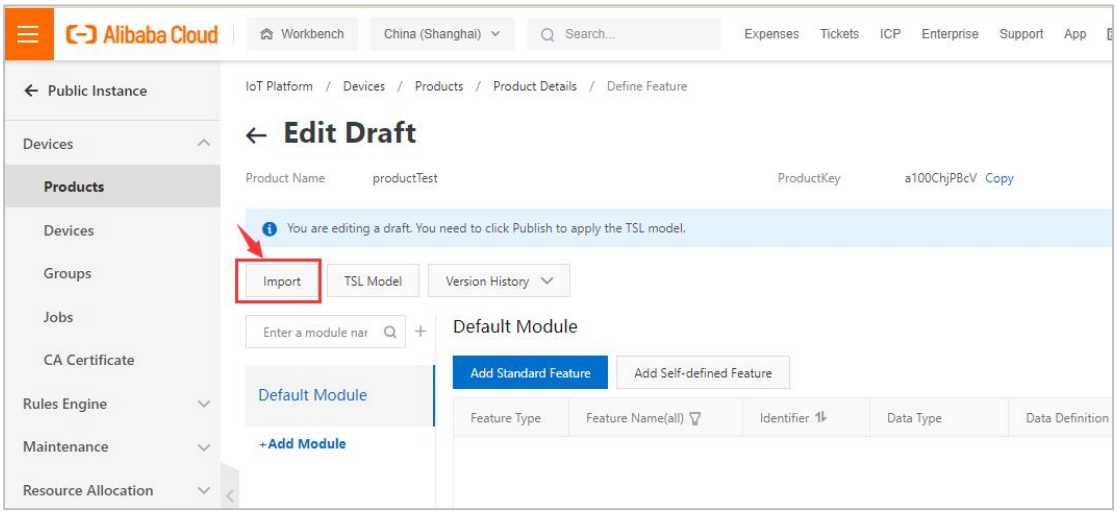


Fig. 4-61 Qingcheng Alibaba Cloud Import Model Draft

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.

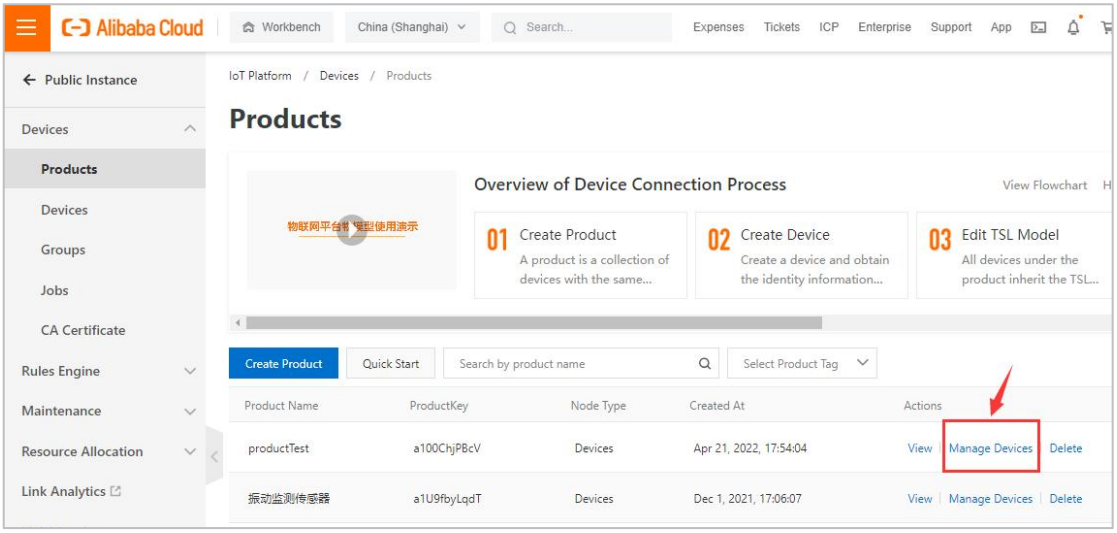


Fig. 4-62 Qingcheng Alibaba Cloud Manage Device

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

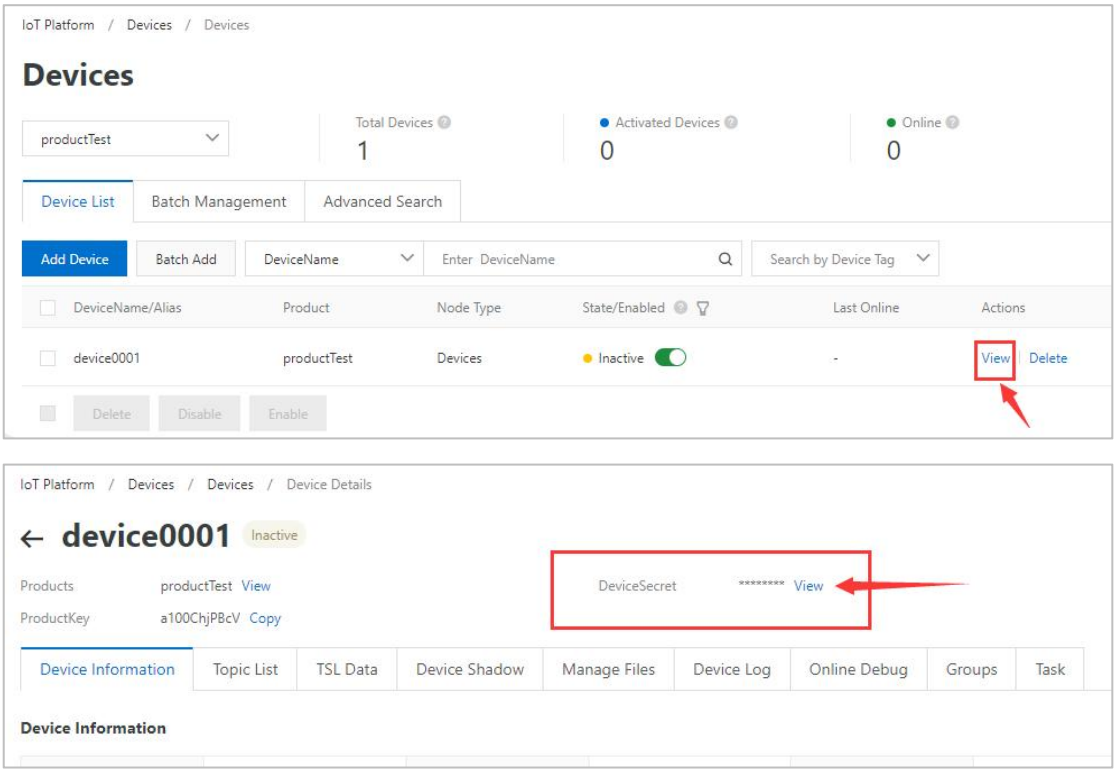


Fig. 4-63 Qingcheng Alibaba Cloud View Device Secret

Step 19: Copy the product key and device secret.

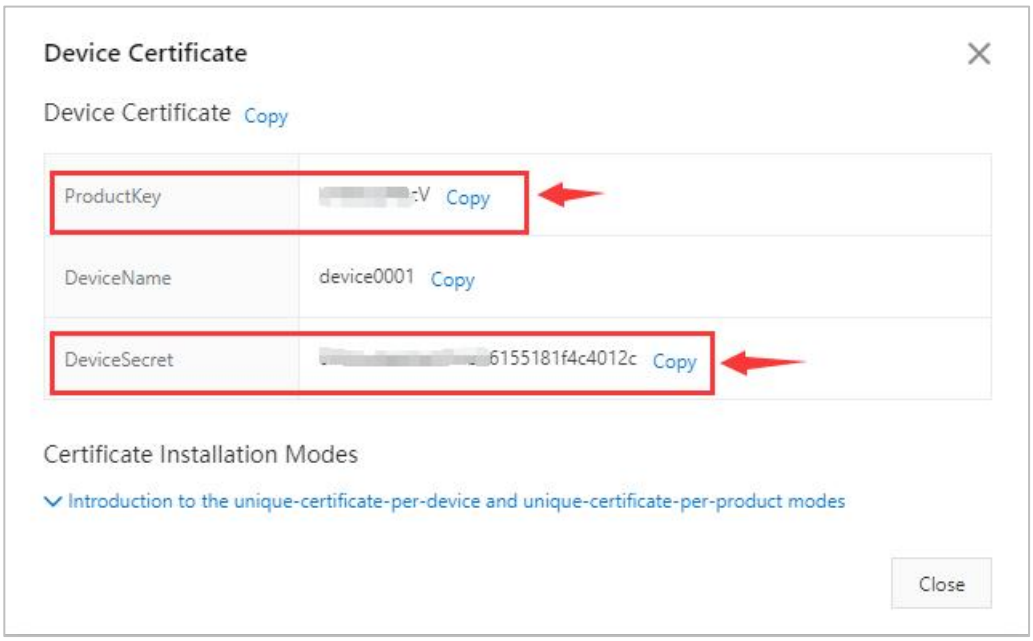


Fig. 4-64 Qingcheng Alibaba Cloud Copy Key and Secret

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.

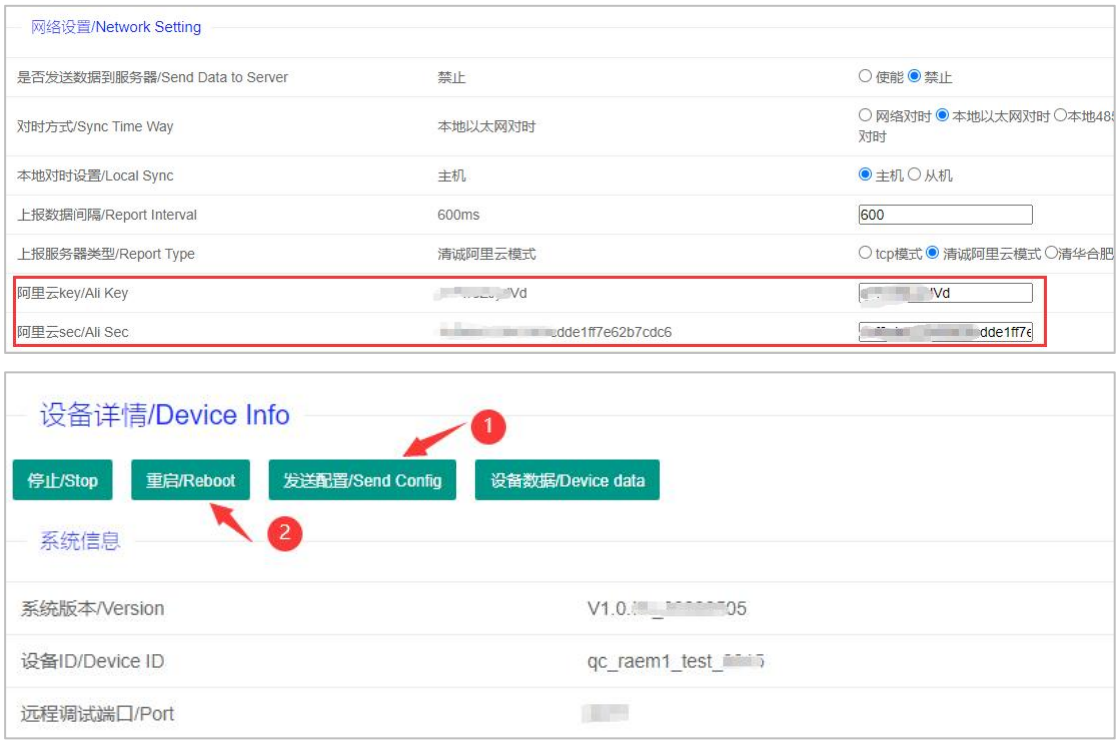


Fig. 4-65 Qingcheng Alibaba Cloud Configure Ali Key and Secret

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

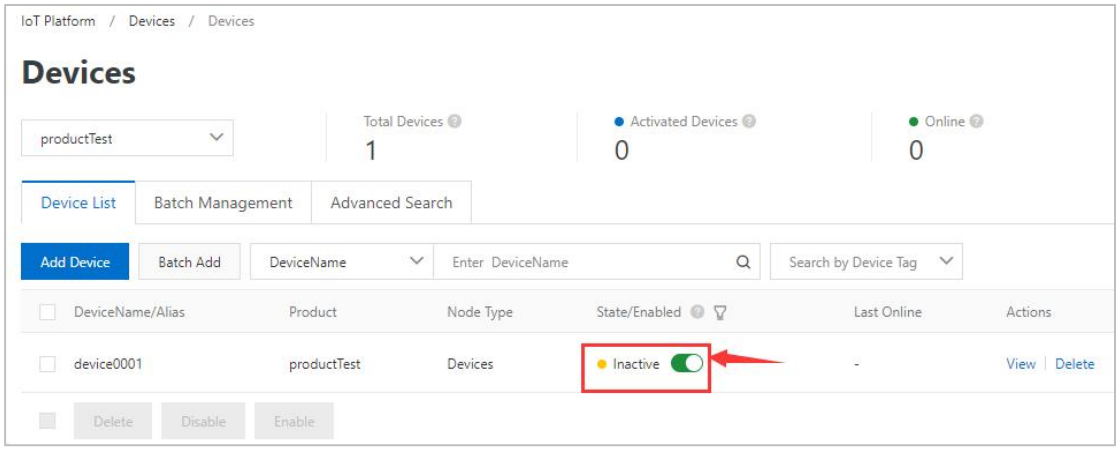


Fig. 4-66 Qingcheng Alibaba Cloud activate device

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)

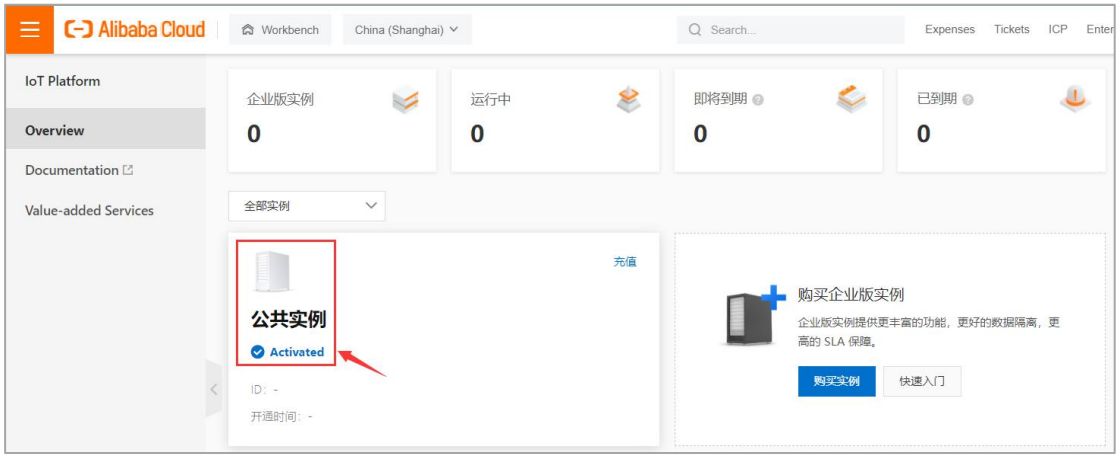


Fig. 4-67 Qingcheng Alibaba Cloud

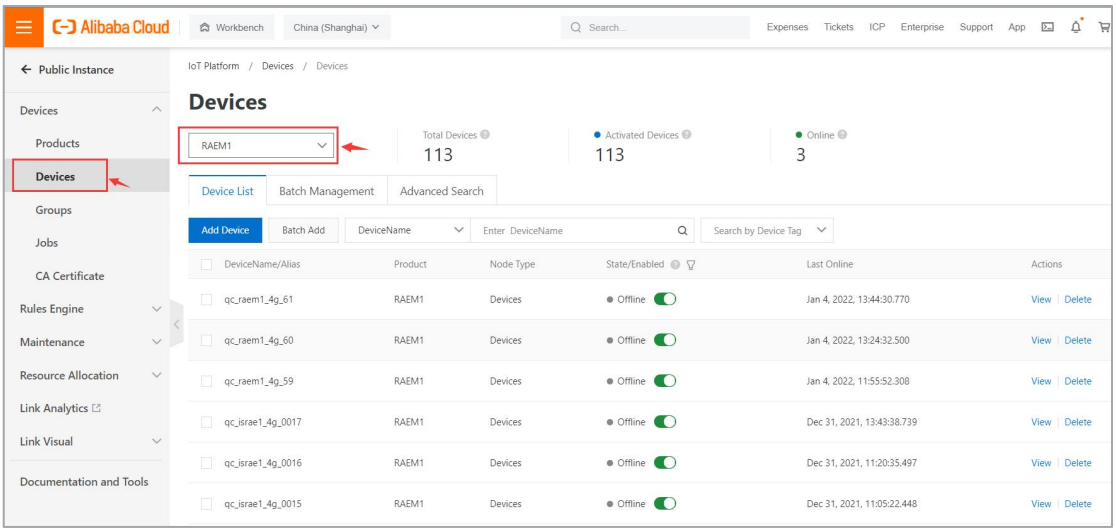


Fig. 4-68 Qingcheng Alibaba Cloud

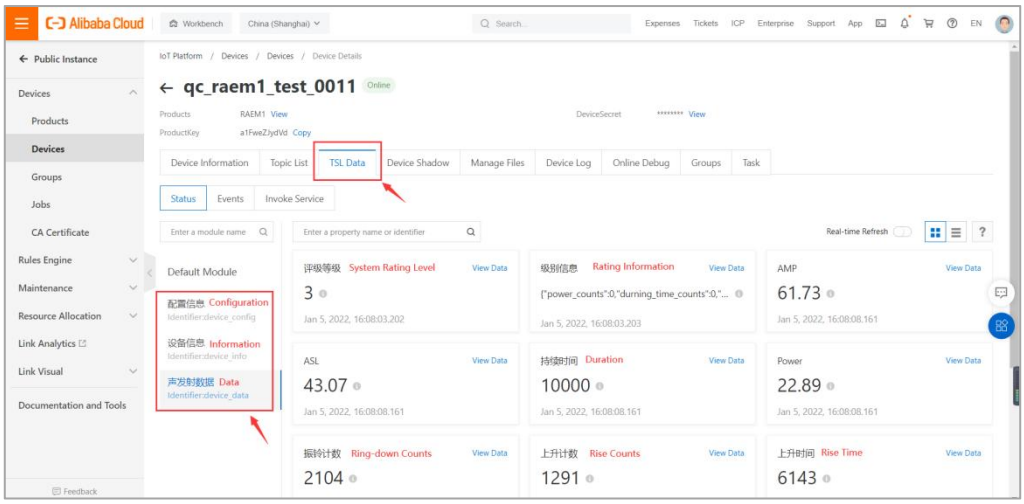


Fig. 4-69 Qingcheng Alibaba Cloud

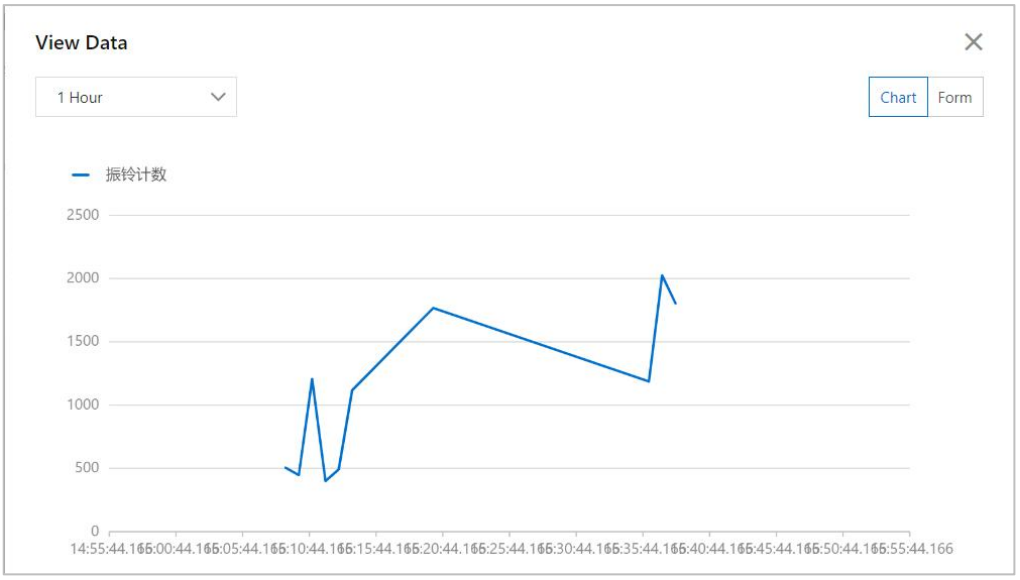


Fig. 4-70 Qingcheng Alibaba Cloud

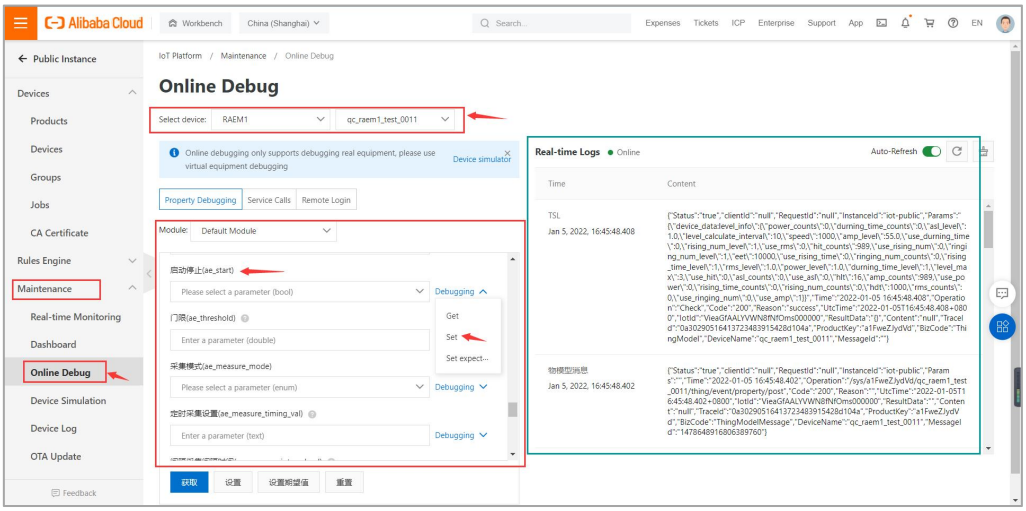


Fig. 4-71 Qingcheng Alibaba Cloud

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 3.3.6 for details.

5.1.1 Save Parameter & Waveform

[Storage Settings] The page settings allow data to be transferred and saved on the computer.

- **Save Wave**: When the status is "Yes", the waveform data can be stored on the local SD card.
- **Save Param**: When the status is "Yes", the parameter data can be stored on the local SD card.

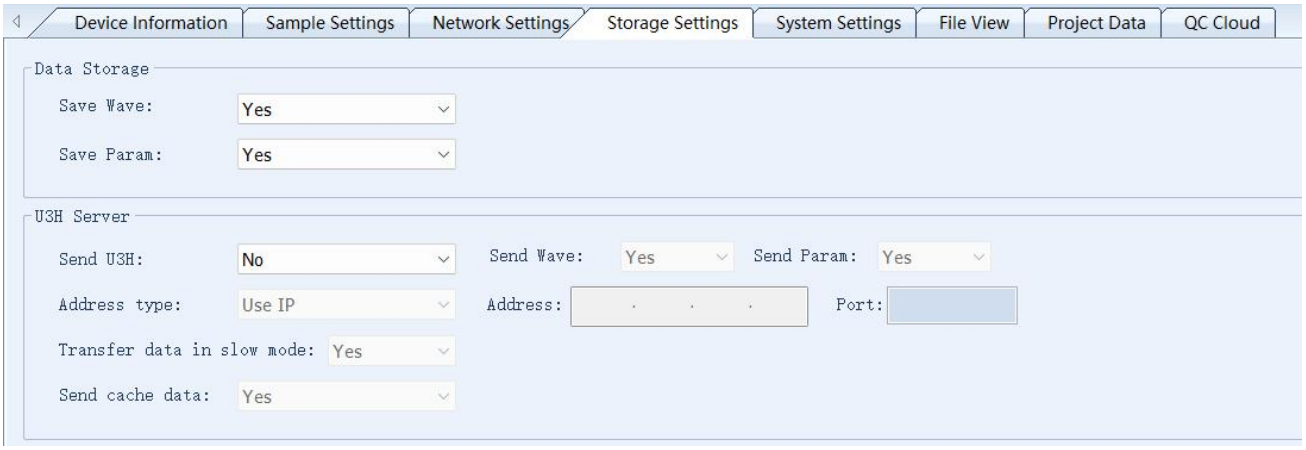


Fig. 5-1 Save parameter and waveform settings

5.2 SWAE 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,

Qingcheng IoT cloud platform and Amazon AWS S3 cloud service respectively.

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.

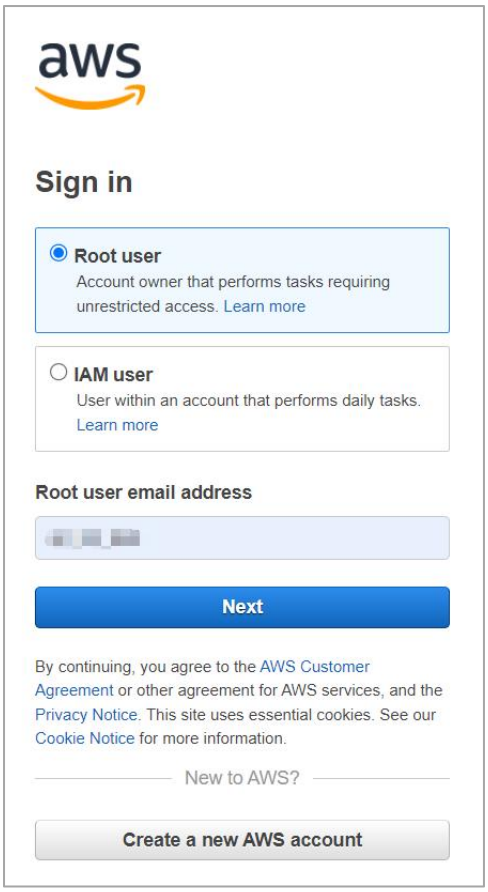


Fig. 5-2 Sign up for AWS Root account

2) Create new accounts in AWS

➢ Go to IAM service

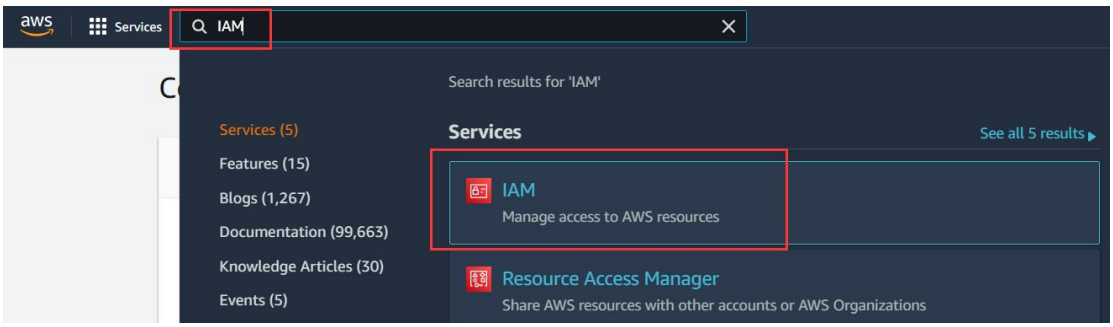


Fig. 5-3 Search for IAM

➢ Add users

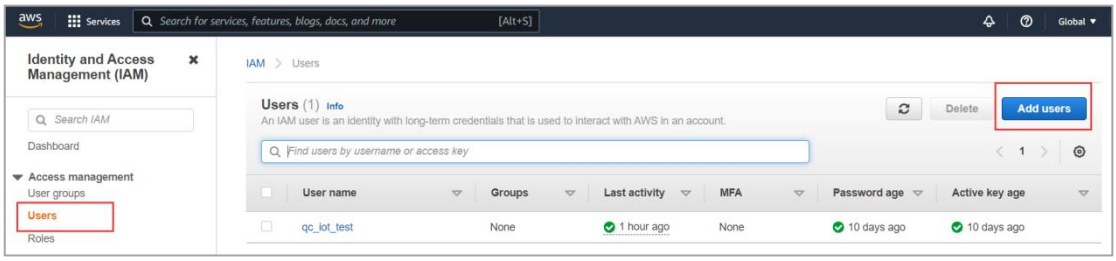


Fig. 5-4 Add users

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

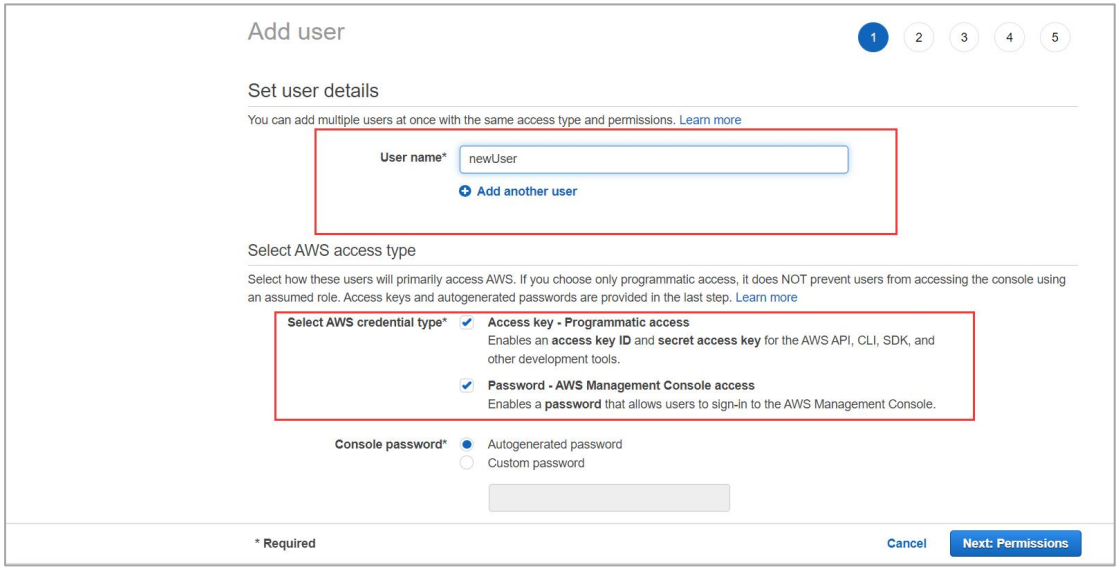


Fig. 5-5 User adding step 1

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

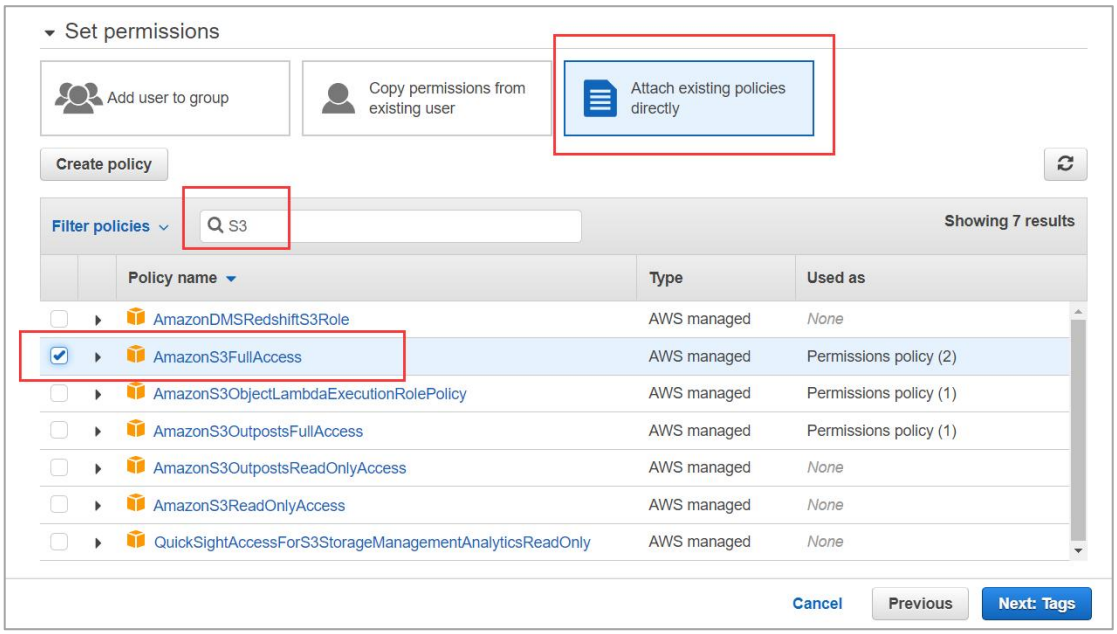


Fig. 5-6 User adding Step 2

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

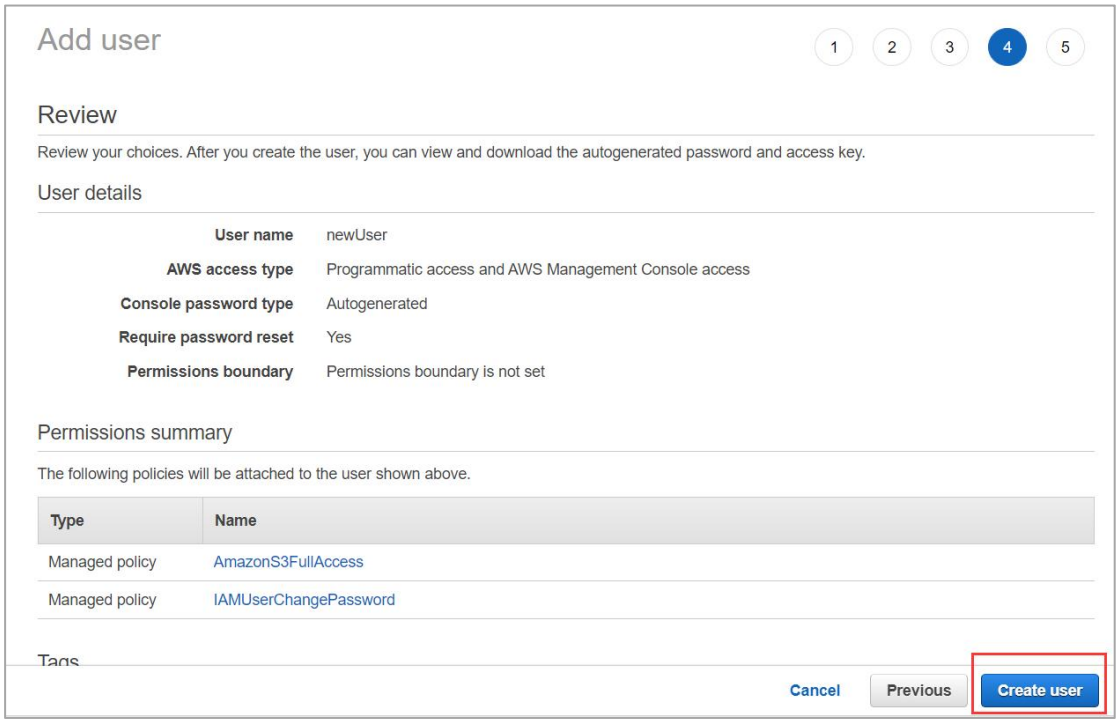


Fig. 5-7 User adding Step 4

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

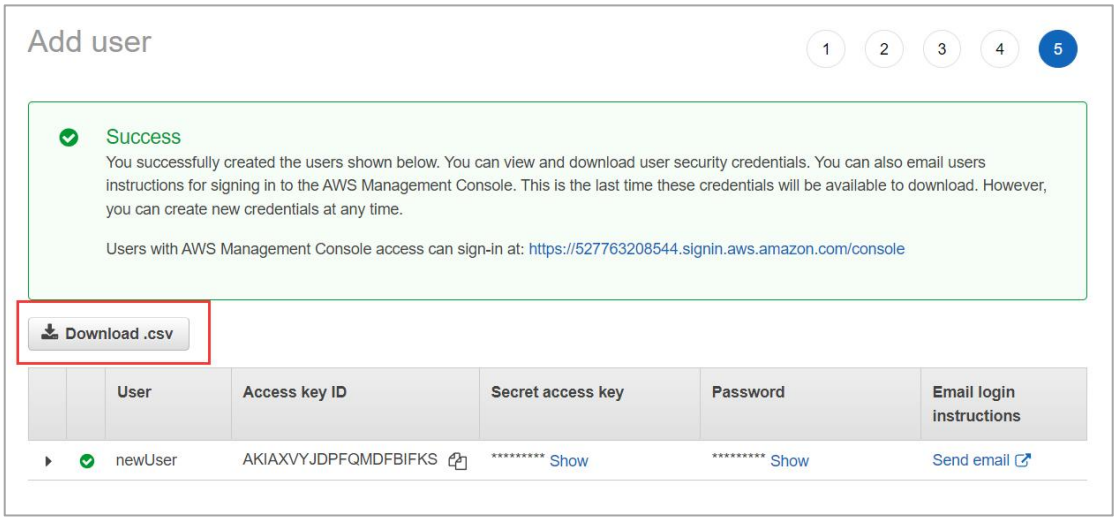
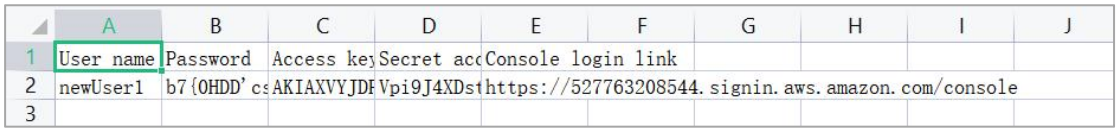


Fig. 5-8 User adding Step 5



	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. 5-9 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.

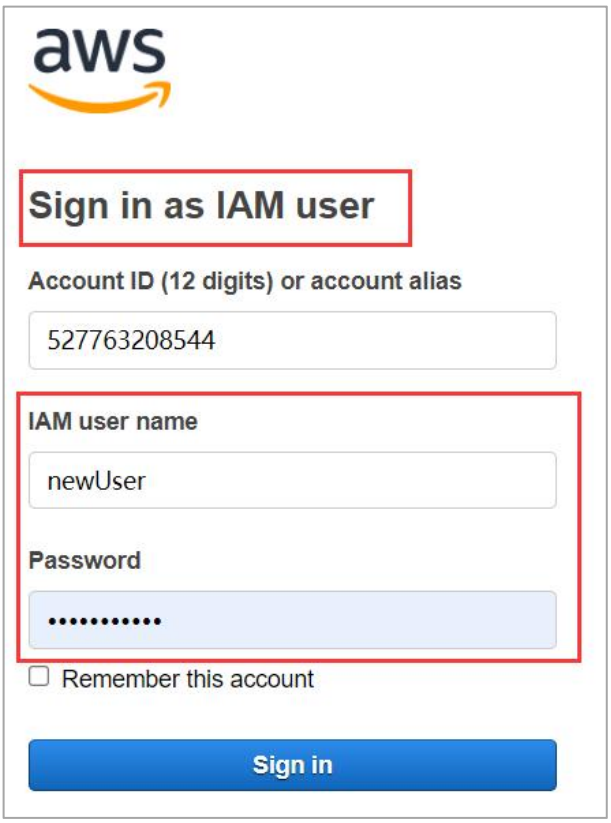


Fig. 5-10 Console Login Link

➢ Search for S3

Fig. 5-11 Search for S3

➢ Create bucket

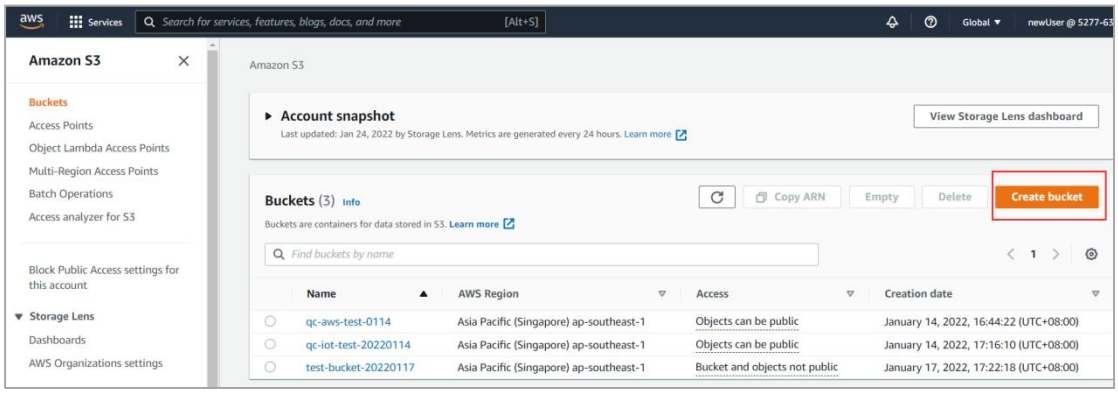


Fig. 5-12 Create bucket

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

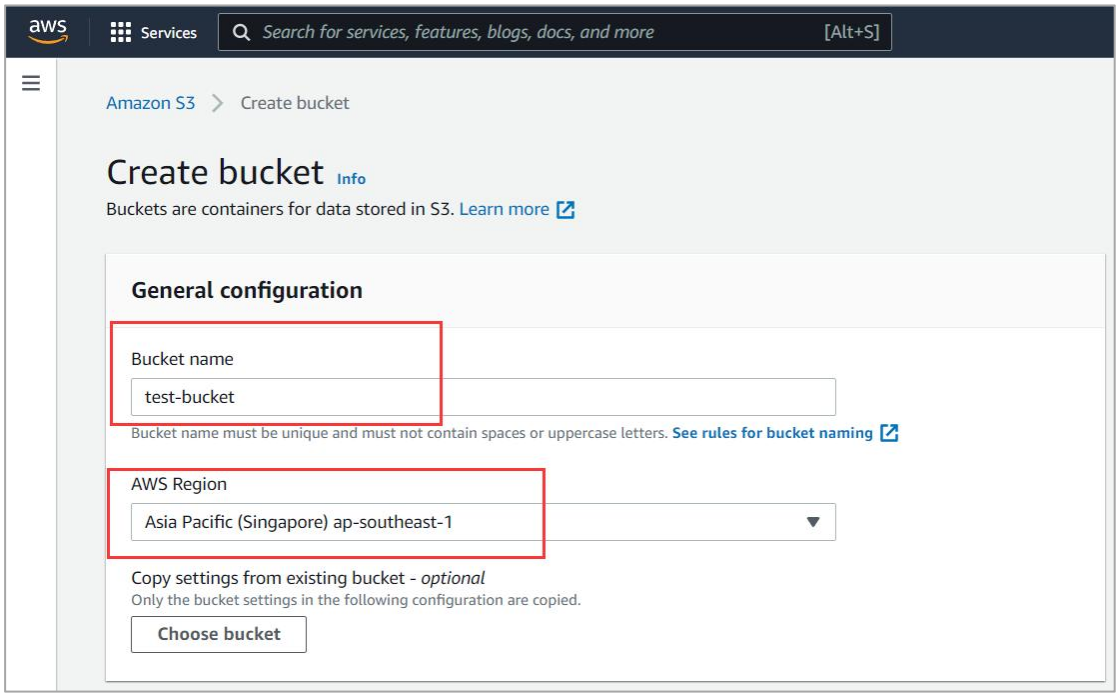
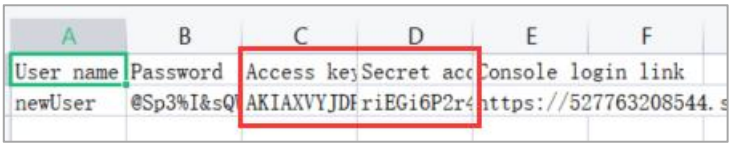


Fig. 5-13 Enter bucket information

4) Configure RAEM1 AWS

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



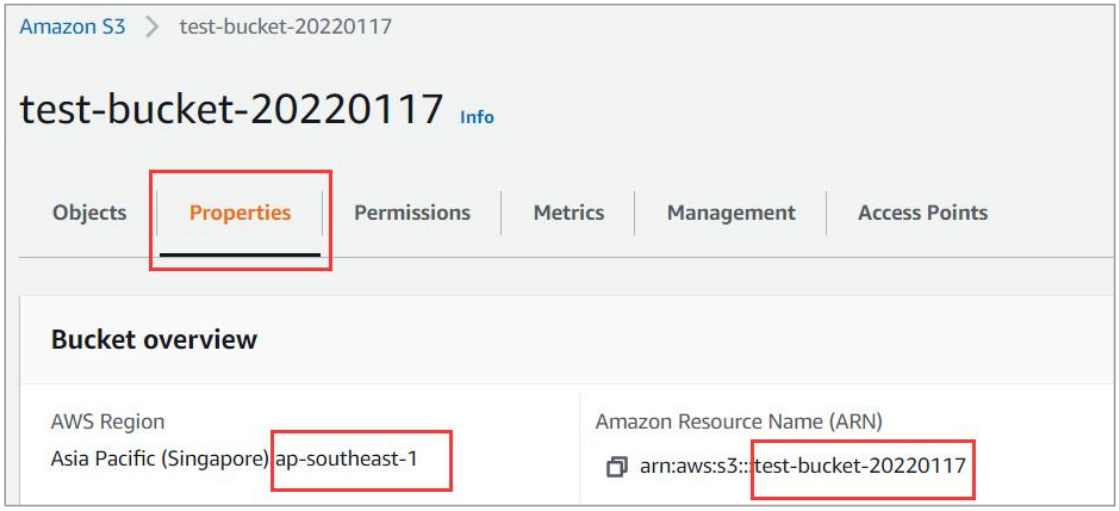


Fig. 5-14 Get AWS S3 Information

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

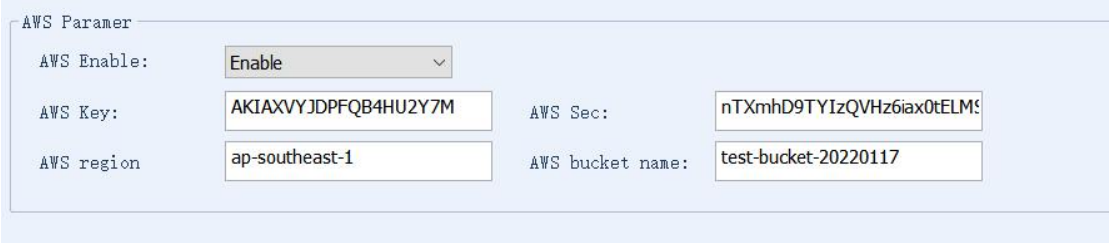


Fig. 5-15 Enter AWS configuration

➢ 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.

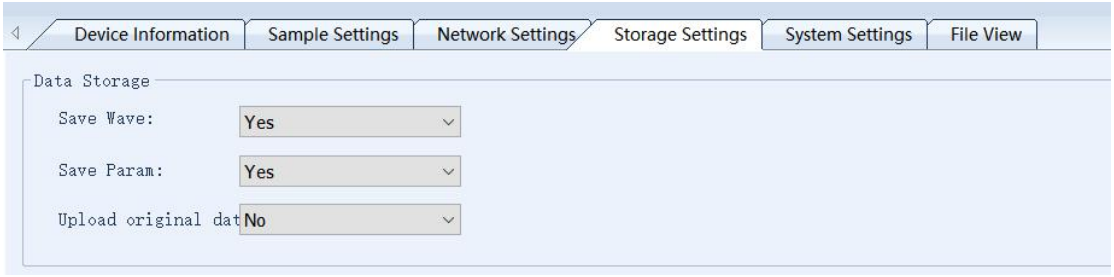


Fig. 5-16 Data Storage settings for AWS

➢ 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.

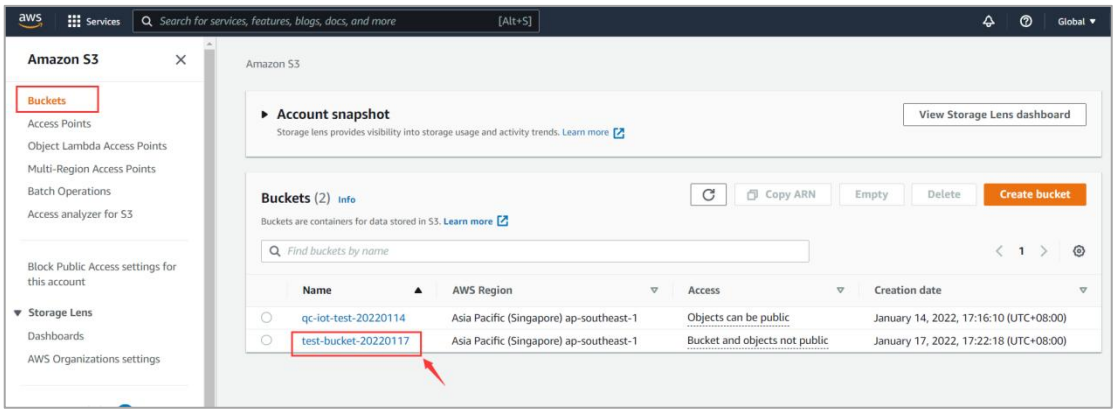


Fig. 5-17 Select bucket

➢ Choose "tmp/" folder

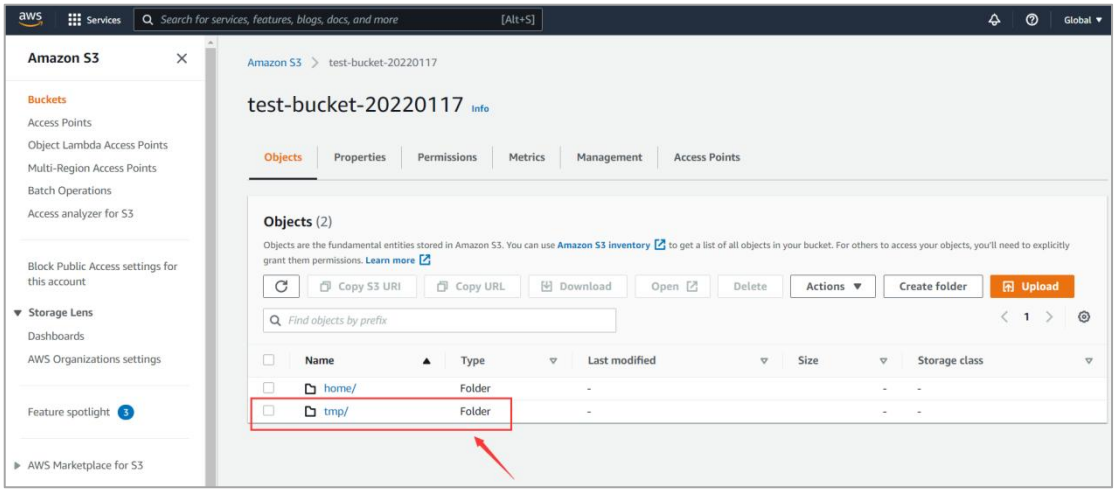


Fig. 5-18 Open "tmp/" folder

➢ Choose "aws_data/" folder. Inside the folder, the RAEM1 data packs are all listed. Click on the

name to start further operations.

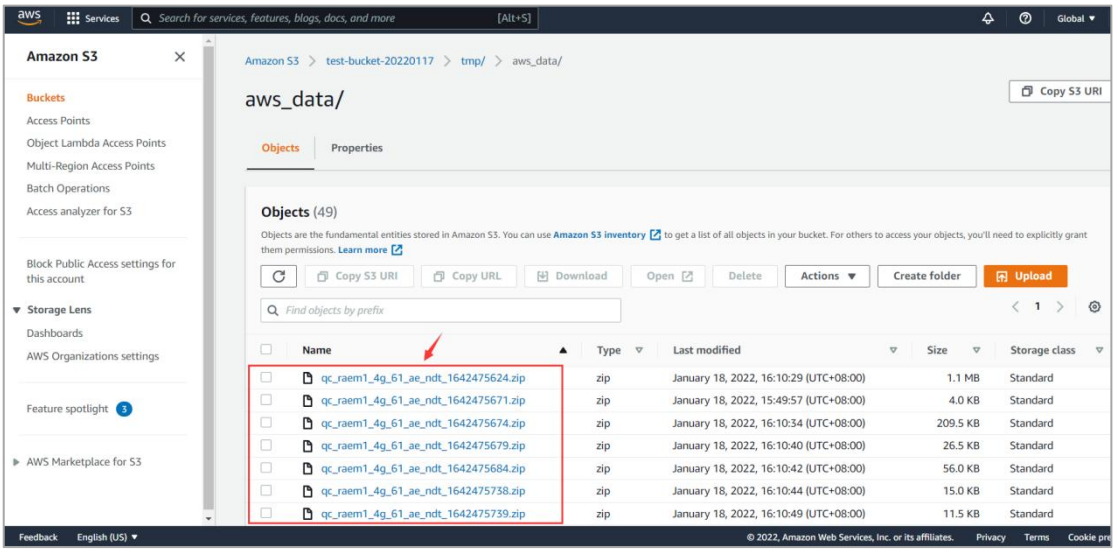


Fig. 5-19 Data packs in the bucket

6. Data Format Conversion

The format of RAEM1-6 data needs to be converted before in-depth data analysis can be carried out on SWAE 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 3.3.6.

The converted files (.pra and .aed) can be opened and analyzed in SWAE software. For details about how to use SWAE software, please contact our company to obtain the SWAE 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 RAEM1-6 data from the configuration software. 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.

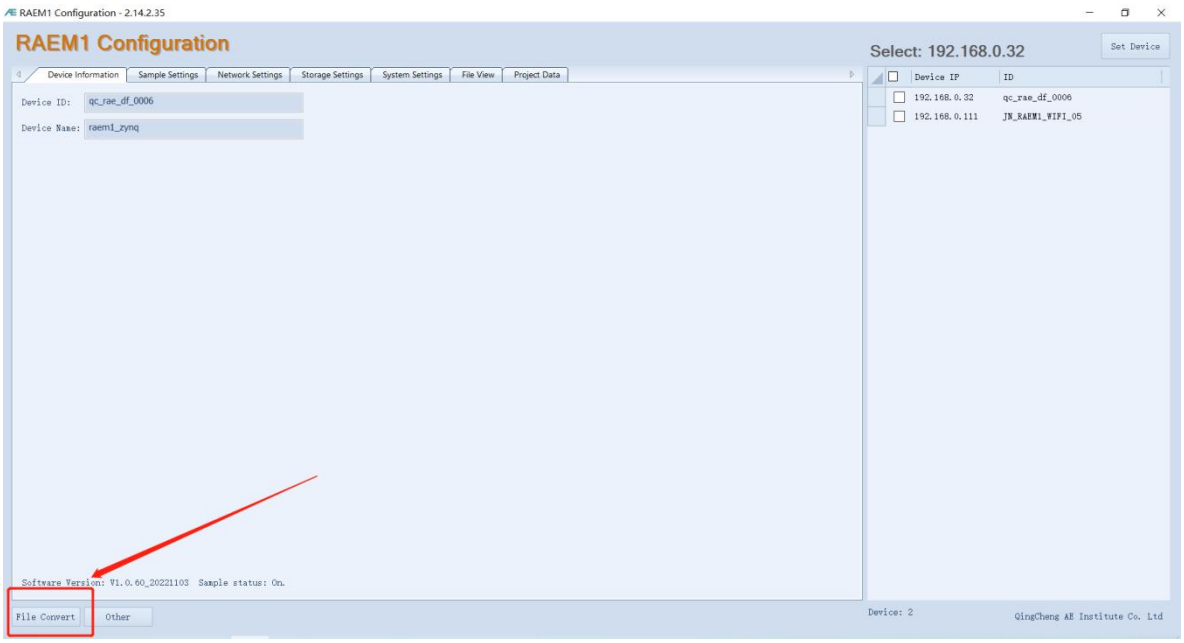


Fig. 6-1 RAEM1 Configuring the file conversion function of the software

3） Click on 'Add Directory' and select the directory corresponding to the .pra and .aed files. Each directory will serve as a channel. The channel number can be modified by double clicking the left button. The right-click menu can delete the current or all added directories. (Note: If the file is of ZIP type, the ZIP package option needs to be checked, otherwise it does not need to be checked), select the directory address for saving. The sampling rate should be consistent with the sampling rate of RAEM1-6.

Note:

1. If the converted data contains waveform data, it is necessary to accurately fill in the sampling rate and sampling length.

2. The sampling rate should be filled in according to the setting at the time of collection. If unsure, you can compare the number of points and duration of the waveform displayed on the cloud platform, and fill in: (points/duration) × 1000.

For example, if the waveform duration is 993 and the number of points is 993, the sampling rate can be calculated using the formula: (number of points/duration) × 1000 to obtain (993 ÷ 993) × 1000=1000KHz

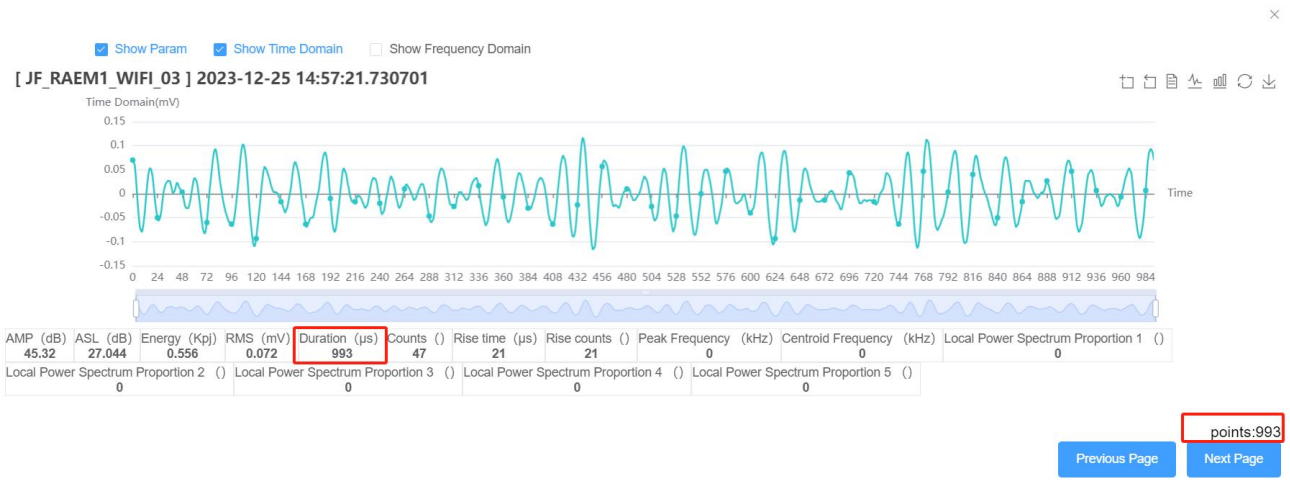


Fig. 6-2 Waveform points

3. Sampling length: The length of a single sample, measured in points, refers to the length that a single frame waveform can record and store. If set to 4000, it means that each frame of waveform only stores 4000 points, and if there are less than 4000 points, add 0 as one frame of waveform. The numerical values filled in here are consistent with the software collection settings.

4） Click on [Convert U3H]:

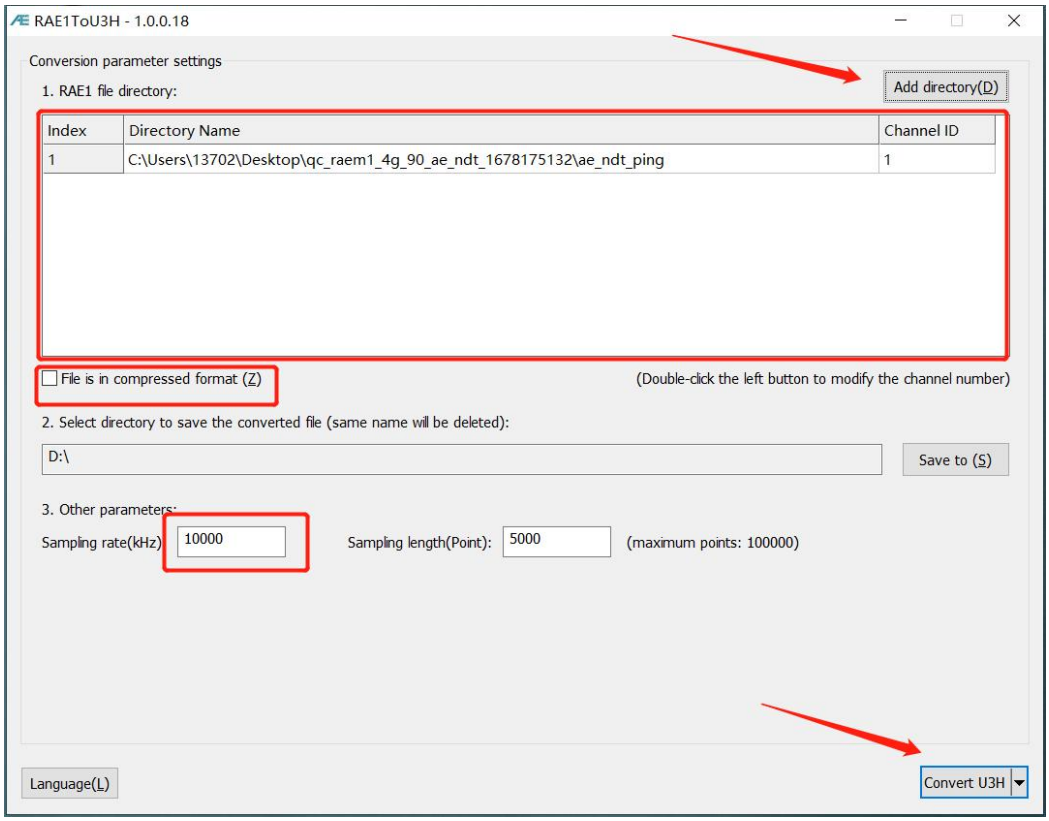


Fig. 6-3 RAE1ToU3H main screen

5） 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.

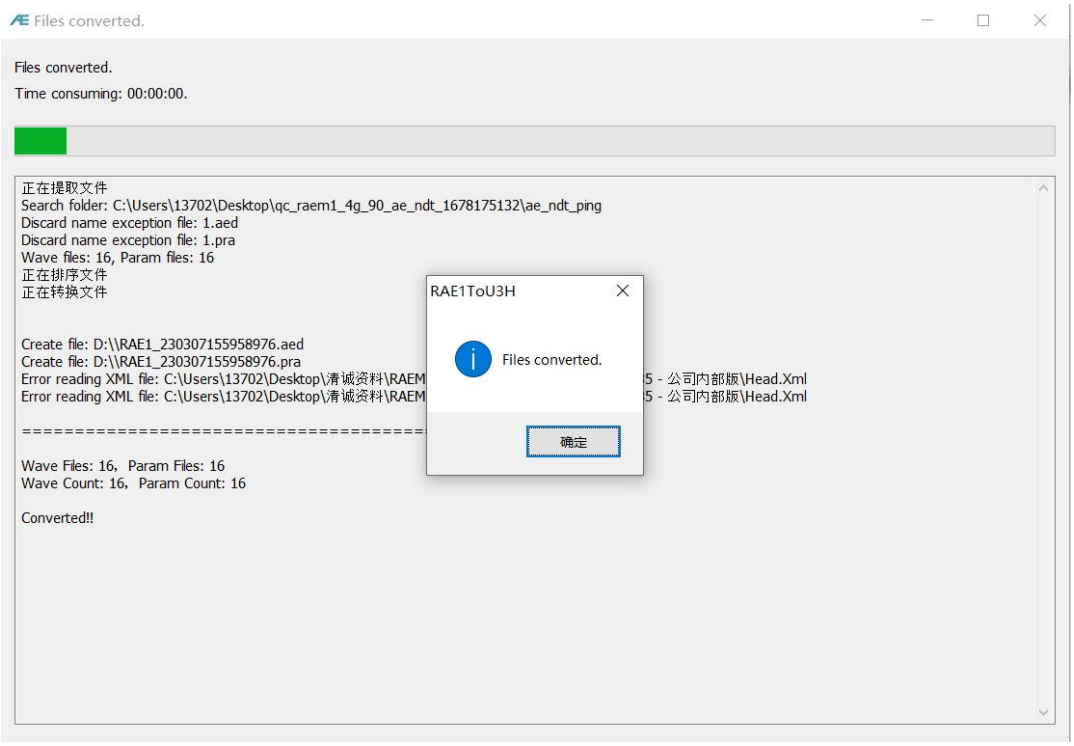


Fig. 6-4 RAE1ToU3H conversion screen

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

Fig. 6-5 3 hours of data generated after conversion

7) 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.

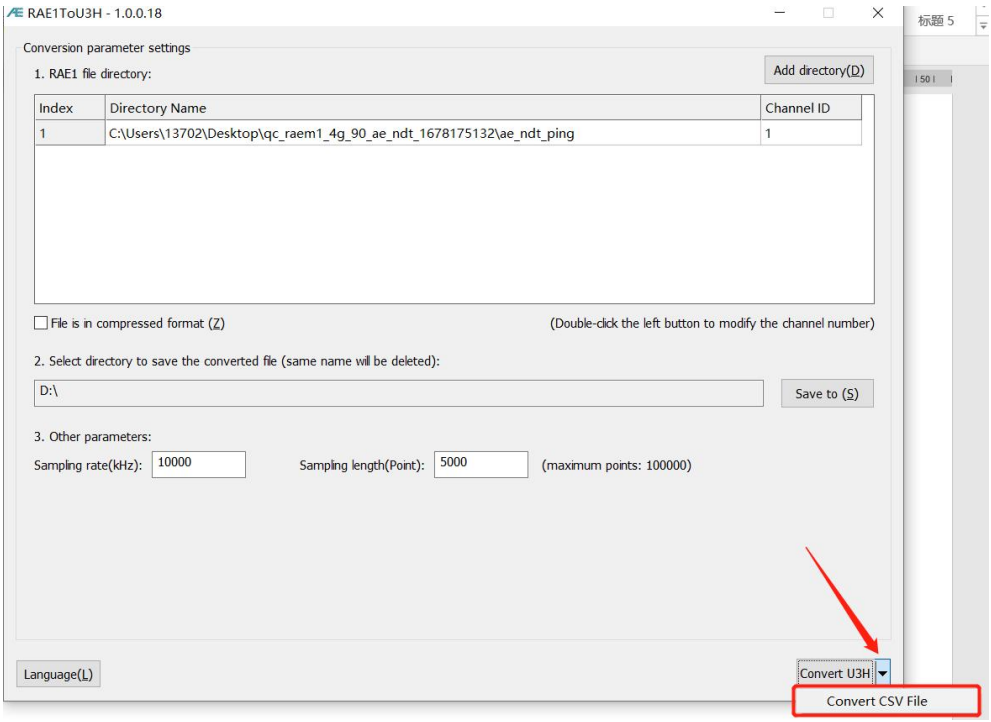


Fig. 6-6 Converting RAE1ToU3H to CSV button

Fig. 6-7 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. 6-8 CSV file format

7. Transmission Protocols for Third Party Development

RAEM1-6 devices can provide some protocols for the third party development. Some protocol details are shown below:

- The TCP protocol can output all acoustic emission parameters with the highest amplitude within the "reporting time interval";
- The U3H mode can output all the AE parameters and waveform.

7.1 TCP Integration Protocol

The TCP protocol outputs all AE Hit parameters.

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
AMP, Amplitude, in dB
ASL, Average signal level value, in dB
Power, Energy, in kpJ
RMS, root mean square, measured in mV
Rise time, in μs
Rise count
Count
Duration, in μs
Report time, with timestamp before decimal point and us part after decimal point

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, 0xA5A5A5A5
- 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, 0xA5A5A5A5
- 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.

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