RAEM1 USER'S MANUAL
Operation Guide

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Qingcheng AE Institute (Guangzhou) Co., Ltd.
601-9, Building 3, 232 Kezhu Rd
Guangzhou, China

www.aendt.com
sales2@ae-ndt.com
+86 19128609186

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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.

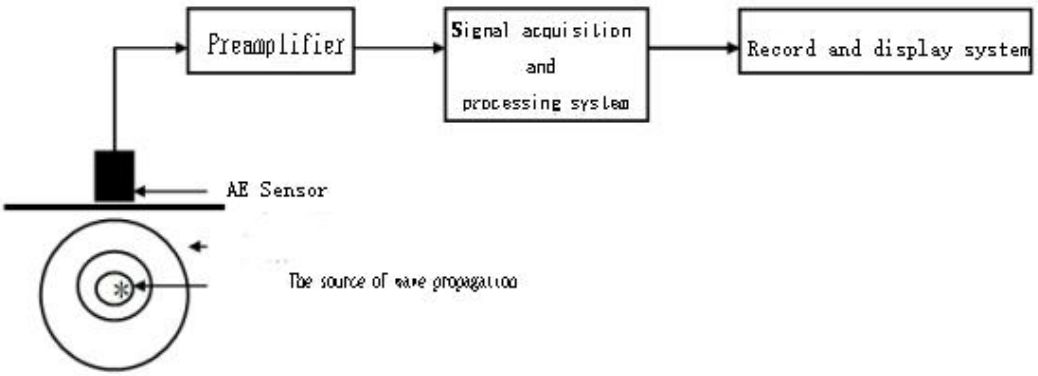


Fig. 1-1 Block diagram of acoustic emission testing principle

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 based on 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 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) sample 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, 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 Ω.

(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 ~ 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.

(15) **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 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.

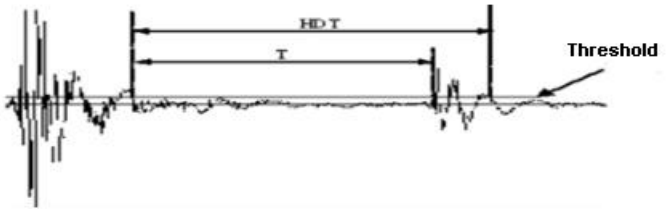


Fig. 1-2 HDT definition diagram

(16) **HLT**: Hit lock time, in unit of micro-second (μs). The setting range is 1 ~ 20,000,000 (positive integer), can be directly input in the text box. 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 (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.

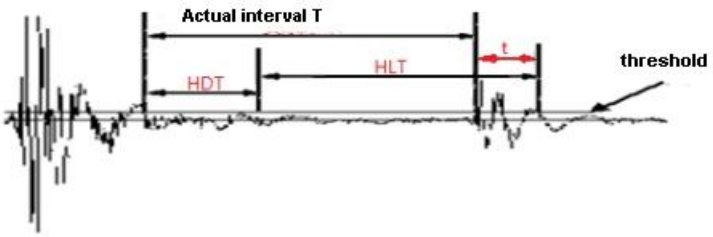


Fig. 1-3 HLT definition diagram

(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 U3H software server (because previously it only connects to U3H instruments).

2. Product Introduction

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

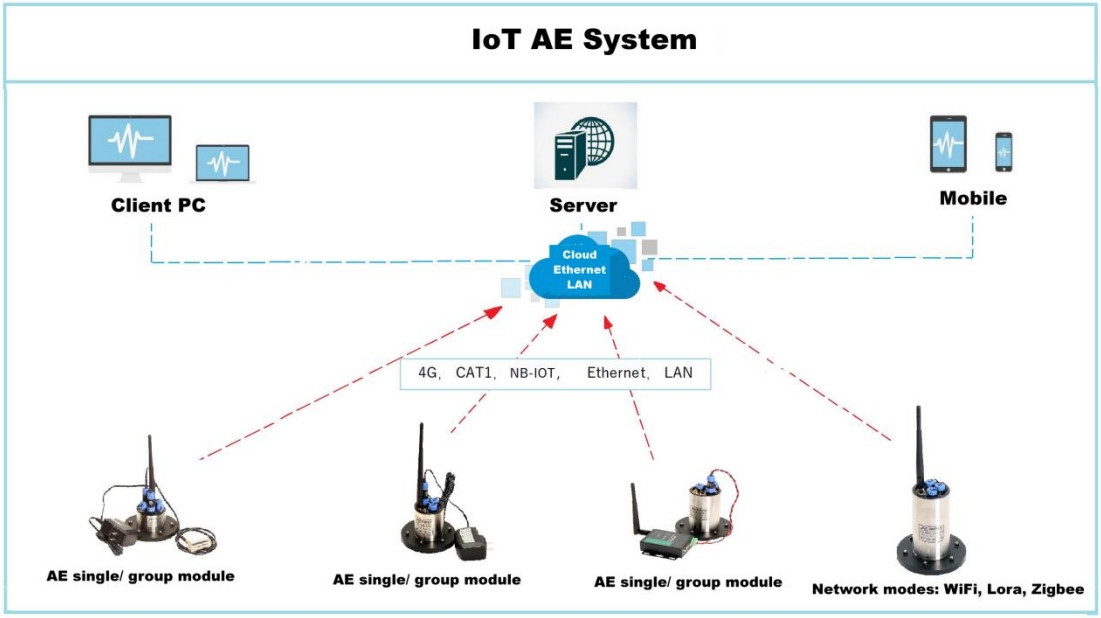


Fig. 2-1 IoT AE system

2.1 RAEM1 Introduction

RAEM1 remote acoustic emission system consists of three parts:

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

RAEM1 is an intelligent IoT acoustic emission system integrating AE signal acquisition control, analysis, storage with communication. RAEM1 host is an aluminum alloy cylinder with PCB boards inside and a magnet bottom. Each RAEM1 represents an acoustic emission channel. RAEM1 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 can be built-in or external to RAEM1. Power supply can also be built-in or external. Multiple data communication methods (Wi-Fi/ 4G/ Ethernet/ RS485 etc.) can be selected

based on the user's demands. There is SD storage card built-in to prevent stored data loss when the power is lost.

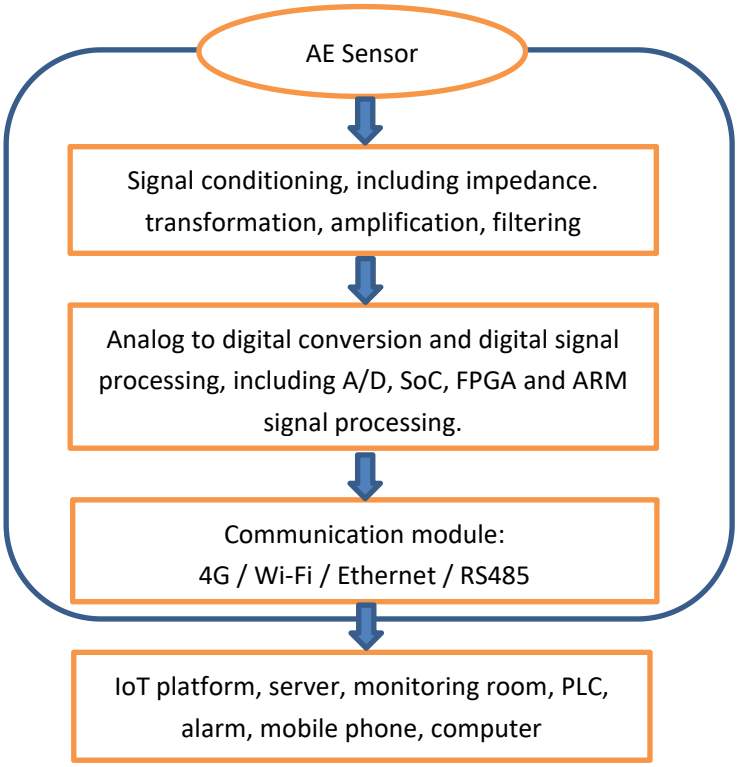


Fig. 2-2 RAEM1 Functional modules flow diagram.

Output data types are AE parameters, waveform, and parameter ratings. 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 SWAE signal analysis software. It can also be sent to SWAE software directly for real-time analysis.

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

2.2 Hardware Introduction

The regular RAEM1 system consists of a RAEM1 cylinder connected with an external sensor and 12V DC power supply, and one or two types of communication methods, including Ethernet and Wi-Fi or 4G network.

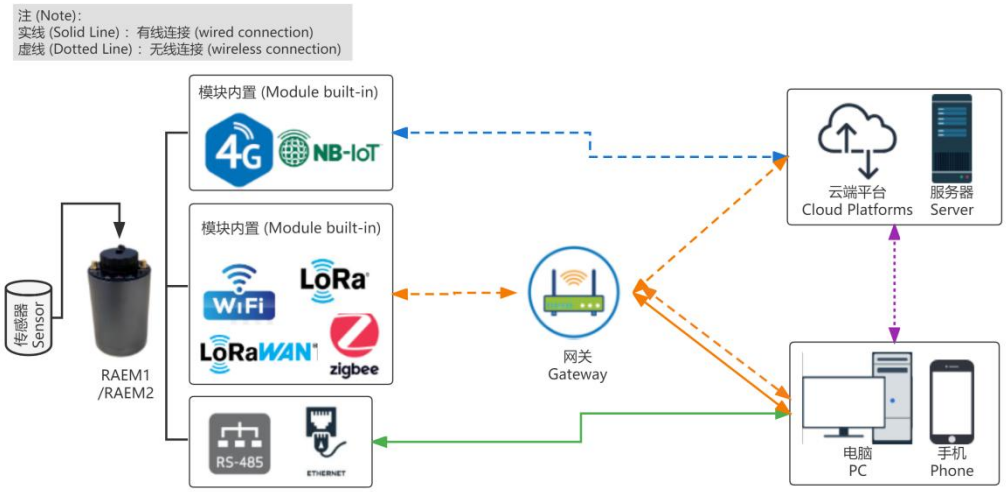


Fig. 2-3 Regular version of RAEM1 connection diagram

Figure 2-4 is a set of RAEM1 hardware which equips with the Ethernet and 4G communication. The set includes a RAEM1 with a magnet base, an integral preamp sensor (and the magnetic holder), a 4G extension antenna, a coaxial cable, 12V power adaptor, and the wire connector with Ethernet cable and power cable.

The top of RAEM1 indication is as Figure 2-5:

- **Power switch:** turns on or off the power supply of the device.
- **Cable socket:** the connector socket to be plugged in the wire connector with Ethernet cable and power cable.
- **Sensor connector:** to connect to sensor via the coaxial cable.
- **Antenna connector:** to connect the extension antenna.
- **Three indicator lights:**
  - **POWER Light:** shows the status of the device power. After connecting to power and turning on, it should be solid on.
  - **RUN Light:** shows the operation states of the device. During normal operation, the RUN light should be flashing every second.
  - **ALARM Light (still in development, function to be confirmed)**: Hit/Alarm indicator. When there is a hit, the ALARM light flashes once.

 RAEM1 host cylinder	 Antenna	 Connector with Ethernet cable and power
 Sensor and magnetic holder	 Sensor Coaxial cable	 12V power adaptor

Fig. 2-4 Regular version of RAEM1 hardware.

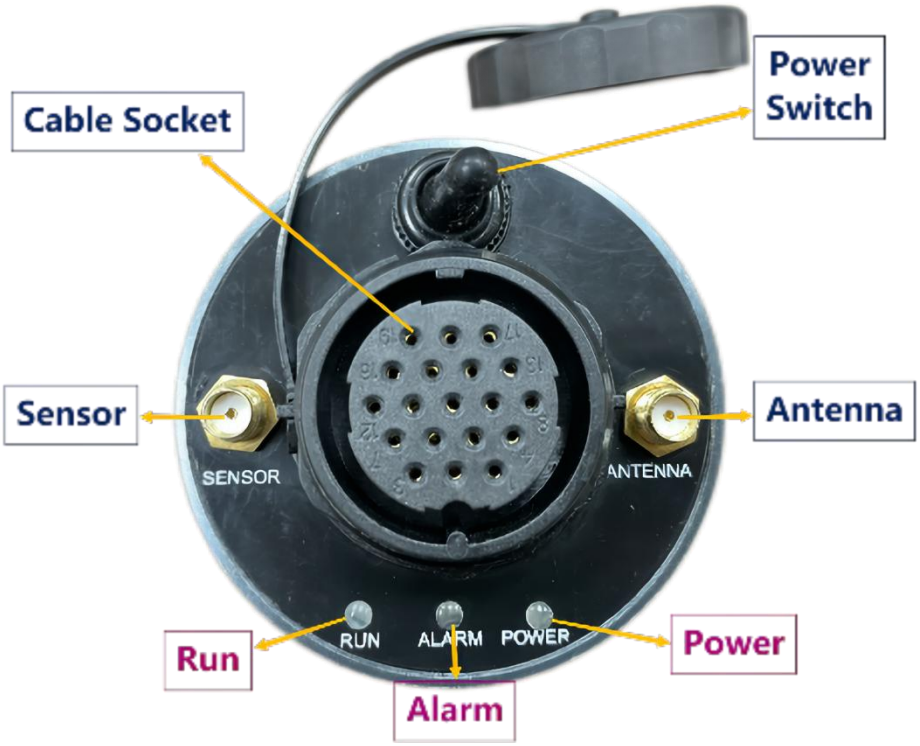


Fig. 2-5 Regular version of RAEM1 top part function diagram

2.3 RAEM1 Technical Specifications

- Single channel AE input, sampling rate 2MHz, sampling accuracy 16-bits.
- Signal input bandwidth 10k-1000kHz.
- The dynamic range is 70dB.
- Compatible sensors: integral preamp series 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.
- Original waveform or filtered waveform data.
- Acoustic emission characteristic parameters, including arrival time, amplitude, counts, energy, rise time, rise counts, duration, RMS, ASL, peak frequency, frequency centroid, 5 partial power spectral segments.
- Parameter ratings, based on the national and international AE monitoring standards, can automatically generate intensity ratings, activity ratings, and intensity activity ratings.
- The built-in 64G memory SD card can store the above three types of data.
- Optional communication methods: 4G, Wi-Fi, Ethernet, RS485.
- Battery power supply or external power supply, power adaptor outputs 12V DC.
- Operational temperature: -20℃--+50℃;
- The protection grade of collector is IP65.
- Cylinder dimensions: Φ62mm, height 105mm;
- The module has magnetic base and can be absorbed on the metal surface.

2.4 Quick Start of RAEM1

The regular version of RAEM1 (Wi-Fi + Ethernet) connection steps are as followed:

1) Read the RAEM1 label to figure out the matching power adaptor and sensor. The input voltage is 12V. The

sensor type is normally the integral sensor with built-in preamplifier. The preamp voltage is supplied by RAEM1 sensor port. The analog filter in RAEM1 also requires the sensor frequency range to match. If mismatching the sensor type, it may cause some damages on the sensor or not fully functioning. So please pay attention to the label.

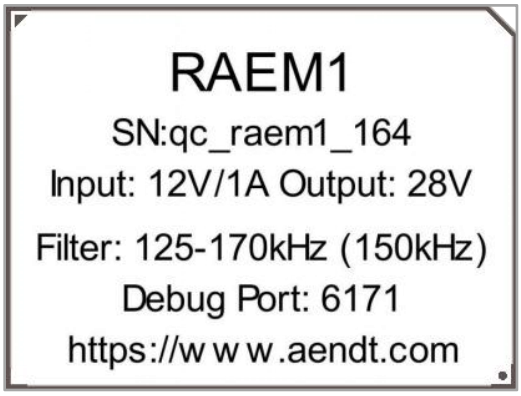


Fig. 2-6 Regular version of RAEM1 Product Label

2) Plug in the wire cable (one with Ethernet cable and the power cable) to the cable socket on top of the RAEM1.
3) Connect the black power cable to the power adaptor (12V) and plug in the power adaptor to the wall adaptor of AC power.
4) Connect the antenna and the sensor (double check the RAEM1 label for matching preamp voltage and filter range) to the RAEM1; (The complete connection diagram is shown below)
5) Turn on the power switch and wait for the **POWER** light to be stable and the **RUN** light to start flashing.
6) If the RAEM1 device has been configured previously, RAEM1 can automatically connect to the Wi-Fi and start data acquisition and transmission.
7) But for the first-time use, plug in the Ethernet cable to the computer for local operations. For the first time use, it is required to configure the Ethernet settings in PC. Please follow **Section 3.1** to configure Ethernet settings.

Fig. 2-7 Regular version of RAEM1 Hardware Connection

2.5 Configuration Tool and Software and Cloud Introduction

After powering RAEM1, it automatically starts to collect data and communicate through the existing configurations and communication connections. Users can check the RAEM1 current configurations and modify the settings through their equipped communication methods. Some communication methods also support real-time parameters display, or even real-time waveform and parameter display and analysis.

The factory configuration settings of the RAEM1 are the recommended configurations and they have passed the factory tests. It is suggested to use the default configurations. If the configuration is required to be modified, it is suggested to save the default factory configuration as a configuration file in the computer before modifying the configurations. Please see **Section 4** for configuration file save and read.

RAEM1 starts to collect data automatically after start. When there is a HIT or multiple HITs happened, RAEM1 will pack the data in 5 seconds including all the HITs during this time and generate a zip file. When there is no HIT, there will be no data files. Based on different communication methods, the files can be stored in the local storage SD card or be uploaded to the cloud servers. After data acquisition, users can use the cloud or the local network to

access and download RAEM1 data packs.

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

There are several ways to view and download RAEM1 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.

The table below lists all the communication methods and their corresponding software or platforms for RAEM1 configuration and data access:

Communication	Configuration	Real-time Data View	Data Download
Ethernet	RAEM1 Configuration Software	SWAE	RAEM1 Configuration Software
Wi-Fi (Hotspot Mode)	RAEM1 Configuration Software	SWAE	RAEM1 Configuration Software
Wi-Fi (Router Mode)	RAEM1 Configuration Software/ Qingcheng IoT Cloud/ Qingcheng Alibaba Cloud	SWAE/ Qingcheng IoT Cloud	RAEM1 Configuration Software/ Qingcheng IoT Cloud/ AWS S3
4G	Qingcheng IoT Cloud/ Qingcheng Alibaba Cloud	Qingcheng IoT Cloud	Qingcheng IoT Cloud/ AWS S3

Table 2-1 Regular version of RAEM1 communication methods and software

- **RAEM1 Configuration Software:** is a Windows executable software specified for RAEM1 configuration developed by Qawrums Ltd. It requires RAEM1 to connect to the computer, via cable connection using Ethernet or wireless connection through Wi-Fi. Using the RAEM1 Configuration software, it can access and modify the RAEM1 device information, acquisition settings, data storage, communication settings, system settings and file view for data downloads. Please see **Section 4** for more detail.

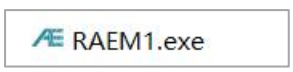


Fig. 2-8 Screenshots of RAEM1 Configuration software

- **Qingcheng IoT Cloud:** is Qingcheng's own IoT cloud platform specified for Qingcheng's IoT products. It requires wireless communication modules in RAEM1, 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 5** 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 6 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 SAEU3H and RAEM series. It allows users to view real-time AE feature parameters and waveform collected and sent by RAEM1. Please see **Section 7** for more detail.
- **AWS S3**: RAEM1 also supports to upload data to AWS S3 bucket. Please see **Section 8.2.2** for more information.

In the following sections, each communication method will be introduced with their detail connection methods and compatible software and cloud servers, followed by each software introduction and cloud server usage.

3. Communication Method Configuration

3.1 Ethernet Connection

RAEM1 can directly connect to PC using Ethernet cable. Or multiple RAEM1s can connect to PC at the same time via the switches/routers. After the hardware connection, it needs to configure the computer network settings so that they can be connected to the software (listed in Table 3-1) for the remote configuration and control purposes. View and follow the corresponding software introduction sections for setup instruction guides.

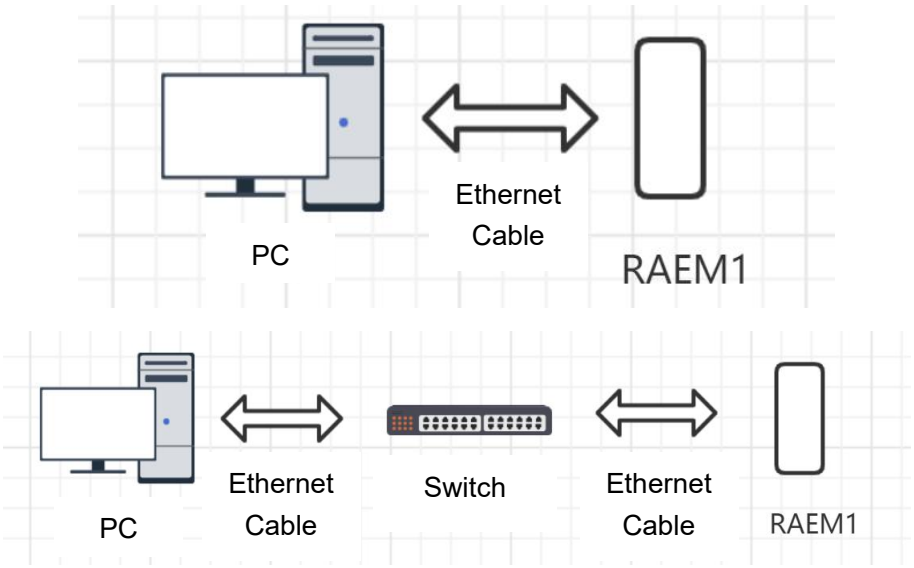


Fig. 3-1 RAEM1 Ethernet Connections

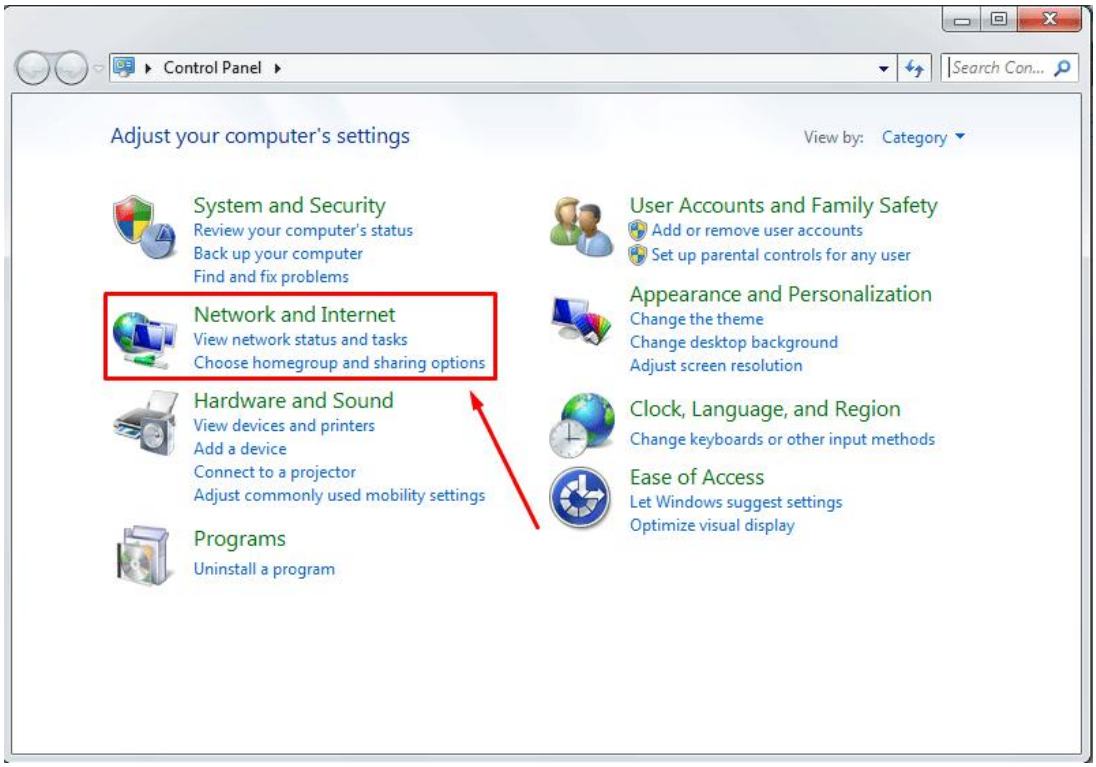
Communication	Configuration	Real-time Data View	Data Download
Ethernet	RAEM1 Configuration Software	SWAE	RAEM1 Configuration Software

Table 3-1 Ethernet Connection and corresponding software

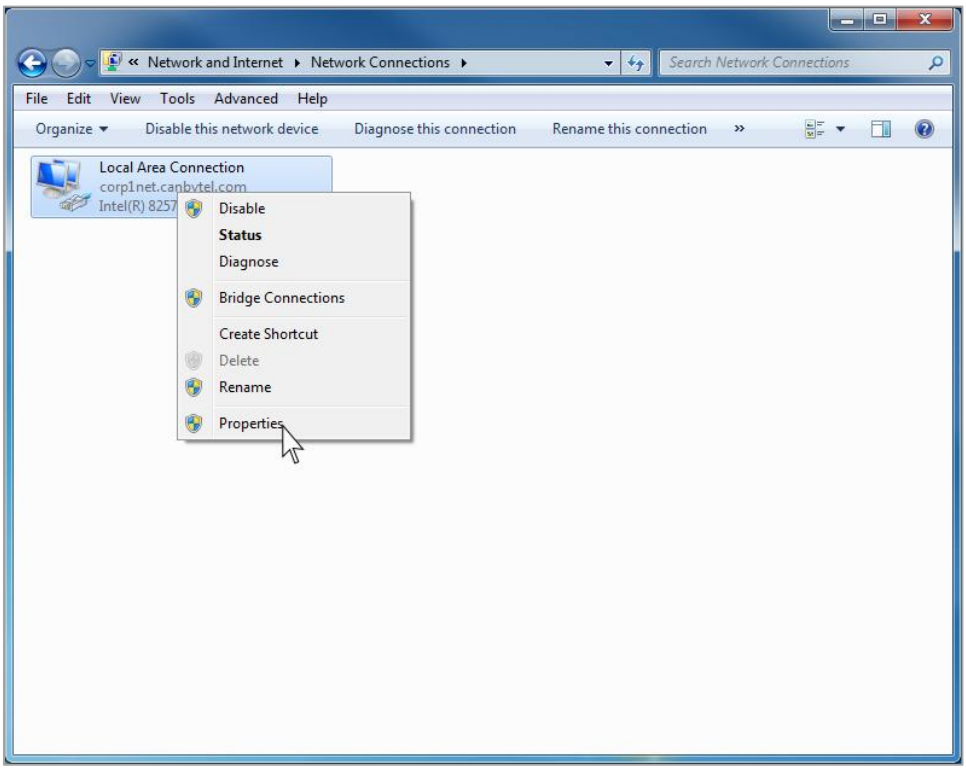
The default Ethernet IP address of RAEM1 is **192.168.0.101**. When connecting directly to PC but the connection fails, please follow the steps below to configure LAN attributes and then try to connect to PC again:

- **Ethernet Duplex Mode:** open **Control Panel** >> **Network and Internet**>> **Network Connections**. Choose the local area connection. Right click and choose **Properties** and then choose **Configure**. In the **Advanced** Tab, choose **Speed & Duplex**. On the **Value** drop-down menu, select **100Mbps Full Duplex**. Click **OK** to confirm.
- **Configure Ethernet IPv4:** choose **Internet Protocol Version 4 (TCP/IPv4)**, and then click **Properties**. In the pop-up window, check **Use the following IP address**. Then enter the **IP address** as **192.168.0.XXX** (XXX can be

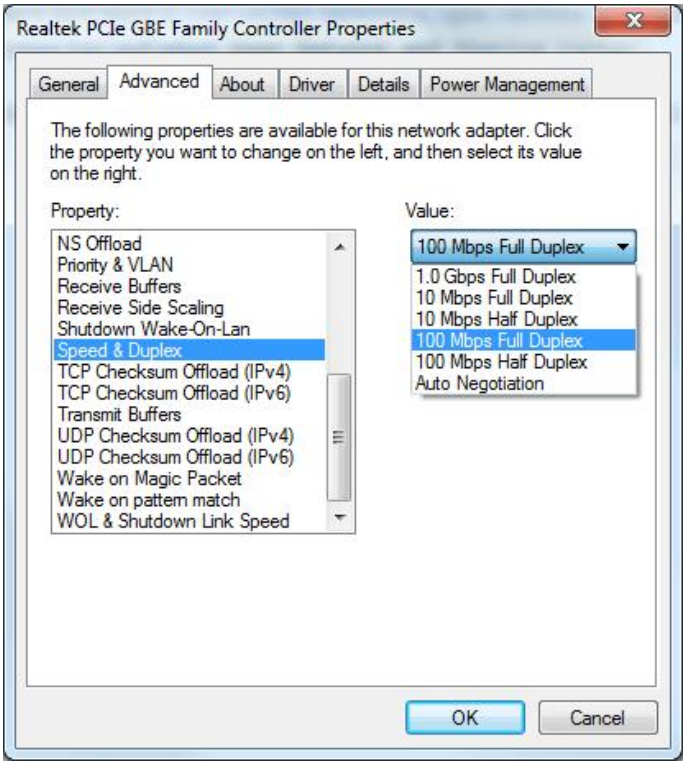
any integer number but never be the same as the RAEM1 device IP address to avoid conflicts). **Subnet mask** is **255.255.255.0**. **Default gateway** is **192.168.0.1**. Click **OK** to confirm.



(a)

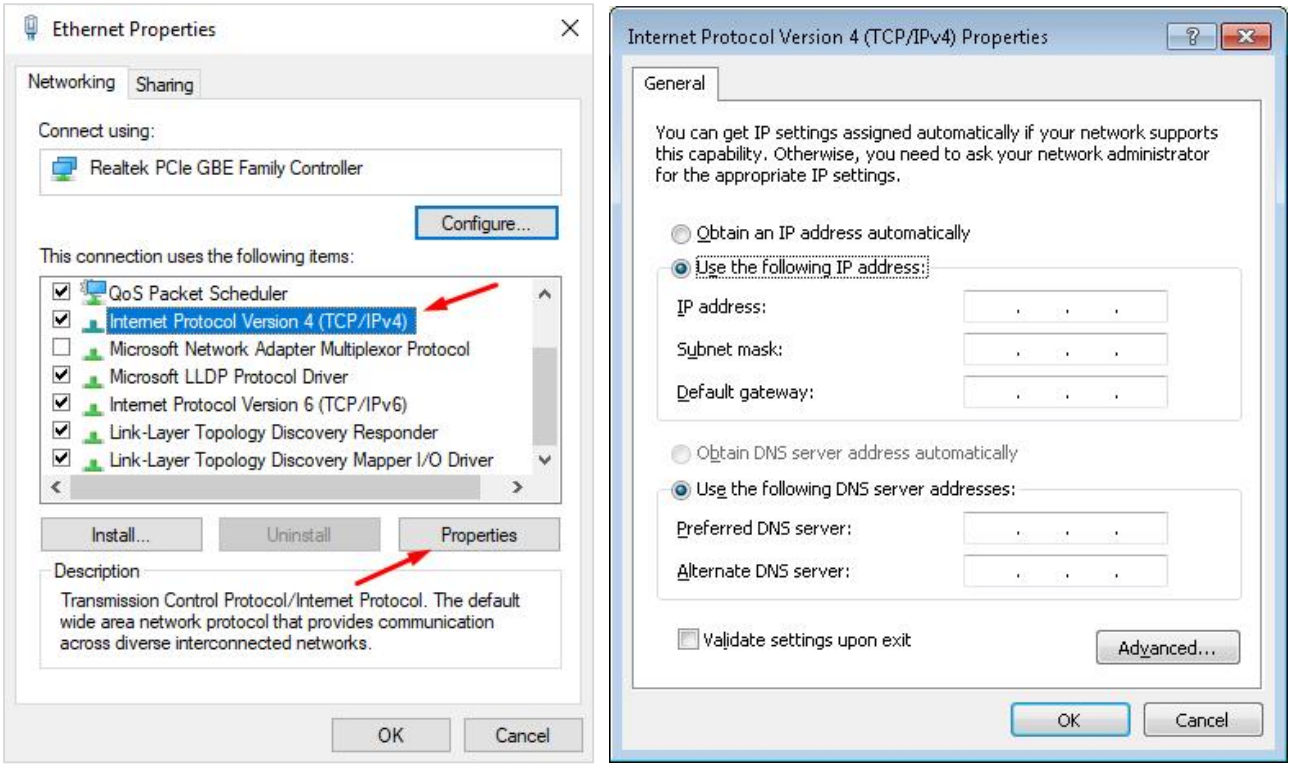


(b)



(c)

Fig. 3-2 LAN Full Duplex Mode (a/b/c)



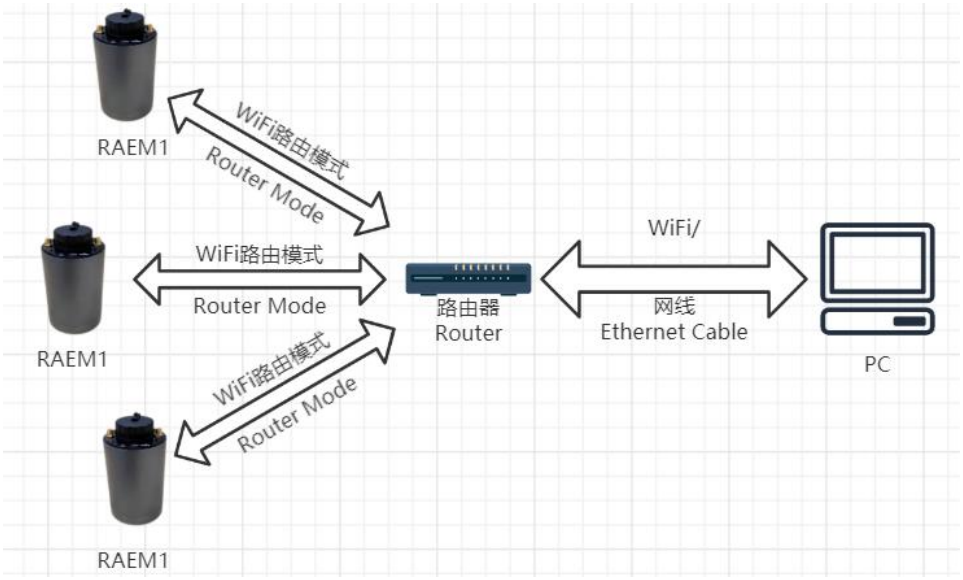
(a) (b)

Fig. 3-3 Ethernet IP Settings

3.2 Wi-Fi Connection

There are two modes for Wi-Fi connection, the **Hotspot mode** and **Router mode**, as shown in Figure 3-4. After successful connection, it needs to configure the PC and the RAEM1 to be able to connect to the corresponding software listed in Table 3-2 for further operations. View and follow the corresponding software sections for connection and instructions.

(a) Hotspot Mode Connection



(b) Router Mode Connection

Fig. 3-4 RAEM1 Wi-Fi Connection Diagram

Communication	Configuration	Real-time Data View	Data Download
Wi-Fi (Hotspot Mode)	RAEM1 Configuration Software	SWAE	RAEM1 Configuration Software
Wi-Fi (Router Mode)	RAEM1 Configuration Software/ Qingcheng IoT Cloud/ Alibaba Cloud	SWAE/ Qingcheng IoT Cloud/ Alibaba Cloud	RAEM1 Configuration Software/ Qingcheng IoT Cloud/ AWS S3

Table 3-2 Wi-Fi Connection and Corresponding Software

3.2.1 Hotspot Mode

RAEM1 Wi-Fi Hotspot mode connection is like the Ethernet connection but using wireless WiFi instead of Ethernet cable.

The factory default mode of RAEM1 is Hotspot mode. At this mode, RAEM1 will release a Hotspot for connection. The Hotspot information is as listed in the table below. The name is e.g., qc_raem1_wifi_0001, and the default password is 88888888. When the computer connects to the RAEM1 Hotspot, it can configure the RAEM1.

Hotspot Name	qc_raem1_wifi_xxxx
Hotspot Password	88888888
Device Address	192.168.100.1

Table 3-3 RAEM1 Hotspot mode information

3.2.2 Router Mode

Refer to Figure 3-4 (b) for connection. Under the Router Mode, if the router can access the Internet, RAEM1 can acquire dynamic IP address and communicate with the server. By accessing the Internet through the router, it can log in the cloud platform to configure RAEM1 settings and view or download data. If there is no Internet in the router, it can configure the settings and access data through local network, same as Ethernet and Hotspot mode.

Before configuring RAEM1 to router, find out the router ID and password and router network address. **It is important that the router network subnet is non-zero.** Because the default LAN static address of RAEM1 is at **192.168.0.XXX**, which is the zero subnet. To avoid network conflicts, make sure the router network is at **192.168.A.XXX**., which A must not be zero.

Fig. 3-5 Modify to Router Mode (RAEM1 Configuration software)

Then configure the RAEM1 to router mode in the RAEM1 Configuration software.

Test case: a router ID was **qc_wifi_test** and the password was 88888888. Because the default Wi-Fi mode of RAEM1 was Hotspot mode, so it needs to first make RAEM1 available to the RAEM1 Configuration Software

through either RAEM1 Hotspot or Ethernet cable by following the previous chapters, following by changing to the Wi-Fi router mode. In the *RAEM1 Configuration Tool* software, check the desired device in the checkbox and change the **communication setting** from "Hotspot" mode to "Router" mode and enter the router ID and password. Click "**Set Device"** button in the top right corner to send the configuration to the device. Right click on the device and select "**Reboot device"** to make the router mode take effect. **Rebooting takes some time, and it must NOT be interrupted or turned off during the rebooting. After reboots, it cannot be connected and controlled until the RAEM1 restarts completely and the RUN light flashes again.** After rebooting RAEM1 completely, it automatically connected to the router.

Note: It may take some time for the RAEM1 to reboot. Please DO NOT interrupt or turn off the RAEM1 before it completes the rebooting and starts running normally.

After configuring the RAEM1 to Router Mode, RAEM1 will need to be restarted to connect to the preset Router ID automatically. The configuration setting in the RAEM1 Configuration software is as shown in Figure 3-5. Please see Section 4.3.2 for more information.

Under the router mode, after both the RAEM1s and the PC connect to the router, it will list all the RAEM1 that are connected to the route in the RAEM1 Configuration software. Users can select devices to configure based on their device IP or ID.

3.3 4G Connection

The 4G module needs a 4G SIM card with data available. RAEM1 doesn't come with 4G SIM cards. So, users need to source their own 4G SIM card and install it in the RAEM1. **It might require to change the 4G network APN of the RAEM1 in the RAEM1 Configuration software (System Settings >> Other >> System APN) through Ethernet cable for the first-time setup.**

Fig. 3-6 Wi-Fi Hotspot Mode Connection

1) Carefully rotate the top plastic part of the RAEM1 in anti-clockwise direction so that the PCBs are exposed.
2) Find the SIM card slot on the 2nd PCB layer from the top.
3) Insert the 4G SIM card into the SIM card slot. Make sure the cut corner should be inside the slot and the metal interface is facing down.
4) Push the SIM card in the slot completely. You should feel that there is a click feeling when the SIM card is well inserted.
5) Gently and carefully rotate the PCBs back in the cylinder in clockwise direction. When rotating the part in the cylinder, be careful not to over-bend or damage the ribbon cable in between the PCB and the cylinder case. Try not to open RAEM1 cylinder many times because it might accidentally break the hardware and it will require repairing.

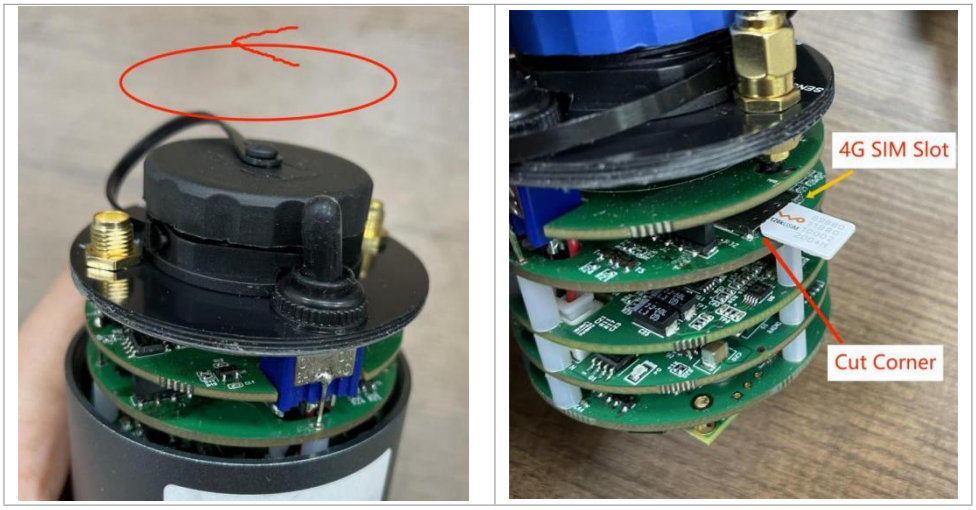


Fig. 3-7 Insert 4G SIM Card

4G network connection automatically starts after powering. It doesn't require manual operation. It can enhance the 4G signal strength by connecting the external antenna. After successful connection, it can use the software in Table 3-4 for configuration and operations. Review and follow the corresponding software introduction sections for connection and operations.

Communication	Configuration	Real-time Data View	Data Download
4G	Qingcheng IoT Cloud/ Alibaba Cloud	Qingcheng IoT Cloud/ Alibaba Cloud	Qingcheng IoT Cloud/ AWS S3

Table 3-4 4G corresponding software

4. RAEM1 Configuration Software

4.1 Introduction to RAEM1 Configuration Software

RAEM1 Configuration Tool Software is a Windows executive program developed for RAEM1 series configuration purpose exclusively. Users can use the software to configure RAEM1 when it is operating.

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

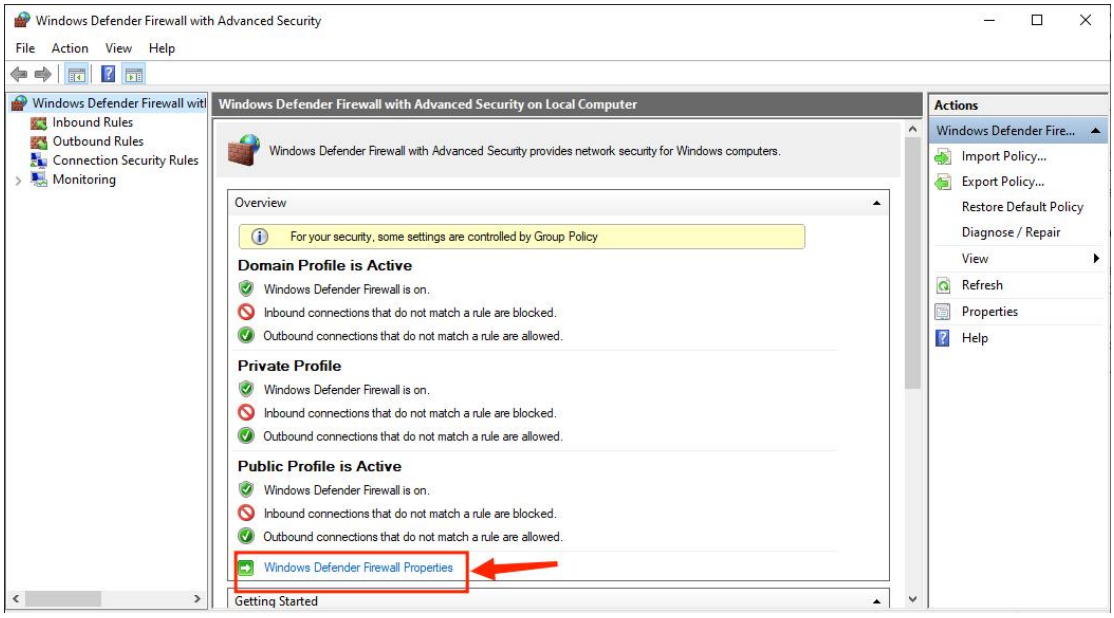
To use RAEM1 Configuration software, **the firewall function and the WLAN function on the computer must be turned off.** The following is to turn off the firewall.

① Open **Windows Defender Firewall with Advanced Security**.

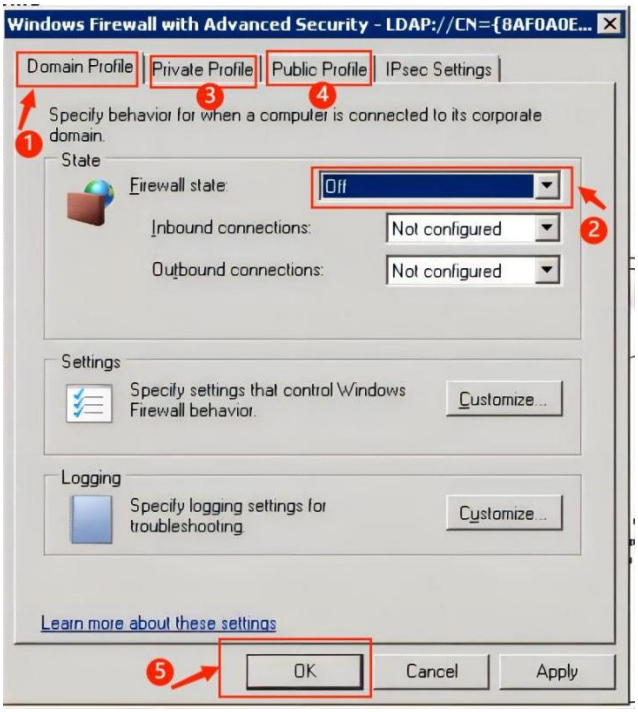
② Click **Windows Defender Firewall Properties.**

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

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



(a)



(b)

Fig. 4-1 Turn off Windows Defender Firewall (a & b)

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.

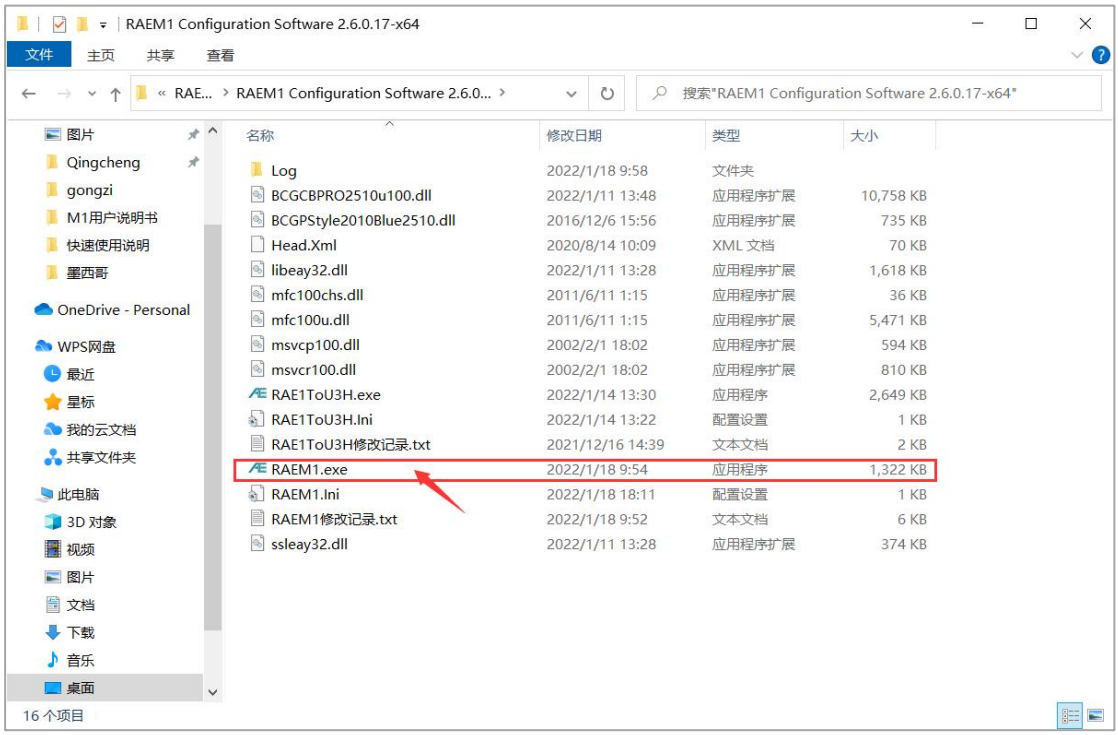


Fig. 4-2 RAEM1 Configuration software executive program location

The operation steps of RAEM1 Configuration software are:

① 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.**

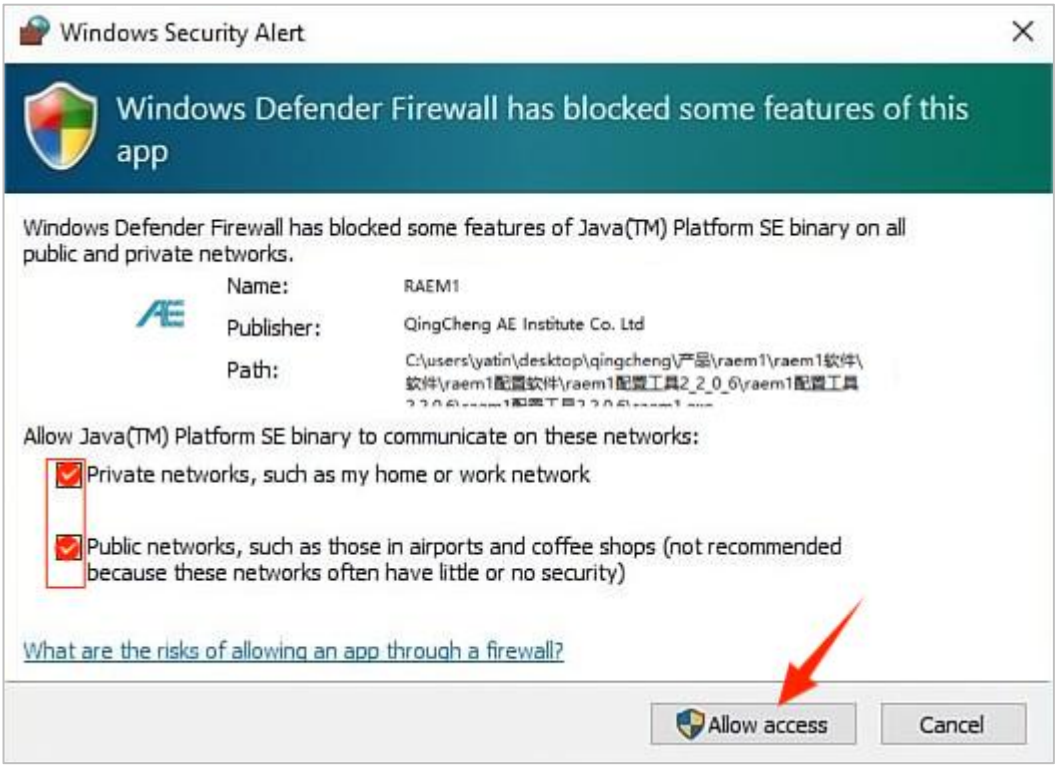


Fig. 4-3 Firewall Security Alert

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

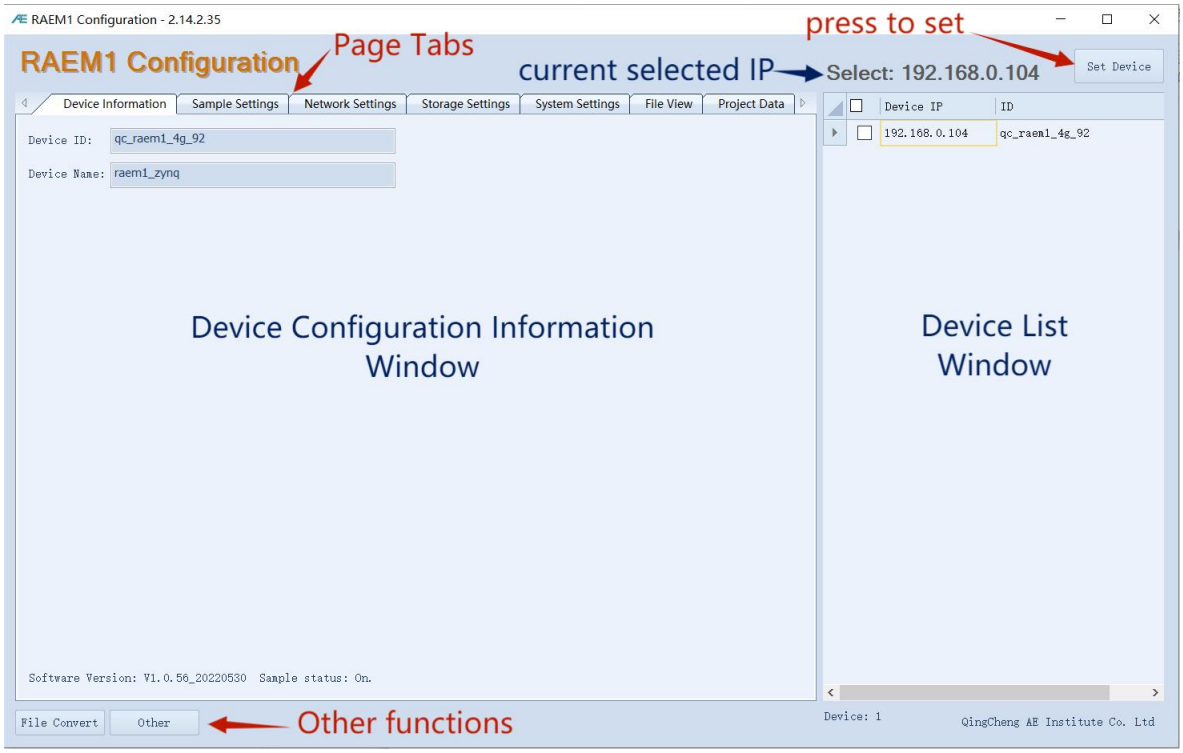


Fig. 4-4 RAEM1 Configuration Main Interface

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

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

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

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

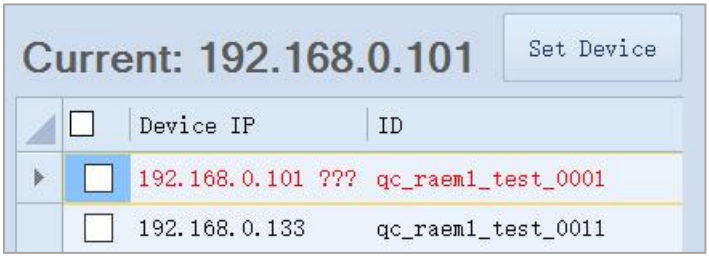


Fig. 4-5 RAEM1 Configuration Tool Device Offline

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

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

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

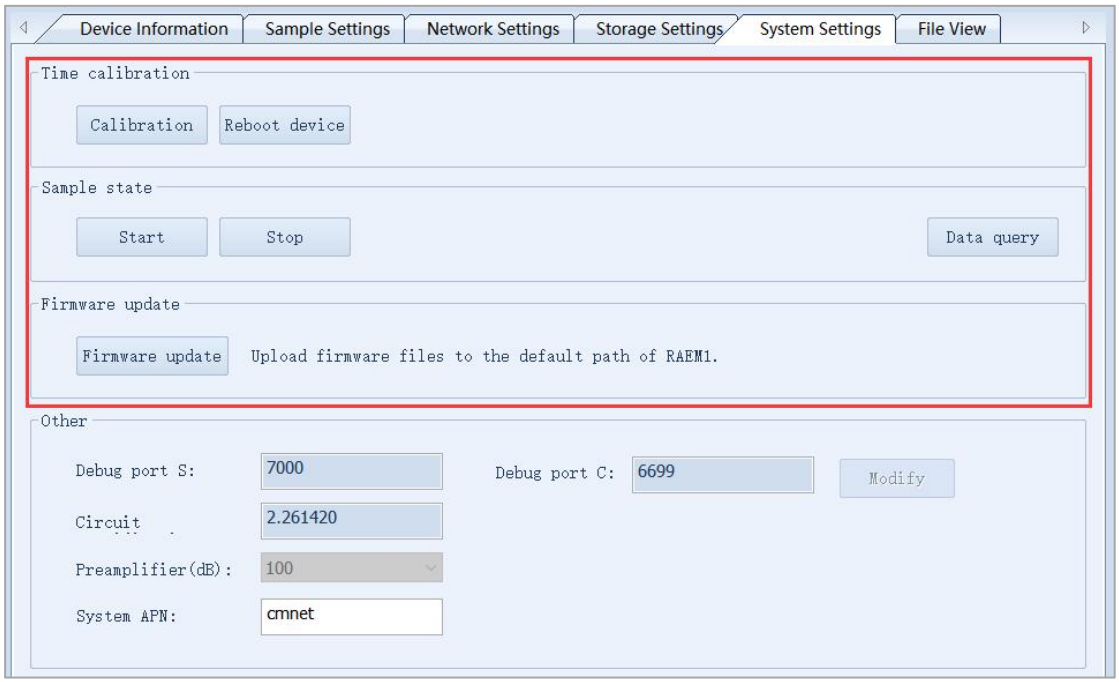


Fig. 4-6 RAEM1 Configuration Software System setting buttons.

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

✧ **Start sampling**: send command to the device to require the device to start collecting.

✧ **Stop sampling**: send command to the device to stop it from collecting data.

✧ **Calibrate device time**: apply the current PC time to the device.

✧ **Reread device info**: read the device settings information again, whether it is checked or not.

- **Reboot device**: make the device restart.
- **Firmware file upload**: used to update the device firmware. It can choose one or multiple files at the same time (maximum 20 files at a time).
- **AST check**: this function is exclusive for certain type of RAEM1. It requires two sensors for Auto Sensor Test (AST) check. The device sends out the excitation signal to the transmitter sensor to generate the acoustic waves and the receiver sensor collects the acoustic signals. Based on the receiving signals, it can test out how the sensor sensitivity and coupling status.
- **Enter sleep mode**: by enabling the sleep mode, it stops acquisition, transmission, and communication to save power. But be careful with this function because it may require some efforts to wake up the device.

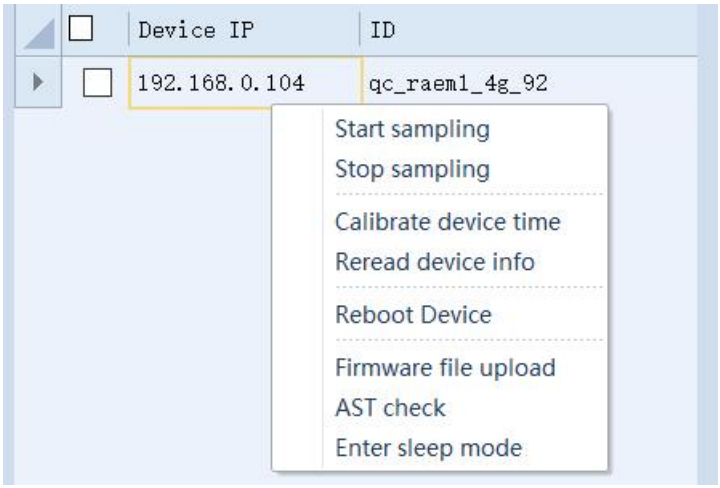


Fig. 4-7 RAEM1 Configuration Software context menu

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

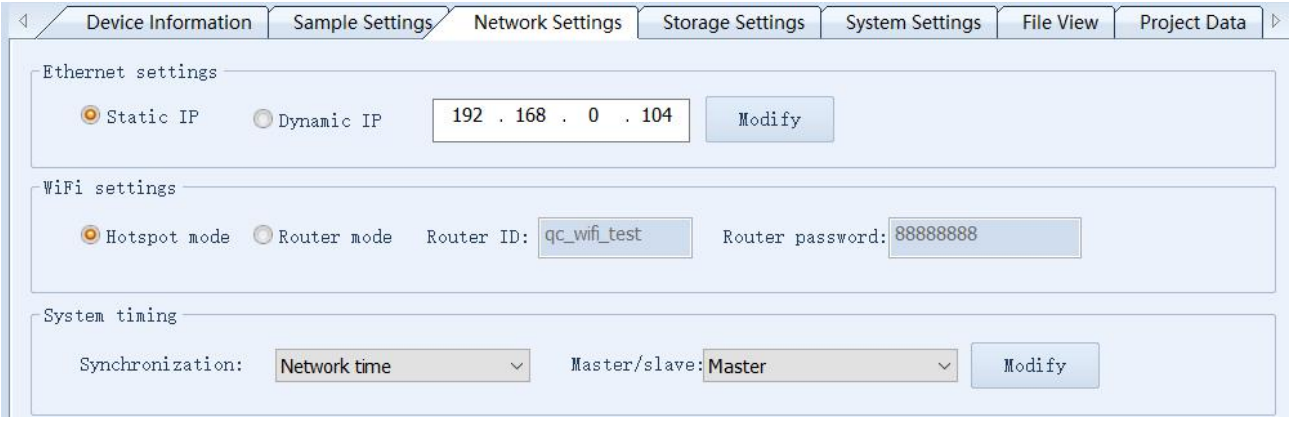


Fig. 4-8 RAEM1 Configuration Software **Modify** button.

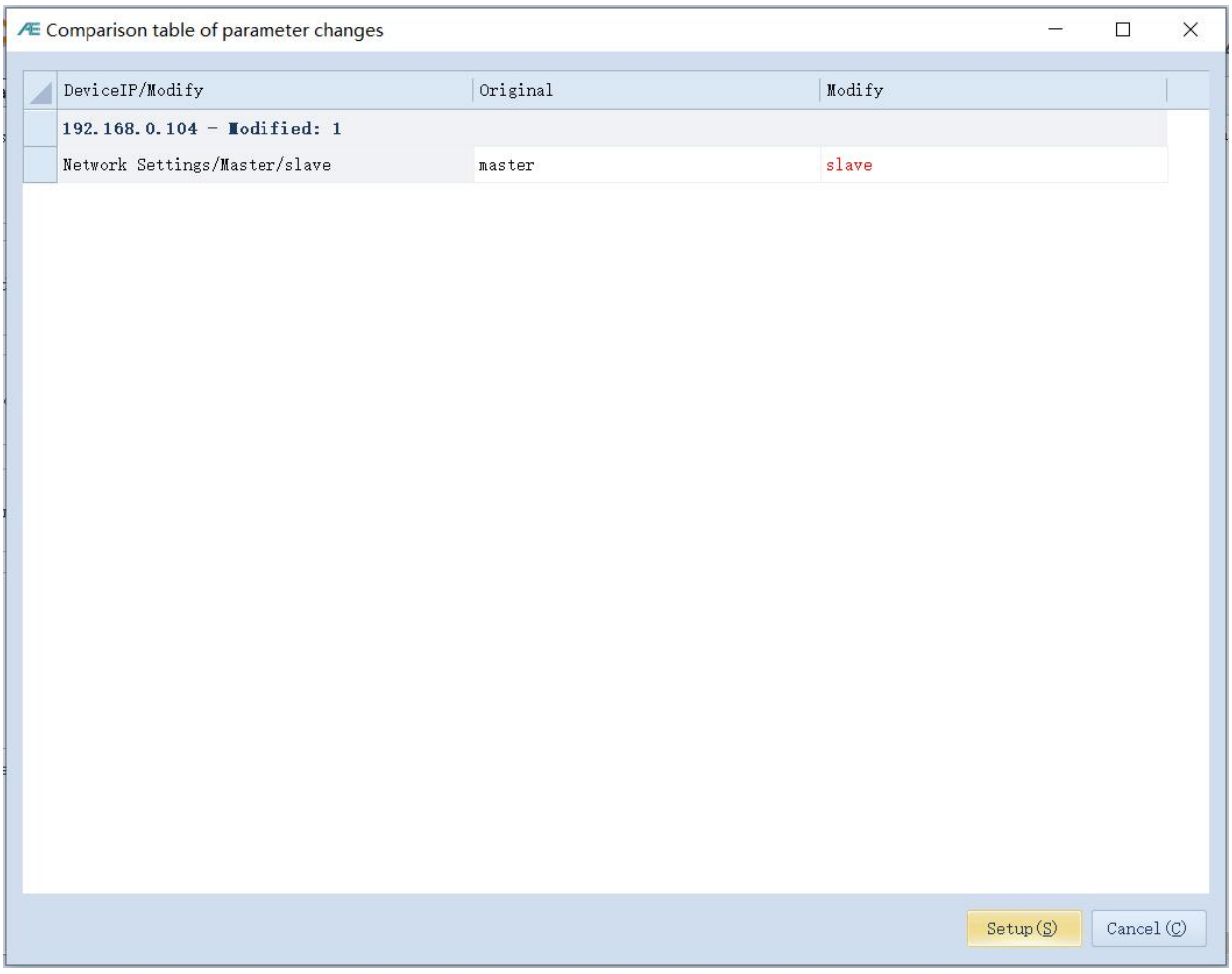


Fig. 4-9 RAEM1 Configuration Software **Modify** Confirmation window.

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.

4.2 Sample Settings

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

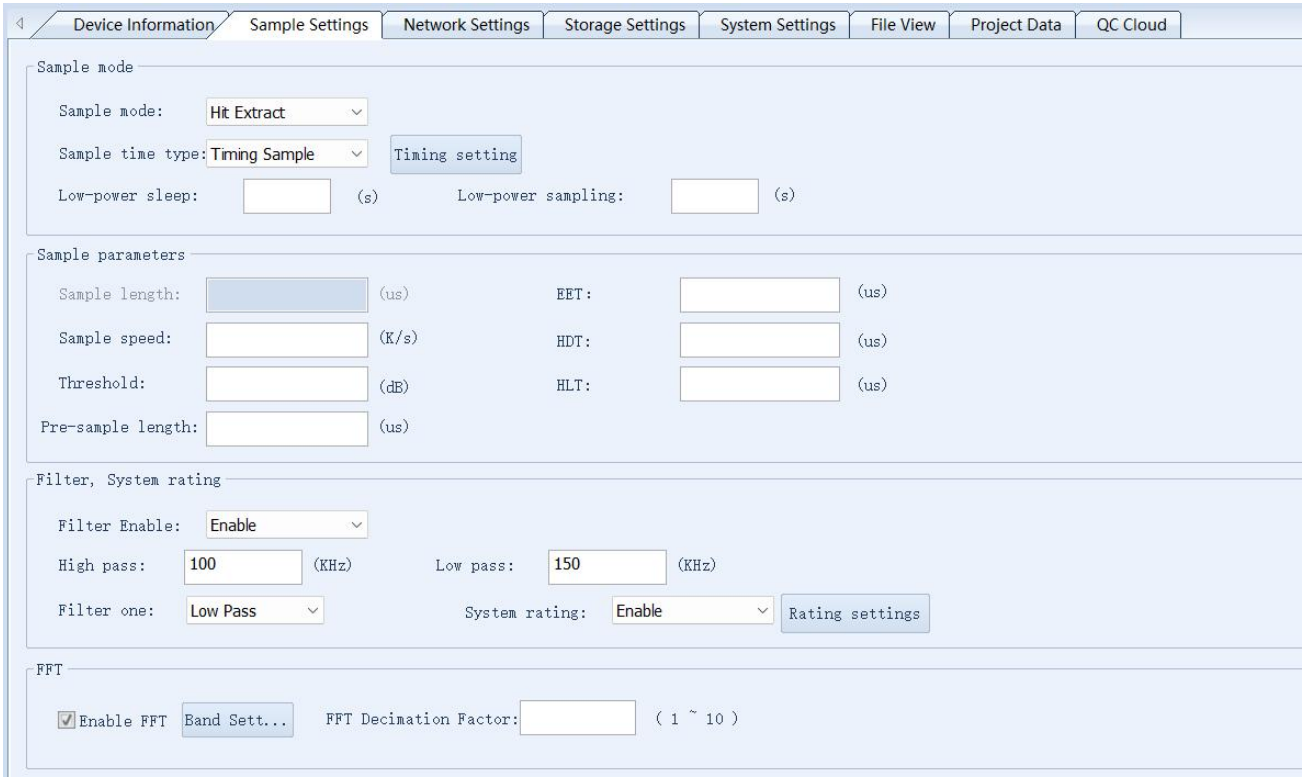


Fig. 4-10 RAEM1 Configuration software Sample Settings page

- **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 ~ 50000us (positive integer), can be directly input in the text box. It refers to the waiting time interval of a hit signal 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.

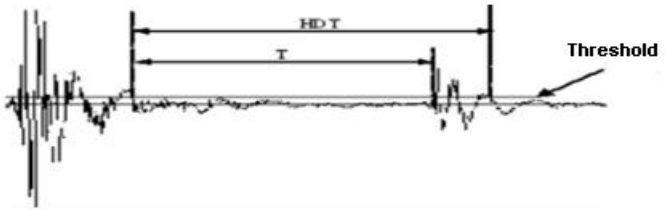


Fig. 4-11 HDT definition diagram

- **HLT**: Hit lock time, in unit of micro-second (us). The setting range is 1 ~ 20,000,000 (positive integer), can be directly input in the text box. 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 (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.

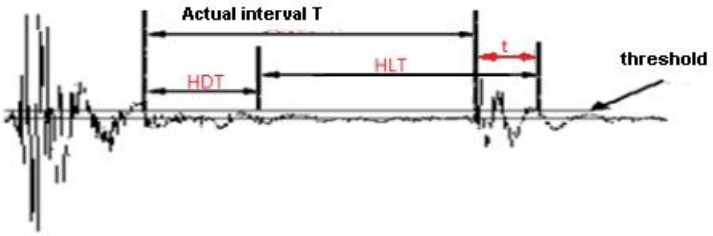


Fig. 4-12 HLT definition diagram

- **Pre-sampling point count (us)**: A segment of data is collected before the acoustic emission signal crosses the threshold. The length unit of this segment of data is microsecond (us). This setting is only valid for generating waveforms and does not affect parameter generation.

4.2.2 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.

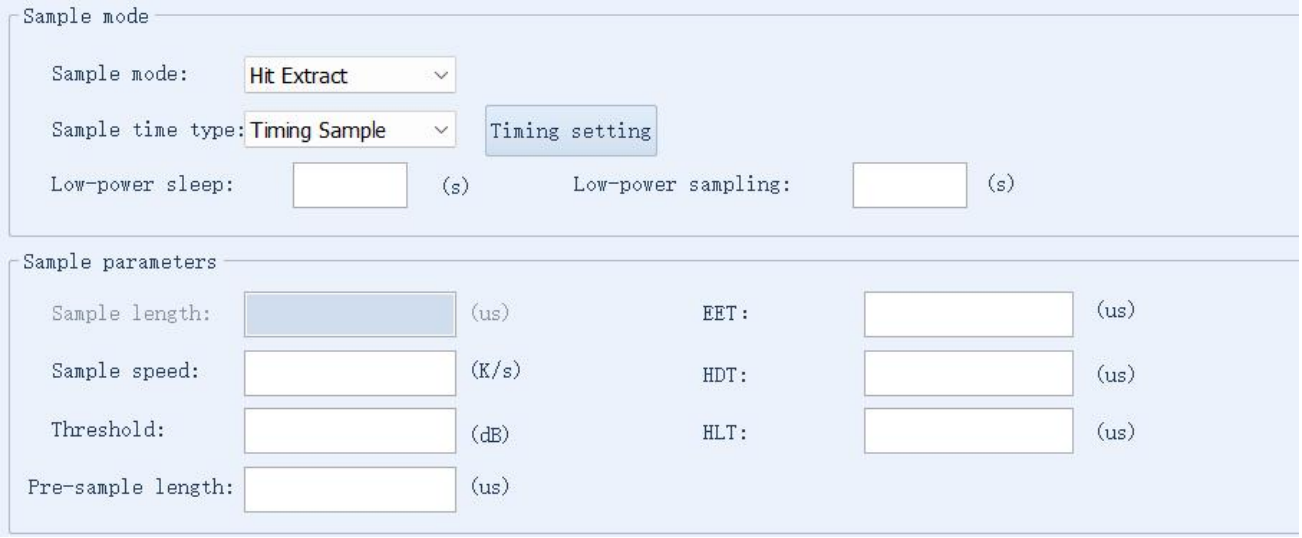


Fig. 4-13 Sample Mode - Hit Extract Mode

- **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.

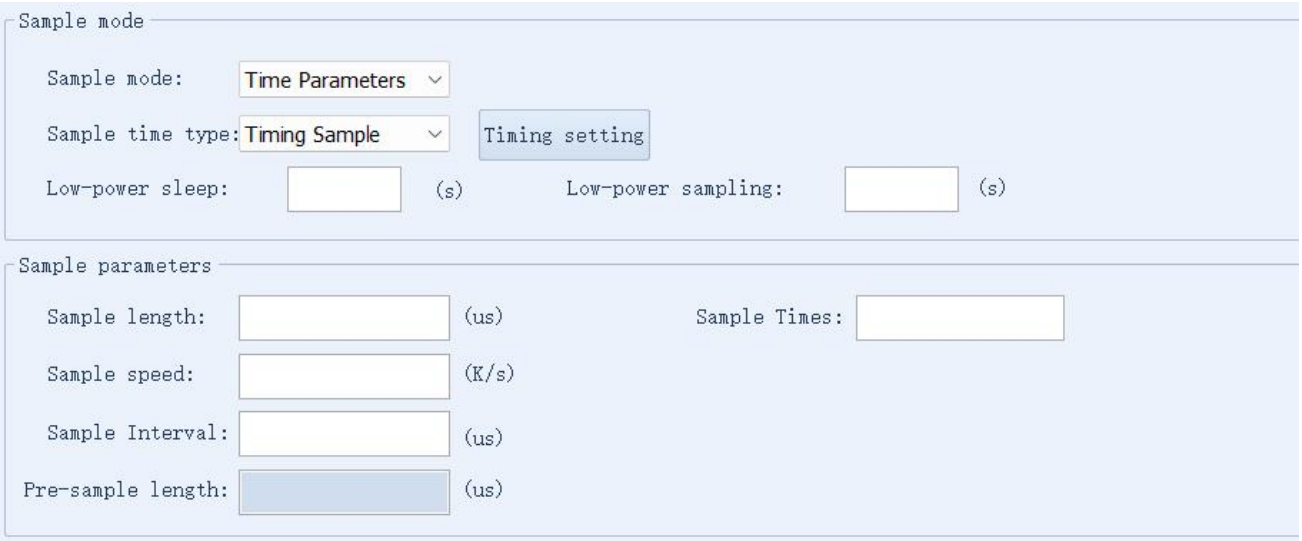


Fig. 4-14 Sample Mode - Time Parameters Mode

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 in a specific date, accurate to the seconds. The interface is shown below.

Fig. 4-15 Hit Extract Mode - Timing Sample

Click **Timing setting** to add acquisition time periods:

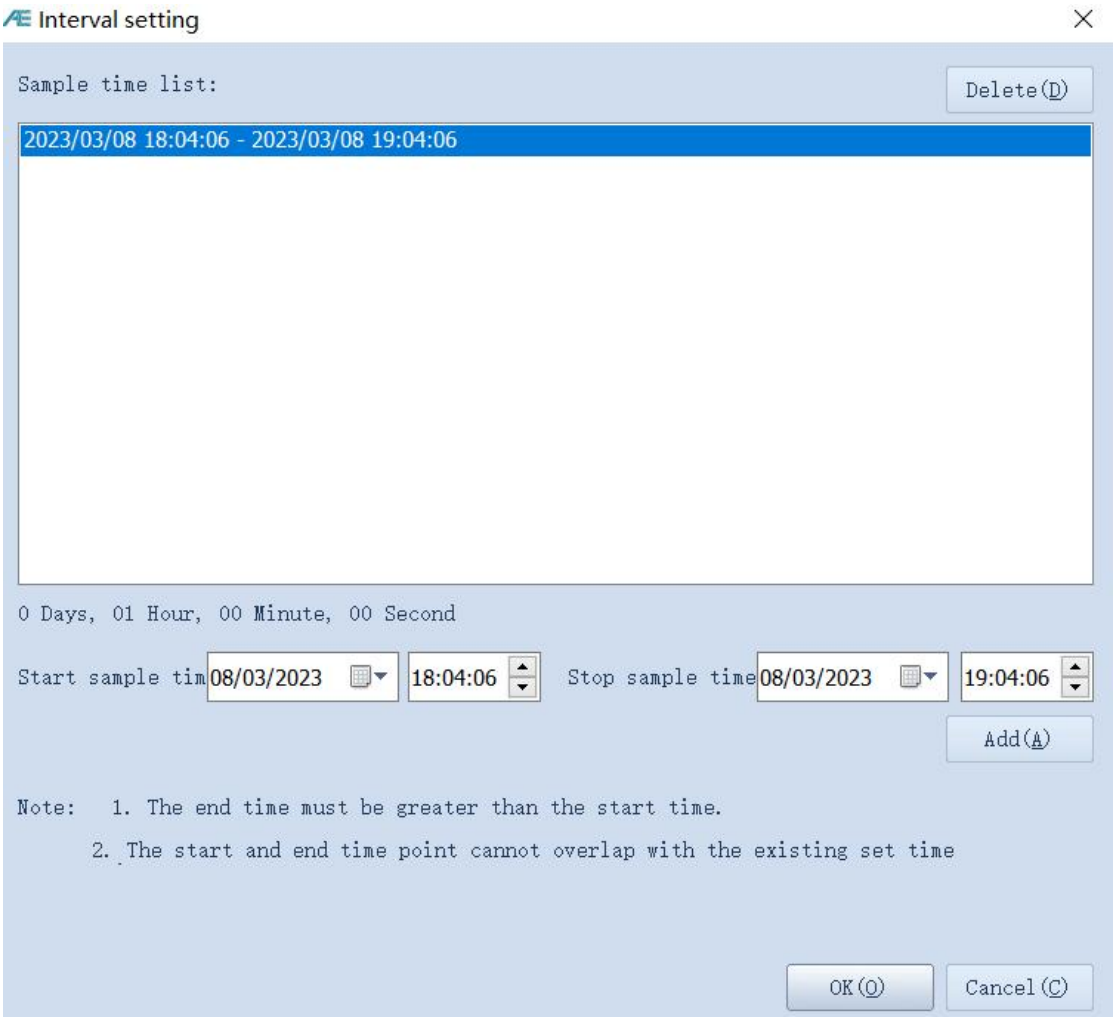


Fig. 4-16 Timing Sample settings page

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

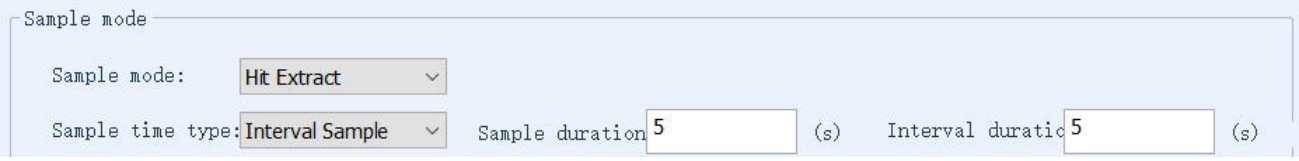


Fig. 4-17 Interval Sample settings

- 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.

4.2.3 Filter

The filters in the software is the digital filter.

- Filter Enable: whether to enable the digital filter function.
- Filter One: There are three options: low-pass, band-pass, high pass, or choose not to use a digital filter.
- High pass (KHz): Refers to the lower limit of the frequency domain, which cannot pass when the signal frequency is below this frequency.
- Low pass (KHz): Low pass refers to the upper limit of the frequency domain, and cannot pass when the signal frequency is higher than this frequency.

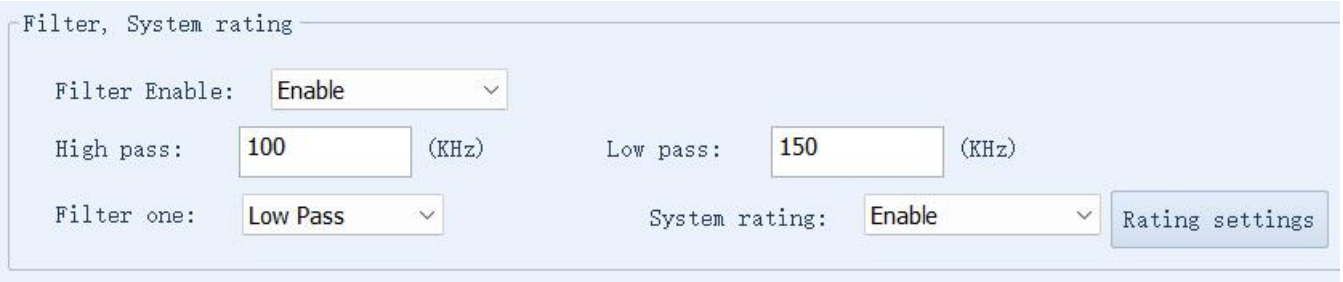


Fig. 4-18 Filer settings

4.2.4 System Ratings

System rating allows users to set different intensity, activity, and rating rules based on their needs. The collected parameter data will be classified into different levels according to the rating settings. Users can determine the next action based on the result level.

There are 8 parameters for rating: amplitude, ASL, energy, duration, counts, rise counts, rise time, and RMS. After establishing the rating rules, a final rating result for a certain period of time is made based on the magnitude (intensity) and frequency (activity) of the parameter values collected over a certain period of time, as well as the level of the established rules.

In the **Sample Settings** >> **System rating**, enable the function and press **Rating settings**. At the bottom left corner of the Rating Settings window, press **Add Strength** or **Add Activity** to create rating levels. Each rating level can have one or multiple rules. Any one rule under that rating level reaches, that rating level will trigger and

report. Each rule can also have one or more parameters as thresholds. It requires all the parameters in the rule reach the set values to make it conform the rule.

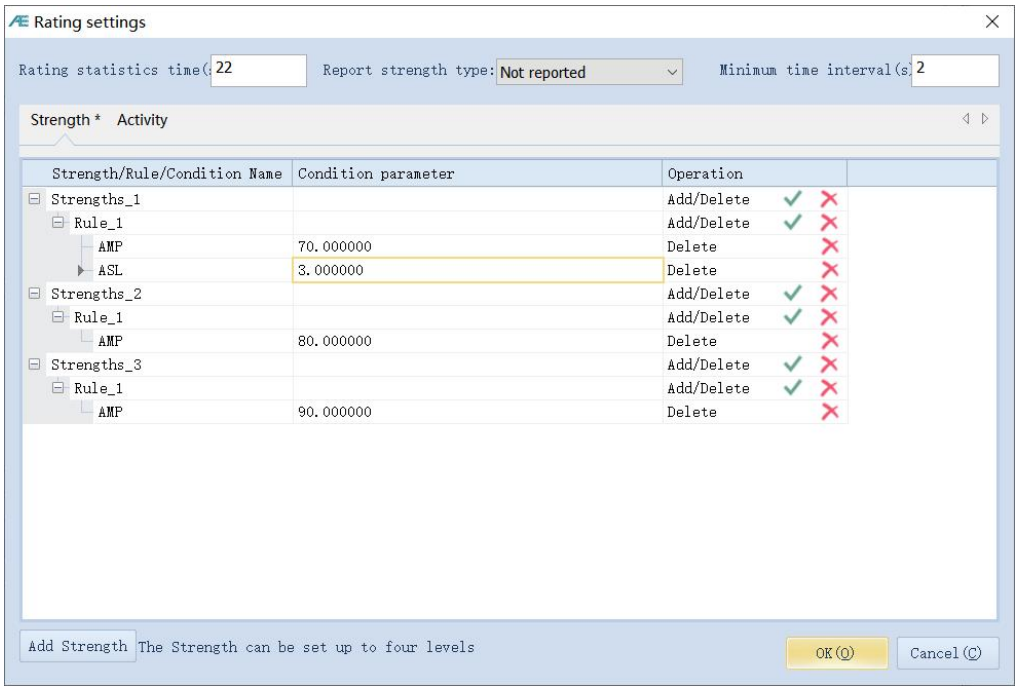


Fig. 4-19 System Rating Intensity Setting

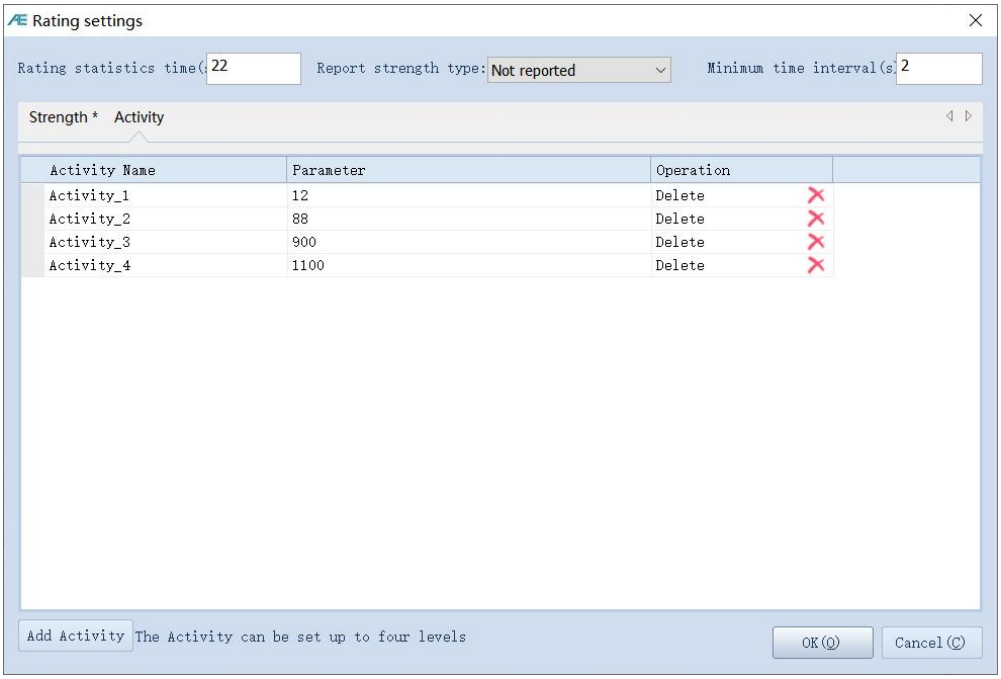


Fig. 4-20 System rating Activity setting

4.2.5 FFT

FFT Decimation Factor: The value can be selected from 1 to 10, which means that one is extracted from every few original sampling points (waveform sampling rate) on average for FFT calculation;

Starting frequency (KHz): the starting frequency of the power spectrum band;

End frequency (KHz): The end frequency of the power spectrum band. After selecting the enabled parameter, press "**Auto Spacing**" to auto proportionally allocate the frequency range set here;

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";

Auto Spacing: is also automatically allocation. The set numerical range will be automatically divided equally according to the selected number of local power spectrum segments. The automatically distributed values allow users to modify them again.

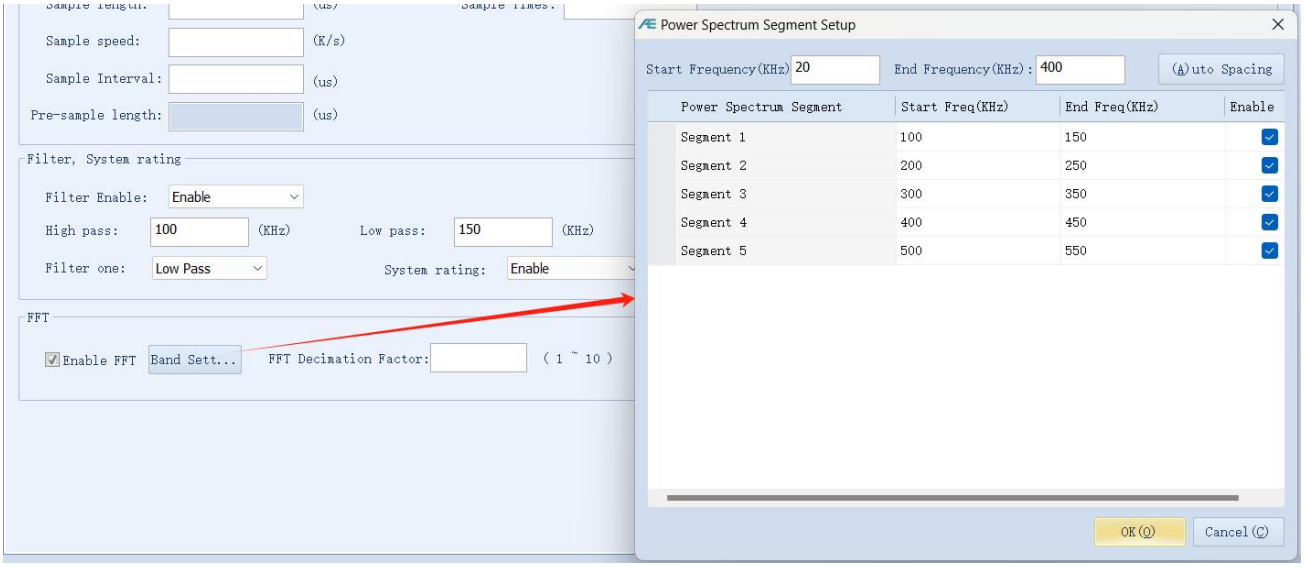


Fig. 4-21 FFT setting

4.3 Network Settings

The default factory device IP addresses for different connection are:

Ethernet	192.168.0.101
Wi-Fi Hotspot mode	192.168.100.1

Table 4-1 RAEM1 device IP list

4.3.1 Ethernet Settings

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

- **Static IP**: the IP address in the text-box below will be used as the Ethernet/LAN static IP address of RAEM1.

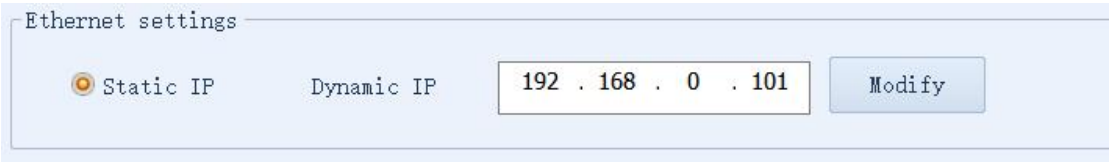


Fig. 4-22 Ethernet IP settings

The default setting is static IP, 192.168.0.101. That means when the computer is set at 192.168.0.xxx, for example 192.168.0.20 (computer IP cannot be the same as the device to avoid conflicts), it can connect to the device.

- **Dynamic IP**: the device (RAEM1) will get the IP address dynamically from the router. After the RAEM1 is connected to a router using "Router Mode" ID and password, the router will assign the a new dynamic IP address to RAEM1. If the device IP has changed, in the same network, the device list of RAEM1 Configuration software will appear with a new device IP address but with the same old device ID.

4.3.2 Wi-Fi Settings

The default Wi-Fi mode of RAEM1 is Hotspot mode. RAEM1 releases a Hotspot for connection. The Hotspot ID is for example **qc_raem1_wifi_0001** and the default password is 88888888. When the computer searches for RAEM1 Hotspot, it can configure the RAEM1 after connecting to the RAEM1 Hotspot.

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

Fig. 4-23 Router mode settings

When it is changed to the router mode:

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

② Then reboot the device.

③ Connect the computer to the router network.

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

4.3.3 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. Click "Modify" button to change.

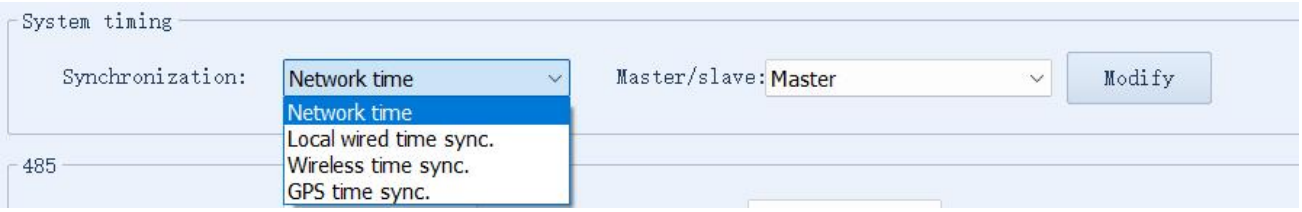


Fig. 4-24 System timing

4.3.4 485

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

4.4 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. When it is disabled, the data can still be uploaded to the Alibaba Cloud/ TCP server/ SWAE software, but NOT stored in the local SD card.

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

❖ **U3H Server**:

- **Send U3H**: whether to send the real-time data to the SWAE software. It is disabled by default.
- **Send Wave**: whether to send the waveform to the SWAE software. It is disabled by default.
- **Send Param**: whether to send the parameters to the SWAE software. It is disabled by default.
- **Address type**: It can be **Auto**, or user defined (**Enter IP**). But **it is suggested to choose "Enter IP" always**. Find out the IP address of the PC that uses SWAE software and enter the IP address to the address text-box.
- **Address**: If **Enter IP** is selected, it needs to enter the target PC address here.
- **Port**: can be configured. The default is 18883.

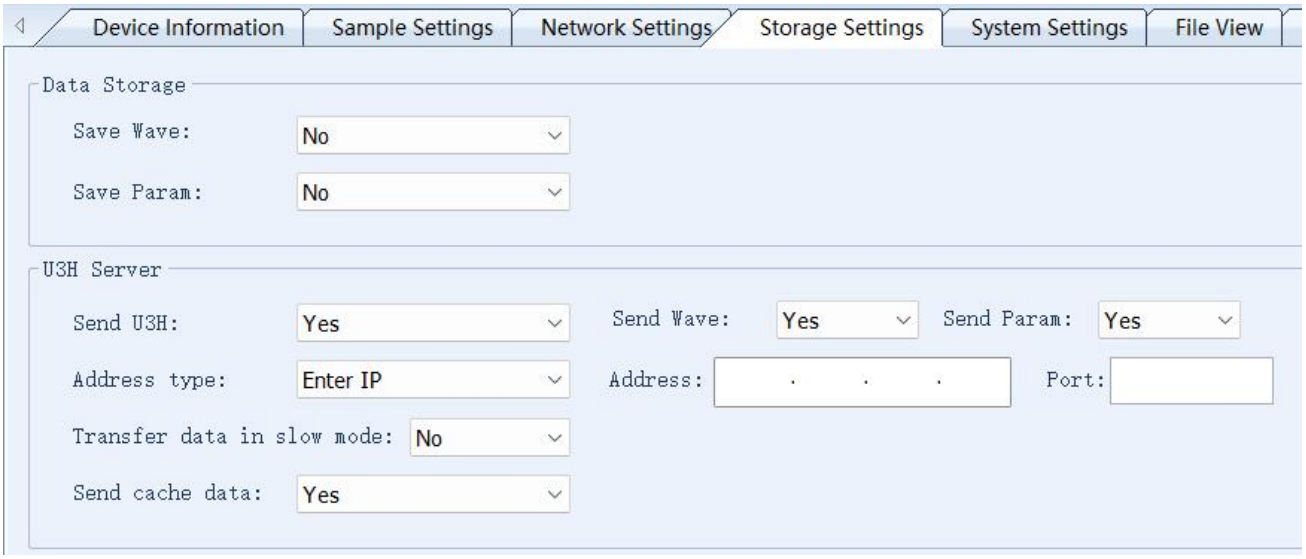


Fig. 4-25 Storage Settings

4.5 System Settings

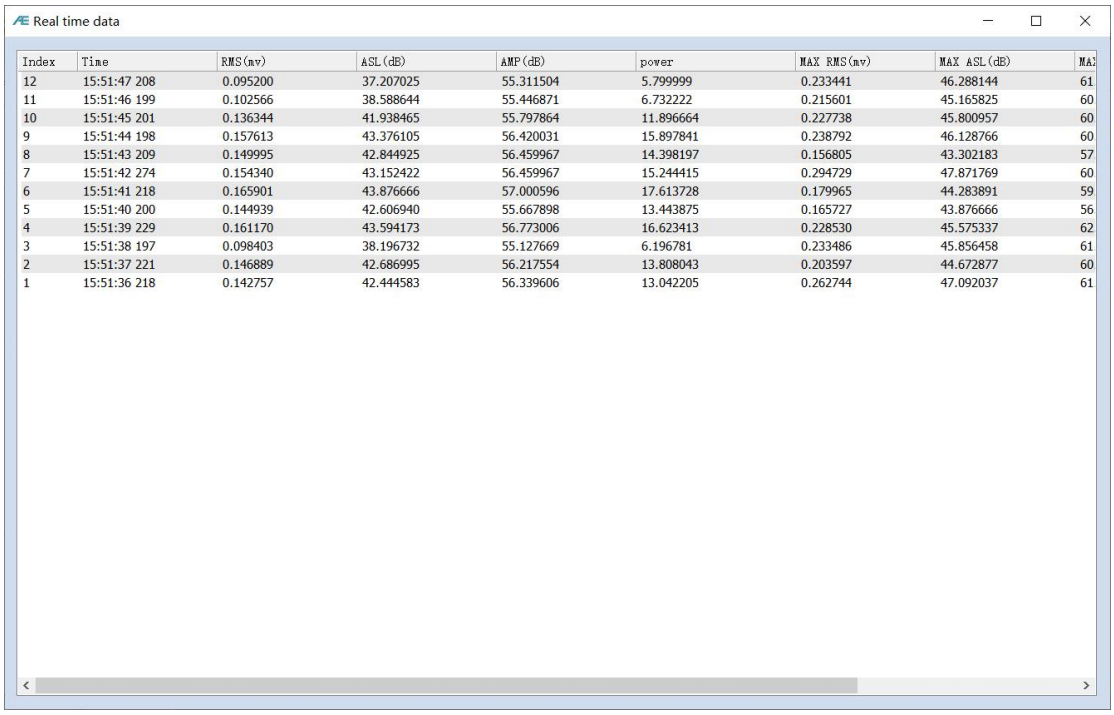
4.5.1 Time Calibration

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

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

4.5.2 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)	MAI
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. 4-24 Real time data page

4.5.3 Firmware Update

There are two files to update the firmware:

- update.zip
- md5sum.txt

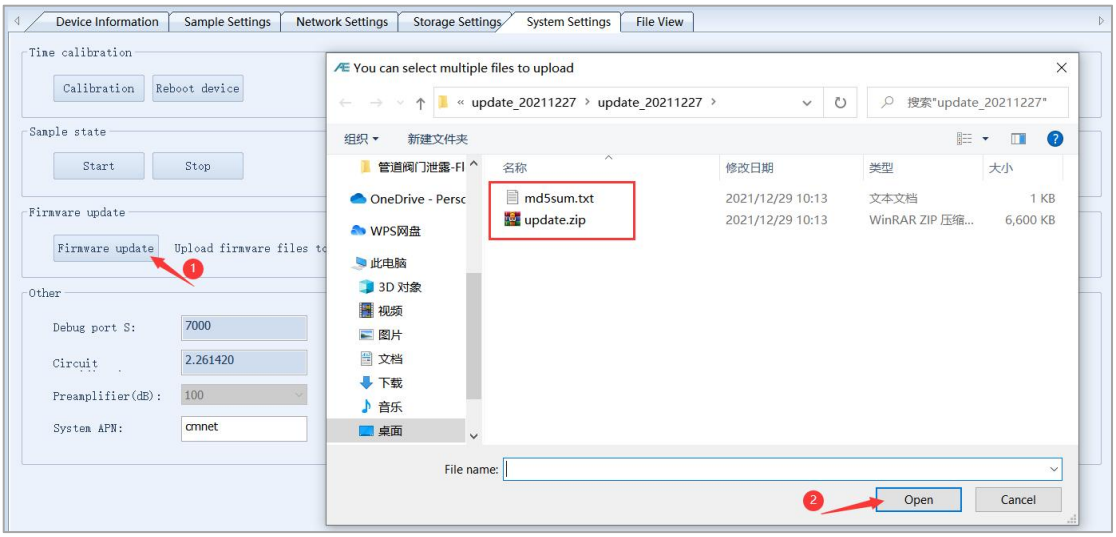


Fig. 4-25 Firmware update

Click **Firmware update** button to upload **update.zip** and **md5sum.txt** files in order. **After uploading the files, the system will update automatically followed by rebooting**. Please don't interrupt the process by disconnecting

the power or manual restart during the process. It also supports multiple files for uploading. You can choose both files to upload at the same time.

4.5.4 Other

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

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

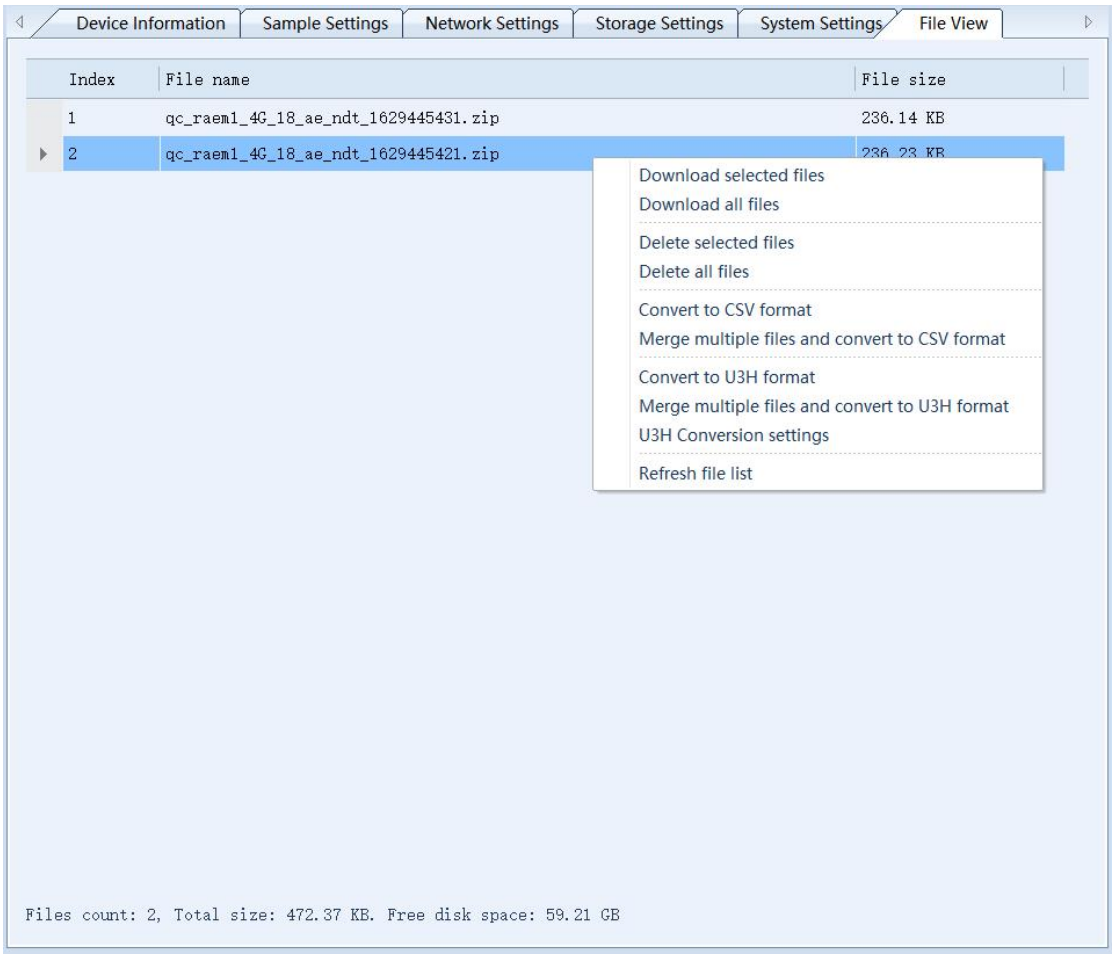


Fig. 4-28 File View

4.7 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 reporting mode, restart the device for the setting to take effect.)**

- **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.

4.7.1 QC Aliyun (Alibaba Cloud) Mode

QC Aliyun mode is used to set the RAEM1 to be able to communication to the Alibaba Cloud server. In this mode, users can view the RAEM1 in the QC Alibaba Cloud platform for its real-time AE parameters, parameter ratings and configurations. But the waveform is not yet supported to be viewed or download currently. It requires the devices to have Internet function in this mode. The following 3 types of devices can access Internet:

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

Table 4-2 QC Aliyun Mode network setup

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

4.7.2 TCP Mode and TCP Mode V2

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

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

TCP mode v2 is an additional version based on the TCP mode with more parameter types for communication supported. 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, energy, RMS
TCP mode v2	9	Amplitude, ASL, energy, RMS, rise time, rise counts, counts, duration, reporting time

Table 4-3 TCP Mode setup

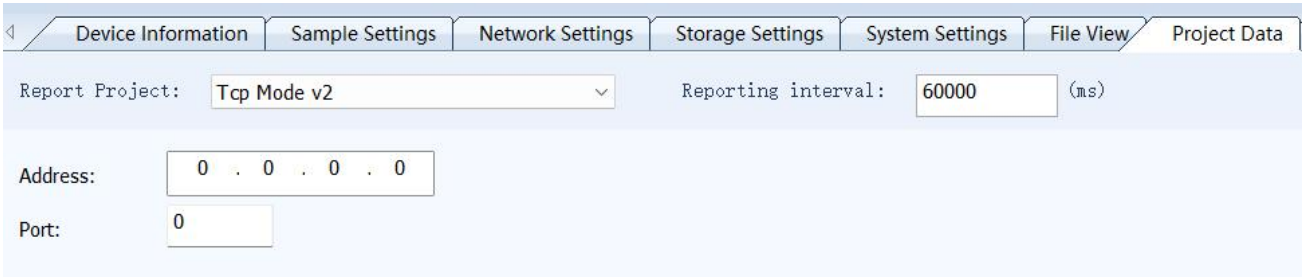


Fig. 4-29 TCP Mode setup

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

Under the TCP mode or TCP mode v2, if the server has background program, it can receive the corresponding data. Under TCP mode, 4 parameter data can be received, while in TCP mode v2, 9 parameter data can be received.

The TCP mode server test code as follow:

```
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. 4-30 TCP mode test code

The context that the server receives is:

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

Fig. 4-31 TCP mode server receiving data

TCP Mode outputs 4 AE characteristic parameters, including amplitude, ASL, energy and RMS. The format of

the output data is device ID + amplitude + ASL + Energy + RMS + timestamp, separated by comma.

TCP Mode v2 outputs 9 parameters, including Amplitude, ASL, energy, RMS, rise time, rise counts, counts, duration, reporting time. The format is device ID + amplitude + ASL + energy + RMS + rise time + rise counts + 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
```

Fig. 4-32 TCP mode v2 server receiving data

Note: When selecting TCP V2 mode, the server IP cannot be filled in with the same IP address as the one sent to the U3H server.

4.7.3 QC Cloud Connection

Send parameter: After ticking, you can send parameter data to Qingcheng Cloud platform.

Send wave: After ticking, you can send waveform data to Qingcheng Cloud platform.

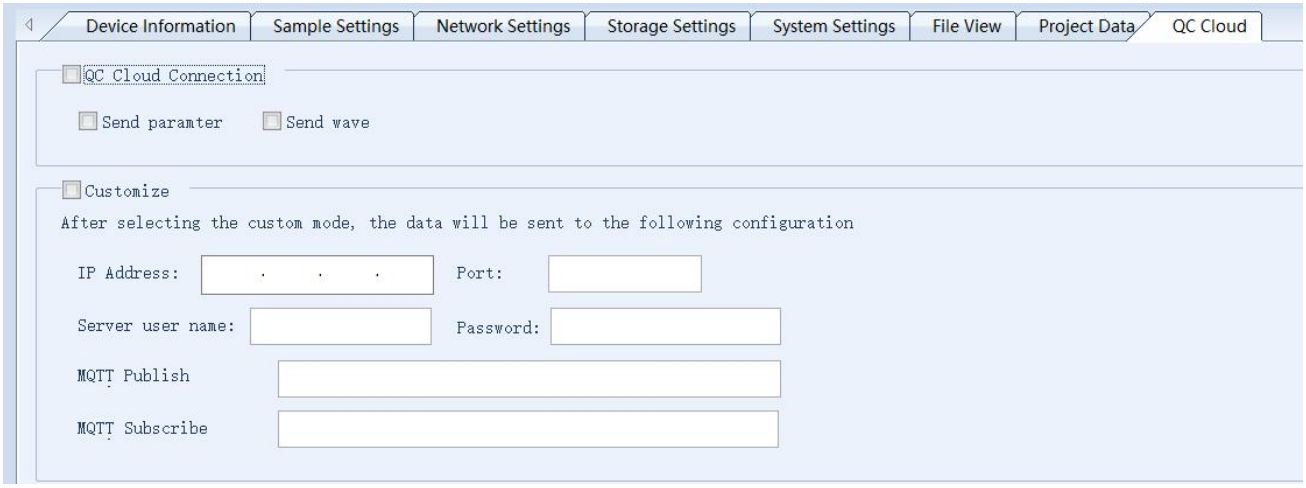


Fig. 4-33 QC Cloud Connection Operating Page

5. Qingcheng IoT Cloud Platform

Qingcheng Internet of Things Cloud Platform is a cloud platform developed for our own IoT 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 input the username 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 Ltd. Please contact us for user registration and login information.

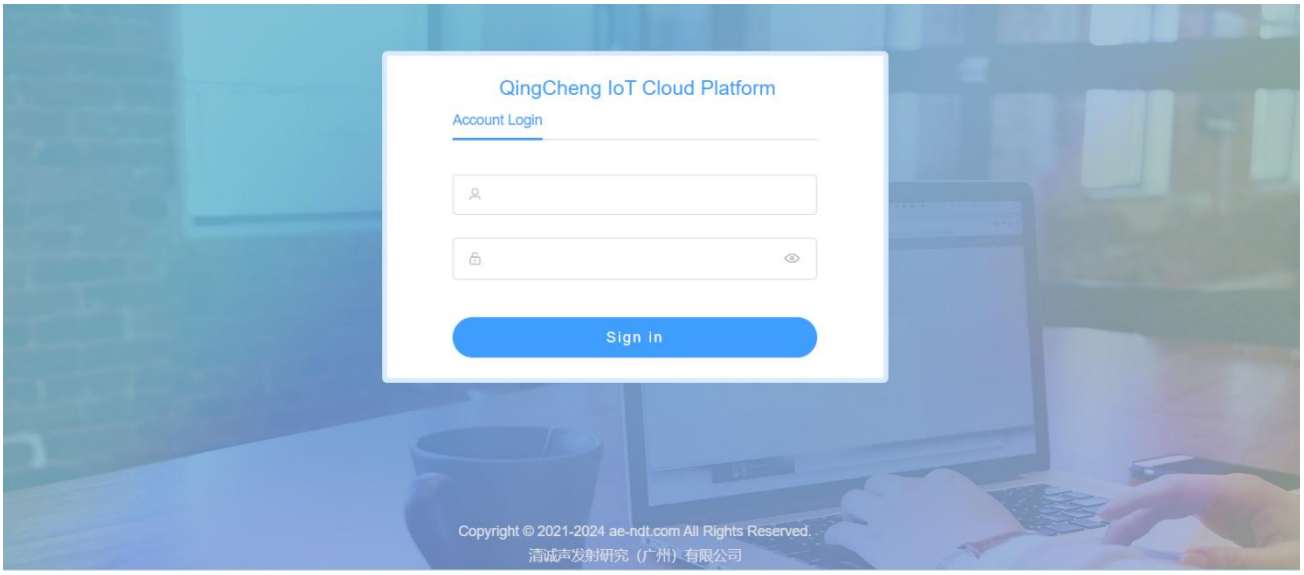


Fig. 5-1 Qingcheng IoT cloud platform login

After login, you can convert to Chinese/English, change the user interface, and change the password.

Fig. 5-2 Basic Profile Menu Example

5.1 IoT Product

5.1.1 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, such as storage tank bottom testing or some localization group testing.

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.

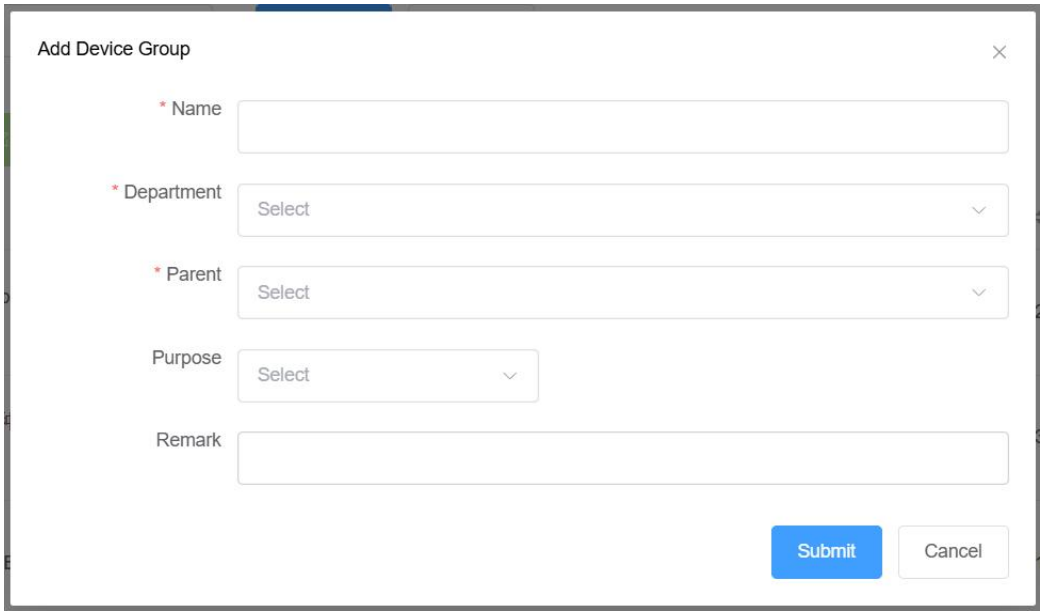


Fig. 5-3 Device Group "Add" window

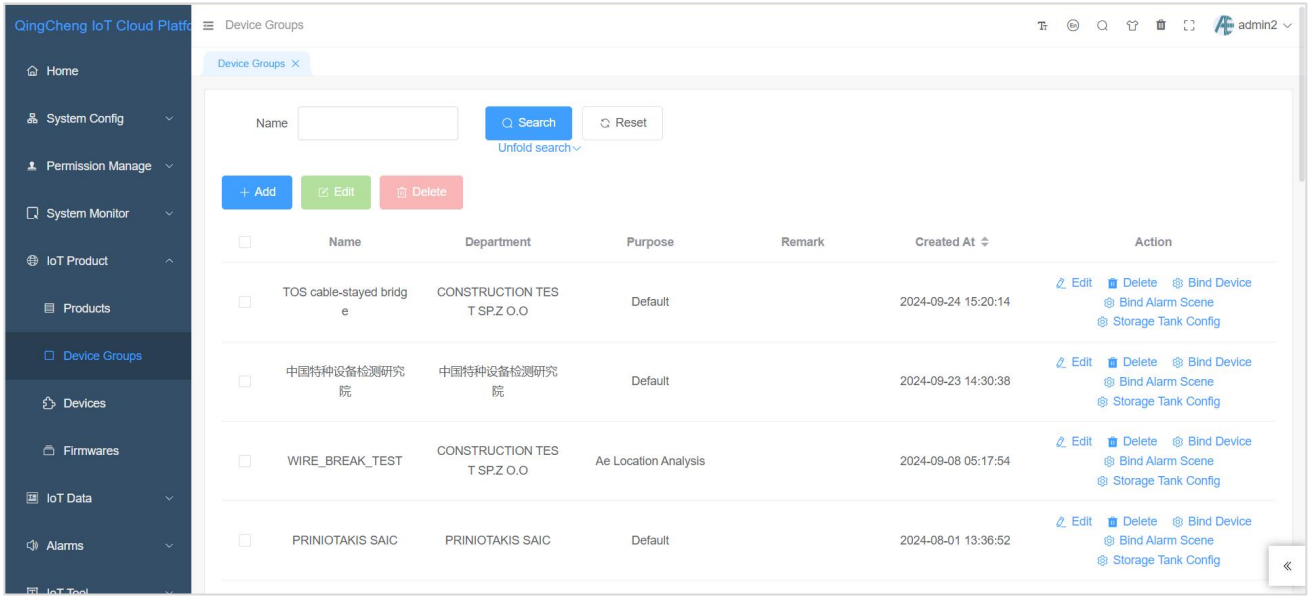


Fig. 5-4 Device Group page of Qingcheng IoT cloud platform

- **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.

5.1.1.1 Storage Tank Configuration

[Storage Tank Config] is 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.

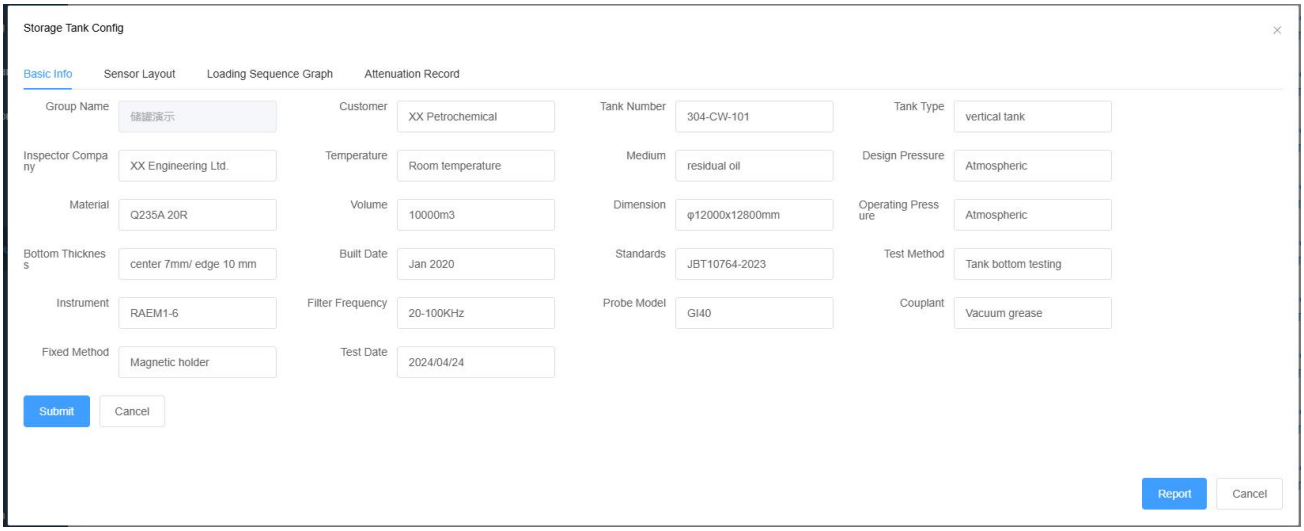


Fig. 5-5 Storage tank configuration - basic information

- **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.

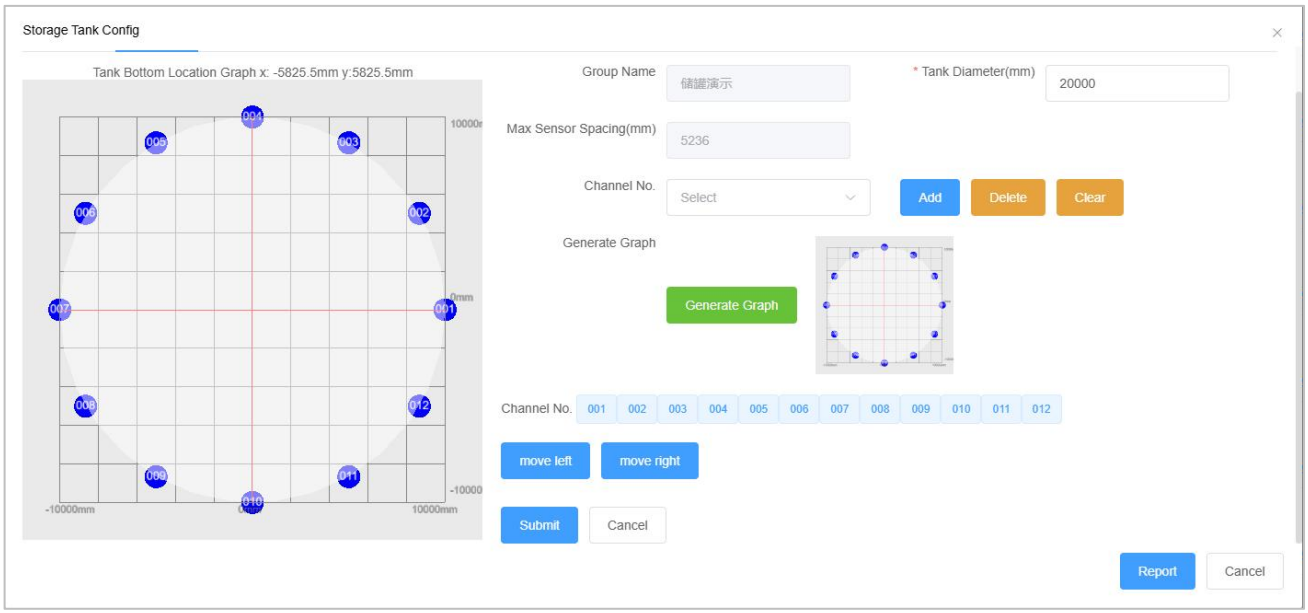


Fig. 5-6 Storage tank configuration - Sensor layout

- **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.

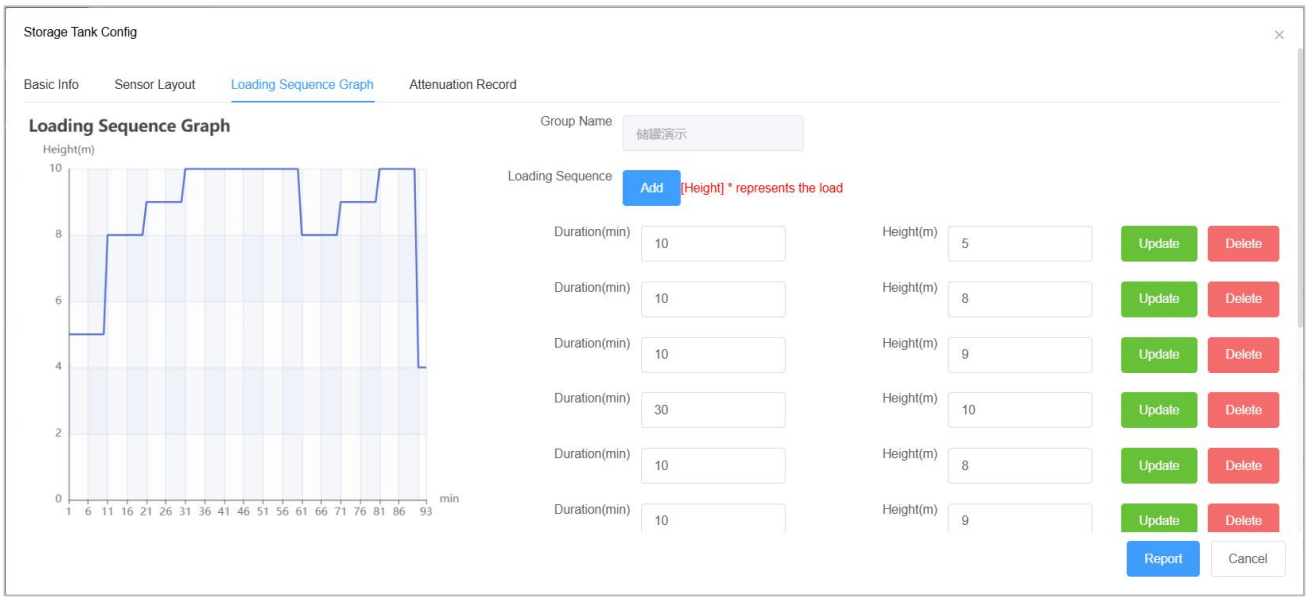


Fig. 5-7 Storage tank configuration - loading sequence

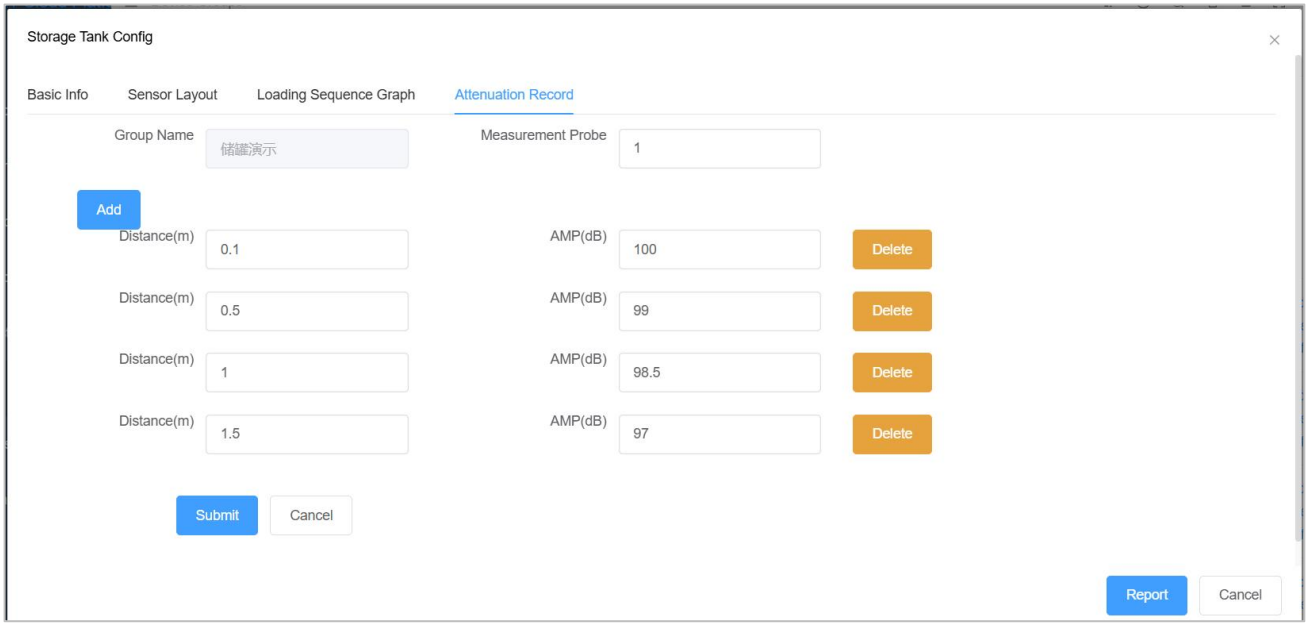


Fig. 5-8 Storage tank configuration - Attenuation record

5.1.2 Devices

Devices page lists all the IoT AE devices under this account. Users can search for desired devices through different search items, such as **SN., Product, Device Group, Product Type**, or **Status** to start filtering searches. And

the following table lists all devices on the current platform.

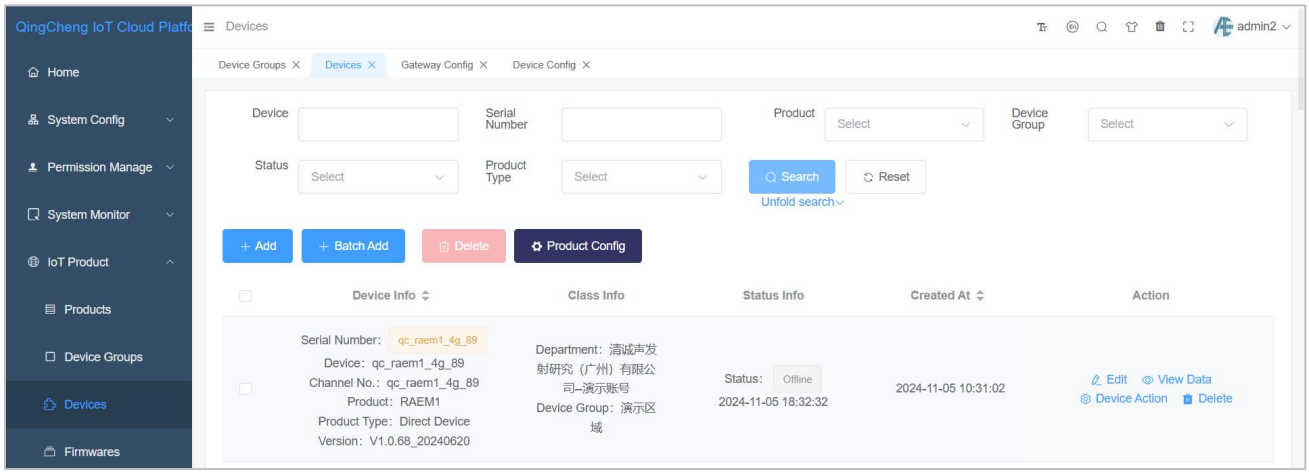


Fig. 5-9 Devices page

Click **+Add** to add a new device.

- **Series Number:** Fill in the device SN. on the product label (required)
- **Name:** User-defined (required)
- **Channel No.:** User-defined (required)
- **Department:** Select the department which the device belongs. (Required)
- **Product Type & Product Name:** Select the product (required)
- **Device group:** Select group which the newly added device belongs (required)
- **Data store:** Select the server which the data is stored. (Required)
- **Server Connection:** Select the server which the device is connected. (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.

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.

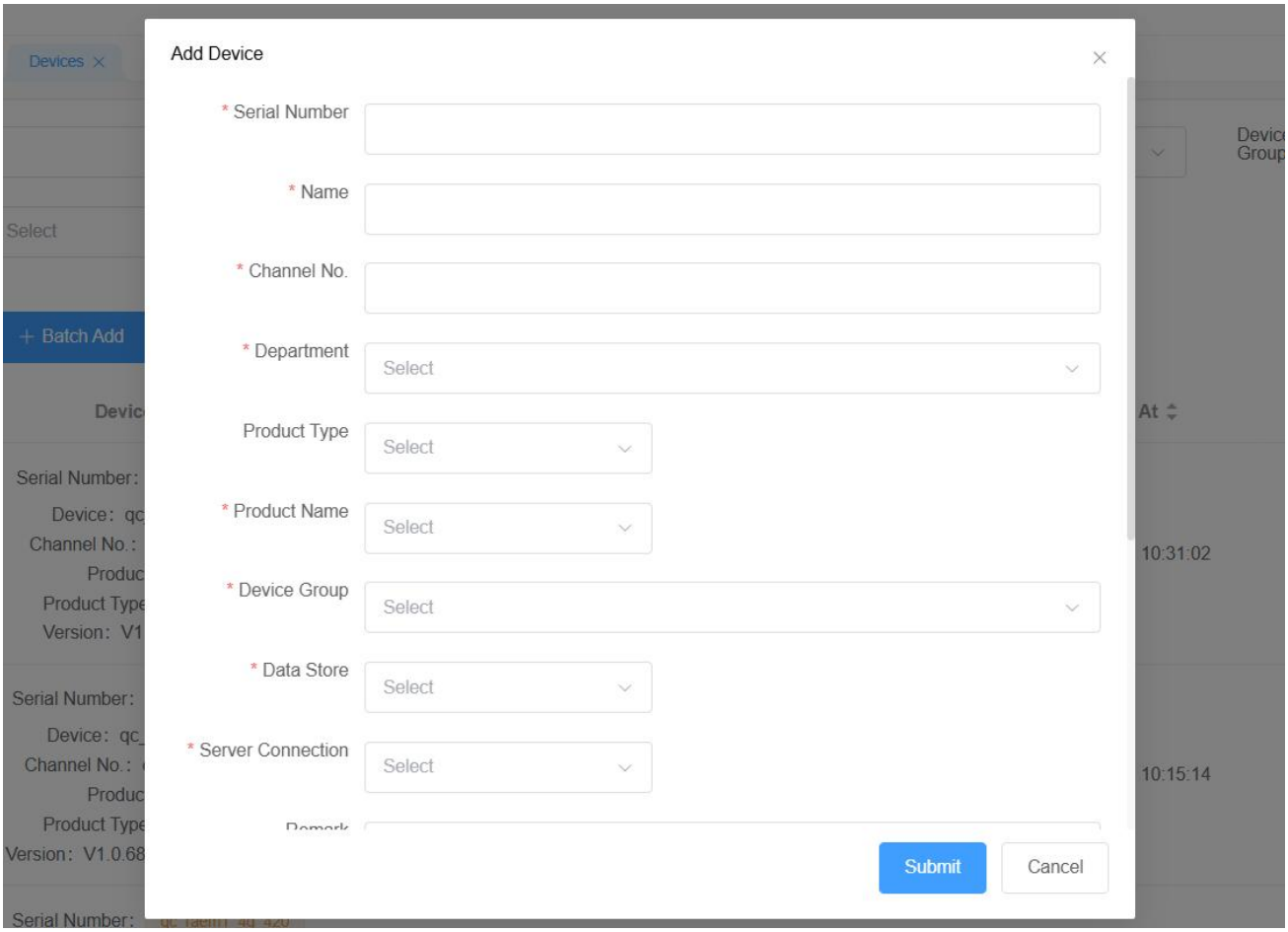


Fig. 5-10 Add Device page

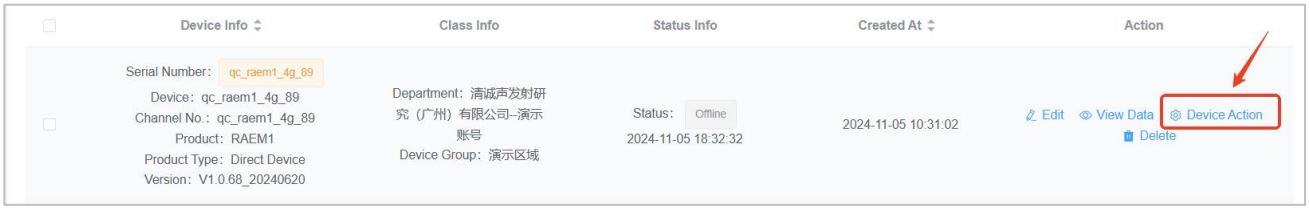


Fig. 5-11 Device Action button

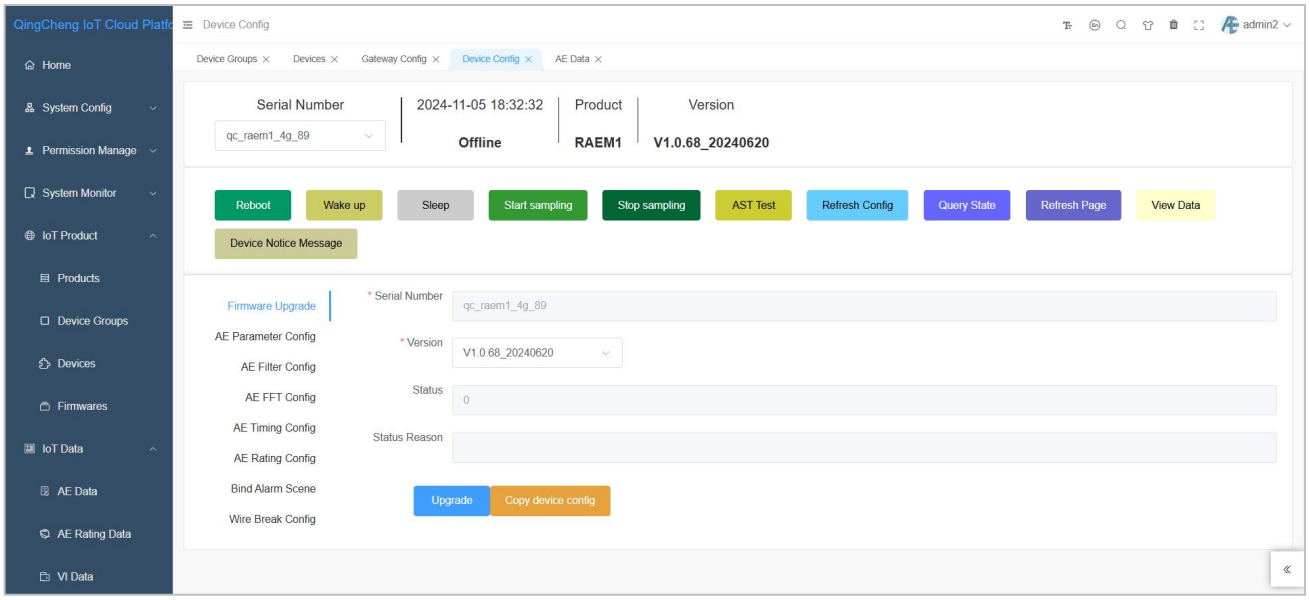


Fig. 5-12 Device Action page

5.1.2.1 AE Parameter Configuration

- **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, 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, 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 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 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 (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 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, 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 sampling mode, but not for envelope sampling mode.

➢ **Sampling times**

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

➢ **Sampling interval**

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

- **Enable sending parameters**

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

- **Enable sending waves**

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

- **System time**

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

Operation steps:

Click on '**Devices >> Device Action**' to enter the operation page.

Parameter configuration operation: Click on "**AE Parameter Config**" in the left column to enter the parameter setting page.

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.

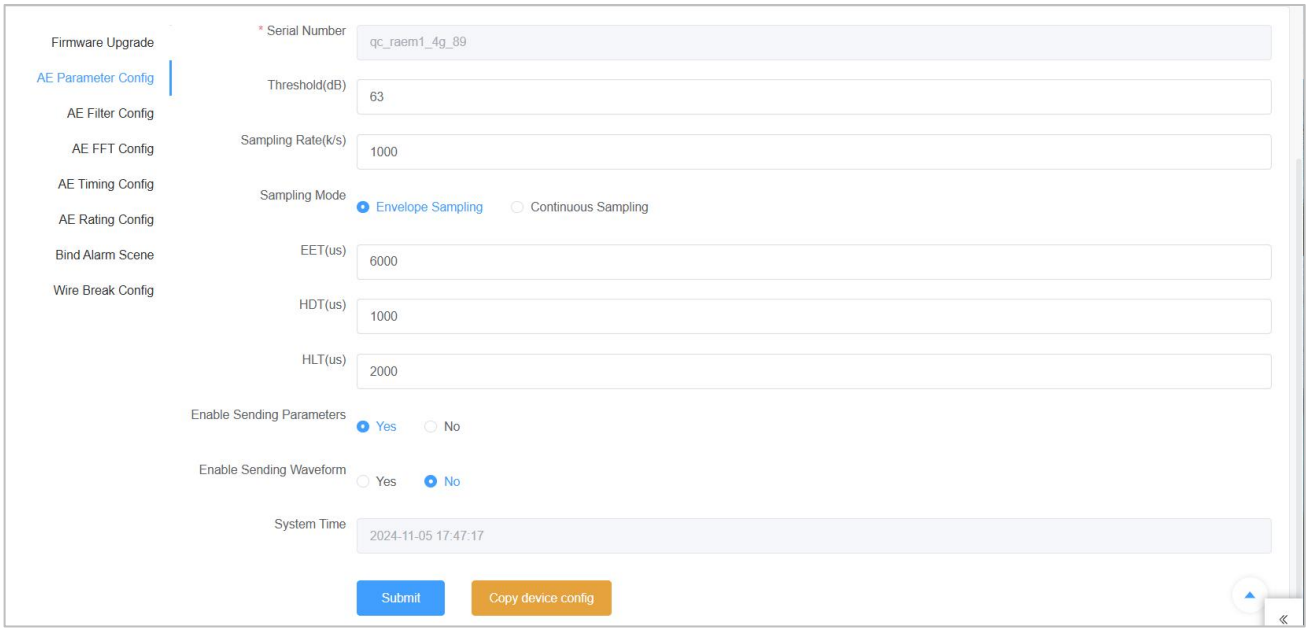


Fig. 5-13 Device Action - Parameter Config page

5.1.2.2 AE Filter Configuration

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.

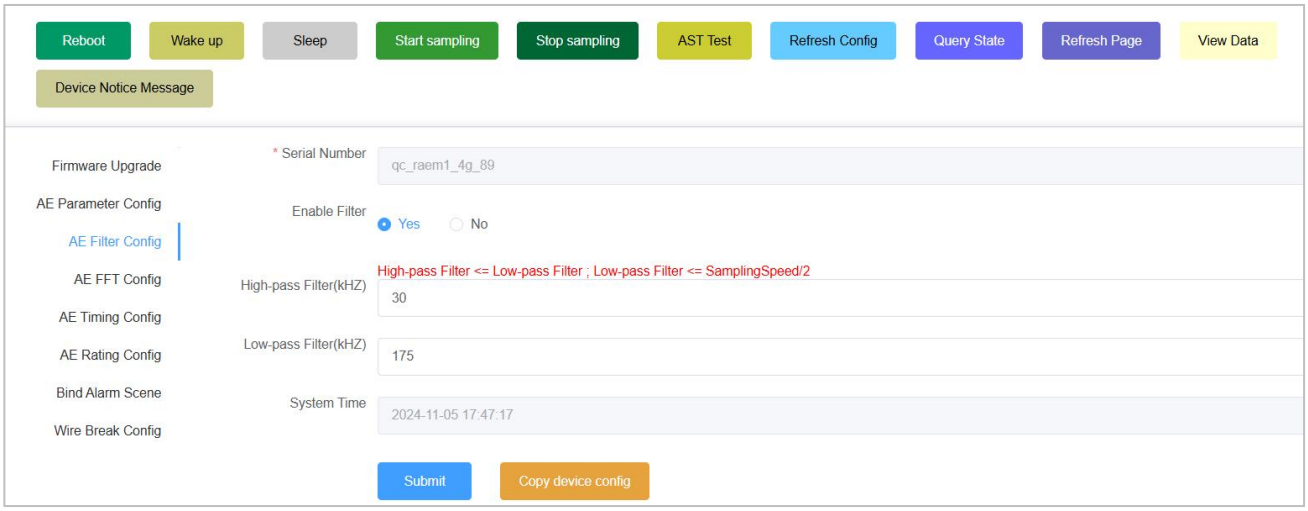


Fig. 5-14 AE Filter Config

5.1.2.3 AE FFT Configuration

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 "**Fast Input**" 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";

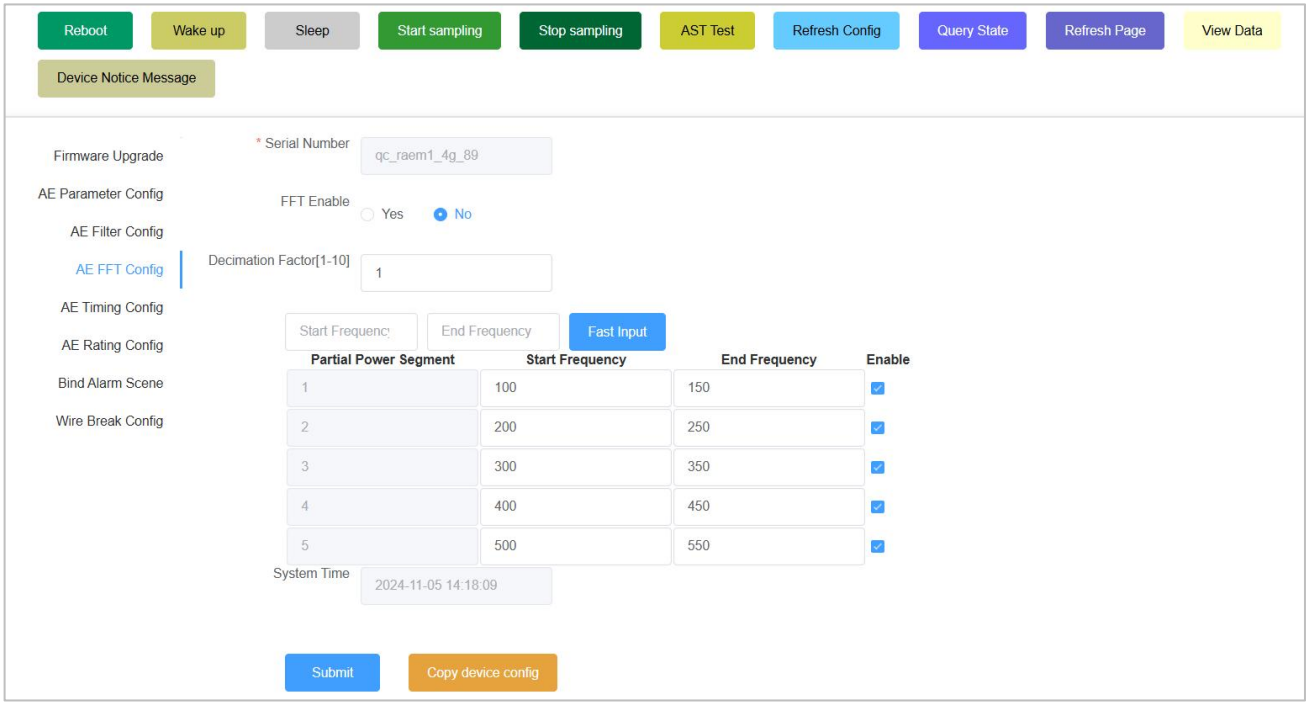


Fig. 5-15 AE FFT Config

5.1.2.4 AE Timing Configuration

You can configure timing sampling mode. By default, the sampling mode is **continuous sampling mode**. The other option is **Scheduled sampling, Interval sampling mode and trigger mode**.

The default is continuous sampling mode, which means that the acquisition is continuous and uninterrupted.

Another type is the interval sampling mode, which means that after collecting 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 the collection (in seconds). The scheduled sampling mode means collecting data according to the set envelope or continuous (parameter) method when the start time is up, and stopping the collection when the end time is up. Its minimum unit is days.

Operation steps:

Steps for timing configuration operation: Click on "**Timing Configuration**" in the left column to enter the mode modification page.

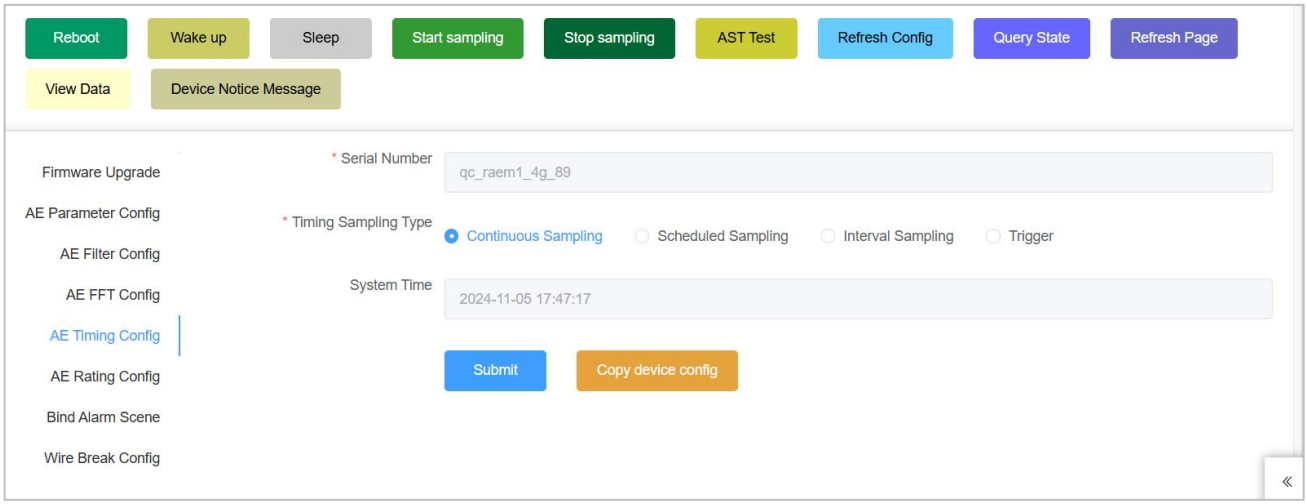


Fig. 5-16 AE Timing Config

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.

5.1.2.5 AE Rating Configuration

Rating is to evaluate the overall performance levels of the current acoustic emission events according to the defined rating rules, 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 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 5-1 Rating level standards

- **Enable rating**

Whether the rating function is enabled.

- **Intensity config**

If a comprehensive rating is required, the intensity should not exceed 3 levels. Click **Add intensity** to add an intensity level. Under the same intensity level, you can add multiple rules. The relationship between different rules of the same intensity level is **OR** condition. That is, if one of the rules is met, the intensity of this level is reached. In the same rule, add one or more parameters as the intensity level conditions. The relation of all these parameters under the same rule is **AND** condition. That is, the rule can be considered as reached only when every parameter condition in this rule is met. For example, the intensity level 1 has two rules. Rule 1 is when the amplitude (AMP) exceeds 70dB and 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 after the first alarm is reported. However, if an intensity higher than this level occurs within that period, the system will also report an alarm. The default value is 10 seconds.

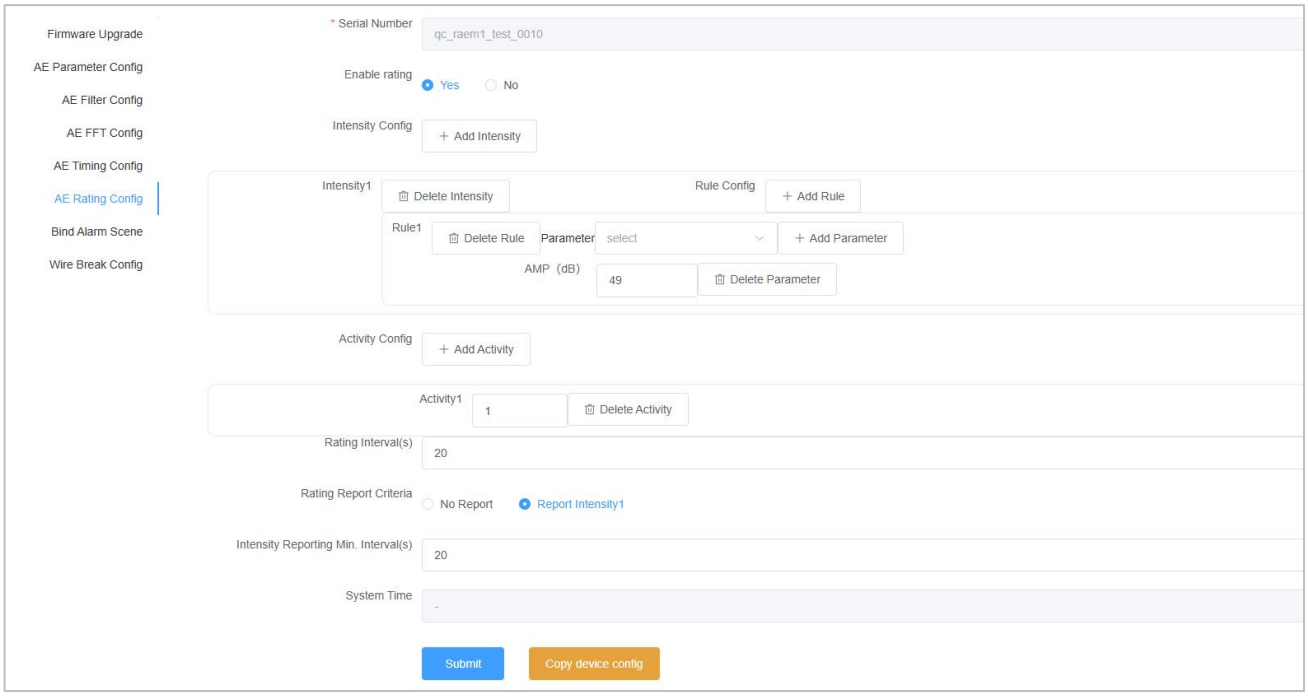


Fig. 5-17 AE Rating Config

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.

5.2 IoT Data

5.2.1 AE Data

The **IoT Data** page displays the correlation graph of the selected parameters changes of the devices over time. You can click **IoT Data > AE Data** on the left menu bar or click **IoT Product > Devices > View Data** to enter the **AE Data** page. The graphs are the correlation graphs of each parameters and time by default.

- **Product:** select the product type of the device.
- **Device:** select one or multiple the serial number of the devices to display.

- **Parameters:** select one or multiple parameters to display the correlation graphs between the selected parameters and time. The optional parameters include amplitude [dB], ASL (average signal level [dB]), Power (energy [KpJ]), duration [μs], counts, rise time [μs], RMS (effective voltage value [mV]), rise counts, peak frequency [KHz], centroid frequency [KHz], and five partial power spectrum segments.
- **Created At**: you can choose a time slot of data for display, such as today, yesterday, the last 10 minutes, last hour, last week, last month, three months or last year or any set amount period.

(1) Data viewing

[Product] Select "RAEM1", **[Device Number]** Select according to the actual device number, **[Creation Time]** Users can choose according to their needs. After setting up, click on '**Search**' to update the chart display. When the mouse moves over the icon, the readings and time of the parameters corresponding to the horizontal and vertical coordinate points will be displayed.

Or simply click on '**View Data**' on the '**Device Configuration Page**'.

Fig. 5-18 AE Data page

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. In 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.

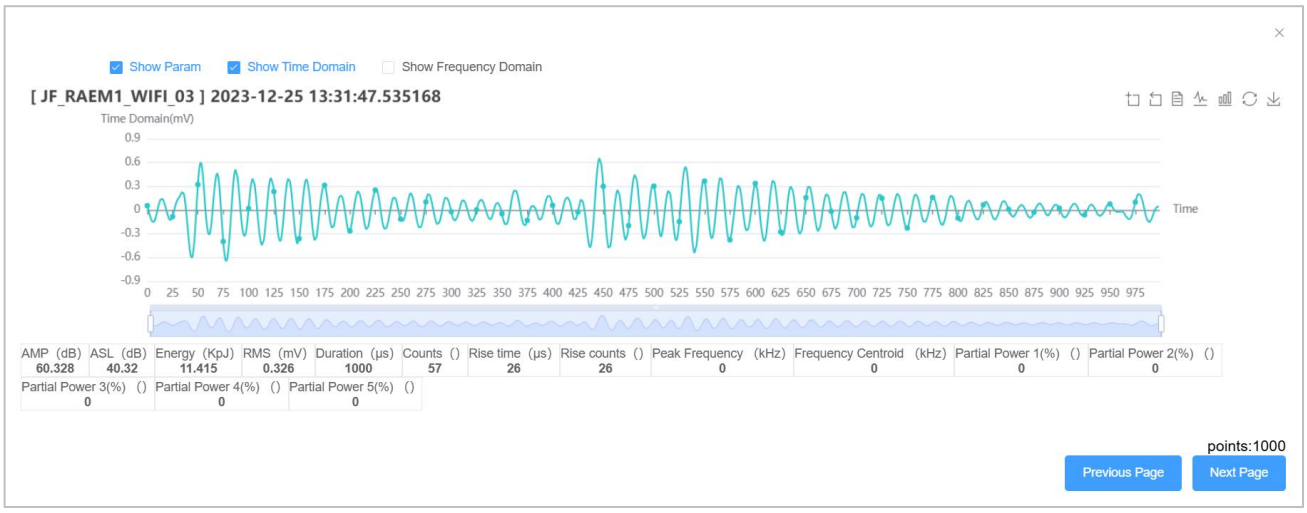


Fig. 5-19 Waveform page from the AE Data

Fig. 5-20 Graph function buttons

The buttons in the upper right corner in both parameter graphs and waveform graphs are the functions to modify the graphs, which are Regional Zoom In, Regional Zoom Out, Data Table, Line Chart, Bar Chart, Restore, and Save as Image.

- **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**:
- **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.

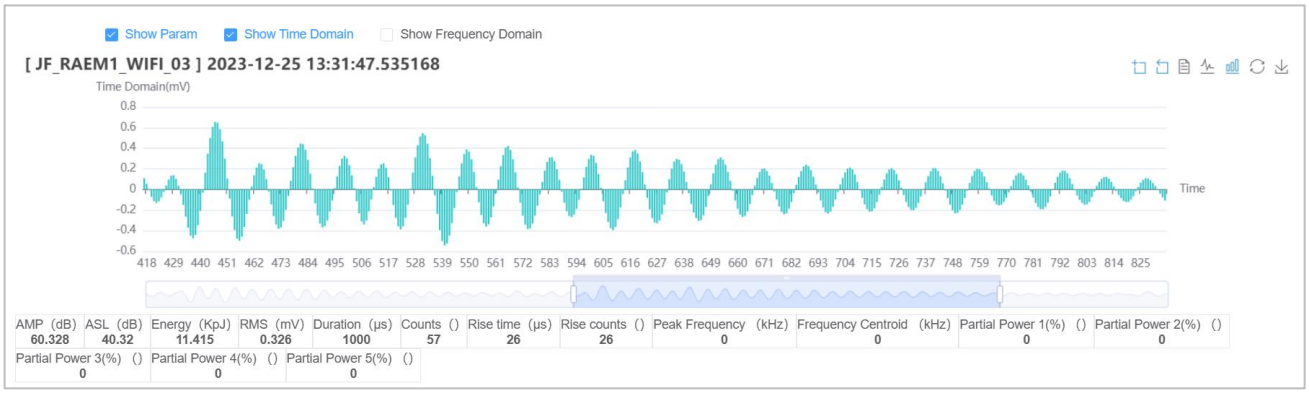


Fig. 5-21 Waveform page switch to bar chart

(2) Data Download Procedure

- **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.

Click **Download** to open the page.

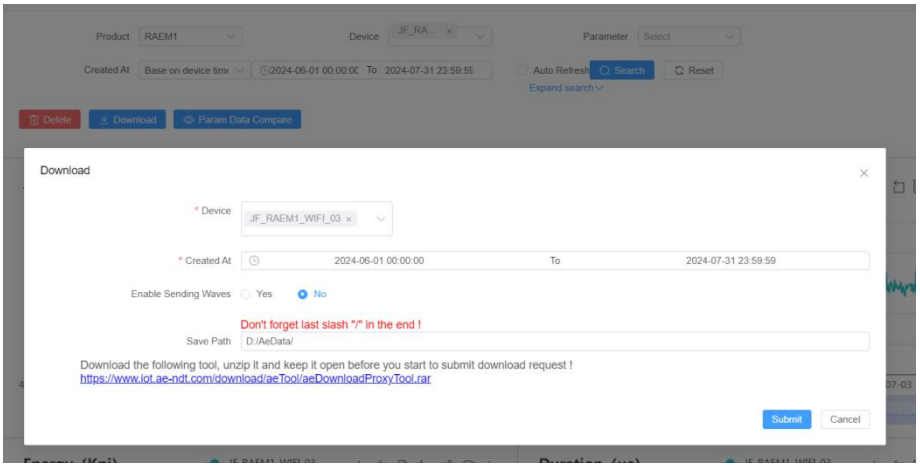


Fig. 5-22 AE data download page

Download and decompress the compressed file, run the **aeDownloadProxyTool.exe**, select **Device** and **Created time**, if you want to download the waveform data, you need to select **Yes** for **Enable Sending Waves**, and click **Submit** after the setting is complete.

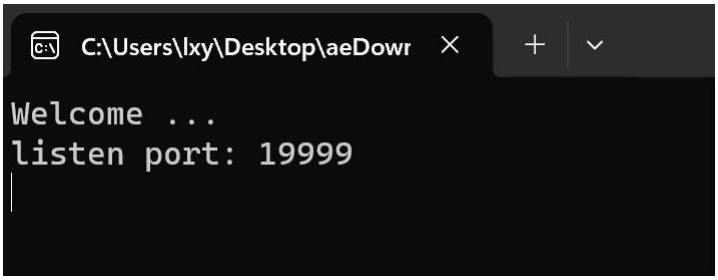


Fig. 5-23 AE Download Proxy Tool window

After submission, when the running Tool window displays **download finish!!!**, data download is complete.

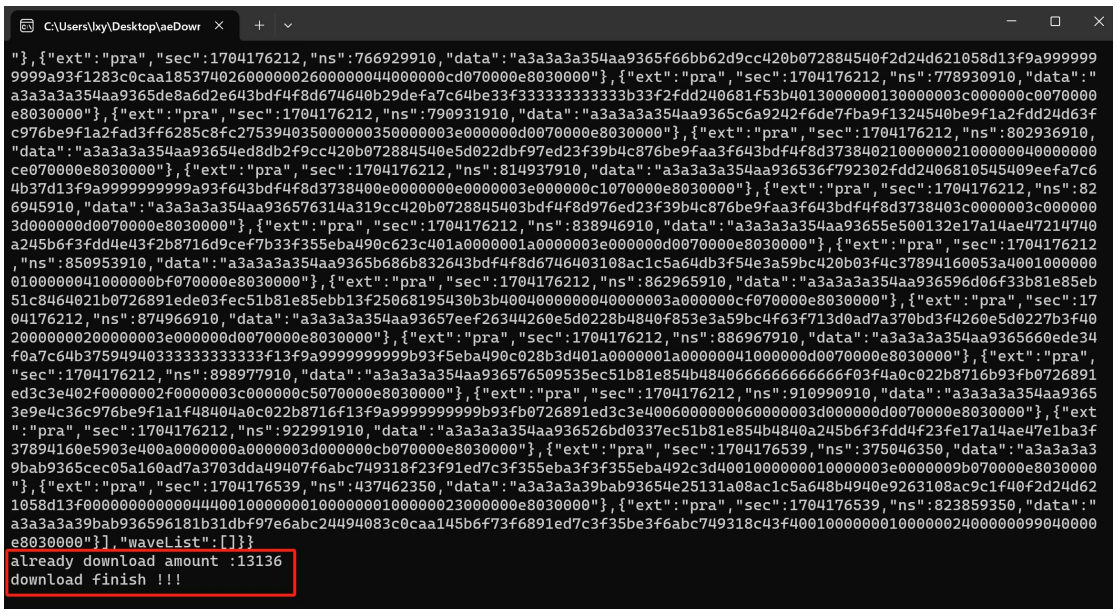


Fig. 5-24 AE data download finish window

After the download is complete, you can view the downloaded data in the save directory.

Attention:

The save directory is D:/AeData/ (The file save path can be changed). The data is stored in a subfolder under this directory. The subfolder name is the time when data is downloaded.

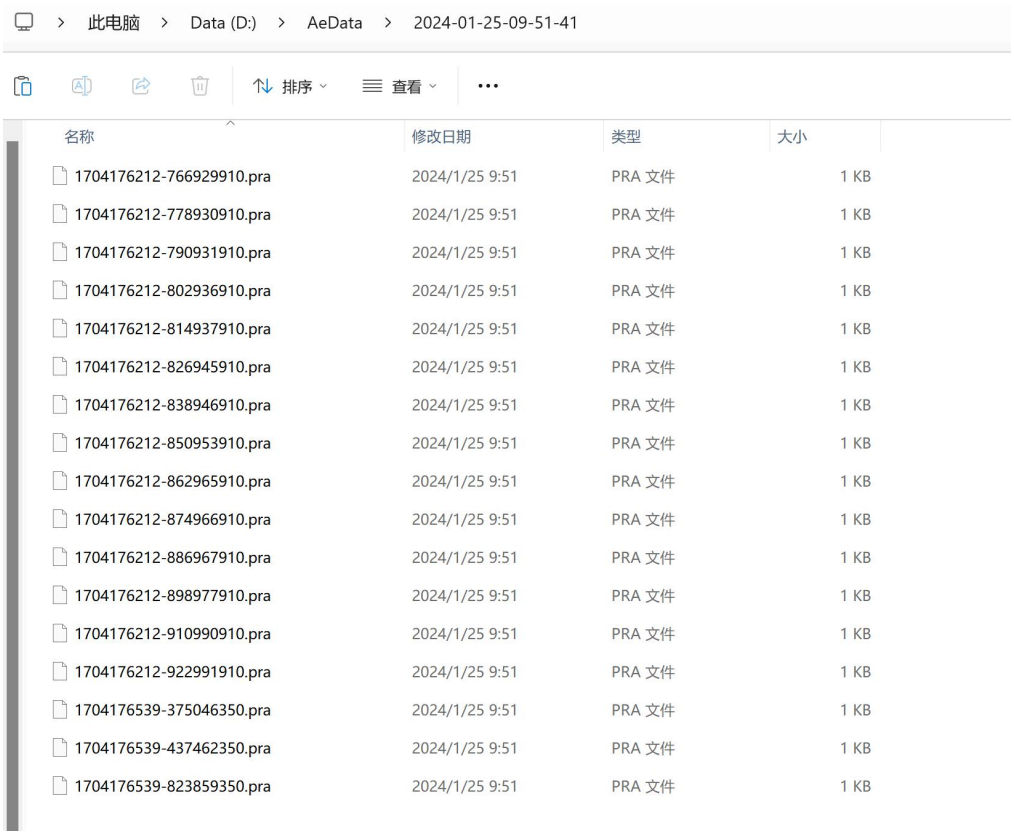


Fig. 5-25 Downloaded file

Data format conversion operation:

For specific steps, please refer to the **RAE1toU3H** software conversion in **Section 9**.

Data replay operation:

Open SWAE Software and check whether to support RAEM1 devices.

Click **Data Replay**, and then click **Replay Settings**, and select the data file to be replayed. Data files mainly include waveform files whose suffix is **.aed** and parameter files whose suffix is **.pra**. To improve data replay speed and efficiency, you can select only the parameter file (.pra) for replay.

① By default, parameter and waveform are selected, and the type of data replay can be modified as required. When both of them are selected, the parameter file and waveform file will be replayed at the same time.

Note: If **Waveform to parameter** is selected, a new parameter file will be automatically generated when the waveform is replayed.

② Set replay speed (FPS), the maximum value could be 100000, click **OK** after setting.

③ Click **Replay**.

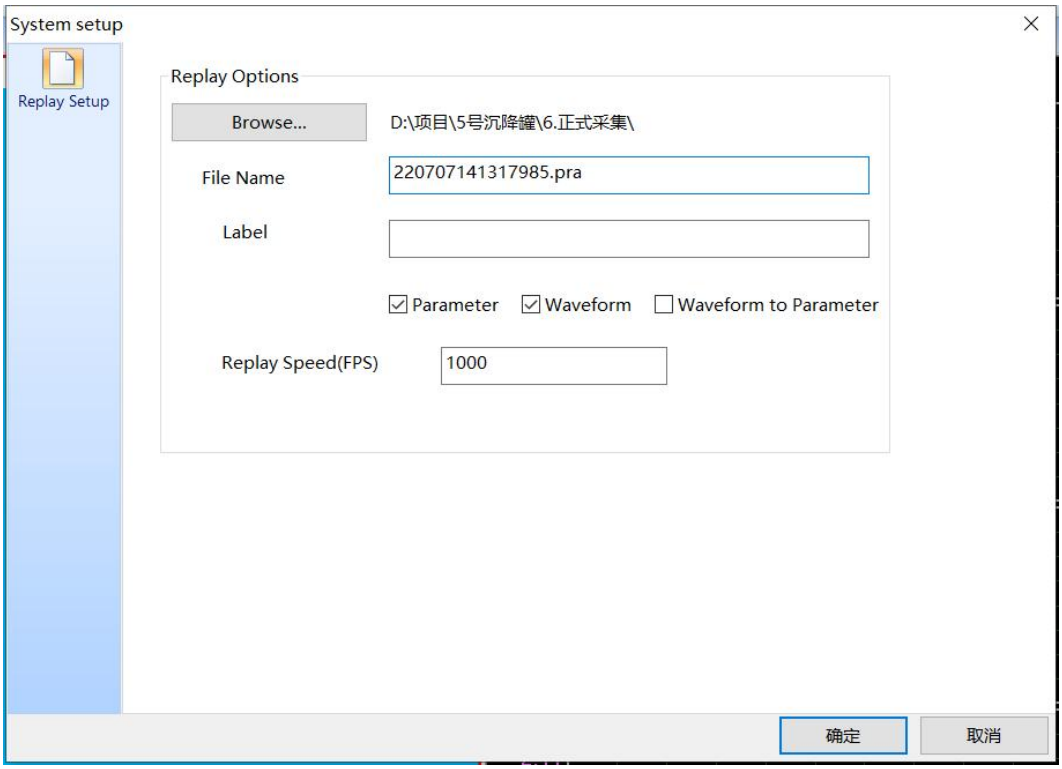


Fig. 5-26 AE data replay setting window

(3) Data deletion operation

Click **AE Data**, select the **Product, Device, Created time,** click **Delete**, then you can delete the data of the selected device during this period.

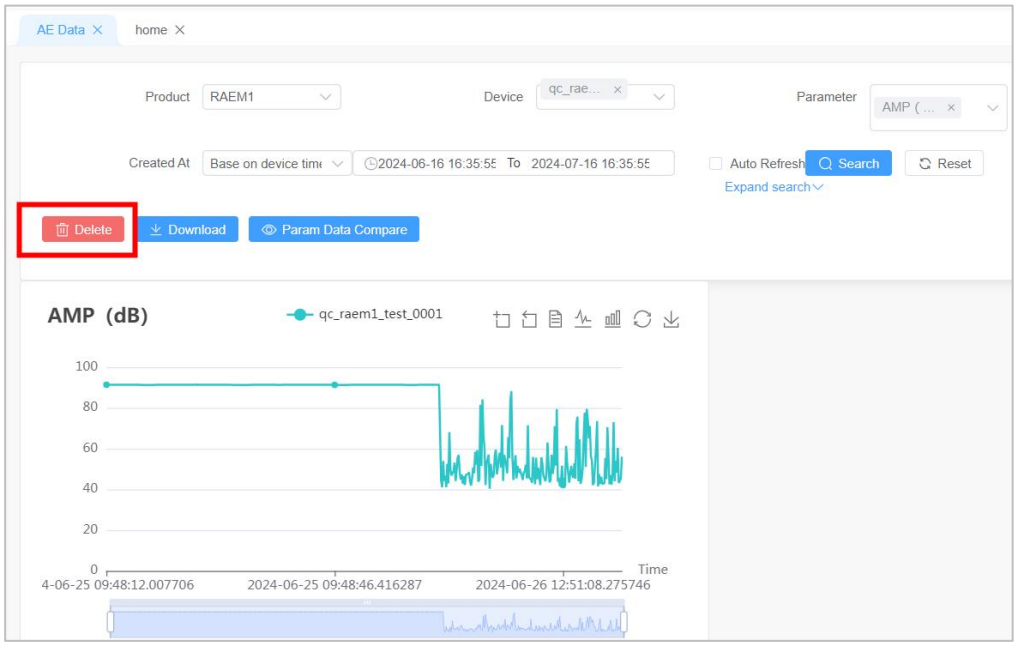


Fig. 5-27 AE data delete window

5.2.2 AE Rating Data

Users need to firstly **enable AE rating** function in the **Devices > Device Action > AE Rating Config** in Section 5.1.2.5, and **set up related rating rules and levels**. The device will then obtain a rating result after the set time, and the data will be displayed on the relevant page.

Rating results view operation: **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]** to update the data display.

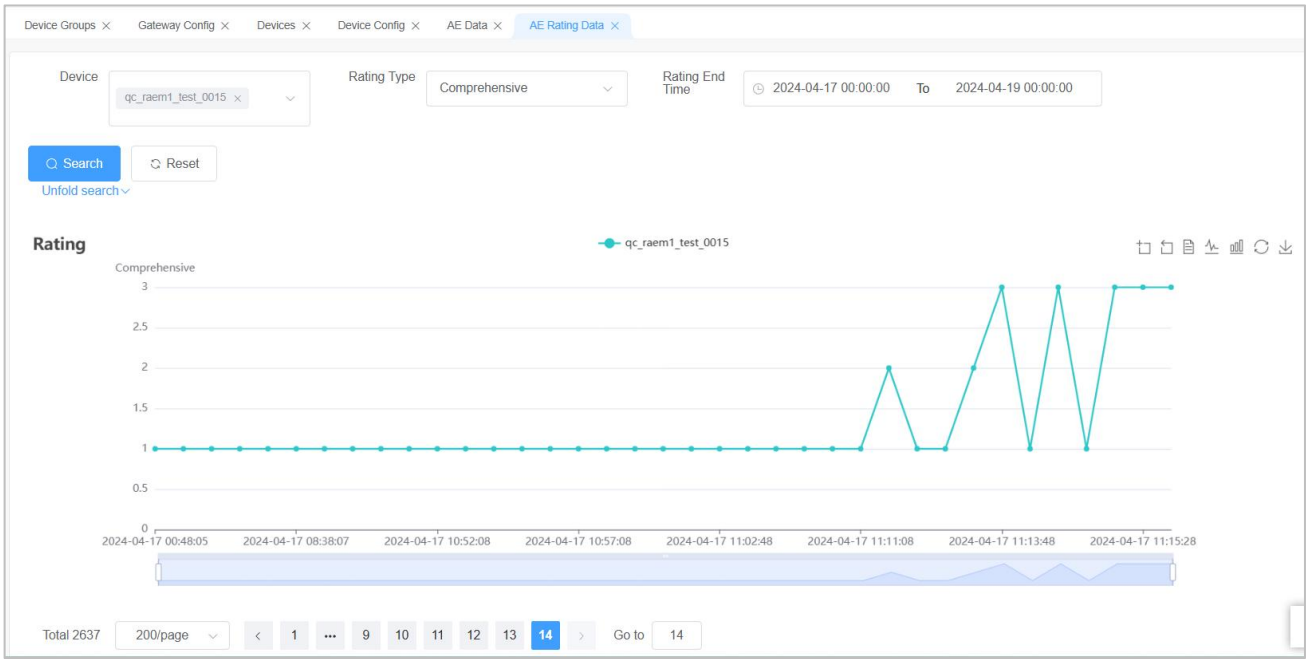


Fig. 5-28 AE Rating Data window

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

+ Add Graph: Add additional correlation graph;

Save Settings: Save all existing settings, including devices, time frame, points, and all the correlation graphs setup.

Restore Settings: Restore all settings previously saved;

Points: The maximum number of points displayed in the relevant chart can be selected from 100, 200, 500, 1000, 2000, 5000, 10000, and 20000;

Statistics mode: There are two statistical methods to choose from: **maximum value** and **average value**;

Display mode: includes three display modes: **line, bar,** or **scatter** graphs;

[X] axis: The X-axis parameters include arrival time, amplitude (AMP) (dB), ASL (dB), energy (KpJ), RMS (mV), duration (us), counts, rise time (us), rise counts, peak frequency (KHz), centroid frequency (KHz), and 5 partial power spectrum segments;

[X] Range: Optional **[X] Custom** or **[X] Auto**;

- **[X] Custom**: Filter out values that are not within this range based on the maximum and minimum values entered by the user;
- **[X] Auto**: The coordinate display range of the relevant graph will be automatically adjusted according to the data distribution situation;

[Y] axis: The Y-axis parameters include amplitude (AMP) (dB), ASL (dB), energy (KpJ), RMS (mV), duration (us), counts, rise time (us), rise counts, peak frequency (KHz), centroid frequency (KHz), and 5 partial power spectrum segments;

[Y] Range: Optional **[Y] Custom** or **[Y] Auto**;

- **[Y] Custom**: Filter out values that are not within this range based on the maximum and minimum values entered by the user;
- **[Y] Auto**: The coordinate display range of the relevant graph will be automatically adjusted according to the data distribution situation.

Operation steps:

Select **[Product]** and **[Device]** → Select the time frame **[Created At]** → Select **[Points]** → **[Add Graph]** if needed. Select **[Statistics Mode]** according to specific needs → Select **[Display Mode]** → select **[X] axis** parameter → select **[X] Range**. select **[Y] axis** parameter → select **[Y] Range**. → After finish settings, click **[Start Statistics]** to obtain and display data. If you want to save and restore all these settings later, click **[Save**

Settings] to save and click **[Restore Settings]** to restore.

Fig. 5-29 Correlogram

5.3 Alarms

5.3.1 Alarm Users

The **[Alarm Users]** is used to set up alarm notification output settings. When an alarm is triggered, information will be sent to the preset phone or email.

Click **[Alarms]** → **[Alarm Users]**. Click **[+Add]** to add user's contact and fill in the information.

- **Contact (Required)**: Name of the user.
- **Department (Required)**: Select the department of the new user.
- **Language**: Choose between Chinese or English.
- **Phone (Required)**: The phone number for alarm notifications.
- **Email**: The email address for receiving alarm notifications.
- **Receive Freq (Required)**: (Note: The notification frequency is determined by the higher value between the frequency set in the alarm scenario and the frequency set by the alarm user).

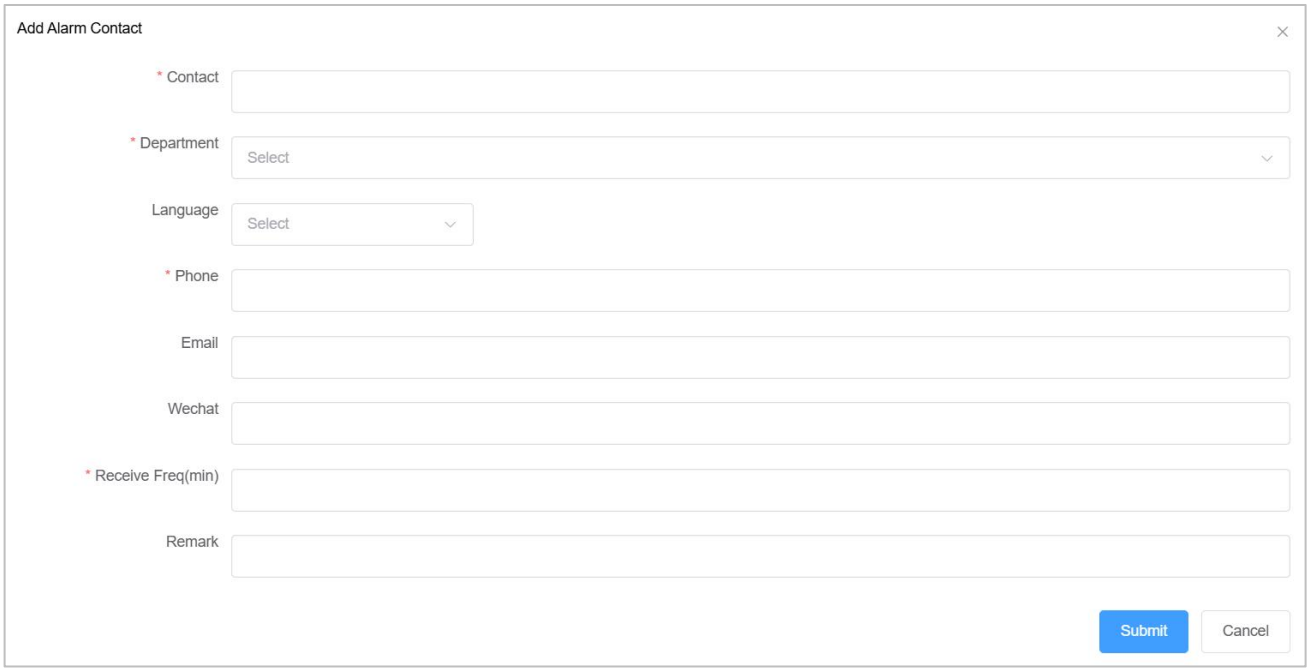


Fig. 5-30 Add new alarm user

- **Bind Alarm Scene: Bind user with alarm scene.**

Fig. 5-31 Bind user with alarm scene

5.3.2 Alarm Scenario

Alarm Scenario: This page is used for users to customize alarm scene. For example, in the application of monitoring wire breakage in bridge cables, the scene can be customized as **Wire Break Monitoring.**

Click **[Alarms]** → **[Alarm Scenario]**. Click **[+Add]** to set up the alarm scene.

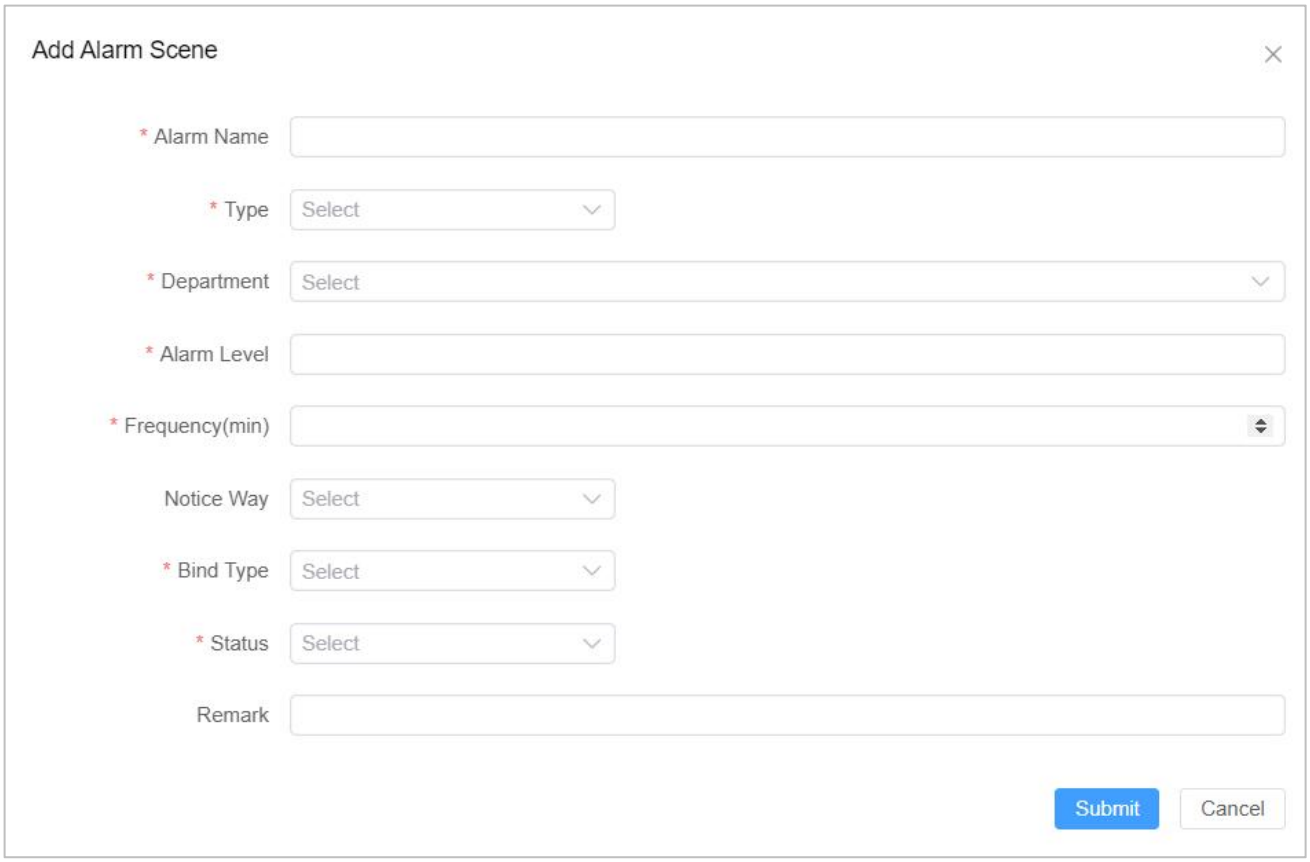


Fig. 5-32 Add new alarm scene page

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: bind alert users;

Fig. 5-33 Bind scene with contact

Bind Device: Bind to the devices that requires an alarm.

Fig. 5-34 Bind scene with device

5.3.3 User Messages

Click **[Alarms]** → **[User Messages]**, you can view the recent alarm notifications.

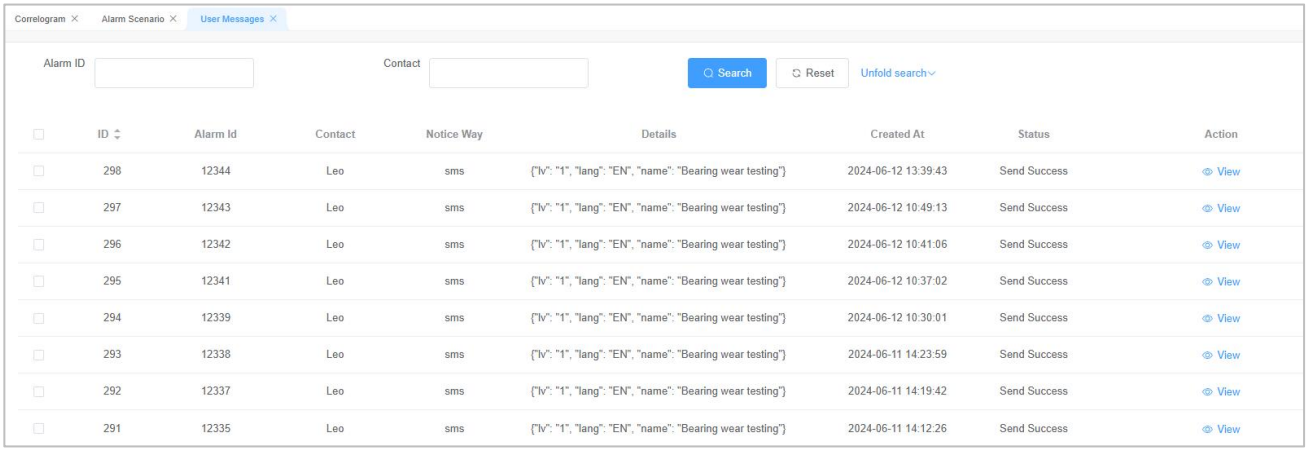


Fig. 5-35 View alarm message

Click **[View]** to navigate to the **[Alarm Log]** page to manage alarm notifications.

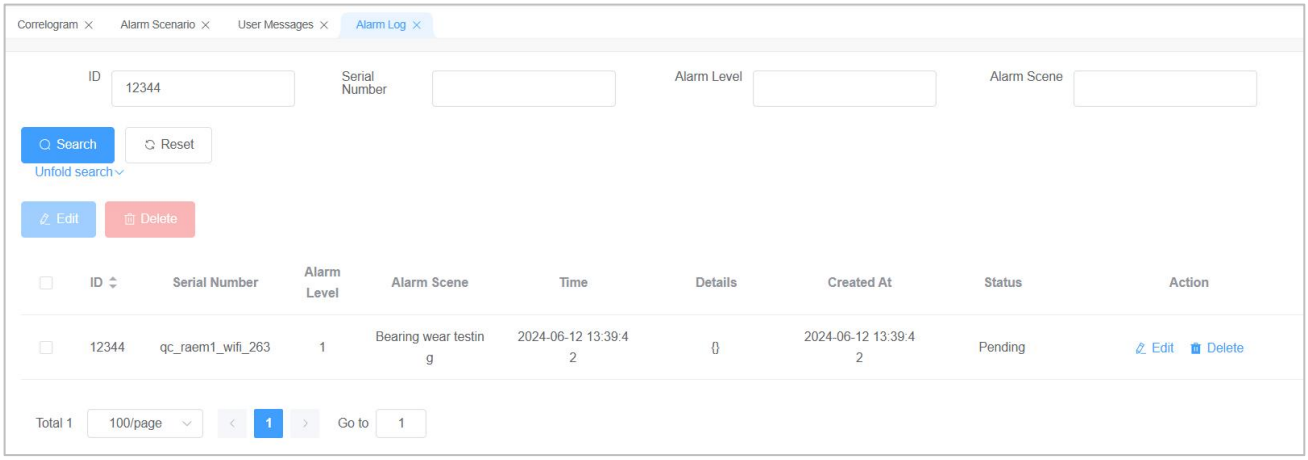


Fig. 5-36 View alarm log

Click **[Edit]** button to process the alarm message. The status can be "Pending", "Handling" and "Solved".

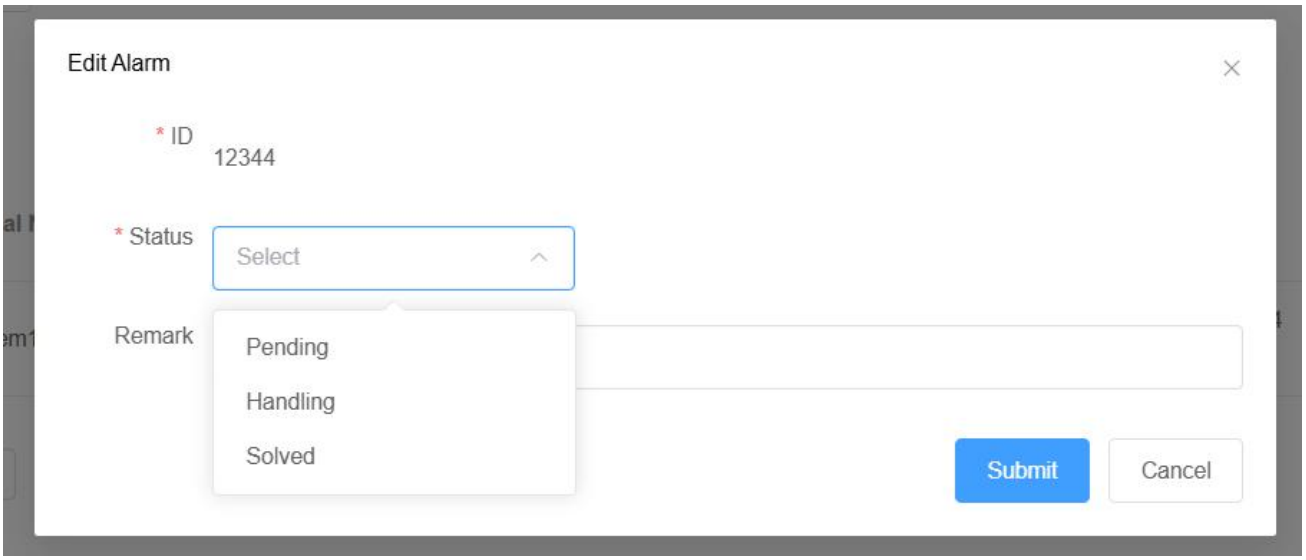


Fig. 5-37 Handle alarm page

5.4 AST Function

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: You can obtain the most recent AST results.

Time Interval (s): The interval in seconds for sending the AST test.

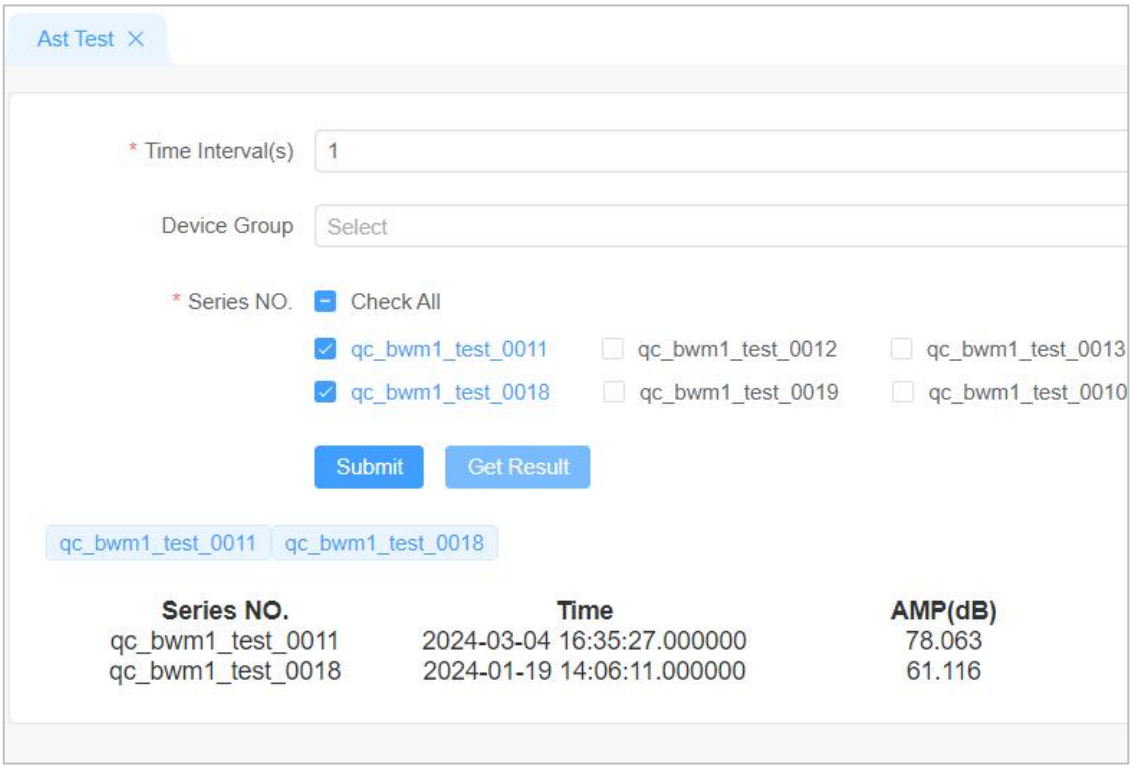


Fig. 5-38 AST page and testing results

5.5 Storage Tank Report

Click on **[IoT Application]** → **[Storage Tank]** → **[Storage Tank Report]**. Enter the tank inspection report page to set the scheduled inspection time in order to view and download the reports.

- **[Classifications]**: Users set recommended values for acoustic emission source classifications parameters based on the standard '*JB10764-2023 Non destructive Testing Atmospheric Pressure Metal Storage Tank Acoustic Emission Testing and Evaluation Method*';
- **[Add]**: add new equipment for regular tank inspection, with automatic report output upon completion of the inspection;
  - Add: Add the 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]**: to review and verify the newly issued reports, and changed the report status;
- **[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 → select **[Storage Tank Config]** after creation ;

2. Fill in basic information, sensor layout, loading sequence graph, and attenuation record. For specific operation steps, refer to Section 5.1.1;

3. **[IoT Application]** → **[Storage Tank]** → **[Storage Tank Report]** → **[Classifications]** to set the recommended values of acoustic emission source classification parameters 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]** to select the department, device group, and select devices → **[Add]** the tank inspection time (start time and end time) → **[Submit]**;

5. Waiting for the tank inspection to be completed;

6. Return to the storage tank report page, click on **[Search]** → Find the report → **[View Report]** → **[Verify]** to change the report status to "Verified" or "Pending". In the **[View Report]**, click the **[Download]** button at the bottom right corner to download the report in PDF format.

5.6 Storage Tank Data

[IoT Application] → **[Storage Tank]** → **[Storage Tank Data]** to enter the storage 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.

6. Qingcheng Alibaba Cloud Platform

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

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

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

Table 6-1 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.

6.1 Register

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

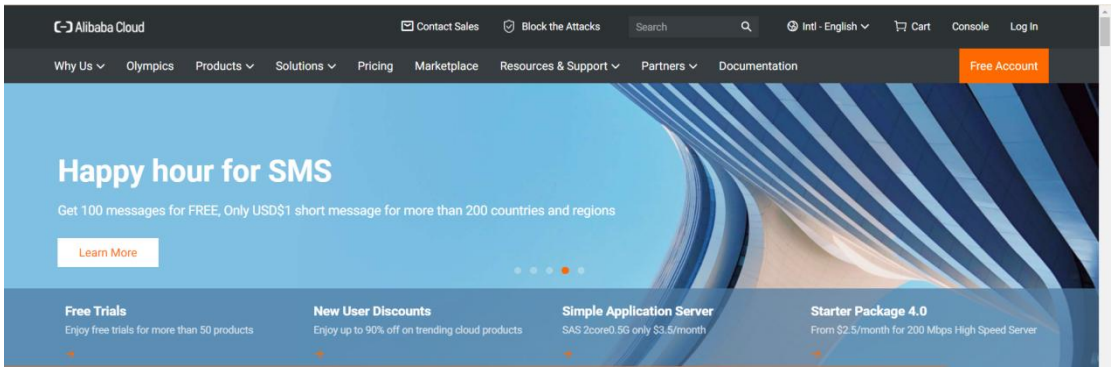


Fig. 6-1 Qingcheng Alibaba Cloud Registration

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

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

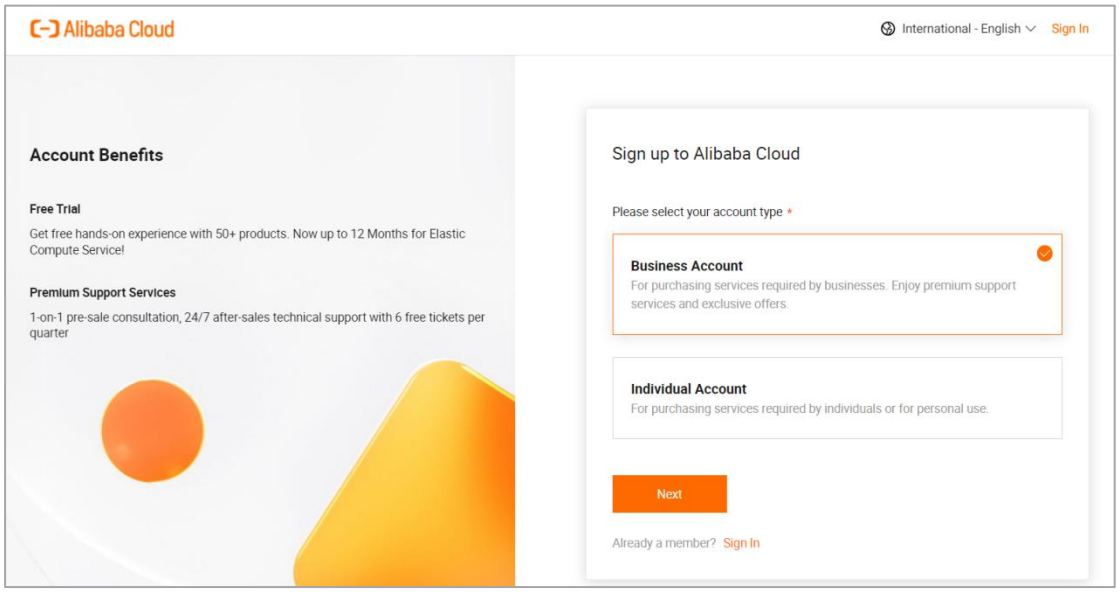


Fig. 6-2 Qingcheng Alibaba Cloud -Business Account

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 check the agreements below.

⑦ Click **Sign Up** (Step 2 of 2).

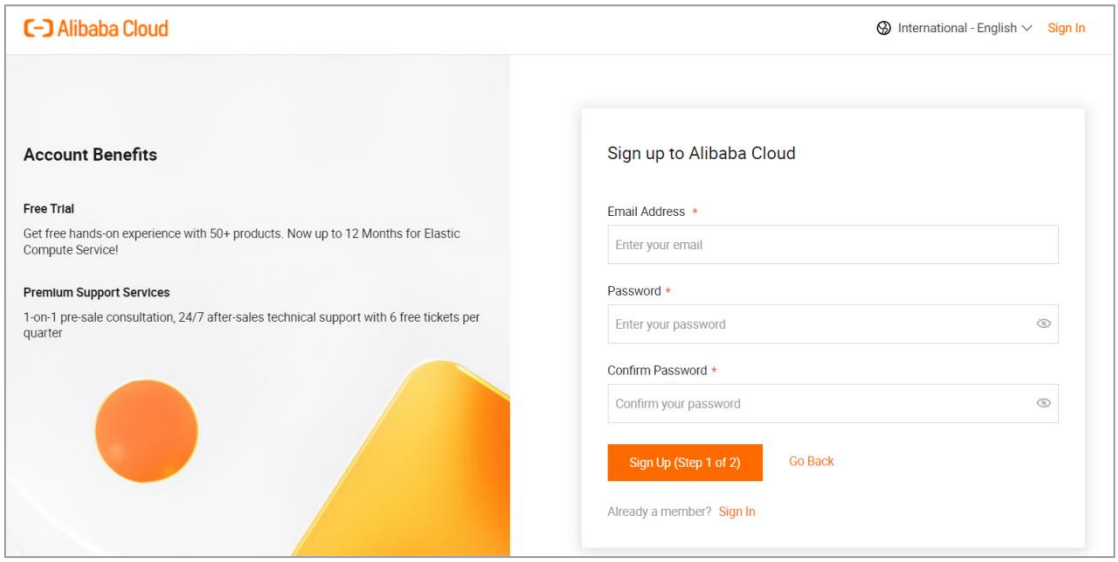


Fig. 6-3 Qingcheng Alibaba Cloud Account Info

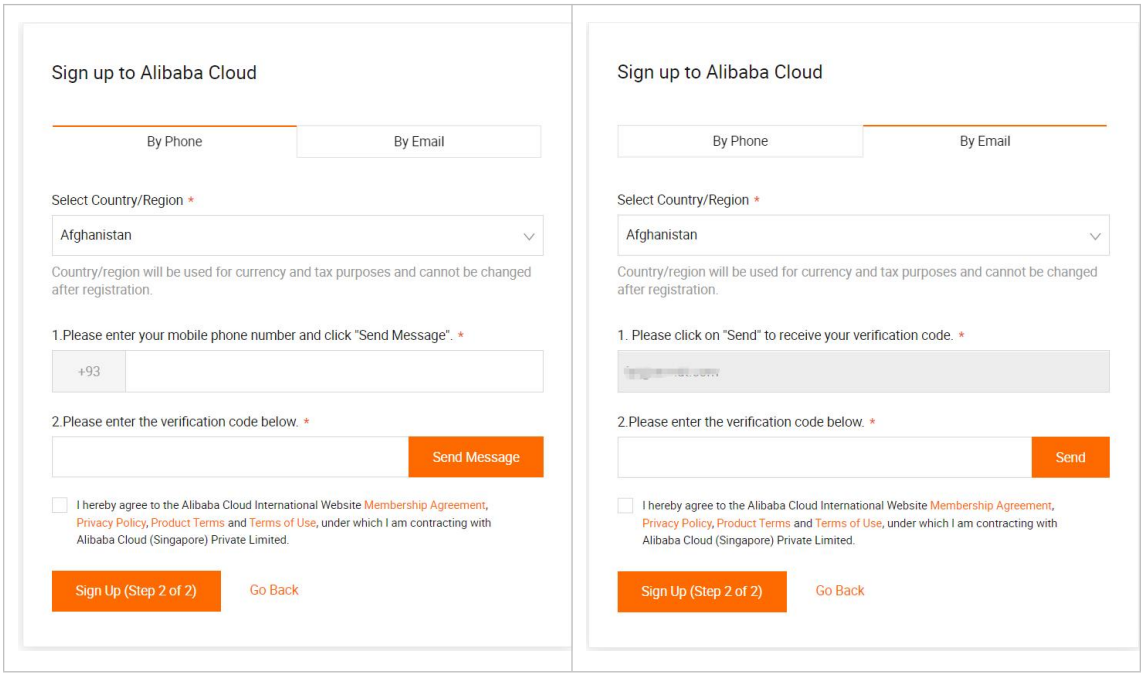


Fig. 6-4 Qingcheng Alibaba Cloud Registration Method

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

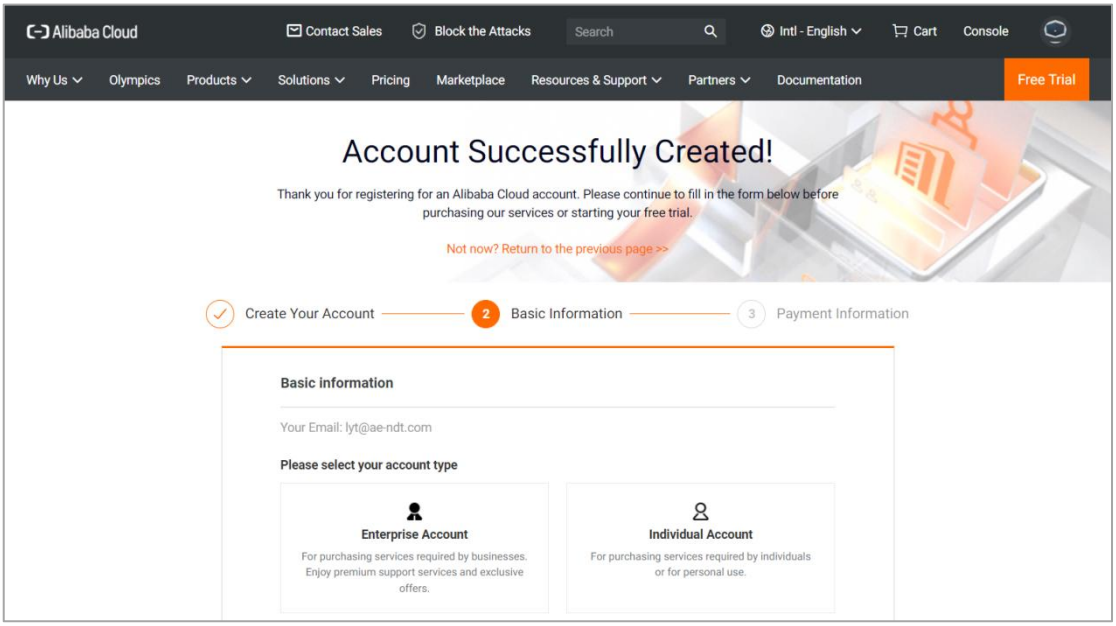


Fig. 6-5 Qingcheng Alibaba Cloud Account Created

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

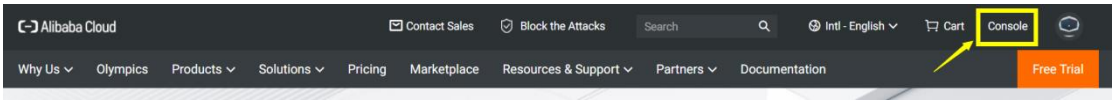


Fig. 6-6 Qingcheng Alibaba Cloud Select Console

Step 6: Click the ☰ icon at the upper left corner.

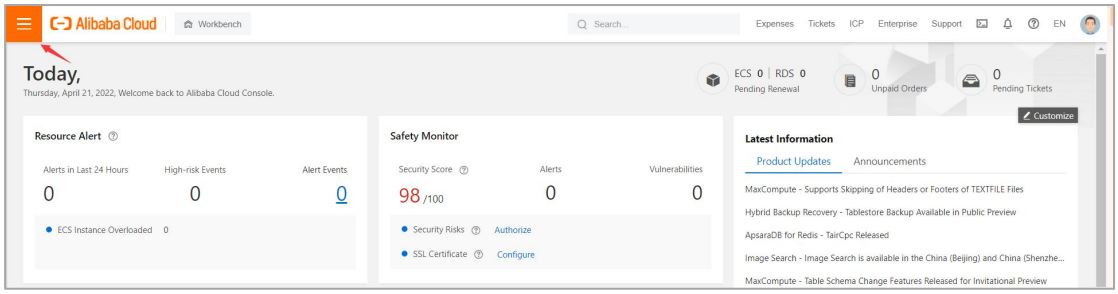


Fig. 6-7 Qingcheng Alibaba Cloud Menu Icon

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

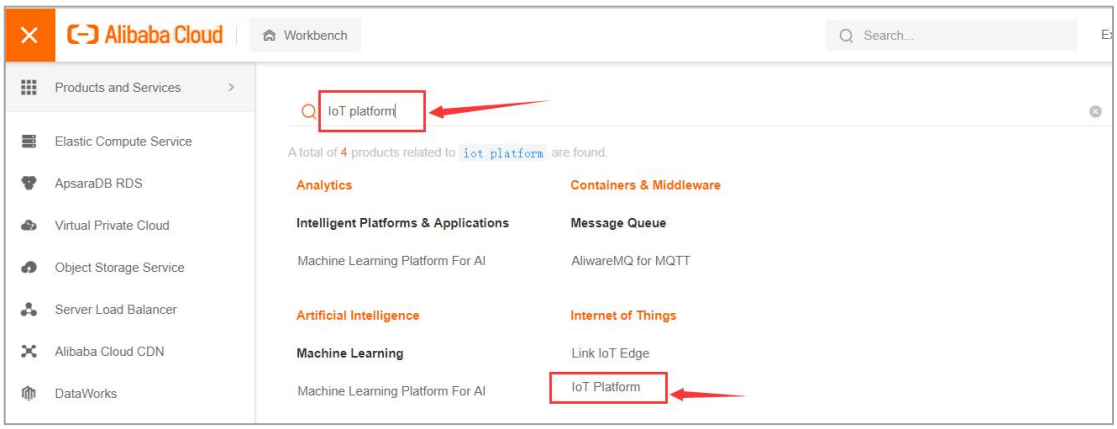


Fig. 6-8 Qingcheng Alibaba Cloud Search IoT Platform

Step 8: Activate Now.

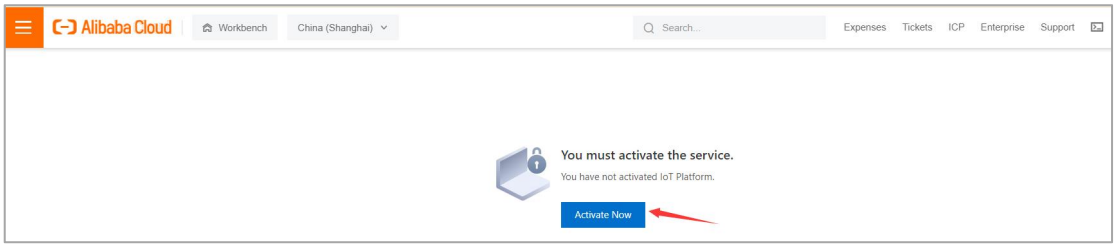


Fig. 6-9 Qingcheng Alibaba Cloud Activate IoT Platform

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.

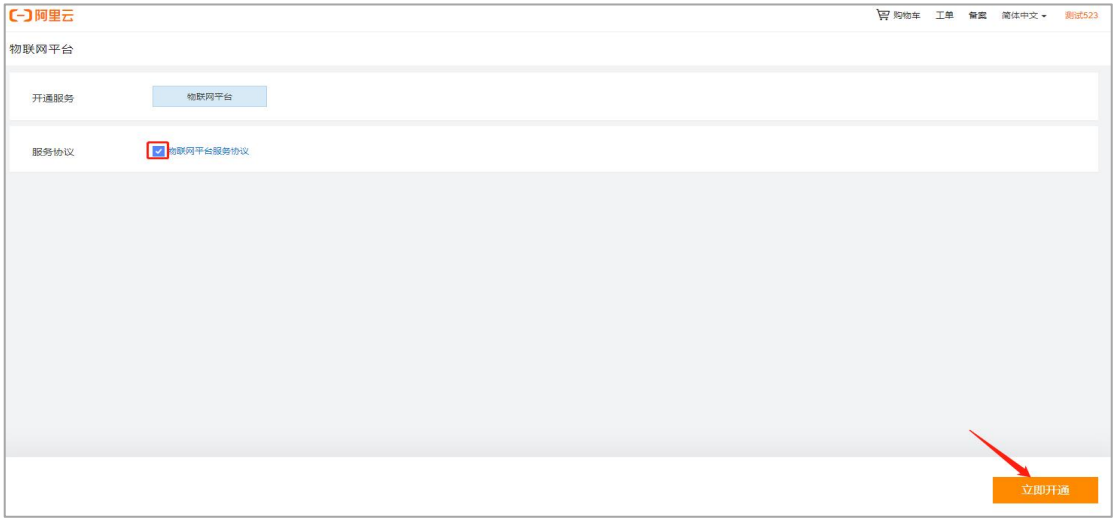


Fig. 6-10 Qingcheng Alibaba Cloud Activate Now

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

Fig. 6-11 Qingcheng Alibaba Cloud Activate Succeed

6.2 Create Product and Devices

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

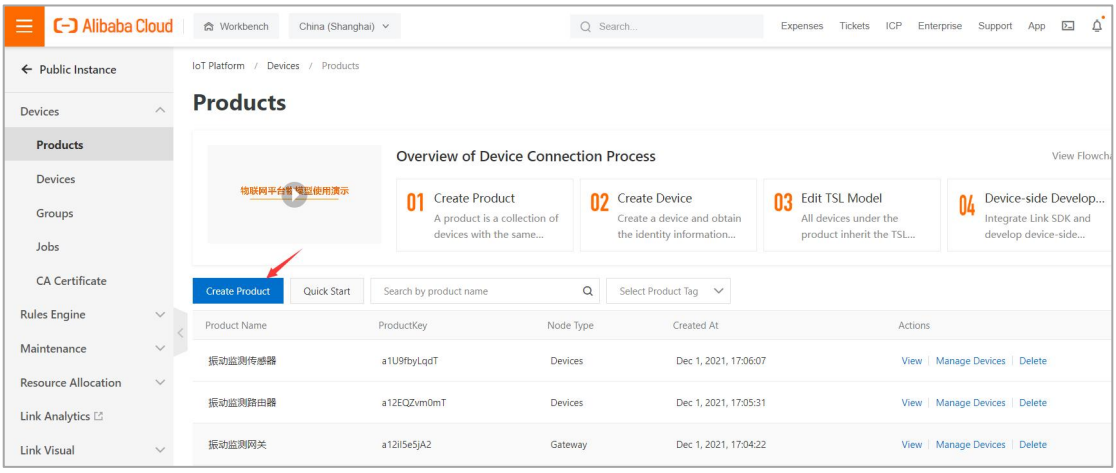


Fig. 6-12 Qingcheng Alibaba Cloud Create Product

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**.

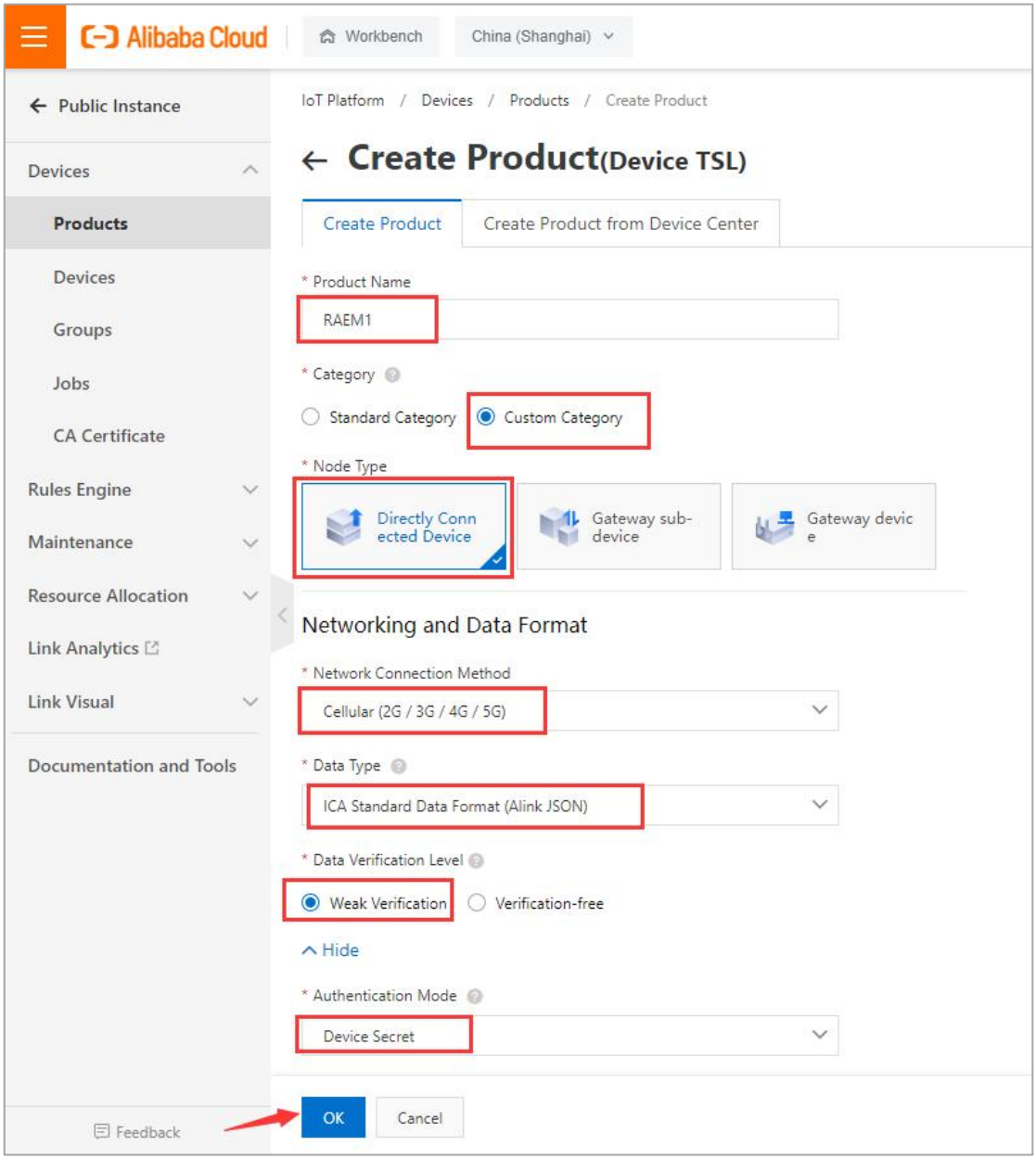


Fig. 6-13 Qingcheng Alibaba Cloud Create Product Info

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

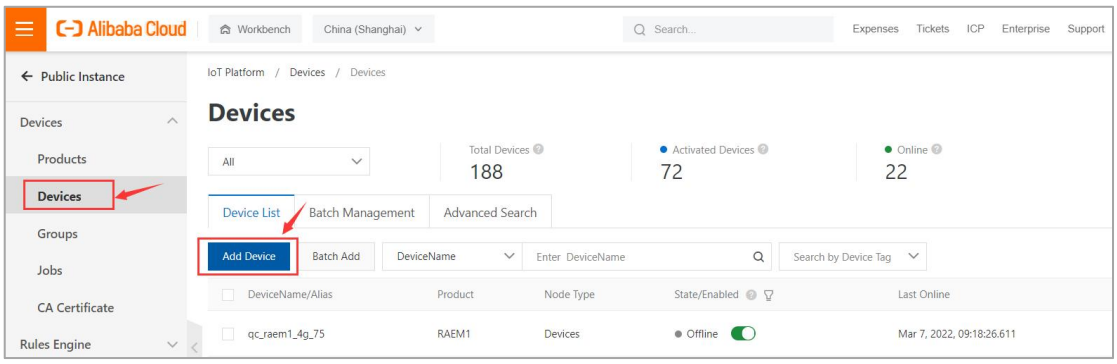


Fig. 6-14 Qingcheng Alibaba Cloud Add Device

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

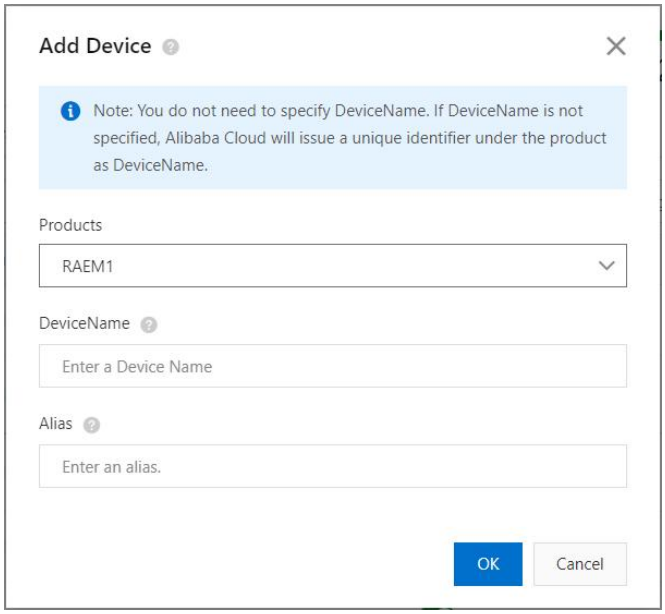


Fig. 6-15 Qingcheng Alibaba Cloud Device Info

6.3 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.

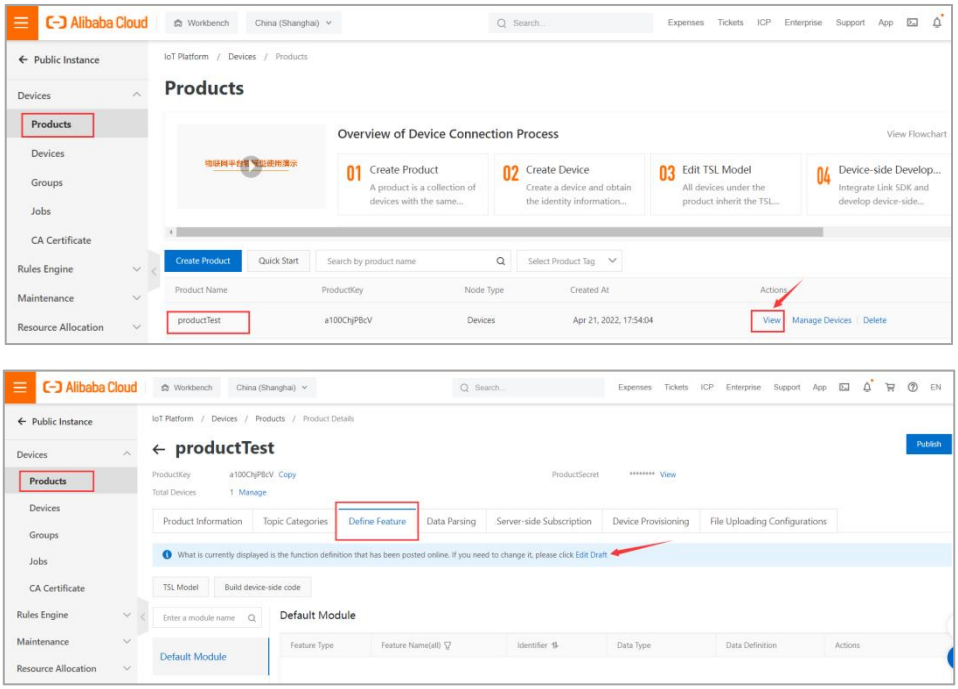


Fig. 6-16 Qingcheng Alibaba Cloud Edit Product Draft

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.

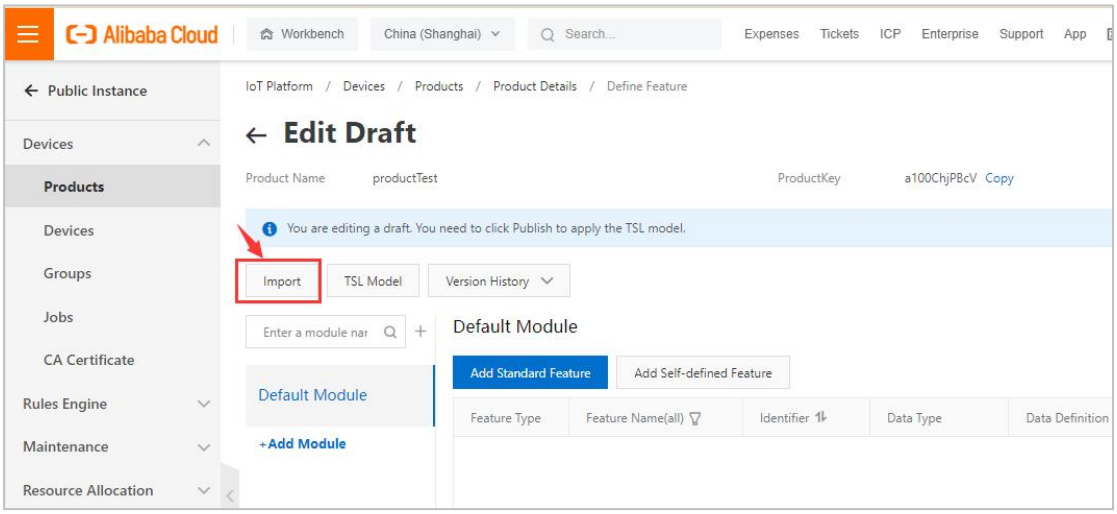


Fig. 6-17 Qingcheng Alibaba Cloud Import Model Draft

6.4 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.

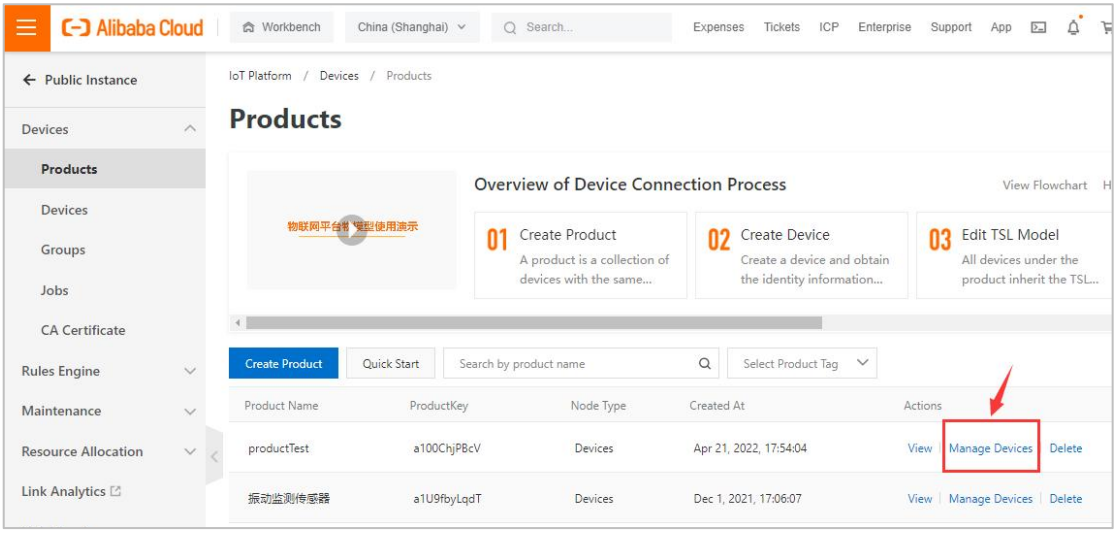


Fig. 6-18 Qingcheng Alibaba Cloud Manage Device

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

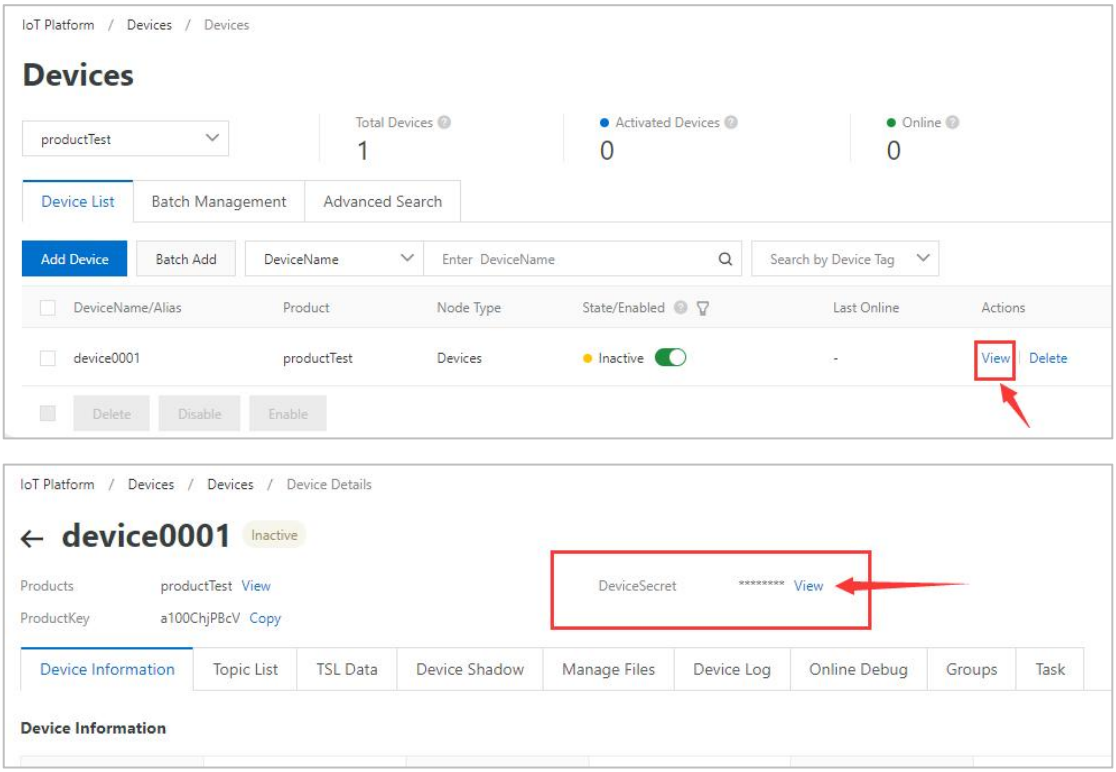


Fig. 6-19 Qingcheng Alibaba Cloud View Device Secret

Step 19: Copy the product key and device secret.

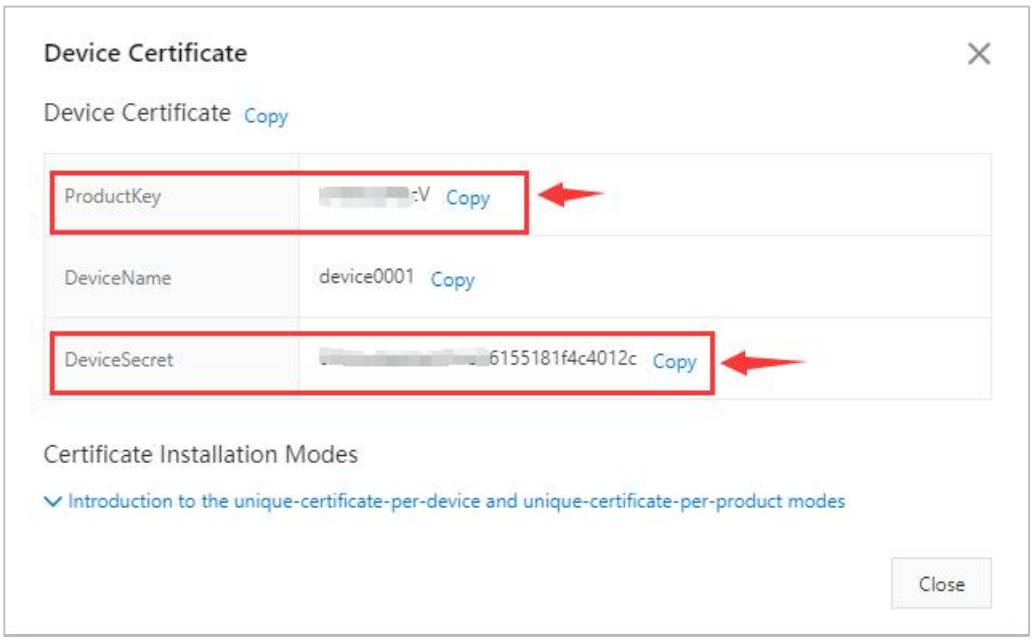


Fig. 6-20 Qingcheng Alibaba Cloud Copy Key and Secret

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.

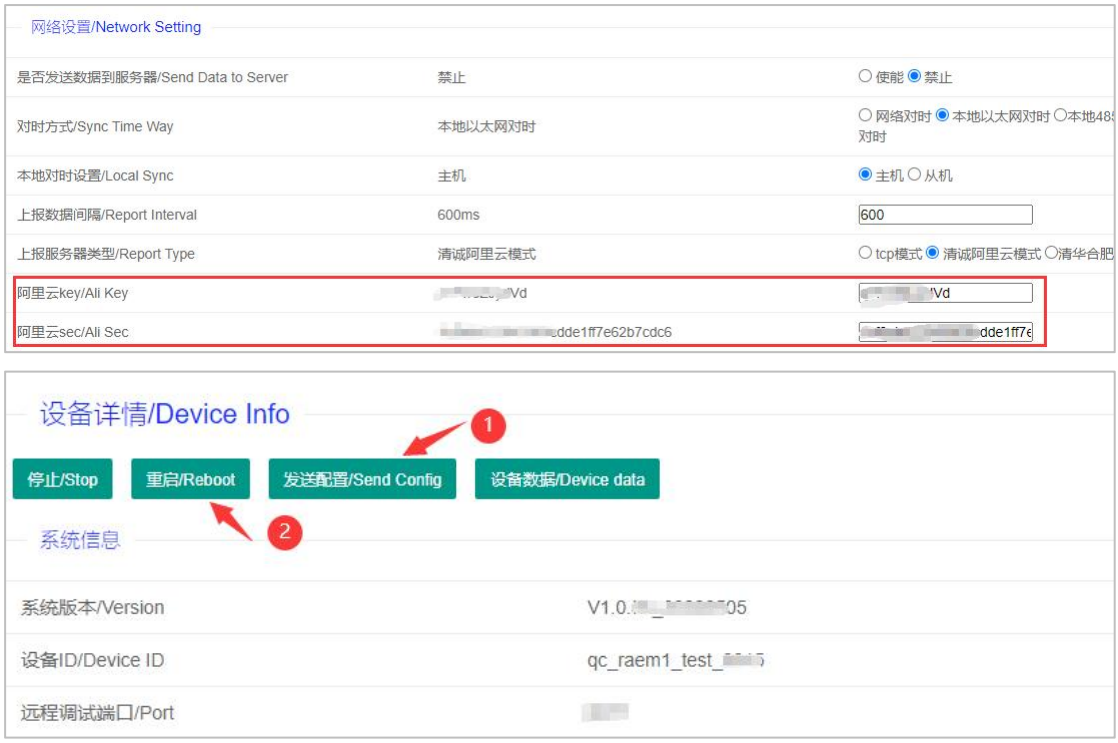


Fig. 6-21 Qingcheng Alibaba Cloud Configure Ali Key and Secret

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

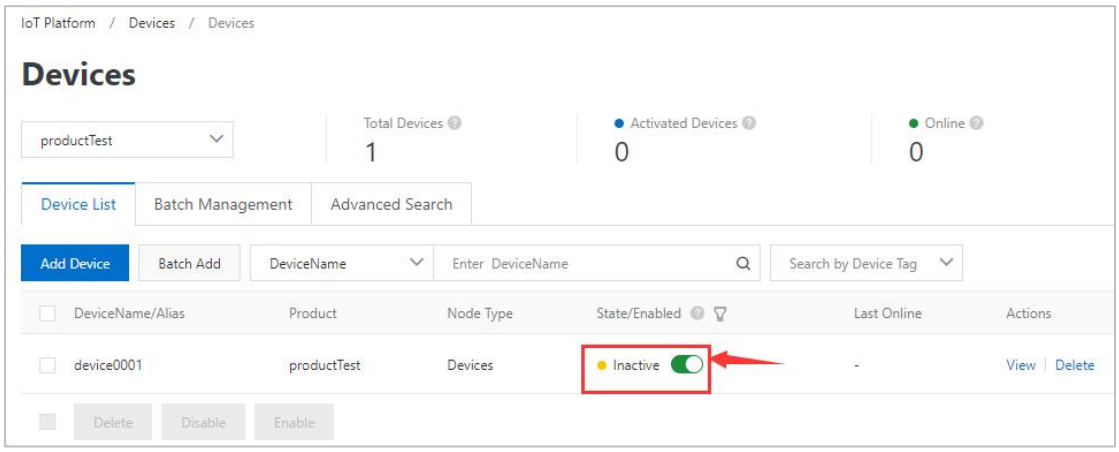


Fig. 6-22 Qingcheng Alibaba Cloud activate device

6.5 View Devices

(1) Choose **Public Examples**. (See Figure 6-23).

(2) Select **Devices** >> **Devices** in the left column (Figure 6-24). 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 6-25)

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 6-26)

(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 textbox on the left column and click **Debugging** >> **Set** to send the configurations to the devices. Click **Get** to read the current settings. (Figure 6-27)

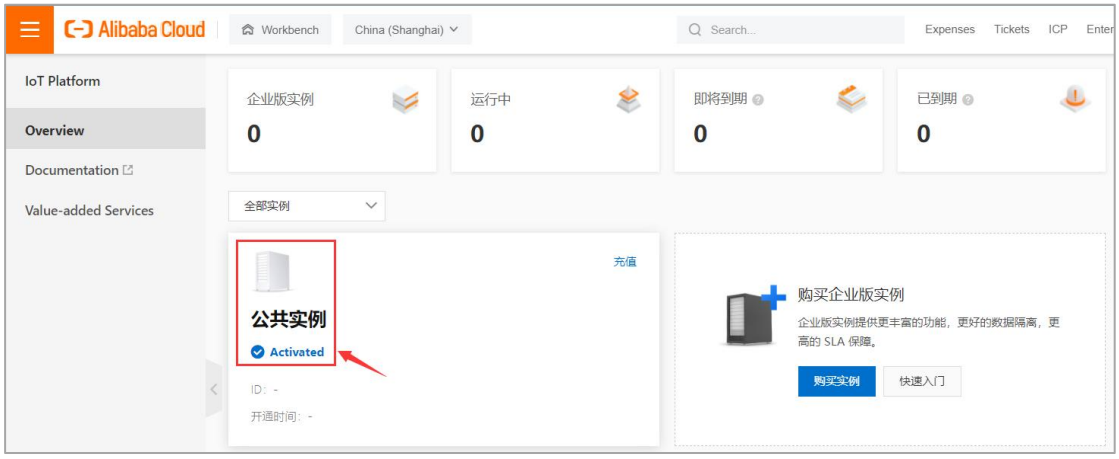


Fig. 6-23 Qingcheng Alibaba Cloud

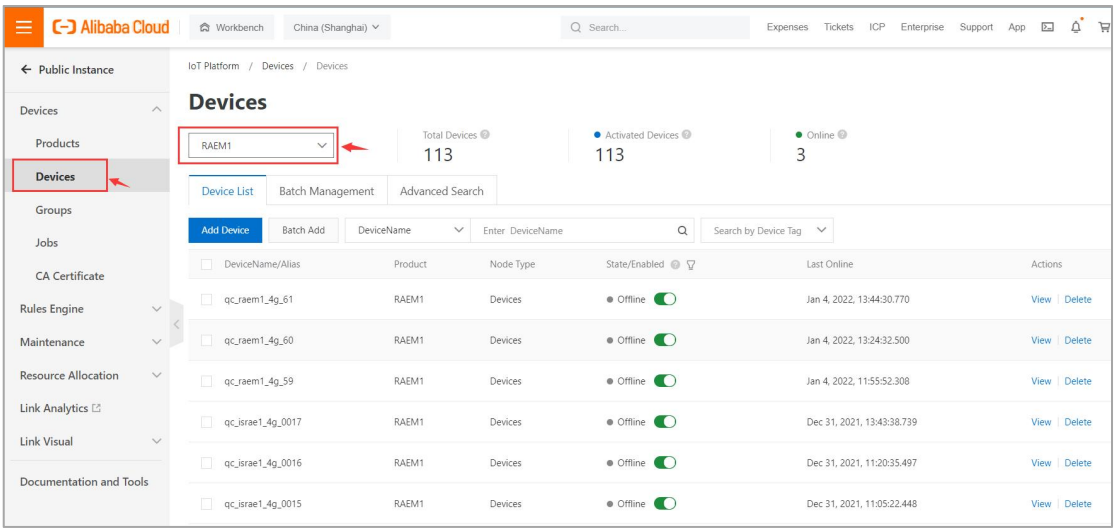


Fig. 6-24 Qingcheng Alibaba Cloud

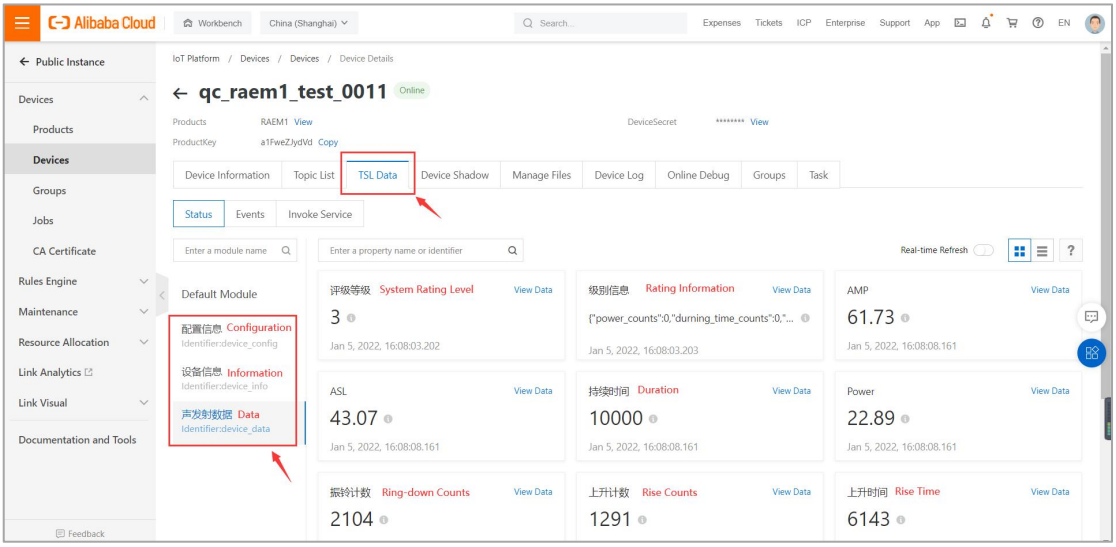


Fig. 6-25 Qingcheng Alibaba Cloud

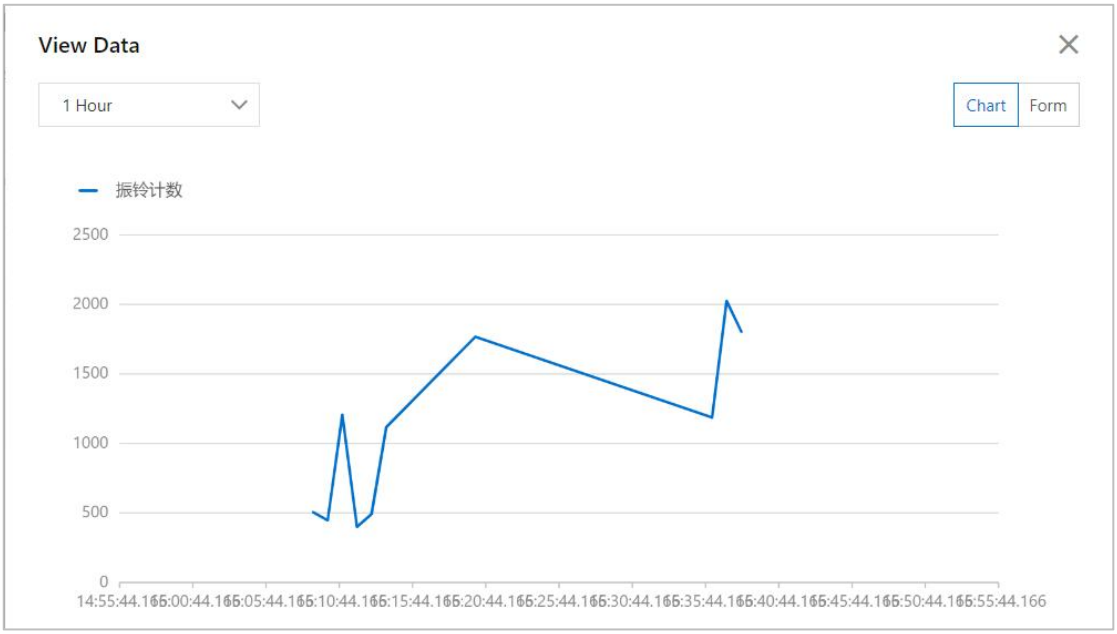


Fig. 6-26 Qingcheng Alibaba Cloud

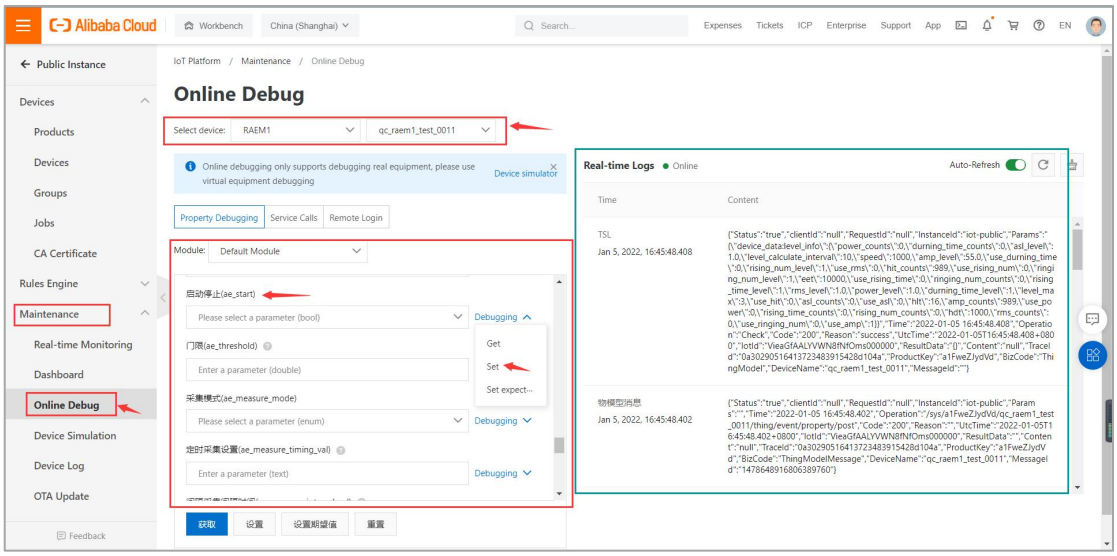


Fig. 6-27 Qingcheng Alibaba Cloud

7. SWAE Software Online Acquisition

The SWAE software supports both SAEU3H and RAEM1 online acquisition data display, including parameter real-time display and waveform real-time display. Connect RAEM1 to the PC through SWAE software and configure the PC, hardware and software. When the RAEM1 starts acquisition, it starts to display real-time data on the software.

- Data communication method: Ethernet connection, or Wi-Fi connection

Notes:

By default, RAEM1 supports two network segments for data transmission to SWAE software: 192.168.0. xx and 192.168.100.xx. If it needs to be configured to other certain segments, choose **Use IP**, and enter the target computer IP address in the RAEM1 Configuration software so that the RAEM1 can send the data to the dedicated computer IP address. Please make sure the RAEM1 device IP address and the target computer IP address are in the same network segment.

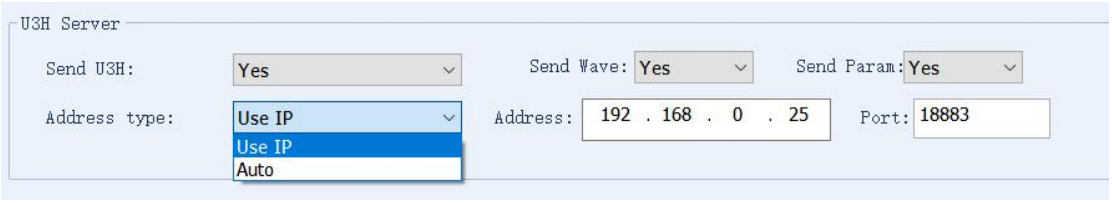


Fig. 7-1 RAEM1 Configuration Software target PC IP setting

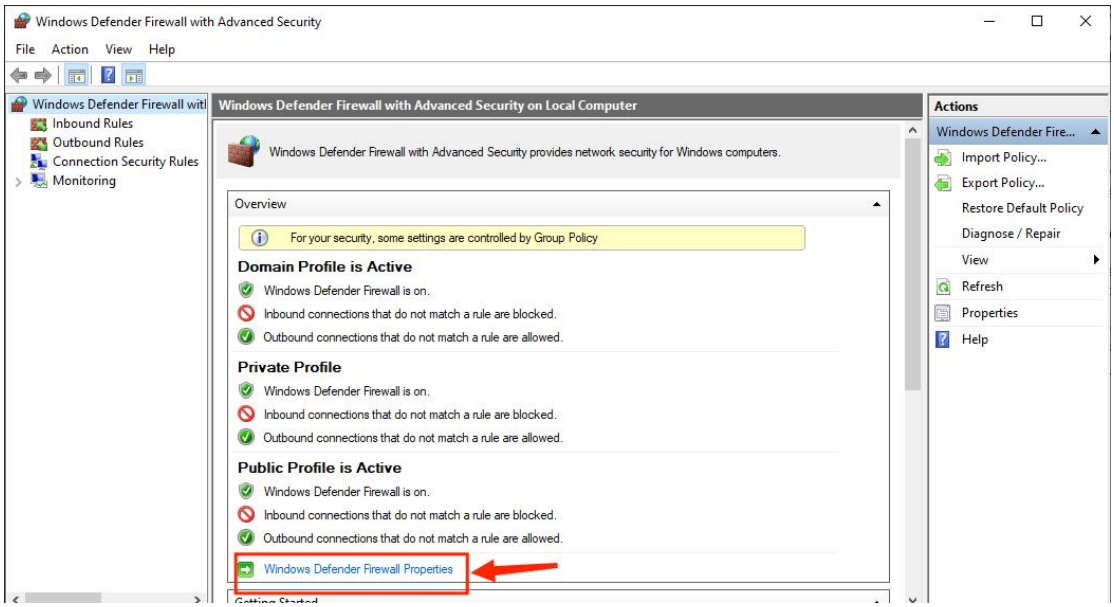
To use SWAE online data acquisition function, the firewall must be turned off:

① Open **Windows Defender Firewall with Advanced Security**.

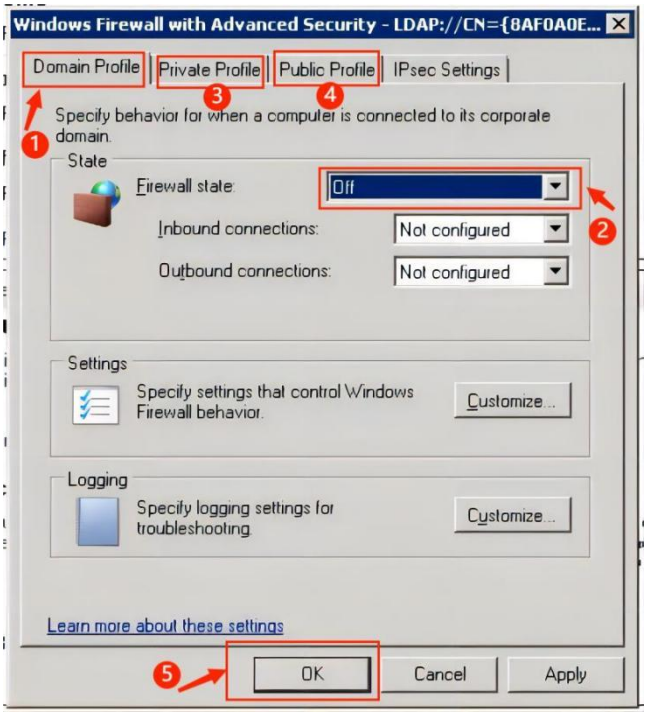
② Click **Windows Defender Firewall Properties**.

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.



(a)



(b)

Fig. 7-2 Turn off Windows Defender Firewall (a & b)

After installing the SWAE software, open the software and click the upper left corner icon to confirm or switch the product type. A window will pop up to show current product type to connect. Choose **Yes** to switch product or **NO** to cancel and continue.

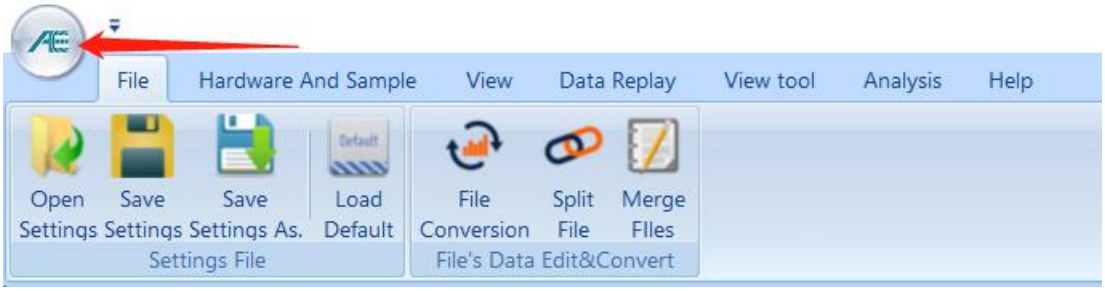


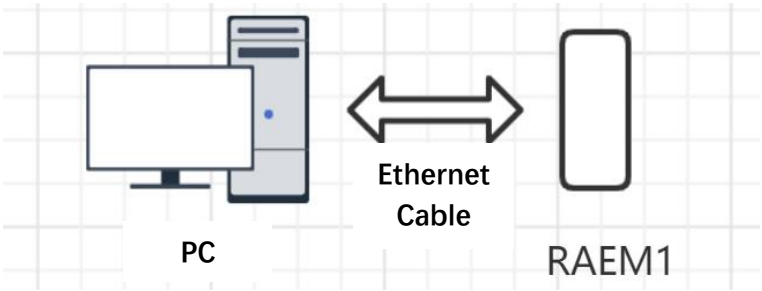
Fig. 7-3 SWAE icon to switch product

Fig. 7-4 Warning window for product types

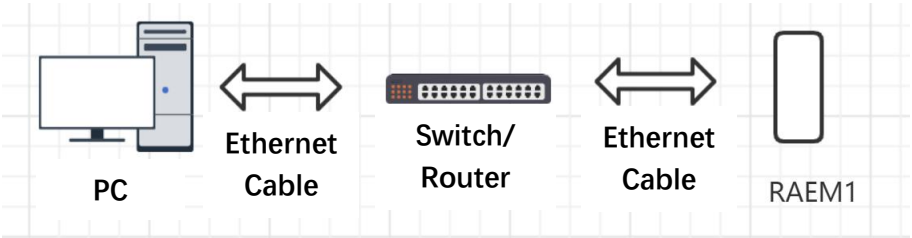
7.1 Ethernet Transmission

7.1.1 Single RAEM1 Direct Ethernet Connection

- Connect RAEM1 to PC. It can be directly connected PC through Ethernet cable. Or use a switch/router to form a local network.



A. Ethernet cable connection



B. Switch/ router connection

Fig. 7-5 Ethernet Connections

➢ The default Ethernet address of RAEM1 at factory settings is 192.168.0.101. So, when it is first used, change the PC IP address to any address of 192.168.0.xxx, but NOT the same as the RAEM1. We configure it as 192.168.0.20 for example.

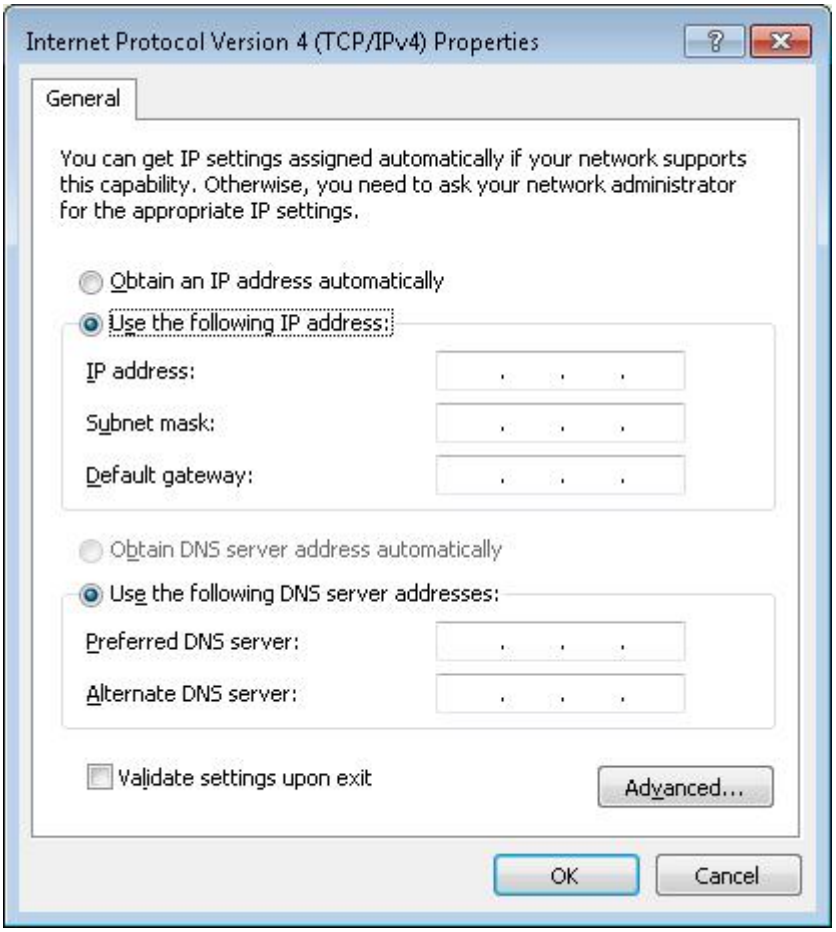


Fig. 7-6 Change PC IP address

➢ In the RAEM1 Configuration software **Storage Settings** page, **disable** the **Data Storage** >> **Save Wave** and **Save Param** and **Upload original data**.

➢ **Enable Send U3H**, **Send Wave** and **Send Param**. Change the Address type to **use IP** and enter the target PC IP address as it is set in the above step.

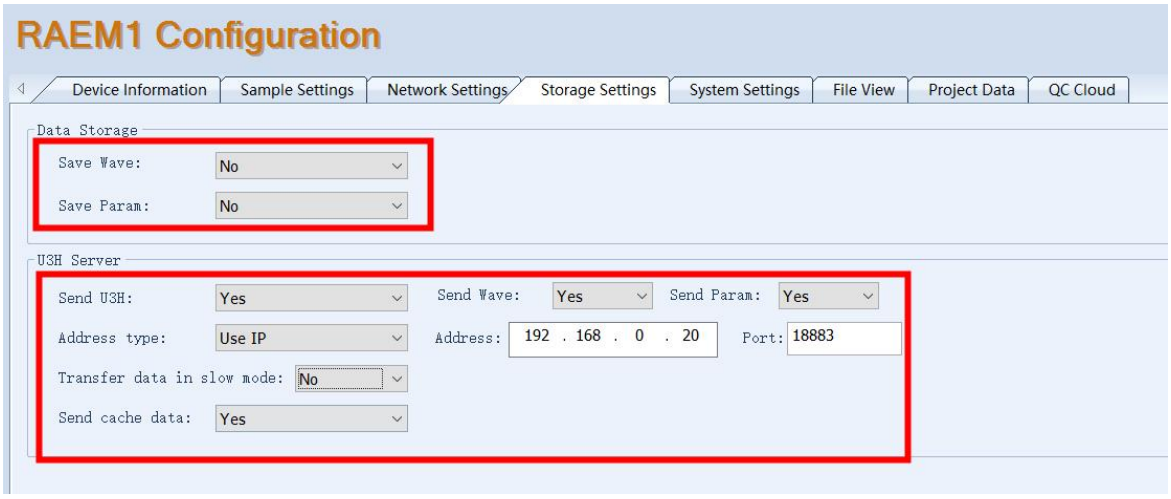


Fig. 7-7 Turn on **Send U3H**

Note: The reason of disabling the data local SD card storage is because it may slow down the data sending to SWAE software which could cause data lost. If the data is sent to SWAE software, all the original data will be saved in U3H format files in SWAE software.

- Turn on SWAE software, and click **Hardware and Sample** >> **Sample Setting:**

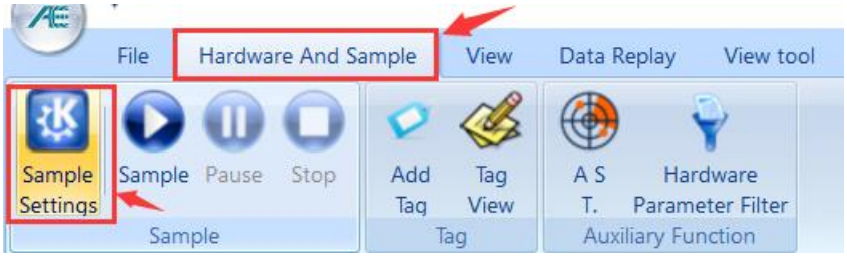


Fig. 7-8 SWAE software sample settings

(1) **IP Address:** the IP address of the PC. It is set to be the same as the last step, 192.168.0.20.

(2) **Port:** the default is 18883.

(3) **Sample length:** it only affects the display on SWAE software. It is suggested to set the value equal to RAEM1 sample rate times EET.

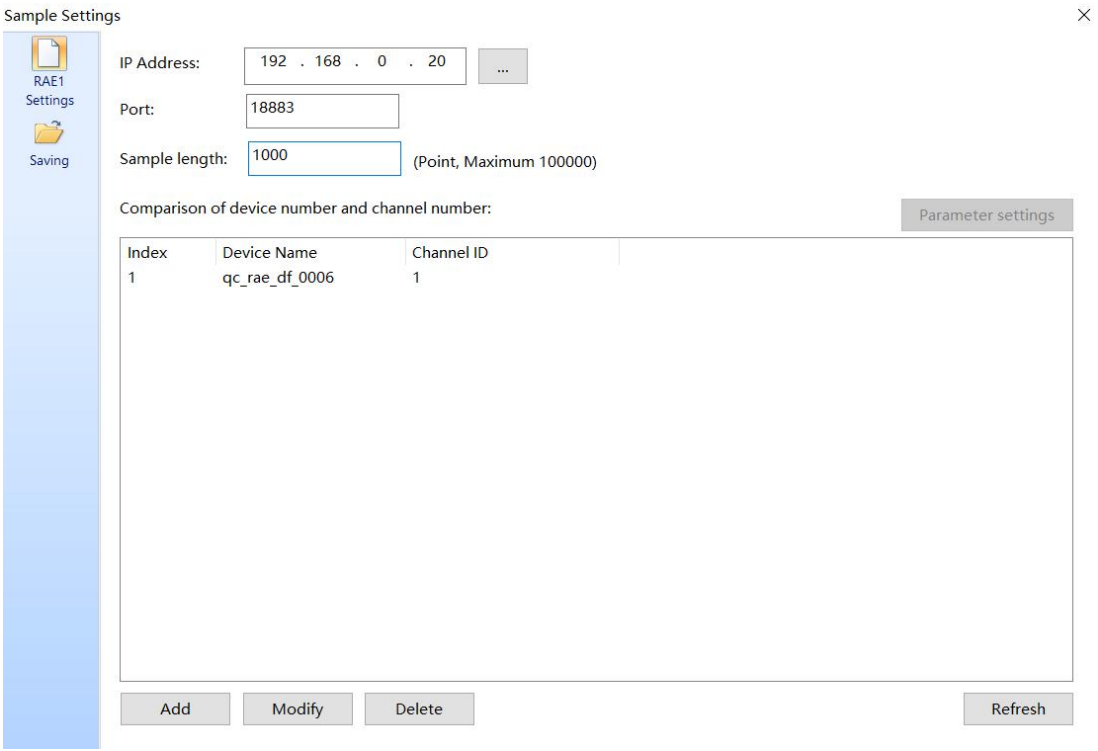


Fig. 7-9 Change Sample Settings

(4) Click [Refresh] button to automatically add the RAEM1. Or manually add the RAEM1. Click **Add** button and set the **device number** and **channel number** in the pop-up window:

- **Device number**: enter the last 4 digit of the device ID

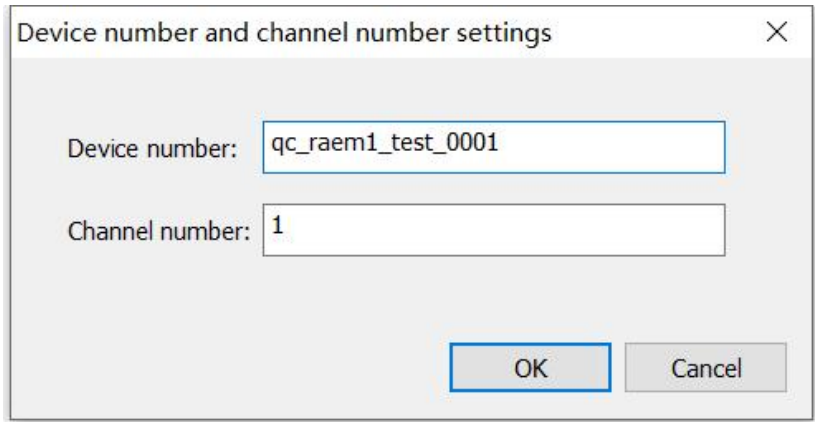


Fig. 7-10 Device number and channel number page

- **Channel number:** manually define the channel number. It can start with 1.

➢ Click **OK** to save the changes and then click **Sample** to start data acquisition:

Fig. 7-11 Click Sample button

- **Define the data save path:** the data sent from RAEM1 will be saved as U3H format (.PRA & .AED).

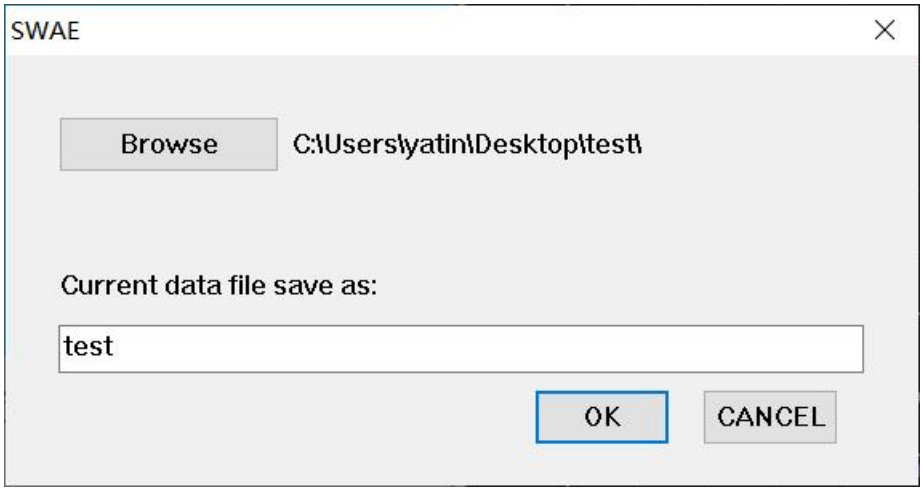


Fig. 7-12 Data save path

- After starting sampling, there will be a network matching process which might last for 1 to 30 seconds. Once the network is matched, there are parameters and waveform sending in and displaying in the software. The waveform will display first and after 3 seconds the parameters show up too.

No	Arrival time(dd:hh:mm:s...	AE cha...	Amplit...	Counts	Duration(us)	Energy(KpJ)	Rise counts
10	6:23:35:31:664 100000	1	95.2	23	1348	57142.525	1
11	6:23:35:31:667 241000	1	60.1	35	610	27.418	35
12	6:23:35:31:670 604000	1	58.9	10	239	18.840	0
13	6:23:35:35:088 760000	1	95.6	19	1456	52214.099	1
14	6:23:35:36:207 796000	1	94.2	36	1345	25639.810	0
15	6:23:35:36:871 860000	1	95.5	18	1520	58513.934	1
16	6:23:35:43:266 453000	1	95.5	27	1490	38946.721	2
17	6:23:35:44:039 742032	1	95.5	35	1397	44770.026	2
18	6:23:35:47:913 735000	1	92.8	20	952	11160.638	0
19	6:23:35:50:023 749000	1	89.2	21	1053	8872.437	1
20	6:23:35:50:999 584000	1	91.9	31	1099	14856.765	0
21	6:23:35:51:853 267000	1	94.3	30	1201	26540.397	1
22	6:23:35:52:442 258256	1	91.5	14	1054	8520.384	0
23	6:23:35:53:203 501000	1	95.0	31	1188	31687.641	2

Fig. 7-13 Data table in SWAE

- Scroll the mouse on the waveform view to switch channels:

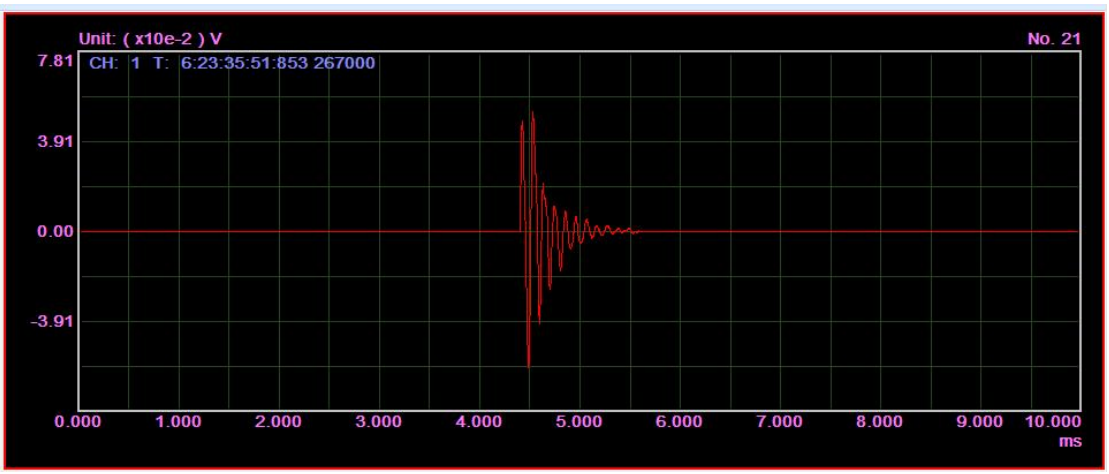


Fig. 7-14 Waveform View

7.1.2 Multiple RAEM1 Ethernet Connection

- Connect multiple RAEM1s to PC using switches or router to form a local network. The figure below shows the connections using Ethernet cables.

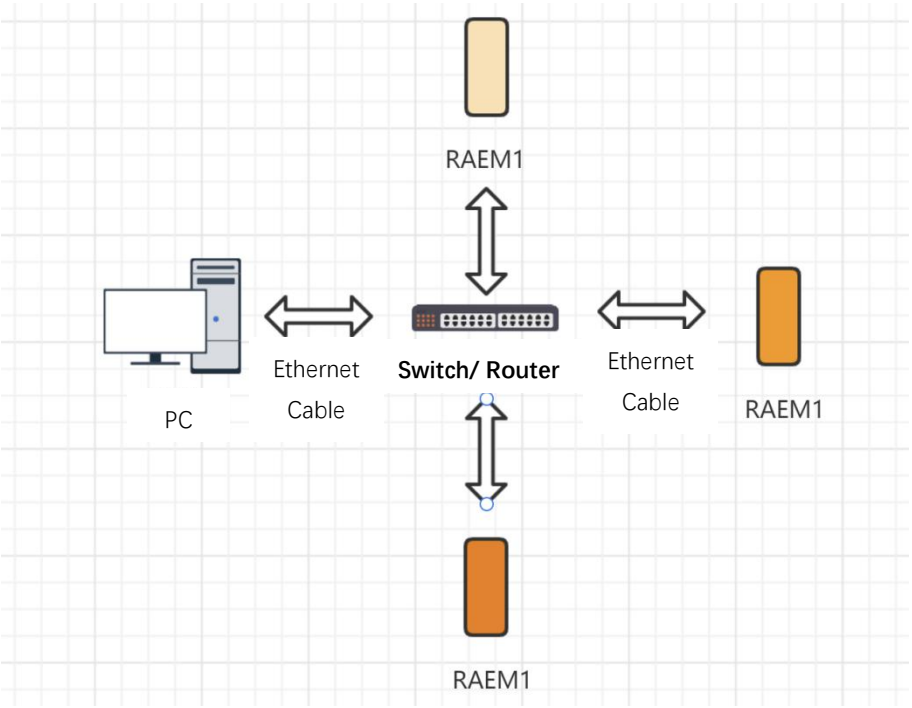


Fig. 7-15 Ethernet Multiple RAEM1 networking

- There are two types of networks forming for multiple devices networking, **static IP** and **dynamic IP**. In **static IP** form, it must make sure each RAEM1 has a different IP address; while the **dynamic IP** requires the router to assign the dynamic IP addresses.

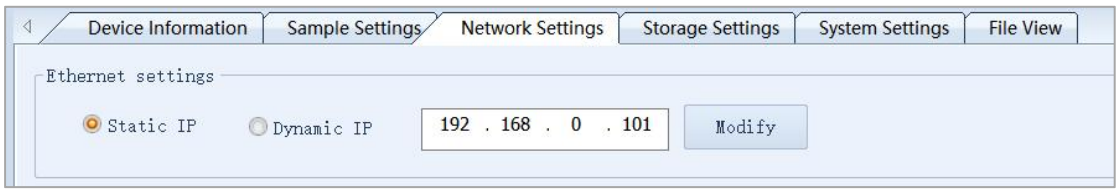


Fig. 7-16 Static IP setting

1) **Static IP networking:** in the network connection above there are 3 RAEM1s and they can be configured as static IP:

ID	Static IP address
qc_raem1_test_0001	192.168.0.101
qc_raem1_test_0002	192.168.0.102
qc_raem1_test_0003	192.168.0.103

Table 7-1 Static IP address

2) **Dynamic IP networking:** change the settings to **Dynamic IP** and connect them to the router.

- In the RAEM1 Configuration software **Storage Settings** page, disable the **Data Storage** >> **Save Wave** and **Save Param** and **Upload original data.**
- Enable **Send U3H**, **Send Wave** and **Send Param**. Change the Address type to **use IP** and enter the target PC IP address.

Note: The reason of disabling the data local SD card storage is because it may slow down the data sending to U3H which could cause data lost. If the data is sent to SWAE, all the original data will be saved in U3H format files in SWAE software.

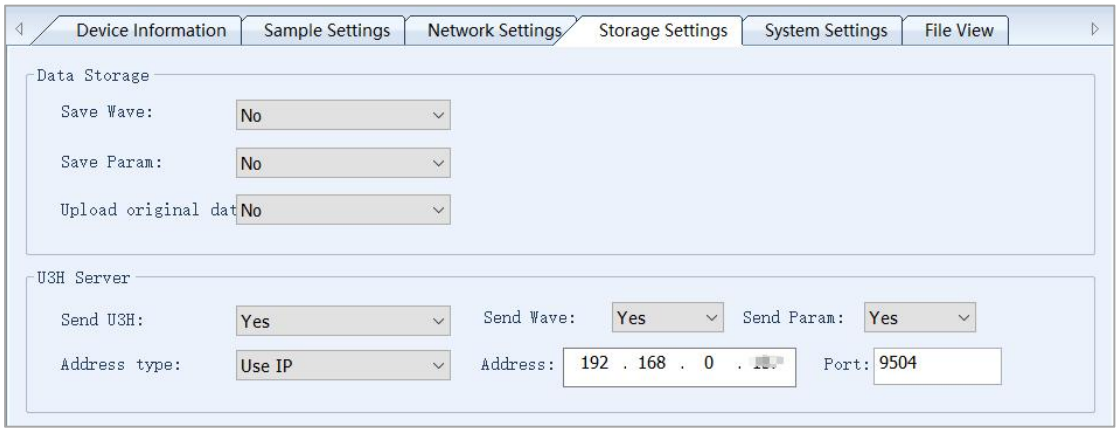


Fig. 7-17 Ethernet Multiple device networking IP settings

- If it is **static IP** mode, change the PC IP address to between 192.168.0.20 and 192.168.0.30.
- Turn on SWAE software, and click **Hardware and Sample** >> **Sample Setting:**

(1) IP Address: the IP address of the PC. It is set to be the same as the last step, 192.168.0.20.

(2) Port: the default is 18883.

(3) Sample length: it only affects the display on SWAE software. It is suggested to set the value equal to RAEM1 sample rate times EET.

(4) Click **Add** button and set the **device number** and **channel number** in the pop-up window:

- **Device number**: enter the last 4 digit of the device number

- **Channel number**: manually define the channel number. It can start with 1. When adding a new channel, channel number increases by one.

(5) Click **OK** to save the changes and then click **Sample** to start data acquisition.

(6) Define the data save path: the data sent from RAEM1 will be saved as U3H format (. PRA &. AED).

(7) After starting sampling, there will be a network matching process which might last for 1 to 30 seconds. Once the network is matched, there are parameters and waveform sending in and displaying in the software. The waveform will display first and after 3 seconds the parameters show up too.

Comparison of device number and channel number:

Index	Device Name	Channel ID
1	0001	1
2	0002	2
3	0003	3

Fig. 7-18 Channel number and device ID list

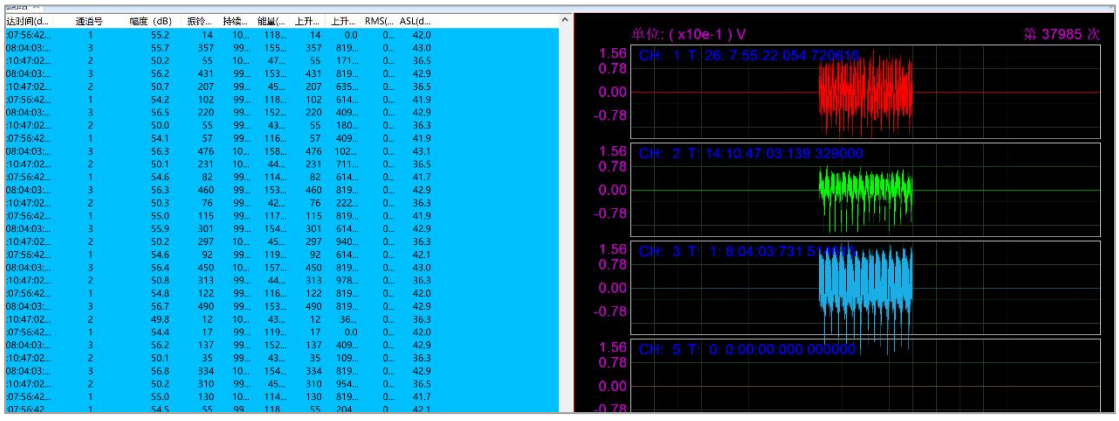


Fig. 7-19 Data Table and Waveform View

7.2 Wi-Fi Transmission

7.2.1 Wi-Fi Hotspot Mode

- Connect RAEM1 to PC. It can be directly connected PC through Wi-Fi Hotspot.

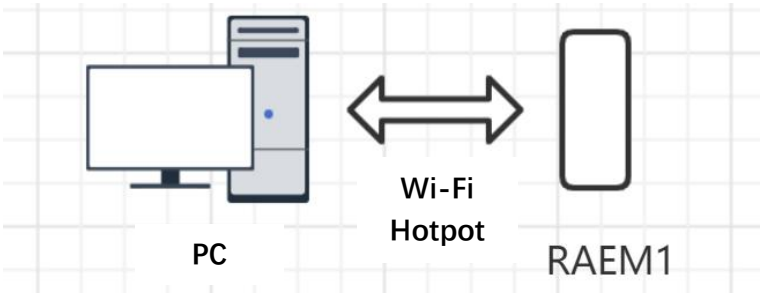


Fig. 7-20 Wi-Fi Hotspot Mode Connection

- In the RAEM1 Configuration software **Storage Settings** page, disable the **Data Storage** >> **Save Wave** and **Save Param** and **Upload original data**.

- Enable **Send U3H**, **Send Wave** and **Send Param**. Change the Address type to **use IP** and enter the target PC IP address.

Note: The reason of disabling the data local SD card storage is because it may slow down the data sending to SWAE which could cause data lost. If the data is sent to SWAE, all the original data will be saved in U3H format files in SWAE software.

- The default Wi-Fi Hotspot address of RAEM1 is **192.168.100.1**. Once connecting to the Hotspot released by the RAEM1, it will automatically assign the PC IP address. Just by clicking the Hotspot properties, it shows the PC target IP address.

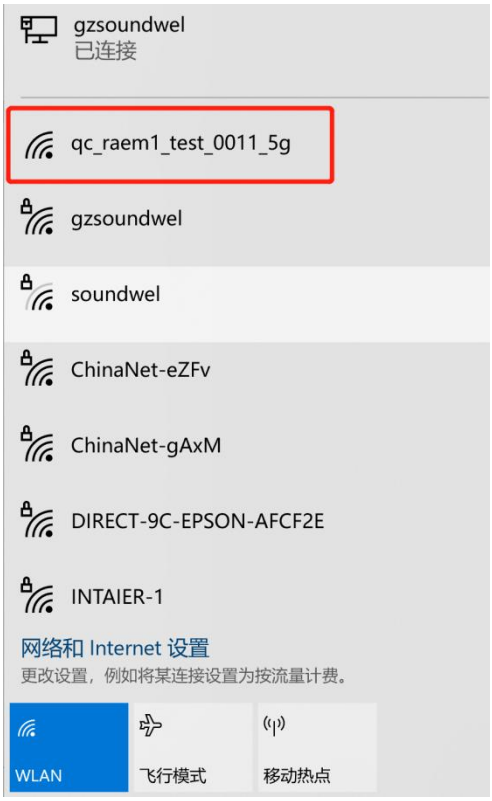


Fig. 7-21 Connecting Hotspot

- Turn on SWAE software, and click **Hardware and Sample** >> **Sample Setting**:

(1) **IP Address:** the IP address of the PC. It is set to be the same as the last step, 192.168.100.20.

(2) **Port:** the default is 18883.

(3) **Sample length:** it only affects the display on SWAE software. It is suggested to set the value equal to RAEM1 sample rate times EET.

(4) Click **Add** button and set the **device number** and **channel number** in the pop-up window:

- **Device number:** enter the last 4 digit of the device ID

- **Channel number:** manually define the channel number. It can start with 1.

- Click **OK** to save the changes and then click **Sample** to start data acquisition:

- Define the data save path: the data sent from RAEM1 will be saved as U3H format (. PRA &. AED).

- After starting sampling, there will be a network matching process which might last for 1 to 30 seconds. Once the network is matched, there are parameters and waveform sending in and displaying in the software.

Fig. 7-22 Check the Hotspot IP address

7.2.2 Wi-Fi Router Mode

- Connect multiple RAEM1s to PC through Wi-Fi using switches or router to form a local network. When multiple devices connect to a router, it will assign them with different IP addresses. Click the router property to check the PC assigned IP address.
- In the RAEM1 Configuration software Storage Settings page, disable the **Data Storage** >> **Save Wave** and **Save Param** and **Upload original data**.
- Enable **Send U3H**, **Send Wave** and **Send Param**. Change the Address type to **use IP** and enter the target PC IP address.

Note: The reason of disabling the data local SD card storage is because it may slow down the data sending to SWAE which could cause data lost. If the data is sent to SWAE, all the original data will be saved in U3H format files in SWAE software.

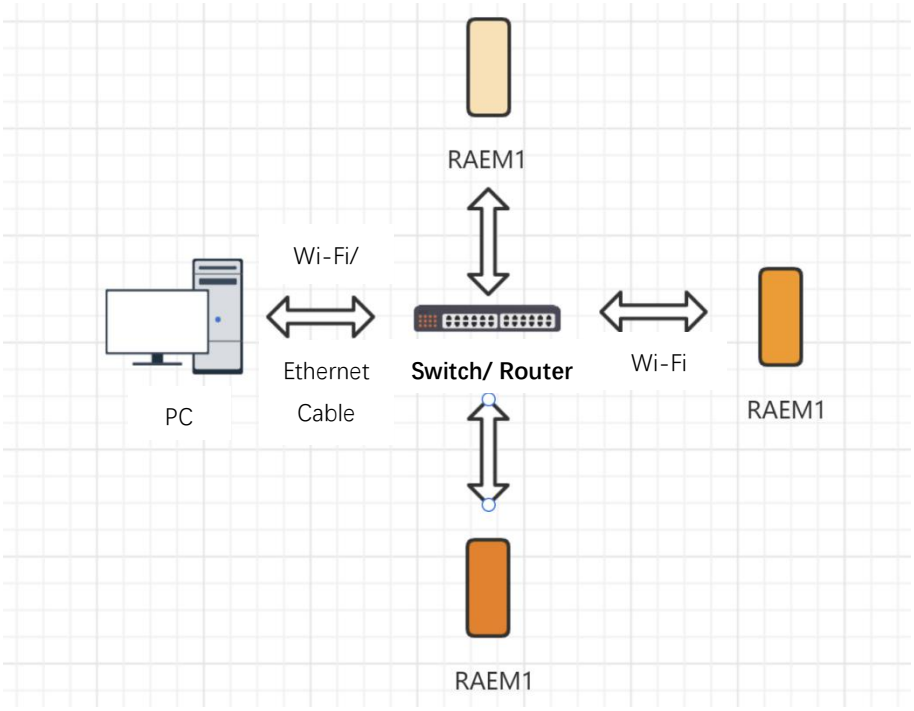


Fig. 7-23 Wi-Fi Router mode networking

Fig. 7-24 Wi-Fi Router PC address

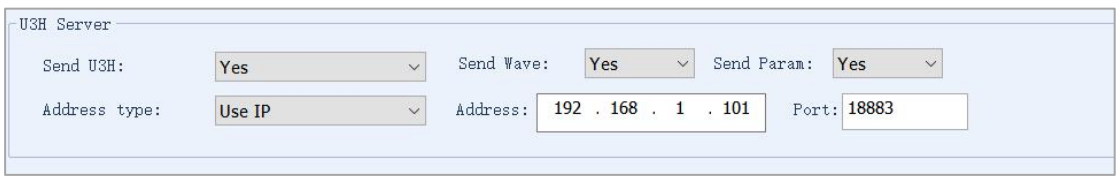


Fig. 7-25 Wi-Fi Router mode networking IP settings

- Turn on SWAE software, and click **Hardware and Sample** >> **Sample Setting**:

① **IP Address:** the IP address of the PC. It is set to be the same as the last step, 192.168.1.101.

② **Port:** the default is 18883.

③ **Sample length:** it only affects the display on SWAE software. It is suggested to set the value equal to RAEM1 sample rate times EET.

④ Click **Add** button and set the **device number** and **channel number** in the pop-up window:

⑤ - **Device number:** enter the last 4 digit of the device ID

⑥ - **Channel number:** manually define the channel number. It can start with 1.

⑦ Click **OK** to save the changes and then click **Sample** to start data acquisition:

⑧ Define the data save path: the data sent from RAEM1 will be saved as U3H format (. PRA &. AED).

⑨ After starting sampling, there will be a network matching process which might last for 1 to 30 seconds. Once the network is matched, there are parameters and waveform sending in and displaying in the software.

8. Data Access

There are 3 ways to access the RAEM1 data packages, **RAEM1 Configuration software**, C**loud platform** and **SWAE software**.

8.1 RAEM1 Configuration Software Access

RAEM1 Configuration software has the **File View** function to access the RAEM1 data packages stored in the local storage card. It also supports the data downloads and format conversion. Please see **Section 4.6** for details.

8.1.1 **Save Parameter** and **Waveform**

On **Storage Settings** page, you can configure data to be saved on your computer.

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

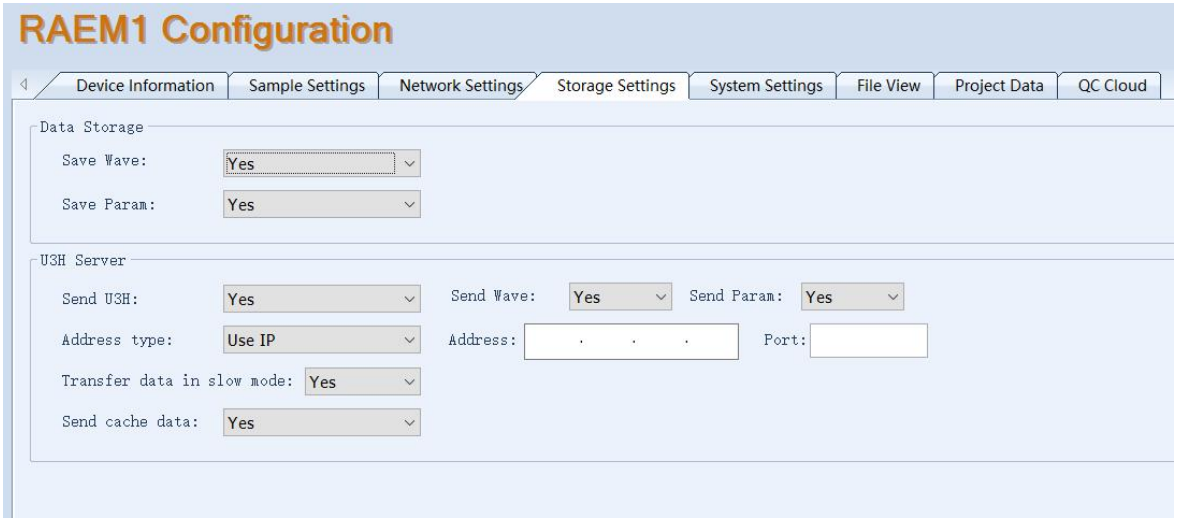


Fig. 8-1 Storage Settings page

8.2SWAE Software Access

For detailed instructions on transferring data to the SWAE software, please refer to **sections 7.1** or **7.2**.

8.3 Cloud Platform Access

There are two cloud servers available to upload data to, **Qingcheng IoT Cloud** and **AWS S3**.

8.3.1 Qingcheng IoT Cloud Access

For detailed steps, please refer to **section 5.2.1 AE Data - Data Download Procedures**.

8.3.2 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.

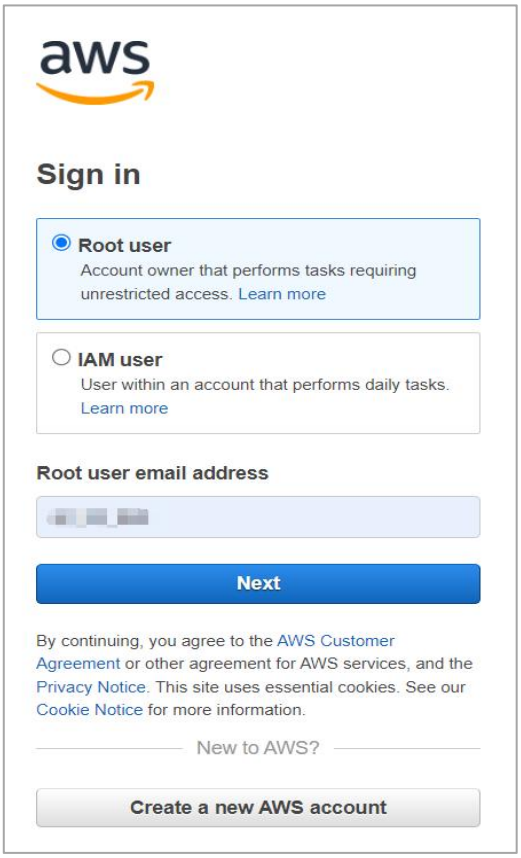


Fig. 8-1 Sign up for AWS Root account

2) Create new accounts in AWS

- Go to IAM service

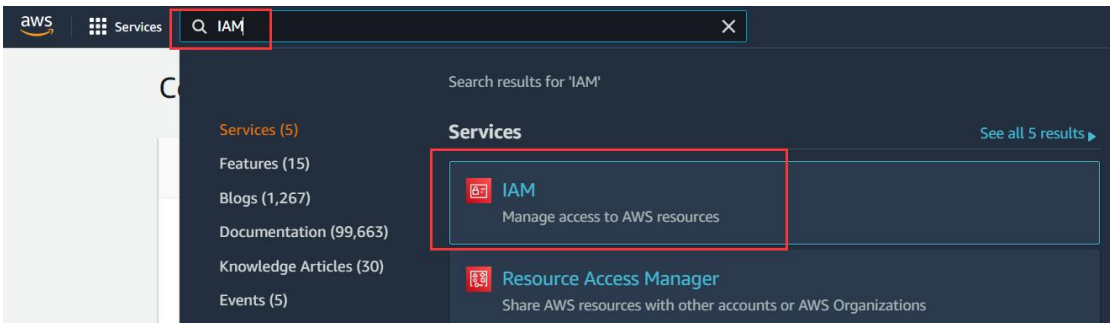


Fig. 8-2 Search for IAM

- Add users

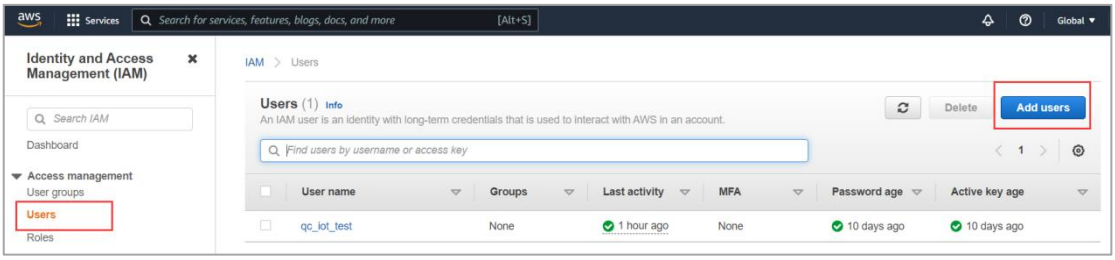


Fig. 8-3 Add users

- Step 1: enter the user's name and check the **Access key** and **password**.

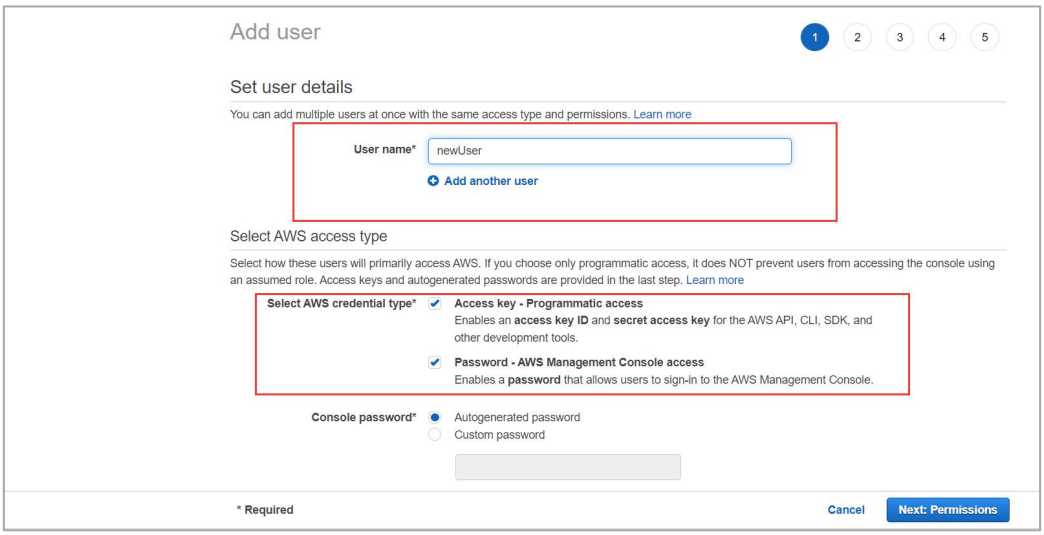


Fig. 8-4 User adding step 1

- Step 2: select **attaching existing policies directly** and search for **S3**, check **AmazonS3FullAccess**.

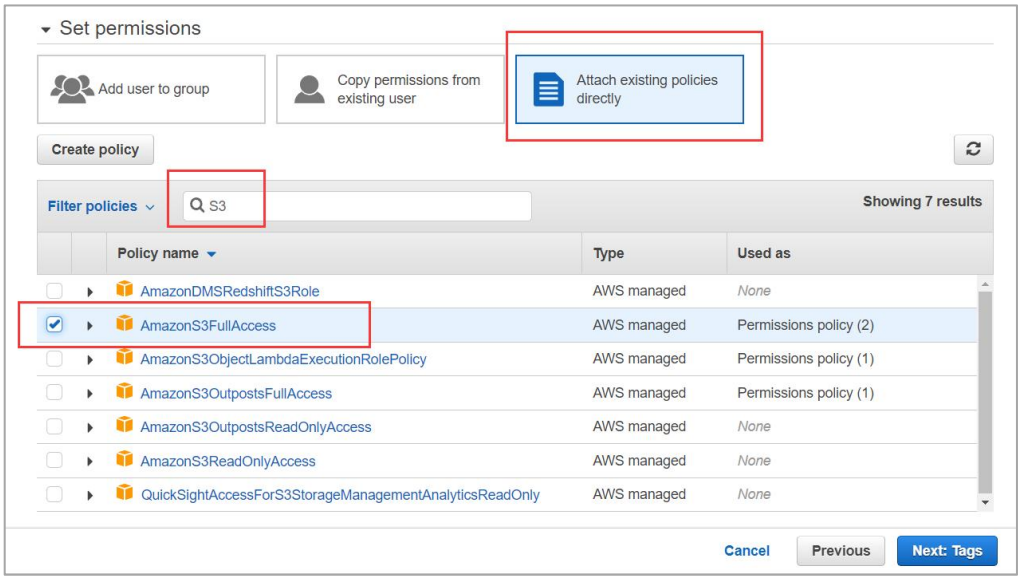


Fig. 8-5 User adding Step 2

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

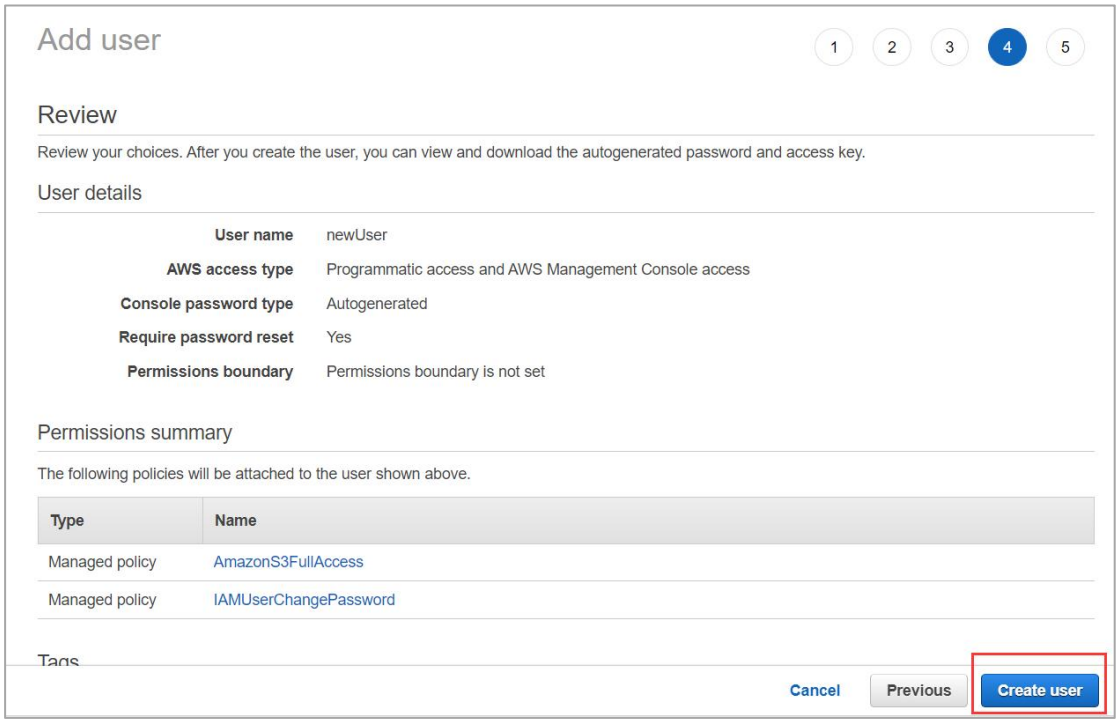


Fig. 8-6 User adding Step 4

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

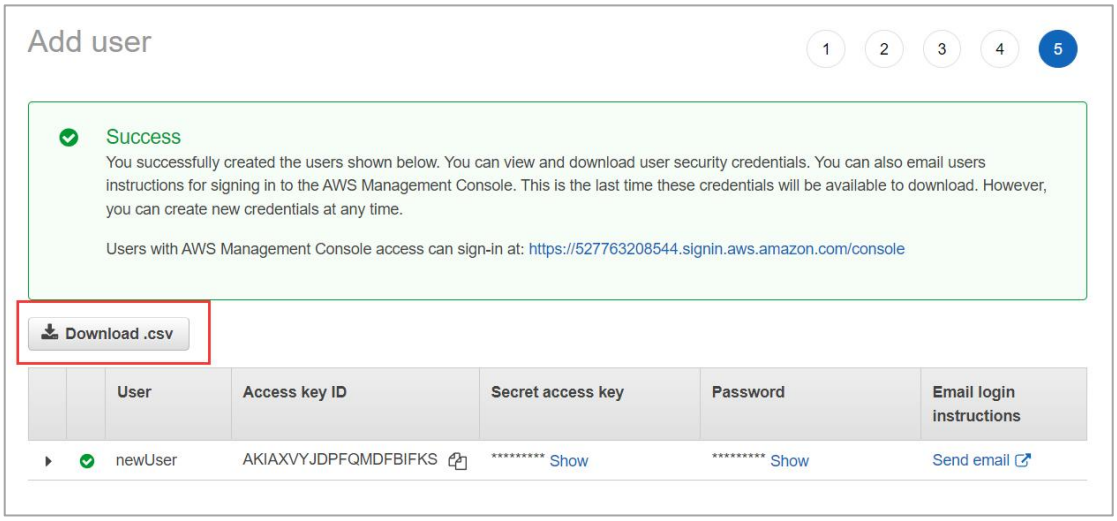
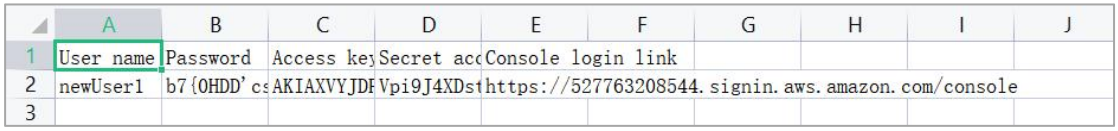


Fig. 8-7 User adding Step 5



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

Fig. 8-8 Access key and secrete

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

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

Fig. 8-9 Console Login Link

➢ Search for S3

Fig. 8-10 Search for S3

➢ Create bucket

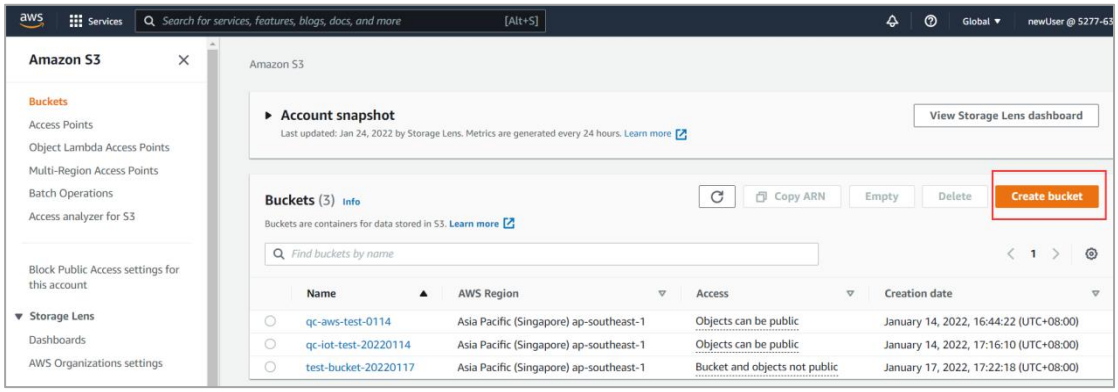


Fig. 8-11 Create bucket

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

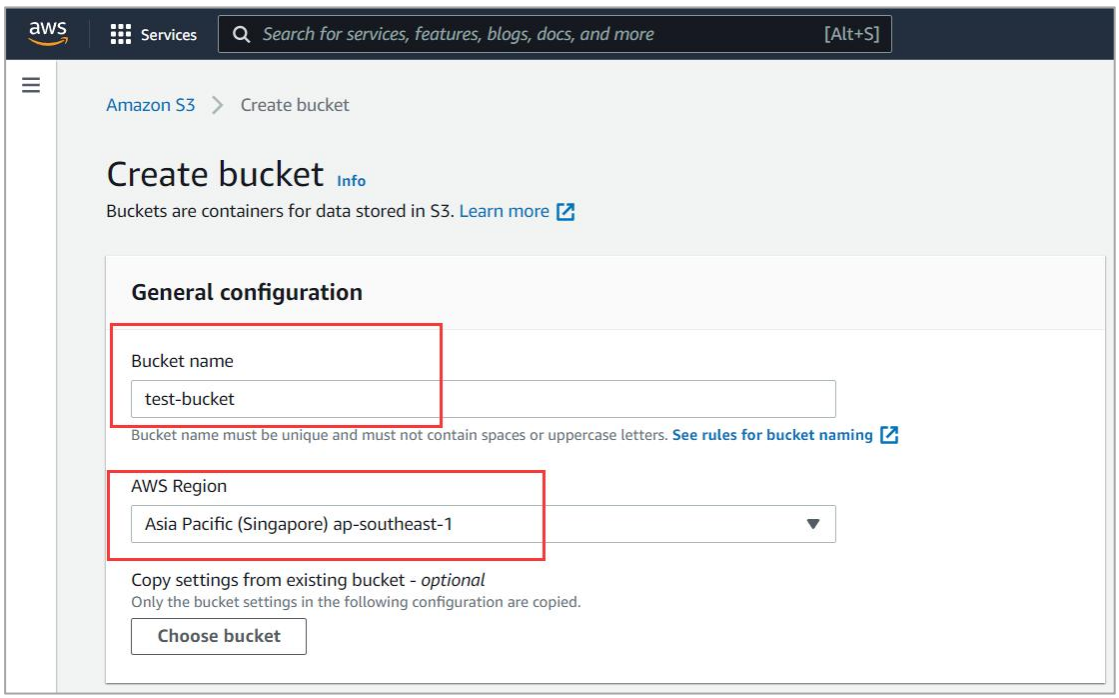
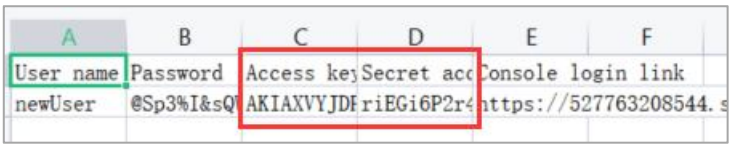


Fig. 8-12 Enter bucket information

4) Configure RAEM1 AWS

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



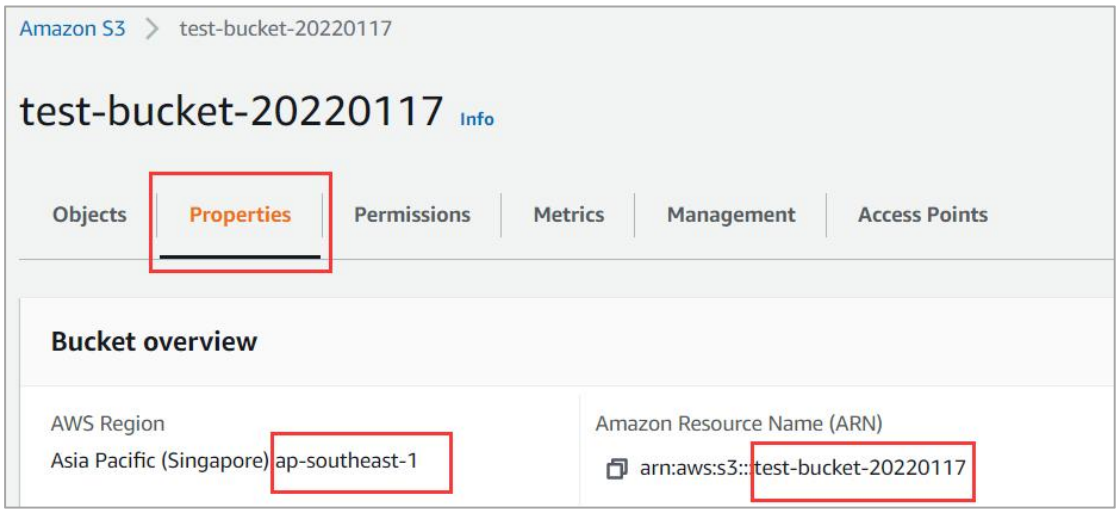


Fig. 8-13 Get AWS S3 Information

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

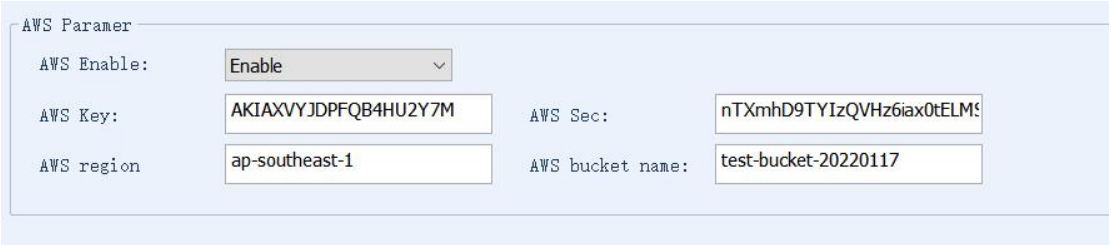


Fig. 8-14 Enter AWS configuration

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

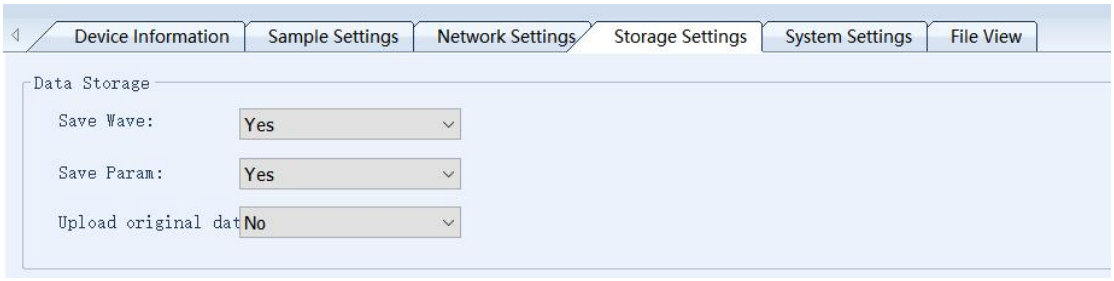


Fig. 8-15 Data Storage settings for AWS

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

◆ Data Access

➢ When there are HITs, RAEM1 will pack the data every 5 seconds and then store in the local storage first. If there is no data, there will be no data packs. Then based on the network availability, it will start upload the data packs to the specified AWS S3 bucket. If the network connection stops when it is uploading. It will stop and retry when the connection is back. Once the data packs are uploaded to the cloud server successfully, the local storage copies will be deleted. To access and download the data packs in AWS S3:

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

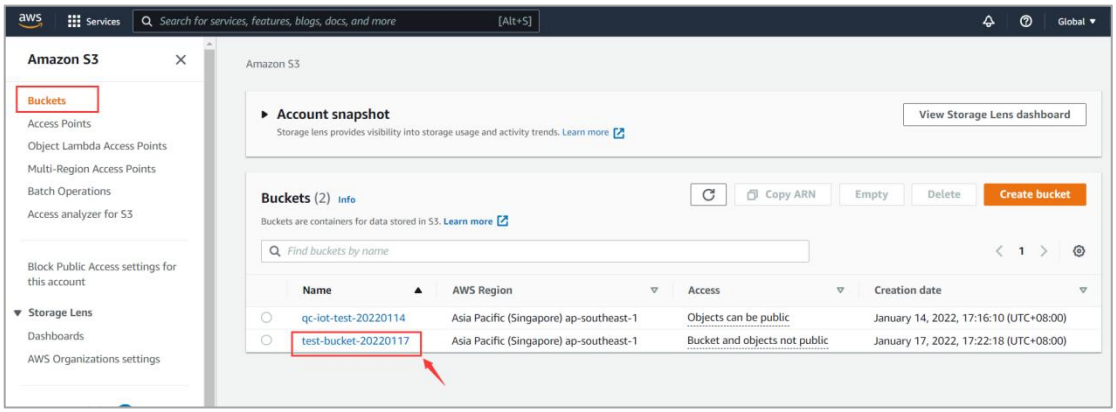


Fig. 8-16 Select bucket

➢ Choose **tmp/** folder

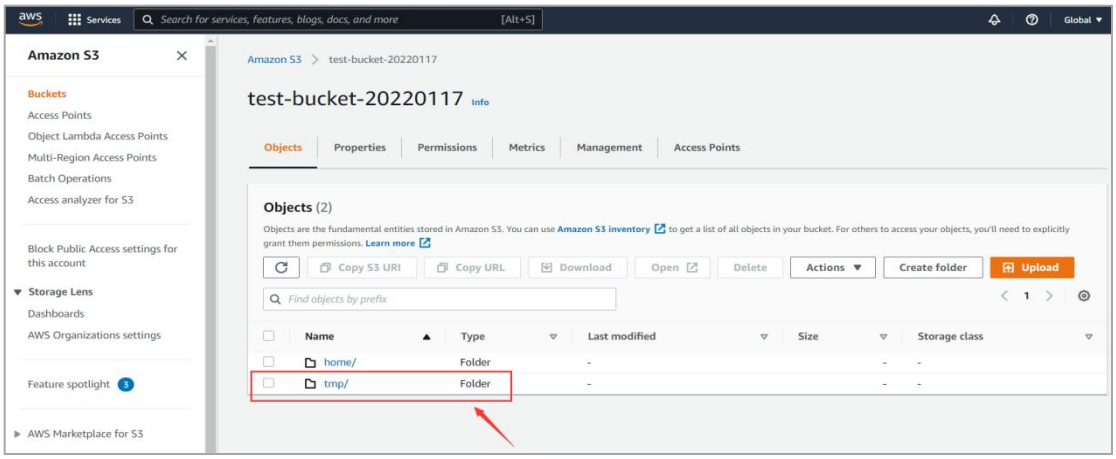


Fig. 8-17 Open **tmp/** folder

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

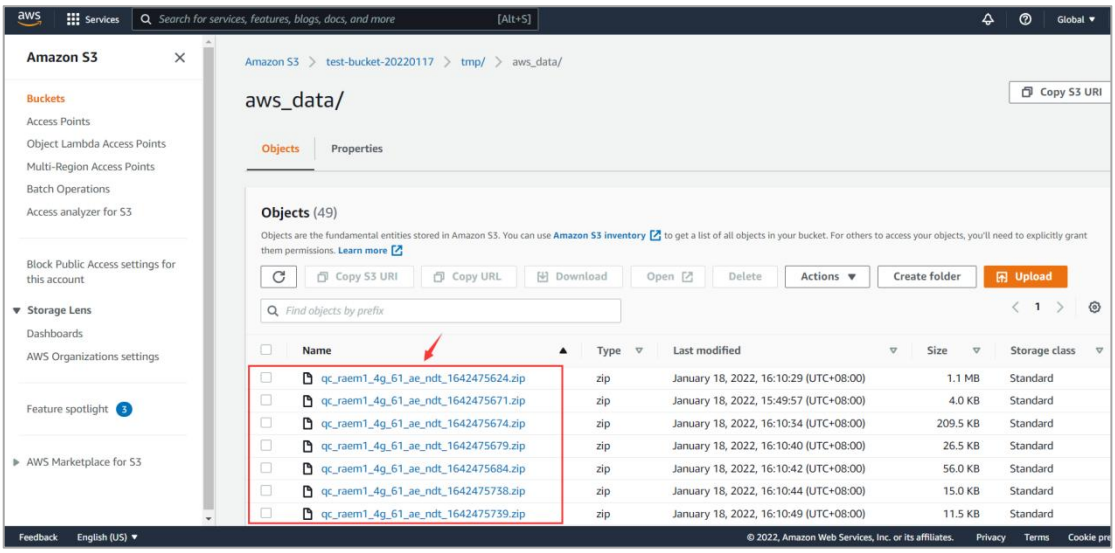


Fig. 8-18 Data packs in the bucket

9. Data Analysis

The RAEM1 data needs data format conversions to be able to display and be analyzed in Qingcheng SWAE analysis software and the third-party analysis software.

The data packs generated from RAEM1 can be converted into the SWAE software readable formats using Qingcheng's **RAE1toU3H** software. It can also be opened through **RAEM1 Configuration software** >> **File Convert** button at the left bottom corner. The **File View** tab of the **RAEM1 Configuration software** also can download and convert the data files of RAEM1 to U3H or CSV formats too. Please see Section 4.6 for detail.

After downloading data using the RAEM1 configuration software, file conversion or merging operations can be performed through the RAE1toU3H software. The converted data format is .PRA and .AED files (note: multiple .pra and .aed files of the same device can be converted together, and the downloaded .pra and .aed files can be stored in one folder. If multiple RAEM1 are converted into multiple channels, each RAEM1's .pra and .aed files can be placed in a separate folder).

The converted files (.PRA & .AED) can be replayed and analyzed in SWAE software. Please contact Qingcheng for the user's manual of SWAE software for detail. The conversion software also supports CSV format conversion which can be then imported and analyzed in the third-party software. Multiple-channel RAEM1 data conversion is also supported in this software.

The conversion steps of **RAE1toU3H** software:

1) Open **RAE1toU3H.exe**. It can also be opened through **RAEM1 Configuration software** >> **File Convert** button at the bottom left corner. See Figure 9-1.

2) In the **RAE1toU3H** interface, click **Add directory** to add the folders to be converted. Each folder directory will be converted to one individual channel. Double click to modify the **channel ID**. Right click to delete the selected or all the file directories. Check the box to indicate that **File is in compressed format**. Choose the save directory. Make sure the sampling rate is the same as the RAEM1 sampling rate. Click **Convert U3H** button to start conversion.

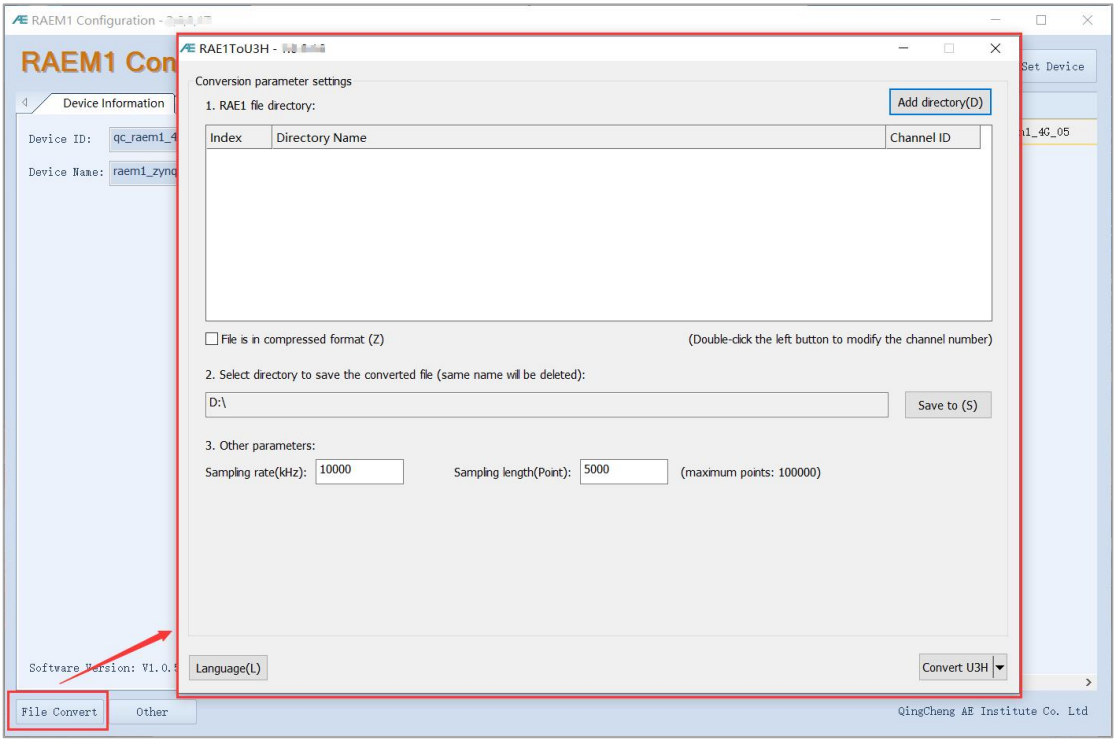


Fig. 9-1 Open **RAE1ToU3H**

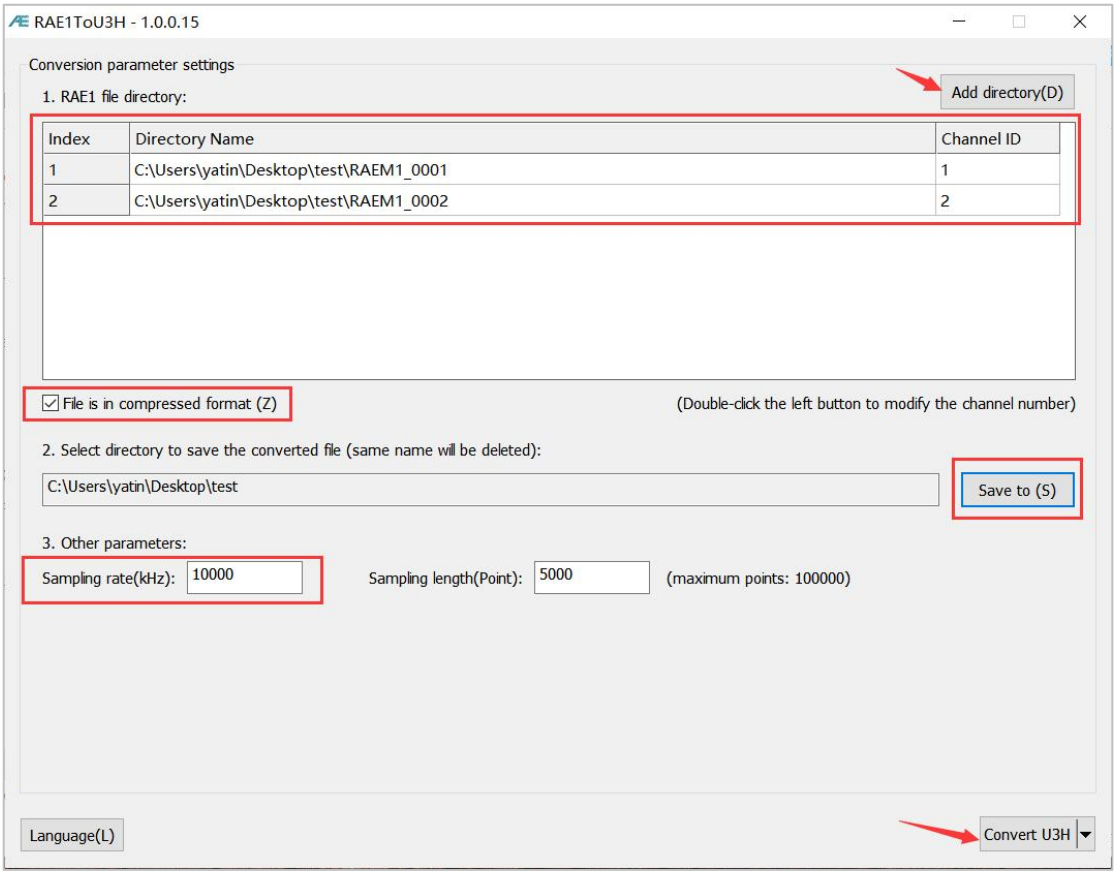


Fig. 9-2 RAE1ToU3H Interface

3) Once it starts conversion, there is a pop-up window to show the conversion process. After the conversion is done, it should look like below. Click **OK** to close the window.

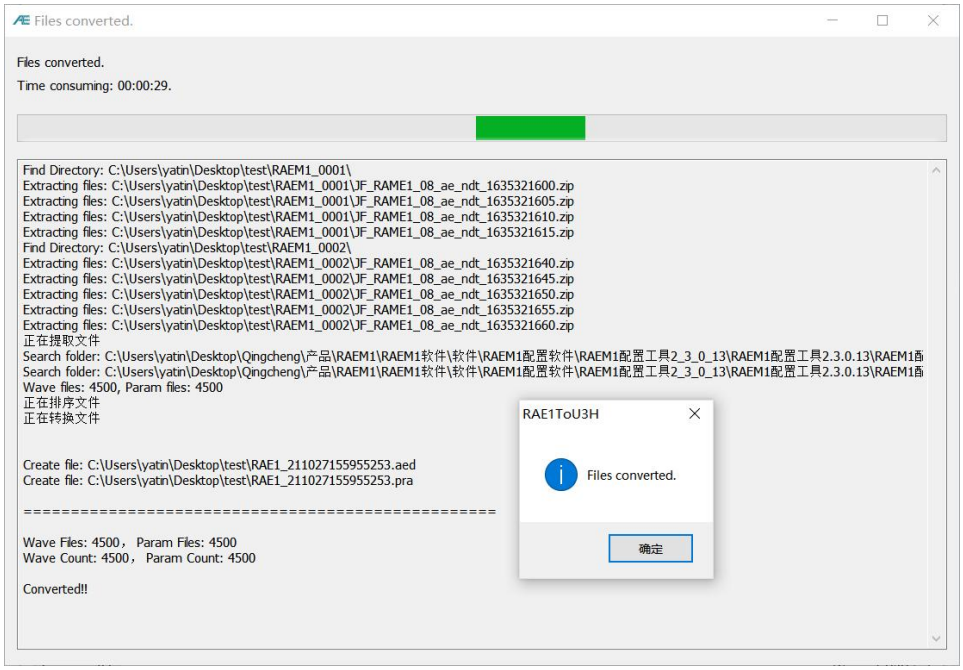


Fig. 9-3 RAE1ToU3H Conversion Window

4) In the target save directory, there will be two corresponding U3H format files, **PRA** and **AED** files respectively. They can be opened and replayed in SWAE software for data analysis.

Fig. 9-4 Convert to U3H Files

5) If CSV format is wanted, click the ▼ button next to the **Convert U3H** button. After conversion, there should be corresponding CSV files in the target directory. They should have **RAE1** prefixes. If there are more than 800,000 rows in a CSV file, it will automatically generate another new CSV file. In the result CSV files, the first column is timestamp, and the second column is the voltage values of each waveform sampling points.

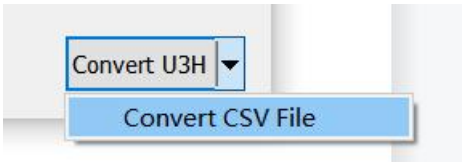


Fig. 9-5 RAE1ToU3H Convert to CSV format

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

Fig. 9-6 Result CSV file in the target directory

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				

Fig. 9-7 CSV File Layout

10. Transmission Protocols for Third Party Development

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

10.1 TCP Integration Protocol U3H mode

Using the TCP protocol, it outputs all AE hit parameters with the highest amplitude within the **Reporting Time Interval**.

U3H mode outputs all AE hit parameters and waveforms.

10.1.1 TCP Mode v2 Network Attributes

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

10.1.2 TCP Mode v2 Parameter Transmission

The TCP mode v2 supports parameter transmission. It needs to select **Tcp Mode v2** under **Project Data** in **RAEM1 Configuration software**.

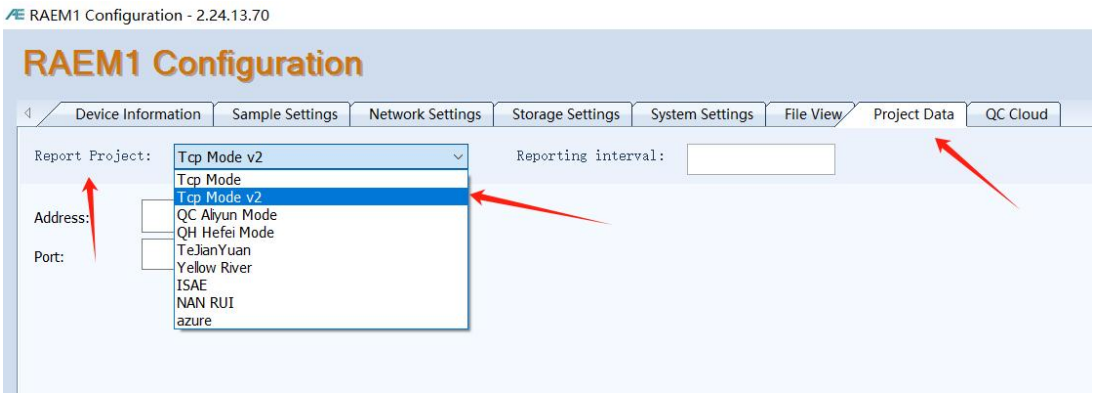


Fig. 10-1 RAEM1 Configuration software TCP Mode v2 function

The structure of the sent protocol is as follows:

Device ID
Amplitude, in dB
ASL, in dB
Power, in KpJ
RMS, in mV
Rise time, in μs
Rise counts
Counts
Duration, in μs
Report time. It includes a timestamp before the decimal point and the microseconds (μs) portion after the decimal point.

10.1.3 U3H Mode Parameter Transmission

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

Fig. 10-2 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:

Protocol Version	4 bytes
Arrival time (second)	unsigned int, 4 bytes
Arrival time (micro-second)	unsigned int, 4 bytes
AMP (dB)	Double, 8 bytes
Power (KpJ)	Double, 8 bytes
RMS (mV)	Double, 8 bytes
ASL (dB)	Double, 8 bytes
Rise time (us)	unsigned int, 4 bytes
Rise counts	unsigned int, 4 bytes
Duration (us)	unsigned int, 4 bytes
Counts	unsigned int, 4 bytes

10.1.4 U3H Mode Waveform Transmission

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

Fig. 10-3 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
Protocol 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.

10.2 485 Integration Protocol

10.2.1 485 Interface Attributes

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

10.2.2 485 Master Mode

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

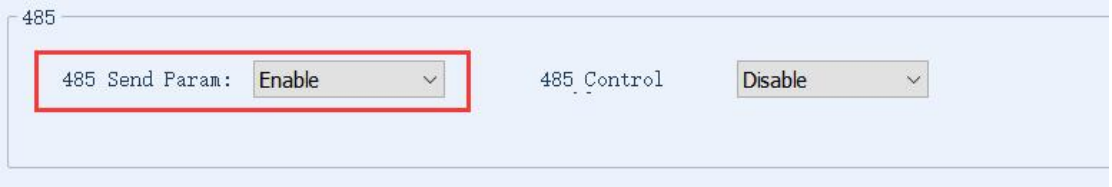


Fig. 10-4 RAEM1 Configuration software **485 Send Param** function

The protocol format is:

Protocol Header	Protocol Content	CRC Verification	Protocol End

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

10.2.3 485 Slave Mode

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

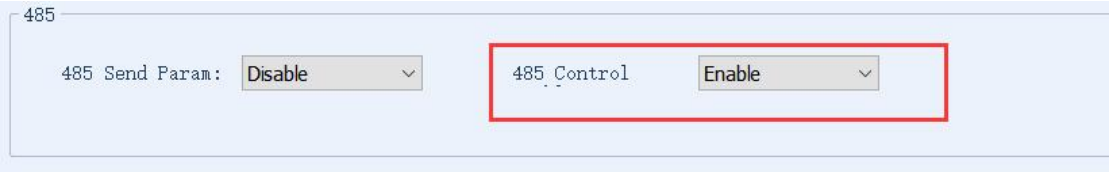


Fig. 10-5 RAEM1 Configuration software **485 Send Param** function

The protocol format is:

Protocol Header	Protocol Content	CRC Verification	Protocol End

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

10.2.4 485 Master/Slave Mode

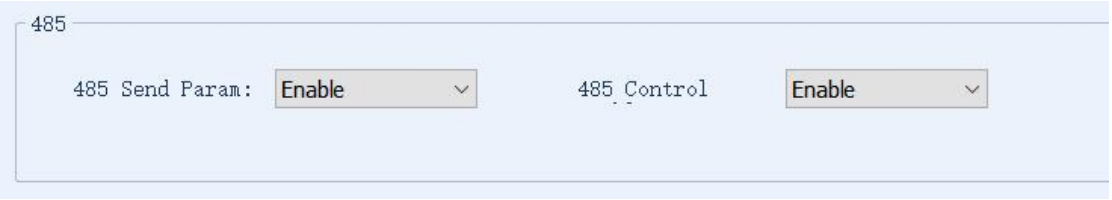


Fig. 10-6 RAEM1 Configuration software 485 functions

When enable the **485 Send Param** and **485 control** functions at the same time, the device will enter the Master/Slave mode automatically. The communication process in this mode is:

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

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

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

Please contact us for up-to-date detail protocols.