RAEM1-6 Detection And Remote Monitoring System User's Manual

Version: V2.0.2

November, 2025

Qingcheng AE Institute (Guangzhou) Co,. Ltd.
www.aendt.com Email: sales2@ae-ndt.com Cell/WhatsApp: +86 19128609186

Table of Content

1. Technical Background

1.1. Acoustic Emission Introduction

The phenomenon where a localized source rapidly releases energy to generate transient elastic waves is acoustic emission (AE), also known as stress wave emission. The detection method that evaluates material properties or structural integrity by receiving and analyzing such acoustic emission signals is called acoustic emission testing. Material deformation and crack propagation under stress are critical mechanisms leading to structural failure. Sources directly associated with deformation and fracture mechanisms are referred to as acoustic emission sources.

The principle of acoustic emission detection is illustrated in Figure 1-1. Elastic waves generated by the acoustic emission source propagate to the material's surface, inducing detectable surface displacement through acoustic emission sensors. These sensors convert mechanical vibrations into electrical signals, which are then amplified, processed, and recorded. By analyzing and interpreting the recorded acoustic emission signals, researchers can identify the underlying mechanisms responsible for the material's acoustic emission.

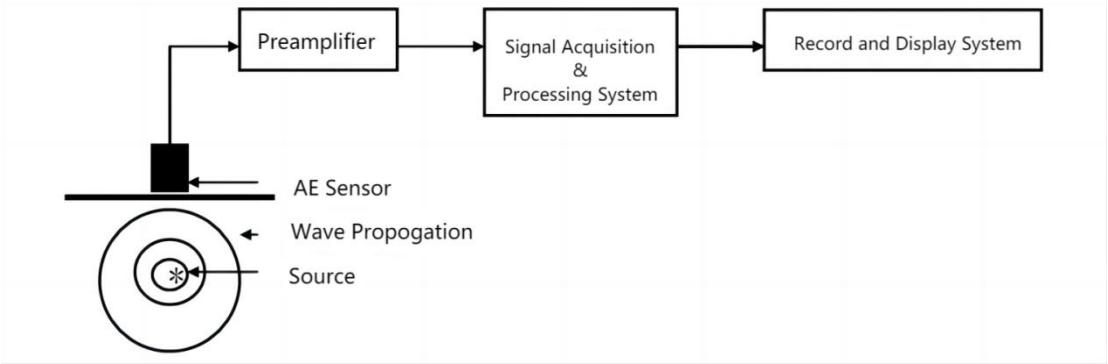


Fig. 1-1 Block diagram of acoustic emission detection principle

1.2. The Main Purpose of Acoustic Emission Detection

- Determine the location of the acoustic emission source

- Analyze the nature of the acoustic emission source
- Determine the time and load of acoustic emission
- Rate the severity of the sound source

1.3. Characteristics of Acoustic Emission Detection

The discovery of each acoustic emission source means the application of acoustic emission system. The acoustic emission detection method is different from other conventional nondestructive testing methods in many aspects. Its advantages are mainly manifested as follows:

- It is a dynamic detection method, and the detected energy comes from the object itself, rather than from the detection instrument
- It is sensitive to linear defects and can detect the activity of defects under external structural stress
- Can detect and evaluate the state of defects in the whole structure
- Can provide real-time or continuous information about how defects change with external variables such as load
- The proximity requirement for the detected object is not high
- Can be used for the detection of in-service pressure vessels
- The pressure test for pressure vessels can prevent the catastrophic failure of the inspected object caused by unknown discontinuous defects and limit its maximum working pressure
- Suitable for object detection with complex geometry

The main purpose of acoustic emission detection/monitoring is to prevent the spread of damage by detecting hidden defects, even hidden defects in inaccessible parts of the structure.

1.4. Acoustic Emission Technology Application

At present, the acoustic emission technology has been applied in many fields,

mainly including the following aspects:

- Petroleum chemical industry
- Electric power industry
- Material test
- Civil engineering
- Aerospace and aviation industry
- Metal processing
- Transport

1.5. Acoustic Emission Technical Terms

(1) **Emission signal start point**: the start point of the emission signal identified by the system processor, usually defined by an amplitude above the threshold;

(2) **Termination point of acoustic emission signal**: the identification termination point of acoustic emission signal is usually defined as the last crossing point between the signal and the threshold;

(3) **Duration**: The time interval between the start and end of an acoustic emission signal.

(4) **Rise time of acoustic emission signal**: the time interval between the start point of the signal and its peak value.

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

(6) **Attenuation**: The reduction in acoustic emission amplitude per unit distance, typically measured in decibels per unit distance.

(7) **Average Signal Level (ASL)**: The time-averaged logarithmic acoustic emission signal after rectification, measured in dB using a logarithmic scale. At the input of the preamplifier, 0dB equals 1μV.

(8) **Root Mean Square (RMS)**: it represents the effective average value of a signal amplitude in volts (V).

(9) **Acoustic Emission Channel**: a system consisting of a sensor, a preamplifier or impedance matching transformer, a filter, a secondary amplifier, a connecting cable, and a signal detector or processor;

(10) **Acoustic Emission Count**: Also known as ringing count, it measures the number of times the acoustic emission signal exceeds the preset threshold within the selected detection interval.

(11) **Acoustic Emission Event**: A localized material change that triggers acoustic emission.

(12) **Event count**: Count each identifiable acoustic emission event individually.

(13) **Coupling agent**: or known as Couplant. the material filled between the sensor and the contact surface of the specimen, which can improve the ability of sound energy to pass through the interface during acoustic emission monitoring;

(14) **Decibel (dB)**: A logarithmic measurement of the amplitude of an acoustic emission signal, with reference to 1μV. The formula is dB = 20lg(A/1μV), where A represents the measured voltage amplitude of the acoustic emission signal.

(15) **Dynamic range**: the decibel difference between an overload level and a minimum signal level (typically 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 the arrival time and distance determined by the artificial acoustic emission signal, which is used for positioning calculation;

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

(18) **Continuous Acoustic Emission**: a qualitative description of the level of continuous signals generated by rapid acoustic emission events;

(19) **Acoustic Emission Energy**: the energy released by the acoustic emission event;

(20) **Threshold**: The threshold value used for monitoring data analysis;

(21) **Monitoring area**: the part of the structure monitored by acoustic emission;

(22) **Scope of detection**: part of the object to be detected by acoustic emission technology;

(23) **Felicity effect**: The phenomenon where detectable acoustic emission signals occur when the stress level is lower than the previous one, while maintaining a fixed preset sensitivity threshold.

(24) **Felicity ratio**: The ratio of the stress at the onset of the Felicity effect to the maximum stress applied previously.

(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 triggers data collection from a system channel.

(27) **Kaiser effect:** The phenomenon where no detectable acoustic emission signals occur at a given sensitivity level until the stress exceeds the previously applied threshold.

1.6. RAEM1-6 Acoustic Emission Product Terminology

(1) **Channel**: a path through which acoustic emission signals enter the acquisition card via sensors, amplifiers, and data cables for independent processing;

(2) **Sampling rate**, also known as sampling speed, refers to the number of points an analog-to-digital converter (ADC) samples per second from an analog voltage signal. For example, 10MS/s means it samples 10 million (10^6) points per second.

(3) **Threshold**: A preset threshold in dB. When the amplitude of the collected signal exceeds this threshold, the acoustic emission processor identifies the starting point of the acoustic emission signal.

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

(5) **TCP/IP**, also known as the Network Communication Protocol, is a widely

adopted data transmission protocol in computers.

(6) **AST (Automatic Sensor Testing)** is a technique where sensors emit mechanical pulse signals under voltage excitation, which are then received by adjacent sensors to evaluate their sensitivity.

(7) **ADC**: Analog-to-Digital Converter, which converts analog voltage signals into digital signals.

(8) **Analog filter**: a filter implemented by analog circuit devices;

(9) **Digital filter**: Filters the frequency of the digitized signal. You can choose whether to enable it or not. High pass refers to the lower limit of the frequency domain, and low pass refers to the upper limit of the frequency domain.

(10) **Pre-amplifier**: an electronic amplification circuit that amplifies the weak voltage signal output by the sensor and realizes impedance transformation to adapt to the long-distance transmission of the signal, and outputs the analog signal;

(11) **Coaxial cable**: a signal cable that transmits the output signal of the preamplifier to the acquisition host. The inner layer is a single core wire, and the outer layer is a shielding covering layer. The impedance is generally 75 Ω;

(12) **Acoustic Emission Internet of Things (IoT-AE)**: A network that connects acoustic emission devices to the Internet through acoustic emission sensors and other information sensing devices according to agreed protocols, so as to realize intelligent identification, positioning, tracking, monitoring and management of acoustic emission acquisition systems;

(13) **Capture mode:**

Envelope capture: Identifies the start and duration of an impact signal using thresholds, HDT, HLT, and other parameters.

Continuous acquisition: Identify a collision signal according to the acquisition threshold and acquisition length.

Fixed-length acquisition: The data starts at the threshold trigger time of the acoustic emission signal or the external parameter trigger time, and stops at the sampling length.

(14) **Trigger method:**

Threshold triggering: Primarily designed for capturing transient acoustic emission signals. The system determines whether to record acoustic emission waveform data based on voltage levels. When the channel is in standby mode and the voltage exceeds the preset threshold, recording is initiated, with the duration controlled by the "sampling length" parameter. The threshold is typically set 10-100 dB higher than the noise level, with the specific range adjustable. In engineering practice, 40dB is the standard threshold commonly used.

Software triggering: The system status automatically triggers the process. It starts data collection when awake and stops when dormant. Manual software operation initiates and terminates data collection when in continuous active status.

External triggering: The system collects control waveform data based on external input. Set the "External Trigger Threshold%" parameter to 5-100% of the external measurement range (-10V to +10V).

(15) **System rating**: The system rating level is determined by the size (intensity) and frequency (activity) of the selected parameters. If the collected parameters exceed any specified rating level, they are rated accordingly.

(16) **EET**: The acquisition cutoff time is set within the range of 1μs to 50000μs. When the acoustic emission signal remains above the threshold for an extended period and the predefined hit detection time (HDT) fails to identify the emission parameters, this cutoff time takes effect, setting the 'duration' in the generated parameter row. All subsequent feature parameters are then calculated based on this duration. EET is only applicable to envelope acquisition mode and is not valid for continuous or fixed-length acquisitions.

(17) **HDT (Hit Definition Time)**: Defines the time interval (or impact detection time) in microseconds (μs). The HDT setting ranges from 100μs to 50,000μs (positive integers) and can be directly entered in the text box. This parameter specifies the waiting time interval for impact signals to accurately determine their endpoint. When the set HDT value exceeds the threshold time interval T between adjacent wave packets, both packets are classified as a single acoustic emission impact

signal. If the HDT value is less than the T interval, the packets are separated into two distinct acoustic emission impact signals. For identical signals, a higher HDT setting yields fewer extracted acoustic emission parameters, while a lower setting produces more parameters.

HDT is only effective for envelope acquisition mode, but not for continuous or fixed-length acquisition.

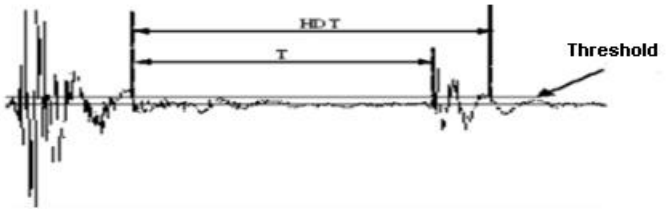


Fig. 1-2 HDT Definition

(18) **HLT (Hit Lock Time)**: measured in microseconds (μs). The adjustable range spans from 100 to 20,000,000 (positive integers), which can be directly entered in the text box. This parameter defines the time window during which the measurement circuit is deactivated to prevent signal capture of reflected or late-arriving waves. Specifically, after the termination of the previous acoustic emission event, a delay period (HLT) is observed before subsequent signals are ignored. The duration of this window is influenced by factors such as signal attenuation and structural dimensions. Excessive HLT settings may result in missed acoustic emission signals. As illustrated in the figure below, even if the next acoustic emission signal at time t has exceeded the threshold, the HLT period remains active, causing the t-period signal to be excluded from acquisition.

HLT is only applicable to envelope capture mode, not to continuous or fixed-length capture.

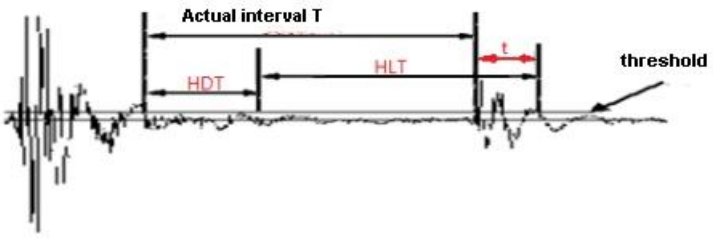


Fig. 1-3 HLT Definition

(19) **Sampling length (us)**: The duration a single frame waveform can record and store. Valid for continuous acquisition mode, with a range of 8ms to 1000ms (Note: When sampling length exceeds 100ms, waveform transmission uses continuous sampling for upload, with the sampling method determined by setting 'continuous sampling time').

(20) **Pre-trigger duration (us)**: Collects data before the acoustic emission signal crosses the threshold. This setting only affects waveform generation and does not influence parameter generation. The envelope capture mode remains active. Maximum 128K data points.

(21) **Sampling duration (us)**: The length of a single frame waveform for fixed-length acquisition. Valid for fixed-length acquisition. The setting ranges from 6ms to 50ms.

(22) **Continuous Sampling Duration (us)**: it is active in continuous acquisition mode for waveform sampling transmission. When the configured sampling interval exceeds the maximum allowable duration for complete frame upload, the system calculates the duration based on the sampling interval. However, waveform data is uploaded starting from the initial acquisition point, with the continuous sampling duration marking the endpoint for waveform feature transmission. (Note: The maximum range is set to 100ms. When configuring this parameter, the value must not exceed the sampling interval.)

2. Product Introduction

The RAEM1-6 acoustic emission system can connect to computers within a local LAN via WiFi or Ethernet, or to a cloud platform through WiFi, Ethernet, or 4G.

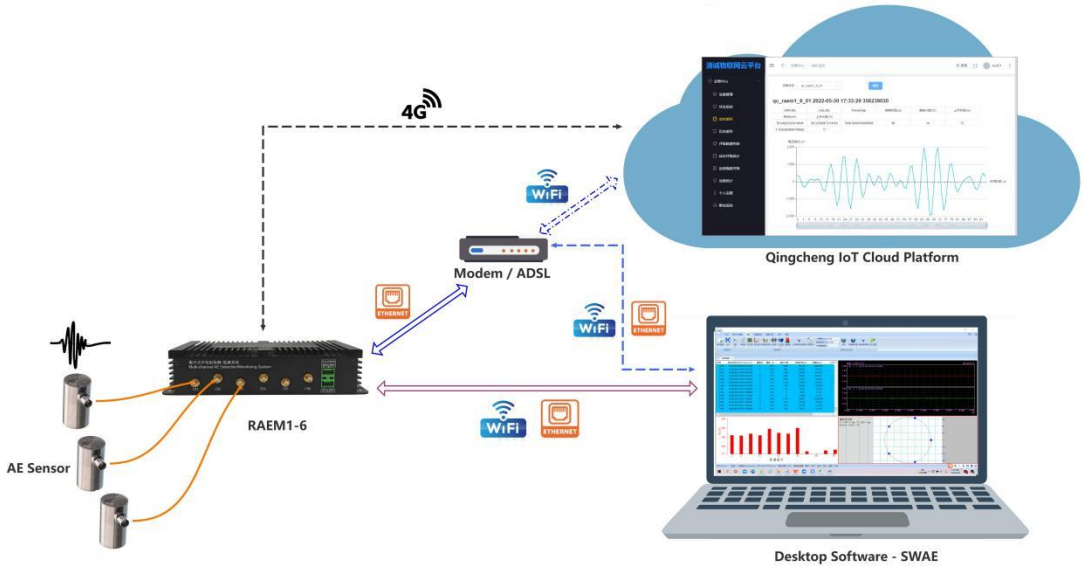


Fig. 2-1 RAEM1-6 Connection Diagram

2.1. About RAEM1-6

RAEM1-6 is a multi-channel intelligent acoustic emission system integrating automatic control signal acquisition, processing and analysis, data storage, clock synchronization and wireless communication. The shell is made of aluminum alloy, which is robust and durable. It can be flexibly configured with 2 up to 6 acoustic emission channels and can be cascaded between multiple devices.

A single RAEM1-6 device can connect up to six acoustic emission sensors with preamplifiers simultaneously, offering gain options of 26dB, 34dB, or 40dB (Note: Each RAEM1_6 device supports only one preamp voltage). The chassis's channel count can also be customized to meet user requirements.

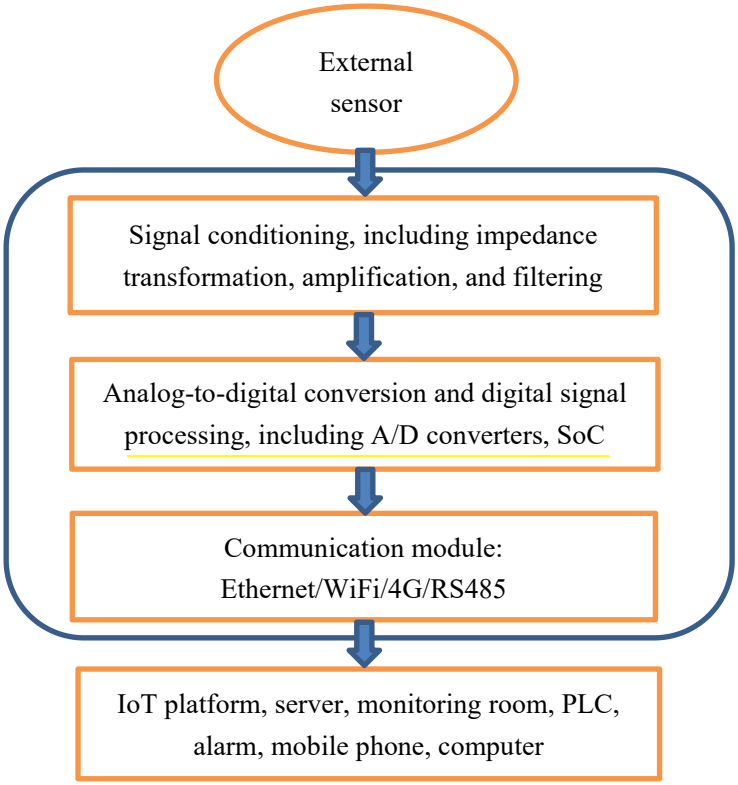


Fig. 2-2 Flowchart of RAEM1-6 Functional Module

2.2. RAEM1-6 Technical Specifications

Channel Combination	Flexible from 2 up to 6 channels per case, or can be cascaded (up to 128 channels)
Trigger Mode	Threshold trigger, external input trigger, software trigger
Sample Mode (Acquisition)	Envelop collection, fixed-length collection, streaming collection
Time Mode	Continuous, Schedule, or Interval timing
Sample Speed/Rate	The maximum sampling rate per channel is 2000,000 points per second (2000kHz)
Sample Resolution	16-bit
Waveform Sample Length	Each channel can support up to 128,000 points per waveform sample length simultaneously, and channels can be set independently.

Waveform Pre-sampling Length	The pre-sampling length can reach up to 128k sample points, and channels can be set independently.
System Noise	Better than 30dB
Dynamic Range	Better than 70dB
Input Bandwidth	10kHz-800kHz (-3dB, pass-through)
Analog Filter	Software selectable (kHz): 20-100kHz/ 20-400kHz/ 70-100kHz/ 70-400kHz/ Pass-through/ Bypassed
Digital Filter	Set any value in between 0 to 1000 kHz frequency range as pass-through/ high-pass/ low-pass/ band-pass filter
Preamp Voltage	28V40dB / 12V34dB / 5V26dB *Note: Non-programmable with factory-set preamplifier voltage; match with the sensors/preamp in the order*
Output Data	Waveform, parameters, parameter ratings
AE Characteristic Parameters	Arrival time, amplitude, (ringing) count, energy, rise time, duration, RMS, ASL, frequency centroid, peak frequency, 5 partial power spectrum
Clock Synchronization	Synchronization options include RS485 (long-distance wired), cascaded (short-distance wired), WiFi (indoor wireless), or GPS (outdoor wireless). Synchronization accuracy within RAEM1-6 is ≤100ns, while the synchronization accuracy between multiple RAEM1-6 can be 500ns or better.
Communication	Ethernet port (Gigabit) / WiFi /4G *Note: Ethernet port is compulsory. Users can add one wireless communication, either WiFi or 4G.*
External Input	Up to 4 inputs, input range from -10V to 10V. Maximum sample rate of 1MHz; external trigger capability.
Alarm Output	2 channels

Temperature Range	-20℃~60℃
Power Input	Rated 24VDC/2A, operating voltage range 9V-36V
Dimension	Length × Width × Height: 23.2cm×12.5cm×5.2cm
Weight	1.25kg

2.3. Hardware Connection

The RAEM1-6 identification is shown in Figure 2-3 and Figure 2-4 below:

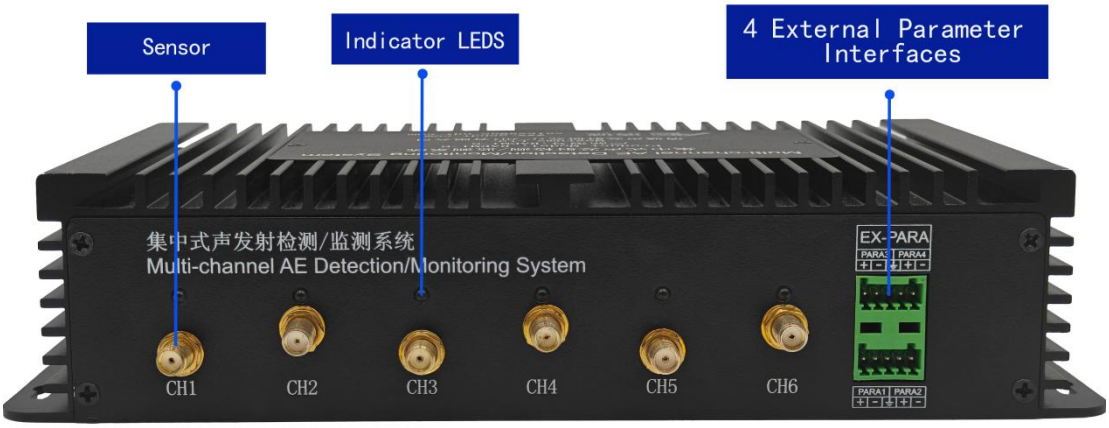


Fig. 2-3 Front view of the RAEM1-6

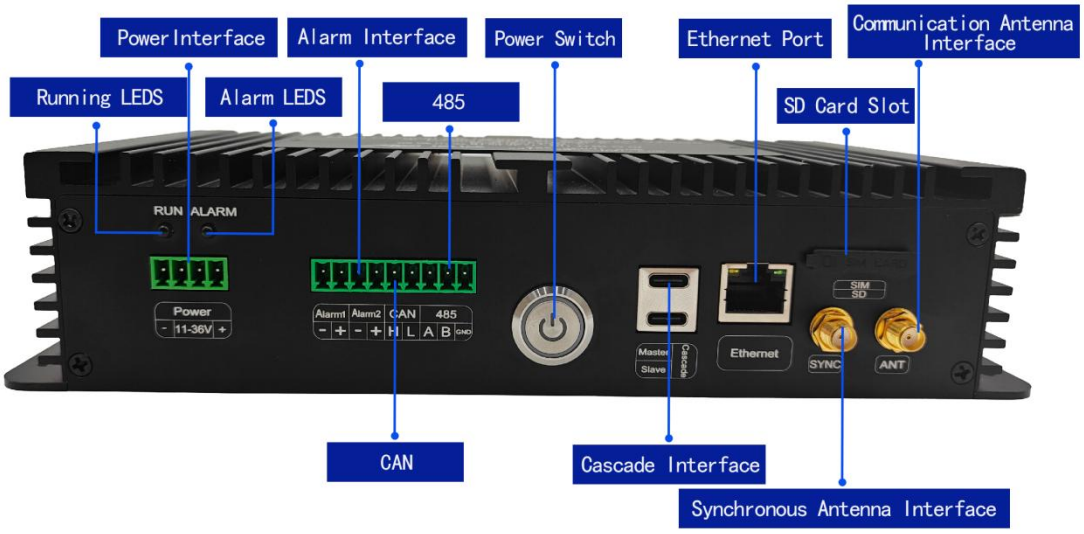


Fig. 2-4 Back view of the RAEM1-6

- **Sensor:** The sensor with built-in preamp or external preamp should be connected to these sensor ports. There are Chanel #1 to #6 from left to right. SMA connectors. Before connecting, please make sure the preamp voltage supplied by RAEM1-6 is matched with the connected preamp.
- **Indicator light:** During acquisition, this LED flashes each time there is acoustic emission signal in that channel.
- **External Parameter Interface**: The external interface is two rows of KF2EDGK-2.54-5P connector (5 Position Terminal Block Header, Male Pins 0.1" (2.54mm)). There are four external input channels for input range from -10V to 10V. For more information, see Chapter 4.3.5.
- **RUN:** The running LED indicates that RAEM1-6 is powered and is running.
- **Power Interface:** The power interface is KF2EDGK-3.81-4P connector (4 Position Terminal Block Header, Male Pins 0.15" (3.81mm)). The input power voltage range is suggested from 11 to 36V.
- **Alarm LED:** After the alarm output is enabled, when there is alarm output signal, the alarm LED will light up once.
- The next big interface is KF2EDGK-3.81-9P connector (9 Position Terminal Block Header, Male Pins 0.15" (3.81mm)). It includes the following functions:
  - **Alarm Interface**: It has two alarm output interfaces, and the alarm circuit uses optocouplers for isolation. It supports three output forms: high level (12V), switching (12V pull-up), and switching (no pull-up). The output hold time setting range is 1μs to 1s, in 1μs increments. (Note: When the alarm output is enabled, the alarm output is triggered when the parameter collected by RAEM1-6 exceeds the set threshold. If the parameter and waveform are collected simultaneously and the parameter exceeds the set threshold, the alarm output time is the length of the complete waveform segment plus the output hold time.) For more information of alarms, see Chapter 4.3.5.

- **CAN:** under developing, not available.
- **RS485:** RS485 is used for long distance clock synchronization of a cascade of multiple RAEM1-6. Select "RS485 Synchronization" as the time synchronization method. Within the local network, select one RAEM1-6 device as the master and other devices as slaves. The slave clocks are synchronized with the master clock.

◆ **Power Switch:** indicates the power status. When the power adaptor is connected to power wall, the power LED is red. When the power button is pressed down, the LED turns green meaning the RAEM1-6 is powered on.

◆ **Cascade Interface:** Type-C connector. It is used for short distance clock synchronization of a cascade of other RAEM1-6. Select "Cascade Synchronization" as the time synchronization method. Within the local network, select a RAEM1-6 as the master and other devices as slaves. The slave clocks are synchronized with the master clock.

◆ **Ethernet Port:** to connect to computer or router for communication.

◆ **Card Slot:** There are two card slots.

- The upper slot is 4G **SIM** (Nano SIM) card slot for 4G communication. See Chapter 6.1 for details.
- The bottom bigger slot is **SD** (TF) card slot. When the RAEM1-6 system crashes, a TF card with the system image file burned into the RAEM1-6 device can be inserted to restore the system to normal operation.

◆ **SYNC:** Synchronization Antenna, using GPS or WiFi.

◆ **ANT:** Antenna for wireless communication, WiFi or 4G.

The connection steps for the RAEM1-6 are as follows:

1) Connect the power cable to the RAEM1-6 power interface, including the KF2EDGK-3.81-4P connector and the power adaptor.
2) Then connect the Ethernet cable to the PC or router.

***Note**: Connect the Ethernet cable to the computer is recommended. Because during initial setup, you may need to modify the configurations using the M1-6 configuration*

software. Refer to Chapter 5.1 for computer Ethernet configuration.

3) Connect the sensors to RAEM1-6. The sensor with built-in preamp or external preamp should be connected to these sensor ports. There are Chanel #1 to #6 from left to right. Before connecting, please make sure the preamp voltage supplied by RAEM1-6 is matched with the connected preamp.
4) Connect the antenna to ANT port (if WiFi or 4G is used).
5) Turn on (press down) the RAEM1-6 power switch and wait for the green RUN indicator to stay on.
6) Open the M1-6 configuration software to modify the RAEM1-6 settings. See Chapter 4 for configurations.
7) Open SWAE or cloud or other display terminals to view and save data.

2.4. Configuration and Software Notes

After the RAEM1-6 device is powered on, it automatically initiates signal acquisition and data transmission based on the existing configuration and hardware connections. The device's current configuration can be viewed and updated through its built-in communication methods.

The factory configuration of RAEM1-6 is the recommended setup, which has passed factory testing. We recommend using it in its default configuration. If you need to change the configuration, save the original factory settings as a configuration file on your computer before making any changes.

To configure the RAEM1-6, use the "**M1-6 Device Configurator**" software. (See Chapter 4)

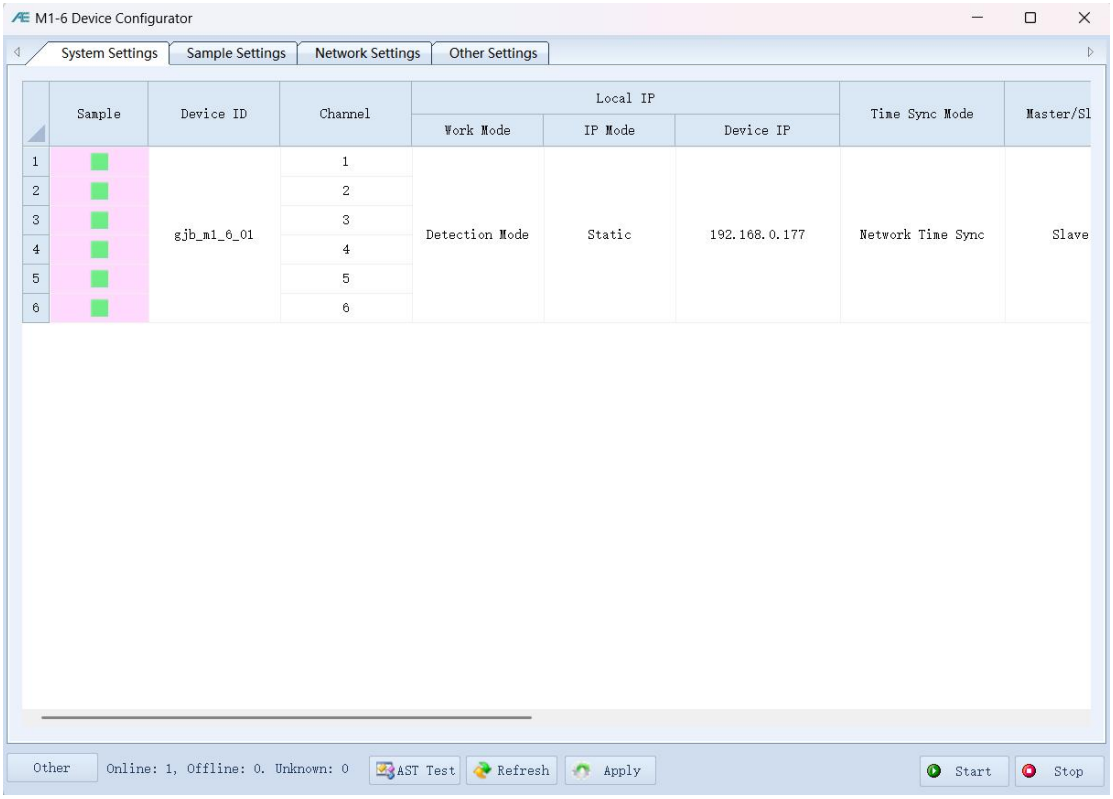


Fig. 2-5 Interface of the RAEM1-6 Configurator

There are two work modes for RAEM1-6, detection mode and monitoring mode respectively.

- **Detection mode**: refers to the function of RAEM1-6 sending data to the SWAE software. In this mode, the parameters and waveform information are complete and not discarded.

Table 2-1 Communication and corresponding software in detection mode for RAEM1-6

Communication	Configuration	View real-time data	Download data
LAN	M1-6 Device Configurator	SWAE software	SWAE software
WiFi (Hotspot)	M1-6 Device Configurator	/	/
WiFi (Router)	M1-6 Device Configurator	SWAE software	SWAE software

- **Monitoring mode**: refers to the function of RAEM1-6 to send data to non-SWAE terminals (cloud platform/server/specific IP address etc.) using MQTT, ISAE,

Modbus, RS485, and TCP transmissions. In this mode, only the parameter group with the largest amplitude within the reporting period of the channel and its corresponding waveform will be sent to the terminals.

Table 2-2 Communication and corresponding software in Monitoring mode for RAEM1-6

Communication	Configuration	View real-time data	Download data
LAN	M1-6 Device Configurator/ Qingcheng IoT Cloud	Qingcheng IoT Cloud	Qingcheng IoT Cloud
WiFi (Router)	M1-6 Device Configurator/ Qingcheng IoT Cloud	Qingcheng IoT Cloud	Qingcheng IoT Cloud
4G	Qingcheng IoT Cloud	Qingcheng IoT Cloud	Qingcheng IoT Cloud

- **M1-6 Device Configurator**: This Windows executable software, developed for RAEM1-6, is accessible via Ethernet. It allows users to configure device information, data acquisition settings, communication, system configurations and others. For detailed instructions and usage, refer to Chapter 5.
- **SWAE software**: this professional acoustic emission analysis software enables real-time display of RAEM1-6 parameters and waveform data. When the RAEM1-6 is configured well to send data to SWAE software, the data display management is in the SWAE. For operations in SWAE, please see SWAE user manual.
- **Qingcheng IoT Cloud Platform**: This is an independently developed cloud platform specifically designed for Qingcheng's IoT products. The RAEM1-6 requires network connectivity (e.g., 4G or WiFi router) to access the internet. After logging into the platform, users can remotely configure the RAEM1-6, monitor real-time parameters, waveform data, and rating metrics, and download uploaded data from the device to the Qingcheng IoT Cloud Platform.

3. Notes Before Software Usage

1) The firewall must be disabled when using M1-6 configuration software or SWAE software.

① Open the Advanced Security Windows Defender Firewall.

② Open Windows Defender Firewall Properties.

③ Under the Domain Profile, change Firewall Status to Off.

④ Repeat step 3 under "Private Profile" and "Public Profile".

⑤ Click OK.

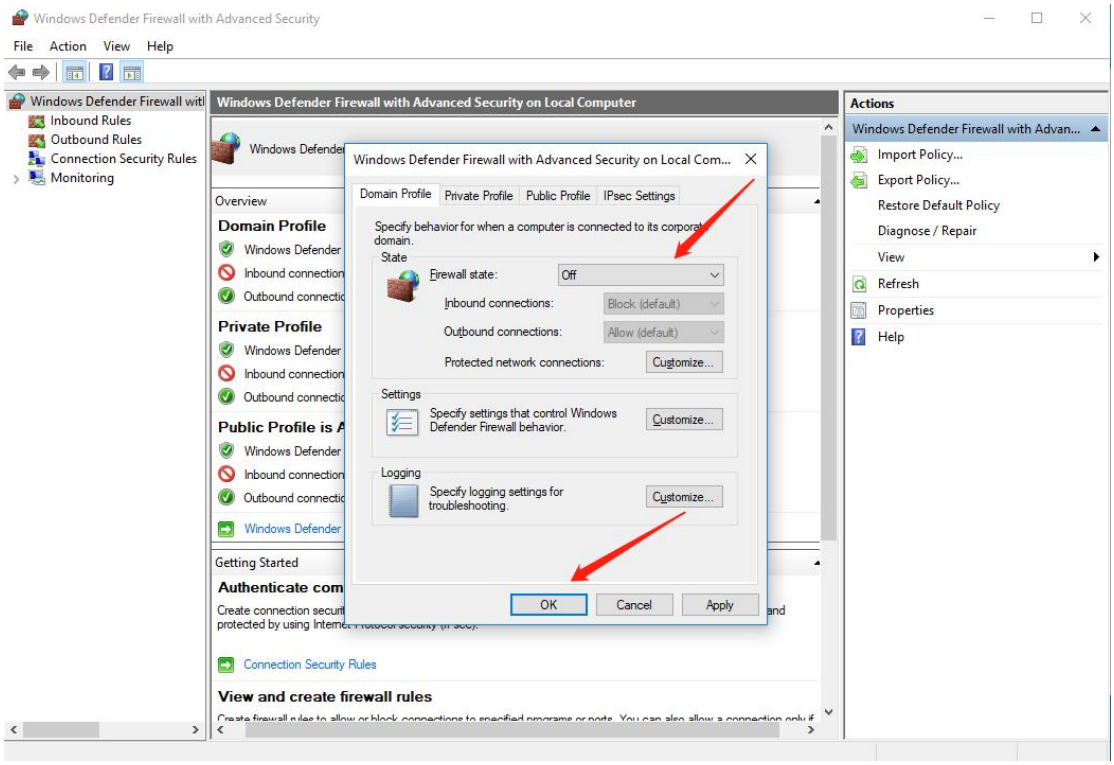


Fig. 3-1 Disable the firewall

2) Install M1-6 Configuration software

Extract and open the M1-6 configuration software folder, then double-click to run "M1-6SettingsTool.exe".

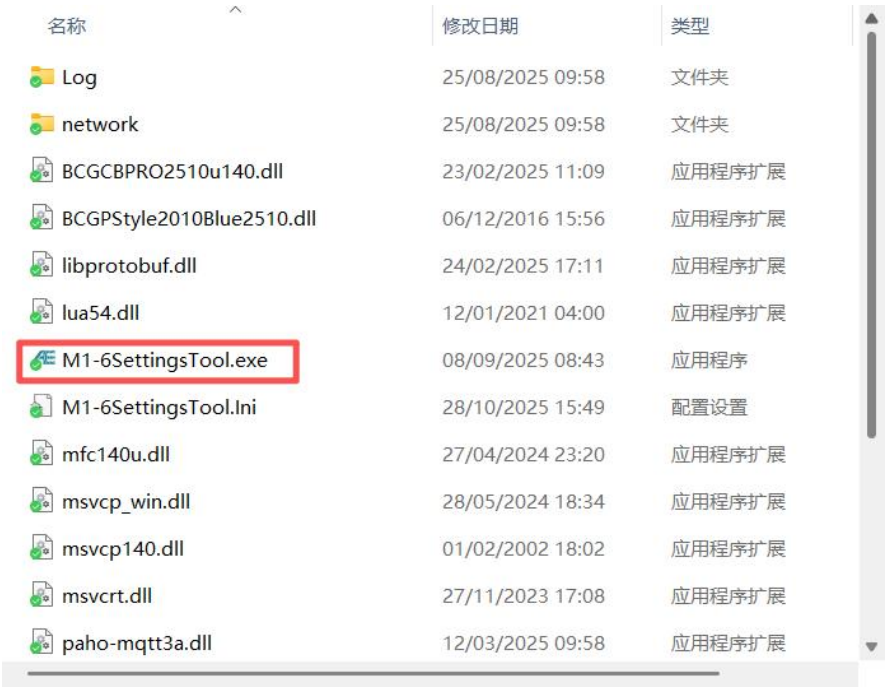


Fig. 3-2 RAEM1-6 Configuration software executable file

The basic M1-6 configuration software operates as follows:

① When you start up, a network permission prompt may appear. Make sure to check both the private network and public network boxes, then click Allow Access. See the figure below:

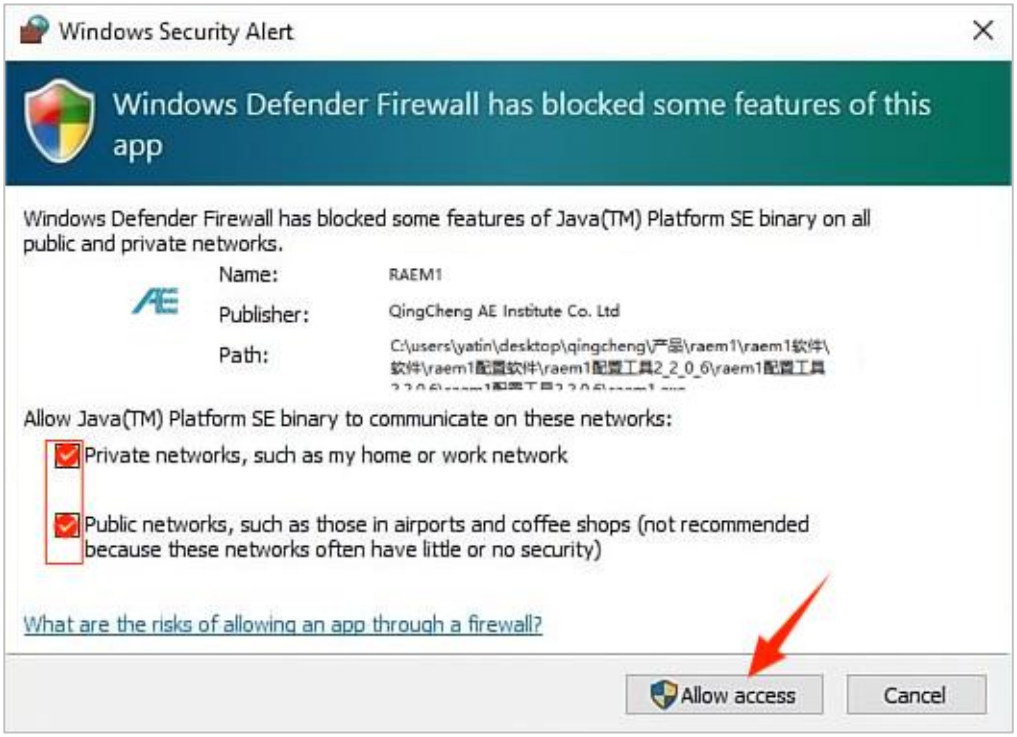


Fig. 3-3 Firewall Configuration

4. M1-6 Configurator Software

4.1. Software Configuration Guide

The M1-6 configuration software is a Windows application developed for RAEM1-6 configurations. After powering RAEM1-6, users can open the software to perform configuration and debugging.

But for the first time connection, please follow Chapter 5.1 or 5.2.1 using Ethernet cable or Hotspot mode to communicate RAEM1-6 and the computer.

When the device is connected to the M1-6 Configurator software successfully, it will be like Figure 4-1. When the device is offline, the screen will be like Figure 4-2 with "Offline" indication next to the device ID.

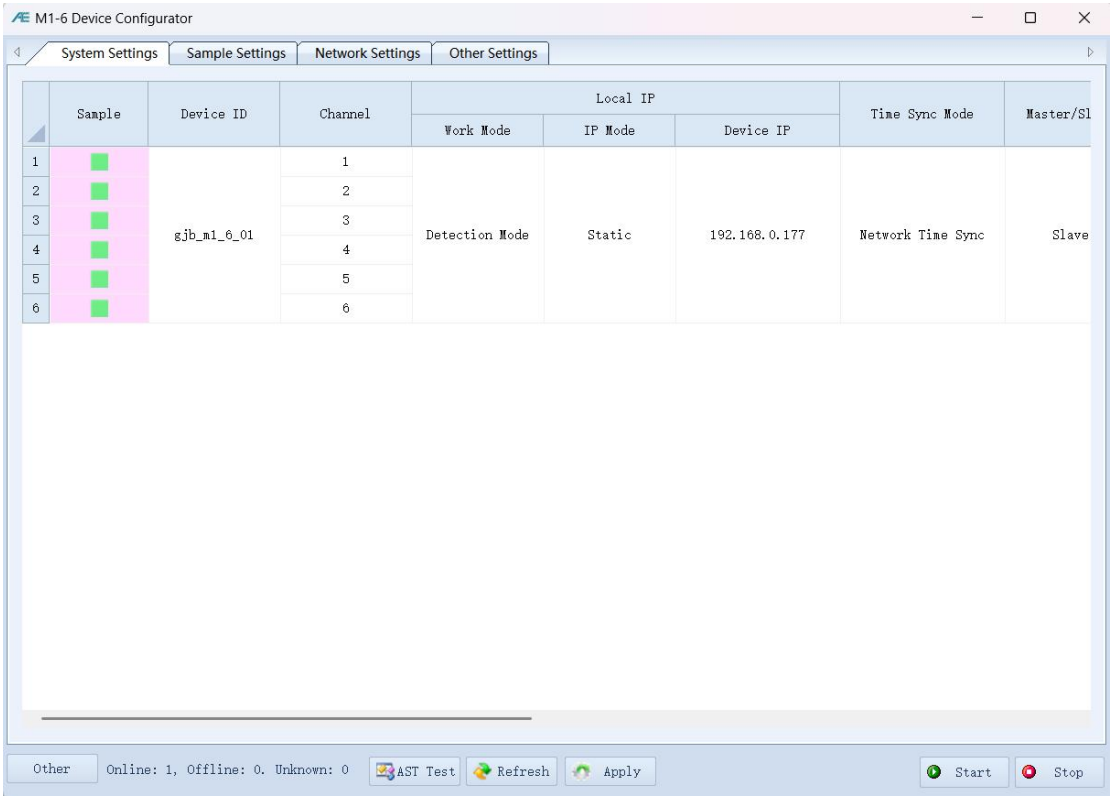


Fig. 4-1 Device is connected to configuration

The color of the collection bar indicates the device status:

① The configuration software interface of RAEM1-6 is shown in Figure 4-1. The system comprises four main sections: System Settings, Sample Settings, Network Settings, and Other Settings.

- "**System Settings**": displays device configuration details, allowing adjustments to IP mode, synchronization methods, master-slave configurations, and reboot functions.
- "**Sample Settings**": includes channel configuration, waveform parameters, FFT settings, and external parameter configurations.
- "**Network Settings**": covers U3H protocol, TCP, Alibaba Cloud, Azure, RS-485 communication, and MQTT.
- "**Other Settings**": provides real-time access to data collected within the last 10 seconds.
- **[AST Test]** button performs automatic sensor testing to verify channel sensitivity and coupling status.
- **[Refresh]** button to re-read all the current configurations. Users can use it to check if the modified configurations have been successful.
- **[Apply]** button at the bottom of the interface sends modified configurations to the RAEM1-6 device and apply them immediately.
- **[Start]** and **[Stop]** buttons are to control the data acquisition of the RAEM1-6. But it should be used with the selection under [Sample Settings]. See detail operations below.
- **[Other]** button in the lower-left corner offers additional functions including file conversion, language selection, and configuration file management. You can also switch the software's display language between Chinese and English. After selecting your preferred language, you'll need to click **[Reboot]** above the [About] button to automatically update the display language.

② The software will automatically detect and display the available RAEM1-6 devices. If the target RAEM1-6 cannot be detected or connected, check the power and the network settings of your computer. Please make sure the software and the

RAEM1-6 is in the same network. For Ethernet connections, see Chapter 5.1. For other methods like WiFi routers, troubleshoot according to Chapter 5.2. When the device loss connection from the software, it will be like Figure 4-2, the background of Device ID box will turn from white to orange.

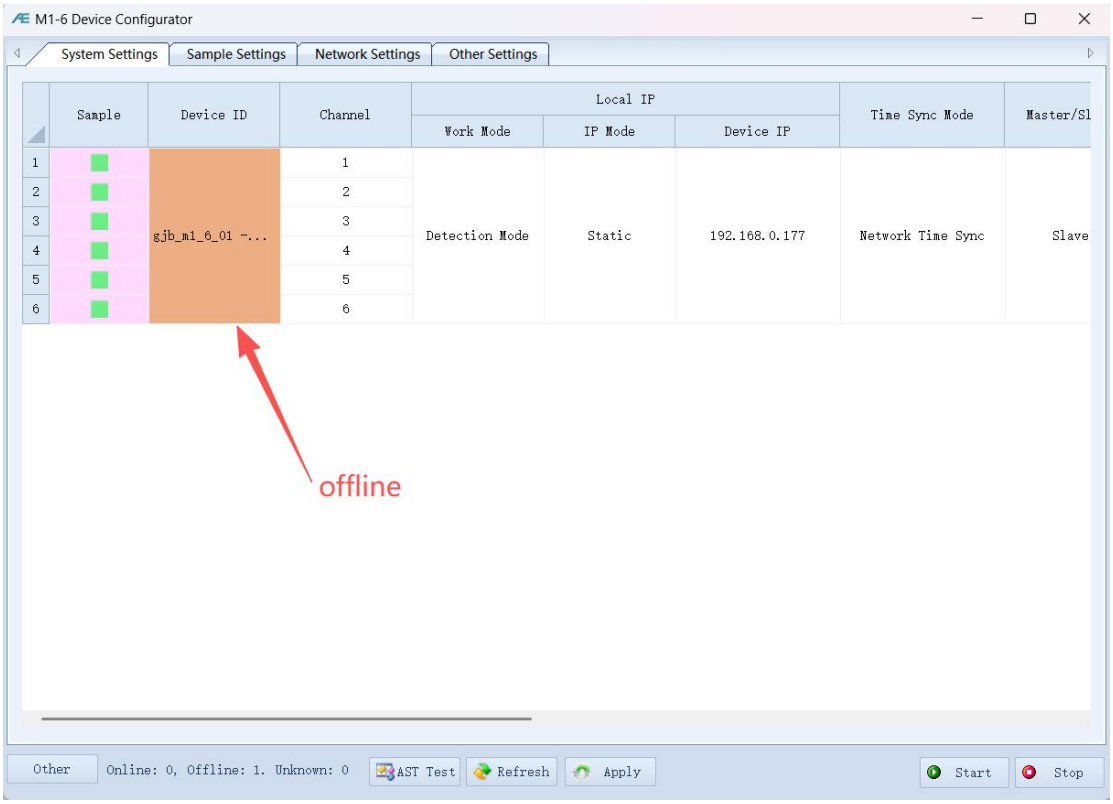


Fig. 4-2 Device is offline

③ To modify device parameters, select the settings to adjust. (**Batch operation**: click the name of the current column to select **[Set Current Column]** to set the whole column with the first row value). Finally, click **[Apply]**.

4.2. System Settings

Function Description:

✧ **Sample**: the box color indicates the acquisition status of the channels. Green means it has started data acquisition. Yellow means the acquisition has stopped.

✧ **Device ID**: the device ID of the RAEM1-6. It cannot be modified.

✧ **Channel**: the channel number of the RAEM1-6 device. It should be corresponds to the actual number in the hardware.

✧ **Work Mode**: There are two work modes: Detection mode and Monitoring mode. (Note: The device needs to be rebooted to take effect after changing the work mode)

- **Detection mode** enables local data collection and transmits the data to SWAE software using the U3H protocol.
- **Monitoring mode** transmits collected data to the terminals using not U3H protocols.

✧ **IP mode**: is divided into static and dynamic. (Note: after modification, the device needs to be rebooted to take effect)

- **Static**: by default, the IP address of Ethernet connection is set as static, such as 192.168.0.xx.
- **Dynamic**: set to "Dynamic" means the IP address is dynamically obtained from the connected router.

✧ **Time Sync Mode**: Time synchronization methods include cascade synchronization, Network Time Sync, RS485 Synchronization, GPS Synchronization, and Wi-Fi Synchronization.

- **Cascade synchronization**: When multiple RAEM1-6 units are connected in series via cascade lines, one unit acts as the master while others serve as slaves. During synchronization, the slave units adopt the master's clock as the reference time.
- **Network time synchronization** is performed using the connected network's reference clock.
- For **RS485 synchronization**, use the RS485 interface to connect the RAEM1-6 units together. Select a RAEM1-6 as the master device in the local

network, with other devices as slaves. The slave clocks are synchronized with the master clock.

- **WiFi synchronization** uses the wireless master device in the WIFI network as the control subject. It sends synchronization sequence beacons containing synchronization time identifiers and data packets to several wireless slave devices in the target device group through wireless directional broadcasting in a specific wireless mode.

- **Satellite navigation synchronization** (compatible with GPS, Beidou, and other systems) utilizes GPS satellite signals to obtain standard timestamp information from navigation satellites, thereby achieving system synchronization.

✧ **Master/Slave** devices means the role during multiple unit network and time synchronization. Only one unit acts as the master while others serve as slaves. During synchronization, the slave units adopt the master's clock as the reference time. (After modifying the master and slave devices, the device must be rebooted to take effect.)

✧ **Time Config**: click [Sync Time] to set the local time and synchronize it to the device based on the synchronization method.

✧ **Software Ver**: actually is the firmware in the RAEM1-6 unit.

✧ **Firmware Update**: for firmware upgrade of the device. Click the button to start the update. Select the firmware package with the file format of "**.tar.gz**". Select the compressed pack and click [Open]. The device will automatically update the firmware and reboot. Please don't interrupt the process and wait until the device is back online again. Then you can **[Refresh]** the firmware version number to check if the update is successful.

✧ **Wireless Mode**: include Hotspot mode and Router mode. See Chapter 5.2 for connection details.

- **Hotspot mode**: RAEM1-6 (WiFi version) by default emit a Hotspot for computer to connect. Once your computer detects this hotspot, simply connect to it to configure the device.
- **Router mode**: the RAEM1-6 can also connect to external WiFi router in Router mode. Enter the WiFi Router name and password next to the "Router Mode" and click "**Apply**" to send to RAEM1-6. It also need to reboot to take effect. After rebooting, make sure the computer and the RAEM1-6 are in the same WiFi network.

✧ **Restart**: software restart/reboot the RAEM1-6.

4.2.1. AST Test

The automatic sensor calibration (AST, Auto Sensor Testing) employs pulse transmission functionality. After emitting a pulse signal through one channel, it monitors signal reception across all channels to verify connectivity, sensor coupling status, and sensitivity. It is recommended to maintain adequate spacing between sensors and set higher thresholds to prevent noise interference from affecting statistical analysis. For example, in steel materials, the distance between sensors should exceed 30cm.

- **Width (us)**: The duration of a single pulse, selectable between 1 and 20, in μs;
- **Interval (ms)**: The time interval between two consecutive pulse groups (where one channel emits a specific number of pulses). This parameter is set to prevent echo interference, with twenty options available between 50 and 1000ms.
- **Number**: the total number of pulse from the start to the end of one cycle transmission at the set interval time.
- **Channel Select**: This option allows you to choose which channel for transmitting pulse signals. All selected channels will receive pulse signals. Selecting "All Channels" means all channels will both transmit and receive pulse signals. The

following displays the number of available channels, and you can select from these options.

- **Cyc Emission**: This mode continuously repeats sending pulse signals. If a single channel is selected, this channel will continuously emit pulses. If all channels are selected, all channels trigger sequential emission and then repeat in cycles. Check this option as needed.
- **Start**: Click the button to initiate pulse transmission.
- **Stop**: Click the button to stop the pulse transmission immediately.
- **Clear Data**: Click this button to clear the completed self-calibration data for the next self-calibration task.
- **Exit**: Click the button to close the window.

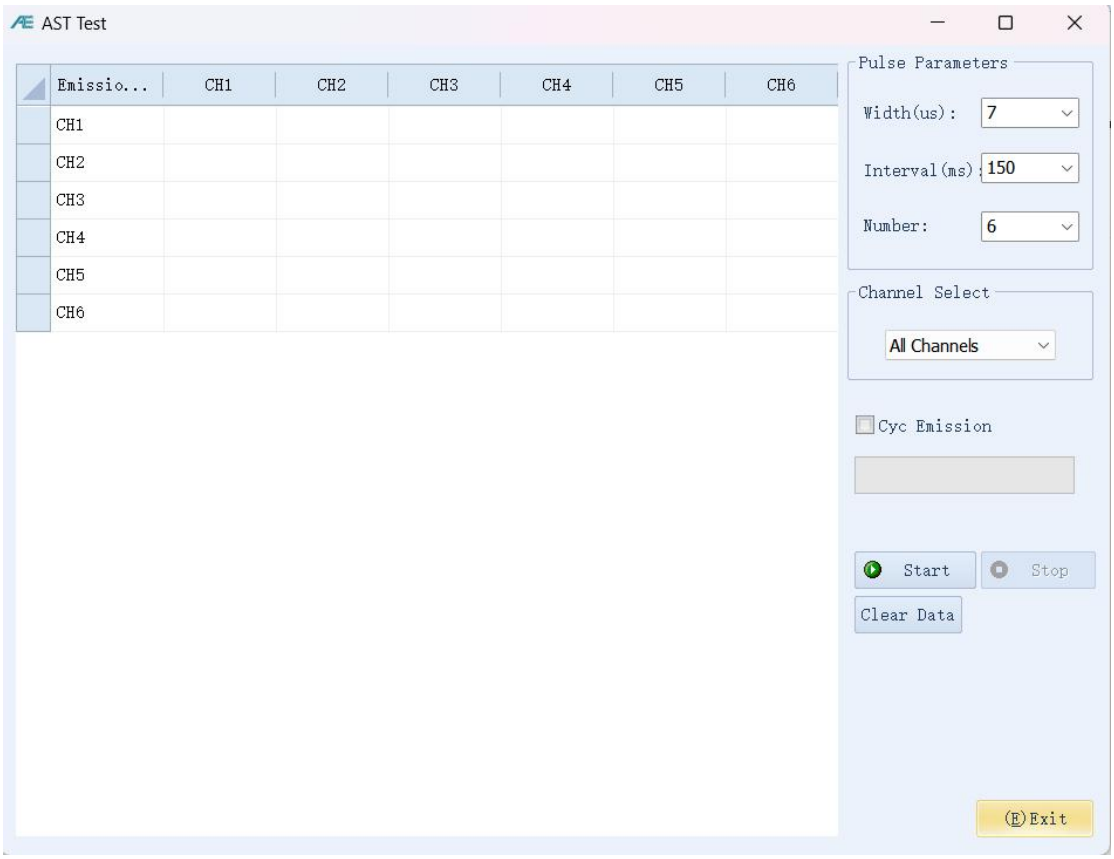


Fig. 4-3 AST Test

4.2.2. Firmware Upgrade

The firmware upgrade package contains 1 file:

- M1-2M-6_xxxx-xx-xx_update.tar.gz

Click the [Firmware Update] button to upload the M1-2M-6_update.tar.gz file. The system will automatically update and restart after the upload. Do not power off or restart manually during the process. (Note: Do not upload .img files.)

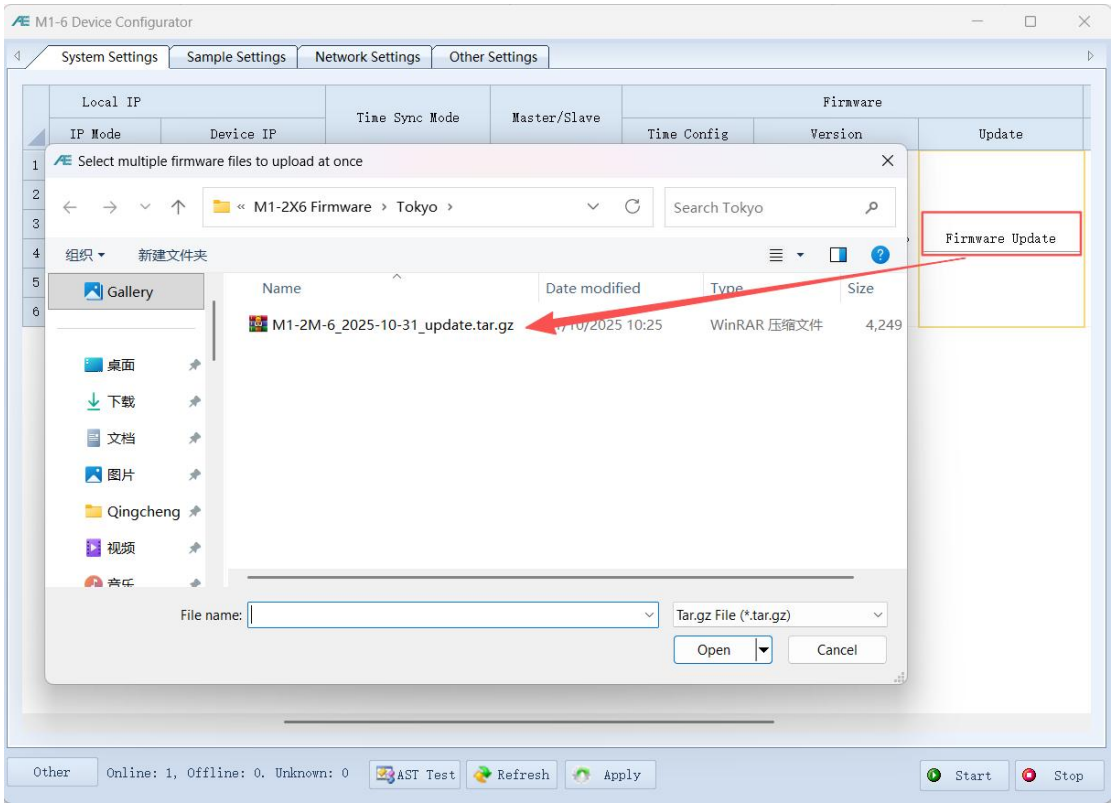


Fig. 4-4 Firmware update upload

4.3. Sample Settings

The **[Sample Settings]** page includes channel settings, waveform settings, parameter settings, FFT settings, and external parameter settings.

4.3.1. Channel Settings

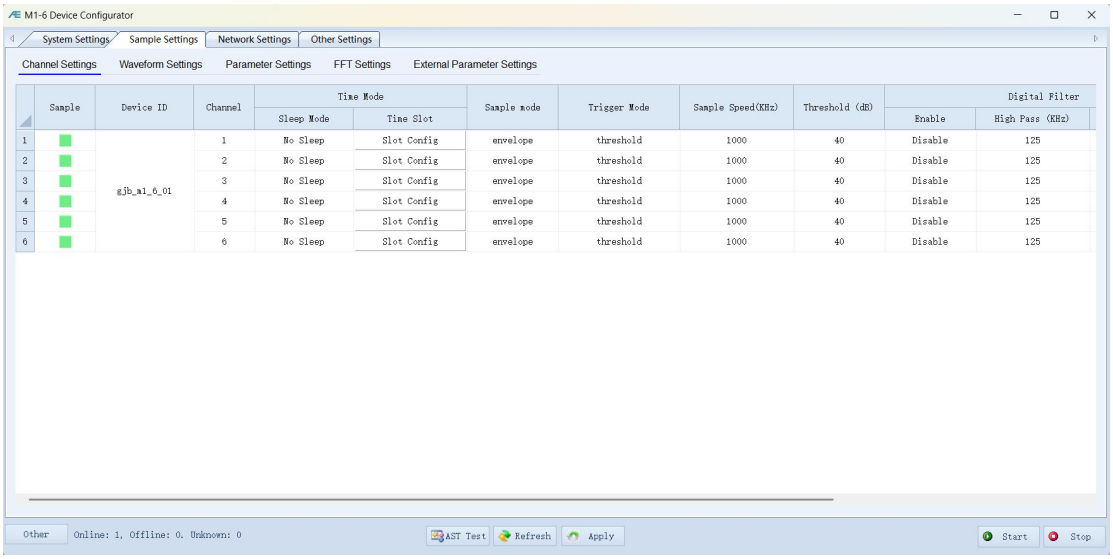


Fig. 4-5 Channel Settings Page

The channel configuration page allows setting the time mode, acquisition mode, trigger method, sampling rate, threshold, digital filter, sensor power switch, and analog filter for RAEM1-6.

Time Mode

There are three time modes: no sleep, scheduled sleep, and interval sleep. The default configuration is no sleep. The time mode determines when data collection starts and how long it lasts.

- **No Sleep**: RAEM1-6 remains active and ready for data collection.
- **Scheduled Sleep** (under development): The system will enter hibernation mode according to user-defined time periods. It supports configuring different time slots for data collection with minute-level precision.
- **Interval Sleep**: Set collection intervals and duration (takes effect after device restart).
  - **Low-power sampling interval (s):** Valid during interval sleep mode. The device enters low-power sleep mode at the set time.
  - **Low-power sampling duration (s):** Valid during interval sleep mode. Set the duration time for device collection.

Steps: Click to select the sleep mode, then click **"Time Slot" >> "Slot Config"** to configure low-power sampling intervals, low-power sampling duration, number of cycles. The "Start sample time" and "Stop time" features are under development and cannot be set yet.

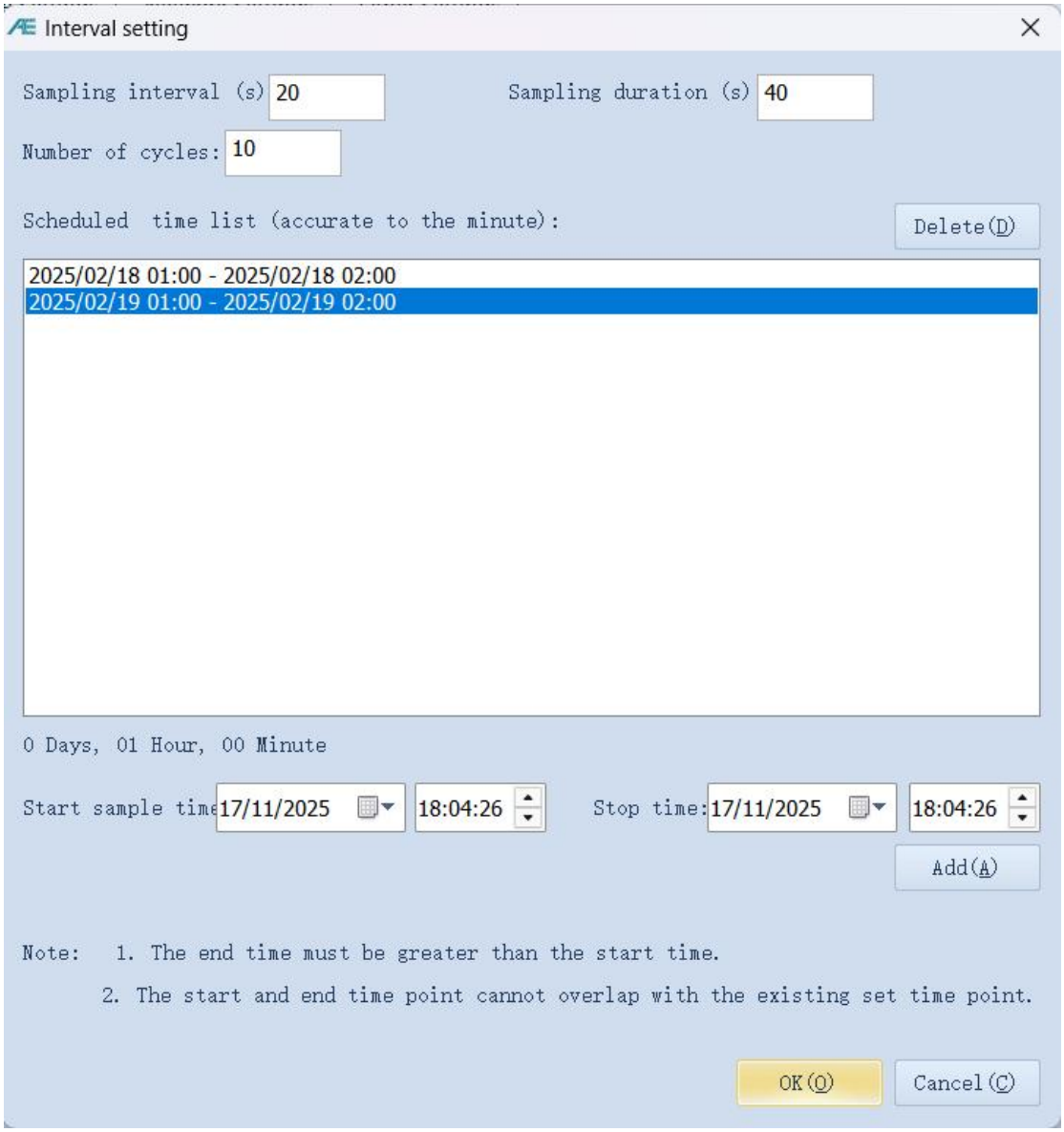


Fig. 4-6 Interval Sleep Settings

Sample Mode

There are three collection modes: envelope collection, fixed-length collection, and streaming collection. The default configuration is **envelope** collection.

- **Envelope**: the envelop acquisition involves extracting envelop shape

waveform signals. An effective acoustic emission signal is identified and captured through parameters such as threshold, EET, HDT, and HLT. When selecting envelope acquisition, the system identifies the start of each acoustic emission impact signal based on predefined thresholds and parameters, then captures and stores the data.

- **Fixed-length** acquisition: The data starts at the threshold trigger time of the acoustic emission signal or the external parameter trigger time, and stops at the predefined sampling length.
- **Streaming** acquisition: initiates when triggered by the threshold, or external inputs, or software (either manual operation or automatic system wake-up). The process terminates when the user issues a stop command or when the system enters sleep mode after wake-up in time-based configurations. Typically, during these operational phases, multiple fixed-length data segments are seamlessly concatenated to generate continuous waveform data, also referred to as waveform stream data.

Trigger Mode

There are three triggering methods: threshold triggering, software triggering, and external parameter triggering.

- **Threshold** triggering: Primarily designed for capturing transient acoustic emission signals. The system determines whether to record acoustic emission waveform data based on voltage levels. When the channel is in standby mode and the voltage exceeds the preset threshold, recording is initiated, with the duration controlled by the "sample length". The threshold is typically set higher than the noise level, with the specific range adjustable between 10 and 100 (integer values). In engineering practice, 40dB is commonly adopted as the standard threshold.
- **Software** triggering: The system status automatically triggers the process. It starts data collection when awake and stops when dormant. Manual software operation initiates and terminates data collection when in continuous active

status.

- **External parameter (Ext-param)** triggering: The system collects control waveform data based on external inputs. Set the **"External Parameter Settings" >> "Ext. Trigger Threshold%"** to 5-100% of the external measurement range (-10V to +10V).

Note: the software and external trigger modes are only available when the "Sample Mode" is not "Threshold" trigger.

There are more than 20 different modes in combination of time mode, sample mode, and trigger method. For example, set the time mode to "No Sleep". Modify the sample mode and trigger method:

- **No Sleep + fixed-length sampling + software trigger**: a fixed length of sample is collected only once when the user start acquisition in software.
- **No Sleep + fixed-length sampling + threshold trigger**: a fixed length of samples are collected after exceeding the threshold;
- **No Sleep + streaming sampling + threshold trigger**: After the threshold is exceeded for the first time, the system continues to collect data. Even if the threshold is not exceeded in the middle, the data will still be collected. The system will stop only when the user stops the collection.
- **No Sleep + streaming sampling + software trigger**: data collection continues when the user start acquisition and until the user stops in the software.

Sampling Speed (kHz)

Supports up to 2000kS/s (=kHz), minimum is 200kS/s. This value indicates the maximum number of data points per second that the channel can capture during acoustic emission signal acquisition. For example, a setting of 1000 (kS/s) means the channel can capture up to 1000k data points per second. A higher setting improves signal accuracy and also increases data volume. It is recommended to set it to approximately 10 times the upper frequency limit of the target frequency range.

Threshold (dB)

Set the preset threshold in dB. When the collected signal amplitude exceeds this threshold, the acoustic emission processor identifies the starting point of the acoustic emission signal and start the data acquisition.

Digital Filter

Apply frequency filtering to the digitized signal. You can choose whether to enable it based on actual conditions. The "High Pass" column sets the lower frequency limit, and the "Low Pass" column sets the upper frequency limit.

- **Band-pass** digital filter setting: set the high-pass and low-pass to any values.
- **Pass-through** digital filter setting: disable the digital filter.
- **Low-pass** digital filter setting: High-pass option set to 0, low-pass option set to the user's desired value.
- **High-pass** digital filter setting: Low-pass option set to 1000, high-pass option set to the user's desired value.

Preamp Power

All the channels output the same phantom power voltage to the preamp. The output voltage is hardware fixed and is determined when ordering with the selection of the sensor and preamplifier. It can be 28V/12V/5V.

Analog Filter

The analog filter processes the analog voltage signal before the ADC converter, allowing the selection of appropriate filter combinations based on actual field conditions. The analog filter selection should be determined by considering both the sensor's frequency response and the target signal frequency range.

- **20kHz~100kHz / 20kHz~400kHz / 70kHz~100kHz / 70kHz~400kHz**
- **Pass-through**: allow all frequency signals pass, no filtering;
- **Bypassed**: Disconnect the analog filter, which can be used to detect whether the circuit has a problem other than the analog filter.

4.3.2. Waveform Settings

The waveform settings page allows configuration of sampling length, preamble length, fixed sampling length, and continuous sampling duration for RAEM1-6.

Note: To modify the settings, select the channel number by checkbox on the left first.

The “Sample" column displays green for active collection and yellow for paused collection. After checking the boxes on the left, you can change the start or stop the acquisition status by pressing the “Start” or “Stop” button at the bottom right corner of the window.

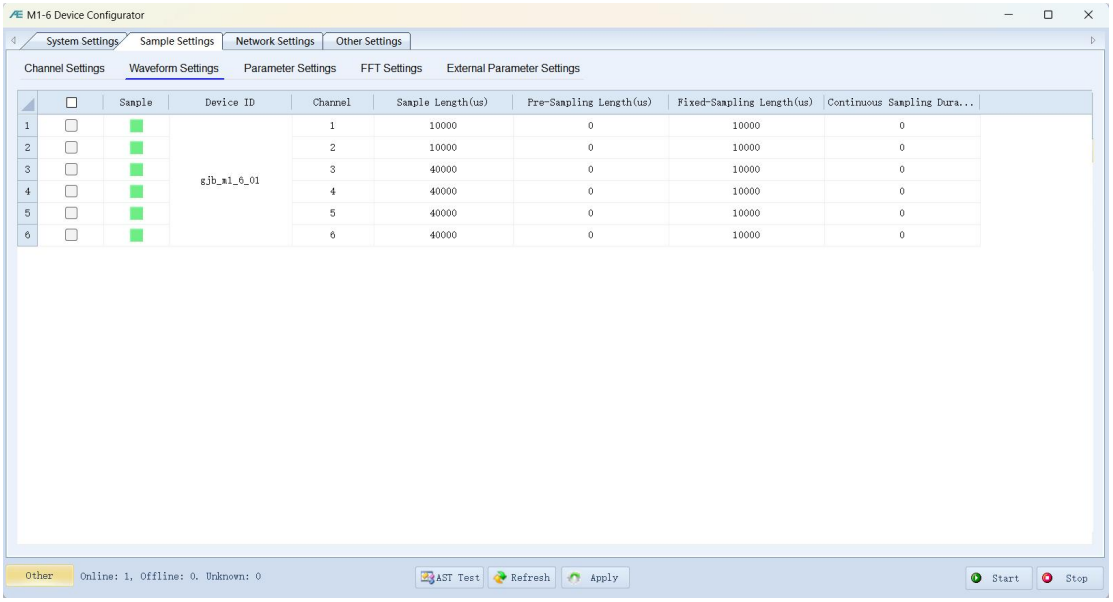


Fig. 4-7 Waveform Settings Page

- **Sampling Length (us)**: The duration a single frame waveform can record and store. Valid for the “Streaming" sample (acquisition) mode, with a range of 6ms to 1000ms (Note: When the sampling length exceeds 100ms, only the first section of this waveform will be uploaded and the uploaded waveform length is determined by the 'Continuous Sampling Duration (us)' below. But the parameter calculation includes the whole sampling length).
- **Pre-Sampling Length (us)**: Collect data before the acoustic emission signal crosses the threshold. This setting only affects waveform generation and does

not impact parameter generation. Valid for the "Envelop" sample (acquisition) mode. Maximum is 128,000 points = sample speed x pre-sampling length.

- **Fixed-Sampling Length (us)**: The length of a single frame waveform for fixed-length acquisition. Valid for the "fixed-length" sample (acquisition) mode. The setting ranges from 6ms to 50ms.
- **Continuous Sampling Duration (us)**: Valid for the "Streaming" sample (acquisition) mode for waveform transmission. When the sampling length exceeds 100ms, only the first section of this waveform will be uploaded and the uploaded waveform length is determined by the 'Continuous Sampling Duration (us)'. (Note: The maximum range is set to 100ms. When configuring this parameter, the value must not exceed the Sampling Length.)

4.3.3. Parameter Settings

The parameter settings page allows configuration of HDT, HLT, EET, and rating parameters for RAEM1-6 in "Envelope" mode. Note: To modify the settings, select the channel number by checkbox on the left first.

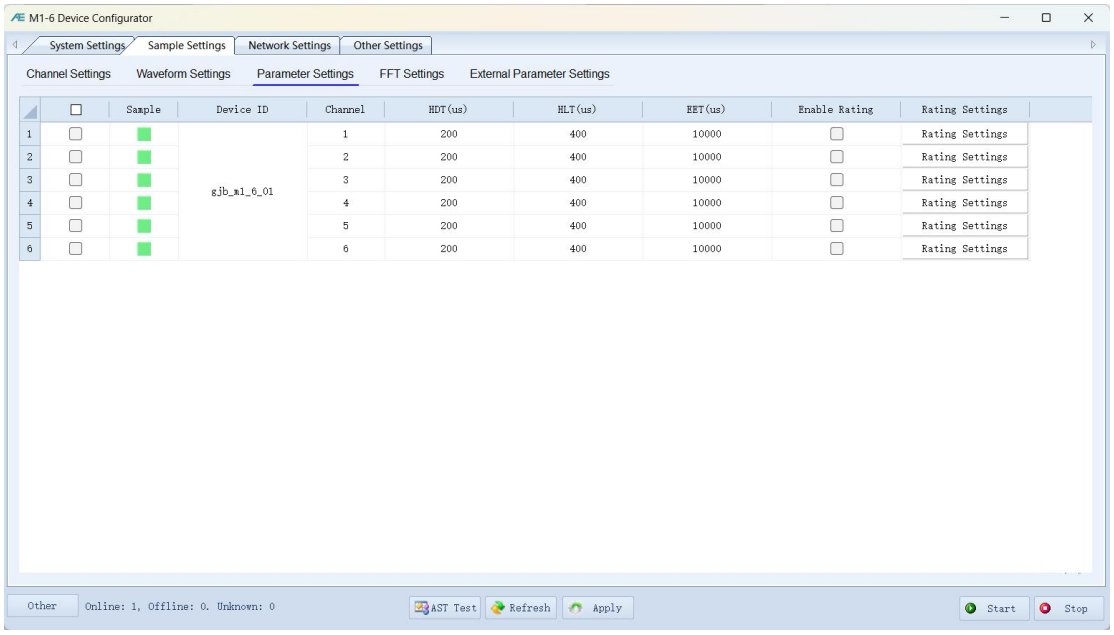


Fig. 4-8 Parameter Settings Page

- **HDT** (Hit Detection Time): impact detection time in microseconds (μs). The HDT setting ranges from 100 to 50,000 μs (positive integers) and can be directly entered in the text box. This parameter specifies the waiting time interval for impact signals to accurately determine their endpoint. When the set HDT value exceeds the threshold time interval T between adjacent wave packets, both packets are classified as a single acoustic emission impact signal. If the HDT value is less than T, the packets are divided into two separate acoustic emission impact signals. For identical signals, a higher HDT setting yields fewer extracted acoustic emission parameters, while a lower setting produces more parameters. HDT is only applicable to Envelope acquisition mode and is invalid for Streaming or Fixed-length acquisitions.

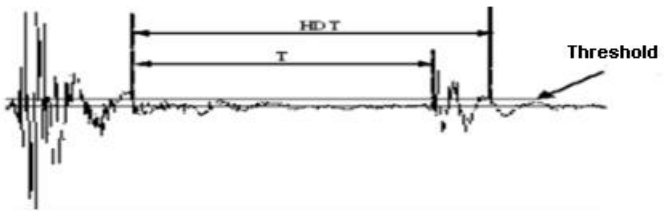


Fig. 4-9 HDT Definition

- **HLT**: Hit Lock Time, measured in microseconds (μs), abbreviated as HLT. The adjustable range from 100 to 20,000,000 (positive integers) and can be directly entered in the text box. This parameter defines the time window during which the measurement circuit is deactivated to prevent signal capture of reflected or late-arriving waves. Specifically, signals from the HDT period after the previous acoustic emission event are ignored during the remaining HLT duration. The set value is influenced by factors such as signal attenuation and structural dimensions. Excessive HLT settings may cause missed subsequent acoustic emission signals. As illustrated in the figure below, even if the next acoustic emission signal in time period t has exceeded the threshold, the HLT period remains active, resulting in signal omission. HLT is only applicable to Envelope acquisition mode and is invalid for Streaming or Fixed-length acquisitions.

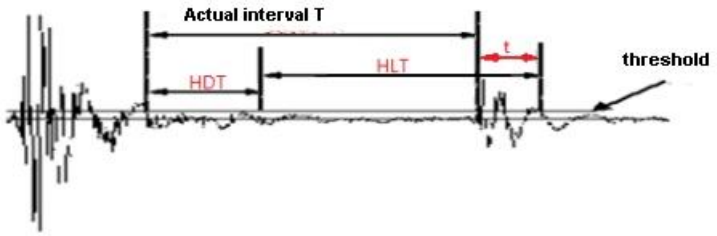


Fig. 4-10 HLT Definition

- **EET:** The enforced end time (EET) is measured in microseconds (μs) with a range of 1-50000μs. When the acoustic emission signal remains above the threshold for a sustained period, and the preset Hit Detection Time (HDT) fails to identify the emission parameters, this EET activates as the 'Duration' in the generated parameter row. All subsequent feature parameters are then calculated based on this duration. EET is only applicable to Envelope acquisition mode and is invalid for Streaming or Fixed-length acquisitions.

4.3.3.1. Rating Settings

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

The rating system comprises eight parameters: amplitude, ASL, energy, duration, counts, rising count, rising time, and RMS. After establishing the rating criteria, the final evaluation is determined by comparing the intensity (parameter values) and activity (occurrence rate) of collected data over a specified period against the predefined thresholds (conditions).

In the **Sample Settings >> Parameter Settings**, check the "**Enable Rating**" checkbox and click "**Rating Settings**" button.

- **Statistical time(s)**: study the data within this duration and provide intensity, activity and comprehensive results based on intensity and activity rules. The unit

is seconds, with a default of 20 seconds.

- **Report level**: Select no report or report a specific intensity level. If you select report level 1, the alarm will trigger only when the intensity is level 1 or higher.
- **Min report interval(s)**: The system will not report alarms of the same intensity level within this minimum report interval after the first alarm. However, if an alarm of higher intensity occurs within this interval, the system will report it. The default is 10 seconds.

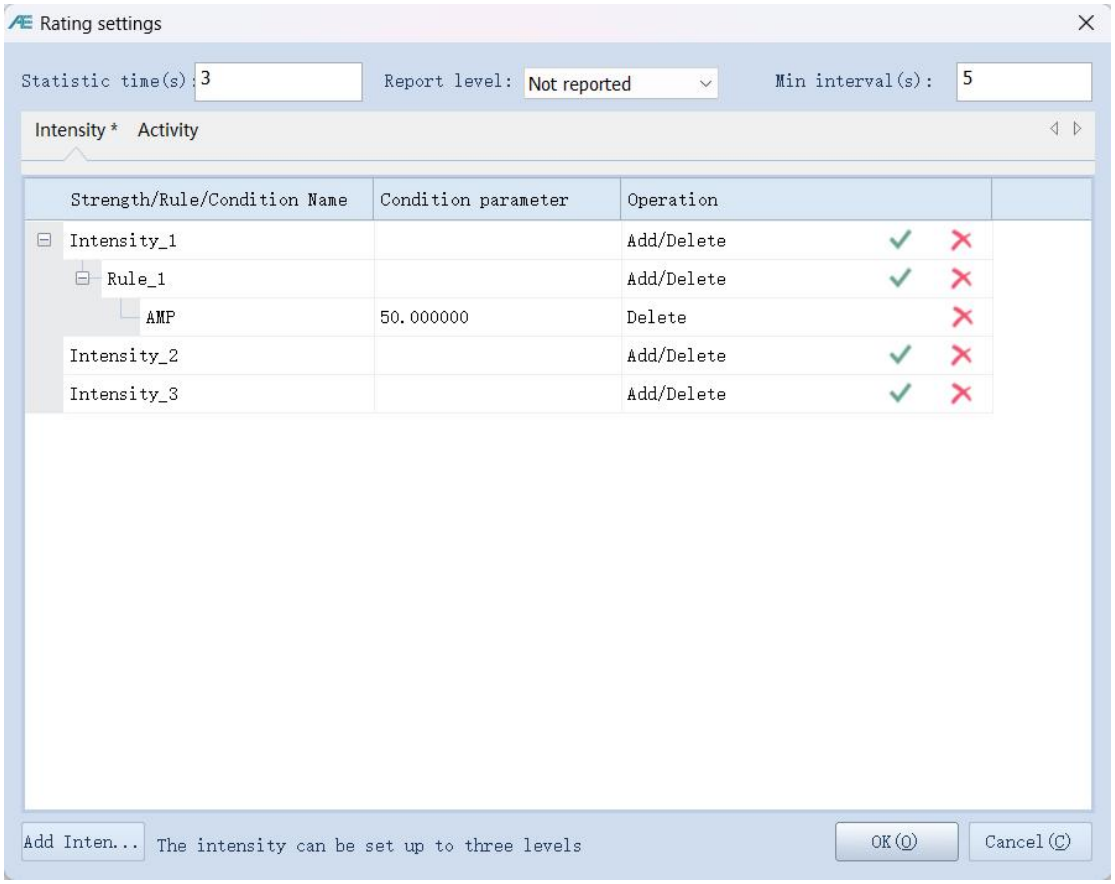


Fig. 4-11 Rating Intensity Settings

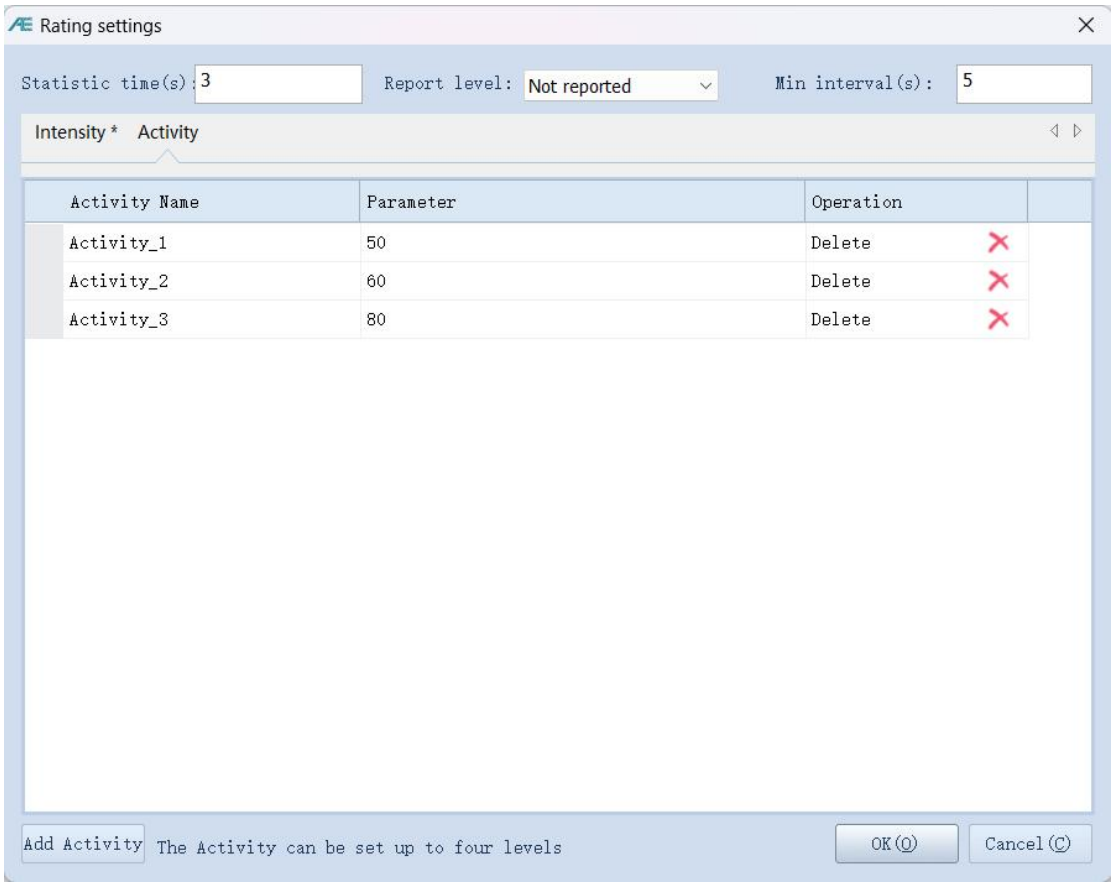


Fig. 4-12 Rating Activity Settings

At the bottom left corner of the Rating Settings window, press "Add Intensity" or "Add Activity" button to create new or next 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.

4.3.4. FFT Settings

The FFT Setting page is for FFT related configurations.

Note: To modify the settings, select the channel number by checkbox on the left first.

- To obtain FFT or frequency related parameters, make the the "**FFT Function**"

enable.

- **Decimation Rate**: cannot be modified for now. The fixed value is 1, which means that one is extracted from every few original sampling points (waveform sampling rate) on average for FFT calculation.
- **Power Spectrum Settings**: a partial power spectrum quantifies the proportion of a signal's total energy within a specific, user-defined frequency range. Click to open the settings.
- **Starting frequency (kHz)**: The starting frequency of the partial power spectrum band.
- **End frequency (kHz)**: The end frequency of the partial power spectrum band.

After filling the frequency range, press "Auto Spacing" button to proportionally distribute the set frequency range.

- **Auto Spacing**: The set numerical range will be evenly divided according to the selected number of partial power spectrum. Users can modify the automatically distributed values in the table below.

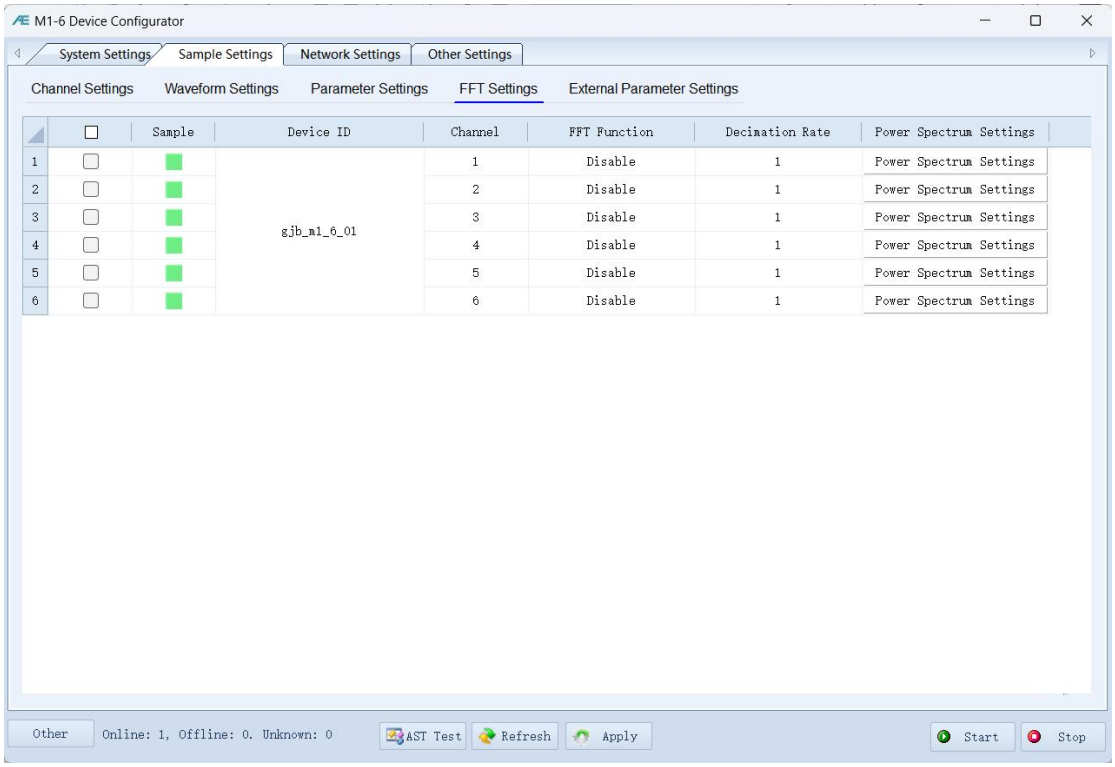


Fig. 4-13 FFT Settings Page

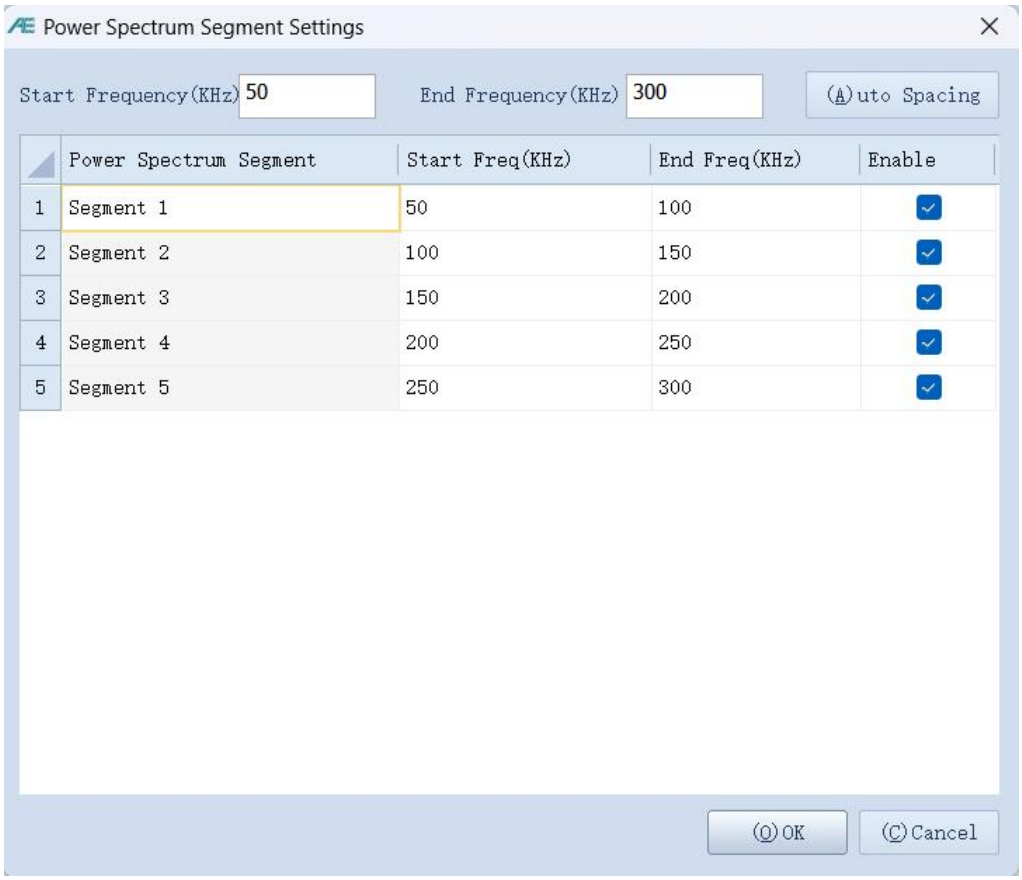


Fig. 4-14 Power spectrum frequency band setting

4.3.5. External Parameter Settings

The RAEM1-6 features four external reference interfaces with a measurement range of -10V to +10V, along with two alarm output interfaces.

- **Select Device**: to select which RAEM1-6 device to modify the external configurations.
- **Save Setting**: this button is to save the modified configurations of this page. But the saved modification is not yet sent to the RAEM1-6 device until the bottom "**Apply**" button is pressed.

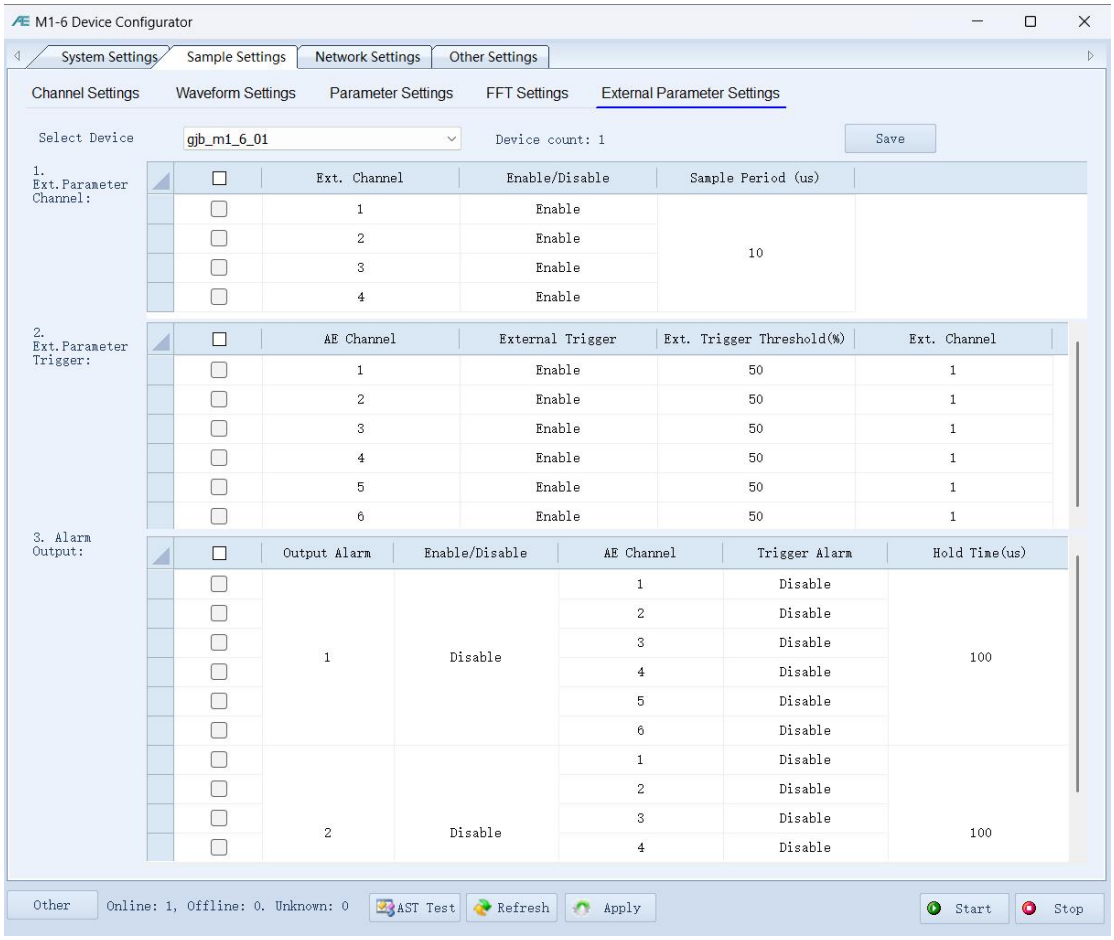


Fig. 4-15 External parameter settings

Note: To modify the settings, select the channel number by checkbox on the left first.

1. External Parameter Channel:

- **Ext. Channel**: the external input channels, in total of 4 channels.
- **Enable/Disable**: this is to enable or disable the external input channels.
- **Sampling Period (μs)**: External input sampling frequency supports up to 1MHz. Set to 100KHz by default. The unit is in microsecond (μs), which means take one sample point every k microseconds, k=1/100kHz=10μs by default. The minimum value is 1μs.

2. External Parameter Trigger

- **External Trigger**: enable to use the values of external inputs as threshold to trigger the data acquisition.

- **Ext. Trigger Threshold (%)**: Enter a value between 5% and 100% (positive integer) in the text box. The external trigger threshold percentage means the percentage of the absolution value of the input range. The external input range is -10V to +10V. For example, 50% is the external trigger threshold. If the absolution value of the external input exceeds the 50%*| ± 10V|=|5V|, the corresponding AE channel starts to collect the waveform.
- **Ext. Channel**: there are four external input channels in total. So users can select which external input channel to trigger which AE channels.

3. Alarm Output

When the RAEM1-6 alarm output is enabled, an alarm output is triggered when the parameters acquired by the RAEM1-6 exceed the set threshold in the [Channel Settings].

- **Trigger Alarm**: specify enabling whether the AE channels to trigger the corresponding alarm output.
- **Hold Time (μs)**: The setting range is 1μs to 1s, in 1μs increments. (Note: If parameters and waveforms are acquired simultaneously, the alarm output time is the length of the complete waveform segment plus the hold time.)
- **Output Format**: Three output formats are available: Pulse (High-level), Passive Switching, and Active Switching.
  - **Pulse (High-level)**: Use when requiring the rapid alarm. After triggering the threshold, a 12V high-level pulse is output within 1μs. The pulse duration is defined by the "Hold Time (μs)" above. (Note: the ALARM "-" pin is connected to the GND of the connected alarm device, and there is no requirement to connect to the GND of RAEM1-6).
  - **Active Switching**: Signals containing a power supply, such as 12V DC, which is often used in situations where the connected device does not have a signal power supply. Used in non-fast alarm situations. After triggering the

threshold, the logic output high level will be responded within 3ms (Note: the ALARM "-" pin is connected to the GND of the connected alarm device, and the GND of RAEM1-6 must be connected to the GND of the connected alarm device).

- **Passive Switching**: passive switching signal that has no power supply, which is often used in situations where the connected device has a signal power supply. Used in non-fast alarm situations. After triggering the threshold, the logic output high level will be responded within 3ms (Note: the ALARM "-" pin is connected to the GND of the connected alarm device, and the GND of RAEM1-6 must be connected to the GND of the connected alarm device).

4.4. Network Settings

In the "**Protocol:**", select one protocol for data transmission. After setting, it needs to reboot the device to take effect. Contact us for latest transmission protocols.

4.4.1. U3H Protocol

The U3H protocol configuration enables data collection and transmission to SWAE software via network port or WiFi communication.

This mode only works in Detection Mode. (Change the system settings to **[Detection Mode]** and reboot the device.)

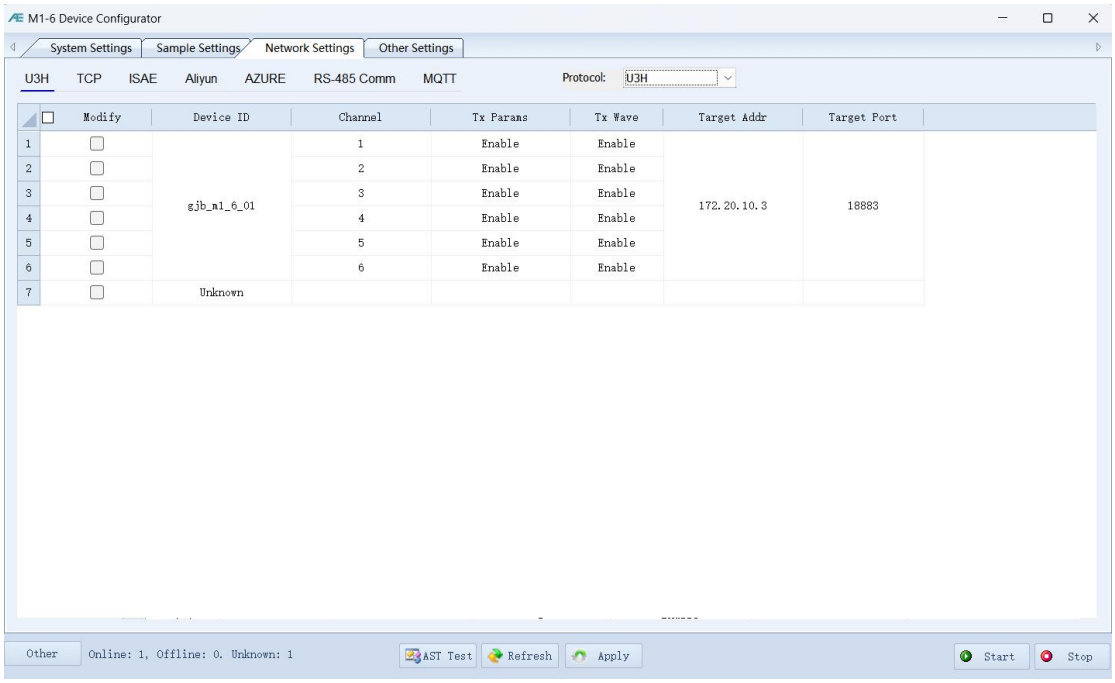


Fig. 4-16 U3H Protocol Settings Page

- **Tx Params**: enable to send AE feature parameters using the protocol.
- **Tx Wave**: enable to send AE waveform using the protocol.
- **Target Addr**: The destination IP address for sending to the PC running SWAE software. If using Ethernet port, enter the PC Ethernet IPv4 address. If using WiFi, enter the PC WiFi IPv4 address.
- **Target Port**: usually the default 18883.

4.4.2. TCP

This TCP mode is a TCP protocol defined by QAWRUMS. The data is selected to send according to the protocol's format and report time interval (not all the collected data will be sent). Configure the corresponding server address and reporting port. The report time interval is in milliseconds (ms), with a minimum value of 200.

This mode works in Monitoring Mode. (Change the system setting to **[Monitoring Mode]** and restart the device.)

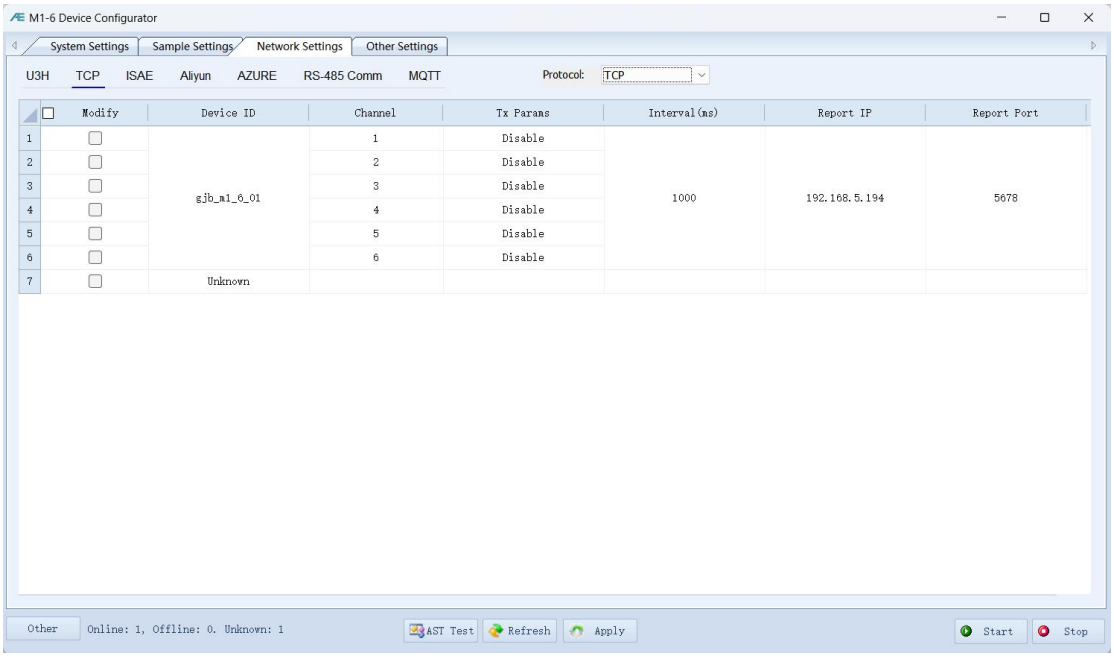


Fig. 4-17 TCP Settings Page

- **Tx Params**: enable to send AE feature parameters using the protocol.
- **Interval (ms)**: The interval for reporting data to the server. During this interval, the set of data with the largest amplitude (AMP) is selected for upload. The default reporting interval is 1000ms (1s), and the minimum can be adjusted to 200ms.
- **Report IP**: the server's IP address;
- **Report Port:** The port number for the connected server.

4.4.3. ISAE

Similar to the TCP protocol, the RAEM1-6 system allows real-time monitoring of all channel parameters and configuration details through serial port communication or software applications.

This mode works in Monitoring mode. (Change the system settings to **[Monitoring mode]** and restart the device.)

- **Tx Params**: enable to send AE feature parameters using the protocol.
- **Interval (ms)**: The interval for reporting data to the server. During this interval, the set of data with the largest amplitude (AMP) is selected for upload. The

default reporting interval is 1000ms (1s), and the minimum can be adjusted to 200ms.

- **Report IP**: the server's IP address;
- **Report Port:** The port number for the connected server. Avoid using common port numbers to prevent conflicts.

4.4.4. Aliyun (Under Development)

RAEM1-6 supports data transmission and bidirectional communication with Alibaba Cloud servers. When configured in this mode, the corresponding device appears in the Qingcheng Alibaba Cloud IoT, displaying real-time uploaded parameters, parameter ratings, and configuration details. This mode requires internet connectivity, and the following three device types are compatible:

Once the Alibaba Cloud Key and Sec parameters are configured, RAEM1-6 will automatically connect to the Alibaba Cloud platform and upload the data.

4.4.5. AZURE (Under Development)

RAEM1-6 can transfer data to the AZURE platform. The process is completed by configuring the key and time interval in the M1-6 configuration software.

4.4.6. RS485 Communication (Under Development)

The RAEM1-6 is equipped with RS485 communication, enabling data or command transmission via the RS485 communication protocol defined by QAWRUMS.

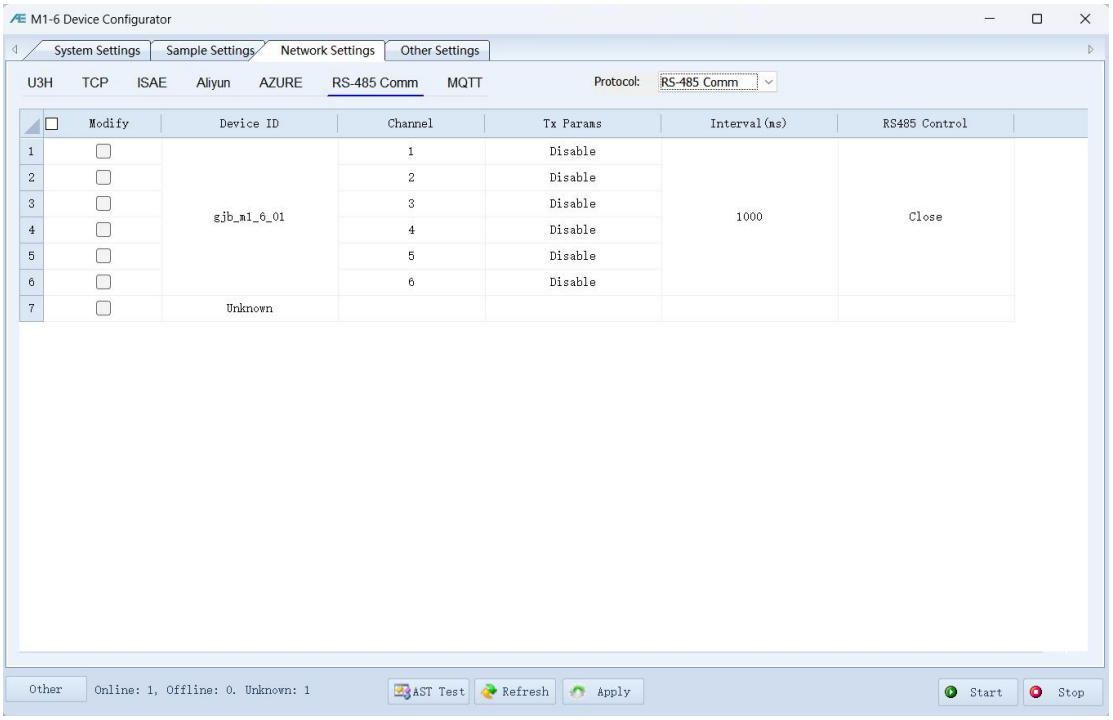


Fig. 4-18 RS485 Communication Settings Page

When both the 485 transmission parameters and 485 control functions are enabled, the system enters master-slave auto-switching mode. The device communication process in this mode is as follows:

1) The default device operates in master mode, continuously sending parameter data;

2) Every 5 seconds, a frame of switching mode command is sent to notify the slave that the mode has switched and control commands can be transmitted. When the slave receives the control command, it must send the control command back within 1 second, meaning the host mode waiting time is only 1 second. The mode switching command is shown at the end of this protocol.

3) After completing data reception in slave mode, it will automatically switch back to master mode to continue sending data.

4.4.7. MQTT

RAEM1-6 is equipped with the MQTT protocol, which transmits data by selecting the largest set of data according to the protocol's format and reporting

interval.

① If you need to send data to the Qingcheng IoT cloud platform, no modification is required. Use the default settings.

② To send to a user-specified private cloud platform, enter "user" as the [Target Addr] and enter other settings as needed.

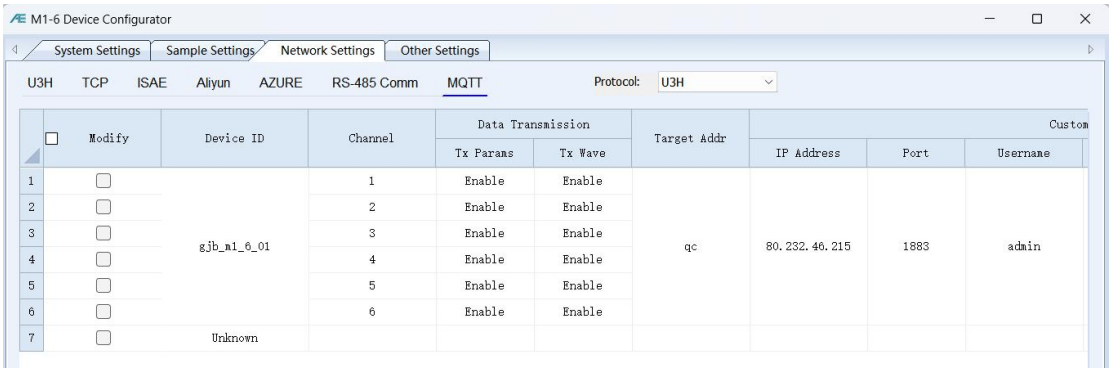


Fig. 4-19 MQTT Settings Page

4.5. Other Settings

Real-time Query: Enter the real-time data page to query the data collected in the last 10 seconds. This function is only used to check whether the test device is collecting data. To view all data, you need to view the original file.

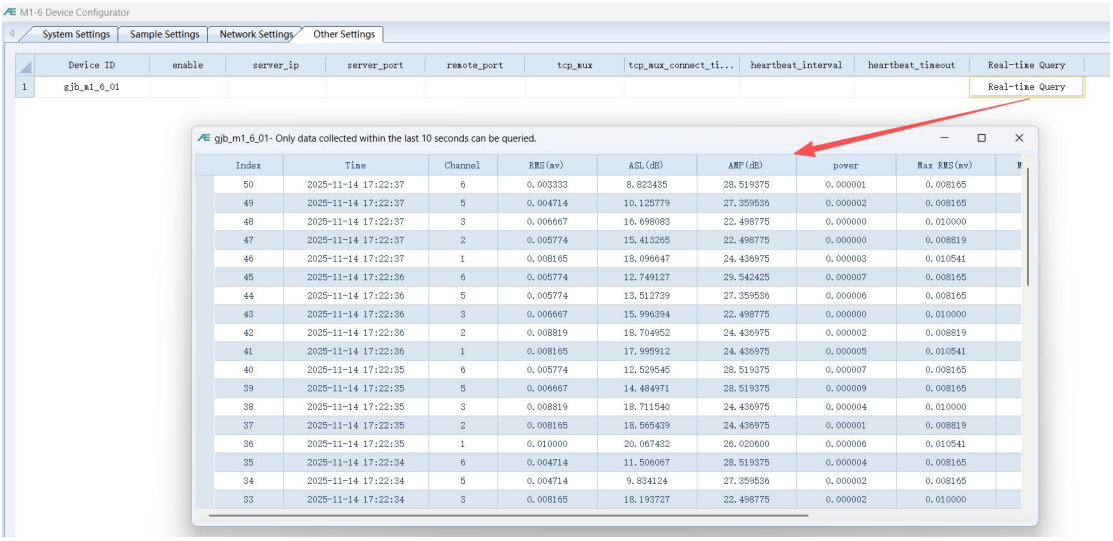


Fig. 4-20 Real-time data query

5. Detection Mode Usage Guide

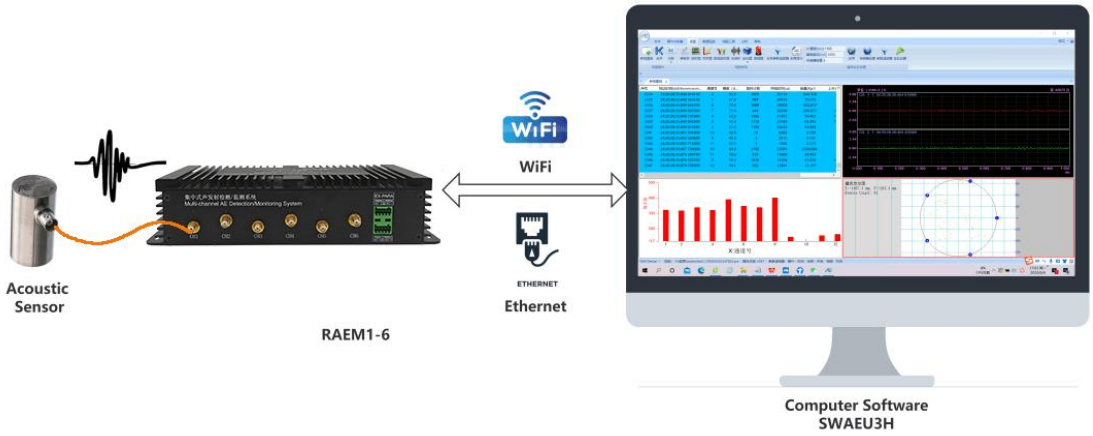


Fig. 5-1 RAEM1-6 detector connection diagram

The RAEM1-6 can be used as a desktop detector. It operates without external network or cloud connectivity, relying solely on local LAN connections. These can be either wired (via Ethernet cable) or wireless (using a WiFi router).

When used as a desktop detector, the RAEM1-6 requires SWAE software. This is defined as **'Detection Mode'** in the M1-6 Configurator software. Configuration is performed via the RAEM1-6 configuration software, while real-time data display and analysis are handled by SWAE.

5.1. Ethernet Connection

RAEM1-6 can be configured either by connecting directly to a PC via Ethernet, or by connecting multiple RAEM1-6 units to a PC through switches or routers.

But before starting the M1-6 configuration software or SWAE software, you must disable the firewall (see Chapter 3).

5.1.1. Computer Ethernet Configuration

After connecting the hardware, you need to configure the computer accordingly

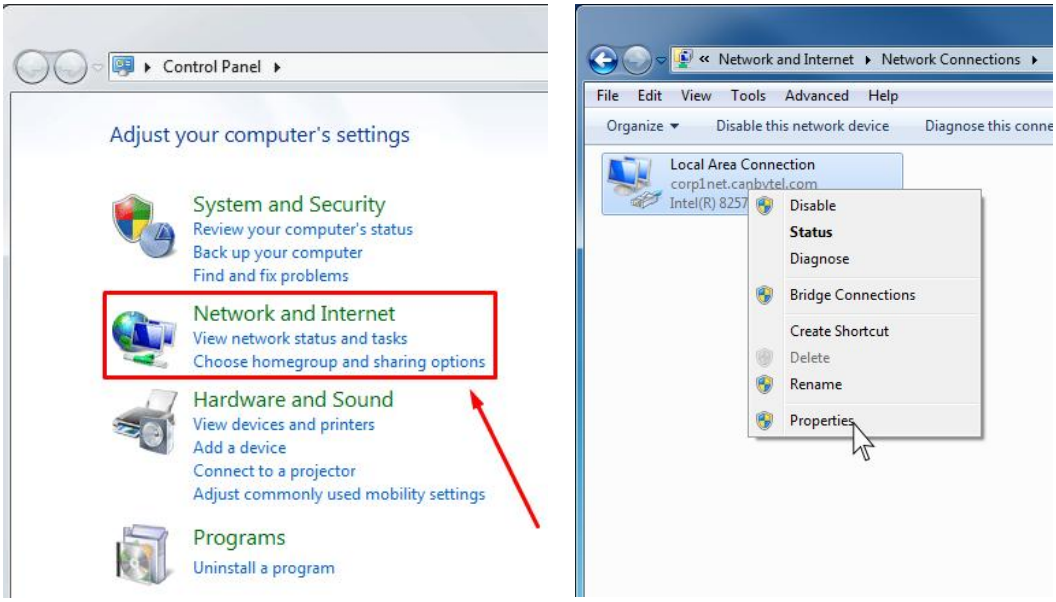
to successfully connect to the configuration software.

The default RAEM1-6 device's Ethernet IP address is 192.168.0.101. If the RAEM1-6 and computer connection is via Ethernet cable, their Ethernet IP address should be in the same network subnet, i.e. 192.168.0.XX.

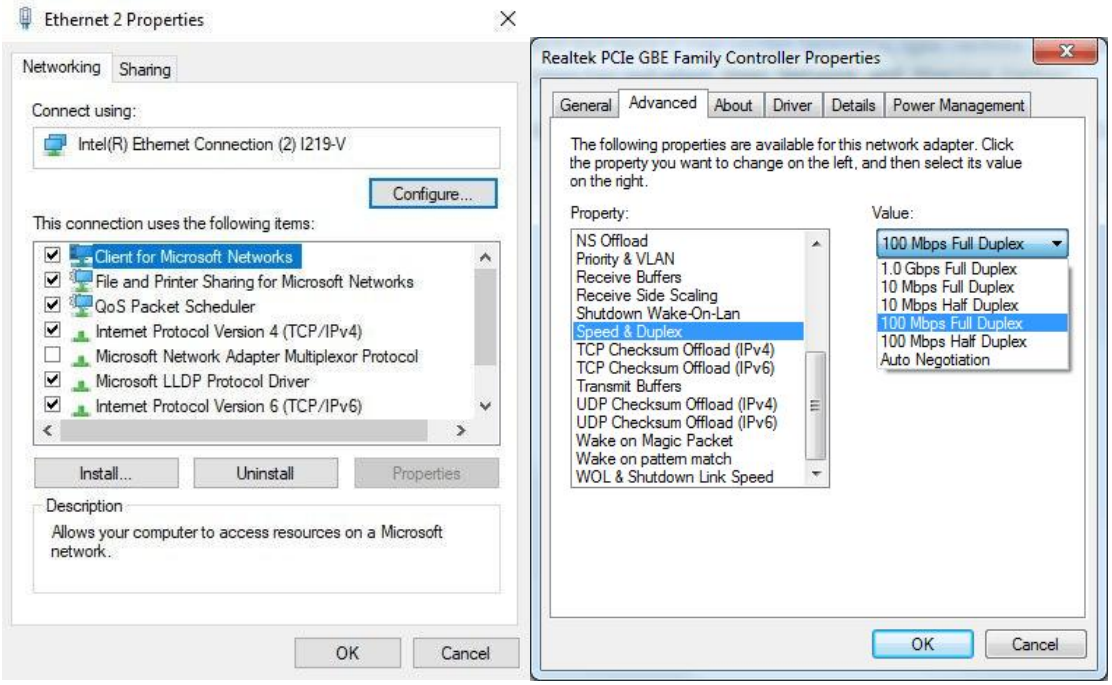
If the connection fails when using a PC, configure the computer's Ethernet properties as follows and try connecting again:

(1) **Configure Ethernet full-duplex mode**: Open **Control Panel >> Network and Internet >> Network Connections**. Double-click the connected Ethernet and right click menu and select **[Properties]**. Click the "**Configure..**" button >> "**Advanced**". In the "Properties" section, locate "**Speed & Duplex**" and select "**Auto-negotiate**". Click "**OK**".

(2) **Configure the Ethernet IPv4 address:** In the "**Ethernet Properties**" window, double-click "**Internet Protocol Version 4 (TCP/IPv4)**". In the pop-up window, select "**Use the following IP address:**". Enter the IP address "192.168.0.XX" (where XX can be any number but **NEVER** the same as the RAEM1-6) and the subnet mask "255.255.255.0". Click "OK".



(a)



(b)

Fig. 5-2 Ethernet Full-Duplex Mode Settings (a) (b)

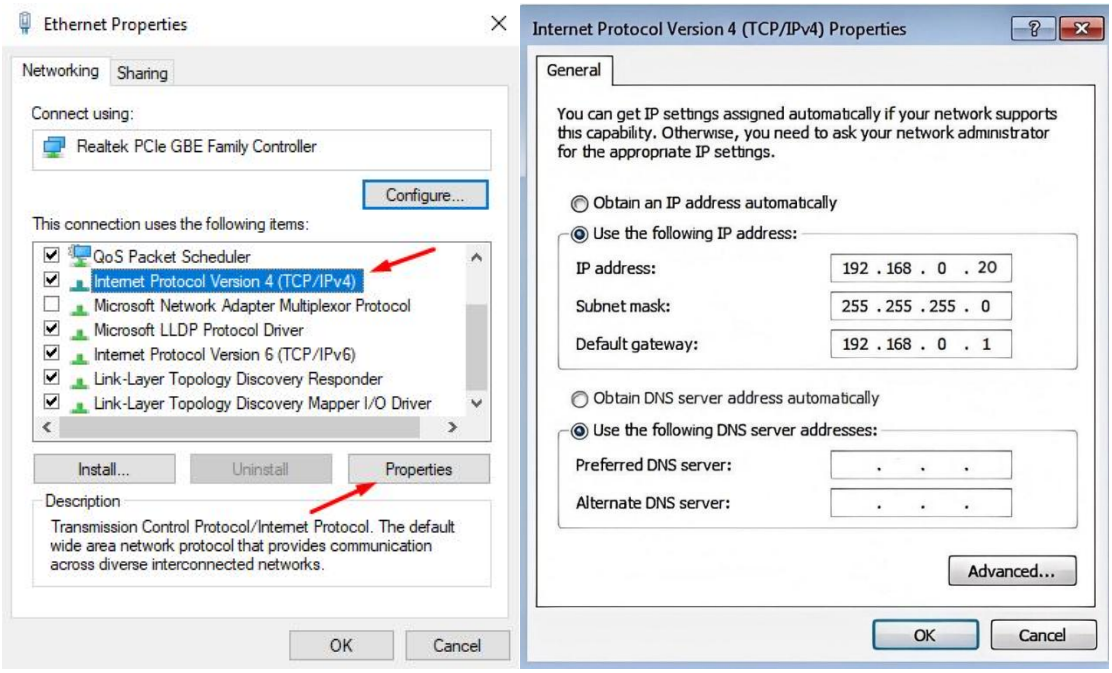


Fig. 5-3 Ethernet IPv4 settings

5.1.2. Ethernet Connection of Single Device

For network configuration, RAEM1-6 can be directly connected to computers via Ethernet or configured as a local area network (LAN) using switches or routers.

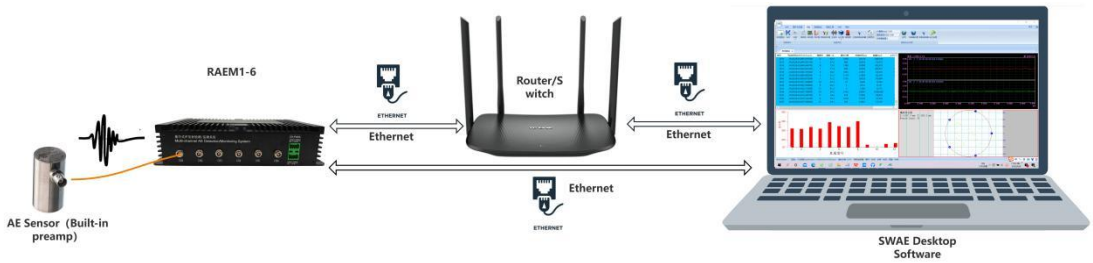


Fig. 5-4 Single RAEM1-6 Ethernet networking diagram

RAEM1-6 Configuration Software Settings for SWAE:

(1) In the M1-6 configuration software, **'System Settings' >> 'Local IP' >> 'Work Mode'** make sure it is in '**Detection Mode**'.

(2) In the M1-6 configuration software, navigate to **[Network Settings] >> [U3H]** (which refers to the protocols to send SWAE). Select the "**U3H**" in the **"Protocol"**.

(3) To be able to modify the settings in this page, please check all the checkbox on the left of the "**Device ID**" before the modifications on the right. Under **[Tx Wave]** (send waveform) and **[Tx Params]** (send parameters), then select '**Enable**'.

(4) Double-click the IP address in the **[Target Address]** field and enter the specific computer's IPv4 address. When Ethernet cable is directly connect to PC, the PC LAN IPv4 address should be in the same network as RAEM1-6 (192.168.0.xxx). So enter the computer IPv4 address as set similar in Figure 5-3. the The default target port is 18883.

(5) After all modifications, click **"Apply"** button at the bottom to send settings to RAEM1-6. This will enable RAEM1-6 to send data to the specific IP where SWAE software is. Also click **"Restart"** button at the most right end of the **"System Settings"** tab to reboot the RAEM1-6 to take effect. Once the RAEM1-6 is back online, the modified settings are ready to use.

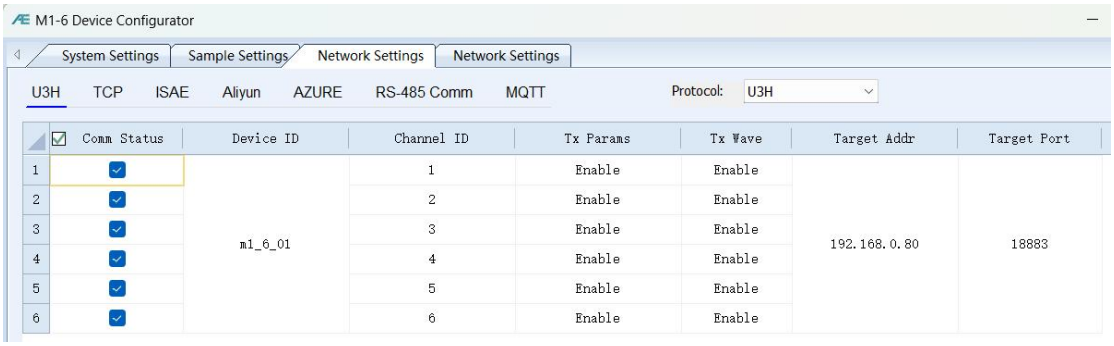


Fig. 5-5 Configuration to enable with SWAE

SWAE software settings:

Refer to Chapter 5.3 of the SWAE software configuration and the SWAE software user manual.

5.1.3. Ethernet Connection of Multiple Devices

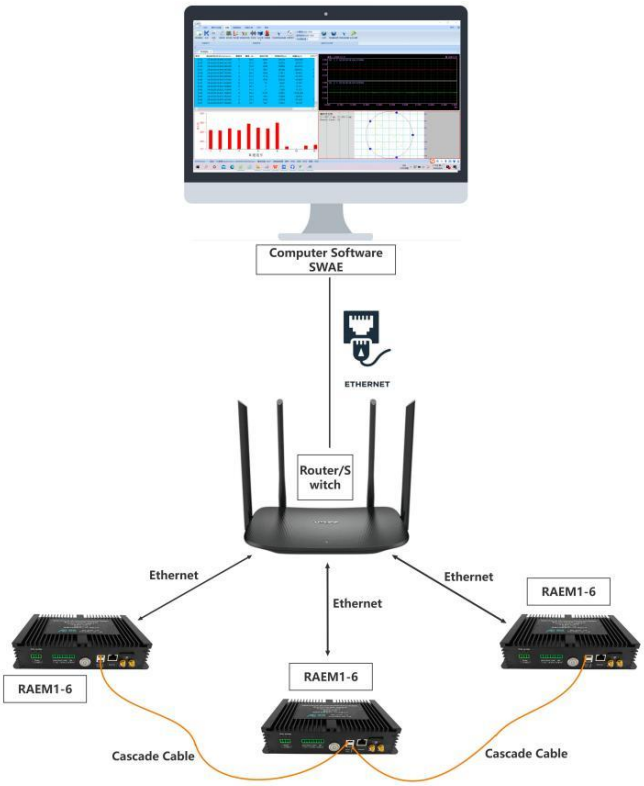


Fig. 5-6 Ethernet multi-machine networking diagram

To set up a network with multiple RAEM1-6 units, connect them through switches or routers to form a local area network (LAN) using Ethernet cables. Then

the cascade of RAEM1-6 is connected through the cascade ports (Type-C) of RAEM1-6 using the cascade cables.

RAEM1-6 configuration software settings:

Multiple RAEM1-6 devices can be networked in two modes: static IP or dynamic IP. For static IP networking, each RAEM1-6 device must have a unique device IP address. Dynamic IP networking requires a router to assign dynamic IP addresses.

- **Static IP**: The configured static IP will serve as the destination address for RAEM1-6 Ethernet.

The default factory setting is a static IP address of 192.168.0.101. The computer should configure within the 192.168.0.XXX network range (but never the same as RAEM1-6). For example, configuring the computer IP address as 192.168.0.5 will enable the computer to connect to RAEM1-6.

- **Dynamic IP**: The IP address is dynamically assigned by the connected router. The **[System Settings]** section of the M1-6 configuration software lists all RAEM1-6 devices connected to this router or other connection methods. If the device IP of RAEM1-6 changes, the updated IP will appear in the list as a new device. You can identify RAEM1-6 by its device ID in the list and find its corresponding dynamic IP.

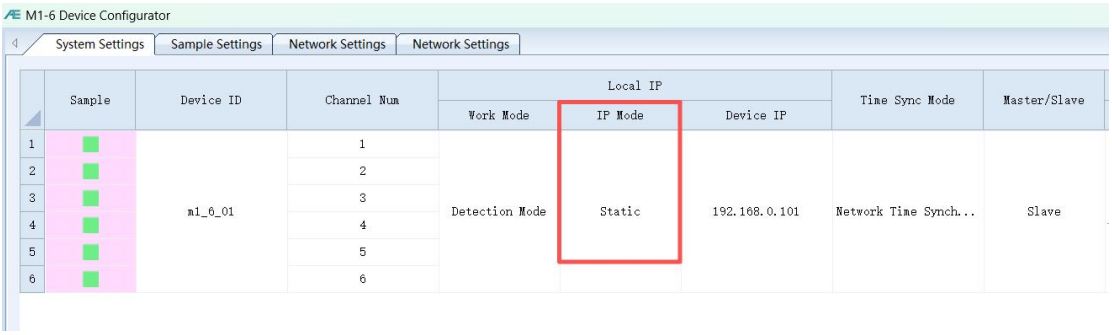


Fig. 5-7 Static IP Settings

1) For example, in a **static IP** network setup, the three RAEM1-6 devices shown in the diagram can be configured in static IP mode with the following addresses:

Equipment number	Equipment IP
m1_6_06	192.168.0.101
m1_6_05	192.168.0.102
m1_6_04	192.168.0.103

Or configure three RAEM1-6 devices to form a **dynamic IP** network.

2) In the M1-6 configuration software, **'System Settings' >> 'Local IP' >> 'Work Mode'** make sure it is in **'Detection Mode'**.

3) **'System Settings' >> 'Time Sync Mode'**, select **'Cascade Sync'**.

4) Only one of the RAEM1-6 device in the cascade can be the master, the other devices should be slaves. In the **'System Settings' >> 'Master/Slave'**, select either the 'Master' or 'Slave'.

5) In the M1-6 configuration software, navigate to **[Network Settings] >> [U3H]** (which refers to the protocols to send SWAE). Select the **'U3H'** in the **'Protocol'**.

6) To be able to modify the settings in this page, please check all the checkbox on the left of the **'Device ID'** before the modifications on the right. Under **[Tx Wave]** (send waveform) and **[Tx Params]** (send parameters), then select **'Enable'**.

7) Double-click the IP address in the **[Target Address]** field and enter the specific computer's IPv4 address. When Ethernet cable is directly connect to PC, the PC LAN IPv4 address should be in the same network as RAEM1-6 (192.168.0.xxx). So enter the computer IPv4 address as set similar in Figure 5-3. the The default target port is 18883.

8) After all modifications, click **'Apply'** button at the bottom to send settings to RAEM1-6. This will enable RAEM1-6 to send data to the specific IP where SWAE software is. Also click 'Restart' button at the most right end of the **'System Settings'** tab to reboot the RAEM1-6 to take effect. Once the RAEM1-6 is back

online, the modified settings are ready to use.

SWAE software settings:

Refer to Chapter 5.3 of the SWAE software configuration.

5.2. WiFi Connection

5.2.1. Hotspot Mode

RAEM1-6 can connect directly to a PC via its built-in WiFi, but due to transmission speed and stability limitations, this method is recommended only for use with the M1-6 Configurator software exclusively for configurations.

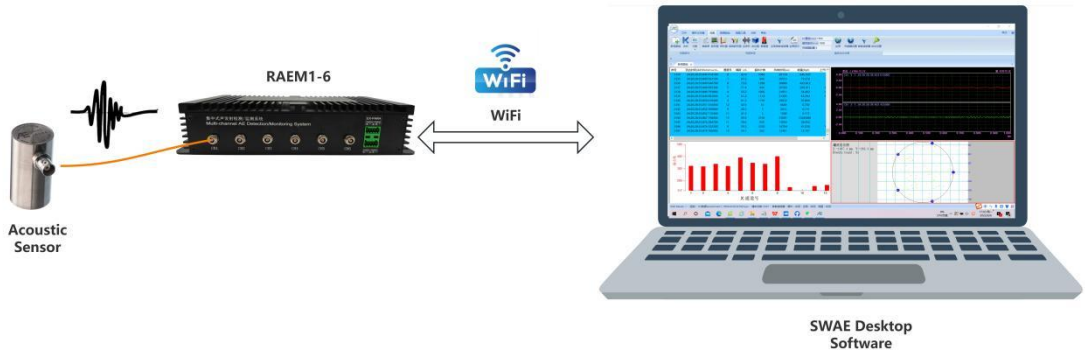


Fig. 5-8 Hotspot mode connection

The WiFi version of RAEM1-6 comes with a factory default **Hotspot** mode. By factory default it emits the Hotspot with the name of the device ID (i.e. "**m1_6_xx**"). Once your computer connects to this Hotspot, you can read the device in the M1-6 Configurator software.

5.2.2. Router Mode

Fig. 5-9 Router mode connection

For better wireless transmission speed and stability, RAEM1-6 can connect to a WiFi router for both configurations and data transmission.

To switch RAEM1-6 from default **Hotspot mode to Router mode**:

1) connect RAEM1-6 to computer via Ethernet cable or Hotspot like mentioned in the previous sections.
2) Then in the M1-6 configuration software, **'System Settings' >> 'Wireless Mode'**, double click 'Hotspot mode' and in the drop-down menu, select **'Router mode'**.
3) Next, under the **'Router ID'** enter the WiFi router name, and in the **'Router PWD'** enter the WiFi router password. (Please don't use the network that requires identifications)
4) After changing, click **'Apply'** button at the bottom to send settings to RAEM1-6.
5) Finally click **'Restart'** button on the right to reboot the RAEM1-6 device to take effect. Make sure the computer is connected to the same WiFi network. Once RAEM1-6 is back online, it should automatically connected to the specified WiFi network.

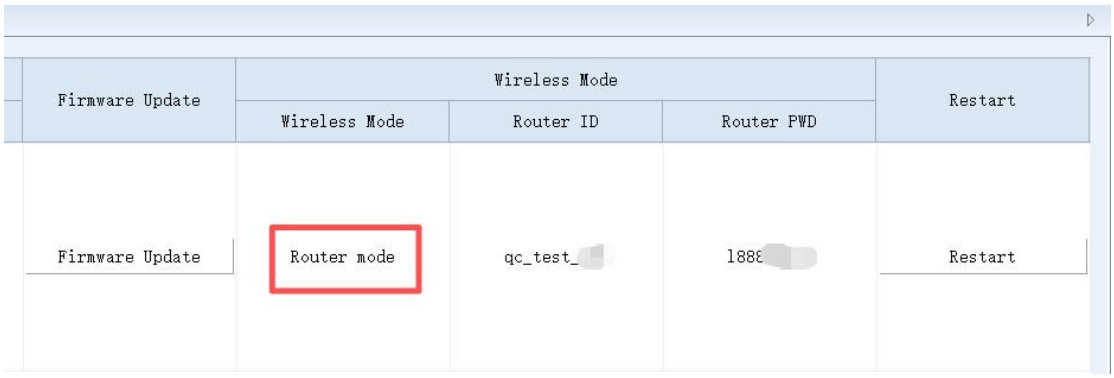


Fig. 5-10 Change to Router Mode

To make the RAEM1-6 **send data to SWAE**:

9) In the M1-6 configuration software, **'System Settings' >> 'Local IP' >> 'Work Mode'** make sure it is in **'Detection Mode'**.

10) In the M1-6 configuration software, navigate to **[Network Settings] >> [U3H]** (which refers to the protocols to send SWAE). Select the **'U3H'** in the **'Protocol'**.

11) To be able to modify the settings in this page, please check all the checkbox on the left of the **'Device ID'** before the modifications on the right. Under **[Tx Wave]** (send waveform) and **[Tx Params]** (send parameters), then select **'Enable'**.

12) Double-click the IP address in the **[Target Address]** field and enter the specific computer's WiFi IPv4 address. Go to the computer's **Settings >> Network & Internet >> Wi-Fi** and click on the network you are connected to. Find and copy the **'IPv4 Address'**. The default target port is 18883.

13) After all modifications, click **'Apply'** button at the bottom to send settings to RAEM1-6. This will enable RAEM1-6 to send data to the specific IP where SWAE software is. Also click 'Restart' button at the most right end of the **'System**

Settings' tab to reboot the RAEM1-6 to take effect. Once the RAEM1-6 is back online, the modified settings are ready to use.

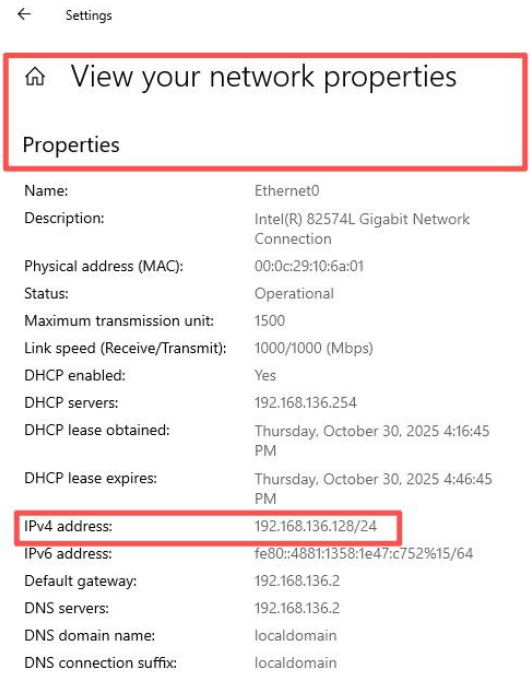


Fig. 5-11 Router Properties: PC IPv4 Address

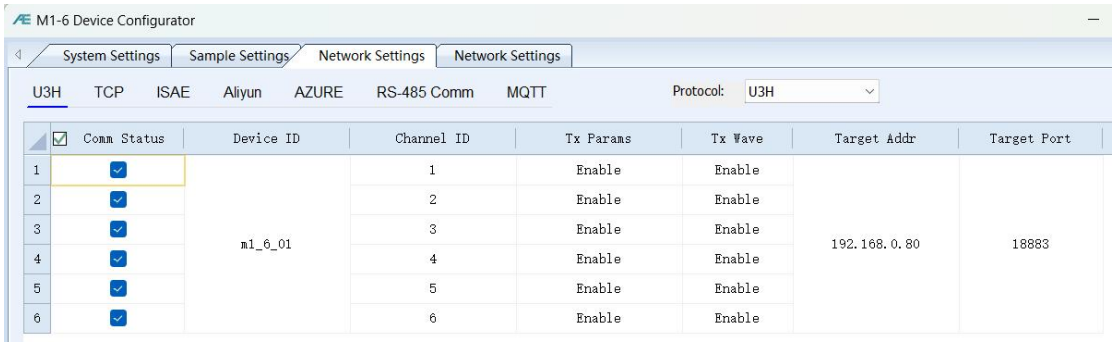


Fig. 5-12 Configuration to enable with SWAE

5.2.3. WiFi Networking of Multiple Devices

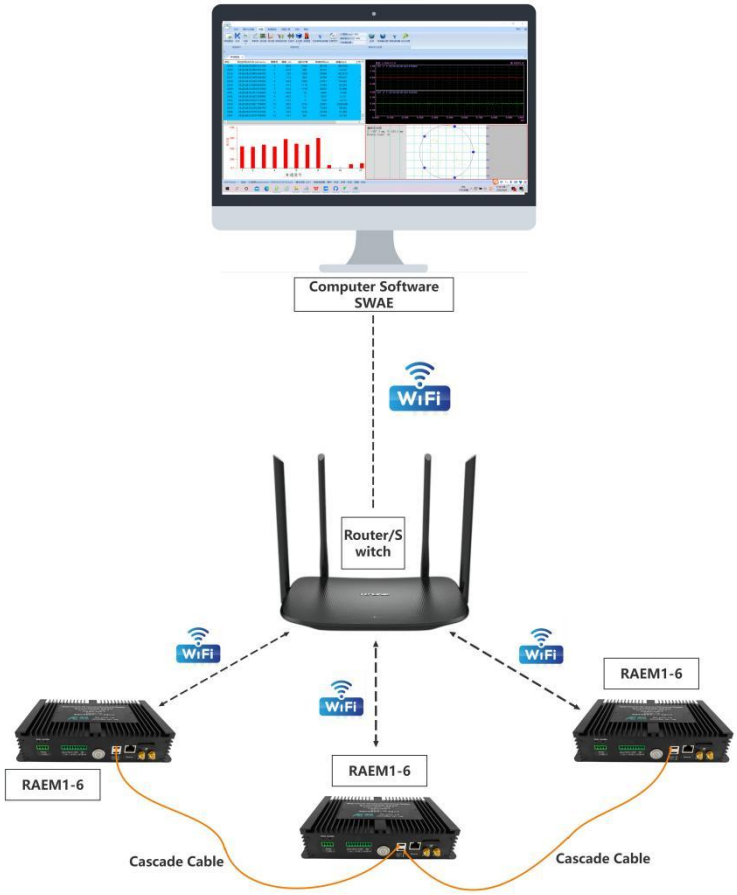


Fig. 5-13 Multiple RAEM1-6 WiFi Connections

To connect multiple RAEM1-6 units simultaneously via WiFi, they must be configured as a network. Connect the RAEM1-6 units to a WiFi router using 'Router mode' as mentioned in Chapter 5.2.2. Then connect your computer to the router via WiFi. Once connected, all devices will appear in the configuration software.

The cascade of RAEM1-6 is connected through the cascade ports (Type-C) of RAEM1-6 using the cascade cables.

Note: The clock synchronization using wireless (WiFi or GPS) is an option but the wireless clock synchronization hardware must be installed to be available.

At the factory, the master-slave mode and the clock synchronization of the multiple RAEM1-6 devices are usually done before shipping, and the user does not need to operate.

RAEM1-6 configuration software settings:

Multiple RAEM1-6 devices can be networked in two modes: static IP or dynamic IP. For static IP networking, each RAEM1-6 device must have a unique device IP address. Dynamic IP networking requires a router to assign dynamic IP addresses.

- **Static IP**: The configured static IP will serve as the destination address for RAEM1-6 Ethernet.

The default factory setting is a static IP address of 192.168.0.101. The computer should configure within the 192.168.0.XXX network range (but never the same as RAEM1-6). For example, configuring the computer IP address as 192.168.0.5 will enable the computer to connect to RAEM1-6.

- **Dynamic IP**: The IP address is dynamically assigned by the connected router. The **[System Settings]** section of the M1-6 configuration software lists all RAEM1-6 devices connected to this router or other connection methods. If the device IP of RAEM1-6 changes, the updated IP will appear in the list as a new device. You can identify RAEM1-6 by its device ID in the list and find its corresponding dynamic IP.

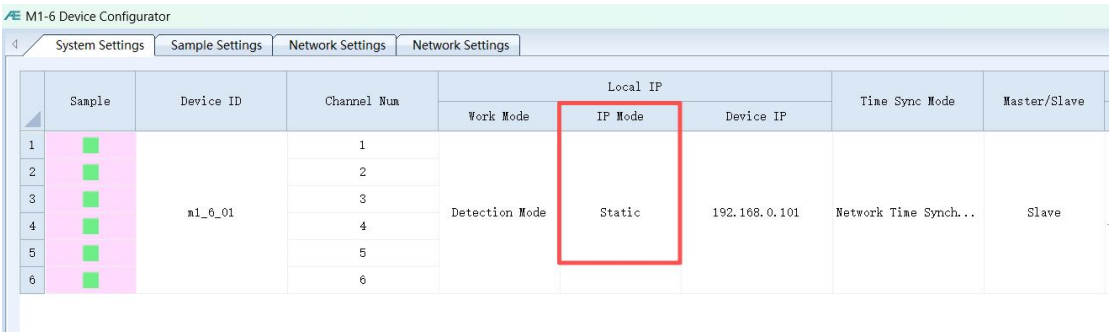


Fig. 5-14 Static IP Settings

1) For example, in a **static IP** network setup, the three RAEM1-6 devices shown in the diagram can be configured in static IP mode with the following addresses:

Equipment number	Equipment IP
m1_6_06	192.168.0.101

m1_6_05	192.168.0.102
m1_6_04	192.168.0.103

Or configure three RAEM1-6 devices to form a **dynamic IP** network.

2) In the M1-6 configuration software, **'System Settings' >> 'Local IP' >> 'Work Mode'** make sure it is in **'Detection Mode'**.

3) **'System Settings' >> 'Time Sync Mode'**, select **'Cascade Sync'**.

4) Only one of the RAEM1-6 device in the cascade can be the master, the other devices should be slaves. In the **'System Settings' >> 'Master/Slave'**, select either the 'Master' or 'Slave'.

5) In the M1-6 configuration software, navigate to **[Network Settings] >> [U3H]** (which refers to the protocols to send SWAE). Select the **'U3H'** in the **'Protocol'**.

6) To be able to modify the settings in this page, please check all the checkbox on the left of the **'Device ID'** before the modifications on the right. Under **[Tx Wave]** (send waveform) and **[Tx Params]** (send parameters), then select **'Enable'**.

7) Double-click the IP address in the **[Target Address]** field and enter the specific computer's WiFi IPv4 address. Go to the computer's **Settings >> Network & Internet >> Wi-Fi** and click on the network you are connected to. Find and copy the **'IPv4 Address'**. The default target port is 18883.

8) After all modifications, click **'Apply'** button at the bottom to send settings to RAEM1-6. This will enable RAEM1-6 to send data to the specific IP where SWAE software is. Also click 'Restart' button at the most right end of the **'System Settings'** tab to reboot the RAEM1-6 to take effect. Once the RAEM1-6 is back online, the modified settings are ready to use.

SWAE software settings:

Refer to Section 4.3 of the SWAE software configuration.

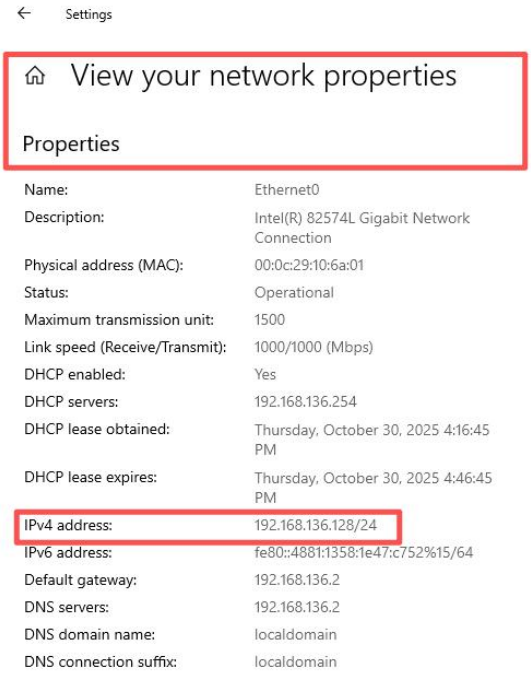


Fig. 5-15 Router Properties: PC IPv4 Address

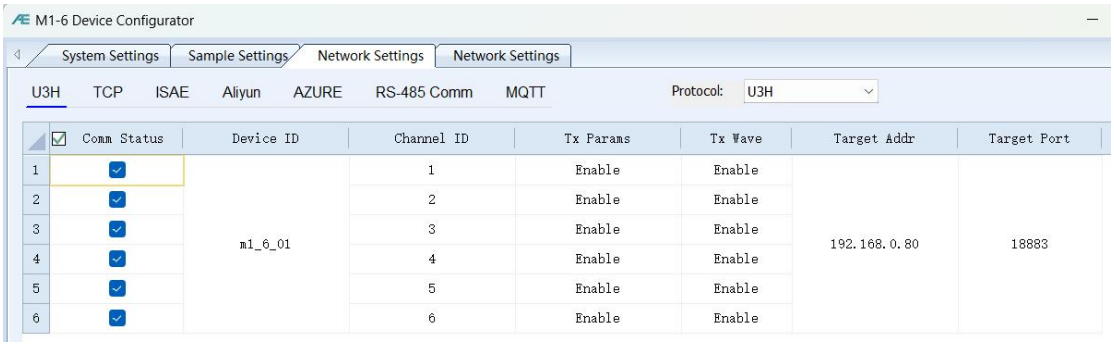


Fig. 5-16 Configuration to enable with SWAE

5.3. SWAE software settings

The SWAE Software supported devices include SAEU3H and RAEM1 and RAEM1-6. During acquisition, the current software supported devices must correspond to the connected acoustic emission devices. Data replay, data analysis and other operations are consistent of both two modes.

You can click the "AE" icon in the upper left corner to view the current supported devices. The current supporting device type should be **“RAEM1”** (RAEM1-6 is considered as RAEM1 series). To switch, click the "AE" icon in the upper left corner, then click the "Yes" button in the popup window, and wait for the software to start.

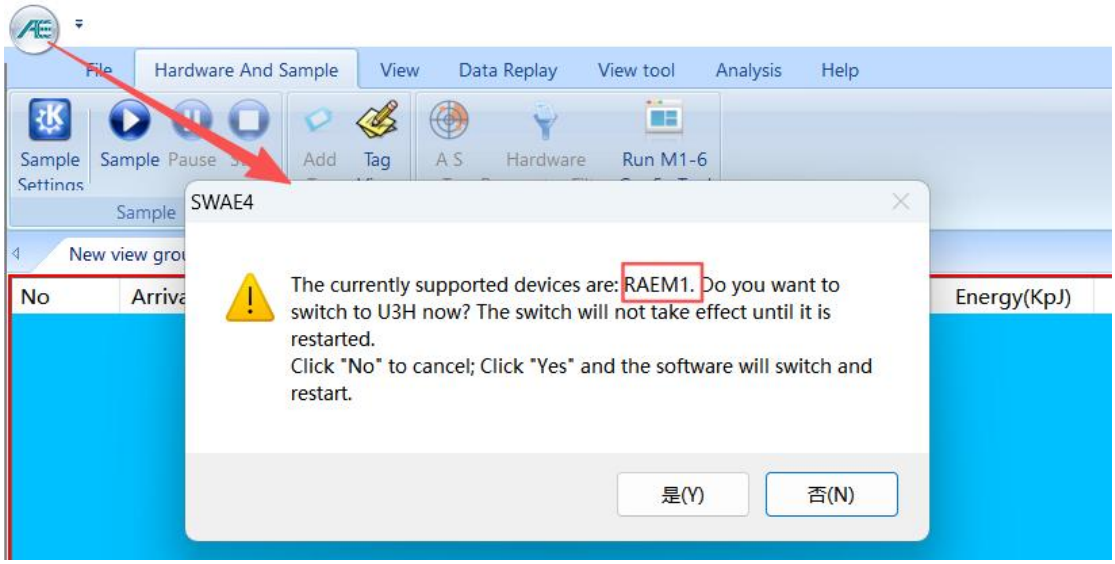


Fig. 5-17 AE software supported device interface

Select **[Hardware and Sample]**, then click **[Sample Settings]**.

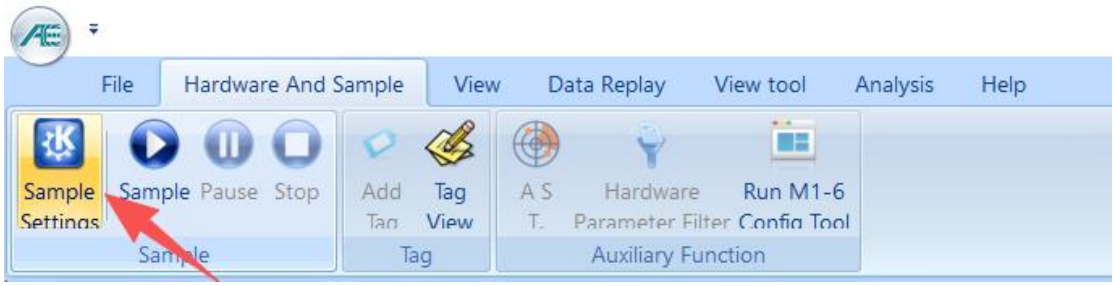


Fig. 5-18 SWAE software acquisition settings

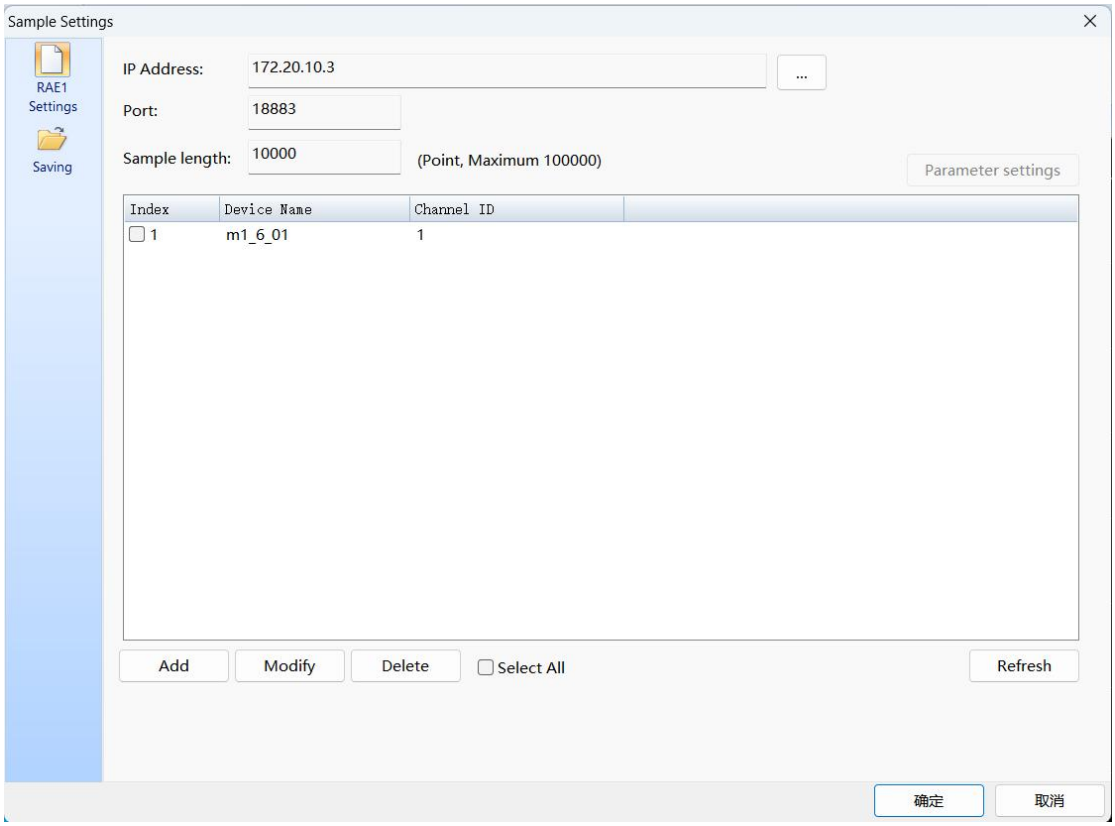


Fig. 5-19 Sample Settings for RAEM1 series

The "Sample settings" page for **RAEM1** series (RAEM1 & RAEM1-6 instruments) is shown as above.

- The "**IP Address**" here should be the computer IP address receiving the data from RAEM1 series. (same as "Target Addr" in the configuration software). Click the ... button to see what the current IP address are in the available communication methods.
- The "**Port**" number should be consistent with the port number in RAEM1 Configuration software, i.e. 18883.
- The "**Sample length**" is only related to the waveform view display in the SWAE software, not effects on the performance of RAEM1. The sample length here means the number of sample points display in each section of the waveform view. The maximum number is 100,000 (points). It's also related to the sample speed in RAEM1. For example, you set 2000 (kS/s) sample speed in the RAEM1 Configuration, and the sample length is 1000 (points) in the SWAE software, the

length in the waveform view will be 1000/2000kS/s = 0.5ms.

- Below is the device list. Although SWAE will automatically display the data when it receives data from any available devices or channels and it will automatically number the channels based on the receive time. In case of random channel assignments by the software, **it's better to assign the channels in advance in the list.** Click "**Refresh**" button at the right below the table, and the software will display all available devices in the network. If the device list is not correct, use the "**Add**", "**Modify**" and "**Delete**" buttons below to correct it. The "Device Name" should be the same as the device name in the RAEM1 Configuration software. Start with Channel #1. **The checkbox next to the "Index" can be checked or not** so that the SWAE will display the checked channels.

- The "**Saving**" is where to save the result data.

More information about the settings can be viewed in the **"SWAE software User Manual"**.

After clicking **[OK]** to save, click the **[Sample]** button to start receiving data from RAEM1-6 devices.

Fig. 5-20 Click to start acquisition

You can observe the parameters and waveform being transmitted online.

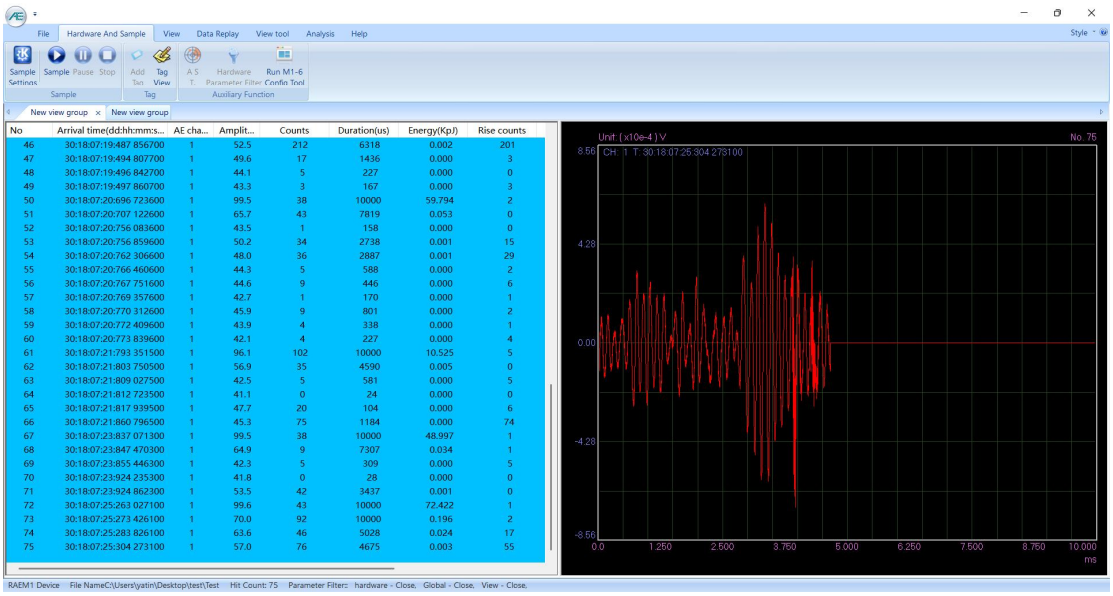


Fig. 5-21 Data table and waveform data

6. Monitoring Mode Usage Guide

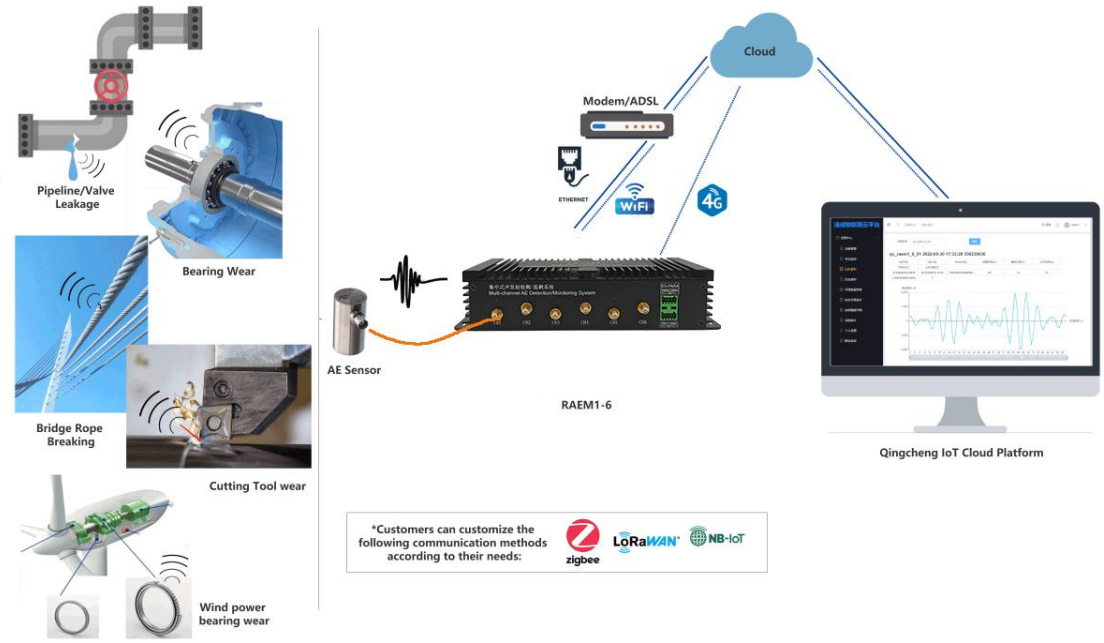


Fig. 6-1 Schematic Diagram of RAEM1-6 Monitoring System Connection

In addition to its function as a detector, the RAEM1-6 can also be used as a monitoring device. Specifically, the RAEM1-6 can upload data to various cloud platforms (Qingcheng IoT Cloud Platform or user-owned private cloud platform) via existing LAN, WiFi, and 4G communication methods, enabling long-term unattended IoT monitoring of monitored objects. The IoT cloud provides flexible alarm threshold settings and can proactively push alarm information to client mobile phones. The IoT cloud can be Qingcheng IoT Cloud Platform or a user-owned private cloud platform.

Note: WiFi and 4G modules cannot be simultaneously built into the RAEM1-6; only one can be selected.

Monitoring Mode: The RAEM1-6 uses MQTT, ISAE, TCP, and Modbus TCP communication protocols to send data to the cloud. In this mode, the data reported is the parameter with the largest amplitude within the reporting period of that channel, along with its corresponding waveform.

6.1. 4G Network Connection

The RAEM1-6 can connect directly to the cloud server via mobile internet using a 4G IoT SIM card for parameter configuration, data transmission, and display analysis. A 4G antenna and an IoT SIM card are required. After hardware connection, first use Ethernet connection in the detection mode (refer to Chapter 5.1.2) to change the operating mode to **"Monitoring Mode"**, selecting **"MQTT"** as the communication protocol. After modification, restart the device and log in to the cloud platform to check the RAEM1-6 status. Once it displays "Online," you can begin operation.

SIM card installation:

The SIM card slot is located on the back of the RAEM1-6, as the size of a Nano SIM card. Simply insert the IoT network card to activate it. Note that the SIM card slot has a notch facing inward, with the metal chip side facing downward. Since the slot is positioned relatively inward, inserting or removing the card requires a thin pen or similar tool. To insert, push the SIM card in until it clicks into place. To remove, first push the card inward with a pen until it clicks out.

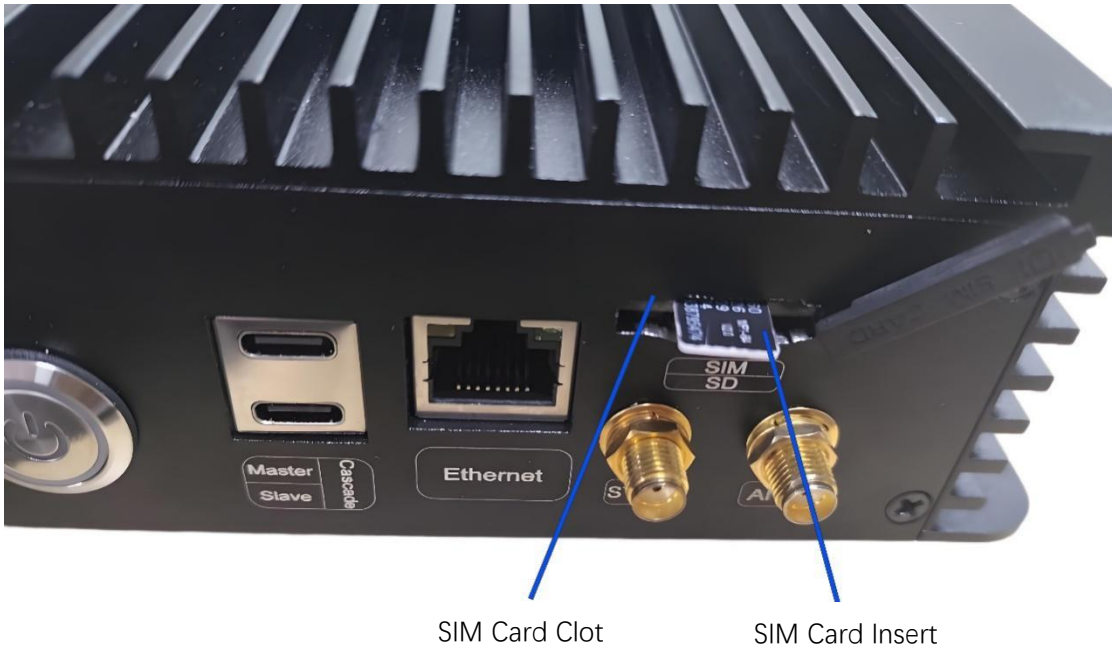


Fig. 6-2 RAEM1-6 SIM Installation Diagram

6.2. LAN/ WiFi Network Connections

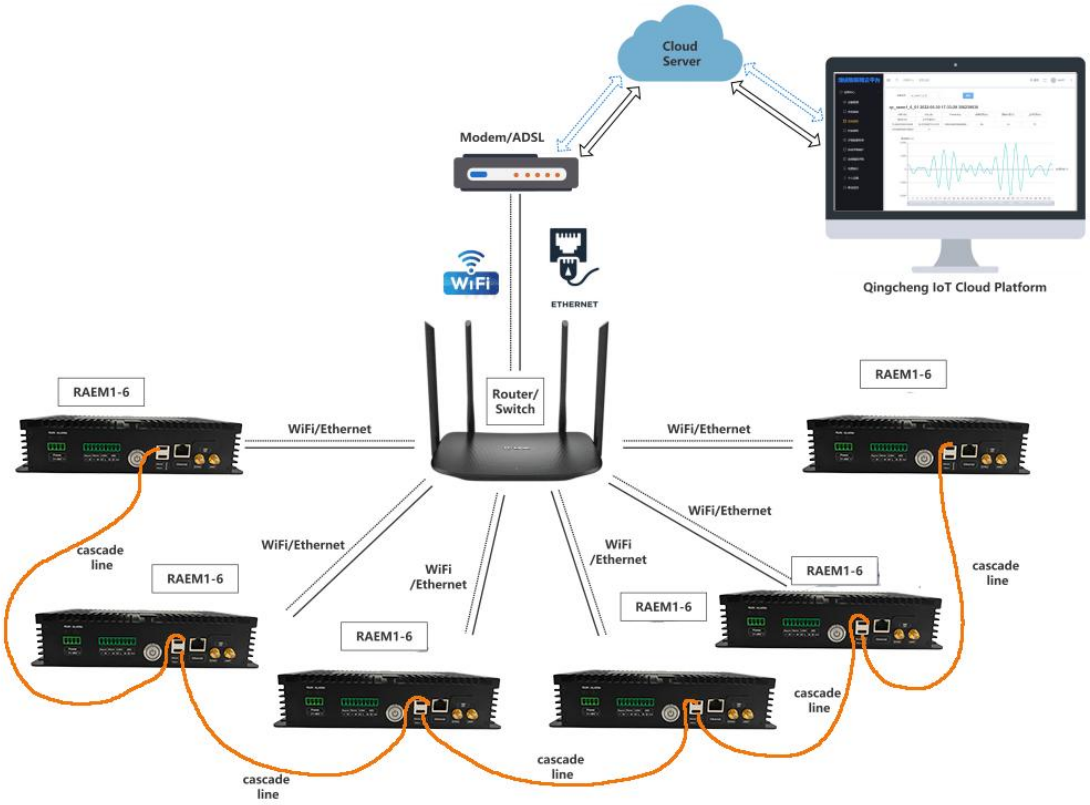


Fig. 6-3 RAEM1-6 Multi-Device Network Cloud Monitoring Diagram

Single or multiple RAEM1-6 devices can be used as a monitoring system to connect to the internet via a router. First, connect the RAEM1-6 devices to the router using network cables or wirelessly (Chapter 5.2.2 Router Mode). Then, connect the router to the Internet and log in to the IoT cloud platform. Configure the router to automatically assign IP addresses to devices.

Note: Choose a router/switch that does not require authentication for Internet access.

After successful connection, you can directly access the internet to view the devices and begin operations on the IoT cloud platform. If the computer and RAEM1-6 devices are on the same Wi-Fi router network, you can also use the "RAEM1-6 Configuration Software" for local configuration and simple debugging.

RAEM1-6 Configuration Software Settings:

① Refer to *Chapter 5.1 Ethernet Connection* or *5.2 WiFi Connection* to connect the RAEM1-6 hardware to network and the related configuration settings in the M1-6 Configurator software.

② In the RAEM1-6 configuration software, change the working mode to **"Monitoring Mode"** in the **[System Settings]** section, and select "**Dynamic**" for the IP mode.

③ In **[Network Settings]**, select **"MQTT"** in the **"Protocol:".**

④ To make some modifications on the table below, first check the **"Modify"** checkbox next to the Device ID. Each checkbox corresponds to each channel. Only when the channel "Modify" checkbox is enabled, the modification will be sent to the device.

⑤ If the data is sent to the Qingcheng IoT Cloud Platform, the settings on the MQTT settings page do not need to be modified. If the data needs to be sent to a customer-specified platform, change "**Target Address**" to **"user"**, and fill in information under the **"Customer Server"** section on the right.

⑥ Under the **"Data Transmission"**, the **[Tx Param]** and **[Tx Wave]** are to enable or disable sending parameter and/or waveform through MQTT protocol. (Note: Sending parameters are required; whether to send the waveform depends on the user's needs).

⑦ After the above modifications, click **[Apply]** button at the bottom to send the settings to RAEM1-6. Then restart the device. (Note: When the computer is connected to the same router as the RAEM1-6, local configuration and debugging can be performed on the RAEM1-6 configuration software)

⑧ After the device is online, log in to the Qingcheng Cloud Platform to see that the device status is displayed as **"Online"**.

7. Qingcheng IoT Cloud Platform

Qingcheng IoT Cloud Platform is a cloud-based solution developed for IoT acoustic emission products. Customers can log in to remotely monitor device configurations, modify settings, display real-time waveforms, parameters, and rating data and download data.

Log in to the cloud platform http://cloud.ae-ndt.com/ by entering your username and password. Currently, the cloud platform does not support user registration. All account registrations must be handled by QAWRUMS. Please contact us for account registration and login information inquiries.

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

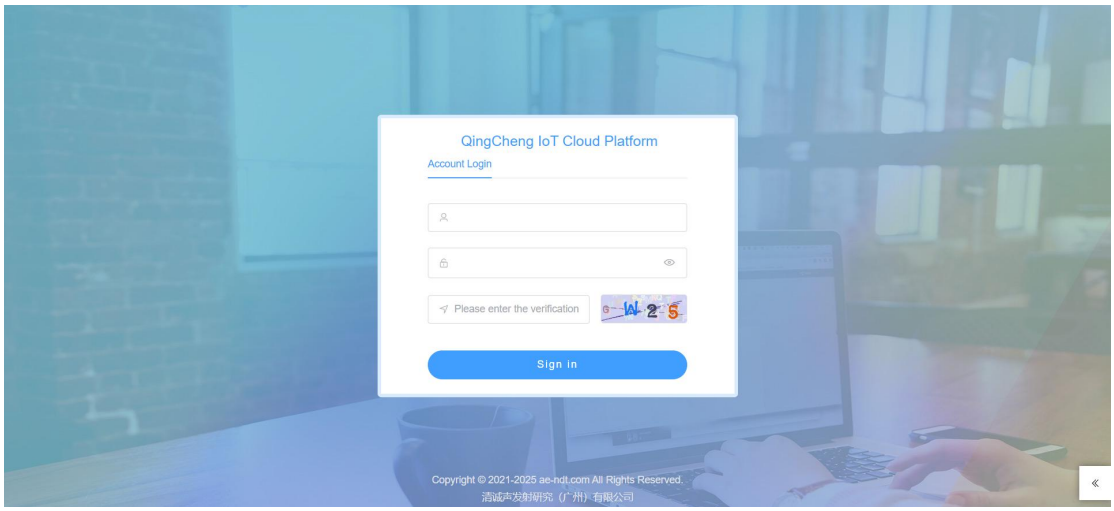


Fig. 7-1 Qingcheng IoT Platform Login

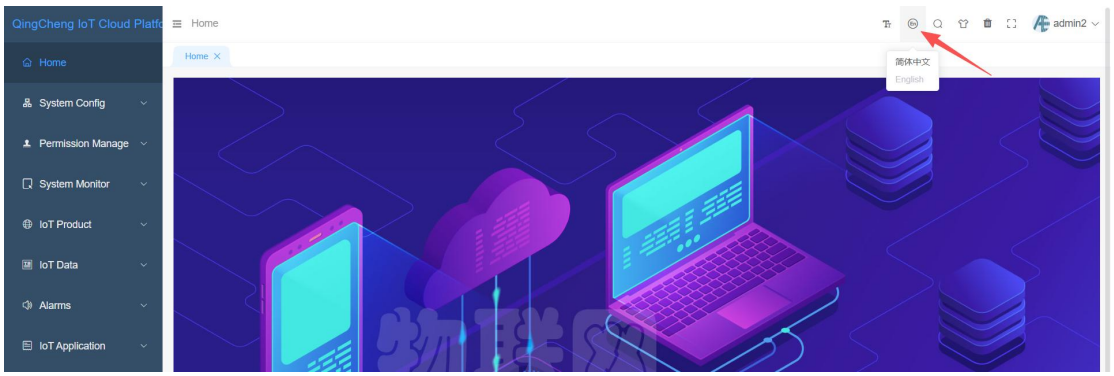


Fig. 7-2 Cloud platform change language

7.1. IoT Product

7.1.1. 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.

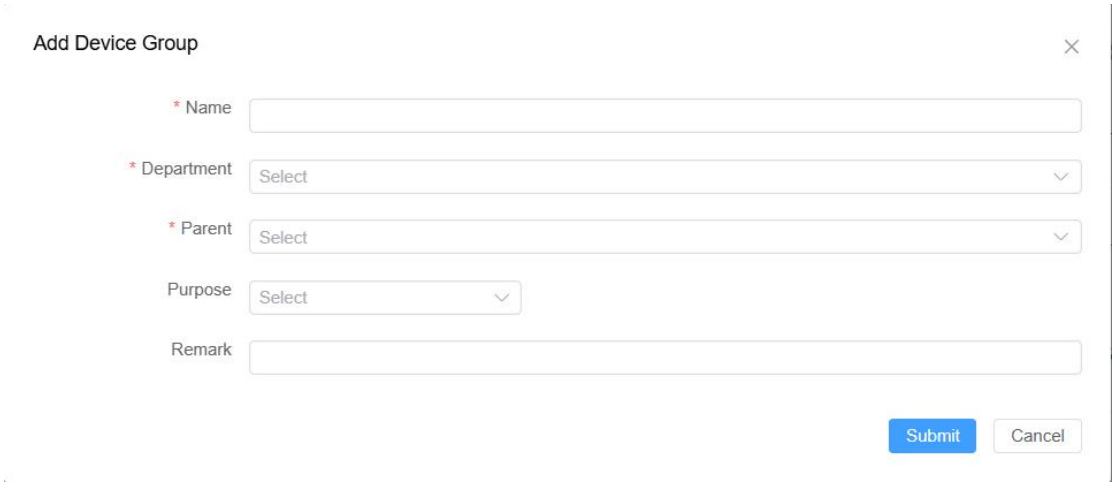


Fig. 7-3 Qingcheng IoT Cloud Platform Device Groups "Add"

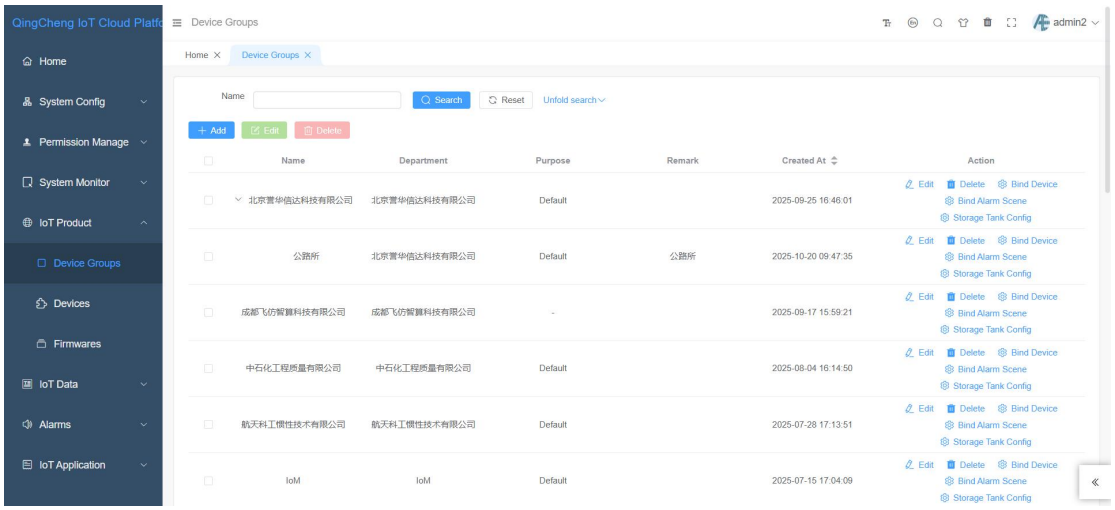


Fig. 7-4 Qingcheng Cloud Platform Device Groups

- **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.

7.1.1.1. 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.

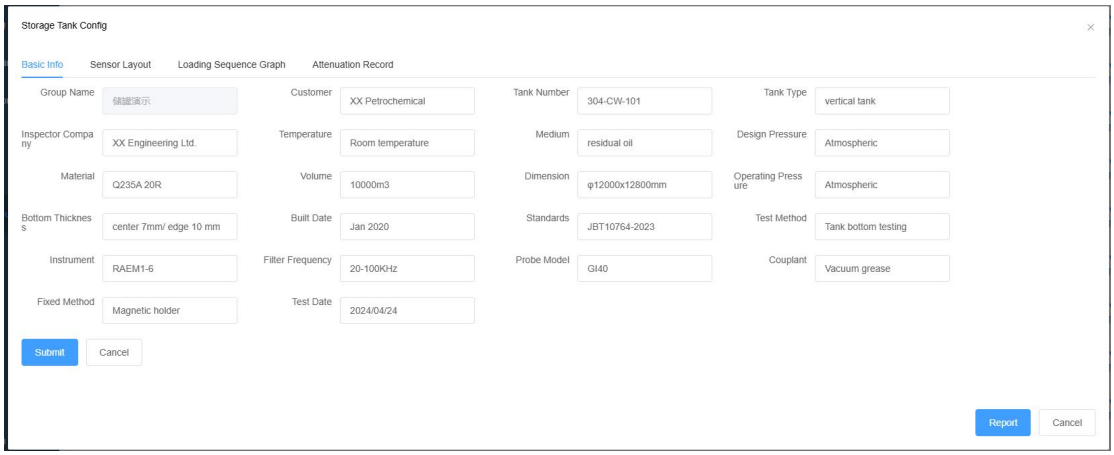


Fig. 7-5 Storage tank configuration - basic information

■ **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.

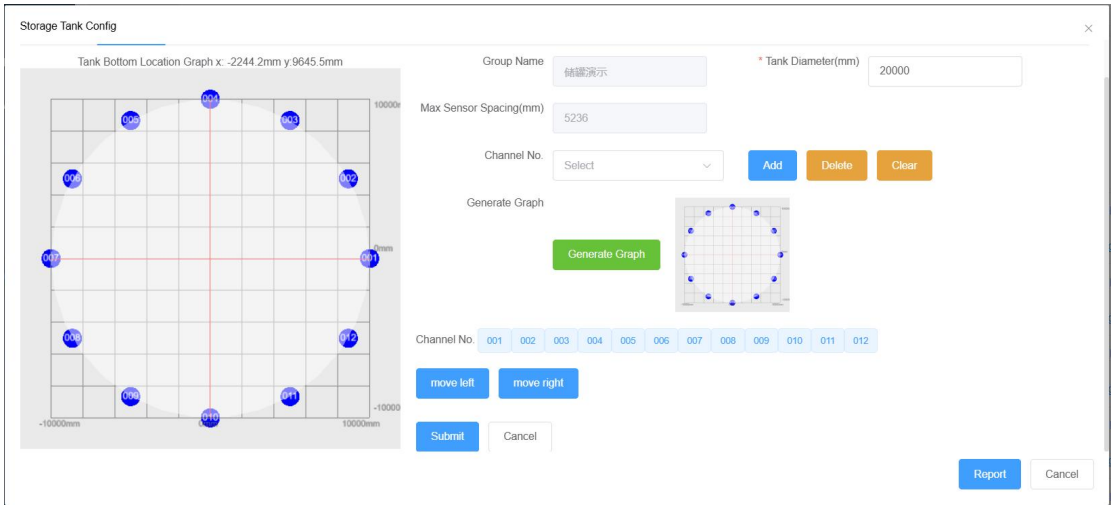


Fig. 7-6 Storage tank configuration - Sensor layout

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.

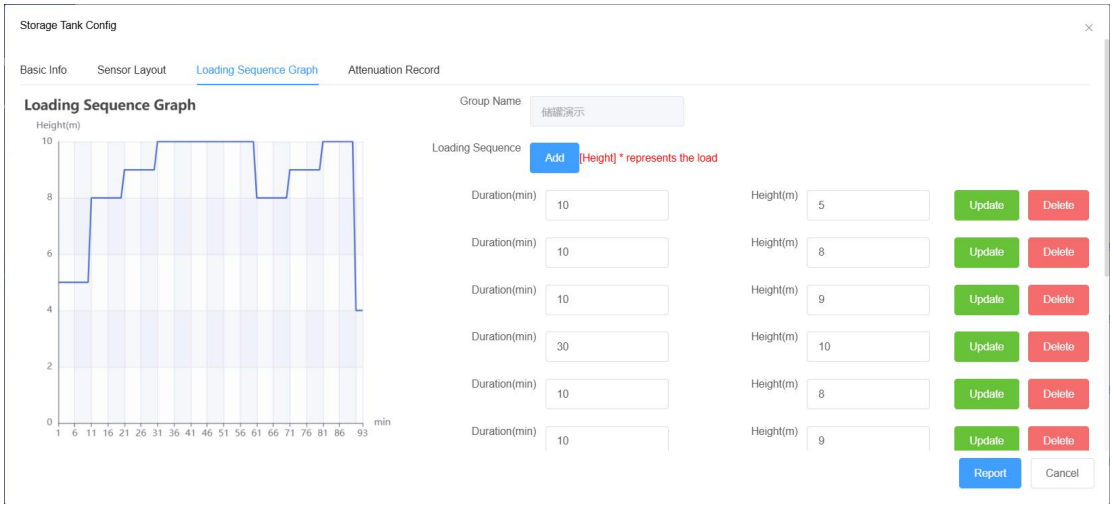


Fig. 7-7 Storage tank configuration - loading sequence

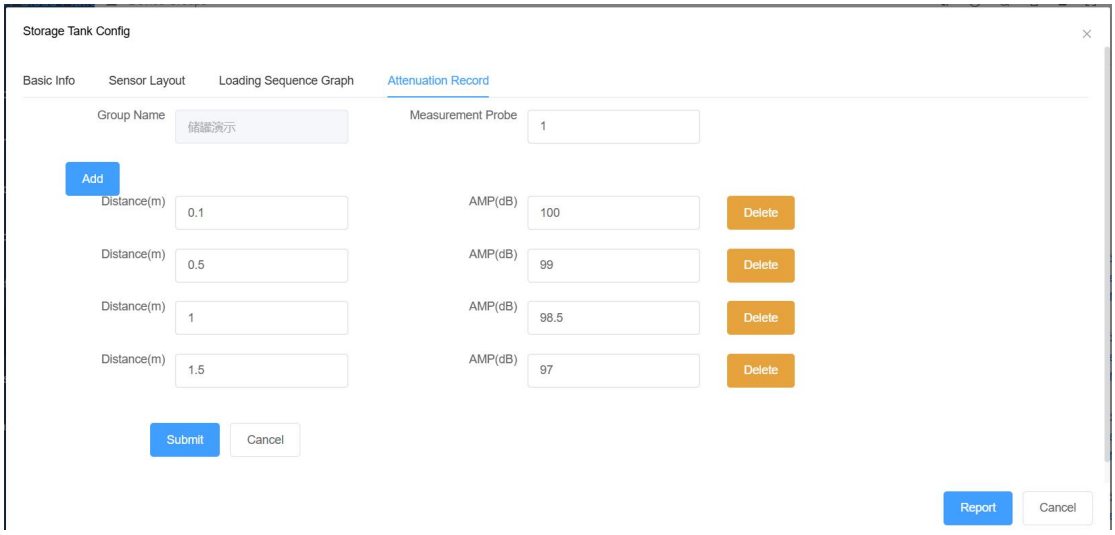


Fig. 7-8 Storage tank configuration - Attenuation record

7.1.2. 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.

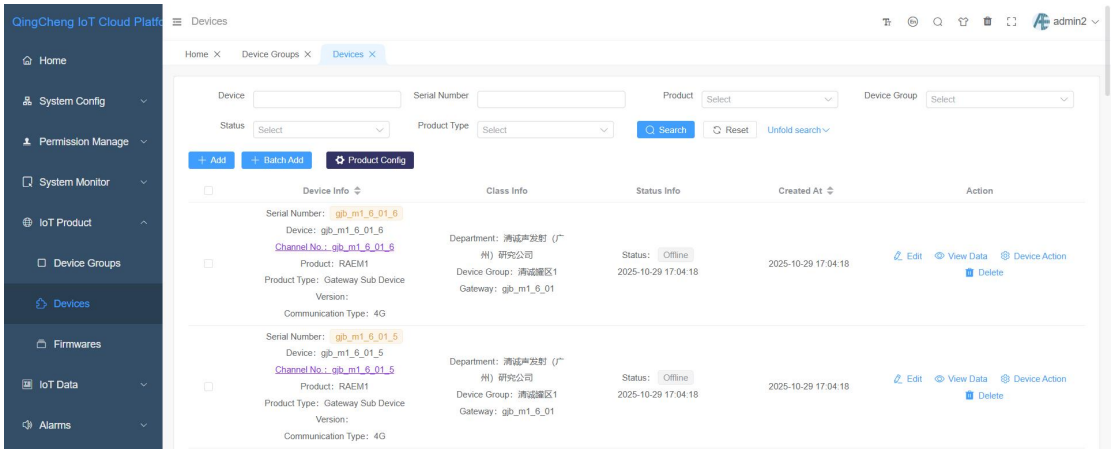


Fig. 7-9 Device list of Qingcheng IoT Cloud Platform

Click **[+Add]** button 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)

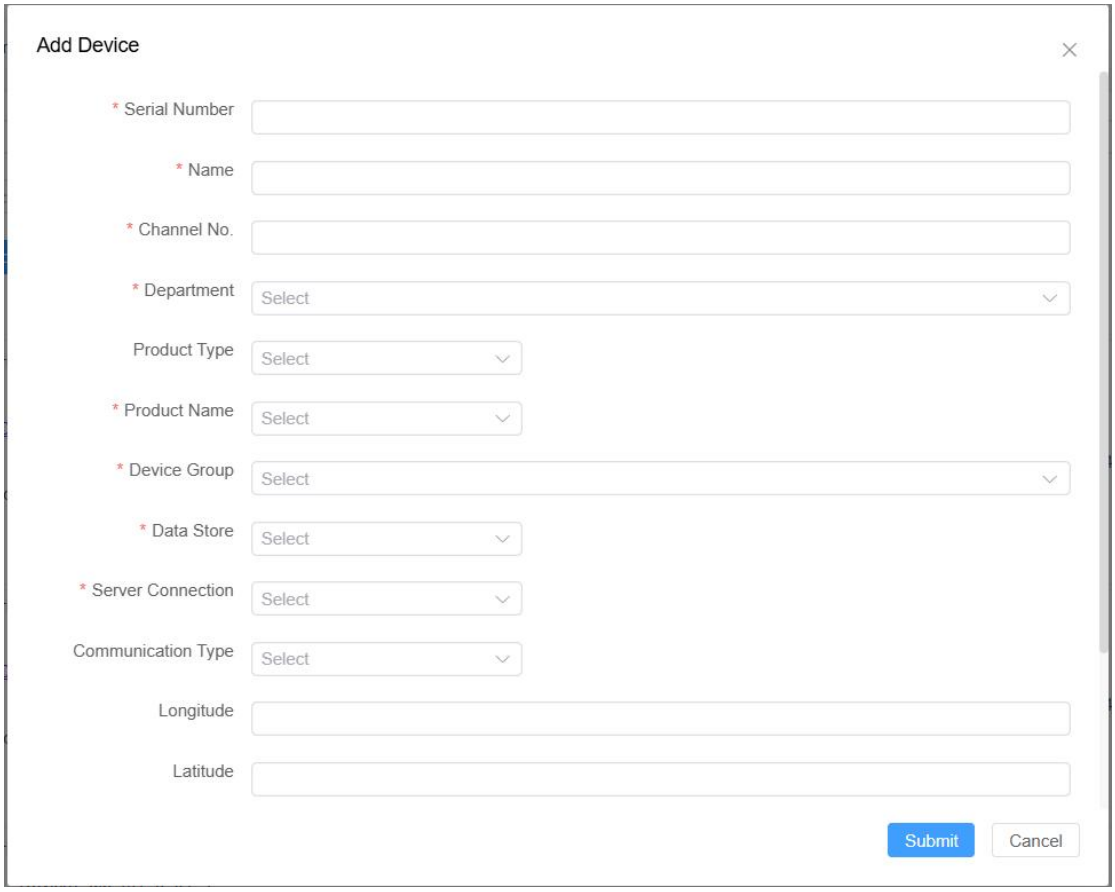


Fig. 7-10 Add device

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.

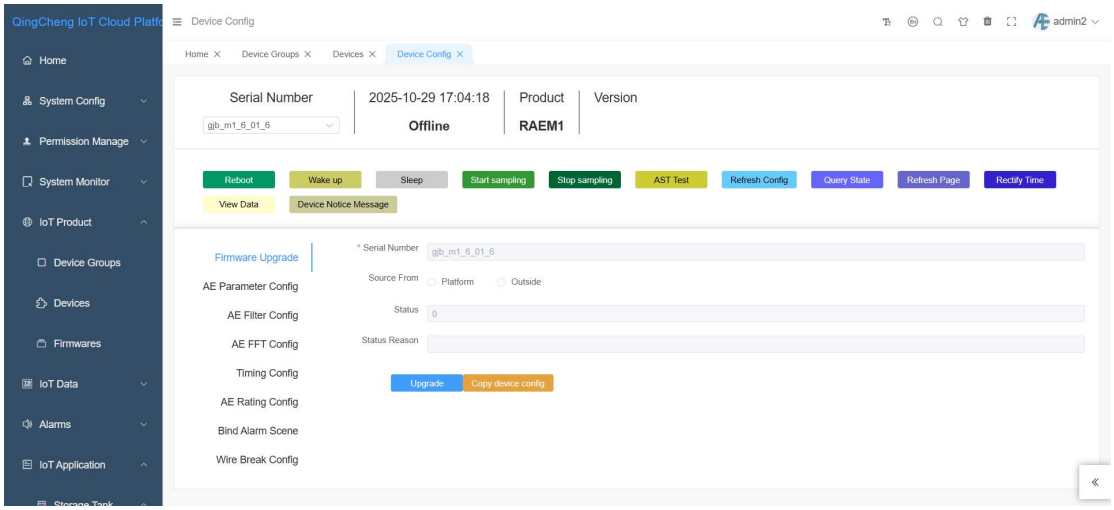


Fig. 7-11 Device Action page

7.1.2.1. 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 (k/s)**

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.

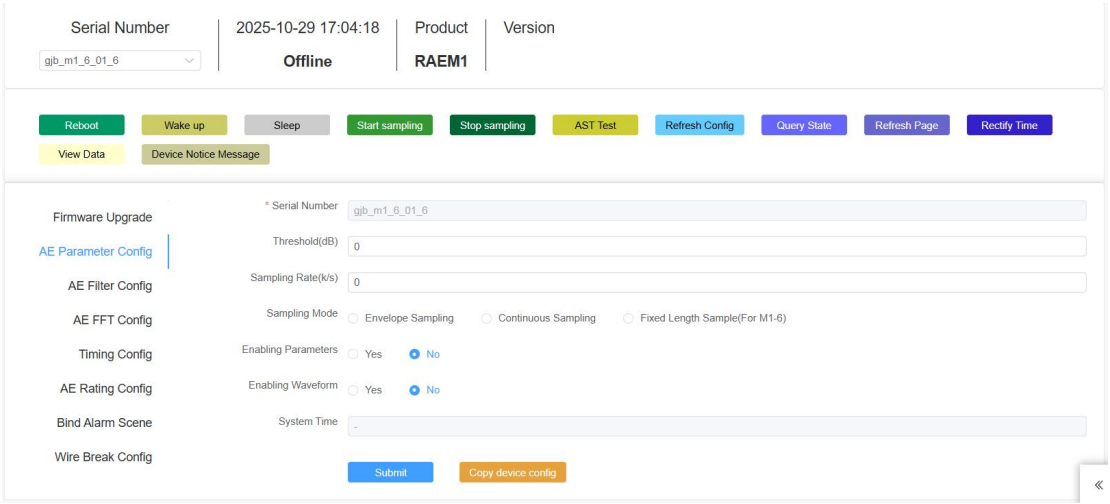


Fig. 7-12 Device Action - Parameter Config page

7.1.2.2. 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.

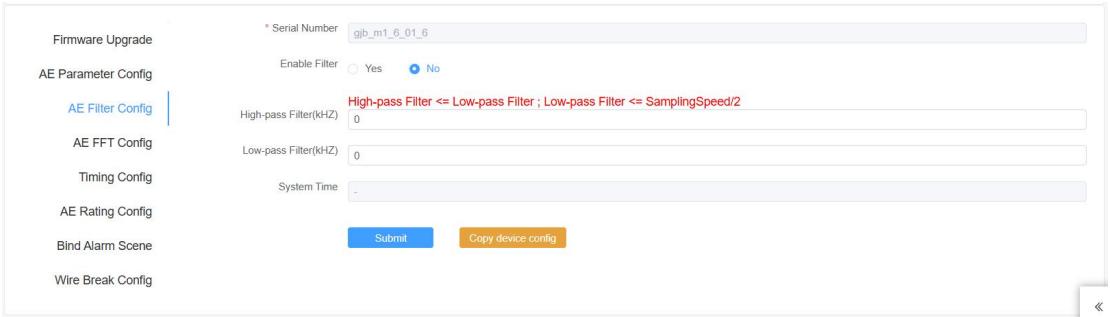


Fig. 7-13 AE Filter Config

7.1.2.3. 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 "**Auto Spacing**" to auto proportionally allocate the frequency range set here.

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

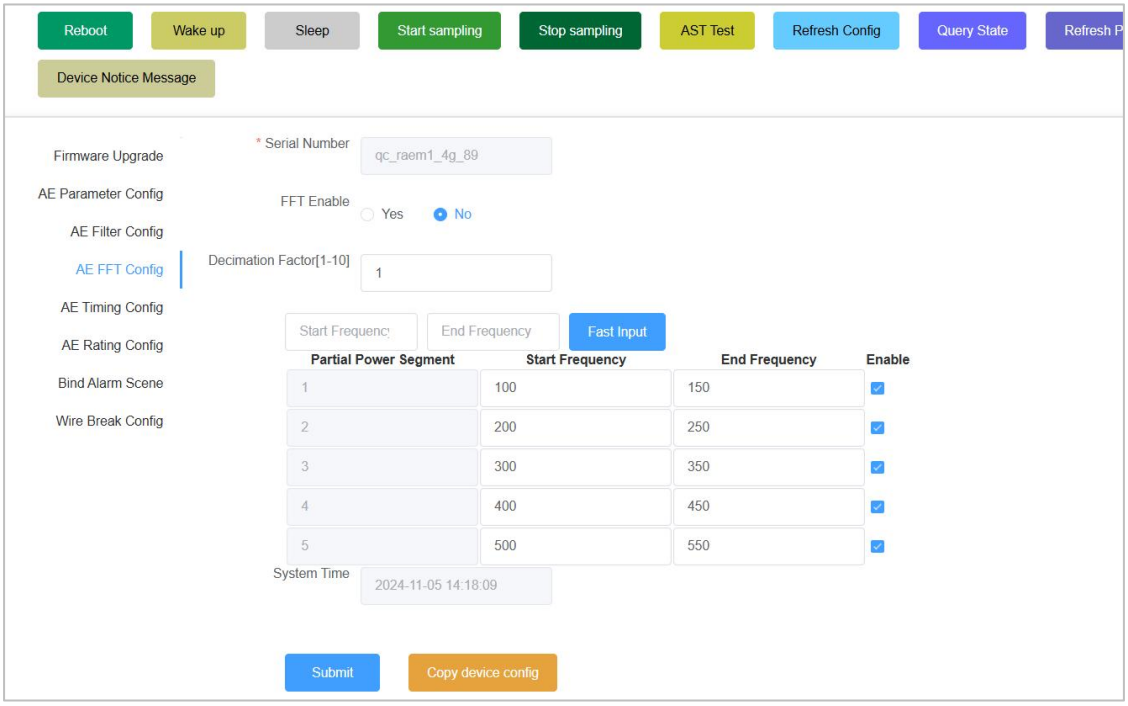


Fig. 5-15 AE FFT Config

7.1.2.4. 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.

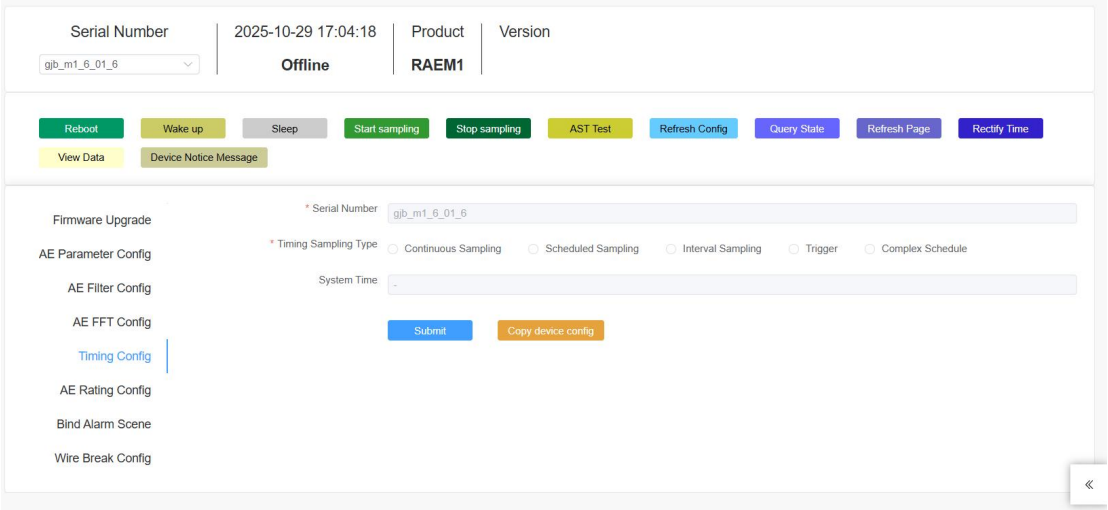


Fig. 7-15 AE Timing Config

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.

7.1.2.5. 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 7-1 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.

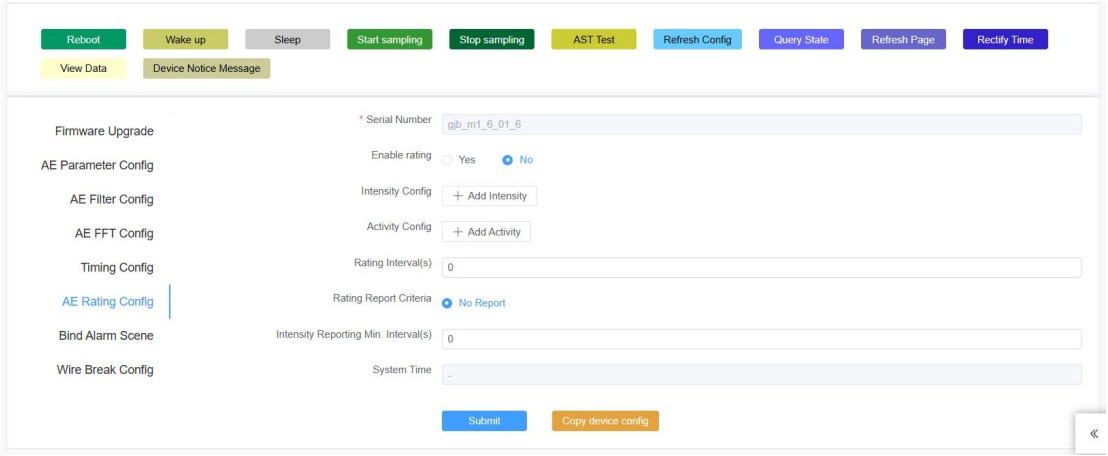


Fig. 7-16 AE Rating Config

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.

7.2. IoT Data

7.2.1. 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" (each channel of RAEM1-6 is considered as an “RAEM1” in the cloud). **[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**'.

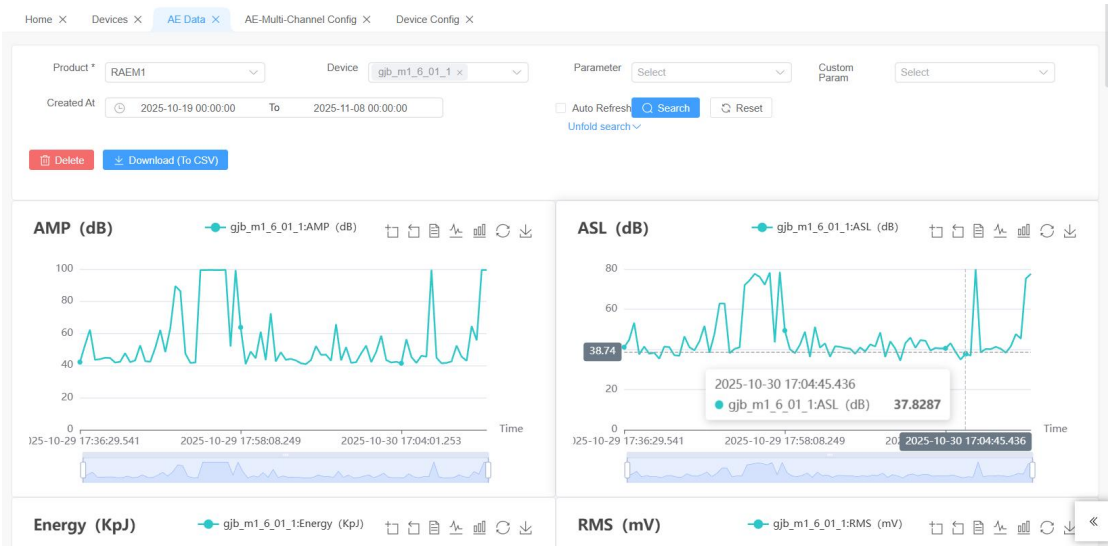


Fig. 7-17 AE Data page

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. 7-18 Waveform page from the AE Data

Fig. 7-19 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**: list all the data points in table list.
- **Switch to line chart**: display data in line chart.
- **Switch to bar chart**: display data in bar chart.
- **Restore**: Restore to default state.
- **Save as Image**: You can save the image to your computer.

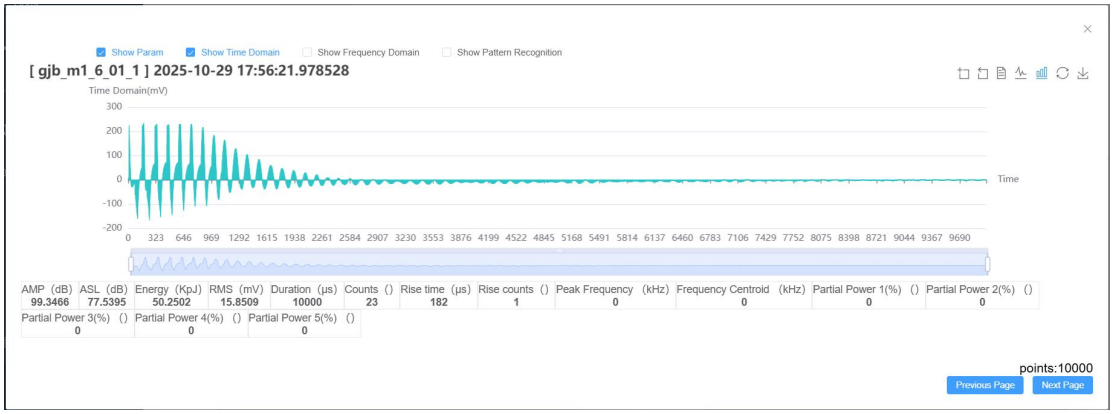


Fig. 7-20 Waveform page switch to bar chart

(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.

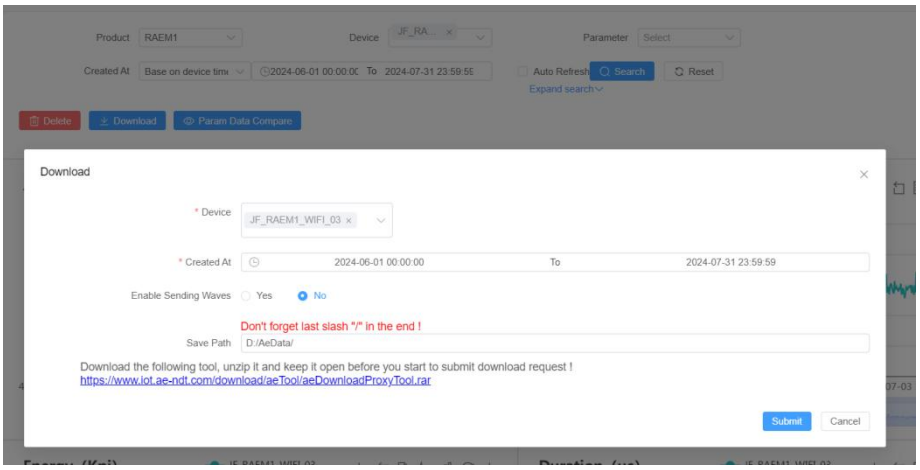


Fig. 7-21 AE data download page

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.

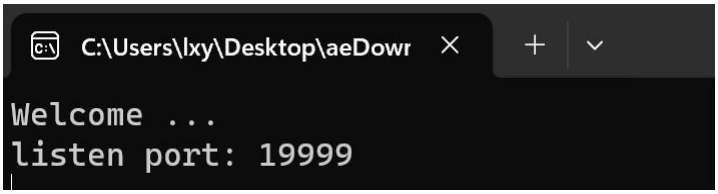


Fig. 7-22 AE Download Proxy Tool window

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

Fig. 7-23 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.

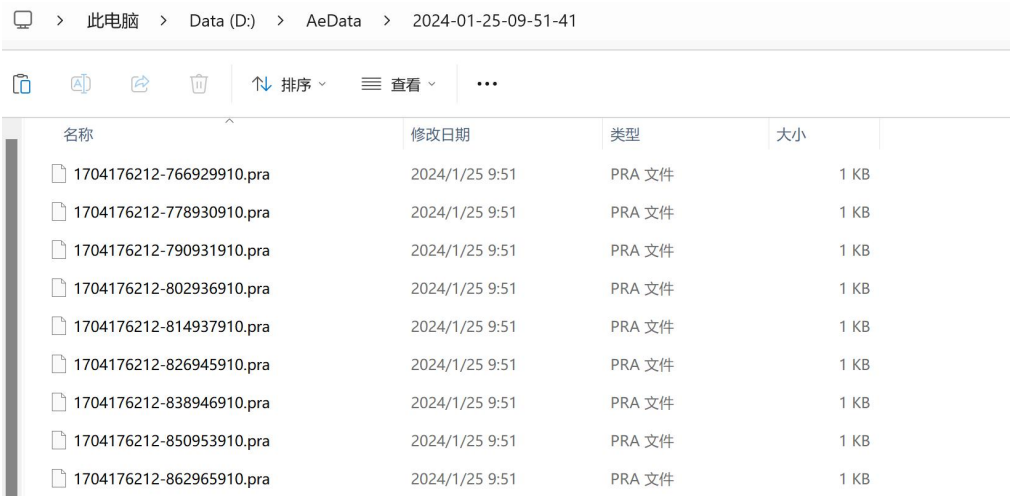


Fig. 7-24 Downloaded file

Data format conversion operation:

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

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**.

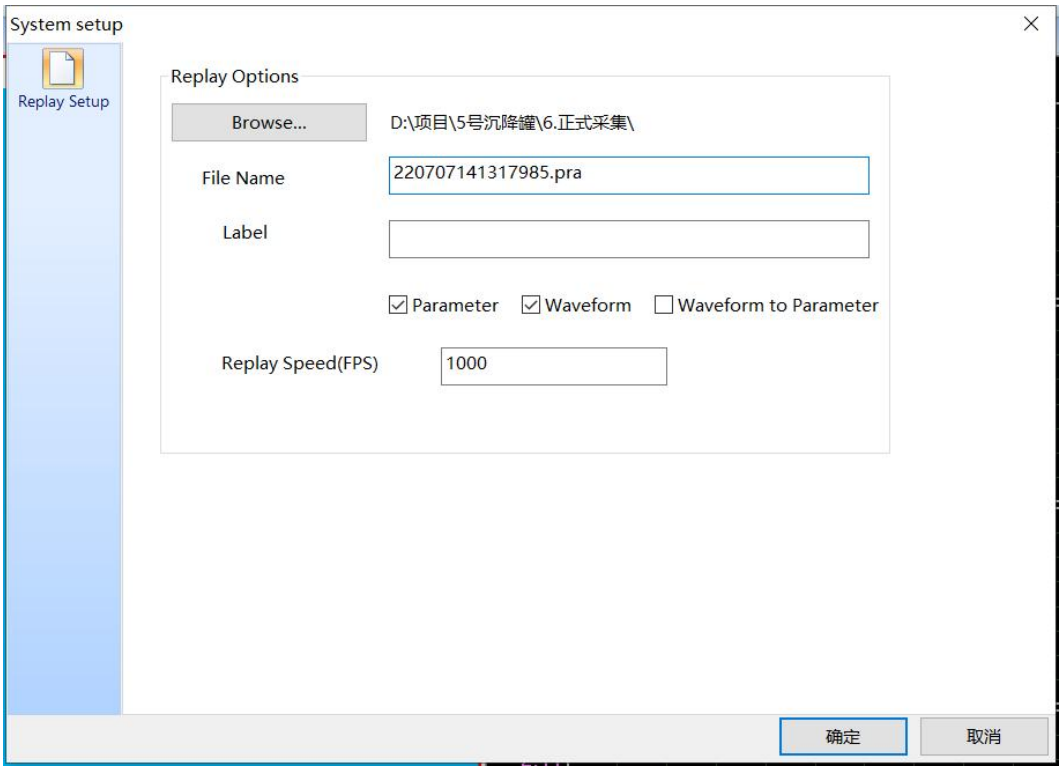


Fig. 7-25 AE data replay setting window

(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.

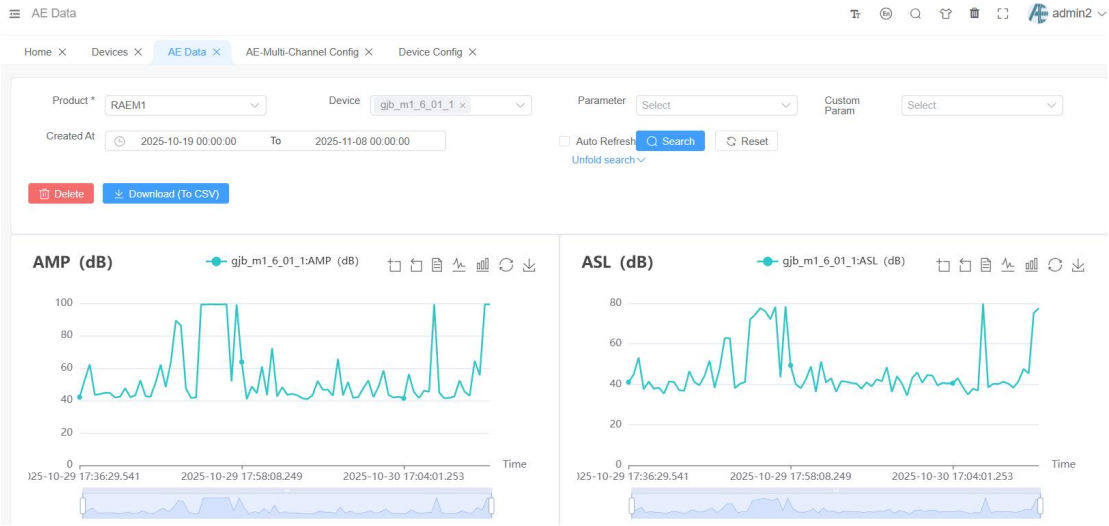


Fig. 7-26 AE data delete window

7.2.2. AE Rating Data

Users need to firstly **enable AE rating** function in the **Devices > Device Action > AE Rating Config** in Chapter 7.1.2.5, 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.

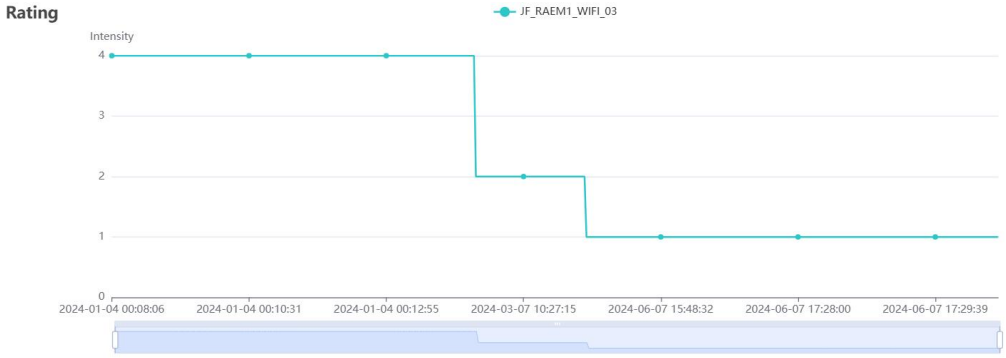


Fig. 7-27 AE Rating Data window

7.2.3. 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. 7-28 Correlogram

7.3. Alarms

7.3.1. 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. 7-29 Add new alarm user

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

Fig. 7-30 Bind user with alarm scene

7.3.2. 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.

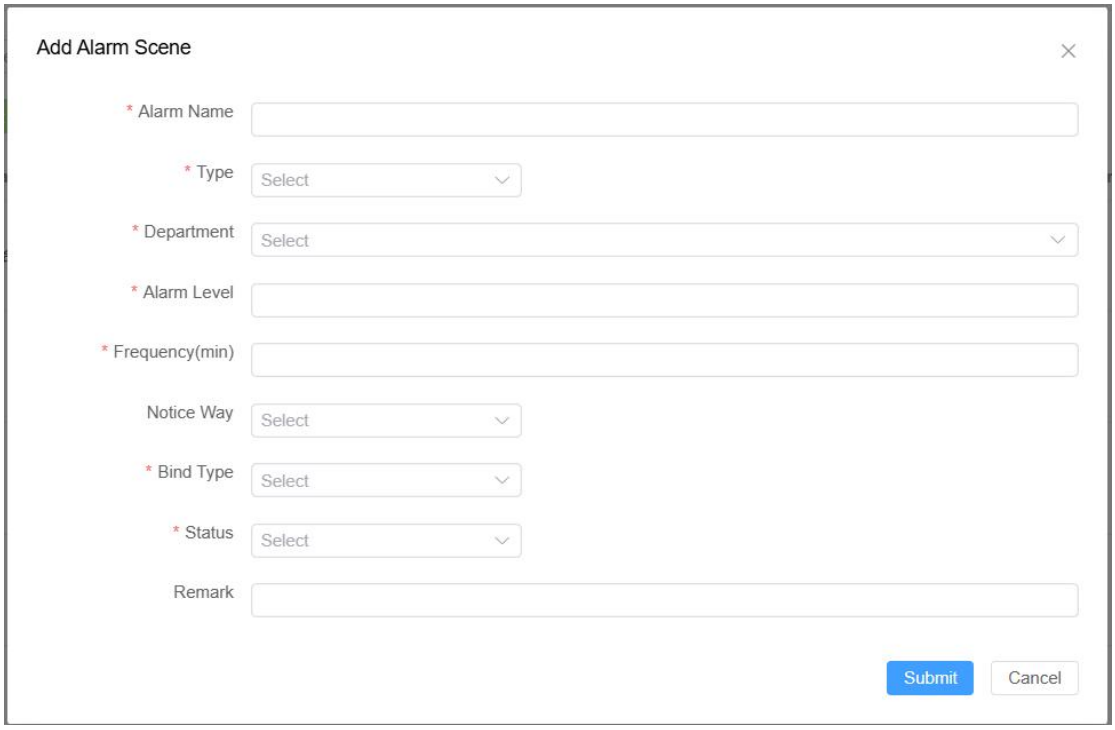


Fig. 7-31 Add new alarm scene page

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. 7-32 Bind scene with contact

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

Fig. 7-33 Bind scene with device

7.3.3. User Messages

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

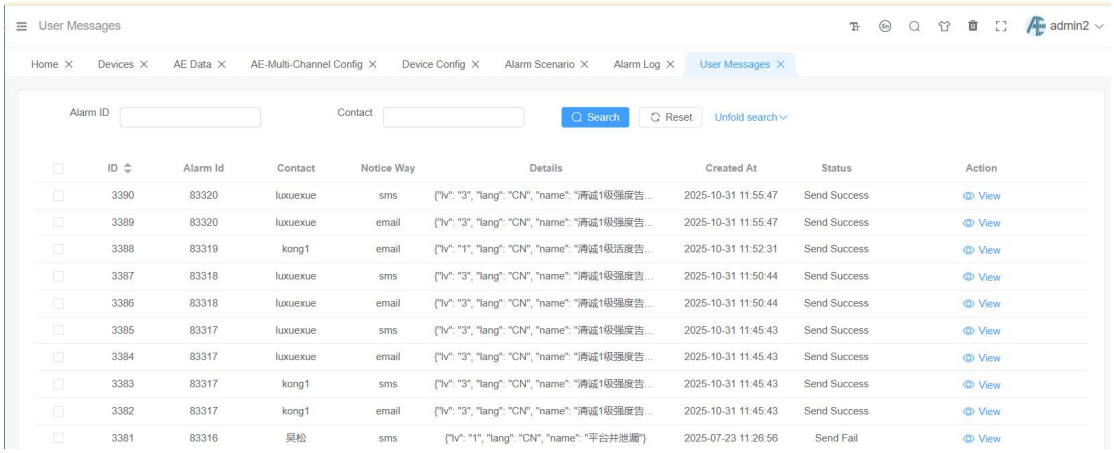


Fig. 7-34 View alarm message

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

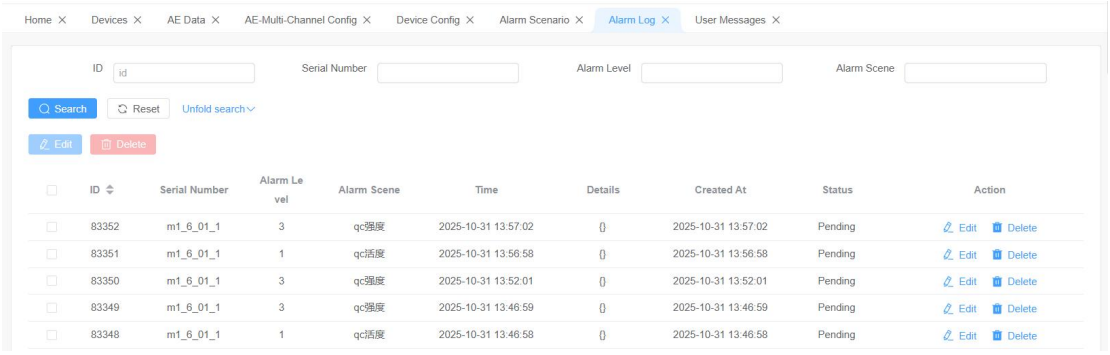


Fig. 7-35 View alarm log

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

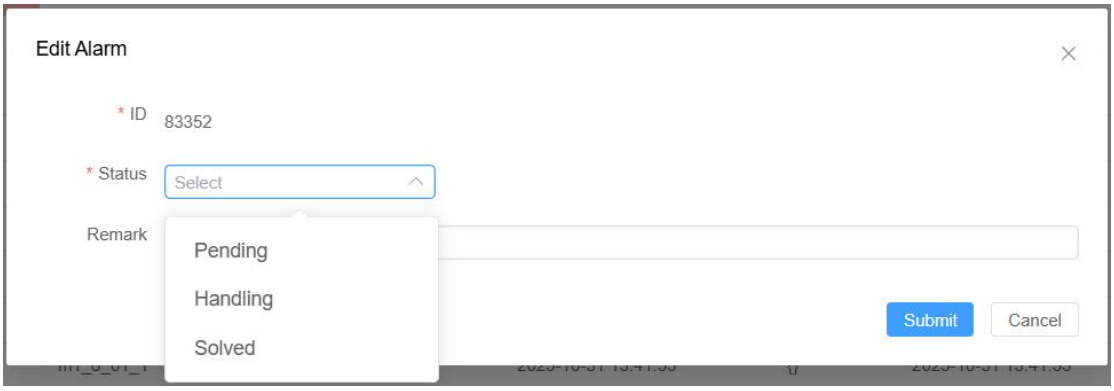


Fig. 7-36 Handle alarm page

7.4. 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.

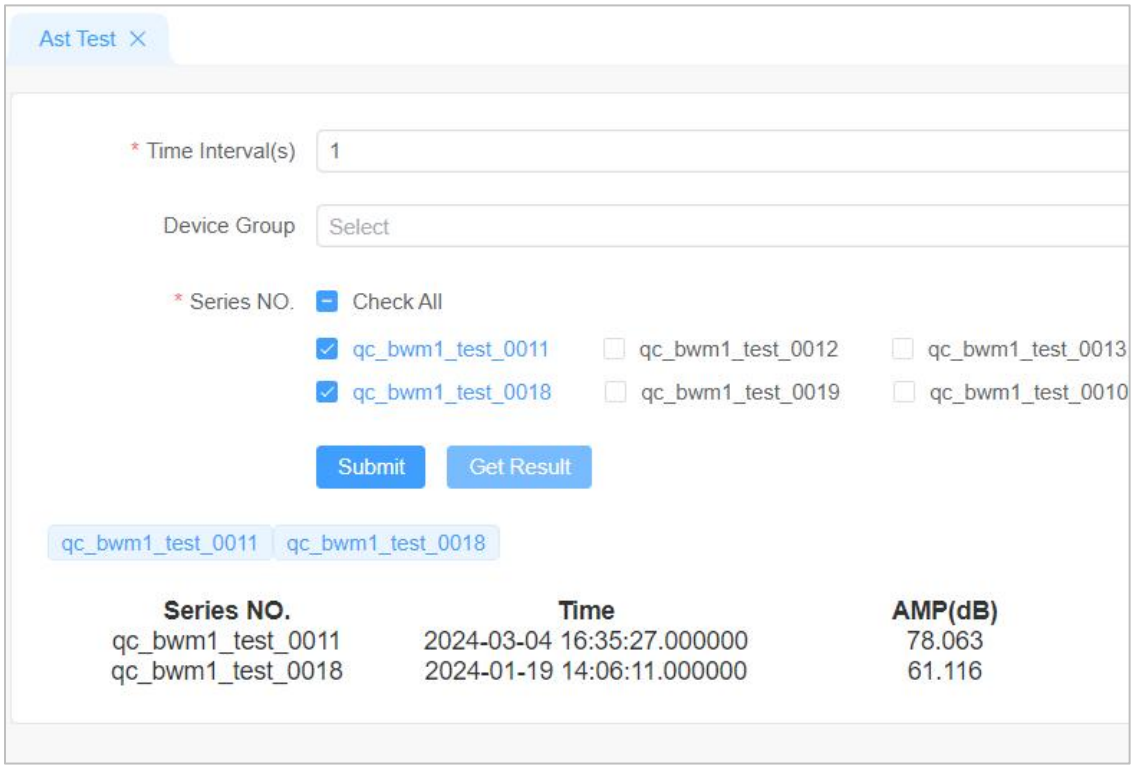


Fig. 7-37 AST page and testing results

7.5. Storage Tank

7.5.1. 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. Refer to Chapter 7.1.1.1.

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.

7.5.2. 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.

7.6. Steel Wire Break Monitoring

In accordance with the standard JT/T 1037-2022 Technical Specifications for Monitoring Highway Bridge Structures, acoustic emission monitoring is conducted on suspension bridge cables, main cables, cable stays of cable-stayed bridges, and suspension rods or tie rods of arch bridges.

Specify the number of broken wires and the broken wire rate for each cable according to the standard (the broken wire rate is the percentage of broken wires to the total number of cables).

Operation steps of steel wire rope break monitoring in bridge:

(1) **[Alarms]** → **[Alarm Scenario]** to enter the alarm name, level, frequency, and notification method. Refer to 7.3.2 Alarm Scenario for details. Select the "Disconnection" type. Bind the device and contact.

(2) **[IoT Product]** → **[Devices]** → **[Device Action]** → **[Wire Break Config]** Enter the total number of steel wires and the number of broken wires according to actual conditions.

(3) **[Alarms]** → **[Wire Break Monitor]** Select the device, creation time, and alarm scenario, then click **[Search]** to view the thread breakage rate and count.

Fig. 7-38 Wire Break Rate