Acoustic Wave (Acoustic Emission)

Monitoring and Detecting of Rotating Equipment

1、Introduction

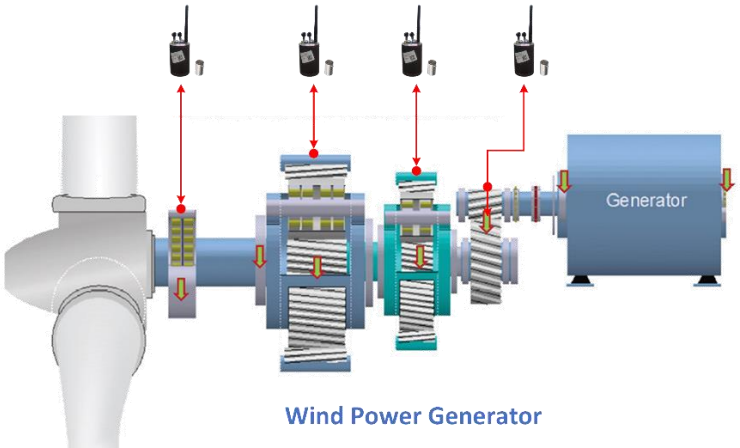
Application：

Condition monitoring of mechanical equipment (damage state, lubrication state, etc.) that mainly rely on rotating action to complete specific functions.

Such as: gear box, centrifugal fan, centrifugal pump, steam turbine, gas turbine, generator, motor, centrifugal compressor, hydraulic turbine, aircraft engine, centrifugal separator, lathe, grinder and other rotating mechanical equipment.

Wind Turbine Bearing/Gearbox　Pump　Turbogenerator　Centrifugal Compressor

Widely used in electric power, petrochemical, metallurgy, machinery manufacturing and aerospace and other important engineering fields



Wind Power Generator

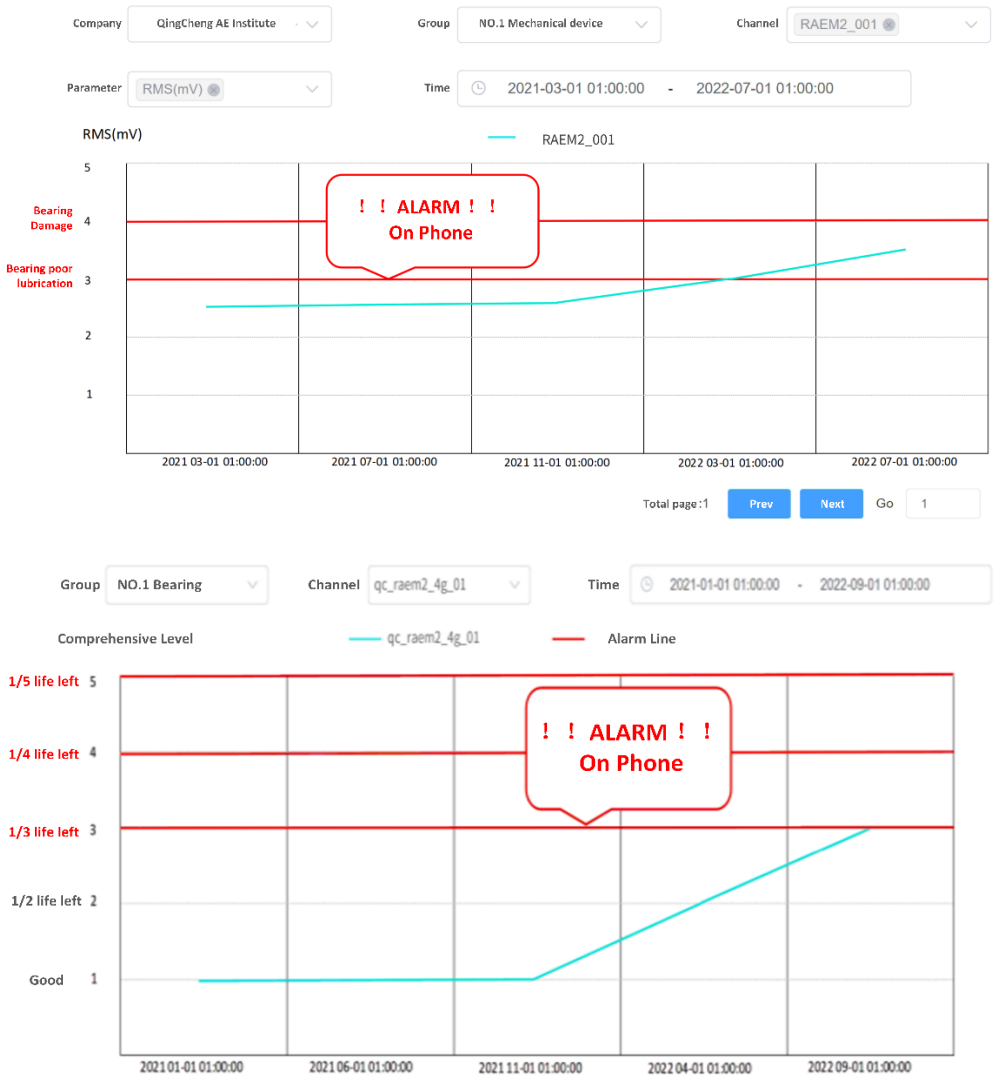
✯ It is mainly used to monitor the damage of bearings (sliding bearings, rolling bearings) of rotating equipment and various parts installed on rotating shaft.

Monitoring Object	Solution	Installation Site	Quantity	Principle
Rolling	Multiple RAEM2;	Fixed part	Multiple	Acoustic waves are generated when rotating equipment is operated,

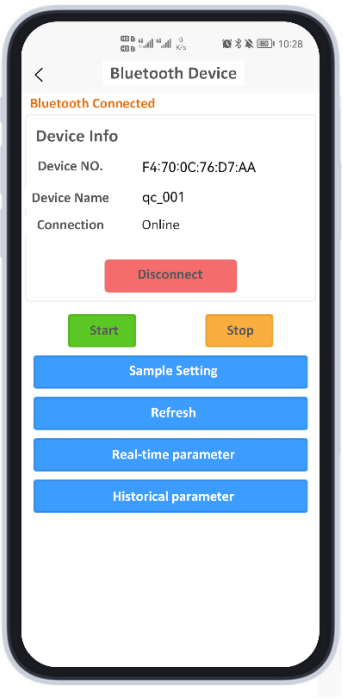
Bearing	Battery powered	of rotating equipment		including those audible to human ears and those outside the audio range that cannot be heard by human ears. The acoustic wave should have a different spectrum for different states (normal operation,wear, lubricant contamination and deterioration, etc.). The acoustic wave is received by RAEM2 monitor, and the corresponding state isobtained through qualitative and quantitative analysis of themonitor and the cloud platform of the Internet of Things.
Sliding Bearing				
Impeller				
Gear				
Coupling				
……				

Results:

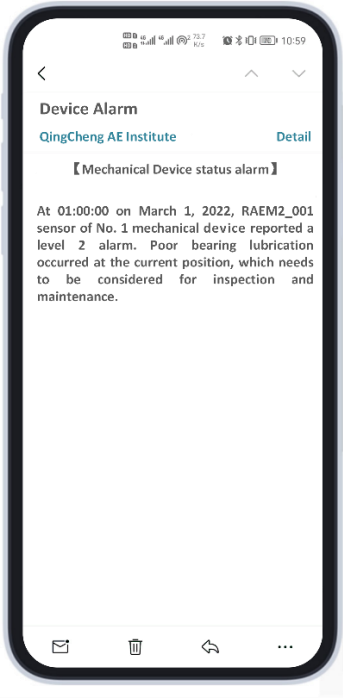
365 days of real-time online monitoring and detection, remote control and use of the Internet of Things, support for mobile phone Bluetooth onsite inspection, automatic analysis of results throughout the whole process, and mobile phone alarm push automatically.



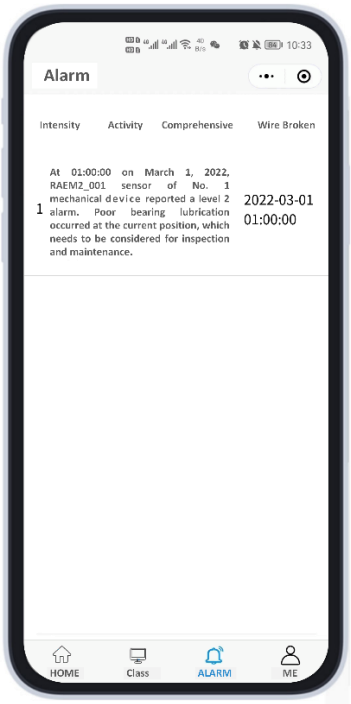
Cloud platform data diagram



Inspection via Bluetooth



Alarm via email



Alarm via mini program

Alarm via SMS

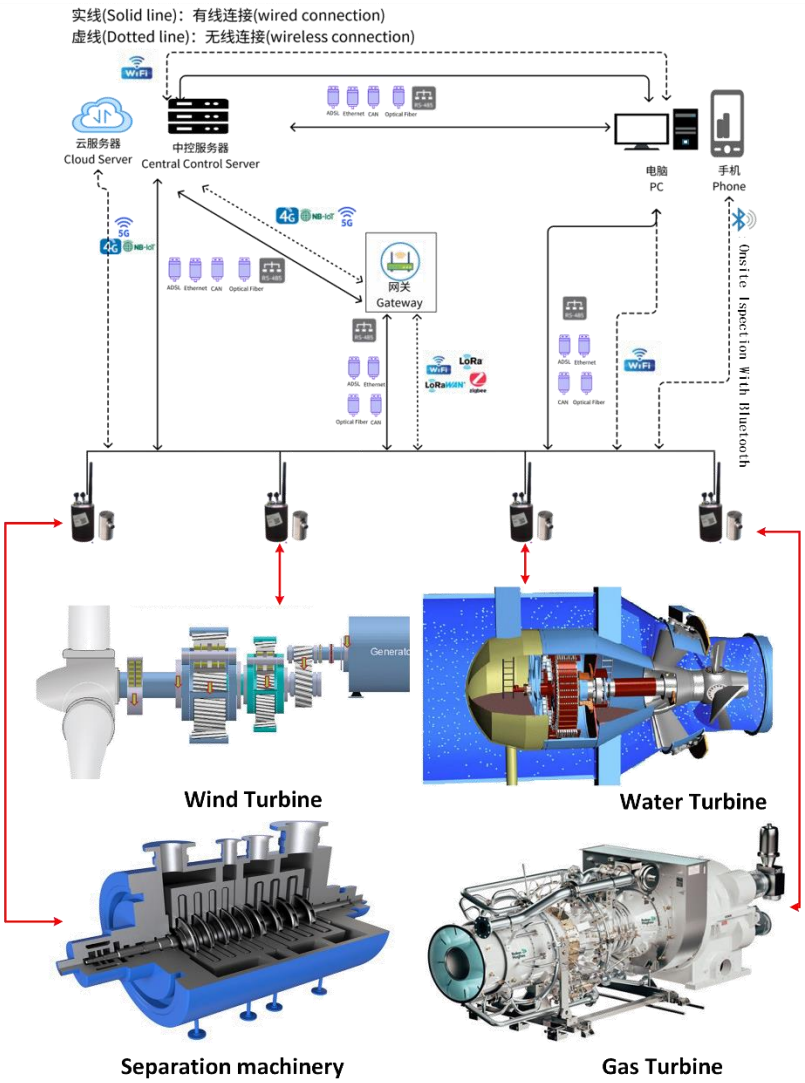
- Real-time online and historical data screen display
- Automatic diagnosis of monitoring results
- Online mobile alarm push

2、Solution-RAEM2 Acoustic Wave (Acoustic Emission) Monitoring System

Various of data transmission communication modes (Wi-Fi, 4G, Ethernet, RS485, etc.) can be configured according

to user requirements to achieve regular detection/local long-term monitoring detection/remote long-term monitoring detection and other application modes.

（Choose the right method of communication according to local conditions）

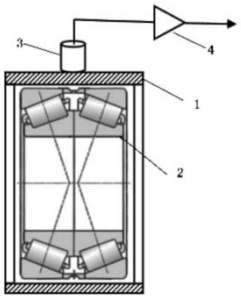


Note: The above systems have the functions of onsite inspection and debugging via mobile app Bluetooth.

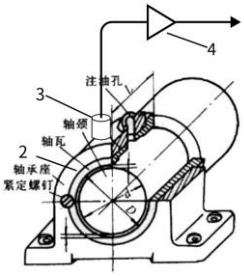
RAEM2+40 Series Sensor:

RAEM2

GI40 Sensor



Rolling Bearing



Sliding Bearing

1 -- Component Housing
2 -- Rotating Component
3 -- Acoustic Emission Sensor
4 -- Signal Acquisition System

Installation site: fixed part of a rotating device.

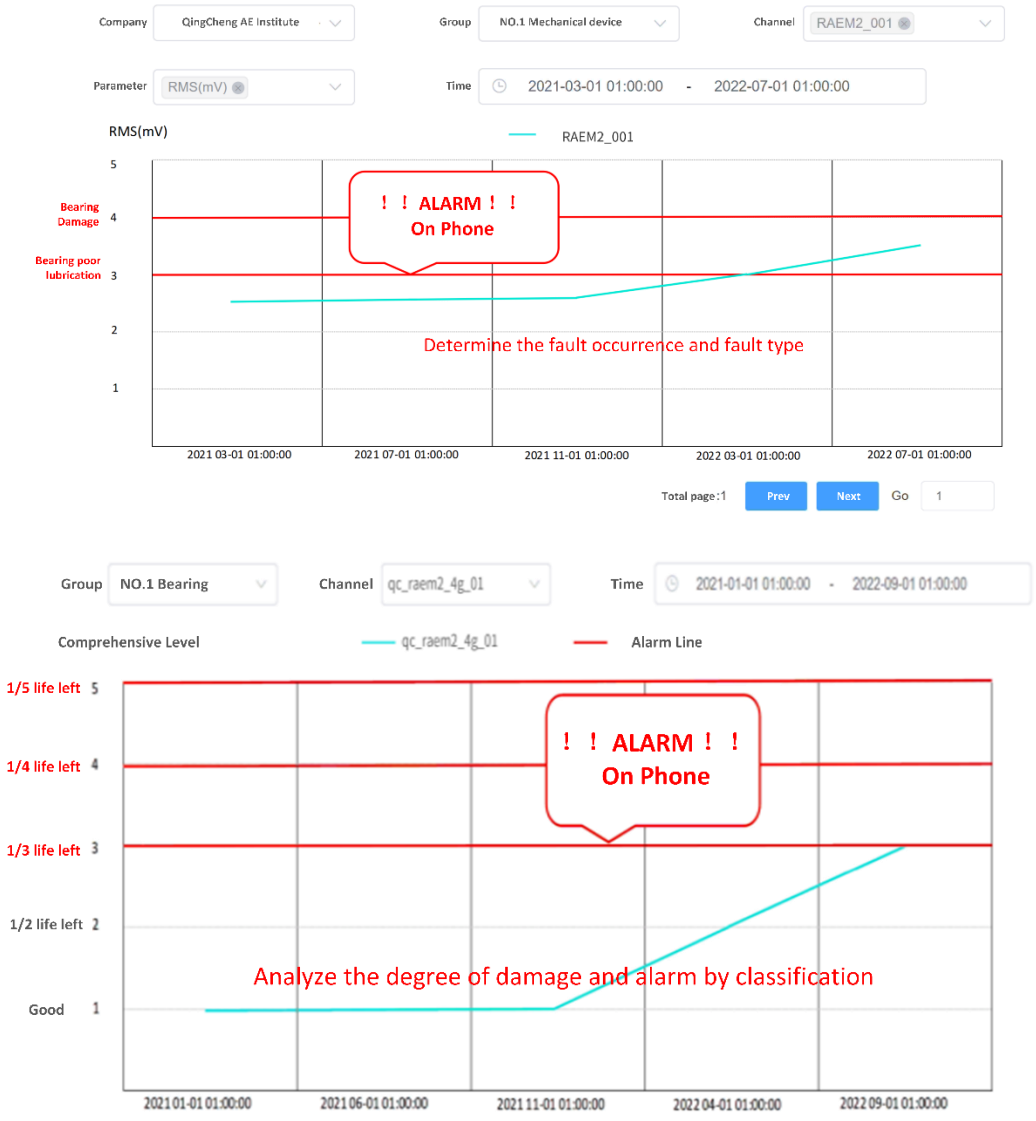
(Multiple monitors can form a multi-channel monitoring system for real-time monitoring of large equipment)

For example, when monitoring the rotating components such as amusement facilities, the monitor should be far away from the position of bolt connection and support as far as possible; In local monitoring, the measured part should be located in the middle of the monitor array.

Characteristic	Procedure
● Time trigger ● Continuous signal acquisition ● Remote monitoring, long-term monitoring and diagnosis ● Low power consumption and low cost	◆ Rotating equipment (bearing, gear box, etc.) needs 1-8 monitors. ◆ The monitor communicates with central control server, monitoring screen or IoT platform though Wi-Fi or gateway or 4G. ◆ Timing start and sleep system, timing data acquisition. ◆ Obtain criteria standard from data analysis and processing ◆ Alarm information based on the criteria

✷ RAEM2 acoustic wave (acoustic emission) monitoring system establishes analysis reference criteria through the

monitoring data of multiple devices of the same model in the field (fail-free, all kinds of faults) of the same equipment, so as to realize the analysis of **different fault occurrence, location, fault degree** and other states of rotating equipment.



3、Main Hardware and Software Introduction

1）Configuration table

Sensor			GI40 Series sensor
Monitor	Name		RAEM1 Collector
	Communication mode	Wired	RS-485
			CAN
			LAN

		Wireless	4G
			WIFI
			Bluetooth (Mobile phone Bluetooth inspection)
			LORA (Networking)
Terminal Device	Phone		APP
			mini program
			SMS
			Email
	Cloud platform		Qingcheng IoT cloud platform
			Ali cloud platform
			Amazon cloud platform
	Software		SWAE Software
			RAME Configuring Software

2) RAEM2 technical parameters

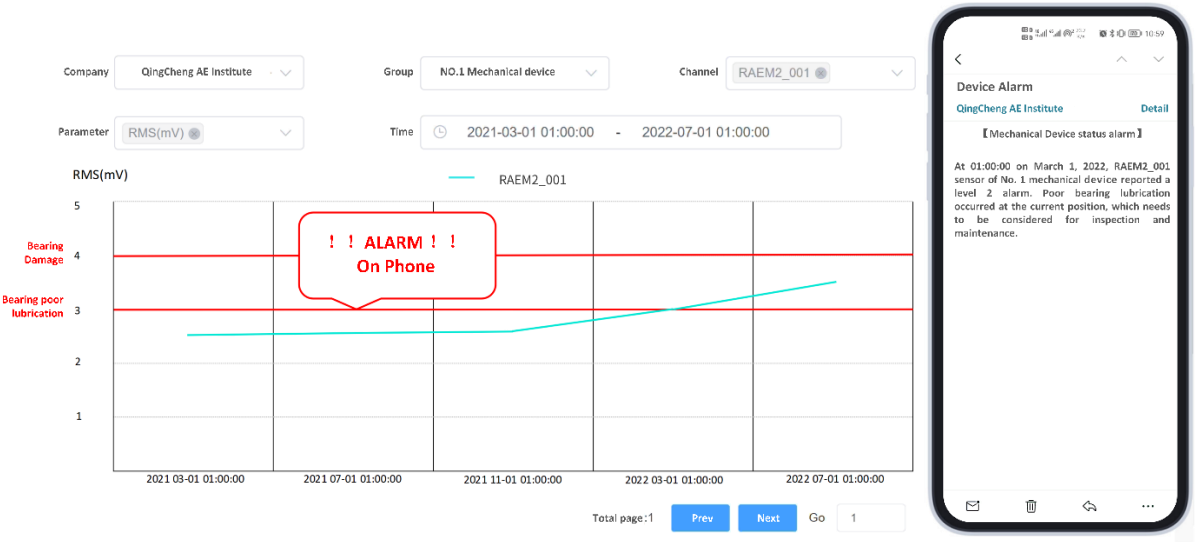
Channel	Single channel AE input	**Sampling accuracy**	16-bit
Acquisition method	Time trigger acquisition	**System noise**	Better than 30dB
Sampling frequency	2M /s	**Dynamic range**	70dB
Protection level	IP65	**Input bandwidth**	10kHz-400kHz
Time Parameter Output	RMS、ASL、energy, amplitude		
Optional Data output port	4G, Wi-Fi, network port, RS485, CAN, lora, Bluetooth, etc.		
Battery	Battery powered, or external power supply (DC 12V)		
Operating temperature	-20℃~60℃		
Dimensions	Diameter φ62mm, height 50mm-120mm		
Installation	Magnetic base, can be adsorbed on the surface of the measured object		

3) Cloud platform

Qingcheng IoT cloud platform, Ali Cloud platform, Amazon cloud platform, etc.

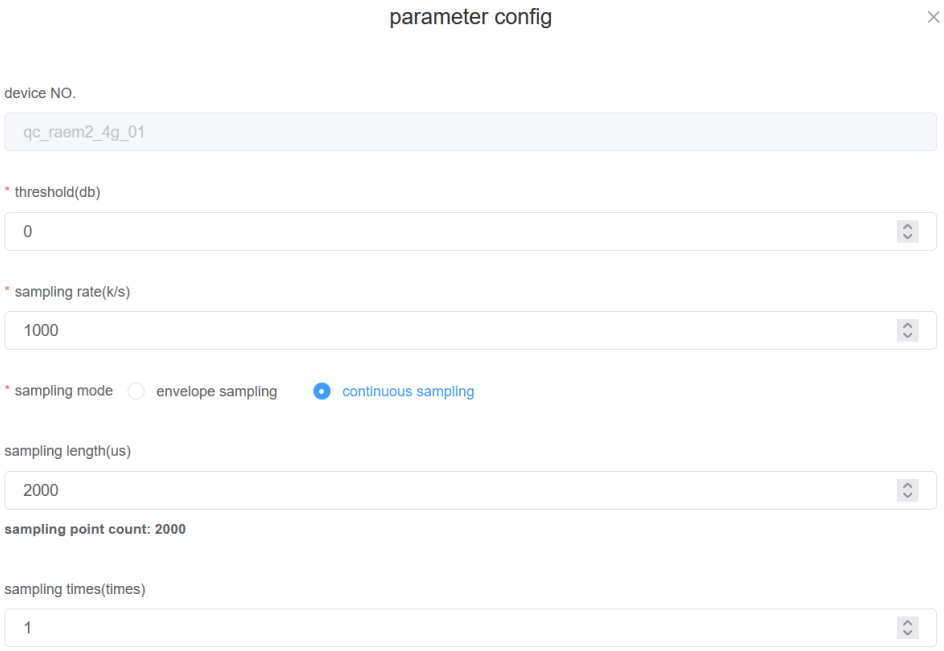
Note: The cloud platform can be customized according to customer requirements.

① **Real-time data display:** users can carry out remote monitoring through the cloud platform and the cloud platform can push alarm information to users automatically when the device is abnormal.

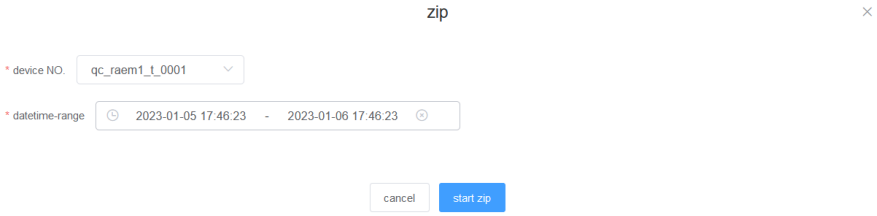


② **Remote system upgrade:** Users can download and install the upgraded software and system from the cloud platform.

③ **Sampling parameter setting:** Users can perform remote configurations on the cloud platform, such as parameter setting, timing configuration, and rating configuration.

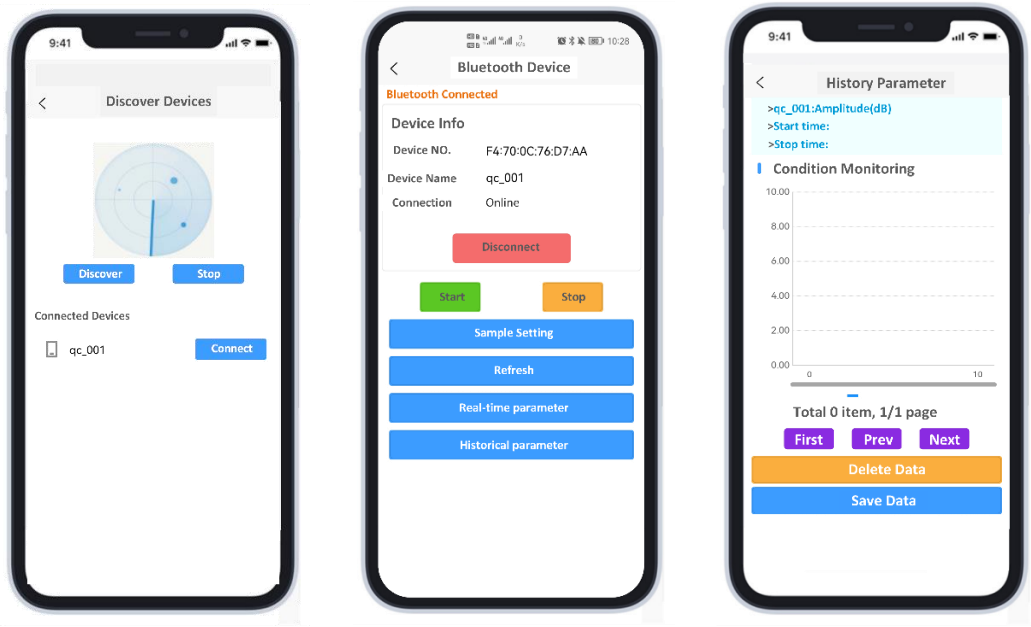


④ **Data download:** Users can download historical data remotely through the cloud platform.



4) Onsite inspection with mobile phone

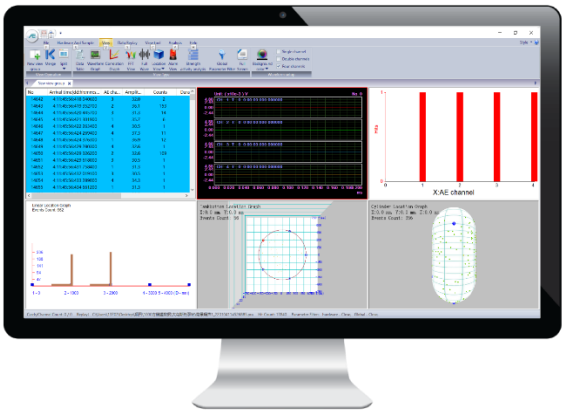
This system supports onsite inspection by connecting devices with smart phone via Bluetooth for device Settings and data monitoring.



Interface of Bluetooth inspection APP

5) SWAE Software-Computer

The data can be downloaded from the cloud for further analysis by SWAE software, or sent directly to SWAE software for real-time analysis and processing to understand the defect details. Such as **defect location analysis, parameter analysis, correlation graph analysis, waveform analysis, FFT, wavelet transform**, **rating analysis,** etc.



4、Scheme Cases

Principle：

Acoustic waves (acoustic emission) are generated when rotating equipment is operated, including those audible to human ears and those outside the audio range that cannot be heard by human ears. The acoustic wave should have a different spectrum for different states (normal operation, wear, lubricant contamination and deterioration, etc.). The acoustic wave is received by the RAEM2 monitor installed on the device, and the corresponding state is obtained through qualitative and quantitative analysis of the monitor and the cloud platform of the Internet of Things.

1）Bearing fault

Case 1:

On-line acoustic wave (acoustic emission) monitoring is carried out on the bearing of a rotating equipment every 4 months to monitor the bearing status of the equipment

According to field data analysis and verification, different fault grade criteria of rotating equipment were obtained (RMS was used to judge in this case).

Three intensity grades were set: **Intact** (level 1), **Poor lubrication** (level 2), **Component damage** (Level 3).

Figure 1: Time-RMS correlation diagram when NO.1 Mechanical equipment qc_RAEM2_001 channel monitoring:

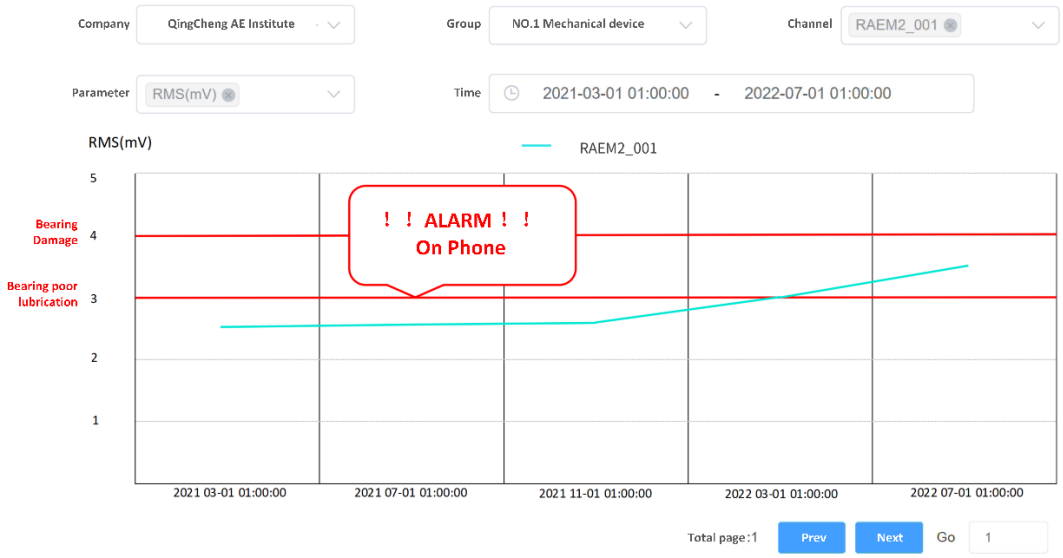
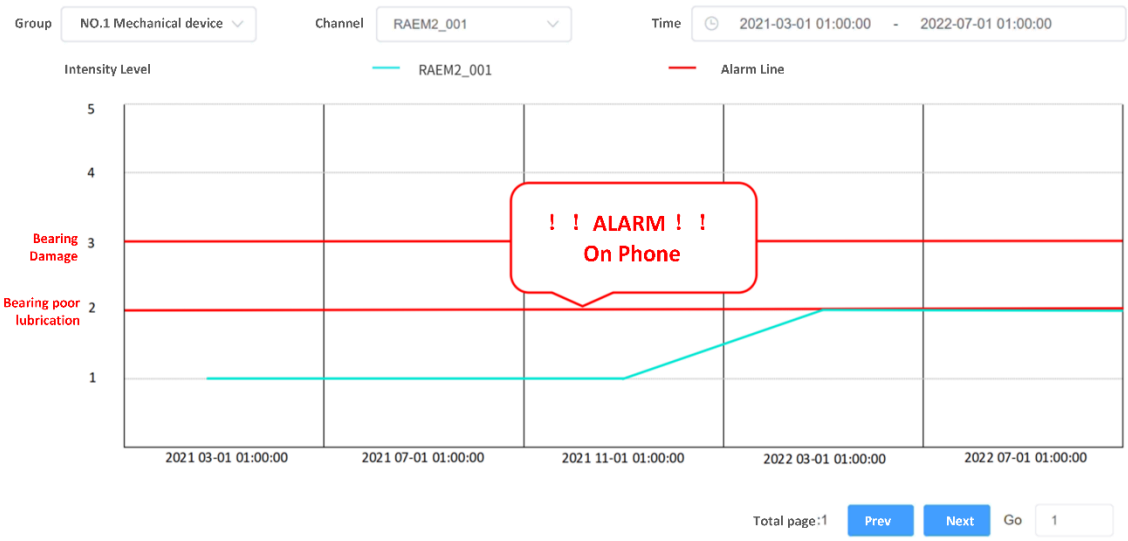


Figure 2: The corresponding intensity levels of RAEM2_001 channel after 0, 4, 8, 12 and 16 months are as follows: 1, 1, 1, 2, 2



According to the data of the cloud platform, RAEM2_001 channel of No. 1 mechanical equipment reaches the level 2 alarm line on 2022-03-01. Poor bearing lubrication occurs near the RAEM2, which needs to be considered for inspection and maintenance (alarm push).

2）Bearing lubrication condition

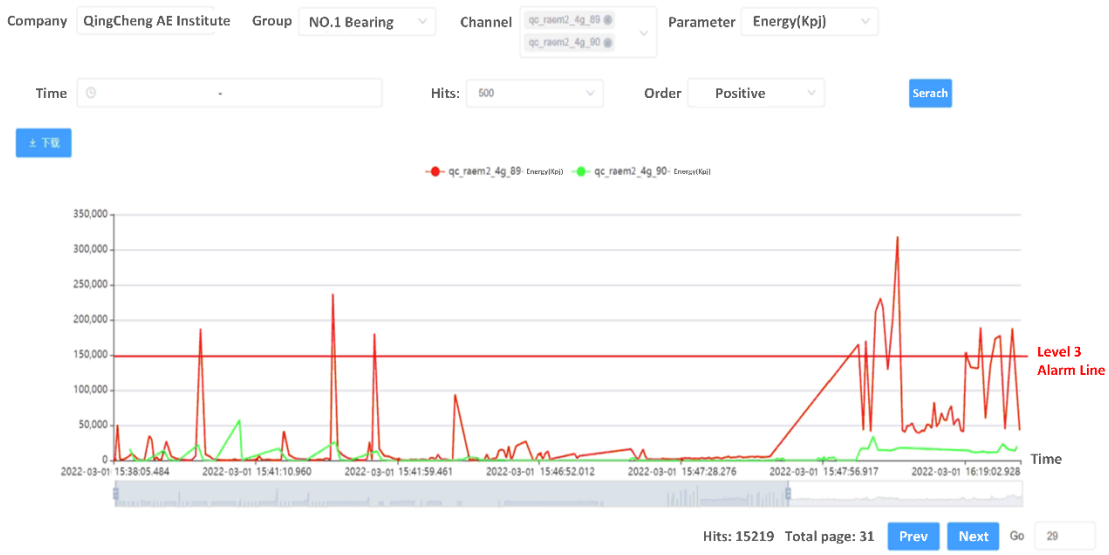
Case 2:

The lubrication state of a bearing of a rotating equipment is monitored online by acoustic emission (AE) for a period of time every 4 months to evaluate the lubrication state of the bearing.

（Data which is sensitive to changes of lubrication state are used for evaluation. In this case, **Energy** combined with

Activity are used for comprehensive rating to obtain lubrication state）

Figure 1: Energy display of qc_ raem2_4g_89 channel and qc_raem2_4g_90 channel at 2022-03-01 on NO.1 mechanical equipment.



The lubrication state of the two channels (locations) is different. The lubrication state of the qc_raem2_4g_89 channel is abnormal.

Figure 2: qc_raem2_4g_89 channel lubrication status rating during monitoring.

According to the cloud platform data, the No. 1 mechanical equipment qc_raem2_4g_89 channel reaches the Level 3 alarm line on 2022-03-01, which means lubrication state is medium here, and it needs to be considering to check or maintenance (alarm push).

3) Bearing damage state

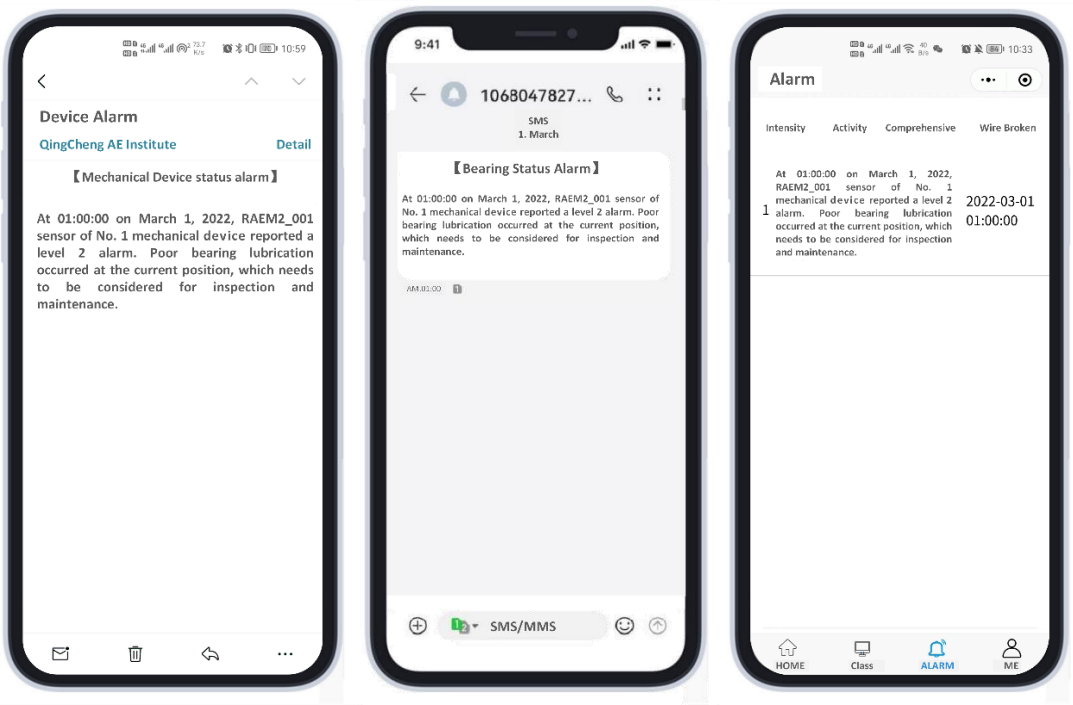
Case 3:

Monitor the status of a bearing of a rotating equipment for a period of time every 5 months, and evaluate the degree of bearing damage.

Cloud platform: Mechanical equipment No. 1 bearing qc_raem2_4g_01 channel after 0, 5, 10, 15, 20 months corresponding levels are respectively: 1, 1, 1, 2, 3

According to the cloud platform data, No. 1 bearing qc_raem2_4g_01 channel reaches the Level 3 alarm line in 2022-09-01. There is obvious local damage to the bearing, with 1/3 of its remaining life, maintenance needs to be considered (alarm push).

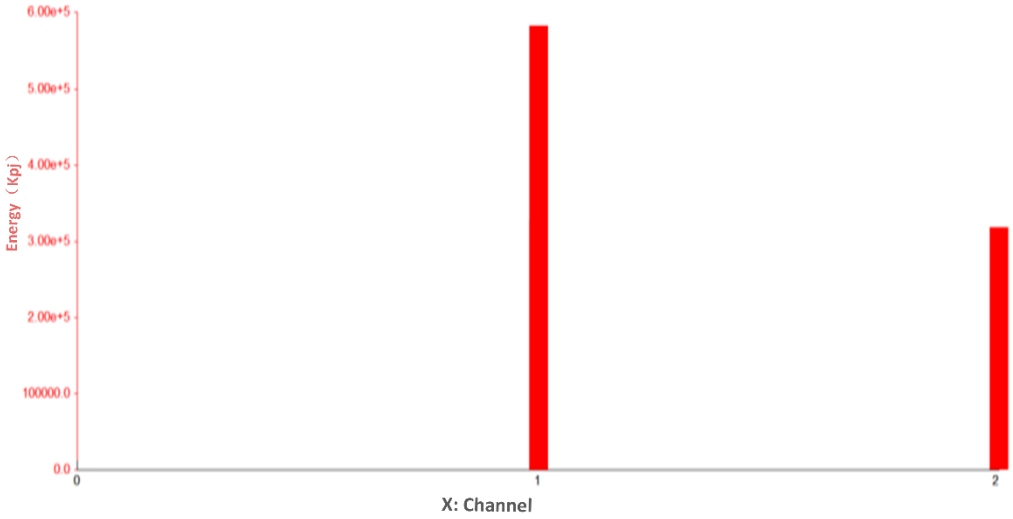
For the above cases, mobile phone synchronous alarm push can be set (email, SMS, Mini program, APP, etc.).



Alarm via email　　Alarm via SMS　　Alarm via mini program

You can also use SWAE software of Qingcheng for further analysis to understand the data in detail.

For example, channel-energy diagram analysis is carried out on the data of the two channels in different lubrication states of the monitoring group:



(It can be seen from the channel-energy diagram that the energy of this group is sensitive to changes in lubrication state monitoring and can be used to evaluate lubrication state)

5、Conclusion

The acoustic wave (acoustic emission) monitoring and detection of (loosening, damage, lubrication, etc.) state of rotating equipment is practicable, and the alarm information is automatically pushed to the user, so as to facilitate the user to carry out maintenance in time, and prolong the life of rotating equipment and prevent the loss and accident caused by the cumulative development of damage.

Advantage

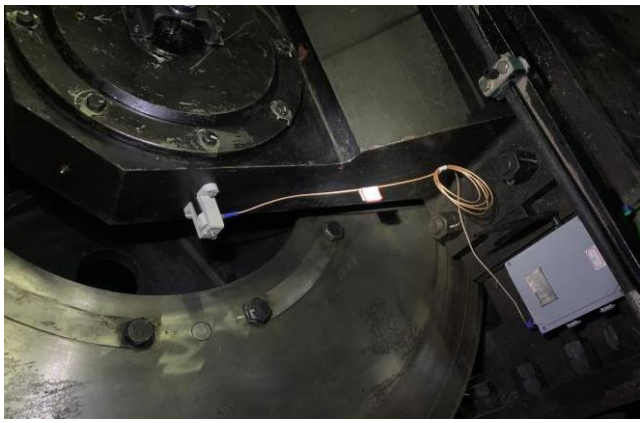
- **Online** ---- Acoustic wave (acoustic emission) monitor is installed on the monitored and diagnosed object to realize all-weather status monitoring and fault diagnosis in the whole period.
- **Intelligent** ---- System automatically provides monitoring and diagnosis results without manual data analysis and processing and manual operation. Data acquisition and analysis report shows the whole process of monitoring and diagnosis automatically.
- **Remote** ---- With the help of the Internet of Things system, users can get the monitoring and diagnosis results of any monitoring and diagnosis points at any distance, including online real-time results and historical process results.

6、Practical Cases

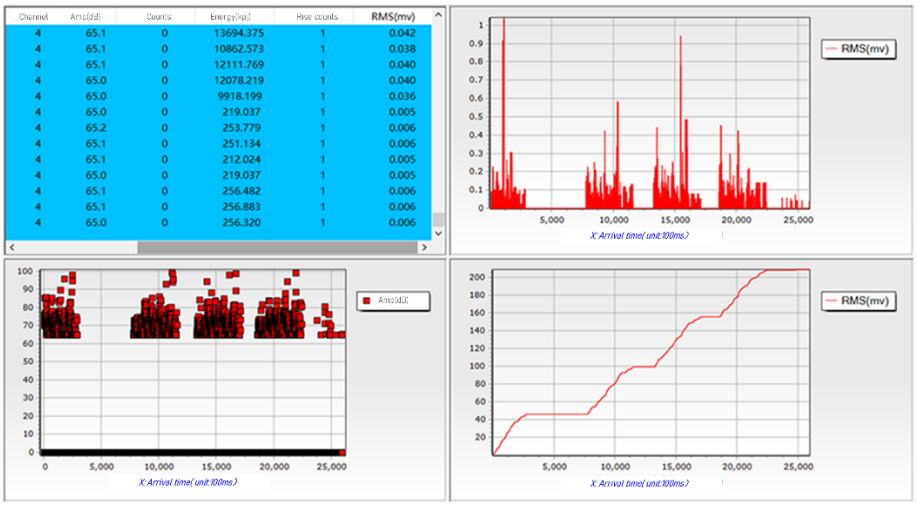
1）Bearing monitoring of amusement park facilities

① Lift winch spindle bearing monitoring:

The instrument is battery powered, and a communication module is added. So the monitoring system could upload the alarm signal to the cloud server and push it to the mobile phone.



Site diagram

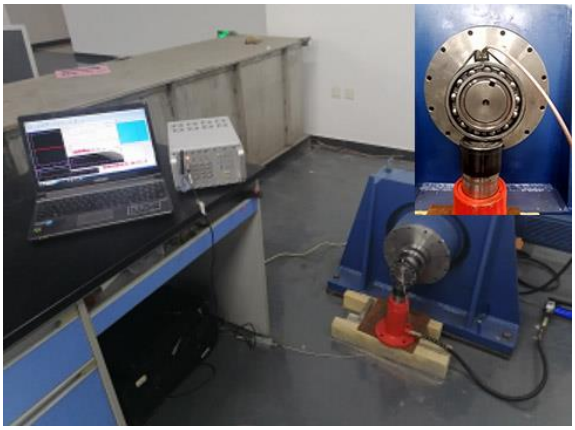


Data display diagram

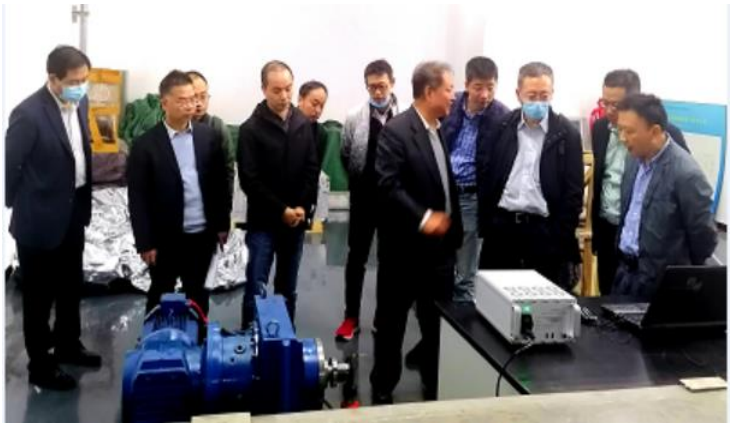
② Main shaft bearing monitoring of wave rolling project:

The monitoring position is the most concentrated part of the force on both sides -- the rotating spindle bearing. The sensor is arranged on the bearing outer ring seat.

2）Damage detection and monitoring of low speed rolling bearing

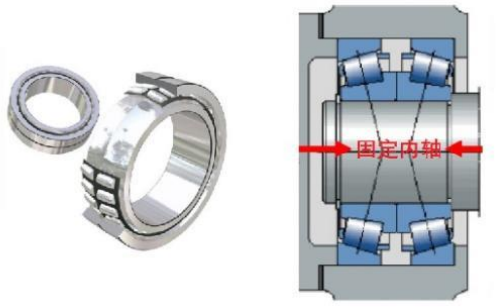


Site Diagram 1

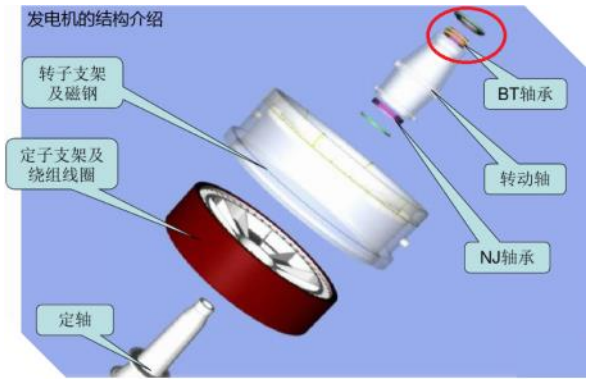


Site Diagram 2

3）Jiangsu Sheyang Wind Power Bearing Online monitoring (BT bearing)

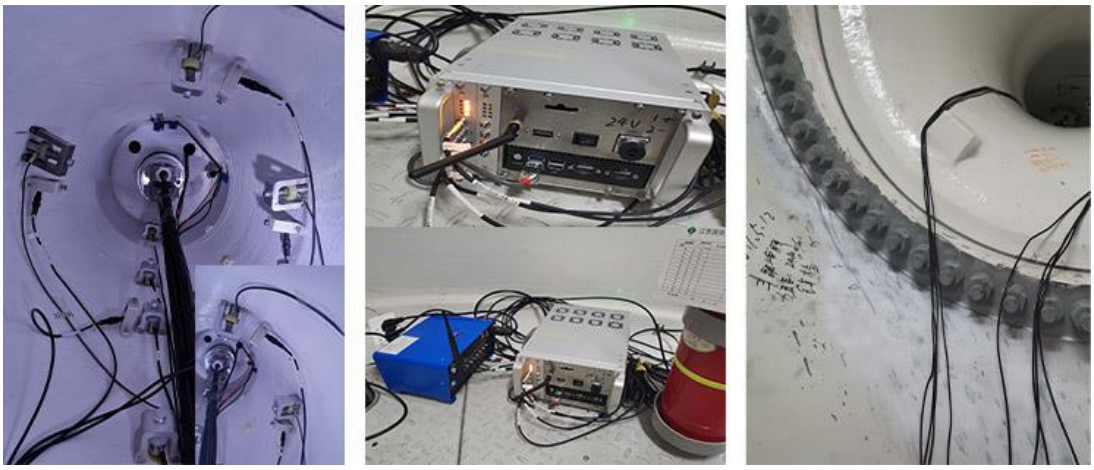


BT bearing is a double row tapered roller bearing, with a double raceway of the outer ring and two inner rings, two inner rings between a ring. Bearing clearance can be adjusted by changing the thickness of the spacer. This type of bearing can bear radial load and axial load of both sides at the same time, can limit the axial displacement of shaft and shell in the bearing axial clearance azimuth. it is mainly used to bear radial load mainly radial and axial combined load, has the characteristics of large bearing capacity, low limit speed.

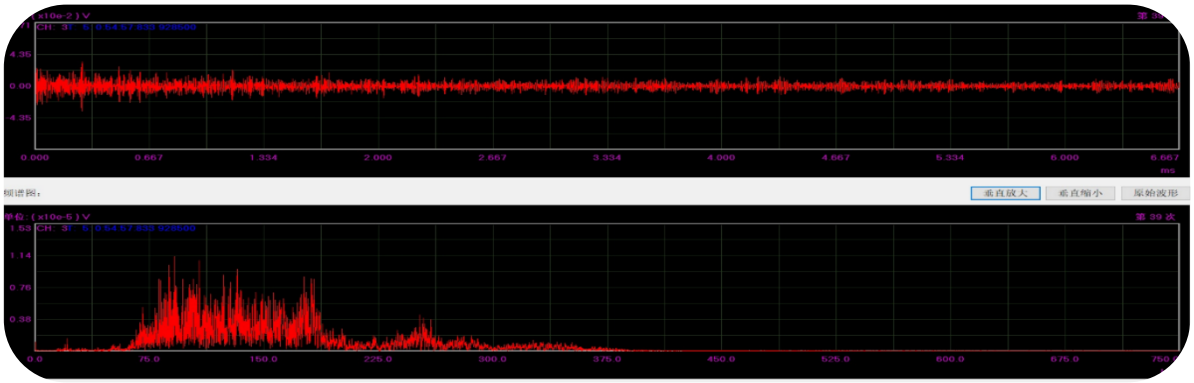


Structure diagram

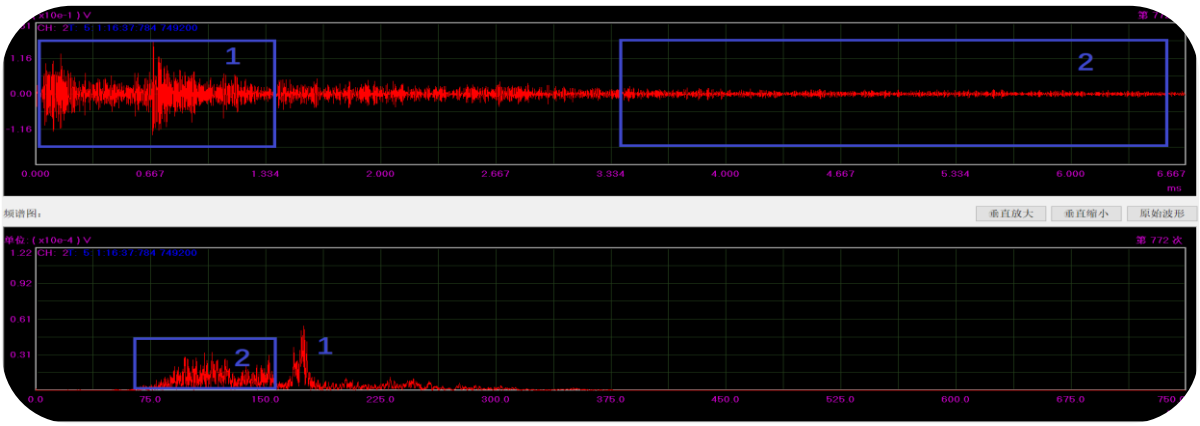
BT bearing between the rotating shaft and the fixed shaft, located in the front end of the main shaft, acoustic emission sensor at the back end of the signal line connected with the host, can only be arranged in the fixed shaft inside, near the position of BT bearing.



Sensor and monitor installation layout



"Good" bearing time domain and frequency domain diagram



Time domain and frequency domain diagram of "bad" bearing

4) Low speed bearing monitoring

Basic test process of wind power bearing monitoring:

① Sensor, preamplifier, detector host and other hardware installation;
② By calibrating the sensitivity of each channel with artificial simulation source, the channel response is as consistent as possible.
③ The signal conditions, such as signal conduction path and attenuation, were roughly evaluated by applying artificial simulation sources to each structural part;
④ When positioning analysis is required, error analysis should be performed with known simulated sources and positioning sources
⑤ Instrument sensor self-calibration test (used to determine instrument status during monitoring, especially sensors
⑥ The threshold value is determined by testing noise;
⑦ Long time big data acquisition, record operation, load, environmental conditions (weather, maintenance, etc.);
⑧ Before the instrument is disassembled, the sensitivity of each channel is calibrated by the simulation source again, and the differences are recorded to be taken into account when analyzing the data.

Scene operation diagram

Basic method of data processing (single data) :

① Longitudinal comparison of acoustic emission data combined with load conditions of a single monitoring object (data selected by the first test in the early morning of March 27 and April 5);

② According to the trend and distribution law of the parameter history chart, the structure of the fault point is judged according to the analysis of bearing fault characteristics.

③ The correlation of parameters can be roughly judged to be signal type and type, such as amplitude -ASL, duration - rise time, ringing count - rise count, amplitude - energy, etc. It can be roughly judged to be crack or friction signal.

④ Comparison analysis and classification of typical time domain signals and their spectrum;

⑤ Abnormal characteristic parameters and waveform signal correlation analysis, conformance identification, such as high energy and high amplitude signal is not necessarily crack signal, mainly to do the verification of the third article (parameter analysis called waveform analysis efficiency);

⑥ Time difference positioning analysis (uniform structural parts have good effect, high accuracy, but high requirements for channel consistency).