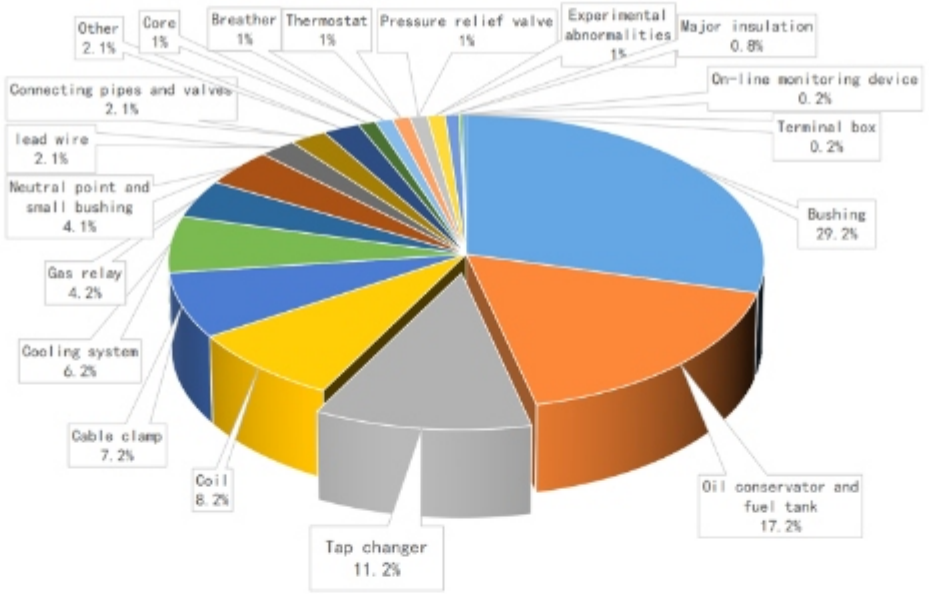
INTELLIGENT ONLINE MONITORING SYSTEM FOR TRANSFORMER ON-LOAD TAP CHANGER

◎ INTELLIGENT SENSE | ◎ DIGITAL EMPOWERMENT | ◎ AIOPS

APPLICATION BACKGROUND

Power transformers are the most critical equipment in the power distribution system, and transformer failures have a significant impact on the stable operation of the power system. Due to the complex internal structure and manufacturing process of transformers, as well as the harsh external operating environment, there are significant differences in the causes, locations, degrees, and types of transformer failures.

According to relevant data statistics, the proportion of transformers that cannot operate normally or are even forced to shut down due to faults in on load tap changers is over 10%.

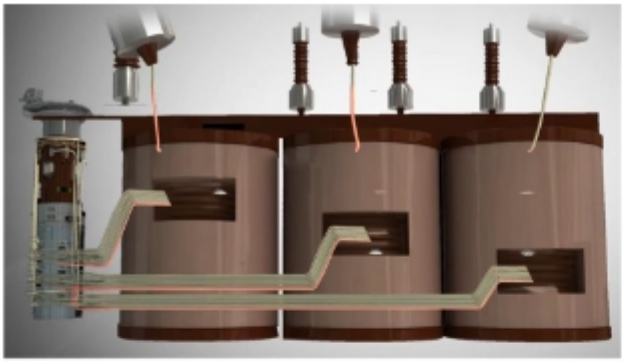


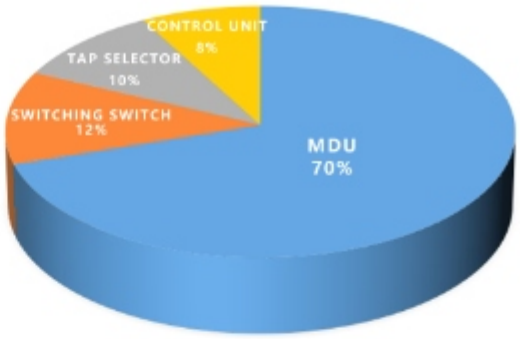
After the large-scale integration of new energy and power electronic devices, the harmonic content of the system will become increasingly high, which poses higher requirements for voltage stability and power quality control in the power system. As a result, the requirements for voltage regulation function and stability of transformers will be further improved. Therefore, meeting the reliability and stability requirements of OLTC is more urgen. Power users need to achieve real-time perception of the operating status of OLTC, intelligent diagnosis, accurate warning, and efficient operation and maintenance.By timely detecting potential faults in switches and assisting operation and maintenance personnel in accurate handling and maintenance, the probability of faults can be greatly reduced, and accident losses can be reduced.

FAULT FACTORS

OLTC is the core component of a transformer that completes on load voltage regulation. As the only frequently operated component inside the transformer, it needs to withstand mechanical and current shocks during operation. After long-term operation, it will experience varying degrees of heating, aging, and damage, leading to contact wear and burning, loose components, and mechanism jamming. In severe cases, electric arcs may even cause the tap changer and transformer to explode.

There are many internal components of the OLTC, and its construction and production process are complex. There are also many fault factors. According to relevant data statistics, the main fault proportion of the OLTC is shown in the figure:





THE TRADITIONAL OLTC MAINTENANCE METHOD HAS MANY SHORTCOMINGS:

The conventional operation and maintenance method for OLTC is to inspect and handle faults or conduct regular preventive maintenance, lacking effective pre sensing means.

The conventional detection method is to lift the Tap changer switching core out for inspection after a power outage, which is time-consuming and laborious, and there is a risk of excessive maintenance, lacking real-time and efficient online monitoring methods.

MONITORING FUNCTIONS

Based on Shanghai Huaming's years of experience in manufacturing and maintaining on load tap changers, and with the help of in-depth theoretical research and analysis of actual fault data, we have launched the HMJK-II on load tap changer monitoring device. This device utilizes an embedded Linux system and modular design, with features such as efficient data collection, stable operation, flexible configuration, accurate monitoring, reliable fault warning and maintenance recommendations.

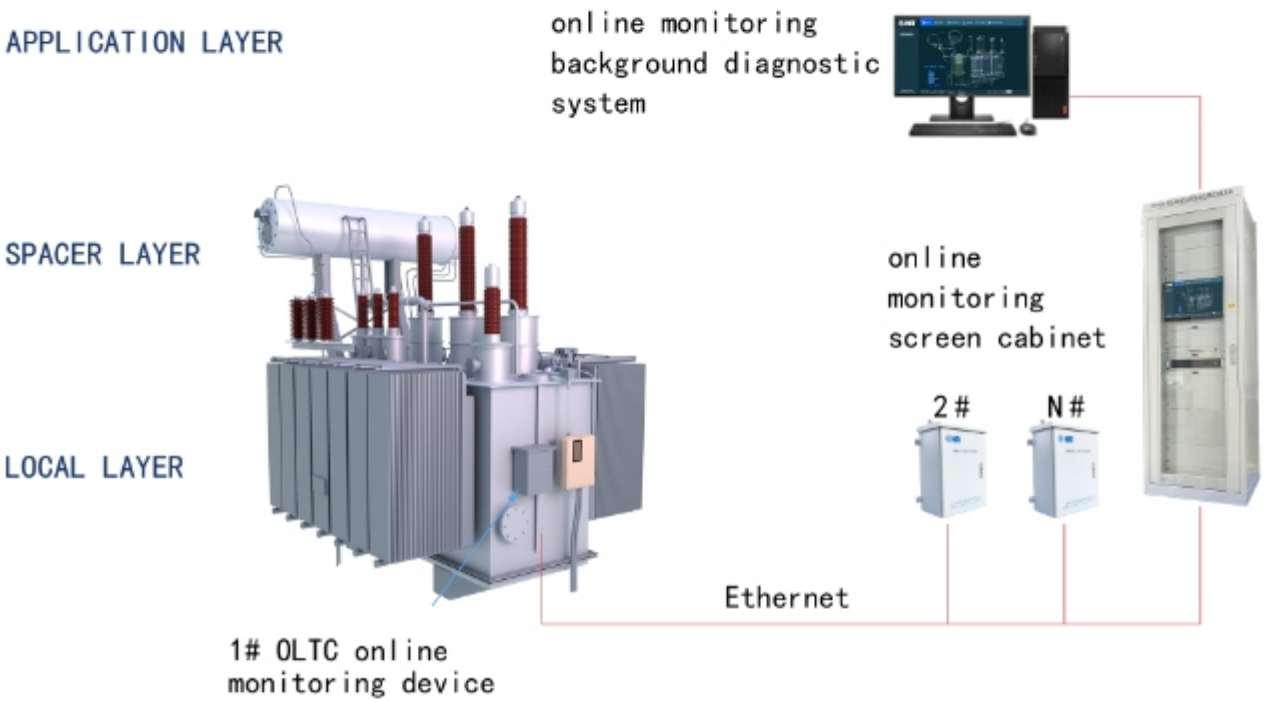
HMJK-Ⅱon-line monitoring device

Num	Functional configuration	HMJK-Ⅱ Basic	HMJK-Ⅱ Extended	HMJK-Ⅱ Enhanced
1	The device supports power communication protocols such as IEC61850 and Modbus	●	●	●
2	The device supports remote access to monitoring data through a web interface	●	●	●
3	The device supports collecting parameters such as single-phase voltage, current, frequency, and power of transformers	●	●	●
4	The device supports collecting oil filter status signals	●	●	●
5	OLTC Tap Position monitoring(include BCD/Gray/Bin/4~20mA)	●	●	●
6	OLTC action count and action time statistics	●	●	●
7	OLTC contact electrical life and wear calculation, providing maintenance and repair suggestions	●	●	●
8	OLTC motor current and voltage monitoring, generating action waveforms and calculating torque	●	●	●
9	OLTC oil temperature and oil pressure monitoring (4-20mA acquisition)	○	●	●
10	OLTC Vibration voiceprint monitoring, generating action waveforms and conducting diagnostic analysis		●	●
11	OLTC Monitoring of micro water content and oil temperature in oil		○	●
12	OLTC DGA Monitoring of dissolved gas content in oil		○	○
13	Monitoring of transformer oil temperature, oil level, iron core current and other status variables			○
14	Fiber optic temperature measurement of transformer winding temperature			○
15	Transformer air cooling control function and life prediction			○
16	Dissolved gas monitoring in transformer DGA oil			○
17	Transformer bushing dielectric loss and partial discharge monitoring			○
18	Integrated status monitoring and diagnostic system backend software		○	●

● included ○ optional

SYSTEM ARCHITECTURE

The intelligent online monitoring system for OLTC consists of three parts: local online monitoring device, remote online monitoring screen cabinet, and background diagnostic system. The hierarchical architecture of the system can adapt to different plant equipment requirements, and can achieve intelligent operation and maintenance functions such as precise monitoring, fault warning, health assessment, life prediction, diagnostic analysis, and auxiliary maintenance of transformers and their on load tap changers.



SYSTEM CHARACTERISTICS

INTELLIGENT SENSE

By using sensors such as vibration voiceprint, micro water, gas, oil temperature, and oil pressure, the operating data of the tap changer can be collected from multiple angles to comprehensively perceive the overall working status of the equipment.

REAL-TIME MONITOR

Adopting a three-layer and two network system architecture, OLTC is comprehensively and in real-time monitored. Through intelligent perception, analysis, diagnosis, and health assessment, it ensures the long-term safe and stable operation of the equipment.

ANALYSIS AND DIAGNOSIS

For the obtained vibration, current and other waveforms, diagnostic algorithms such as coincidence degree, envelope diagram, and time-domain analysis are used to provide strong support for the daily maintenance of OLTC.

HEALTH ASSESSMENT

Based on state monitoring data, use life model algorithms to predict and evaluate the remaining life of tap changers, forming a comprehensive monitoring, maintenance and upkeep system.

MONITORING DEVICE IN WALL MOUNTED BOX

The online monitoring device for OLTC can be installed on site in a dedicated wall mounted chassis near the tap changer. The chassis is connected to the sensor and mechanism box through hard wiring or communication lines, and optical fiber communication is used between the chassis and the remote monitoring screen cabinet, making data transmission convenient and reliable。

power supply	85～265V AC/DC
Communication protocol	IEC 61850、Modbus RTU
Tap position	BCD、4～20mA、Gray、Bin
Input、Output	10 Input(DC110V)、10 Output
Display Panel	9-key keyboard, 5.7-inch LCD display
AC Measurement	3-way Voltage, 0～450V; 3-way current, 0～10A
precision	±0.5% of reading
Ethernet interface	2-Way: RJ45 / LC (wavelength 1310nm)
temperature range	-40℃ ～ +70 ℃
Device size	340mm×200mm×130mm
Wall mounted box size	550mm×320mm×750mm (customizable)

TECHNICAL FEATURES

- Capable of generating waveforms such as motor current, voltage, vibration sound patterns, as well as storing and uploading waveform data. Multiple fault diagnosis algorithms are used for in-depth analysis to accurately determine the status and abnormalities of the equipment.
- It has high scalability and can flexibly configure the rear plug-in board and front panel, as well as expand comprehensive monitoring functions such as transformer DGA, fiber optic temperature measurement, and partial discharge monitoring. It supports multiple monitoring interfaces to meet the diverse needs of customers.

MONITORING DEVICE IN MDU

The HMJK-II intelligent online monitoring device for tap changer can also be integrated and installed in the operating mechanism box on site. This design reduces the space limitation of the external wall mounted box of the transformer and reduces the signal line connection with the mechanism box, making it suitable for old station renovation and user customization needs。

power supply	85～265V AC/DC
Communication protocol	IEC 61850、Modbus RTU
Position Output	BCD/0-20mA/4-20mA/Resistance/one-to-one
Input、Output	10-way Input、10-way Output
Display Panel	9-key keyboard, 5.7-inch LCD display, led display
AC Measurement	3-way Voltage, 0～450V; 3-way current, 0～10A
precision	±0.5% of reading
Ethernet interface	2 Way: RJ45 / LC (wavelength 1310nm)
temperature range	-40℃ ～ +70 ℃
Device size	340mm×200mm×130mm
Wall mounted box size	608mm×366mm×1032mm

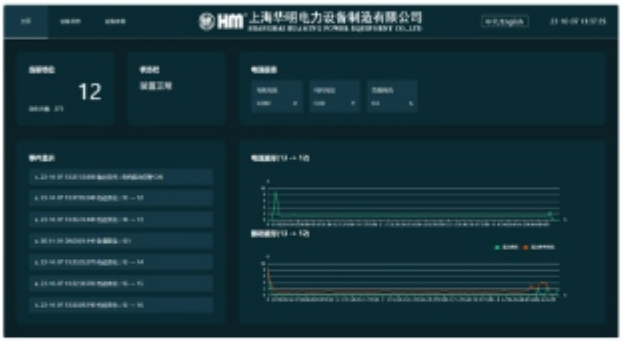
TECHNICAL FEATURES

- When abnormal conditions are detected, internal communication and data exchange can automatically lock the operating mechanism, protecting the tap changer and transformer from potential damage.
- Integrated modular design reduces wiring and simplifies installation and debugging processes, lowering costs while facilitating functional expansion, such as adding CT monitoring function for vacuum circuit breakers.

EMBEDDED WEB INTERFACE

WEB access interface visualization interface: can view real-time information such as OLTC tap position, motor current and vibration waveforms, equipment life prediction, equipment status, etc. Display the action time and current curve area of different gear changes and gear adjustments, as well as the corresponding current waveform and vibration waveform. Provide maintenance suggestions: display the percentage of usage times and time corresponding to each maintenance type, output a maintenance warning signal when it reaches 80% of the set value, and output a maintenance alarm when it reaches 100% of the set value.

VISUAL INTERFACE

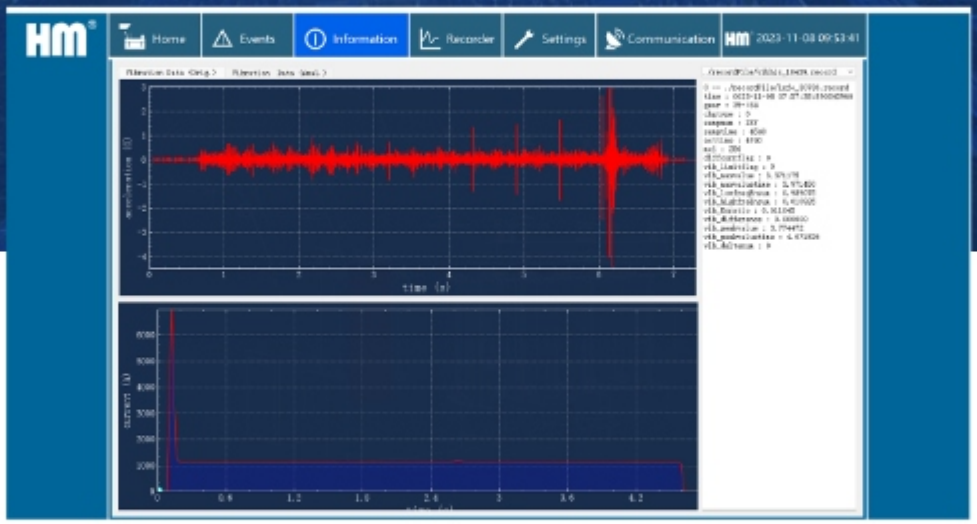


On the homepage, you can view key data such as the tap position information, number of actions, tap switching records, motor current, voltage, and action waveform of the tap changer;

Users can query important information such as historical logs, waveforms, maintenance progress, input/output status, and OLTC switching statistics of monitoring devices;

Can view all parameter settings of monitoring device, as well as information related to tap changer settings.

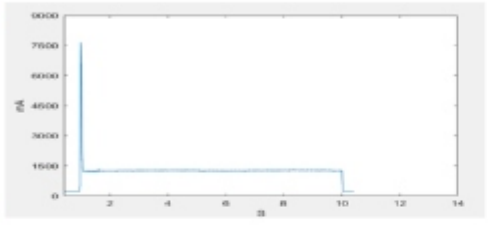
ANALYSIS AND DIAGNOSTIC SYSTEM



The intelligent online monitoring and diagnostic system backend software displays the health status, life prediction, and fault warning information of the on load tap changer in real time, traces historical data and operating trends, customizes 3D models and inspection reports for users, supports manual input of factory, maintenance, and inspection data and equipment ledger, assists users in formulating maintenance and operation plans, and realizes digital twins and intelligent operation and maintenance of OLTC.

TYPICAL WAVEFORM OF THE SYSTEM

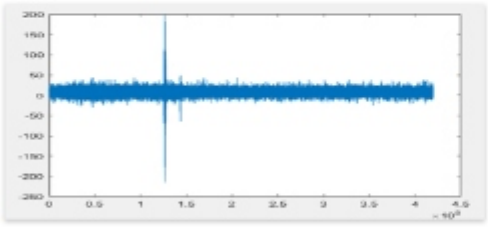
MOTOR CURRENT WAVEFORM



TIME DOMAIN THRESHOLD AND LIMIT CURVE ANALYSIS

Using self-learning algori thms, as the number of tap changing operations increa ses, the standard limit cu rve of the vibration signa l envelope is automaticall y generated;

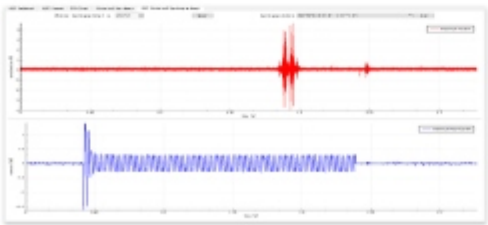
VIBRATION WAVEFORM



FREQUENCY DOMAIN ANALYSIS OF HIGH AND LOW FREQUENCY ENERGY RATIO

Collect the waveform of th e tap changer switching pr ocess, calculate the energ y percentage of the energy analysis period during the actual switching process, and use its proportional r elationship as a fault dia gnosis feature.

HISTORICAL VIBRATION AND MOTOR CURRENT WAVEFORM



SENSOR INSTALLATION

VIBRATION VOICEPRINT SENSOR

Sensitivity	100mV/g
Measuring range	±50g
Frequency range	0.5Hz~20kHz
Self-resonant frequency	≥27kHz

ACETYLENE MONITORING SENSOR IN OIL

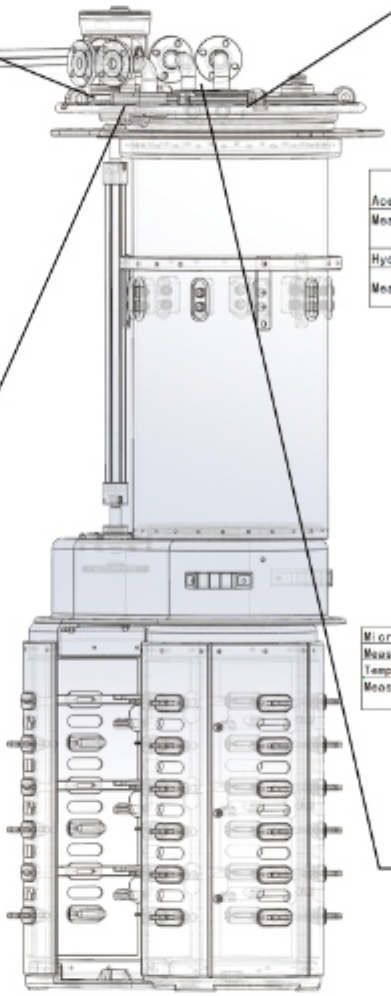
Acetylene measurement range	0~500ppm
Measurement accuracy	±0.1ppm
Hydrogen content measurement	0~5000ppm
Measurement accuracy	±25ppm

MICRO WATER SENSOR

Micro water range	0~1000ppm
Measurement accuracy	±10%
Temperature measurement range	-40℃~120℃
Measurement accuracy	±0.3℃

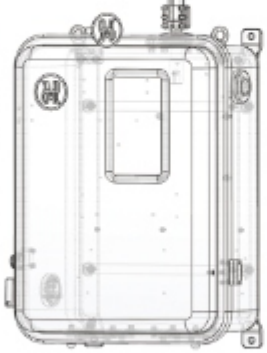
OIL TEMPERATURE AND OIL PRESSURE SENSOR

Temperature measurement range	-40℃~120℃
Measurement accuracy	±0.3℃
Pressure Range	0~3000Pa
Pressure Accuracy	0.5%FS
Pressure stability	Zero point 0.1, full scale 0.1



DGA DISSOLVED GAS MONITORING DEVICE IN OIL

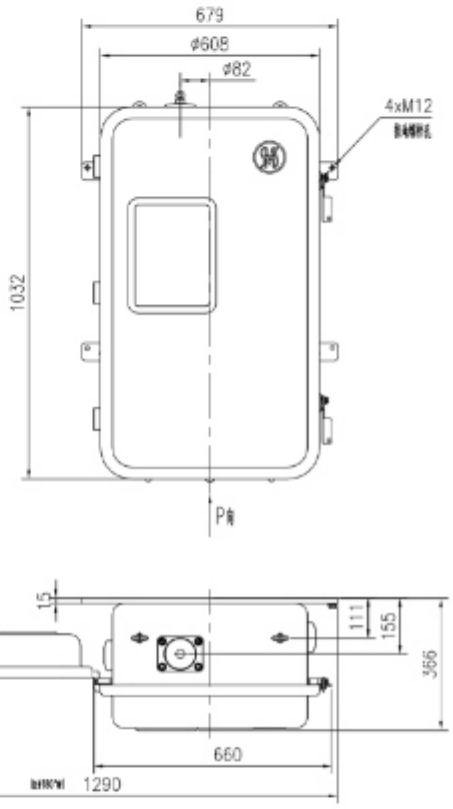
Dissolved gas analysis	H2、CO、CO2、CH4、C2H4、C2H2、C2H6
Monitoring principles	gas chromatography, photoacoustic spectroscopy
Error range	±10%
Operation temperature	-40℃~120℃



FIELD APPLICATIONS

The transformer on load tap changer online monitoring system developed by Huaming Company has been widely promoted and applied in multiple industries in China, such as energy generation, metallurgy and chemical industry, and distribution and transformation. The system has also been piloted and applied in national ultra-high voltage projects. In addition, the monitoring system has also been successful in the international market and has been widely deployed in countries such as Azerbaijan, the Philippines, and Saudi Arabia.

WALL MOUNTED BOX
INSTALLATION DIMENSIONS



INSTALLATION DIMENSIONS
OF THE MECHANISM BOX

FIELD APPLICATION

Shanghai Huaming Electric Power Equipment Manufacturing Co., Ltd
phone：+86-21-5270 8966
fax：+86-21-5270 3385
Address: No. 977 Tongpu Road, Putuo District, Shanghai
website：www.huaming.com