Know your transformers more accurately.

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Operation manual

Transformer winding deformation tester
JYP
(Frequency response and impedance method)

V1.3

Table of Contents

Important tips:

- This manual is the instruction manual of the transformer winding deformation tester, please read it carefully!
- Before use, the operator must carefully read this manual.
- Other devices unrelated to this equipment shall not share power supply terminals with this equipment.
- To prevent the risk of electric shock, the system power supply needs to be reliably grounded.
- During the use of this equipment, the operator shall not leave the test site.
- The transformer core must be reliably grounded with the housing. The tester housing and the measurement impedance housing must be reliably grounded with the transformer housing.
- Do not start the test until the "ground" of this device is connected correctly.
- Before the test, the line end of the tested transformer should be fully discharged.
- Before use, please check the appearance of the tester, check whether the power switch position is in the "off" position, and whether the terminal blocks are normal.
- The winding deformation test should be carried out under the premise of untying all the leads of the transformer (including overhead lines, closed busbars and cables), and keep these leads as far away from the transformer bushing as possible (the surrounding grounding body and metal suspended solids need to be more than 20cm away from the transformer bushing)., especially transformers connected to closed busbars.
- The position of the tap-changer must be correctly recorded during the test. During the frequency response test, the tap changer of the transformer under test is generally placed in the first tap, especially for the on-load voltage regulating transformer, in order to obtain more comprehensive winding information. For no-load voltage regulating transformers, it should be ensured that each measurement is at the same tap position for easy comparison.
- The impedance measuring pliers should be in close contact with the casing clamps. If there is conductive paste or rust on the casing clamp, it must be wiped clean with an abrasive cloth or a dry cotton cloth.
- During the use of this equipment, do not open other software that is not related to the measurement.
- This device uses a common operating system, and there is a possibility of system poisoning and crashing.
- Once a system abnormality occurs, it can generally be eliminated by restarting the software.
- This appliance is not waterproof and should not be used in the open air on rainy days.
- When this device is not in use, put it in a box, and the box is usually laid flat.
- The disposal of this equipment after scrapping shall comply with the requirements of relevant national laws and regulations or be handed over to the company for disposal.
- If you still have any doubts after reading this manual, please contact the company's after-sales service department directly.

- The device is a computer-controlled device, please follow the instructions in the file saving section to back up the data regularly, due to the loss of data caused by computer damage, the company is only responsible for the restoration of the measurement function.

1. Introduction to the system

The transformer winding deformation tester is used to test the deformation of transformer windings of power transformers and other special purposes of voltage level of 6kV and above. Power transformers inevitably suffer from the impact or physical impact of various fault short-circuit currents during operation or transportation, and under the strong electrodynamic action generated by short-circuit currents, the transformer windings may lose stability, resulting in permanent deformation phenomena such as local distortion, bulging or displacement, which will seriously affect the safe operation of the transformer. This instrument measures the winding deformation of the transformer by frequency response analysis method according to the national power industry standard DL/T911-2016 and the international electrotechnical standard IEC60076-18, which is to detect the amplitude-frequency response characteristics of each winding of the transformer, and compare the test results longitudinally or horizontally, and judge the possible deformation of the transformer winding according to the degree of change in the amplitude-frequency response characteristics.

The measurement of low-voltage short-circuit impedance is the basic item of the conventional test project, and the short-circuit impedance value measured before and after the impact of the transformer by the short-circuit current can be preliminarily estimated according to the magnitude of the change. The change in the impedance of the transformer after the short-circuit current impulse from the initially tested low-voltage short-circuit should not be greater than 2%.

The system consists of a measurement part and an analysis software part, the analysis part is completed by a laptop, and the measurement part is connected with the laptop through a USB cable.

1.1 Main technical features

- The swept frequency method is used to measure the characteristics of the transformer winding, and the distortion of the winding such as twisting, bulging or displacement is accurately measured for the transformer of 6kV and above by detecting the amplitude and frequency response characteristics of each winding without the transformer hanging cover and disassembly.
- The measurement speed is fast, and the measurement time is 15 seconds for measuring 100Hz to 1MHz and 1000 logarithmic sweeps for a single winding.
- The frequency accuracy is very high, with a frequency accuracy of 0.005%.
- Digital frequency synthesis is used for higher frequency stability.

- 9 curves can be loaded at the same time, and the relevant parameters of each curve are automatically calculated, the deformation of the winding is automatically diagnosed, and the reference conclusion of diagnosis is given.
- The analysis software used is powerful, and the software and hardware indicators meet the power industry standard DL/T911-2016.
- It adopts Windows platform and is compatible with Windows XP/Windows 7/Windows 8/Windows 10.
- The database is used to save the test data, and the management of the test data is simple and convenient.
- The software management function is powerful, fully considering the needs of on-site use, and the measurement data is automatically saved and exported to generate a Word version of the test report (the corresponding Office software needs to be installed) or JPG picture report, which is convenient for users to issue test reports.
- The software has a high degree of intelligence, and after the input and output signals are connected, all the measurement work can be completed by pressing a button.
- The software interface is simple and intuitive, and the menus such as analysis, storage, report export, and printing will automatically pop up the required menus for the next step only after completing the current step, which is more convenient.

1.2 Main technical indicators

Frequency response method:

- Measurement speed: 100Hz to 1MHz, 1000 point log sweep test time for a single winding is 15 seconds
- Output voltage: automatically adjusted during Vpp-20V test
- Output impedance: 50Ω
- Input impedance: >1MΩ (50Ω matching resistor built into the response channel).
- Swept frequency range:100Hz-2MHz
- Frequency Accuracy: 0.005%
- Sweep mode: linear or logarithmic, sweep interval and number of points can be set arbitrarily
- Curve display: amplitude-frequency curve/phase frequency curve
- Wide dynamic range: -100dB~20dB
- **Impedance method:**
- Supply voltage: AC220V±10%
- Voltage measurement range: AC 1~30V
- Current measurement range: AC 0.001~5A

- Measurement accuracy: Voltage: 0.2%±0.02V

   1. Current: 0.2%±0.05mA

      1. Power: 0.5% ± 0.05W

      2. Impedance:0.5%±0.05

The system has a simple operation process

1) The collector is grounded
2) The collector is wired with the transformer winding
3) The collector is wired with the computer
4)
5) The computer is turned on
6) The collector is powered on
7) Log in to the software
8) Enter the information
9) Select the termination frequency and adjust the test parameters
10) Select the winding
11) Start testing
12) Replace the test winding
13) Select the winding
14) Start testing
15) Save the data
16) Repeat the above process until all winding tests are complete
17) data analysis
18) Report export
19) Close the software
20) Turn off the power of the collector
21) Disassemble the cable from the collector and the computer
22) Disassemble the transformer wiring
23) The test is complete.

2. Preparations

Note: The basic operations involving the computer and Windows operating system in the instruction manual are not included in this instruction manual, please refer to the relevant computer books.

Note: The basic operation of the Windows operating system in the instruction manual is based on the Windows 7 operating system, and the difference between the operation of other Windows systems and the operation of Windows 7 is not included in this instruction manual, please refer to the relevant computer books.

3. Test wiring

3.1 Panel Introduction

The panel of the transformer winding deformation tester is shown in Figure 1。

Figure 1 Instrument panel

1) Impedance test post: connect the tested product through an impedance test line.
2) Frequency response test post: connect the test product through a frequency response wire.
3) Power socket: It is the power input port of the whole machine, connected to 110/220V, 50/60Hz power supply, the socket contains a fuse, and the instrument should be installed with a 1A fuse.
4) Protective Grounding Post: In order to ensure the safety of the operator and the normal operation of the instrument, the terminal of the binding post should be reliably grounded before use.
5) USB communication interface: through the communication cable and PC connection to operate the instrument and data interaction.
6) Test Power Transfer Switch: Used to select the test power supply is an internal 220V power supply and an external power input for the voltage regulator.
7) External Input Post: The external power input interface used to validate the instrument。

3.2 Frequency response wiring

Schematic diagram of the external wiring during the transformer winding deformation test, as shown in Figure 2.

The "excitation end" of the instrument inputs the swept voltage signal into the head of the transformer winding under test through the input resistance (internal resistance), and the voltage signal at the head end is input to the "input end" of the instrument ;The voltage signal at the end of the winding of the transformer under test is input to the "response end" of the instrument;The "grounding" of the transformer winding deformation tester is grounded along with the housing and core of the "transformer under test".。

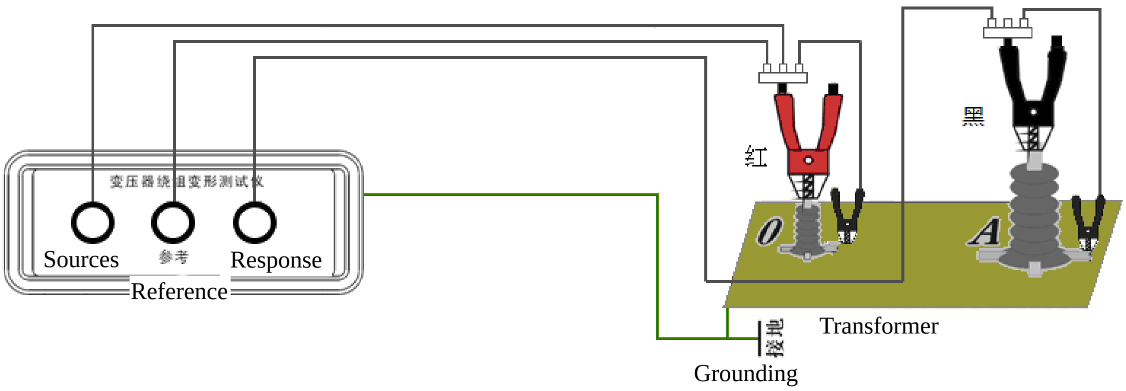


Figure 2 Wiring diagram

Note 1: The swept frequency signal of the winding deformation frequency response test is injected from the end of the winding, the head end is output, and the non-tested winding is suspended. Depending on the wiring group of the transformer, the wiring method of the winding deformation test is also different.

Note 2: The winding deformation test should be carried out under the premise of unwinding all the leads of the transformer (including overhead lines, closed busbars and cables), and keep these leads as far away from the transformer bushing as possible (the surrounding grounding body and metal suspended solids need to be more than 20cm away from the transformer bushing)., especially transformers connected to closed busbars.

Note 3: The position of the tap-changer must be recorded correctly during the test. During the frequency response test, the tap changer of the transformer under test is generally placed in the first tap, especially for the on-load voltage regulating transformer, in order to obtain more comprehensive winding information. For no-load voltage regulating transformers, it should be ensured that each measurement is at the same tap position for easy comparison.

YN wiring

The input impedance of the swept signal is connected to the neutral point O, and the output impedance of the swept signal is connected to A, B, and C respectively. In this measurement method, the interference signal received on the non-measured phase can be absorbed by the low impedance on the signal generator. This is shown in Figure 3。

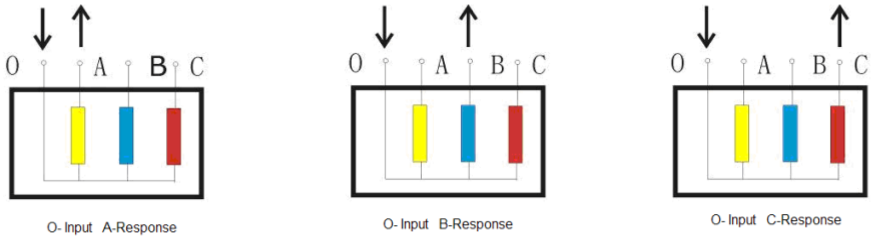


Figure 3 YN wiring

Y wiring

Since the neutral point is not drawn out, it should be wired as follows, as shown in Figure 4.

The input impedance is connected to A, and the output impedance is connected to B for testing.

The input impedance is connected to B, and the output impedance is connected to C for testing.

The input impedance is connected to C, and the output impedance is connected to A.

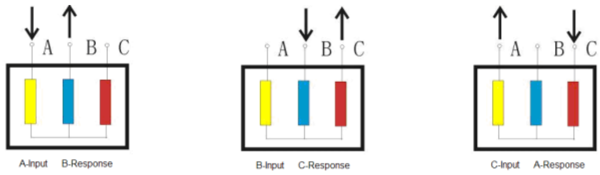


Figure 4 Y wiring

△ wiring is connected internally

Figure 5 shows the wiring method of the inner connection delta wiring winding.

The input impedance is connected to C, and the output impedance is connected to phase A, representing phase A.

The input impedance is connected to A, and the output impedance is connected to phase B, which represents phase B.

The input impedance is connected to B, and the output impedance is connected to Phase C, which represents phase C.

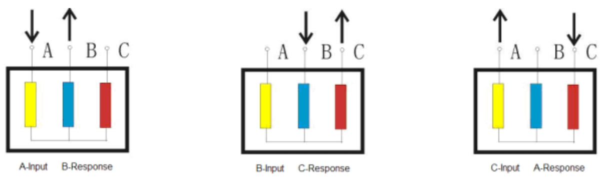


Fig.5. Connecting the δ wiring

Since the two windings connected in series and not measured in series are connected in parallel in the loop, there is a theoretical influence on the test process. If the attenuation exceeds 10dB, the effect of the non-measurement coil can be considered negligible.

External connection Δ wiring

If the windings are unwound, the wiring method for the measurement is shown in Figure 6. If the connection is not unconnected, it can be regarded as an internal connection Δ wiring, and the wiring method is shown in Figure 5.

The input impedance is connected to x, and the output impedance is connected to phase a, which represents phase a.

The input impedance is connected to Y, and the output impedance is connected to phase B, which represents phase B.

The input impedance is connected to Z, and the output impedance is connected to phase C, which represents phase C.

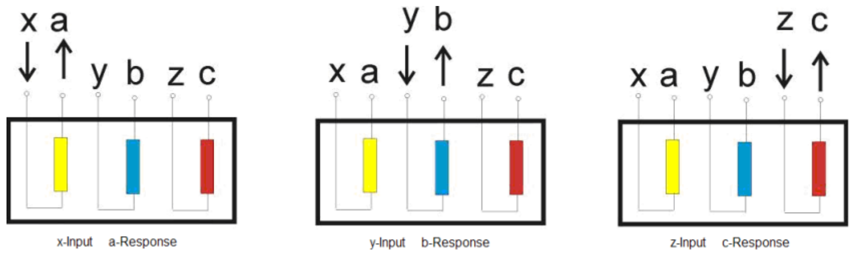


Fig.6. External connection Δ wiring

Transformer wiring with balanced windings

For transformers with balanced windings, the ground must be unwound during testing, as shown in Figure 7。

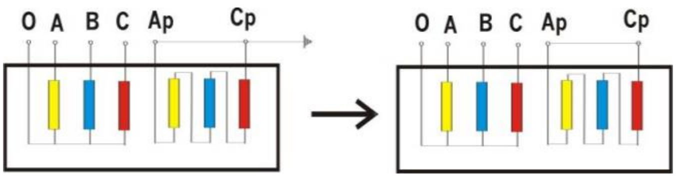


Figure 7 Balanced winding wiring

3.3 Impedance method wiring

Single-phase measurement: Ua, Ia, Ub, and Ib of the instrument panel are connected with the test lead supplied to the instrument panel to the A and B terminals of the transformer, respectively (Figure 8).

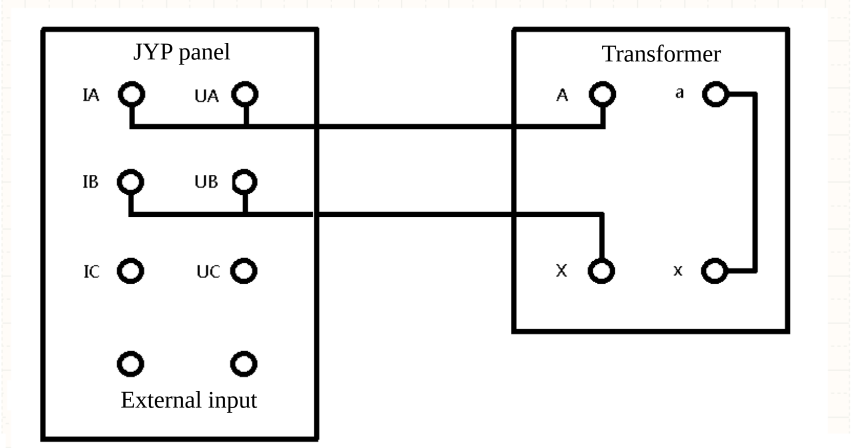


Figure 8 Wiring diagram of single-phase test

Three-phase measurement: Connect the Ua, Ia, Ub, Ib, and Uc, and Ic of the instrument panel to the A, B, and C terminals of the transformer with the test lead that comes with the instrument (Figure 9).

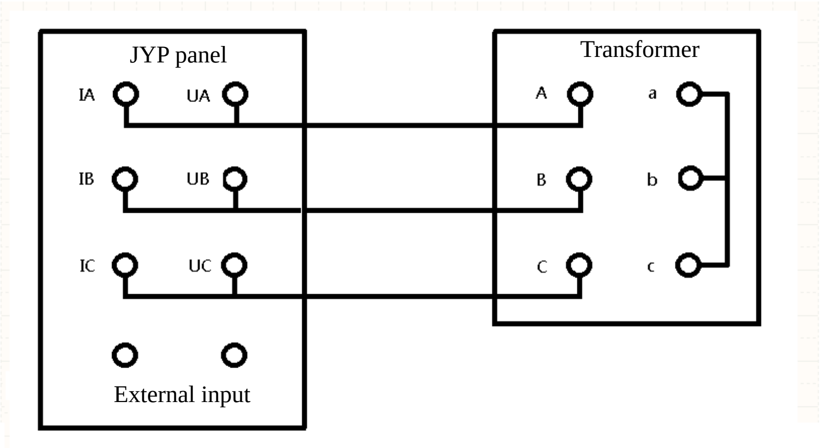


Figure 9 Wiring diagram of three-phase test

Instrument calibration: The external power input verifies the instrument wiring as shown in Figure 10

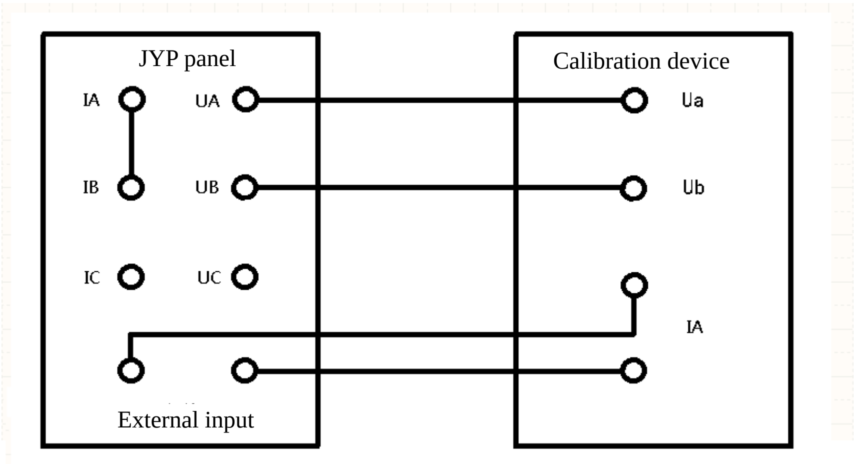


Figure 10 Instrument calibration wiring diagram

4, system testing

4.1 Start the "Winding Deformation Test System" program

1) Double-click to run the application 

(drivers are required to connect the instrument for the first time) to start the Winding Deformation Test System program.

2) Once the startup process is complete, enter the main program interface titled "Winding Deformation Tester Software". Click the serial port selection drop-down menu in the upper left corner of the screen, select the correct port (if there are multiple COM ports, you can open the device manager of the computer, and determine which COM port corresponds to this USB communication interface by plugging and unplugging the USB communication cable), click the open button to connect the test instrument. This is shown in Figure 11.

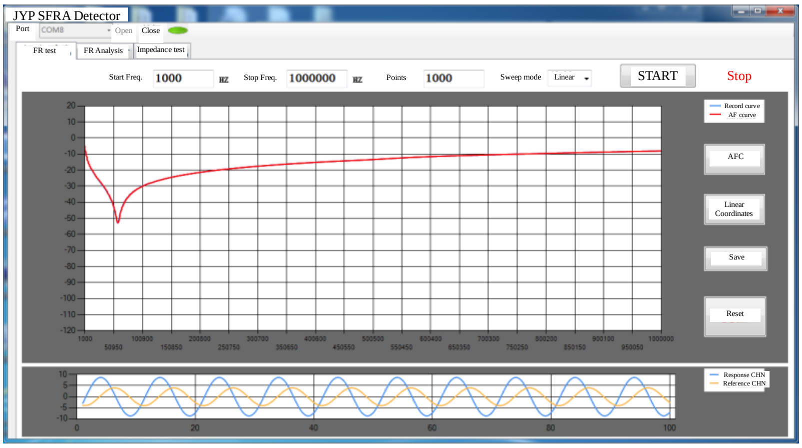


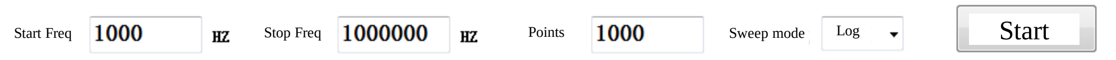
Fig 11 The software main interface

The frequency response test interface is divided into 3 parts:

1) Test the operation area

a) This area is used to edit test parameters and start tests. This is shown in Figure 12.

i.



i. Figure 12 Test parameters

ii. **Start Frequency**: Enter the required start frequency value in this input box, and the start frequency cannot be less than 100Hz.

iii. **Stop Frequency**: Enter the desired end frequency value in this input box, and the end frequency cannot be greater than 2MHz.

iv. **Number of Frequency sweep points:** Enter the required number of sweep points in this input box, and the number of sweep points cannot be greater than 3000.

v. **Sweep mode:** Click the drop-down menu to select the mode as "linear" or "logarithmic".

vi. **Start the test:** After the above four parameters are set, click the "Start" button and the instrument will start the test.

2) Test curve display area

i. This area shows the test curve with the abscissa as the frequency and the ordinate as the dB value (amplitude-frequency characteristic) or angular value (phase-frequency characteristic). This is shown in Figure 13.

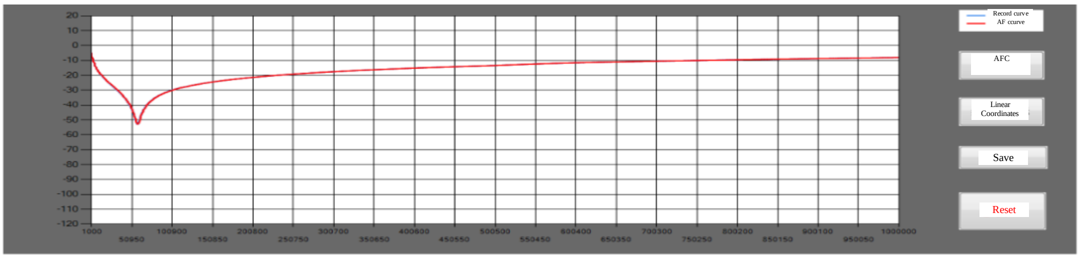


Figure 13 Test curves

Right button function:

Amplitude/Phase Frequency Characteristics: Select whether to display "Amplitude Frequency Curve" or "Phase Frequency Curve", click this button to switch between the two types.

Linear/Logarithmic Coordinates: Choose whether to display "Linear Coordinates" or "Logarithmic Coordinates", click this button to switch between the two modes.

Save: After clicking the save button, the storage information interface will pop up, and after editing, click the save button under the storage information interface, and the data will be saved. This is shown in Figure 14.

Reset: When the test is in progress, after clicking the reset button, the test will be terminated immediately, the instrument will return to the initial state, and the test button can be started again, and a new round of test can be started.

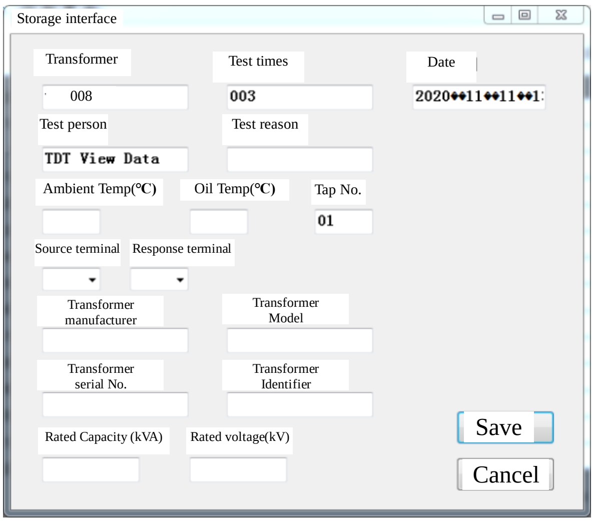


Figure 14: Storage interface

1) Signal waveform display area

This area displays the response channel and reference channel real-time waveforms during the test. This is shown in Figure 15.

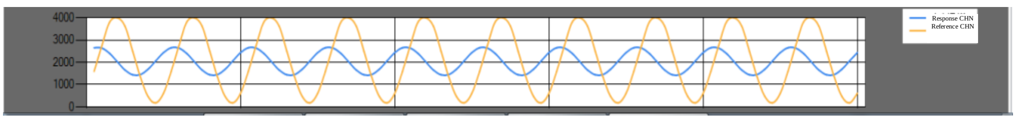


Figure 15 Signal waveform

The frequency response analysis interface is divided into 4 sections:

2） **Record area**

i. The record is in two-level directory, the first directory is the "transformer number" stored in the "storage information", and the second level directory is the "excitation end" + "response end" + "measurement number" stored in the "stored information". as shown in Figure 16。

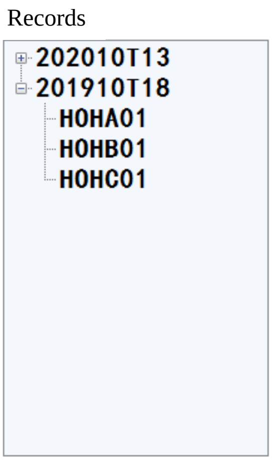


Figure 16: Frequency response records

Click the "+" in front of the first-level directory or double-click the first-level directory directly to open the second-level directory, move the cursor to an item under the second-level directory, and right-click the pop-up menu (double-click the second-level directory to directly access the history),

Access History: This curve is added to the curve information area for display and calculation purposes

View details: You can view the details of the curve storage, as shown in Figure 17, you can modify the saved parameters on this interface, and click the modify button after the modification is completed, and a new record will be created

Export data: You can export the data of the selected curves to .csv file in DL/T911-2016 format, see Appendix B of DL/T911-2016 for details

Import data: You can save the curve data of the .csv file saved in DL/T911-2016 format to the database

Search records: You can fuzzily search the saved records in the database according to the entered transformer number, and double-click the query result to open the record in the history.

Delete Record: The curve is deleted from the database

Note: Deleted data cannot be recovered, please choose carefully.

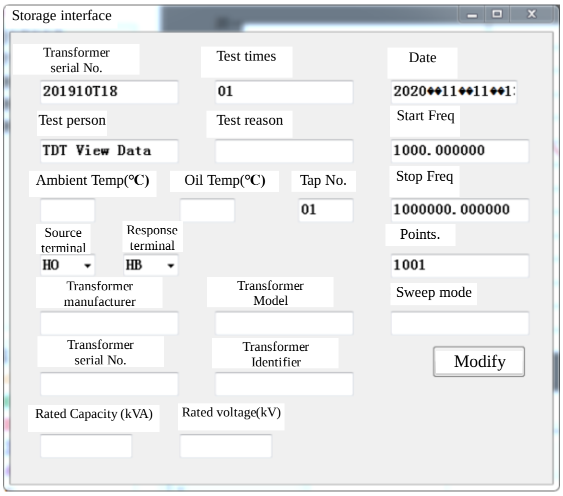


Figure 17 for details and modifications

3） Curve information area

This area displays the curve information retrieved from the records, as shown in Figure 18。

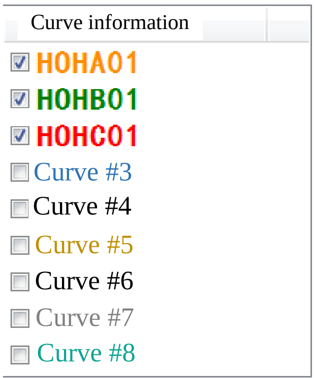


Figure 18 Curve information

Move the cursor to a curve, right-click the pop-up menu,

Curve Details: You can view the details of this curve, as shown in Figure 19

Delete Curve: You can remove this curve. When you select a curve, the display area can display the current curve, and the current curve can be cleared after unchecking.

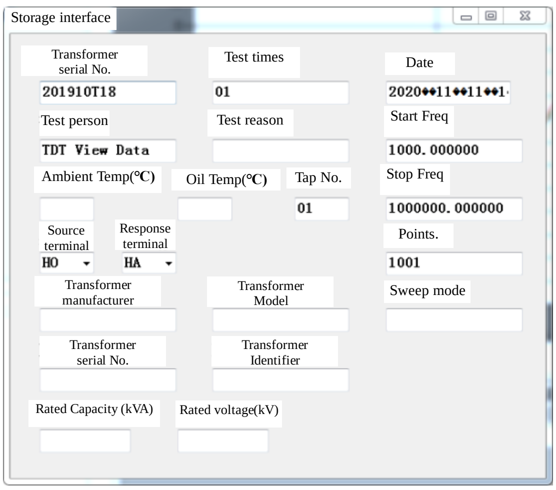


Figure 19 Historical curve details

(3) Curve display area

This area displays the selected curve, you can display the "Amplitude and Frequency Characteristics" and "Phase Frequency Characteristics", select different frequency bands and coordinate forms, and change them by pressing the buttons on the right. The different color curves correspond to the text color of the curve information. This is shown in Figure 20。

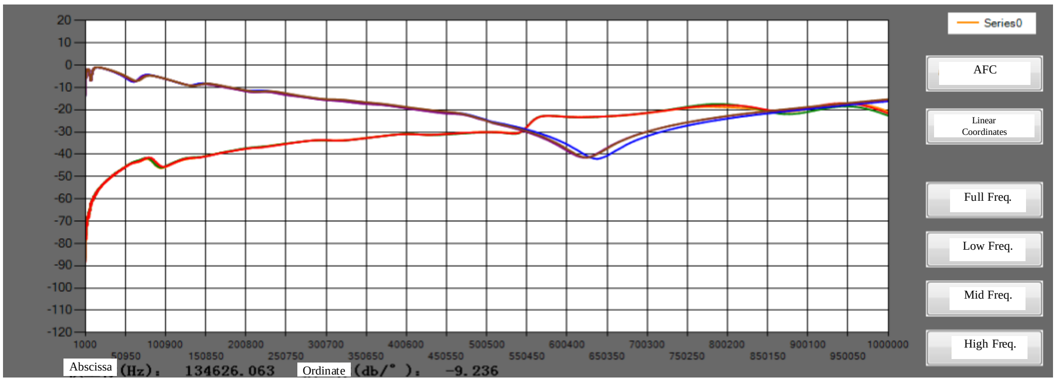


Figure 20 curve display area

Right button function:

Amplitude/Phase Frequency/All Display: Select whether to display "Amplitude Frequency Curve" or "Phase Frequency Curve" or all displays, and click this button to switch between the three types.

Linear/Logarithmic Coordinates: Choose whether to display "Linear Coordinates" or "Logarithmic Coordinates", click this button to switch between the two modes.

All bands: The abscissa is restored to the original coordinates of the curve.

Low frequency band: abscissa range from 1kHz to 100kHz.

Mid-band: abscissa range from 100kHz to 600kHz.

High frequency band: abscissa range from 600kHz to 1MHz.

Curve display area operation:

Enlarge function: In the curve display area, after the mouse left-clicks and drags the selected area, the selected area will be enlarged, and the horizontal and vertical coordinates will appear slider and head circle icons after zooming in. Drag the slider to move the curve, and click the head circle to resume zooming in. This is shown in Figure 21.

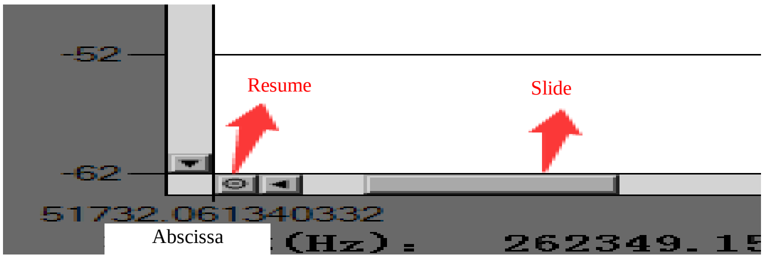


Figure 21 Zoom in function

View coordinate point function: In the curve display area, when the mouse cursor moves to the position near the curve, the mouse cursor will change to a "crosshair" mark, and the frequency information of the current cursor position will be displayed in the lower left corner of the curve display area. The abscissa is the frequency value, the ordinate is selected in the cursor, the amplitude-frequency curve is the dB value, and the phase frequency curve is the angle value. This is shown in Figure 22.

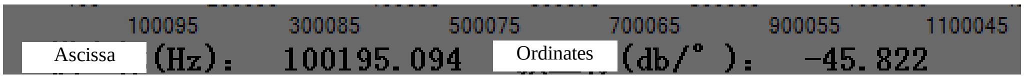


Figure 22 coordinates

4） Data analysis area

In this area, the data is calculated for the selected curve and the data calculation results are reported. This is shown in Figure 23。

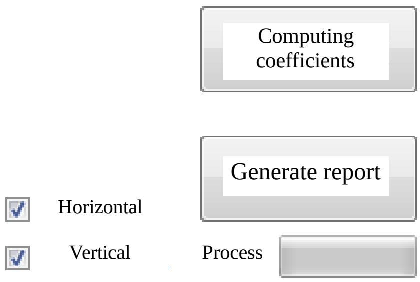


Figure 23 Data analysis area

Right button function:

Computing Coefficients: Calculate the horizontal and vertical comparison data of the selected curves. The analysis is divided into horizontal comparison, vertical comparison, and horizontal comparison is the comparison between windings, 0-1-2 is a group, 3-4-5 is a group, and 6-7- 8 for a group. This is shown in Figure 24. The vertical comparison is the comparison between the same windings, 0-3-6 is a group, 1-4-7 is a group, and 2-5-8 is a group. This is shown in Figure 25. (The horizontal comparison is generally the comparison between the three-phase windings of the same transformer A, B and C, and the vertical comparison is generally the comparison of the same transformer, the same winding, the same tap position, and the test in different periods).。

Horizontal	Vertical			

	低频段 (RLF)	中频段 (RMF)	高频段 (RHF)	RESULT
Curve 0-1	1.61	1.33	0.57	Good consistency
Curve 1-2	1.40	1.41	1.10	Good consisency
Curve 2-0	2.12	0.96	0.31	Good consistency

Figure 24: Horizontal comparison results

Horizontal	Vertical			

	低频段 (RLF)	中频段 (RMF)	高频段 (RHF)	RESULT
Curve 0-3	3.96	4.55	3.39	Normal winding
Curve 3-6	3.96	4.55	3.39	Normal winding
Curve 6-0	10.00	10.00	10.00	Normal winding
Curve 1-4	4.02	4.63	3.49	Normal winding

Figure 25 Vertical comparison results

Report Generation: The report format is in Word format, and the report content contains the following information: Report Generation Time, Curve Information, Curve Graph, Horizontal Comparison Result, and Vertical Comparison Result. Select the Horizontal and Vertical Comparison data to include Horizontal Data and Vertical Comparison data in the Generate Report by ticking the Horizontal and Vertically Compare options next to the Generate Report button. The progress bar at the bottom is used to display the progress of the report generation, and a pop-up window will pop up when the report is generated.

The frequency response test interface is divided into 3 parts:

1) Record area

The history is a two-level catalog, the first level of the catalog is "Transformer Number", and the second level of the catalog is "Measured Items + Test Time". This is shown in Figure 26.

2020T18
- Single2021/1/8
- Three2021/1/11

Figure 26 Impedance method record

Click the "+" in front of the first-level directory or double-click the first-level directory directly to open the second-level directory, move the cursor to an item under the second-level directory, and right-click the pop-up menu (double-click the second-level directory to directly access the history),

Review records: After the record is retrieved, the parameter settings under this historical data will be displayed in the parameter setting area, and the test results will be displayed in the result display area

Search records: You can fuzzily search the saved records in the database according to the entered transformer number, and double-click the query result to open the record in the history.

Delete Records: The selected data is deleted from the database

Note: Deleted data cannot be recovered, please operate carefully.

2) Parameter setting area

Before starting the impedance test, you should enter the correct parameters in this area before starting the test. After the record is retrieved, the parameters set in the history are displayed in this area. This is shown in Figure 27。

Figure 27 Parameter setting area

3) The results display area

The test results and the history records are displayed in this area, as shown in Figure 28。

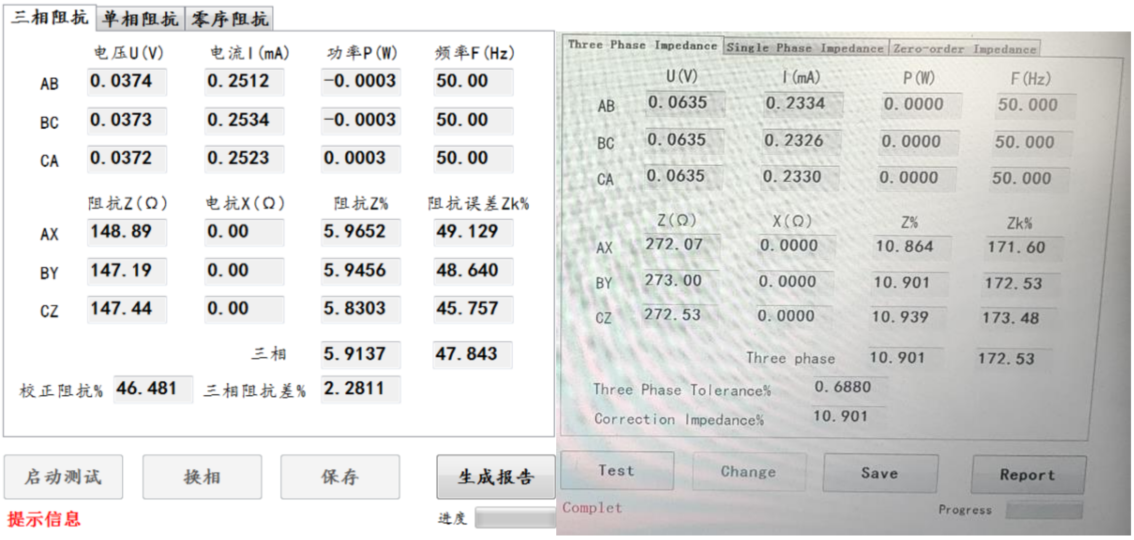


Figure 28 results display area

5. Equipment maintenance

This section provides basic maintenance information, please do not attempt to disassemble, change and repair the transformer winding deformation tester.

5.1 Basic Maintenance

Regularly wipe the surface of the tester and its accessories with a clean cloth.

The tester should be placed in a clean, low humidity location and protected from dirt, and the box should be laid flat to prevent dust from entering the tester.

5.2 Advanced Maintenance

It is carried out by our professional and technical personnel.

6. After sale service

Repair and replace free of charge for quality problem of product in 24 months from procurement date of the instrument, provide repair and technical service for whole life. In case abnormality or fault is found in the instrument, please contact our company in time, so we can organize the most convenient solution plan for you.

Appendix 1: Correlation coefficient as a function of the degree of deformation of transformer windings

Our company's transformer winding deformation tester analyzes the degree of transformer winding deformation in strict accordance with the power industry standard DL/T911-2016 "Frequency Response Analysis Method for Power Transformer Winding Deformation", and the relationship between the specific correlation coefficient and the degree of transformer winding deformation is shown in the following table:

Table A.1 Relationship between correlation coefficient and transformer winding deformation degree (for reference only)

<table>
<tr><th>The degree of winding deformation</th><th>Correlation coefficient R</th></tr>
<tr><td>Severely deformed</td><td>RLF < 0.6</td></tr>
<tr><td>Noticeably deformed</td><td>1.0 > RLF ≥0.6 or RMF <0.6</td></tr>
<tr><td>Mild deformity</td><td>2.0 > RLF ≥1.0 or 0.6 ≤ RMF <1.0</td></tr>
<tr><td>Normal winding</td><td>RLF ≥ 2.0 and RMF ≥1.0 and RH F ≥0.6</td></tr>
<tr><td colspan="2">Note: RLF is the correlation coefficient of the curve in the low frequency band (1kHz～100kHz);
RMF is the correlation coefficient of the curve in the middle frequency band (100kHz～600kHz).
RHF is the correlation coefficient of the curve in the high frequency band (600kHz～1000kHz).</td></tr>
</table>