ZCVF-A 5000kVA/ 1000kV

Variable Frequency Resonant Test System

Kvtester Electronics Technology Co.,Ltd

Dear Client,

Thank you for purchasing our product. Please read the manual in detail prior to first use, which will help you use the equipment skillfully.

Our aim is to improve and perfect the company's products continually, so there may be slight differences between your purchase equipment and its instruction manual. You can find the changes in the appendix. Sorry for the inconvenience. If you have further questions, welcome to contact with our service department.

The input/output terminals and the test column may bring voltage, when you plug/draw the test wire or power outlet, they will cause electric spark. PLEASE CAUTION RISK OF ELECTRICAL SHOCK!

◆ SERIOUS COMMITMENT

All products of our company carry one year limited warranty from the date of shipment. If any such product proves defective during this warranty period we will maintain it for free. Meanwhile we implement lifetime service. Except otherwise agreed by contract.

◆ SAFETY REQUIREMENTS

Please read the following safety precautions carefully to avoid body injury and prevent the product or other relevant sub-assembly to damage. In order to avoid possible danger, this product can only be used within the prescribed scope.

Only qualified technician can carry out maintenance or repair work.

--To avoid fire and personal injury:

Use Proper Power Cord

Only use the power wire supplied by the product or meet the specification of this produce.

Connect and Disconnect Correctly

When the test wire is connected to the live terminal, please do not connect or disconnect the test wire.

Grounding

The product is grounded through the power wire; besides, the

ground pole of the shell must be grounded. To prevent electric shock, the grounding conductor must be connected to the ground.

Make sure the product has been grounded correctly before connecting with the input/output port.

Pay Attention to the Ratings of All Terminals

To prevent the fire hazard or electric shock, please be care of all ratings and labels/marks of this product. Before connecting, please read the instruction manual to acquire information about the ratings.

Do Not Operate without Covers

Do not operate this product when covers or panels removed.

Use Proper Fuse

Only use the fuse with type and rating specified for the product.

Avoid Touching Bare Circuit and Charged Metal

Do not touch the bare connection points and parts of energized equipment.

Do Not Operate with Suspicious Failures

If you encounter operating failure, do not continue. Please contact with our maintenance staff.

Do Not Operate in Wet/Damp Conditions.

Do Not Operate in Explosive Atmospheres.

Ensure Product Surfaces Clean and Dry.

Contents

I. Product overview

The device is mainly for AC voltage test of XLPE cable, hydraulic generator, power transformer, busbar and GIS. It has wide application scope. It is an ideal withstand voltage device for high voltage test department and power installation and repair engineering unit.

The device is mainly composed of frequency power source, excitation transformer, reactor, capacitor voltage divider, compensation capacitor (optional).

Advantages of series resonance in power system:

1. The required power supply capacity is greatly reduced. The series resonant power supply produces high voltage and high current by reactor and the capacitance of the tested product in resonant. In the whole system, the power supply only needs to provide active power consumption of the system, therefore, the power required for the test is only 1/Q of the test capacity.

2. The weight and dimension of the equipment are greatly reduced. The series resonant power supply not only eliminates the bulky high-power voltage regulator and the ordinary high-power frequency test transformer, but also requires the 1/Q of the resonant excitation power to reduce the weight and dimension of the system, which is generally 1/10-1/30 of the common test device.

3. Improve the waveform of the output voltage. The resonant power supply is a resonant filter circuit, which can improve the waveform distortion of output voltage and get a good sinusoidal waveform, which effectively prevents the peak breakdown of the harmonic peak to the test product.

4. Prevent large short circuit current burn fault point. In the series resonant state, when the insulation weakness of the test product is burn down, the circuit detuns immediately and the circuit current drops rapidly to 1/Q of the normal test current. When parallel resonant or test transformer is used to withstand voltage test, the breakdown current will increase dozens of times.

Compared with the two way, the short-circuit current and breakdown current are hundreds of times different. Therefore, the series resonance can effectively find the weakness of the insulation, and there is no hidden trouble in the fault point of the large short circuit current burn.

5. There will be no recovery over-voltage. The sample breakdown, due to the loss of the resonant conditions, high voltage arc disappeared immediately, high voltage arc also immediately extinguished, and the recovery voltage of the re establishment is a long process, it is easy to disconnecting the power before reach the flash-over voltage again, the voltage recovery process is a kind of energy accumulation batch process, the process is long, and there will be no recovery over voltage.

The main functions and technical features of the frequency series resonant test device are as follows:

1. The device has over-voltage, over-current, zero start, system detuning and flash-over protection function. The over-voltage and over-current protection value can be set according to user's needs, and the flash-over protection action to protect the product.

2. Small volume, light weight, very suitable for the operation of the people on the spot.

3. The device has three working modes, which is convenient for users to choose flexibly according to the field conditions and improve the test speed.

The working modes are: **full automatic, manual and automatic tuning manual boost mode.**

4. The data can be stored and printed in different places. The data number is numbered is convenient to help the user to identify and find the data.

5. When the device automatically sweeps the frequency, the starting point of frequency can be set arbitrarily in the specified range. Meanwhile, the LCD screen displays the scanning curve, which is convenient for users to directly understand whether the resonance point is found .

6. Using the DSP technology, it can easily increase and decrease the

function and upgrade according to the needs of the user, and also make the human-computer exchange interface more humanized.

II. Principle of series resonant system

1. Generation of series resonance

There are two ways of power frequency resonance in series and parallel resonance. Resonance is a special phenomenon which is made up of R, L and C components under certain conditions. First, we analyze the characteristics and resonant conditions of R, L and C series circuits. In Figure 1, the R, L, C series circuit, under the function of the sinusoidal voltage U, its complex impedance:

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right) = R + j(X_L - X_C) = R + jX$$

Reactance $X = X_L - X_c$ is a function of angular frequency ω, and the change of X with ω is shown in Figure 2. When ω changes from 0 to ∞, X changes from $-\infty$ to $+\infty$, when $\omega < \omega_0$, $X < 0$, the circuit is capacitive; when $\omega > \omega_0$, $X > 0$, the circuit is inductive; when $\omega = \omega_0$,

$$X(\omega_0) = \omega_0 L - \frac{1}{\omega_0 C} = 0$$

$$X(\omega_c) = \omega_0 L - \frac{1}{\omega_c C} = 0$$

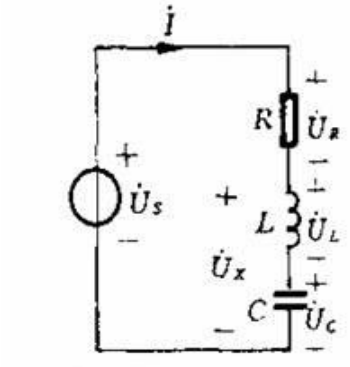


Figure 1

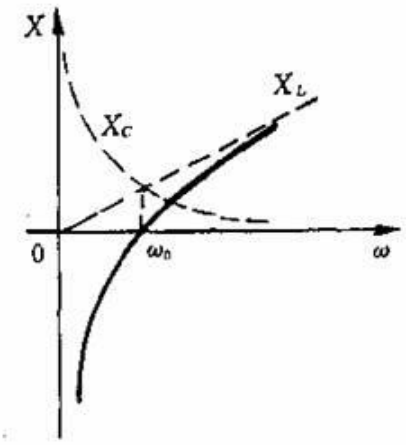


Figure 2

Here, the circuit impedance Z (ω_0) = R is a pure resistance. When the voltage and current are in the same phase, we call the working state of the circuit at this time as resonance. Because the resonance occurs in the R, L, C series circuit, it is also called series resonance. Formula 1 is the condition of resonance in a series circuit. We can get the $\omega_0$resonant angle frequency :

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

Resonant frequency

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

It can be seen that resonant frequency of a series circuit is determined by its own parameters L and C, it is independent of the external conditions, so it is also called the natural frequency of the circuit. When the power frequency is constant, the circuit parameters L or C can be adjusted, which makes the natural frequency of the circuit coincides with the power frequency. When the circuit parameters are constant, the power frequency can be changed to make the resonant frequency coincides with the natural frequency of the circuit.

2. Quality factor of series resonance

When the series circuit resonances, its reactance X (ω_0) = 0, so the complex impedance of the circuit

$$Z(\omega_0) = R$$

It is presented as a pure resistance, and the impedance is the minimum. When resonance, although inductance $X = X_L - X_c = 0$, but the inductance and capacitance are not zero, only two are equal. We call the resonant inductance or capacitance of series resonant circuit impedance characteristics , denoted as ρ, i.e.

$$\rho = \omega_0 L \left(= \frac{1}{\omega_0 C}\right) = \frac{1}{\sqrt{LC}} \cdot L = \sqrt{\frac{L}{C}}$$

Unit of ρ is ohm, which is determined by the circuit parameters L and C, is independent of the frequency.

The performance of the resonant circuit is characterized by the ratio of the characteristic impedance to the resistance in the engineering. It is called the quality factor of the series circuit, which is expressed in Q.

$$Q = \frac{\rho}{R} = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

The quality factor, also called the resonance coefficient, is sometimes referred to as the Q. It is a dimensionless quantity that is determined by the circuit parameters R, L, and C.

3. Voltage relation of series resonance

The voltage of each element at the time of resonance:

$$\dot{U}_{RO} = R\dot{I}_O = \dot{U}_S$$

$$\dot{U}_{LO} = j\omega_0 L\dot{I}_O = j\omega_0 L\frac{\dot{U}_s}{R} = jQ\dot{U}_s$$

$$\dot{U}_{CO} = j\frac{1}{\omega_0 C}\dot{I}_o = -j\frac{1}{\omega_0 C}\frac{\dot{U}_S}{R} = -jQ\dot{U}_S$$

That is, when resonant, the effective value of the inductance voltage and the capacitance voltage is equal, the Q times of the external voltage, but the inductance voltage is ahead of the external voltage 90°, the capacitance voltage is lagged the external voltage 90°, and the total reactance voltage is 0. When the Q of the circuit is high, the value of the inductance voltage and the capacitance voltage will be far greater than the external voltage, so the series resonance is also called the voltage resonance.

The common test items such as transformer, GIS system, SF6 circuit breaker, current transformer, power cable and casing are capacitive, the reactor equipped with the system is inductive, during the test the series resonance is generated by adjusting output frequency of frequency power source, under the condition of loop resonance, the output voltage of the variable frequency power supply is adjusted to make the test voltage reach the

test value. Due to the resonance of the circuit, the lower output voltage of the frequency power source can produce a higher test voltage on the test product.

In actual field application, the high voltage and low voltage on the test product follow the following formula:

$$U_{test} = QU_{excited}$$

U_{test} is the test voltage of HV resonance, Q is the quality factor, and $U_{excited}$ is the output voltage of the excitation transformer.

For example, suppose that the quality factor Q of the series resonance is 30, the excitation transformer selects the tap of 16kV, and the excitation transformer's rated input voltage is 400V. If the excitation transformer's input voltage is 100V, the calculation steps of high voltage are as follows.

(1) Calculate the ratio of excitation transformer.

Ratio N= excitation transformer tap voltage / input rated voltage.

That is: N=16kV/400V=16000/400=40

(2) Calculate the output voltage of excitation transformer.

Excitation transformer output voltage = excitation transformer input voltage * excitation transformer ratio.

That is: $U_{excited}$=100V*40=4kV

(3) Calculate voltage of HV resonant test.

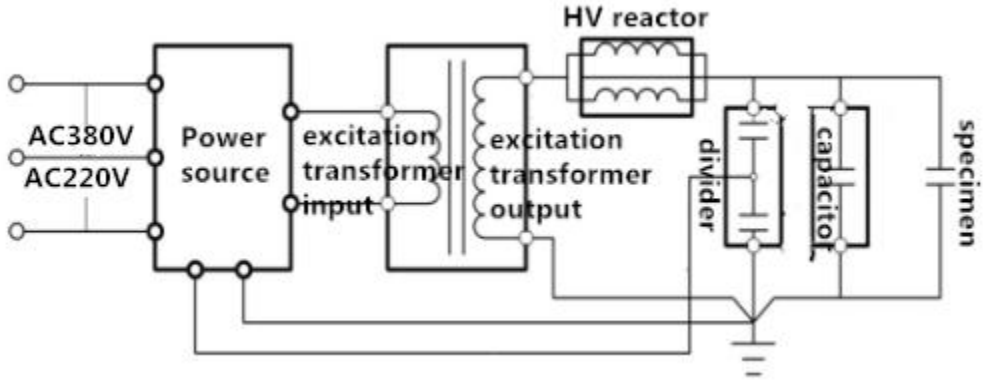
HV resonance test voltage = excitation transformer output voltage * quality factor.

That is: U_{test} =4kV*30=120kV

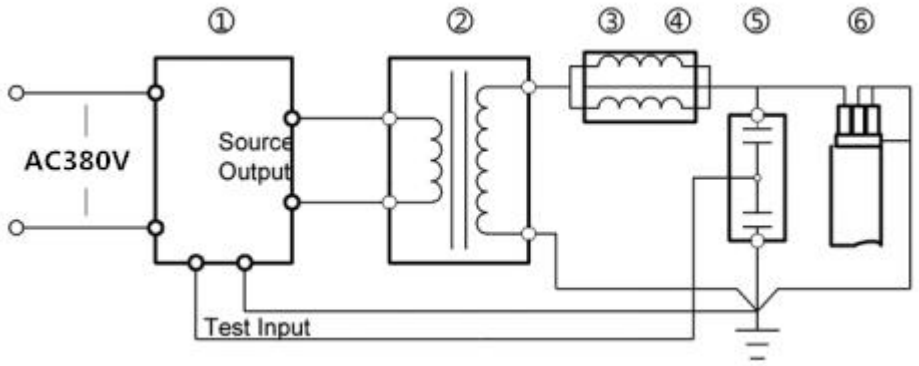
Therefore, the final HV resonance test voltage of the system is 120kV.

III. Application of series resonant system

1. Resonant test system AC hipot test wiring



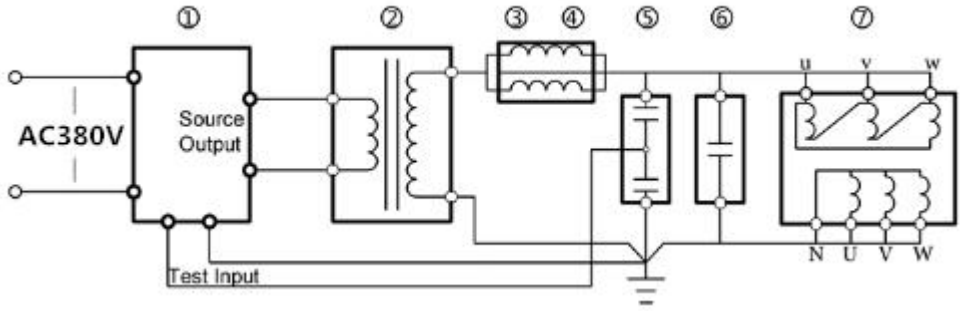
2. Resonant hipot test wiring of cable



①power source ②excitation transformer ③reactor ④reactor

⑤voltage divider ⑥cable

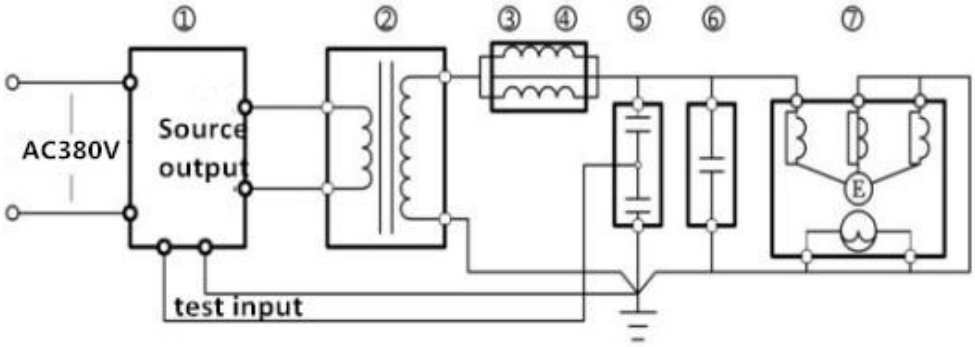
3. Resonant hipot test wiring of transformer



①power source ②excitation transformer ③reactor ④reactor

⑤voltage divider ⑥capacitor (optional) ⑦transformer

4. Resonant hipot test wiring of generator



①power source ②excitation transformer ③reactor ④reactor

⑤voltage divider ⑥capacitor (optional) ⑦generator

IV. Introduction of frequency power source

1. Basic description of equipment

(1) Power supply

Connect the 380V directly to the "input" of the power source.

(2) Operation panel description

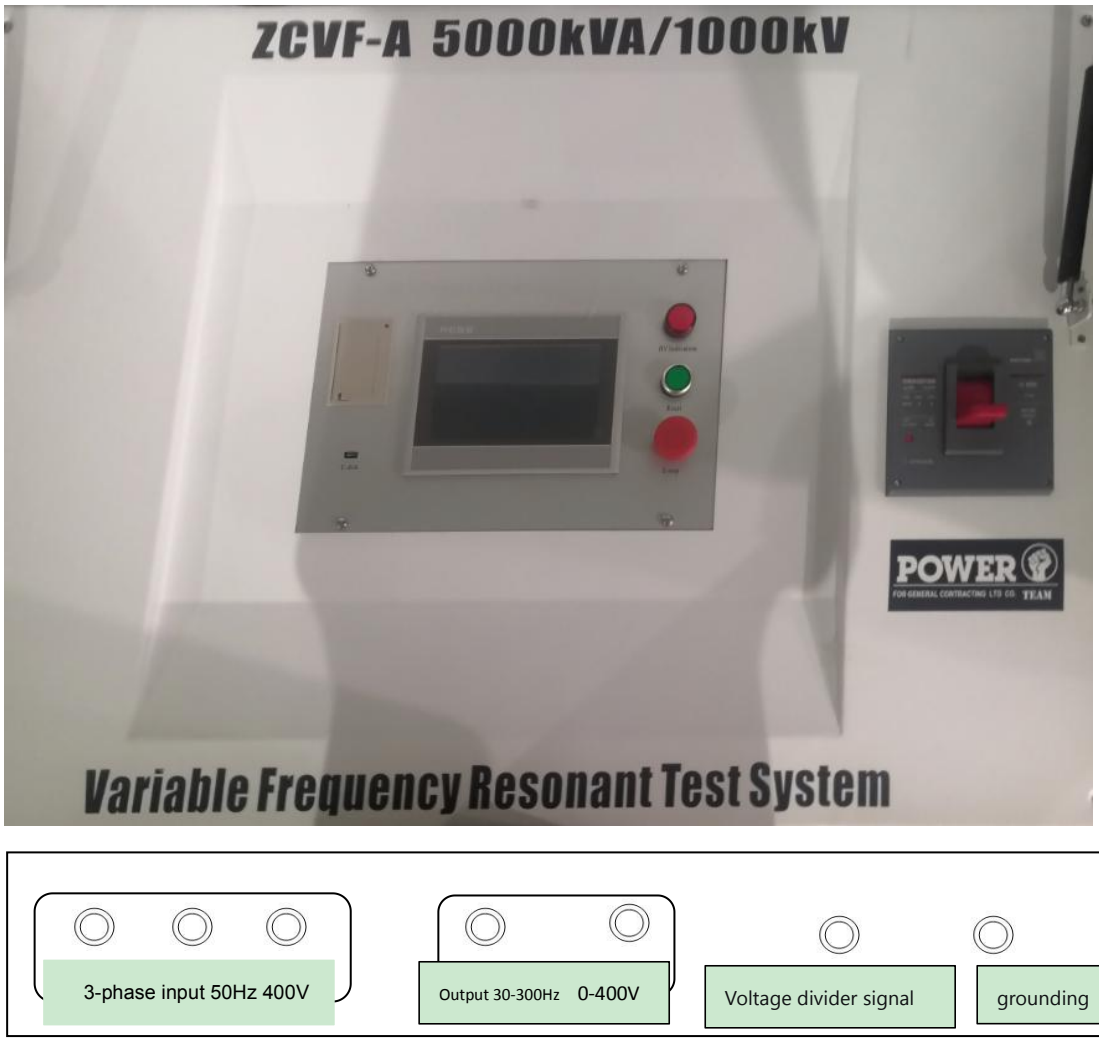


figure1

- Power switch: power supply of the frequency power source.
- Test light: light on when frequency power source powered on.
- Reset: reset after load detuning, frequency power source overheating and other protective actions.
- Emergency: emergency interruption button.

- Voltage divider signal: for the low voltage access of voltage divider, the maximum voltage 100V, and the input impedance 10M.
- Ground: safe grounded.
- USB: connect U disk or mouse.
- LCD: display all parameters, waveform and menus of system.
- Input: 380V±10%, 3 phase. When the power is 380V, then A ,B ,C three-phase can be used as the rated load test; when the power supply is 230V, connect a, C two phases for 1 / 2 load test.
- Output: power source output- excitation transformer input.

(3) Power on

Turn on the power switch of power source, the LCD light on.

Note: the fan on both sides of the instrument are running, indicating that the internal power device of the instrument is working normally, otherwise it means that the instrument is overheated or not reset after the last test. At this time, the power source should be cut off, and placed in the ventilating place for 1 hours or so, and then can be started after the internal temperature is properly reduced.

When the fan is often not started, it is recommended to contact the manufacturer immediately.

Please do not disassemble the instrument when the equipment is not recoverable.

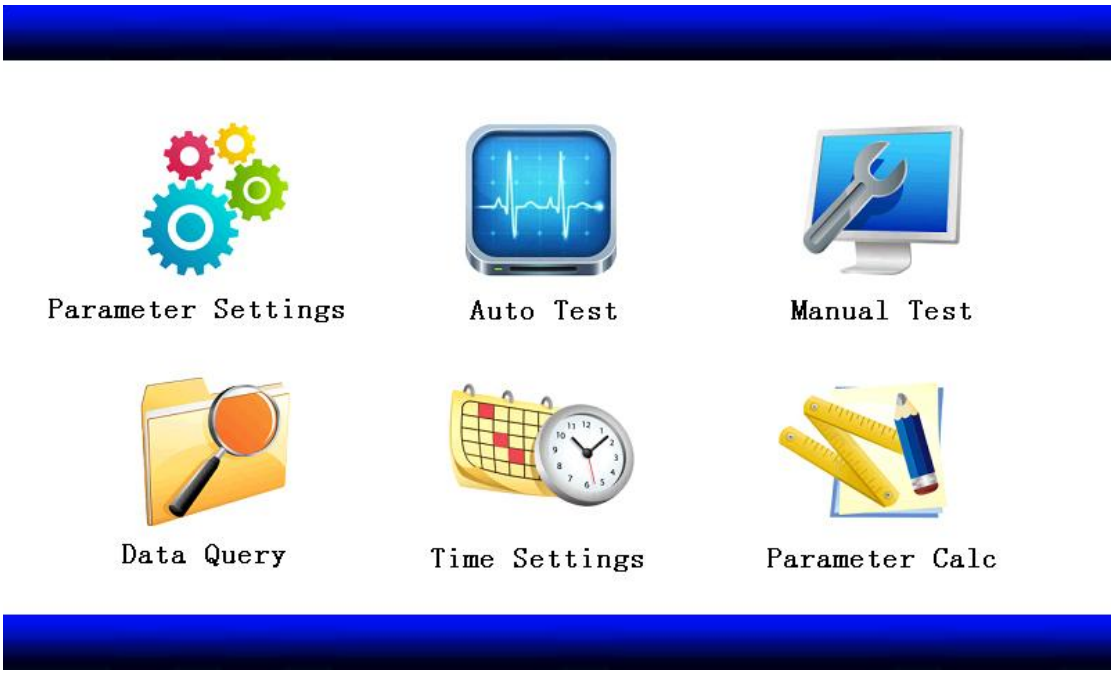


Figure2

Note: Click "Chinese" in the upper left corner to automatically switch the language, the default is Chinese and English switch, other languages can be customized.

(4) Click parameter setting, interface as follows:

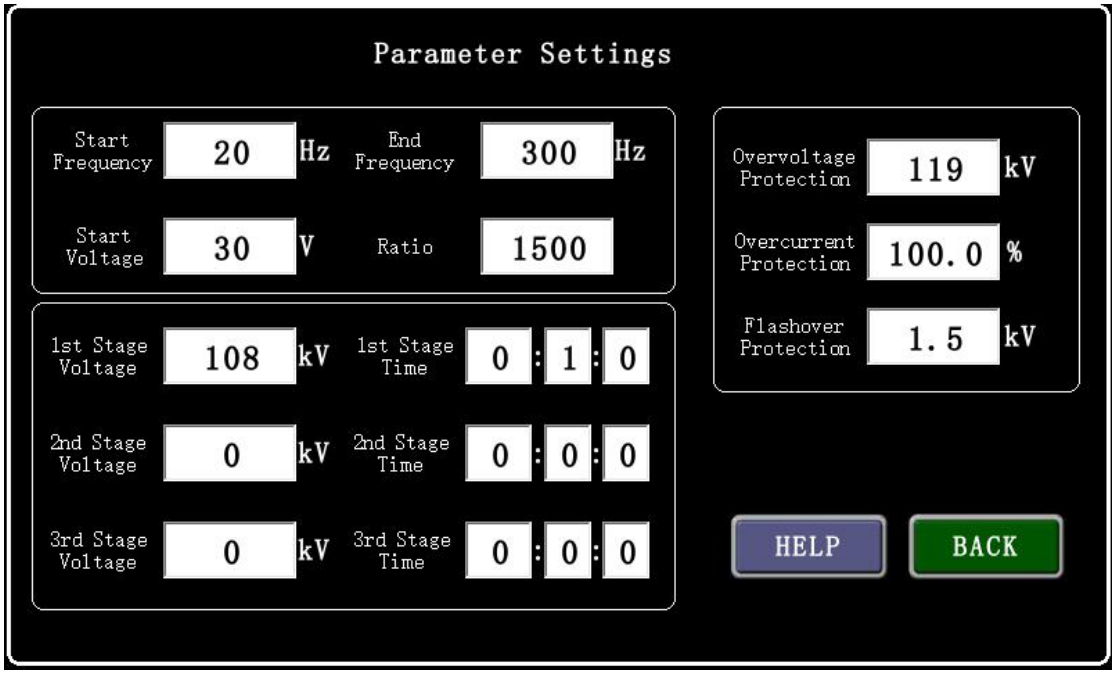


Figure3

- Start frequency: The start frequency of automatic tuning is selected, the lower frequency is 20Hz, and the upper limit frequency is 250Hz. In order

to ensure the scanning accuracy the "start frequency" must be 50Hz smaller than the "end frequency".

● End frequency: The end frequency of automatic tuning is selected, the lower frequency is 70Hz, and the upper limit frequency is 300Hz. In order to ensure the scanning accuracy the "end frequency" of must be 50Hz higher than the "start frequency".

1. "Start frequency" should not be higher than "end frequency" -50Hz.

2. It is suggested that 20Hz ~ 300Hz be used to scan the first test.

3. when the approximate frequency range has been known, it can be selected at the appropriate frequency section to reduce the test time.

● Start voltage: The initial value of the output voltage at the time of tuning. The input range is 5-100V.

1. For the test products with lower Q, such as generator, motor and overhead busbar, the initial value is set to 20 ~ 30V.

2. For the test products with higher Q value, such as power cable, transformer, GIS, and so on, the initial value is set to 15 ~ 20V.

● Stage 1st voltage: set the first stage value of the test voltage

● Stage 1st time: sett the voltage withstand time of the first stage test voltage.

● Stage 2nd voltage: set the second stage value of the test voltage

● Stage 2nd time: sett the voltage withstand time of the second stage test voltage.

● Stage 3rd voltage: set the third stage value of the test voltage

● Stage 3rd time: sett the voltage withstand time of the third stage test voltage.

Our voltage tracking system can automatically check the function of large voltage fluctuation, but the voltage fluctuation of the power grid is small, the fluctuation of the high voltage caused by this is also within the capture range of the instrument, therefore, we strongly suggest that when setting the test voltage, the value of the "**test voltage**" is set to 2%Ue lower than the test

voltage to be applied.

If there is no stages withstand voltage test, only set 1st stage test voltage and corresponding test time, and the test voltage and test time in other stages are set to 0.

● Ratio: the ratio of the capacitance divider, generally is 1500:1, and the "ratio " is set to 1500. (may also be 3000:1, the factory has set up, customer without changing).

● Over voltage protection: set the limit of the test voltage. Automatic termination test when the voltage exceeds, generally 10% higher than the test voltage, the maximum can be set to 1.2 times the rated voltage. When the test voltage changes, the over voltage protection will be automatically updated.

● Over current protection: set the max value of the low voltage output current. When the actual test current is not known, it is generally set up as the rated current of the device.

● Flash over protection: The actual flashover protection voltage value, the default value is 1.5kV, which can be modified by the customer according to the field test.

● Help: points for attention when setting up "parameter settings".

After clicking "help", the display interface is shown in Figure4

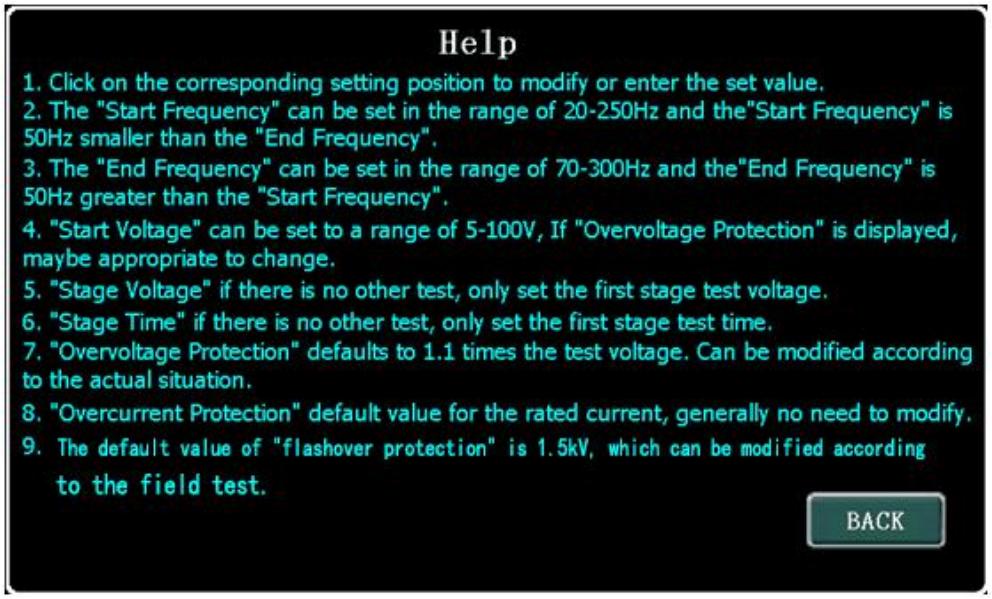


Figure4

● Auto test: when the "parameter settings" is finished, click "auto test" and enter the "auto test" interface, showing the interface as shown in Figure5.

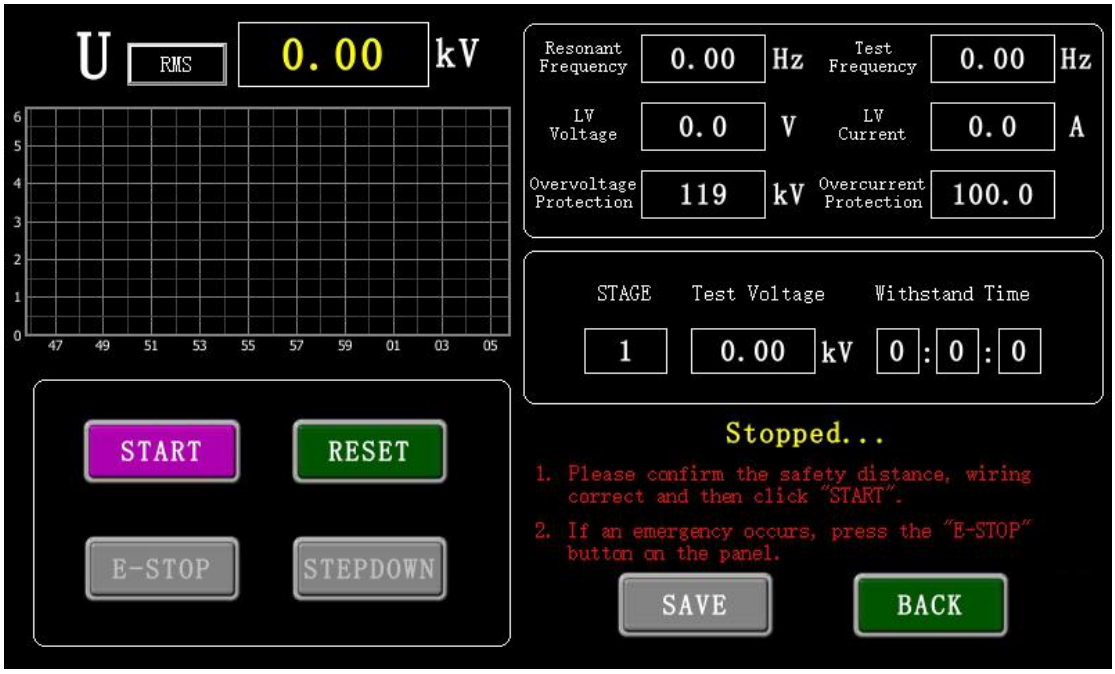


Figure5

Click "**start**", the system automatically searches for the resonant point, and the right lower corner suggests "tuning…". If there is an abnormal situation, please click "emergency"; white represents the voltage curve, and the display interface is shown in Figure6.

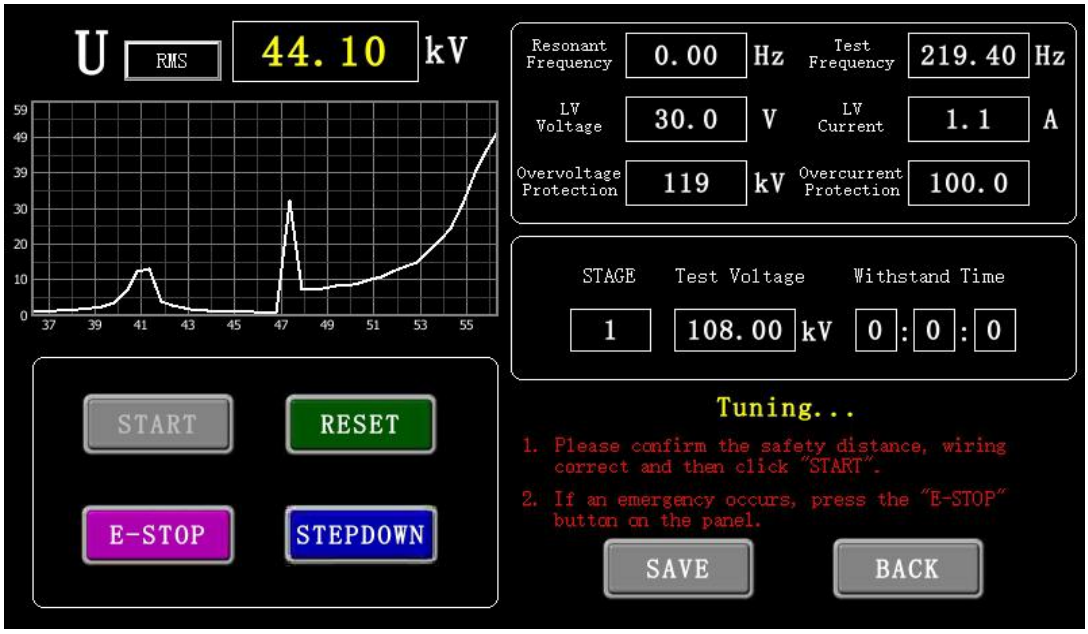


Figure6

Find the resonance point, the system automatically boost, the lower right corner of the prompt "boost ...", if abnormal circumstances, please click "emergency shutdown"; display interface shown in Figure 7.

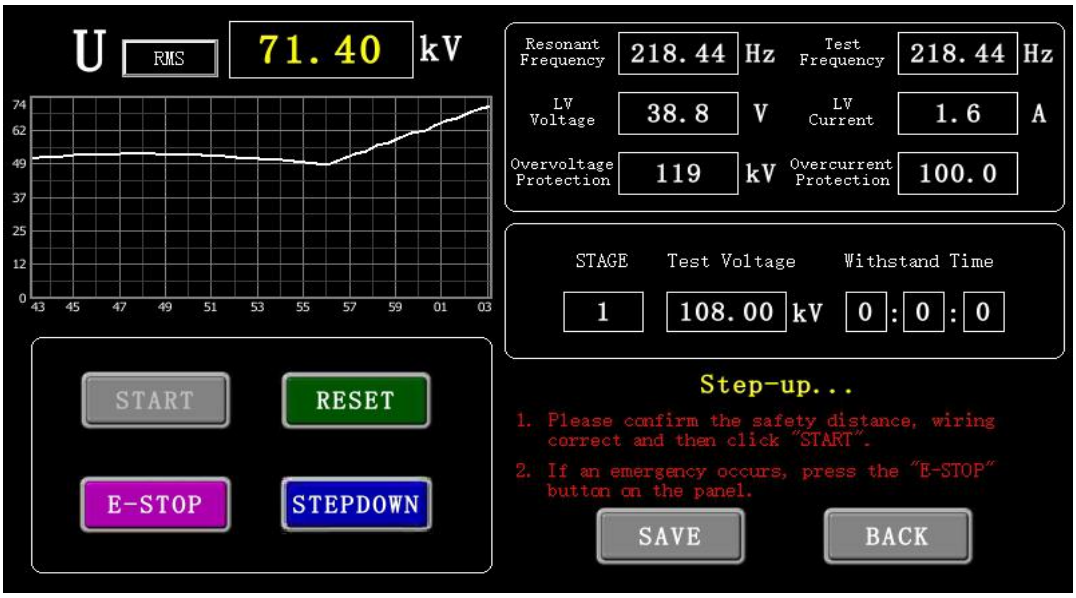


Figure 7

When Urms rises to the withstand voltage of the test, the system automatically presses the time, the lower right corner prompts "the first stage of the test ..." or "the second stage of the test ...", if any, please click "emergency stop"; The interface is shown in Figure 8.

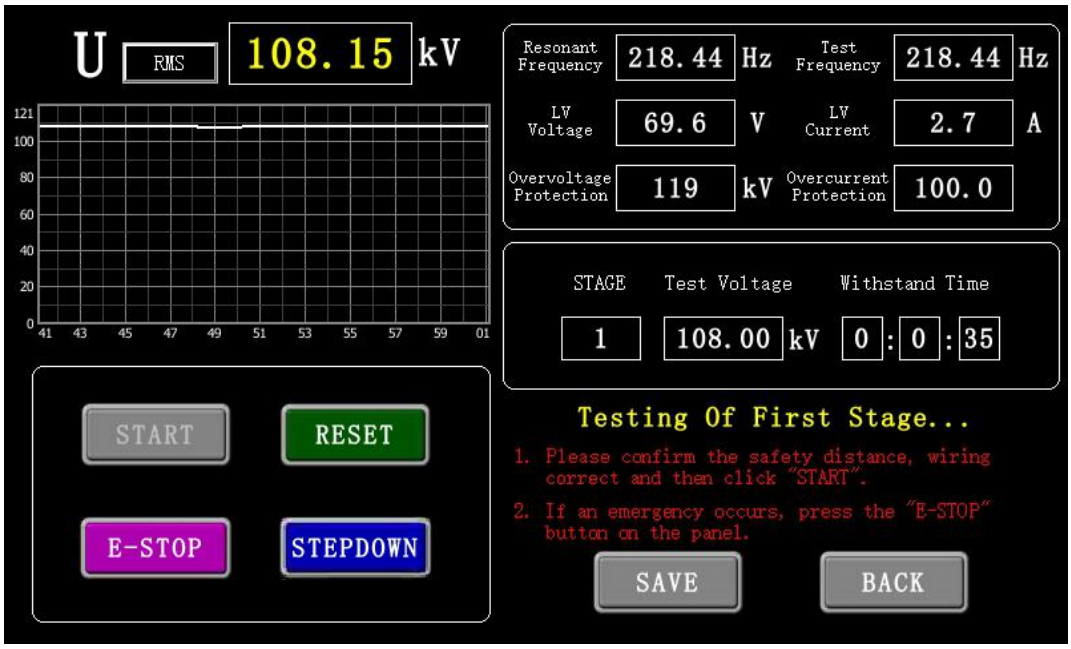


Figure 8

When the time to set the pressure time, the system automatically buck,

the lower right corner of the "buck", if any, please click "emergency shutdown"; display interface shown in Figure 9.

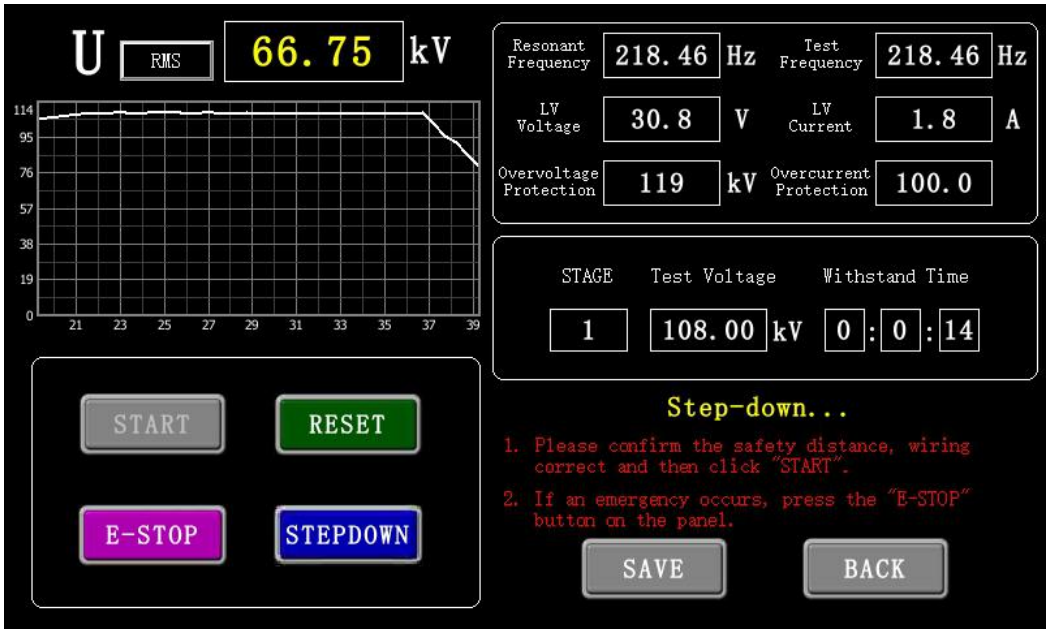


Figure9

When Urms voltage drops to 0, the lower right corner prompts "stop", the display interface shown in Figure 10.

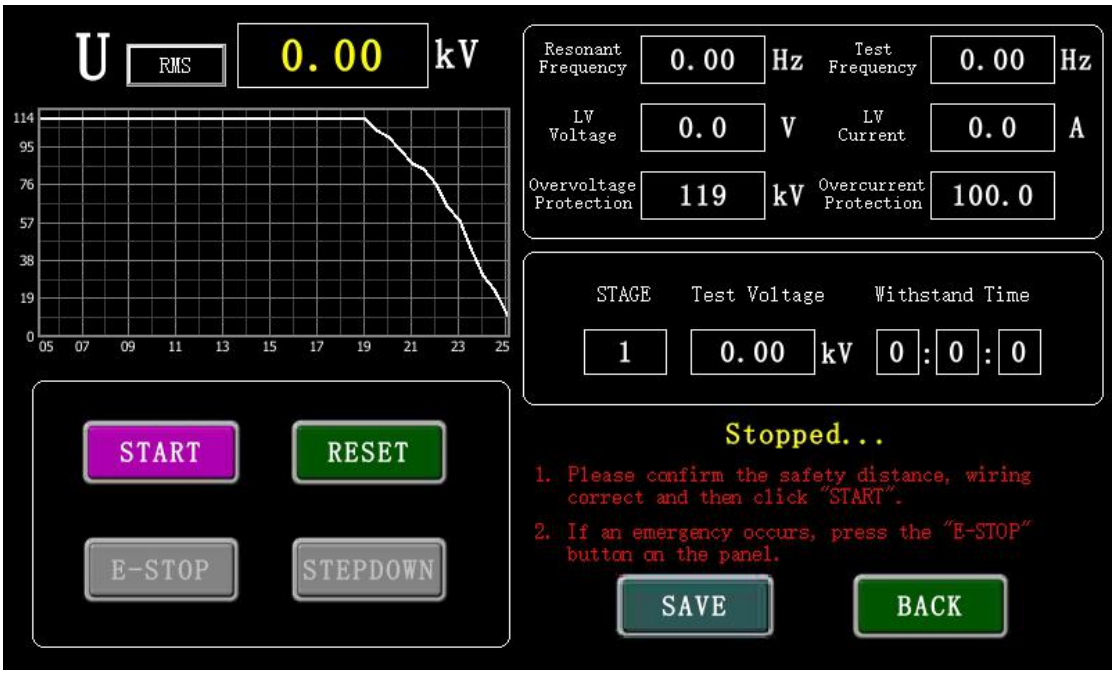


Figure10

At this point you can click the "Save" button, the display interface shown in Figure 11. You can enter the test number to be saved in the corresponding test phase. Then click "OK" to save, or click "Cancel" to discard the save.

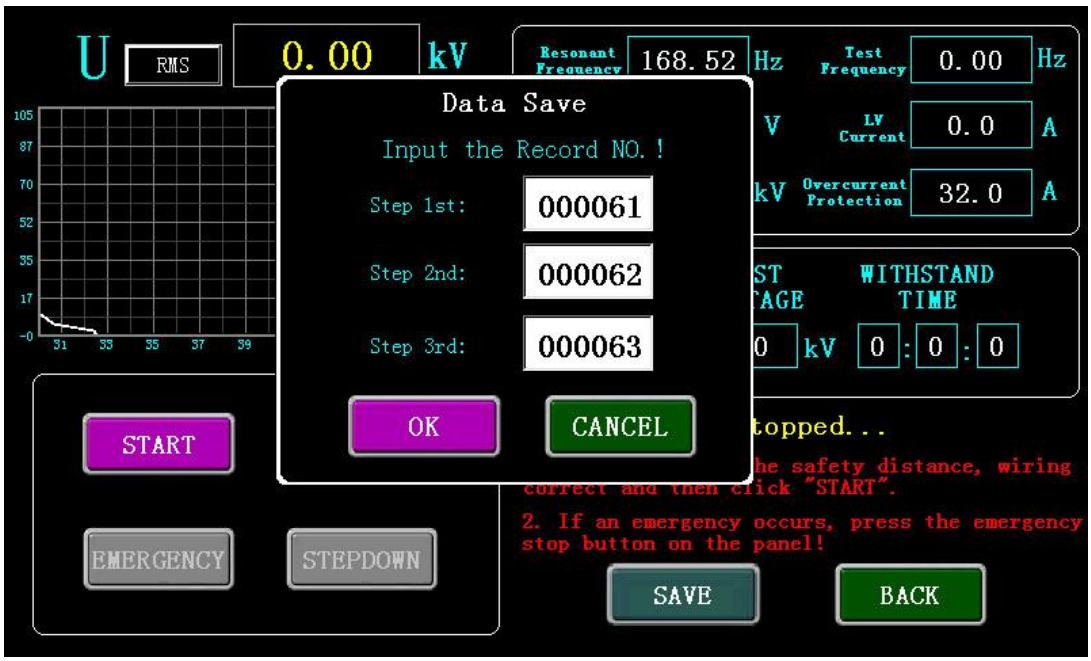


Figure 11

At this point click OK, you can save the data and enter the save data preview interface shown in Figure 12. (Print function is optional)

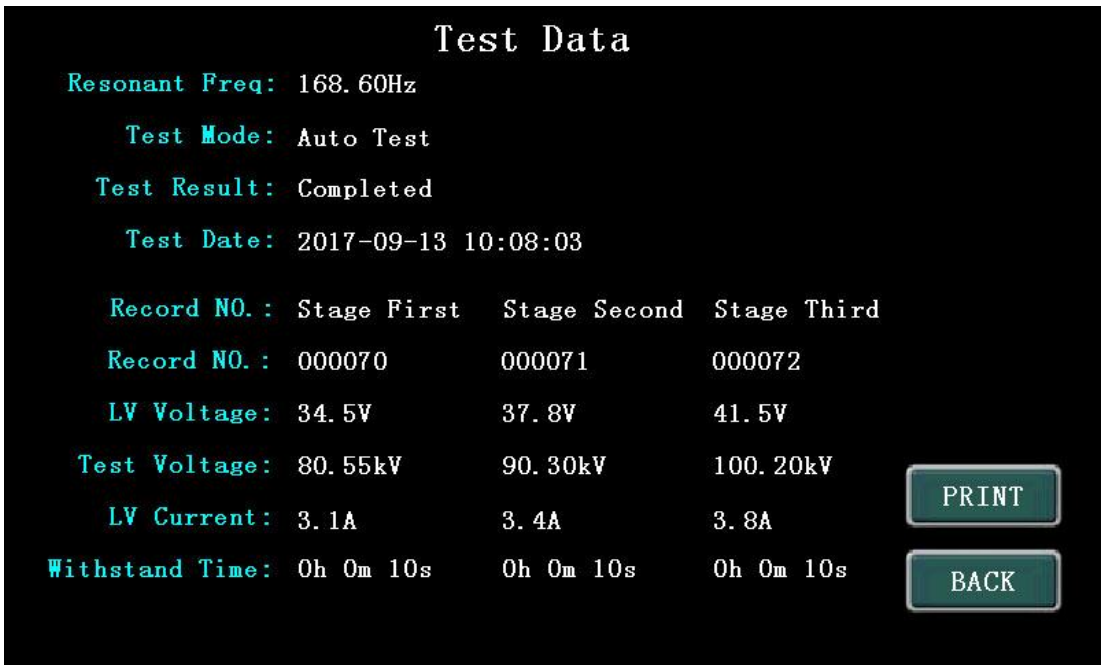


Figure 12

Manual test: When the "test parameters" set up, click on the "manual test", enter the "manual test" interface, the display interface shown in Figure 13.

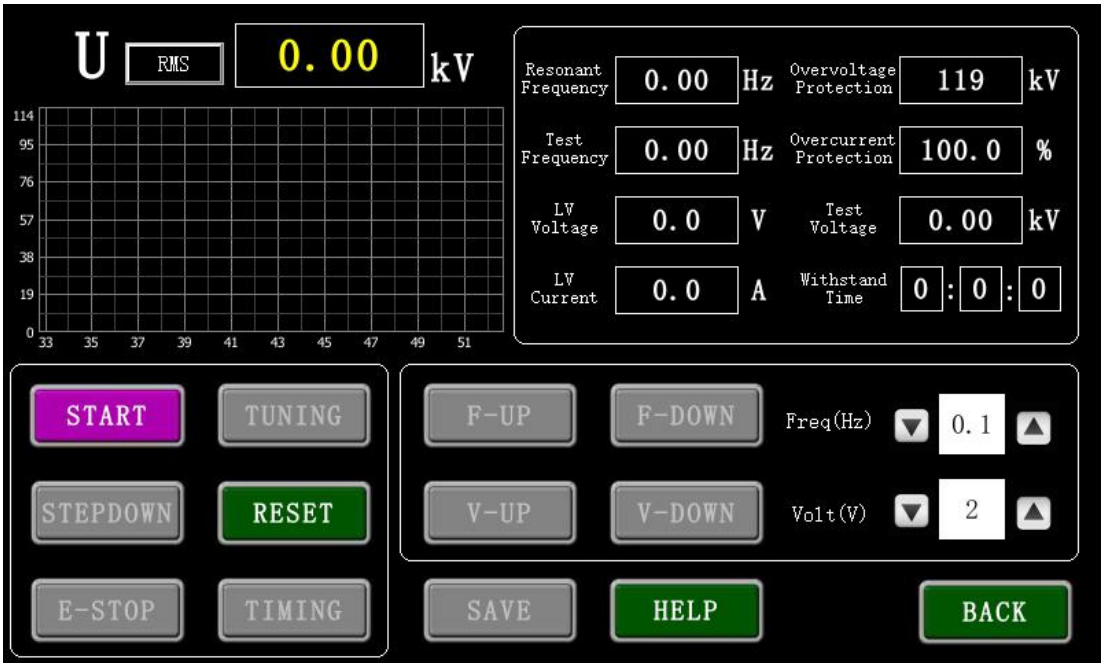


Figure 13

Click on the "start test", such as the need to automatically find the resonance point, click on the "tuning", the system automatically find the resonance point, white line represents the voltage curve, the display interface shown in Figure 14.

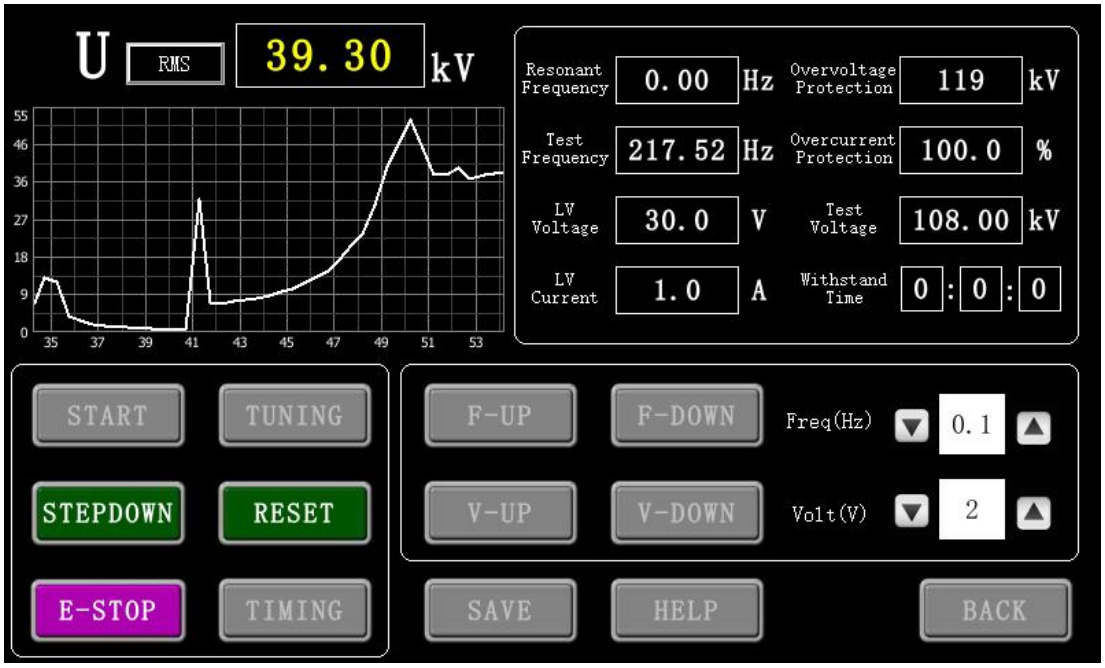


Figure 14

If you do not need to automatically find the resonance point, first click on the "rise voltage", the "U low pressure" rose to 30V, and then click on the "up

frequency" to find the resonance point, find the resonance point, click on "rise voltage", the display interface shown in Figure 15 As shown.

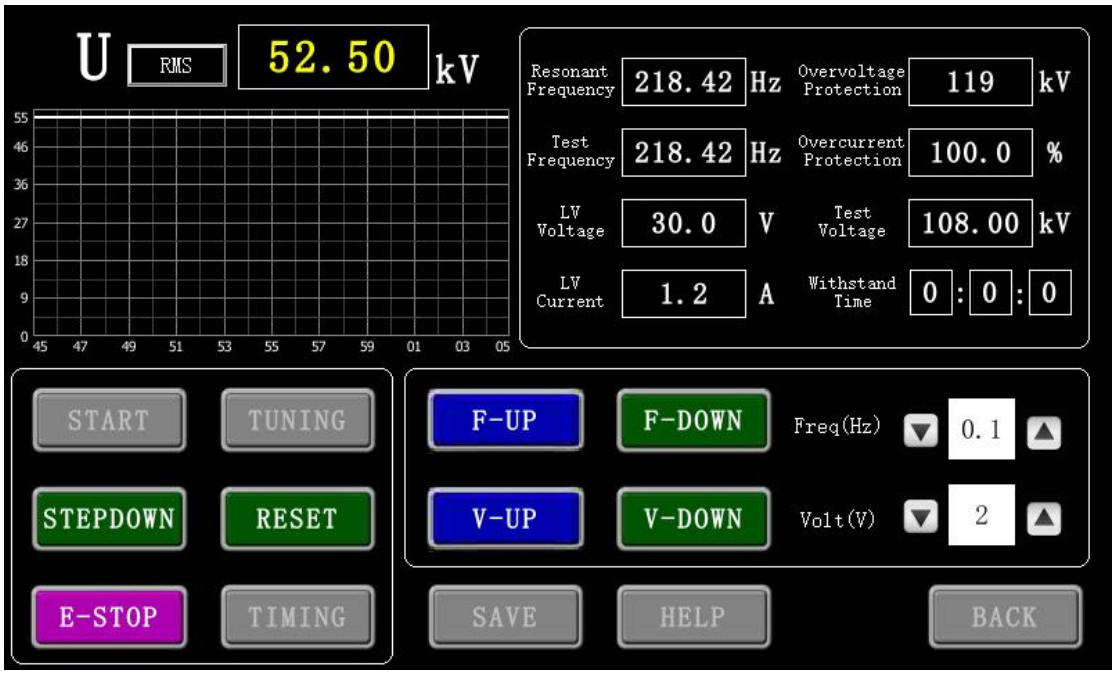


Figure 15

When U_{rms} When voltage rises to the set pressure value, click "Start Timing" and the system starts counting. The display interface is shown in Figure 16.

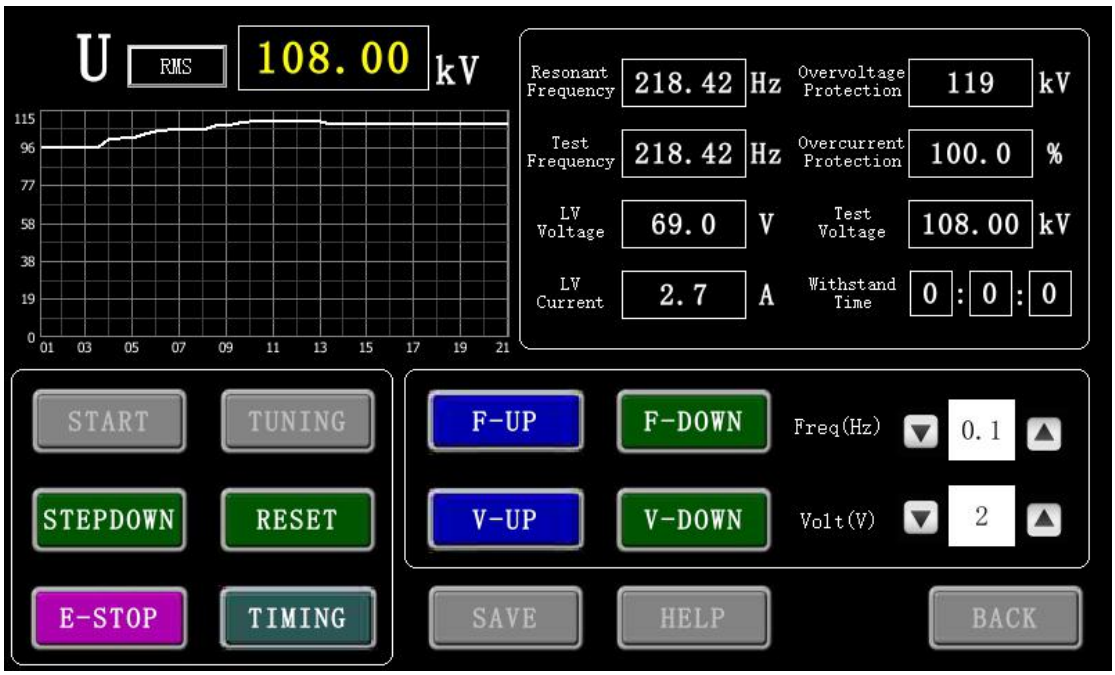


Figure16

When the "pressure time" stop after the stop, click on "buck shutdown",

the system automatically buck, the display interface shown in Figure 17.

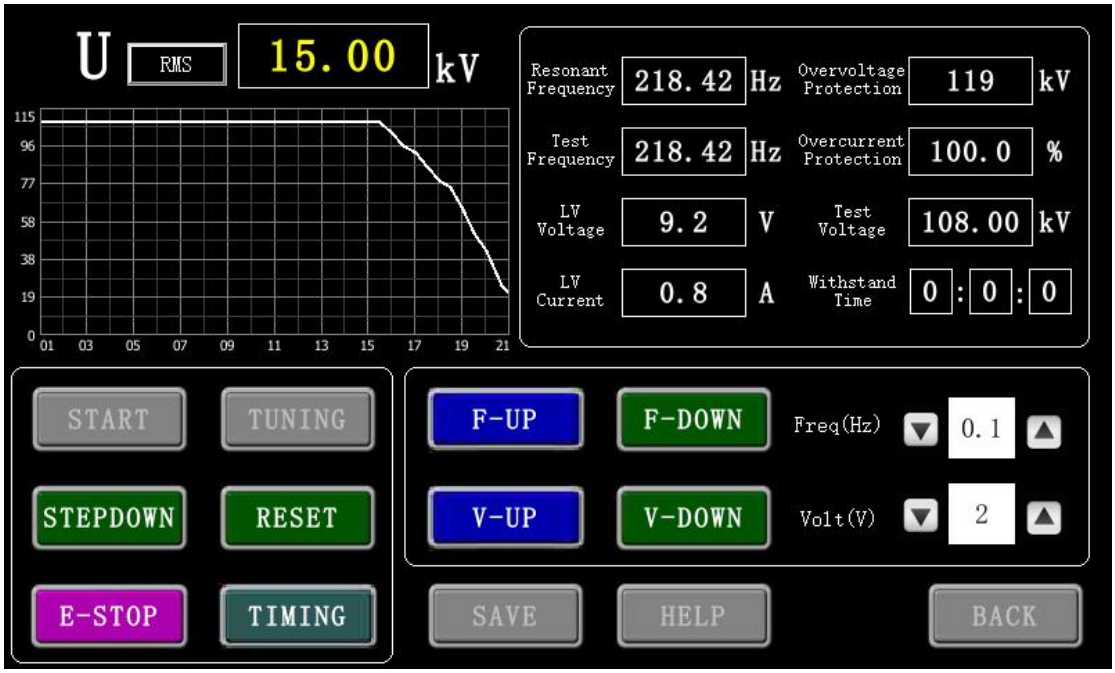


Figure 17

If you need to save the data, you can stop the time in the pressure time, and then "SHUTDOWN".When U_{rms} When the voltage is reduced to 0, the test is completed. Click "Save" to save the data as shown in Figure 18.

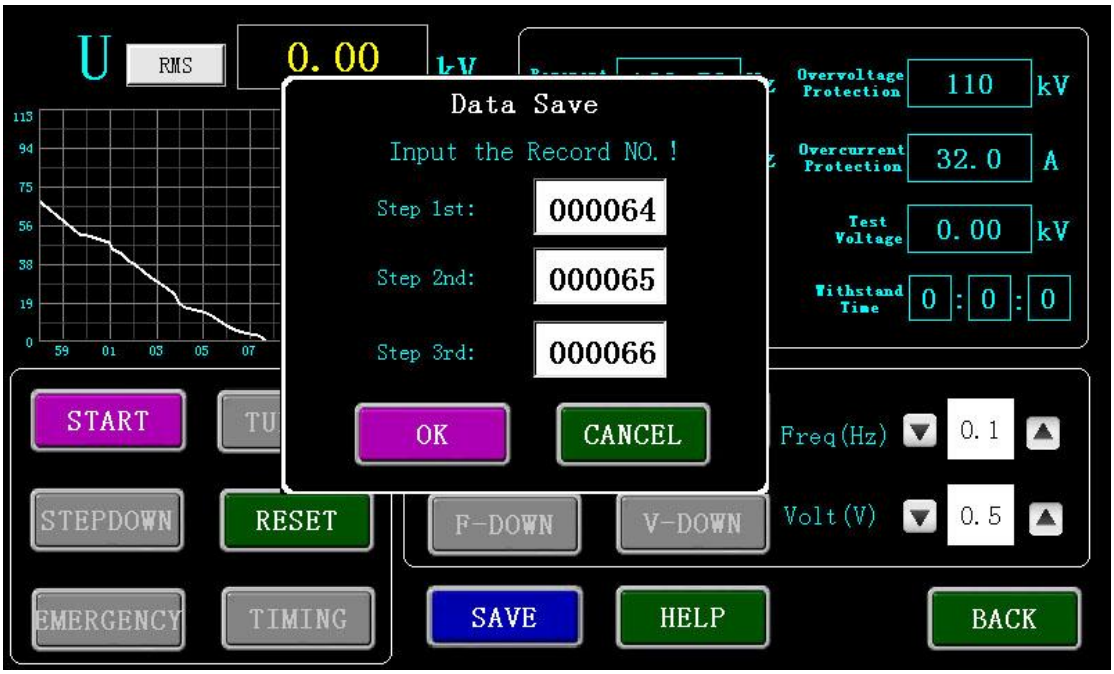


Figure 18

At this point click "OK", save the data and enter the preview interface shown in Figure 19, click "Cancel" to exit without saving. (Print function is

optional)

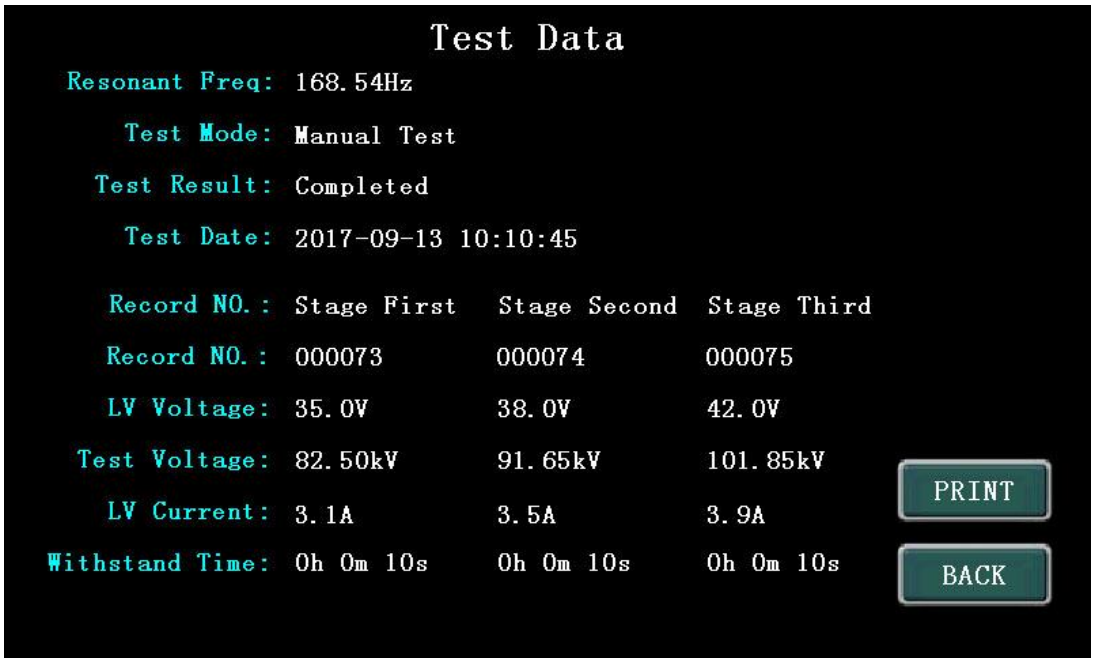


Figure 19

If you encounter an emergency during the test, click "Emergency Shutdown". In the manual boost and manual frequency modulation, according to the test situation, select the voltage adjustment step and frequency adjustment step.

● Data query: back to the main interface after pressing the "data query"; display interface shown in Figure 20.

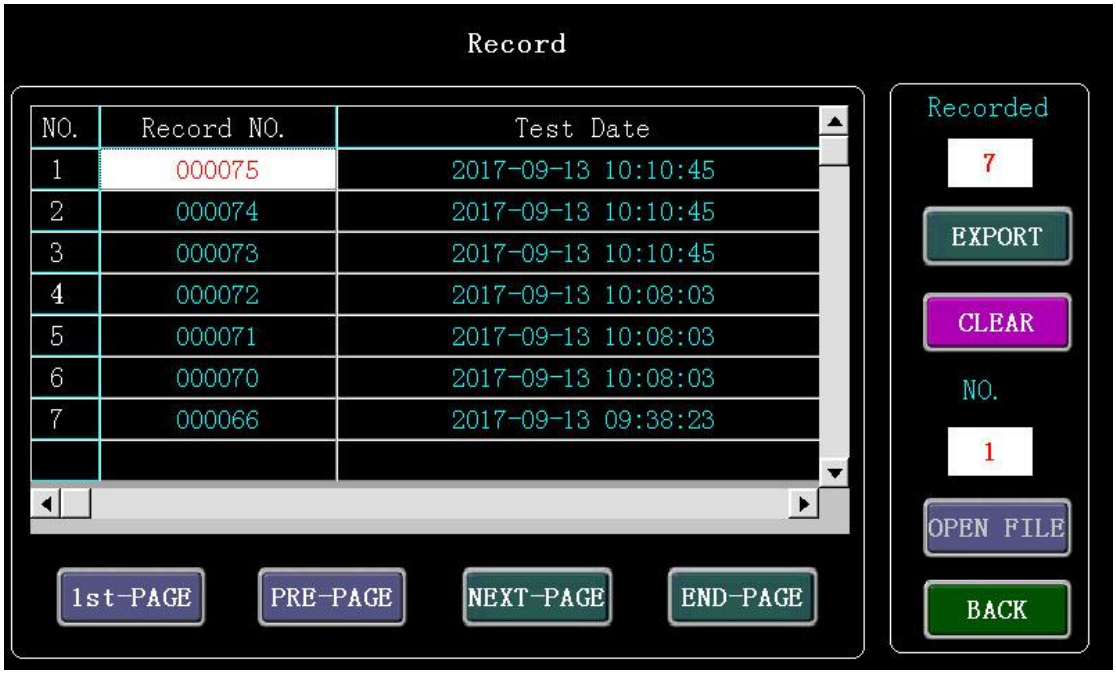


Figure 20

Select the "record number" you want to view and click the "Open File" button to open the record; as shown in Figure 21. (Print function is optional)

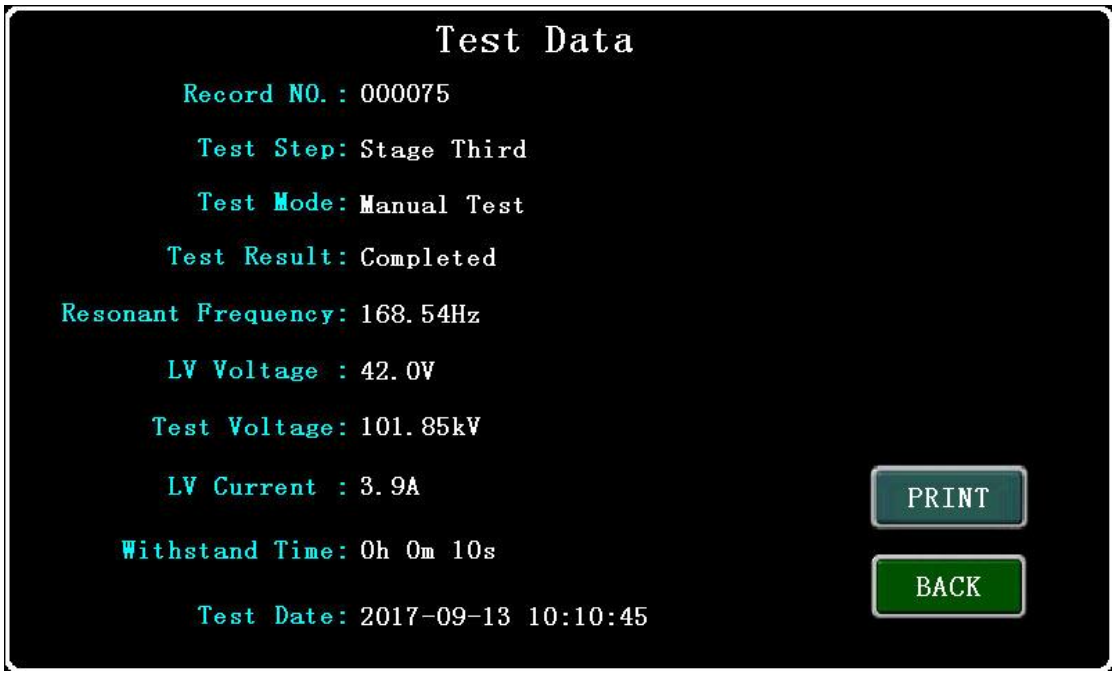


Figure 21

If you need to export all the test records, insert the U disk, wait for U disk recognition, click on the "export data" that can be entered when the page test records to the U disk. If the export is successful as shown in Figure 22.

Figure 22

● Parameter calculation: calculate the inductance, capacitance, frequency parameters, click on "parameter calculation", the display interface shown in Figure 23.

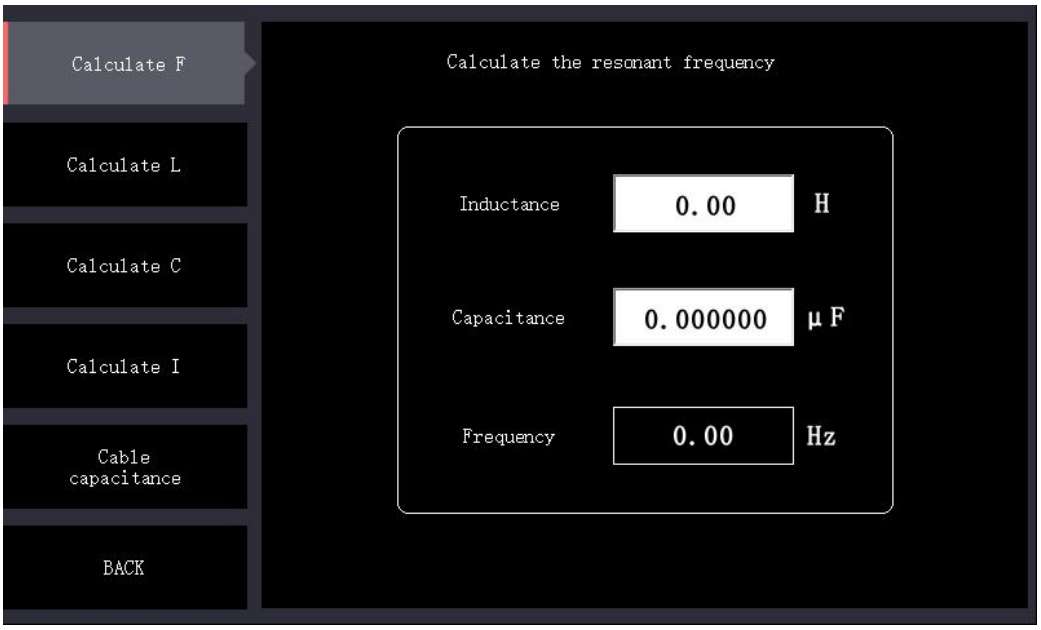


Figure23

Calculation of resonant frequency: when input inductance value, capacitance value, automatically calculate the frequency. The display interface is shown in

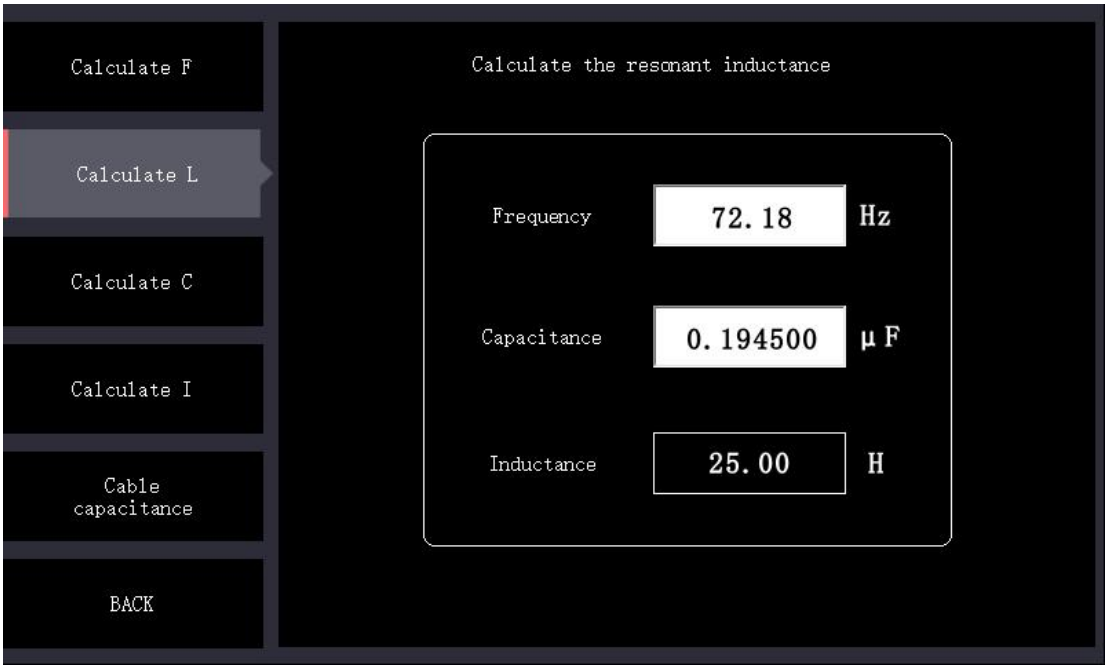


Figure 24.

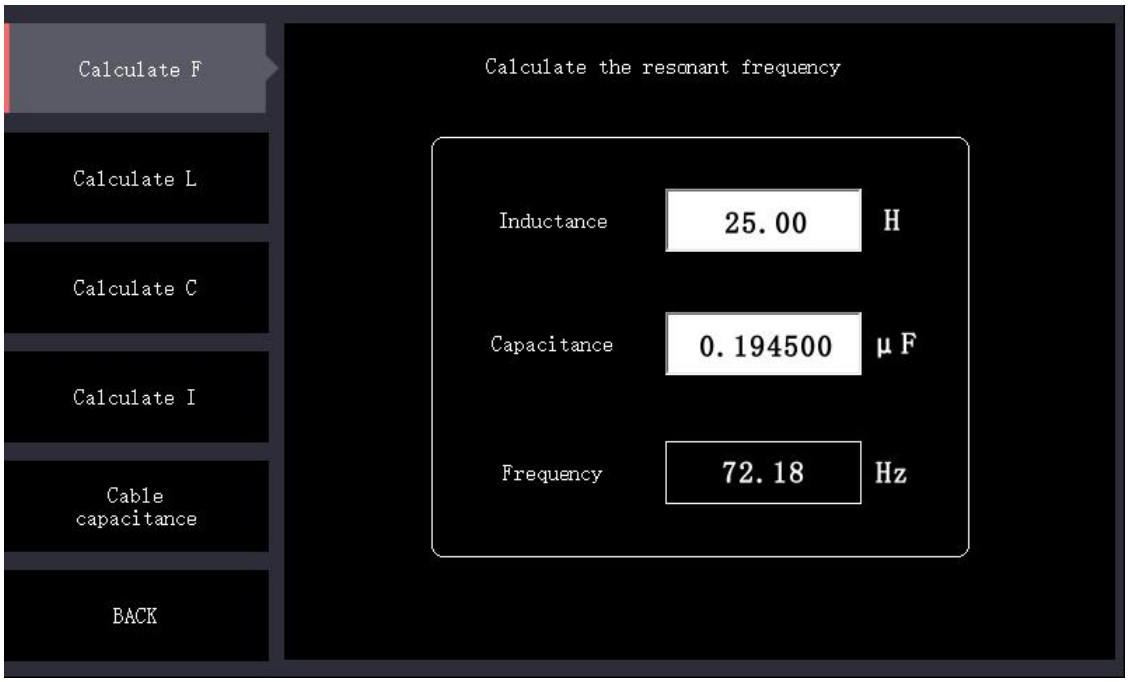


Figure24

Calculation of resonant inductance: when the input frequency value, capacitance value, automatically calculate the inductance value. See Figure 25.

Figure25

Calculation of resonant capacitance: when input frequency value, inductance value, automatically calculate the capacitance value. See Figure 26.

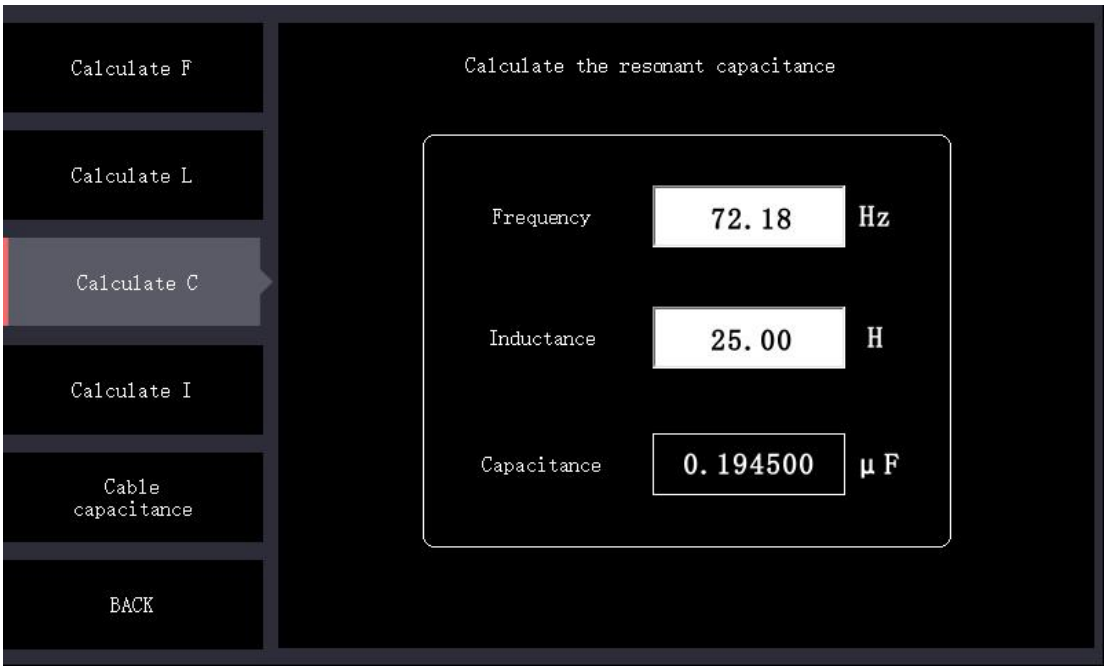


Figure26

Calculation of resonant current: when calculating the current, the previously calculated frequency and capacitance value will be saved to the current calculation interface, input the voltage value of the sample, and calculate the resonant current automatically. See Figure 27.

Figure 27

Cable capacitance query: the user can query the cable capacitance according to the voltage grade of the tested cable, the cross-sectional area of the cable single core and the cable length. The resonant current can be calculated by the cable capacitance, and the inductance value can be calculated within the

range of 30Hz~300Hz to judge the series and parallel combination mode of the reactor in the device. See Figure 28.

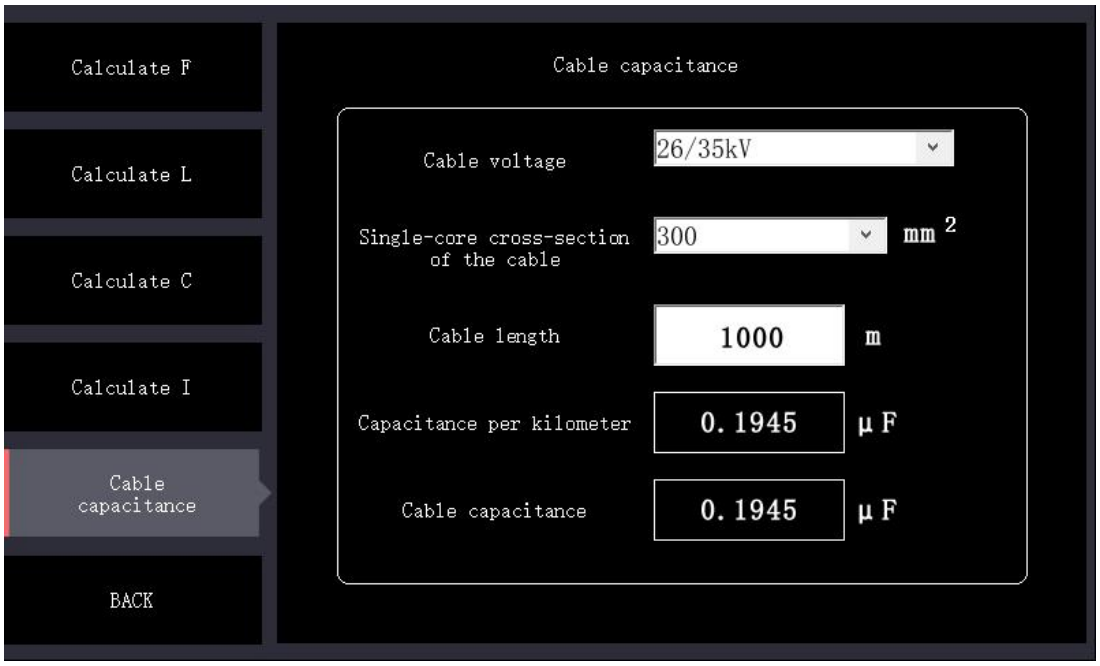


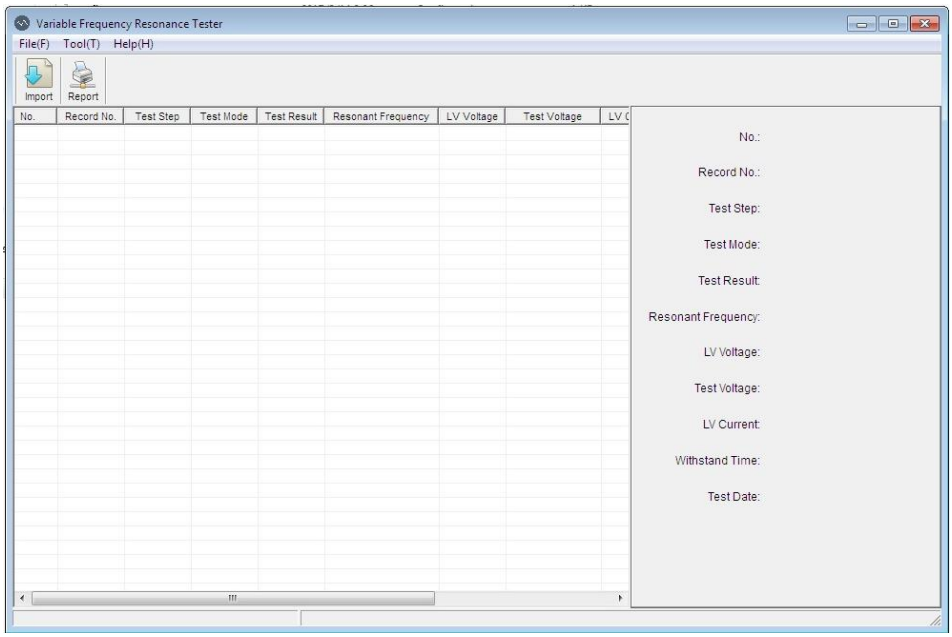
Figure 28

V. Software operation

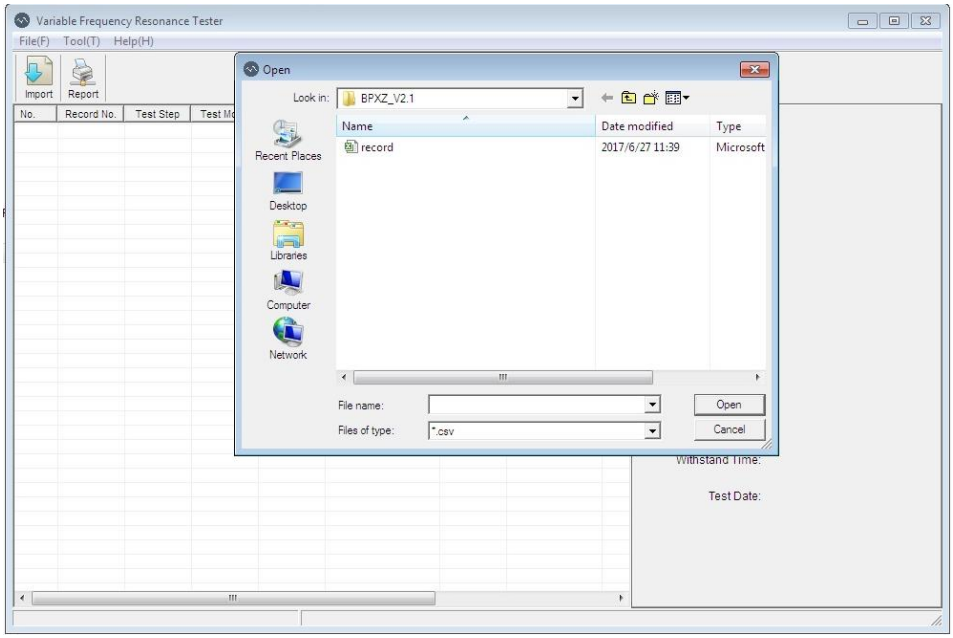
1. Use of the host computer software

Open the U disk with the "host computer software" folder, you can see the software “bpxz.exe”，Open the software。

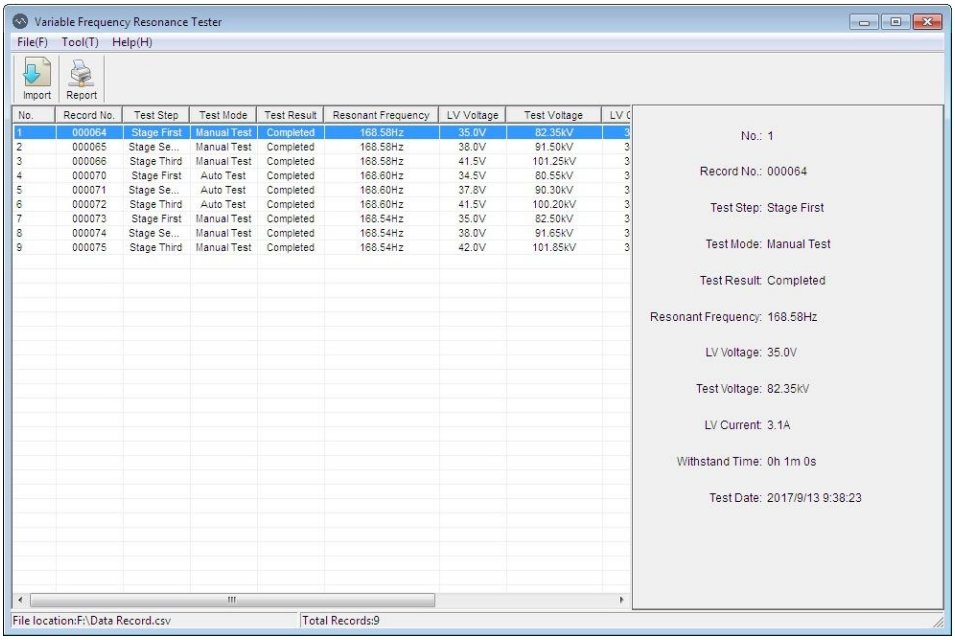
2. Supporting the host computer software operation interface as shown below.



3. Click the "Import Data" icon in the upper left corner and pop up as shown below.



3. Select the file that was dumped with the file name "Data record .csv". Click on the "open" interface as shown below, the left side of the recorded test records, the right side of the selected content of the specific content.



5. If you need to generate a test report, click on the desired entry and click the "Generate report" button at the top right. Will pop up the interface as follows.

6. This report is word format, you can fill in the blank content of the corresponding, save and print.

VI. Common troubleshooting

6.1 General precautions

1. The test equipment should be used by high-pressure test professionals, should be carefully read before using the instructions, and repeated operation training.

2. Operators should be no less than 2 people. The use of the unit should be strictly in accordance with the safety test procedures for high-pressure test.

3. In order to ensure the safety of the test is correct, in addition to the product must be familiar with the instructions, but also in strict accordance with the relevant national standards and procedures for testing operations.

4. The cable can not be connected to the wrong, otherwise it can lead to damage to the test device.

5. When the device is used, the output is high voltage or high voltage, must be reliable grounding, pay attention to safe operation.

6.2 Common causes and exclusions

1. The fan can not be started

1) Emergency stop, fault protection, detuning protection, no "Reset";

2) The internal temperature is too high, the thermal protection of power components;

Remedy: Turn off the instrument, turn the instrument on for about 30 minutes, turn on the power again, press the "Reset" button on the instrument panel, and then start the instrument.

If you still can not start the fan, please contact the manufacturers, not removable equipment!

2. Auto tuning can not be completed, can not find the resonance point

Phenomenon:

The tuning curve is a straight line, and the instrument does not have a resonant point after tuning.

The reason:

The circuit is not well connected, the test circuit wiring error, the installation of a device open circuit.

Method of exclusion:

1) check the grounding device is reliable, grounding cable is broken;

2) check the excitation transformer high and low voltage coil on and off; (low-voltage winding resistance; high-voltage winding resistance of each output on the high-pressure tail)

3) check each reactor on and off; (each winding resistance)

4) check the divider signal line on and off; (1 hole on the core, 2 holes on the shell were conductive; 1 hole on the 2 hole off)

5) check the voltage divider high and low voltage capacitor arm on and off; (high and low voltage capacity)

6) The device itself does not have a resonance point when boosting, but also need to check the compensation capacitor (optional) on and off;

If all parts are normal, still no resonance point, please contact the manufacturers, not removable equipment!

3. Can not be boosted to the test voltage

Phenomenon:

1) The tuning curve is a straight line with a lower spike;

2) low voltage when the test is high, high pressure is low, even in the absence of the test voltage, the low voltage has reached the rated voltage, the circuit automatically buck

Method of exclusion:

1) Reactor does not match the capacitance of the test piece, and does not find the resonant point accurately;

2) Test product loss is higher, the system Q value is too low;

3) Excitation transformer high voltage output voltage is low;

4) High-voltage cable is too long or not using high-pressure anti-corona tin foil;

Method of exclusion:

1) will compensate the capacitor (optional) and access the test circuit, increase the circuit capacity;

2) as much as possible will only reactor in series to improve the loop inductance;

3) to improve the output voltage of the excitation transformer;

4) drying the test sample to improve the insulation strength of the test object to reduce the active loss of the circuit;

5) generally in the device higher voltage output, the use of high-pressure anti-corona tin foil, or ordinary high-voltage output line to a shorter connection, generally not more than 5 meters.

If all processed, still can not solve the problem, please contact the manufacturers, not removable equipment!

VII. Relevant information

7.1 Power cable AC voltage withstand test

Using the frequency range of 20Hz-300Hz AC voltage on the cable circuit voltage test, test voltage and withstand time according to Table 1 requirements.

Table 1 Rubber and plastic cable line AC voltage test voltage and time

Rated voltage U_0/U(kV)	Test voltage	Time(min)
18/30 And below	$2.5U_0$(or $2U_0$)	5(or 60)
21/35-64/110	$2U_0$	60
127/220	$1.7U_0$(or $1.4U_0$)	60
190/330	$1.7U_0$(or $1.3U_0$)	60
290/550	$1.7U_0$(or $1.1U_0$)	60

Note: Table 1 from the "electrical installation installation electrical

equipment transfer test standards" GB 50150-2016 P41

In addition to the above GB, the domestic many places or enterprises have also introduced a corresponding local test standards or enterprise standard, low voltage cable test voltage of 1.6-2.0 times the phase voltage, high voltage cable test voltage is generally 1.4-1.7 times Phase voltage, depending on the local standard is slightly different. For example, Table 2 for the State Grid Corporation Enterprise standard:

Table 2 cross-linked polyethylene cable line AC voltage test voltage and time

Rated voltage U_0/U(kV)	Test Voltage		Time(min)
	New delivery line or not more than 3 years of non-new delivery line	Non-new delivery line	
18/30 and blow	2.5 U_0(2U_0)	2U_0	5(60)
21/35-64/110	2U_0	1.6U_0	60
127/220	1.7U_0	1.36U_0	
190/330			
290/550			

Note: Table 2 from the State Grid Corporation "power cable line test procedures" Q/GDW 11316-2014 P5

7.2 transformer AC voltage test

7.2.1 Transfer test standard

Table 3 Power Transformer AC Test Voltage Reference Table

System nominal voltage kV	Equipment maximum voltage kV	AC withstand voltage kV	
		Oil - immersed power transformers	Dry power transformers
<1	≤1.1	——	2
3	3.6	14	8
6	7.2	20	16
10	12	28	28
15	17.5	36	30
20	24	44	40
35	40.5	68	56
66	72.5	112	——
110	126	160	——

Table 4 Rated voltage 110 (66) kV and above the power transformer neutral point AC voltage test voltage (kV)

System nominal voltage	Equipment maximum voltage	Neutral point grounding	Factory exchange withstand voltage	AC exchange withstand voltage
66	——	——	——	——
110	126	Not directly grounded	95	76
220	252	Direct grounding	85	68
		Not directly grounded	200	160
330	363	Direct grounding	85	68
		Not directly grounded	230	184
500	550	Direct grounding	85	68
		Grounded by a small resistance	140	112
750	800	Direct grounding	150	120

Note: Table 3, Table 4 from the "electrical installation installation electrical equipment transfer test standards" GB 50150-2016 P78

7.2.2 Prevention test standards

Table 5 Power transformer AC test voltage value

Rated Voltage kV	Maximum operating voltage kV	Line end AC test voltage value kV		Neutral point AC test voltage value kV	
		Replace all windings	Part of the replacement winding or handover	Replace all windings	Part of the replacement winding or handover
<1	≤1	3	2.5	3	2.5
3	3.5	18	15	18	15
6	6.9	25	21	25	21
10	11.5	35	30	35	30
15	17.5	45	38	45	38
20	23.0	55	47	55	47
35	40.5	85	72	85	72
66	72.5	140	120	140	120
110	126.0	200	170（195）	95	80
220	252.0	360	306	85	72
		395	336	（200）	（170）
330	363.0	460	391	85	72
		510	434	230	195
500	550.0	630	536	85	72
		680	578	140	120

Note: Table 5 from the "power equipment preventive test process" DL/T 596-1996 P38

7.3 AC voltage withstand test

7.3.1 Handover test standard

Table 6 stator winding AC voltage test voltage

capacity (kW)	Rated voltage (V)	Test voltage (V)
<10000	>36	(1000+2Un)*0.8，Minimum for 1200
>=10000	<24000	(1000+2Un)*0.8
>=10000	>=24000	Consult with the manufacturer

Note: Table 6 from the "electrical installation installation electrical equipment

transfer test standards" GB 50150-2016 P10

7.3.2 Preventive test criteria

Table 7 stator winding AC voltage test

<table>
<tr>
<td rowspan="12">Stator winding AC voltage test</td>
<td rowspan="12">1)Overhaul
2)After replacing the windings</td>
<td colspan="3">1) Replace the stator windings and fix the test voltage as follows:</td>
<td rowspan="12">1) should be carried out after the shutdown is cleared before the contamination is hot. In the standby state, can be carried out in a cold state. Test conditions for hydrogen-cooled generators are described in Table 3 of this Table 1)
2) water cold motor should generally be in the case of water to test, the import unit according to manufacturers, water quality requirements with the table No. 3 description 5)
3) conditions, can be used ultra-low frequency (0.1Hz) withstand voltage, test voltage peak for the frequency test voltage peak 1.2 times
4) Test voltage for all or part of the process of replacing the stator windings Refer to the relevant data</td>
</tr>
<tr>
<td>CapacitykW or kVA</td>
<td>Rated voltage U_n V</td>
<td>Test voltage V</td>
</tr>
<tr>
<td><10000</td>
<td>>36</td>
<td>2 U_n +1000 Minimum for 1500</td>
</tr>
<tr>
<td rowspan="3">>=10000</td>
<td><6000</td>
<td>2.5U_n</td>
</tr>
<tr>
<td>6000～18000</td>
<td>2 U_n +3000</td>
</tr>
<tr>
<td>>18000</td>
<td>By special agreement</td>
</tr>
<tr>
<td colspan="3">2) before or after the overhaul of the stator winding and repair the test voltage after:</td>
</tr>
<tr>
<td colspan="2">Run for 20 years and below</td>
<td>1.5U_n</td>
</tr>
<tr>
<td colspan="2">Run for more than 20 years with overhead lines directly connected</td>
<td>1.5U_n</td>
</tr>
<tr>
<td colspan="2">Run for more than 20 years without direct connection with overhead lines</td>
<td>(1.3～1.5) U_n</td>
</tr>
</table>

Note: Table 7 from the "power equipment preventive test process" DL/T 596-1996 P10

7.4 Resonant device capacity selection

Test Current： $I=2\pi fCU\times10^{-3}$ (A)

The Choice of Frequency (Hz)

1、Generator - 50Hz, take 50Hz

2、Transformers - 45 ~ 65Hz, take 50Hz

3、GIS, switch, bus - 30 ~ 300Hz, take 45Hz

4、Power cable - 30 ~ 300Hz, take 35Hz

The Choice of Voltage(kV)

In accordance with the requirements of the program, determine the maximum test voltage.

Capacitance selection (μF)

According to the maximum capacity of the test object to determine

Maximum capacity of the device:$P=UI\times1.25$ (kVA)

Appendix. Technical solution

Frequency conversion series resonant and voltage resistant test device ZCVF-5000kVA/1000kV

Meet the scopes of the test

1、AC withstand voltage test of 4km of 35kV/300mm2 cable, capacitance ≤0.76uF, test frequency 30-300Hz, test voltage 52kV, test time 60min.

2、AC withstand voltage test of 4km of 110kV/630mm2 cable, capacitance ≤0.752uF, test frequency 30-300Hz, test voltage 128kV, test time 60min.

3、AC withstand voltage test for 1km of 220kV/1200mm2 cable, capacitance ≤0.179uF, test frequency 30-300Hz, test voltage 216kV, test time 60min.

4、AC withstand voltage test of GIS substation equipment of 500kV and below, test frequency is 45-300Hz, electric capacity of 0.01uF, test voltage does not exceed 740kV, and test time is 1min.

Main components of the device

NO.	equipment name	Specifications	Unit	Quantity
1	Frequency Power	ZCVF-200kVA/400V	piece	1
2	Excitation transformer	LCB(J)-200kVA/5kV,10KV,35KV/0.4KV	piece	1
3	High voltage reactor	CHX(f)-1250kVA/250kV/130H/5A	piece	4
4	Capacitive divider	TRF-1000kV-500pF	set	1

Main functions and characteristics

ZCVF series frequency conversion series resonant withstand voltage test device adopts the way of adjusting power frequency to make the reactor and test capacitor achieve resonance to obtain high voltage current on the test product .For it requires small power supply, light weight and small volume ,the device has been widely praised and applied at home and abroad,which is the new method of current high voltage test and trend.

Main functions and its technical characteristics：

1、The device has protection functions such as over-voltage, over-current, zero-position start, system detuning (flash), etc. The over-voltage and over-current protection value can be set according to the user's needs .The flash protection action of the test product can be recorded when the flash occurs that can provide experimental analysis.

2、The whole device is very light in weight, easy to use on site.

3、The device has three working modes: automatic mode, manual mode, automatic tuning manual boost mode; It is convenient for users to choose flexibly according to the site conditions to improve the test speed.

4、It can store and print data in different places. The number of data stored is digital, which is convenient for users to identify and search.

5、When the device sweeps automatically ,the frequency starting point can be set arbitrarily within the specified range .The directions of the sweep can be selected up and down. At the same time the LCD screen displays the scanning curve, which is convenient for the user to understand

intuitively if the resonant point is found .

6、The DSP platform technology can increase or decrease functions and upgrade according to user needs . The man-machine exchange interface is more humanized.

7、The required power capacity is greatly reduced. Series resonant power supply is the use of resonant reactor and the subject capacitance resonance to produce high voltage and high current, in the whole system, the power supply only needs to provide the active power consumption of the system, so the power supply required by the test is only 1/Q of the test capacity.

8、The weight and volume of the equipment are greatly reduced. In the series resonance device, the heavy high-power voltage regulating device and the ordinary high-power power frequency test transformer are eliminated, and the resonant magnetic power supply only needs 1 / Q of the test capacity, so that the system weight and volume are greatly reduced, generally 1 / 10-1 / 30 of the ordinary test device.

9、It can improve effectively the output voltage waveform . Resonant power supply is a resonant filter circuit, which can improve the waveform distortion of the output voltage to obtain a very good sinusoidal waveform .It can prevent effectively the harmonic peak misbreakdown of the test product.

10、Prevent large short circuit current burn fault point. In the series

resonance state, when the insulation weakness of the test product is broken, the circuit immediately deharmonic, the circuit current quickly drops to 1 / Q of the normal test current, and the parallel resonance or test transformer, the breakdown current immediately rises tens of dozens of times. Compared with the two, the short circuit current and the breakdown current differ by hundreds of times. Series resonance can effectively find the insulation weakness, and there is no large short circuit current burn fault point trouble.

11、There will not be any recovery over-voltage. The test breakdown occurs, due to loss of resonance conditions , high voltage also immediately disappear , arc immediately put out, and restore the voltage establishment process is very long . it is easy to disconnect the power supply before reaching flash voltage again, .The voltage of the recovery process is a kind of intermittent oscillation process of energy accumulation, the process is long, and there will not be any recovery over-voltage.

Main technical parameters

1. rated capacity ：5000kVA
2. rated voltage ：250kV；500kV；1000kV
3. rated current ：20A；10A；5A
4. Measurement accuracy: the effective value of the system is 1.5
5. working frequency ：30-300Hz

6. Device output waveform: sine wave
7. Quality factors: the unit itself Q 30 (f=45Hz)
8. Waveform distortion rate: the output voltage waveform distortion rate is 1%
9. Input power supply: 3-phase 380V voltage at 50Hz
10. Working time: 60min under rated load; 1.1 times 1 minute
11. Temperature rise: 65K after 60min of continuous operation under rated load
12. Protection function: over-voltage, over-current, zero-bit start, system detuning(flash) and other protection functions
13. ambient temperature：－20℃-55℃
14. relative humidity ：≤90%RH
15. The altitude:≤3000 Meters

Device capacity verification

The capacity of the device is 5000kVA, divided into four reactors, one reactor is 1250kVA/250kV/5A/130H .

Validation：

1 、 AC withstand voltage test of 35kV / 300mm2 cable 4km,

capacity :0.76uF, test frequency: 30-300Hz, test voltage: 52kV, test time: 60mins.

Use four reactors are used in parallel, L=130/4= 32.5H ：

test frequency ：$f=1/2\pi\sqrt{LC}=1/(2\times3.14\times\sqrt{32.5\times0.76\times10^{-6}})=32.02Hz$

test current ：$I=2\pi fCU_{试}=2\pi\times32.02\times0.76\times10^{-6}\times52\times10^{3}=7.95A$

2 、 AC withstand voltage test of 110kV/630mm^2 cable 4km, capacity ≤0.752uF, test frequency: 30-300Hz, test voltage: 128kV, test time: 60mins.

Use four reactors are used in parallel ，L=130/4=32.5H ：

test frequency：$f=1/2\pi\sqrt{LC}=1/(2\times3.14\times\sqrt{32.5\times0.752\times10^{-6}})=32.19Hz$

test current：$I=2\pi fCU_{试}=2\pi\times32.19\times0.752\times10^{-6}\times128\times10^{3}=19.47A$

3、AC withstand voltage test of 220kV / 1200mm2 cable 1km, capacity ≤0.179uF, test frequency: 30-300Hz, test voltage: 216kV, test time: 60mins.

Use two reactor in series (mutual coefficient 1.15) two groups in parallel，L=130×2×1.15/2=149.5H ：

test

frequency ：$f=1/2\pi\sqrt{LC}=1/(2\times3.14\times\sqrt{149.5\times0.179\times10^{-6}})=30.77Hz$

test current：$I=2\pi fCU_{试}=2\pi\times30.77\times0.179\times10^{-6}\times216\times10^{3}=7.48A$

4、AC withstand voltage test of GIS substation equipment of 500kV and below, test frequency: 45-300Hz ,capacity: ≤0.01uF0.01uF, test voltage : ≤ 740kV, and test time :1min

Use four reactors in series (mutual inductance coefficient 1.25)，

L=130×4×1.25=650H ：

test frequency ： $f=1/2\pi\sqrt{LC}=1/(2\times3.14\times\sqrt{650\times0.01\times10^{-6}})=62.43Hz$

test current ： $I=2\pi fCU_{试}=2\pi\times62.43\times0.01\times10^{-6}\times740\times10^{3}=2.9A$

Meet the experimental requirements .

Test equipment compound mode

COMPOUND MODE / SUBJECTS	REACTOR SELECTION（1000kVA/200kV 四节）	EXCITATION TRANSFORMER OUTPUT END SELECTION	TEST VOLTAGE(kV)
35kV/300mm^2 cable 4km	Use the reactor with four sections in parallel	5kV	≤52kV
110kV/630mm^2 cable 4km	Use the reactor with four sections in parallel	5kV	≤128kV
220kV/1200mm^2 cable 1km	Use two sections in series and two groups in parallel	10kV	≤216kV
500kV and below voltage level GIS and other substation equipment	Use the reactor with four sections in series	35kV	≤740kV

System configuration parameters

(一) Variable frequency power supply ZCVF-200kVA/400V 1 piece

1) Rated output capacity：200kva

2) Working power supply：380±10%V（three phase），power frequency

3) Output voltage：0–400V

4) Rated input current：500A

5) Rated output current：500A

6) Voltage resolution：0.01kV

7) Voltage measurement accuracy：1.5%

8) Frequency regulation range：30–300Hz

9) Frequency regulation resolution：≤0.1Hz

10) Frequency stability ：0.1%

11) performance time：Continuous 60mins at rated capacity

12) temperature rise：Continuous 60mins at rated capacity

Maximum temperature of the components≤65K

13) Noise level：≤50dB

(二）Excitation transformer LCB(J)-200kVA/5kV,10KV,35KV/0.4 KV 1 piece

1) rated capacity ：200kVA

2) input voltage ：0-400V

3) output voltage ：5/10/35kV

4) structure：oil type

(三)High voltage reactor CHX(f)-1250kVA/250kV/130H/5A 4 sections

1) rated capacity：1250kVA;

2) Rate voltage：250kV

3) Rate current：5A

4) inductance value：130H/simple

5) quality factor：Q≥30 (f=45Hz)

6) Structure ：oil type

(四)Capacitive divider:TRF-1000kV-500pF 1SET

1) Rate voltage：1000kV

2) High voltage capacity：500pF

3) Dielectric loss：tgσ≤0.5%

4) Divider ratio：9000：1

5)Measurement accuracy: effective value level 1.5

Reference Standard

DL/T 596-1996	《Procedure Test Procedures for Power Equipment》
GB50150-2016	《Electrical equipment installation engineering electrical equipment handover test standard》
GB10229-88	《Reactor》
GB1094	《Power transformer》
GB1094.1-GB1094.6-96	《Enclosure rating》
GB2900	《Electrotechnical terminology》
GB/T16927.1~2-1997	《High voltage test technology》
DL/T474.4-2006	《Implementation guide for on-site insulation test - AC withstand voltage test》
DL/T1015	《Guidelines for the use of on-site DC and AC withstand voltage test voltage measuring systems》
GB/T311.1-1997	《Insulation and cooperation of high voltage power transmission and transformation equipment》
GB191-2000	《Packaging storage and transportation icon》
JB/T9641-1999	《Test transformer》
IEC358(1990)	《Coupling capacitor and capacitor divider》
GB4793-1984	《Electronic measuring instrument safety requirements》
GB/T3859.2-1993	《Semiconductor converter application guidelines》
GB/T2423.8-1995	《Basic environmental test procedures for electric and electronic products》
DL/T849.6-2004	《Test equipment for power equipment - General technical conditions - Part 6: High-voltage resonance test apparatus》