3 Phases Relay&Protection Tester

ATO-HMJBC802

PART 1

Instruction on   Relay Protection

Chapter 1   Hardware Structure

Section 1   Hardware Structure

◆ High-Performance Industrial Control Computer

High performance Industrial control computer is adopted as the controlling computer, through which you can run the windows operating system directly. 6.4"TFT true color LCD display, tracking ball and optimized keyboard are allocated on the faceplate of this tester, which can be used without the external mouse and keyboard. USB interface, 10-100M net mouth and serial communication interface are located on the back plate of this tester, through which you can access data, communicate data and upgrade software conveniently.

The whole process and the result of the test will all be showed on the LCD. The English operational interface of the complete set is very friendly and convenient. The tracking ball and keyboard on the faceplate will implement the operation. The operation is simple and convenient, and is easy to be mastered. Operator only needs a little knowledge of computer.

Keyboard and mouse interface are also allocated on the faceplate. If you would like to use the external mouse and keyboard, through pluging them with corresponding interfaces, you can operate this tester just like operate a desk-top computer.

◆ Digital Signal Processor Microcomputer

High-speed digital controlling processor is adopted as the output core of the tester. 32 bit double precision arithmetic is employed in the software, through which arbitrary high-accuracy waveforms of each phase can be produced. Since integrative structure is adopted,the structure of the tester is layed compactly.The distance of data transmission is short with tight structure, which overcome the problem of fewer points of waveform output due to long data communicational line and narrow frequency band when using the test controller controlled directly by PC.

◆ D/A Conversion and Low-Pass Filtering

High precision D/A converter is employed for ensuring the precision and linearity of current and voltage in the whole range.

Due to high density of fitting ponit, fidelity of waveform is high and harmonic component is small, which don't have a strict requirement on the low-pass filter. Consequently, it has good

characteristics of transient, phase frequency and amplitude frequency, which is easy to perform accurate phase-shifting and harmonic superposition and ensures very high precision even when the frequency is high.

◆ Voltage and Current Amplifier

For phase current and voltage, we persist in adopting high performance linear amplifier output mode in order to make the current and voltage source to directly output all kinds of waveforms from the DC waveform to the waveforms including all kinds of frequency components, such as square wave, combined waveform overlapped by each order harmonic, fault transient waveform, etc. In addition, the output waveform is clear and smooth without high-frequency radiated interference with neighboring equipments. It can simulate well all kinds of current and voltage characteristics under the circumstance of short circuit fault.

For power amplifier circuit, we adopt import power parts with high-power and hi-fi module style as power output, combining with heat dissipation structure layed elaborately and reasonably, it has enough large power redundancy and thermal capacity. The power amplifier circuit has overheat, overflow, overvoltage and short circuit protections. When overflow occurs in the current circuit and overload or short circuit occurs in the voltage circuit, it will limit the output power automatically, switch off the whole power amplifier circuit and give alarm signal.In order to prevent the overheat of the power amplifier for long time operating under large current, a software time terminating system under large current is set in this tester. It can work for a long period when outputting is 10A or below. When the current is over 10A, the tester will start up the software time termination order. When time is up, the software will forbid power output automatically and give alarm signal. The higher output current is, the shorter the limiting time will be.

◆ Digital Input and output

This tester has 10 channels digital input and 8 channels output.

The switching input circuit is compatible for both the empty contacts and 0-250V electric potential contacts in the input and output circuit. When the electric potential contacts are selected, 0-6V belongs to closed switch and 11-250V belongs to open switch. The switching capacity can test the action time and the action time interval of every phase switch's contact conveniently.

The part of the digital input is isolated from the resources of the mainframe and the amplifier. The end of the digital input is hung, so the common end of the digital input is separated from the

Common End UN, IN of current and voltage parts.

Switching potential input has directivity, you should connect the common end with the positive terminal of potential, and connecting the input end with negative terminal of potential for ensuring the potential of common end is higher than the one of input end. In practice, you should connect the input common end with ＋KM, and connecting the negative terminal of contact with input end.

The output part is the idle contact output of relay. Output capacity is DC：220V／0.2A，AC：220V／0.5A. Output of switching capacity is independent of voltage, current, input and all other parts. Action process of each digital output part is different in each testing module. For details, please refer to the operation instruction on software module.

The connection diagram of two kinds of familiar digital output is as follows:

Mode of potential contact

Mode of free contact
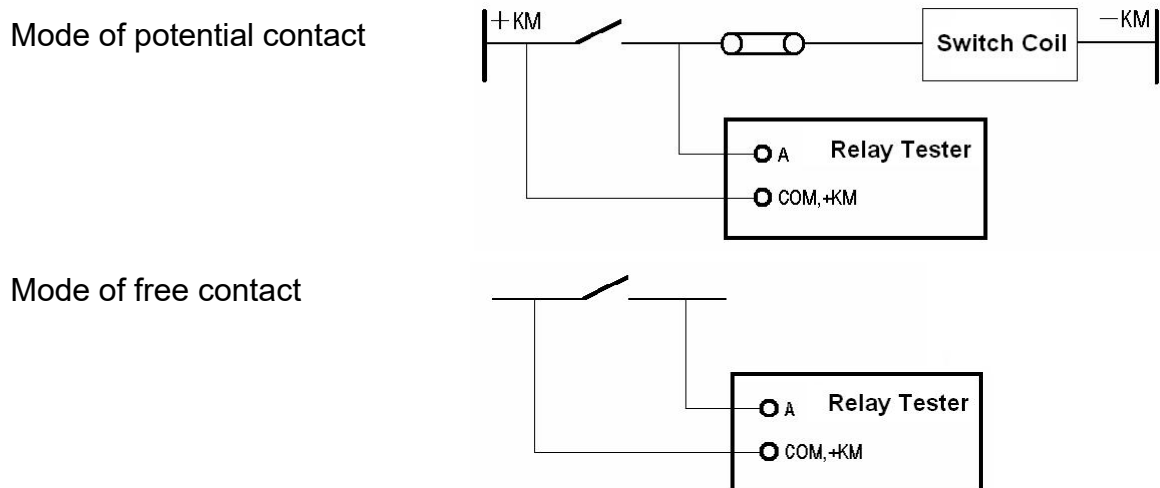
◆ Auxiliary DC Power Supply Output for Special Use

A circuit of special adjustable DC power supply output is allocated on the rear panel, which has 110V and 220V two shifts that can be used as test standby power supply on the spot. Rated current of this power supply is 1.5A, which can be used as DC power supply of protective tester or switch loop supply. If overload or short circuit occurs, corresponding protector tube will be burned out （2A／250V）, you will only need to change this protector tube at that time.

Section 2   Instruction to Front and Rear Panel

◆ **Instruction to Front panel of Device Relay Protection**
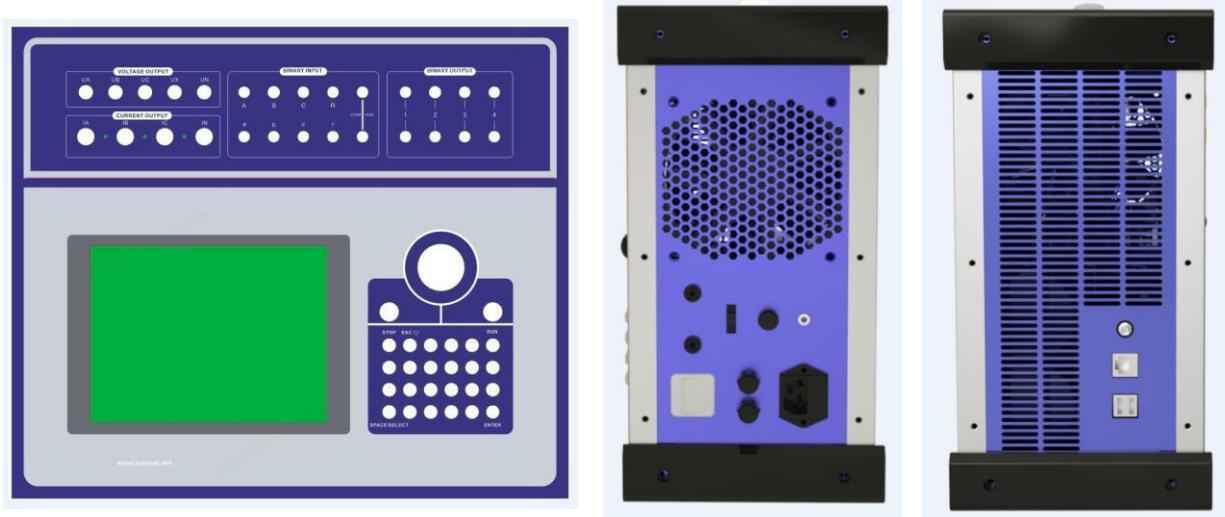
1   Voltage output terminal.

2   Current output terminal: the red signal lamp on the right of this terminal shows whether waveform distortion or load open circuit exists when the current is output

3   Digital input terminal: there are 10 input. Please connect the positive end of inpur to the common end of the tester when inputting potential

5   Power Supply Switch

6   USB communication port: it can be connected with PC outside to doing test

7   USB interface: it can be connected with external equipment like mouse, keyboard, flash disk, printer, etc

8   Ground socket

9   TFT LCD display, defaulted resolution: 800×600

12   Track ball mouseLeft and right key of Track ball mouse

13   Left and right key of Track ball mouse

14   Faceplate optimized keyboard

15   Auxiliary DC power supply output: it can be switched to 110V or 220V, and can be used as on-the-spot testing power supply

16   AC 220V Operational Power Supply socket

17   8 Free relay contact output of Digital Output. Capacity: DC：220V / 0.2A；AC：220V / 0.5A

18   Wind outlet of cool fan

Section 3   Specification

AC current output

Phase current output (effective value)   0~40A,   Output Precision   0.2 degree

3 phase parallel current output (effective value)   0~120A

A Long-time Phase current   10A

Maximum output power of Phase current   450VA

Maximum output power of 3 parallel current   900VA

Maximum Permitted work time of 3 parallel current   10S

Frequency range (fundamental)   0~1000Hz

Harmonic time   0~20

DC current output

Current output $0\sim\pm10A$ / phase, $0\sim\pm30A$ / 3 parallel

Output Precision   0.5 degree

AC voltage output

Phase voltage output (effective value)   0~120V   Output Precision   0.2 degree

Line voltage output (effective value)   0~240V

Phase voltage / Line phase output power   80VA / 100VA

Frequency range (fundamental)   0~1000Hz

Harmonic time   0~20

DC voltage output

Phase voltage output range $0\sim\pm160V$ Output Precision   0.5 degree

Line voltage output range $0\sim\pm320V$

Phase voltage / Line phase output power   70VA / 140VA

10 path digital input and 8 path digital output

Time measuring range   0.1ms $\sim$ 9999s , accuracy of measurement $<$0.1ms

Volume & weight $400\times360\times160mm^3$, 15kg

Chapter 2
Please Read the Following Instruction before Operation

Section 1   General Rules for Use

◆ Industrial control computer and Windows operating system have been set in this tester. Please do not switch on or off the power supply of host too frequently.

◆ USB interfaces are allocated on the faceplate or backplate, which allow hot-swap USB equipment (such as flash disk, etc), but the drawing or inserting must be done after the data transmission has been completed.

◆ In order to ensure that the Windows operating system built in the industrial control computer can run steadily, please do not delete or alter the documents in hardware and the logo on the desktop at will. Please do not operate, alter, increase, delete or use the built-in Windows system to avoid any damage on the operating system. When using the USB disk to copy data, please do ensure that the flash disk is clear without virus, and also please do not use the flash disk to set other software programs in this system.

◆ When connecting outside keyboard or mouse, please do not connect wrong terminal; otherwise the Windows operating system won't be started up normally.

◆ Please do not shut off power supply directly during outputting so as to avoid the wrong protection action due to incorrect output.

◆ When switch quantity is compatible with both idle contact and the potential （0～DC250V） and uses charged contact, the high terminal (anode) of contact potential should be connected with the common end +KM.

◆ Do not insert objects (e.g.screwdrivers,etc.) into the ventilation slots or any input/output sockets. When taking the tester into operation,make sure that the air slots,the power switch and the power supply plug at the test set remain unobstructed.The instrument should be laid uprightly, or unfold the bracket for slightly tilted placement

◆ Do not lead external AC/DC power into the voltage and current output sockets of tester.

◆ If the disturbance is stronger on the spot or high safety is required, before doing the test,

please ground the outlet of power source or the protective earth of the tester.

◆ If the interface data is wrong or you can not input correctly when using this tester, you can settle the problem as follows: delete the 'para' file under the 'E\Relaystar\, and then restart the running program, all data on the interface will be resumed to the default.

Section 2   Procedures of turning on/off Tester

◆ Procedures for Turning On

- Plug the power line of tester in AC220V outlet. If using external computer, please connect well the serial communication line with computer's serial interface and the communication interface on the bottom of the tester.

Checking the wires and ensuring the correct connection, switch on power supply of tester (if you would like to use external keyboard or mouse, please connect them with the tester before switching on the power supply, in this case, the tracking ball is invalid) and the power source of the external computer.A moment later, it will show you the 'Relaystar' software interface. On the main interface, click all kinds of functions testing module logo by using the left key of external connected mouse or tracking ball mouse for doing all tests.

◆ Procedures for Turning Off

Please do not close down the power switch on the faceplate directly. You should terminate the Windows operating system firstly, and then press the power supply button when indication for safe turning off appears on the screen.

- Move cursor on the main interface through mouse or press the 'QUIT' key on the faceplate to quit all functional testing units. After backing to the main interface, press the 'QUIT' key again, a dialog window for confirmation will be ejected on the screen. After your confirmation, you can turn off the power supply switch on the front panel when 'You can turn off the power supply now' appears on the screen, so the machine can be closed safely.

- You can also turn off the device by choosing the 'start' menu of the operation system.

Section 3   Operating mode of Keyboard and Mouse

◆Optimized Keyboard of Faceplate and Its Function

The figure below shows the optimized keyboard of faceplate of Relaystar- /1000/1600 Tester:

ESC/STOP ：ESC key: stop test or cancel choice in the midway.

/QUIT ：Exit/close: close windows, exit tests or close Windows Operating System.

NUM ：Backup functional key, reserved for future use.

Tab ：Tab key: switch the state of 'key trigger' in the module of 'State Series'.

RUN ：Start the test

1 2 3 4 5 6 7 8 9 0 . – ：Input numbers

**←┤** ：Backspace key: for deleting a number or a character left of the cursor position.

⬜ ：Space bar

▲ ▼ ◄ ► ：Move the cursor, down, left or right or increase or decrease data.

ENTER ：Enter key for confirmation

◆ Operating method of Tracking Ball Mouse

The operating mode of tracking ball mouse is the same as the mouse of desktop computer. It can move the cursor up, down, left or right in Windows interface through moving the tracking ball by hand. There are two keys respectively located below the tracking ball, which function as left key and right key of the mouse. Please see the figure below:
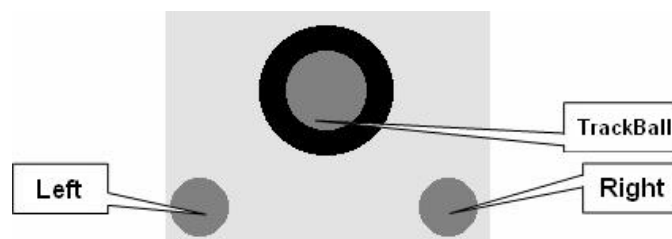
PART　2

Instruction on Software Operation of

Relay Protection Calibrator

# Chapter 3 Brief Instruction on Software Operating Method

Relaystar software is a new generational testing software developed by Wuhan human Company. Its characteristics are，more friendly and beautiful interface, more complete and powerful functions, and it also preserves its unique characteristic of simple and concise interface, easy operation and easy to learn. According to different functions of each testing module, we separate the testing modules to five groups, general testing, common protection, circuit protection, components protection and comprehensive function. Each group includes some sub-menus, such as the 'common testing' includes 'AC Test', 'DC Test', 'Harmonic Superposition', 'State Series I' and 'State Series II', and it can be extended at will. On the right of this window, it displays rolling introduction about the company.
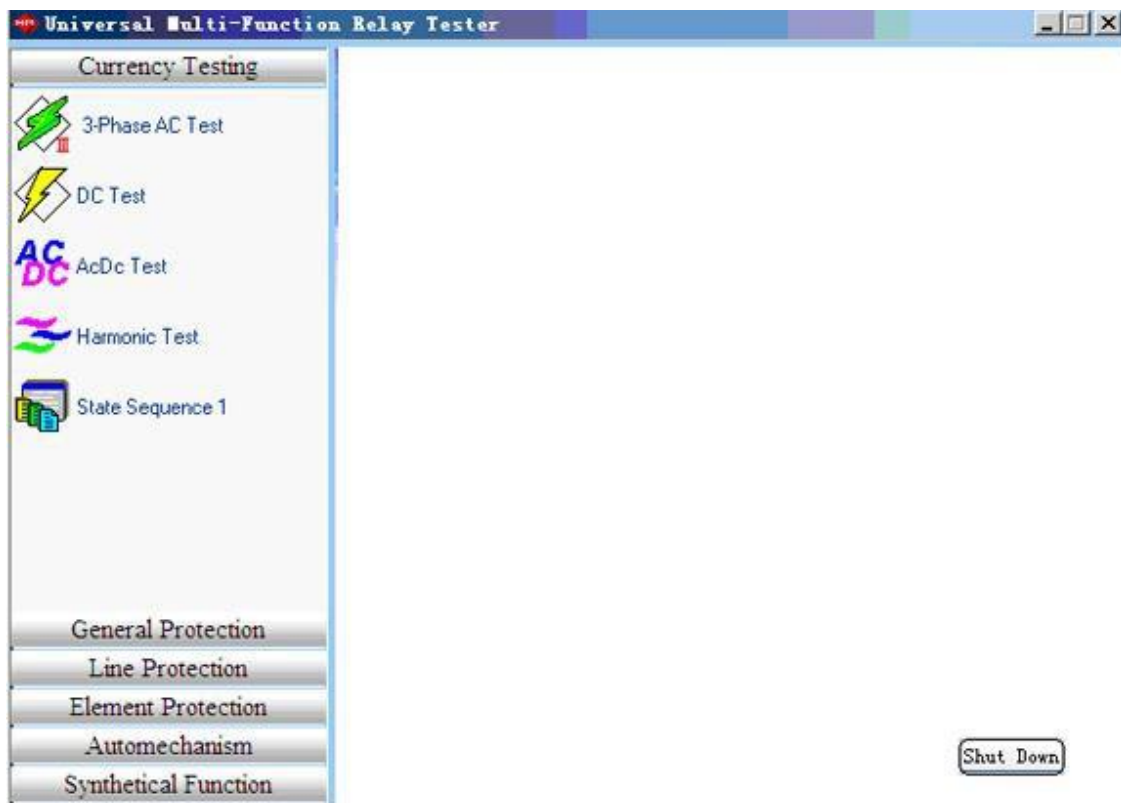
Section 1 IntroductiononCommonFunctionsinMenuBar

Name or symbols of menu items in every testing module are the same, and its definition and function are almost identiacal. We take the 'AC Test module as example for introduction, which can be applied for all functional modules.

- **Opening file**：The shortcut key is Ctrl+O, which is used for calling out testing parameters saved in appointed file and showing the parameters on software interface. If clicking this function,the testing parameters of current module will be saved as the following default path :E:\ Relaystar\Para\name of current module\.
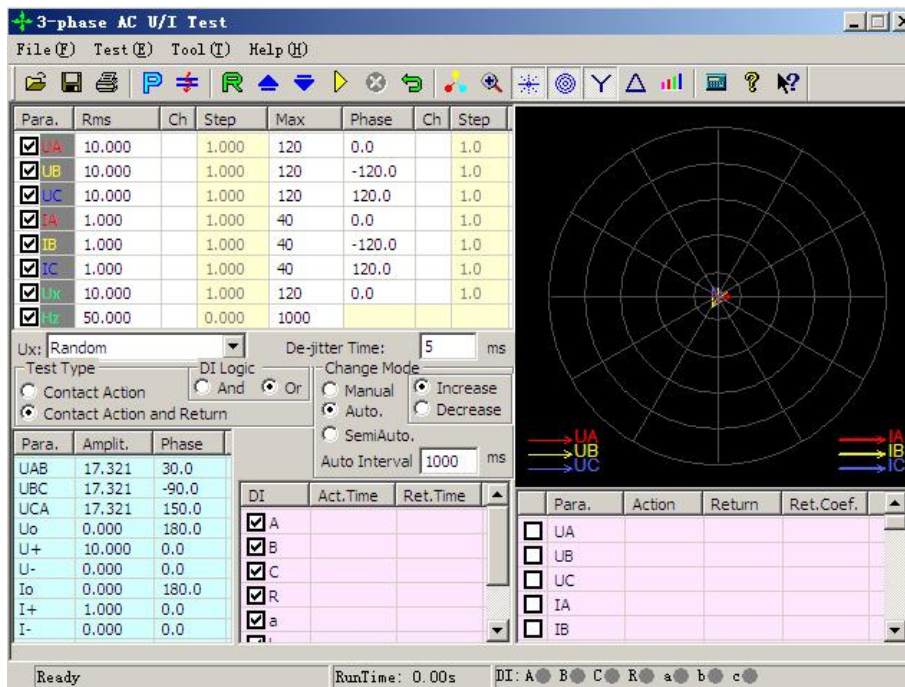
- **Saving parameters**：The shortcut key is Ctrl+S, which is used for saving the testing parameters on software interface and call out them again by using 'Opening parameter' later. Data will be saved in the default file of the current module.

- **ReportingTest**： Shortcut key is Ctrl+R, which is used for calling out the test report saved in appointed file. The contents of test report will be displayed in the test report window and revising or printing the test report can be completed in this window. After every test, a dialog box will be ejected by the system to save the test report. The report will be saved as the following defaulted path: E:\ Relaystar\Test Report\name of current module\

● **Exit**： Shortcut key is Ctrl+X，which is used for exiting current testing module。

● **Start Test**： It has identical function as the <u>run</u> key，which is used for starting the test.

● **Stop Test**： It has identical function as the <u>ESC</u> key, which is used for ending the test normally or compelled terminating program running .

● **Short Circuit Calculation**： After clicking it, a 'short circuit calculation' dialog box will be opened, which is used for short circuit calculation and automatically fill the interface with the calculated results when fault occurs just like the right chart shows. Note that zero sequence compensating factor must be set correctly when the fault type is grounding fault.

Section 2   Introduction on Common Button in the Tool Bar

Botton for opening test parameters (the function is the same as above-mentioned one)

Button for saving test parameters （the function is the same as above-mentioned one）

Button for returning data (for returning parameters to the initial value before the test, which is very convenient for many times repeatable tests)

Button for printing test report （the function is the same as the above-mentioned one）

Button for starting the test （the function is the same as the above-mentioned one）

Button for stopping the test （the function is the same as the above-mentioned one）

Short Circuit Calculation Button （the function is the same as the above-mentioned one）

Button for starting power displaying interface In the module of 'AC Test', you can open the power displaying interface during the test and compare the actual output power of tester with the power measured by the measurer on the spot.

Synchrometer In the module of ' synchronization test', you can start the synchrometer during the test to observe the test visually.

Variable Step Increase Button When the 'manual operation' is selected, press this button to increase manually one step size of variable value. It do the same function as the " ↑ " button on keyboard of tester. This button is noneffective during automatic testing and it will become gray automatically.

Variable Step Degression Button When the 'manual operation' is selected, push this button to reduce manually one step size of variable value. Its function is the same as the " ↓ " button on keyboard of tester. This button is noneffective during automatic testing and it will become gray automatically.。

Vector Diagram Some testing modules can't contain voltage-current vector diagram due to layiout problem. You can open it through this button.

Magnifier for magnifying or reducing the current-voltage vector diagram on every module's interface.

Help Button for checking the version information of the current testing module.and others

Balanced output button for outputting symmetrical current and voltage, which means you only need to change the value of any phase, then other phases will output

amplitude and phase automatically according to symmetrical three-phase AC quantity. If one phase is changeable, other phases will be variables correspondingly.

Recover Ex-factory Parameter Setting Click this button for recovering all testing parameters on the interface to the state of ex-factory default setting. Its function is equal to delete the 'para' file in the'Relaystar' folder.

Switch to sequence component output It is a latest developed function. You can switch to a special sequence component testing interface by clicking this button.For utilizeing this function, the following conditions must be required: 1.There is this icon In the tool bar of current running 'AC Test' interface ; 2. There is the document of 'thres-phase AC test—output component in sequence' in the folder of 'Relaystar)'

Attention：

During the operation, if interface data is wrong or you can not input correctly, you can settle these problems as follows: delete the file of 'para' under 'E: \ Relaystar \ in Windows system, and then restart the operating program, all data on the interface will be recovered to the default.

Chapter 4　　AC Test

The 'AC Test' module is a universal and comprehensive testing module. It has an independent testing unit with 4-phase voltage and 3-phase current output, also independent testing units with six phase voltage and six phase current output and an testing unit according to sequence component output, which can be switched between each other through 3P, 6U, 6I, 12P and five buttons of sequence component. Making use of these modules, we can carry out AC testing under all conditions in power system (note: 6 phase voltage, 6 phase current, 12 phase voltage-current function are only intended for Model 1000/1600). Their common features are as following: through setting corresponding voltage or current as variables, giving the variable certain changeable step size and selecting suitable testing mode ('manual operation', 'semi-automation' and 'full-automation' three modes are available) to test action value, return value, action time and return time of all kinds of voltage and current protection conveniently, and calculating return factor automatically. Since the 'four phase voltage and three-phase current' unit is used often and the operating method of other units is basically the same as it, so we only take the 'four phase voltage and three-phase current' as the example to introduce in detail.

- Flexibly controlling output four phase voltage, three-phase current six phase voltage, six phase current, outputing full twelve phase at the same time.

- Having the function of outputting according to phrase sequence component.Through setting the value of phrase sequence component directly, the module combines each phase voltage and current output automatically.

- For each phrase voltage and current output, both amplitude and phase can be set arbitrarily. The amplitude can be set the upper limit.

- Every component's amplitude value, phase and frequency are variable, and the variable step size can all be set at will.

- Ux can be set to be many kinds of output modes combination and also can be set arbitrary value

- Full-automation, self-automation and manually operating are available, which can be switched between each other in the process of output.

- Amplitude, phase, step size and numbers of variable can be revised directly in the status of output.

- Power value can be displayed directly for verifying power measurer.

- Action value, return value, action time and return time can be measured.
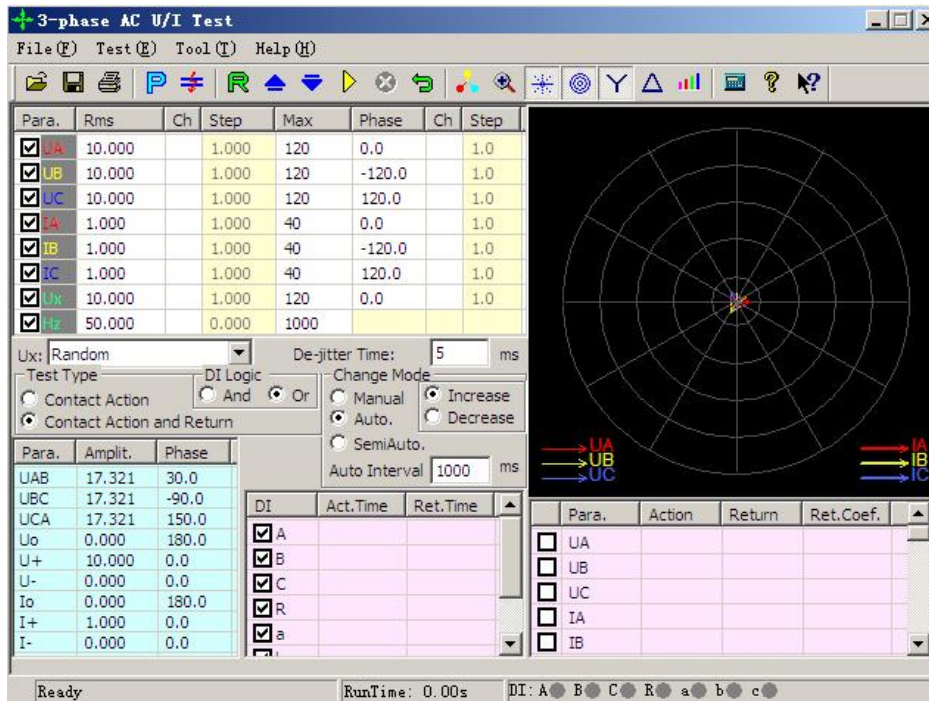
Section 1 Interface Instruction

■ Set AC Component

After entering the effective value of voltage and current, click the 'confirmation (enter)' key or move the cursor to other place, the data entered will automatically be saved to three places of decimals. The default unit of voltage is V, and the default unit of current is A. When setting the phase, you can enter any angle in the range of -180~360°. If the angle overflow the above range, the system will switch it automatically into this range. For example, if entering '-181°', it will be altered to be '179°' automatically. In the vector diagram window, you can observe the real-time diagram of each AC vector.

The single phase largest output of AC voltage is 120V. If you need to output higher voltage, you can connect any two phases voltage in series. Their amplitudes may not be the same, but the phases should be reversed .For example: set Ua to output 120V, 0°, and set Ub to output 120V ,180°, then the effective output value of Uab will be 240V.

The single phase largest output of AC current can reach 40A. If larger current output is required, you can adopt parallel connection and the phase of each phase should be the same when operating in parallel. When selecting heavy current output, thicker and shorter lead wire is prefered, in addition, make sure that output time is as shorter as possible.

The 'variable' column alongside of the effective value set for AC component is used for

choosing whether the output component is alterable. If you click the 'variable' column at the back of certain phase's effective value or phase for '√', it means that the output phase is alterable. Meanwhile, the 'Step Size' column will be changed from gray to highlight, which indicates the 'Step Size' setting permissible . The smallest value of variable step size of amplitude is 0.001, and the smallest value of variable step size of angle is 0.1.

The column of 'upper limit' is used for setting the largest output effective value of each phase. When doing the test,once the output of certain phase can't be estimated and will result in damage to the relay, you can set an 'upper limit value' for this phase,therefore ,the output of this phase will be controlled within the limit value, which ensure the safe operation of relay.

■ Ux

Ux is a special phase, it can set many kinds of output situations：

- When setting it to be $+3U_O$、$-3U_O$、$+\sqrt{3}\times 3U_O$、$-\sqrt{3}\times 3U_O$, combining UA and UB with UC output currently to obtain $3U_O$ component ,and then multiply their coefficient respectively to obtain the U_X output value.The value always varies along with the change of UA, UB and UC.

- If Ux is set to equal the value of certain phase such as UA, the output of U_x is the same as the one of corresponding phase.

- If selecting the 'Any Mode', the output of Ux is the same as other three-phase voltage in the range of output and also can vary its amplitude and angle according to certain step size.

■ Parameters Display

The line voltage, zero sequence, positive sequence and negative sequence components will be shown on the left side of the interface. Through this window, you can monitor the variable situation of 'sequence component' and 'line voltage'. The values of this part are calculated completely according to each phase's component value given above and can't be obtained by setup. Through this window, the operator can observe each sequence component and values of line voltage when protection is performed, which is convenient for recording the operation data of protection according to different demands. For example, when doing low-voltage latching overcurrent test, if the line voltage is given for protection setting value, you can not only see the value of phase voltage when protection acts visually, but also can read directly the value of phase voltage from this window without calculating by operator themselves.

■ Power Measurer Display Button

Display Power				
☑ Primary Power and Current	Voltage Ratio	110 KV /	100 V	
☑ Power Unit as MW	Current Ratio	500 A /	5 A	

Parameter	Phase A	Phase B	Phase C	Summation
Voltage Amplitude(KV)	11.000	11.000	11.000	
Voltage Phase(°)	0.0	-120.0	120.0	
Current Amplitude(A)	100.000	100.000	100.000	
Current Phase(°)	0.0	-120.0	120.0	
Power Factor	1.000	1.000	1.000	
Active Power(MW)	1.100	1.100	1.100	3.300
Reactive Power(MV...	0.000	0.000	0.000	0.000
Apparent Power(MVA)	1.100	1.100	1.100	3.300

When clicking this button, a 'Power Display' box will be ejected just as the right figure shows.

In this displaying box, all kinds of amplitude, phase, power and other data of secondary side will be displayed default. If the data of primary side needs to be displayed, for example, when verifying on-the-spot meter, you only need to select the 'primary side power and current' and input corresponding TV and TA ratio. Click the 'Power unit is megastage' for conversion the power unit from 'KW、Kvar' to 'MW、Mvar' automatically.

■ 'Contact Action' and 'Action and Return'

- When selecting the 'Contact Action' in the column of testaim, the tester will stop the test automatically when it receives signal of protective action, and will record the data of relay action at that time.

- When selecting the 'Action and Return' in the column of test aim, the tester can test the data of relay action and return, and it can also calculate the return coefficient automatically.

■ Modes of Manual Operation, Semi-automatic and Full-automatic Operation

● Mode of Manual Operation

All variables are controlled by hand. Press the ▲ key or ▼ key on the tool bar, or press the "↓" key or "↑" key on the keyboard on front panel, each variable will increase or decrease one step. When relay acts, the tester will give a sound of 'Di" and record the action value and time. If needing to test the return value of the relay, decreasing or increasing the variable till the relay's contact return, the sound of 'Di' will disappear. The tester will record all necessary return data and calculate the return coefficient automatically.

● Mode of Semi-automatic Operation

In this mode, all variable will increase or decrease automatically after starting the test when selecting 'Increase' or 'Decrease'. You can set the interval of increase or decrease. When the

relay acts, the tester will record action value of selected variables automatically and maintain output but the variety will be stopped temporarily. Meanwhile, a dialog box will be ejected for asking the change direction of next step, will you 'increase', 'reduce' or directly 'stop' the test? You should select an order according to the requirement of test.

● Mode of Full-automatic Operation

In this mode, all variables will increase or decrease according to step size after starting the test when you select 'Increase' or 'Decrease'. You can set the interval of increase and decrease. When protection acts, it will record necessary data automatically. If the 'only contact operation' has been selected, the tester will stop the test after obtaining the action data automatically; if the 'test action value and return value' has been selected, the tester will automatically change direction after obtaining the action value and alter the value in the opposite direction till the contact of tester returns so as to measure the return value, record it and calculate the return coefficient.

Attention：

1. In the mode of 'manual Operation', the speeds of increase and decrease variable can not be very quickly when it almost achieve the value of protective operation, so as to ensure the variable stays for enough times at every step size for producing the action. Only doing like this, the result measured will be more accurate.

2. During the automatic test, the internal calculator will be reset to zero with each step process. When measuring the action time of relay, please select the mode of 'manual Operation' and make it to vary slowly if longer time is needed.

■ Directly Set Parameter to Alter Output Value in the Output State

During the test, the software permits to use many functions to directly change output in the state of output:

● You can switch the mode of 'Manual Operation', 'Self-automation' and 'Full-automation' in the output state, switch between 'Increase' or 'Decrease', or switch between 'Contact Action' or 'Action and Return'. You can change the 'Time interval of automatic variety' in the mode of manual operation.

● Whenever parameters need to be amended, it can be changed among all kinds of modes. Click corresponding 'Alteration' box to tick ' √ ' or cancel to complete this operation.

● In the mode of 'Manual Operation', you can change output of each phase at one time. The

concrete operating procedure is as following: directly input the amplitude and phase of each phase needing to be amended one by one (please do not press the 'confirmation' key before completing it). After finishing inputting all values, please press the 'Confirmation' key. Then, the tester will synchronously change output of each phase to be the corresponding input value.

- ■ **Input**

    All input of 'Relaystar' Series Tester share one common terminal. When connecting the protective action contact, connect one end with the common terminal of tester and connect another end with any one of input A、B、C、R、a、b、c. Please note that if the connector has the positive potential, do connect this connector with common terminal.

    In this testing module, input A、B、C、R、a、b、c are effective in default state. The relationship between them is 'or'. When certain digital input is not needed, you can select to close it. When doing the test, switch-off and switch-on contacts of relay can be connected with any digital input (during the line protection, the software defaults the digital input R to be the signal incoming end of reclosing. When connecting the input common terminal (red terminal) with active contact, we normally connect it with the positive end of power supply. The tester will record the time in the column of input as soon as the tester receives the trigger signal of the digital input.

    If the trigger signal occurs in multichannels digital input ,the corresponding data wii be recorded.

■ Confirm the Switch State Change Time

    Off/on of contacts of all kinds of relay and microcomputer protection normally has certain oscillation. To prevent the oscillation from influencing the test result, we usually set certain 'Confirm the Switch State Change Time'. For common relay, 'Confirm the Switch State Change Time' is set to be 20ms, as for the microcomputer type protection, 'Confirm the Switch State Change Time' only needs to be set to be 5ms.

Record Test Result

There is an area for recording the 'action value', 'return value' and 'return coefficient' of test result on the lower right of the interface. It can record three-phase voltage, current, line voltage, voltage, positive sequence, negative sequence and zero sequence component of current, phase and frequency of AC, etc. You only need to tick the box before any item. Just as the

right diagram shows.

Short Circuit Calculation Button

'AC Test' module is a popular module. When more complex test needs to be simulated, please click the Short Calculation button in the tool column. A dialog box of 'Short Calculation' will be ejected, in which you can set arbitrarily.

- **Type of Fault**

Four types of fault are available in the pulldown menu: single phase earthing short circuit, two phase short circuit, three-phase short circuit or normal state, among which the normal state means that the three phase voltage is positive sequence rated voltage and three-phase current is 0A.

- **Fault Direction**

It is 'Forward Direction Fault' in the default mode. When reverse fault needs to be simulated for some directivity protection, you can select the 'Reverse Fault' in pulldown menu.

- **Rated Voltage**

It represents the rated phase voltage of the system. The rated voltage usually is 57.735V, which refers to the Non-fault phase voltage.

- **Setting Impedance**

According to different setting valued given by the setting value list, you can set fault impedance according to 'Z / Φ' or 'R / X' two kinds of modes on the interface. Selecting which kind of mode to set setting impedance depends on the setting value list. Whatever you choose, the value of another kind of mode will be obtained through automatic calculation of the computer.

- **Multiple of Short Circuit Impedance**

Above we set the 'Setting Impedance' in the setting value list, but we often verify it in 0.95 times or 1.05 times when doing the test. So 'Short Circuit Impedance" = 'Times Value' $\times$ 'Setting Impedance',involving 'Short Circuit Impedance' with short circuit calculation again. When doing the 'Zero Sequence Protection' test, the preemptive action of distance protection can be standed aside through flexible setting of short circuit impedance and in the case of not exiting the distance protection.

- **Model for Calculation**

When selecting the 'Maintaining Short Circuit Current', certain short circuit current needs to be set. You can calculate the 'Short Circuit Voltage' of corresponding fault type by using the 'Short Circuit Impedance' and this 'Short Circuit Current' given. When selecting 'Maintaining Short Circuit Voltage', certain short circuit voltage needs to be set. You can calculate the 'Short Circuit Current' of corresponding fault type by using the 'Short Circuit Impedance' and this 'Short Circuit Voltage'. When doing the 'Distance Protection' Test, flexible setting the short circuit

impedance may avoid the priority-action of the 'Distance Protection' under the condition of not exiting the zero sequence protection.

Attention:

'Short Circuit Voltage' represent the fault line voltage when two phases is short circuit, while it refers to the fault phase voltage in the event of other types of short circuits.

- **Zero Sequence Compensating Factor**

When simulating the 'Earthing Distance Protection' Test, the corresponding zero sequence compensating factor must be considered. Software gives three setting modes, please set according to the setting mode of zero sequence compensating factor given in the setting value list.

After finishing the above testing parameters setting, please click the 'confirmation' button, then the software will calculate the short circuit voltage, current and corresponding angles and fill these data on the 'AC Test' interface at once.

■ Function of outputting according to sequence component

The following diagram shows the testing interface of sequence component:

Set directly all kinds of sequence component of voltage-current needed to be output on the interface. For example, when needing to output three phase negative sequence voltage,fill the blank after 'U$-$' with this value and software can calculate automatically the amplitude and phase relations of output voltage of each phase.

| Parameter	Amplitude	Change	Step	Max
☑ U+	10.000		1.000	120
☑ U-	10.000		1.000	120
☑ Uo	10.000		1.000	120
☑ I+	1.000		1.000	30
☑ I-	1.000		1.000	30
☑ Io	1.000		1.000	30
☑ Ux	10.000		1.000	120
☑ Hz	50.000		0.000	1000

Attention:

1. You should note that the amplitude, variation step size and phase are all sequence components,which are combined by three-phase voltage or three-phase current but not actual output of single phase of tester. If changing any sequence component value on the interface (including amplitude and phase) ,software will real-time calculate corresponding three-phase voltage and current ,which will be displayed in the listing area on the lower left side of interface. The tester output voltage and current displayed on the interface rather than sequence component.

2. U_0、I_0、U-、I- on the interface are value of each sequence component,equaling to one third value of $3U_0$、$3I_0$、3U-、3I- in general use, which is the same as the value displayed in the result list on the lower left corner of three-phase AC Test interface. When doing the test, firstly identify which one is the setting values given by protection, U_0、I_0、U-、I- or $3U_0$、$3I_0$、3U-、3I-. If being U_0、I_0、U-、I-, you can set parameter directly according to the setting value; if being $3U_0$、$3I_0$、U-、I-, the actual setting value should divide by 3,and then set parameters according to new setting value.

Chapter 5　　DC Test

DC test module provides special DC voltage and current output ,mainly satisfying the requirements of doing tests including DC voltage relay, time relay and auxiliary relay. Main interface of DC module is as the following figure shows:
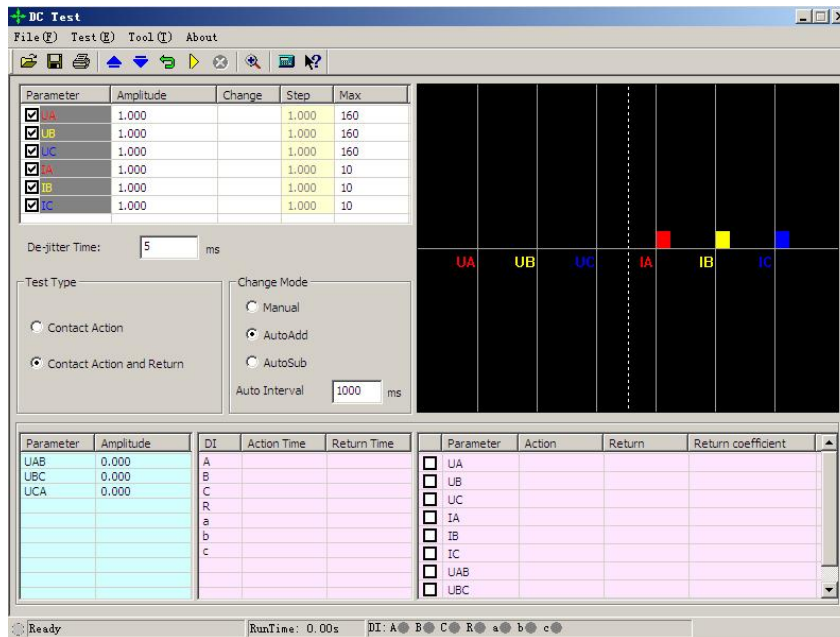
Section 1　　Interface Instruction

Interfaces of 'DC Test' module and 'AC Test' module are very similar, and their operating manner are basically the same. Using DC test, please refer to the 'AC Test'. Here we only illustrate their difference as follows:

■ Parameter Setting

The largest output voltage of each phase is $\pm160\text{V}$. When higher voltage needs to be output, you can adopt two-phase voltage output. One numerical value is positive, and another is negative, then the highest output voltage can achieve 320V. For example, if UA=100V, UB= -100V，then UAB=100－（-100）＝200V. The amplitude of line voltage is displayed on the lower left corner of main interface. Values of UA and UB are not always equal to each other and the positive and negative polarity should be paid attention to.

The largest current output of single phase is 10A. If higher current is needed to be output, you can use the mode of paralleling two-channels or three-channels current. The amplitude of

each phase should be equal basically.

Attention：

   When doing the time test of the relay, the 'Manual Operation' testing mode should be selected due to normal action time is longer. It need not change after loading rated voltage on relay, and just waiting for its action. When connecting wires, the time-delay contact of relay should be connected with the digital input of tester.

■ Independent DC output

   There is one channels independent heavy power DC output power supply on the back panel of tester. When doing test on the spot, we adopt DC power supply to provide one channels DC power supply for relay. This power supply provides 110V or 220V two shifts for outputting, and also have OFF shift closing the output. This DC power supply outputs is through rectifying and filtering of transformer winding, so it has not the function of voltage stabilization and can't ensure high precision.

   If the display of relay can't work well, please measure the working voltage of DC output by the multimeter firstly and check whether the voltage is normal and protector tube works well.

Attention：

   The output can produce as soon as the tester is provided with DC power supply, so please pay attention on safety in utilizing the tester!

Chapter 6   State Series Ⅰ

The state series is mainly for satisfying demands of some special protective tests in power system. For example, for doing the tests of quick switching of power supply for station and automatic switch test of standby power supply ,many times reclosing of protective tester of distribution system. During the state series tests, you can add up to nine states at most. In every state, you can define the voltage-current data and simulate state variety of complex electric network freely according to actual operation. Through reversal on seven pairs input, you can obtain and measure the action value and time of relay. Main interface of State Series I is as the figure shows:

- Flexible controll nine state output at most. 4-phase voltage, 3-phase current or 12-phase voltage-current can be output in every state.

- Every state can be closed, increased, cancelled, inserted, named, and set many kinds of trigger mode.

- Ux can set many kinds of output combination modes

- It can simulate all kinds of complex fault conveniently and flexible, for testing complex logical combination.
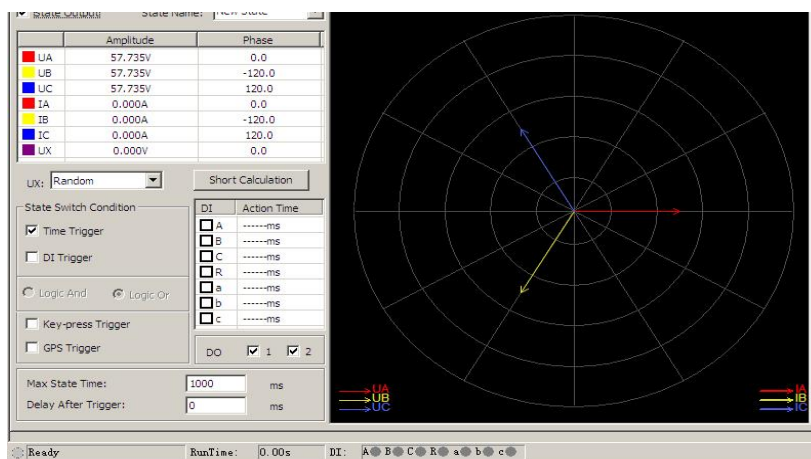
Section 1 Interface Instruction

■ Increase or Delete State

Press the "＋"、"－" button for increasing or deleteing current state. Nine states can be added at

most. If adding new state,it will be added to default current state,the user can also add new state to suitable place in the dialog box ejected.

When you need to delete the state, please select this state by mouse (when certain state is in the current state, its title will be displayed in red characters), then press "－" button.

■ Option for 'State output'

According to actual demand, you can jump over certain state through deleting the '√' before this option. At that time, this state will be displayed in gray, and it won't be included in the whole testing process.

■ Name of State

Since this testing module is always used for doing the 'Reclosing and Post Acceleration' test, the software has defined the names of five state defaulted :'Before the Fault', 'Fault', 'After the Trip', 'Reclosing' and 'Permanent Trip' in the pulldown menu of state for user's selection. Users can also input the self-defining name of state directly in the blank according to requirement. The self-defining name of state won't be setting in this pulldown menu, which can be changed at any time. The self-defining name of state involving in the test still exists when reopening this testing module.

■ State Parameters Setting

The AC parameters in every state can all be set freely, and the mode is the same as the 'AC Test'. When simulating complex test, you can obtain it automatically through opening the function of 'Short Circuit Calculation' on the interface. The results can also be amended.

■ Ux Option for Every State

Ux is a special component, for which you can set several kinds of output forms：

Assuming the parameters are $+3U_0$、$-3U_0$、$+\sqrt{3} \times 3U_0$、$-\sqrt{3} \times 3U_0$, firstly combining current output UA、UB with UC to obtain $3U_0$, then multiplying by corresponding coefficient to arrive at Ux .

If selecting to be equal to the voltage value of certain phase, then U_x output will be changed with the voltage change of this phase and always followe the change..

If selecting 'Any Mode', you can input any number in the range of 0~120 in the parameters column for U_x, and its value is equal to the voltage value and keep constant.

■ Short Circuit Calculation

Click 'Short Circuit calculation' or press ⚓ the button, then a 'Short Circuit Calculation' dialog box will be opened, which is used for simulating the short circuit calculations when all kinds of faults happen, and it will fill the calculated result in current state. You need to pay special attention to set correctly zero sequence compensating factor when it is earthing fault.
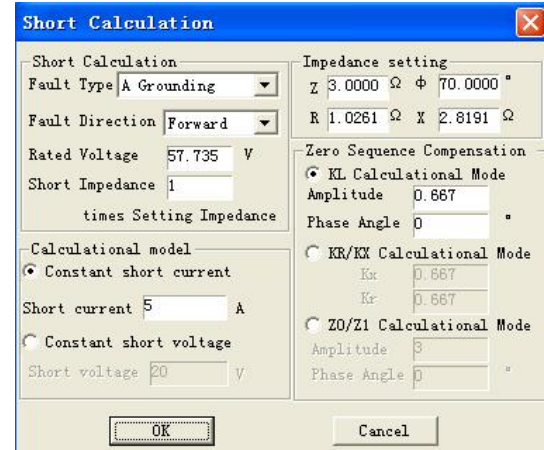
■ Conditions of State Reversing

Only the 'Time Trigger' and 'Input Trigger' can be selected synchronously, other states must be selected separately. They are preconditions of reversing from a state to next state.

- **Time Trigger：**

When this triggerring mode is selected, you can input respectively certain values in the 'Longest State Time' and 'Time Delay after Triggerring'. During the test, it will enter next state after the abovementioned time delay. 'Longest State Time' stands for the longest output time in this state. Function of 'Time Delay after Triggerring' is similar to confirmation time of switch triggering in AC test module,which is be used for avoiding the error due to protective oscillation and usually it is set around 10ms. Please pay special attention that time delay can' be set when simulating the faults of reclosing or post acceleration. Because the post acceleration fault causes by reclosing fault state, the post acceleration protection will act correctly only when it enters the Permanent Trip state. If it output fault component during the period of 'Longest State Time', and also the 'Input Trigger' is selected to be the reversal condition of this state synchronously before the test, the tester will jump over the state of 'Longest State Time' left and get in the state of 'Time Delay after Trigger' when the tester receives the action signal of protection.

In addition, it often avoids the oscillation of protective contacts through setting 'Time Delay after Trigger'.

- **Digital Trigger：**

When this triggerring mode is selected, seven channels input A、B、C、R、a、b、c will all be effective. Relationship of these seven channels input is 'or', and you can cancel redundant input through deleting the '√'in front of it as required. When the tester tests action of the input selected, it will reverse to next state through the 'Time Delay after Trigger'.

In order to avoid 'Oscillation' of contacts influencing the test, you should normally set certain 'Time Delay after Trigger' in this triggering way.

- **Key Trigger：**

When the 'Key Trigger' is selected, during the test, click the 』️ button or press the 'Tab' key on tester's front panel to realize the state trigger reversal . This is a kind of effective mode for controlling the test process by hand.

- **GPS Trigger：**

When GPS trigger is selected, you can use minute impulse or second impulse of GPS clock to test several testers synchronously.

Attention：

1. The Time Trigger and Input Trigger could both be ticked at the same time, then the one whose condition arrives in advance will trigger the reversal.

2. When the Switch Trigger is selected, normally certain 'Time Delay after Trigger' (about 5－20ms) needs to be set for avoiding reversal due to many times error trigger led by contact oscillation.

■ State of Digital Output

You can set the output state of digital output 1 or digital output 2 in each state. If you tick it as' √', so the output of this channel will be closed in this state; otherwise it will be opened. You can set different output of digital output in each state, which can implement switching variety of output during reversal in all state

Chapter 7　Harmonic Superposition Test

The 'Harmonic Superposition' Test unit can implement superposition output of each order harmonic component of 3 phase voltage and current, which is used for testing the working behavior of equipment of power system in all kinds of harmonic conditions. It is often used for verifying constraint coefficient of differential harmonic.

- UA、UB、UC、IA、IB、IC can be overlapped DC and 2～20 order harmonic output.

- Each component can be displayed and recorded according to amplitude, and it also can be displayed and recorded according to percentage of fundamental wave

- You can select automatic variety or manual variety, and the amplitude and phase will all be changed.

- It can measure action value, return value, action time and return time.
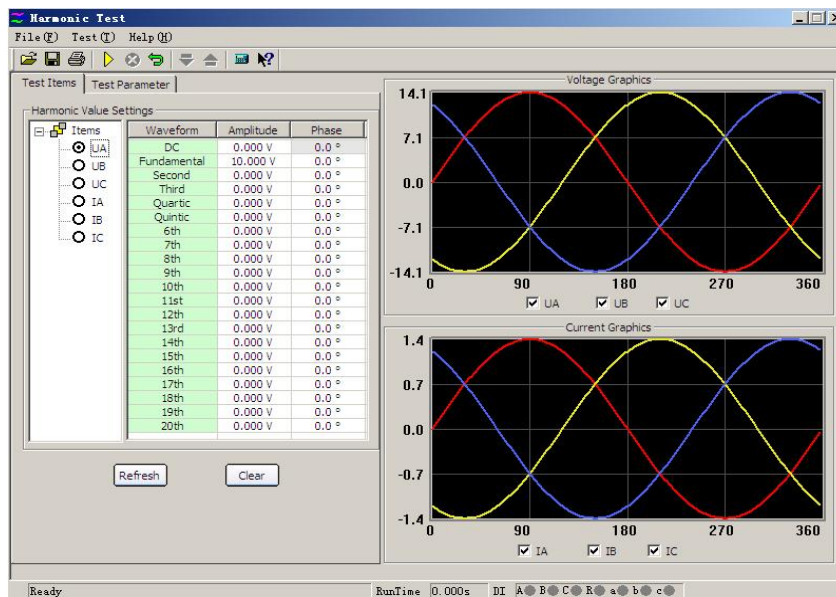
Section 1　Interface Introduction

■ Set Harmonic Data

There are two kinds of displaying modes for harmonic in this module, one is the mode of amplitude and another is percentage of fundamental wave,meanwhile, the amplitude of harmonic has

direct relation with the amplitude of fundamental wave. In addition, the waveform output after superposition also has relation with the amplitude of this fundamental wave.Generally speaking, when doing the harmonic suppression test, the amplitude of fundamental wave should be set larger than the action setting value of relay (such as the starting value of differential protection) in order to ensure the protection can be acted reliably when the harmonic is smaller or is 0.

Set amplitude and phase of harmonic in this page. Data phase of the state selected on the left of diagram stands for the channel of corresponding phase that will superpose harmonic. The amplitude valued can be expressed in two modes. The mode of amplitude value is adopted in this diagram, so its unit is the one of corresponding current-voltage. If you would like to express it in percentage of fundamental wave, then it will display the percentage it accounts for the fundamental wave. Here the phases of fundamental wave and harmonic have little influence on test results, so usually using the default set is OK. In case of any set is needed, please set the phase between the fundamental wave and harmonic according to the setting value of protection.

Data Revert Button：Please set test data before the test. Amplitude and phase during the test may vary. Please just press this key after completing the test to make data 'revert' to the state before the test.

Refresh Button：This button is invalid to parameters participated in previous test, but only be valid to new data amended before doing next test. It can 'refresh' new data amended to be the state before the amendment.

Clear Button：It clears the amplitude values of all waveforms including fundamental wave, DC and 2~20 order harmonic displayed in current window, and the phase will return to its default state, i.e, the phase A returns to '0', the phase B returns to '－120°', the phase C returns to '120°'. This key is only valid to the parameters displayed on current interface.

Here displays the waveform after superposition.

You can select to display all three phases, and also select to display the waveform of single phase. The graph shows the waveform of Phase A voltage after harmonic is superposed. This graph can be compared with the waveform of oscillograph conveniently.
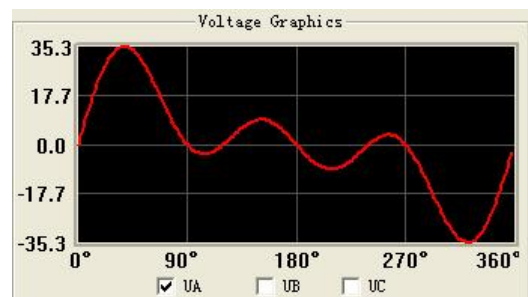
DC ouput range of each phrase voltage is -160~160V, and the output range of fundamental wave and harmonic is 0~120V; DC output range of each phrase current is -10~10A, and the output range of fundamental wave and harmonic is 0~40A.

Summation of waveform effective value superposed in the same channel can't be over 120V (40A). If it is over the range, software will give a hint. At that time, please check the total amplitude. The amplitude superposition test should all be checked when inputting data and outputting variety.

■ Testing Parameters

● Variable Option

Variable：Select the channel needed to change from the pulldown menu. In this diagram, A Phase voltage is selected to be variable.

Waveform: represent harmonic change from DC to 20th order harmonic.

Step Size of Amplitude Value：The step size here is also corresponding with 'Harmonic Expressing Mode'. When 'Express in amplitude value' is selected, the step size can also be expressed by amplitude, and the unit is A or V; however, when selecting the 'Express in percentage of fundamental wave', step size is also the percentage.
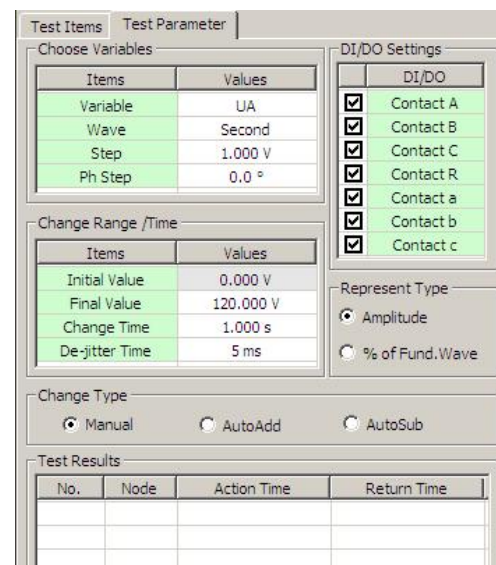
● Range and Time of Variation

Initial Value of Varitaion：The initial data of variation come from the data of foregoing harmonic set,which could not be amended. If the initial value needs to be amended, you must do it on the page of harmonic data. The initial value here is expressed in the way of amplitude.

Upper Limit of Variety：It is the output upper limit value of variable, which can ensure the output value not to be very large and avoid ruining the tester.

Variation Time：Variation time stands for the interval of each step variation, and it is normally set to be slightly larger than the setting action time of protection.

Anti-Oscillating of Contacts：The default value is 5ms. When doing the relay test, you should set longer Anti-Oscillating time according to requirement.

• Expressing Method of Harmonic

You can select 'Express in the mode of amplitude', and also can select 'Express in percentage of fundamental wave' to express data of harmonic component of each phase. When 'Express in percentage of fundamental wave' is selected, the data of each order harmonic on the page of 'harmonic' will be displayed the percentage related to the amplitude of fundamental wave. The step size of amplitude of variable will also be expressed in the percentage of fundamental wave. For example, when the 'Express in amplitude value' is selected, amplitude of the second order harmonic of certain phase voltage is 2V and the amplitude of fundamental wave is 10V, then the second order harmonic displayed is 20% when selecting 'Express in percentage of fundamental wave'.

• Set Digital Quantity

The page of digital quantity is used for defining the action of which channel is effective. It defaults that digital quantity of all seven channels A、B、C、R、a、b、c are effective. When doing the test, you can define the digital quantity of which channel is effective (tick '√' means effective). Relation of each is 'or'.

• Way of Variation

Here Manual Operation and Automation (automatically increase and decrease)two kinds of variation are available for implementing change to harmonic components of each phase during the test.

Chapter 8　High-Low Frequency Test

The 'High-Low Frequency Test' module is mainly used for testing all functions of frequency protection including low frequency load-reduction and high frequency generator-shutting. According to its functions, this module is divided into six test units.

- All test items includes almost all frequency and high-low circle protection

- The frequency can slip down to do low- frequency load-reduction test, and can also slip up to do high-frequency test
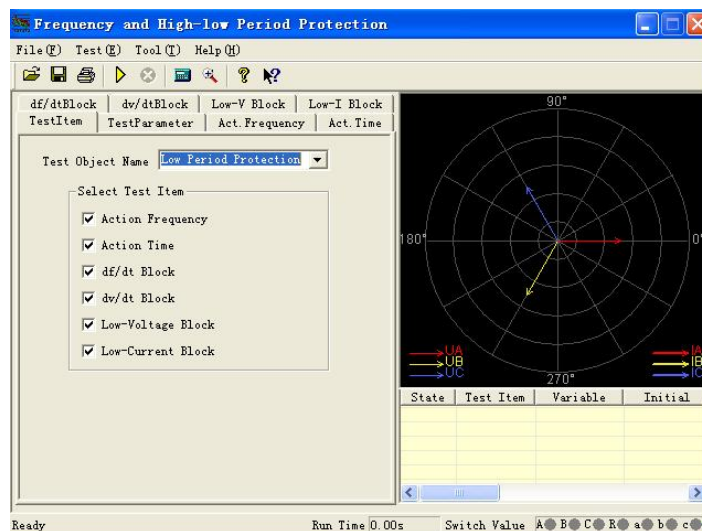
Section 1　Interface Explanation

■ Test items

There are six test items available, they are 'Action Frequency', 'Action time', 'df/dt block', 'dv/dt block', 'Low Voltage block' and 'Low Current block'. According to request, one or more items can be selected. When more than one are selected, corresponding dialog box will be ejected after completing a test item to tell you next test item.

testing objects includes 'Low Cycle Protection', 'Frequency Relay', 'Beat Frequency Relay', 'Low Frequency Relay' and 'High Frequency Relay' five kinds of relays. The 'Low Circle Protection' will be selected under the default situation. Its pulldown
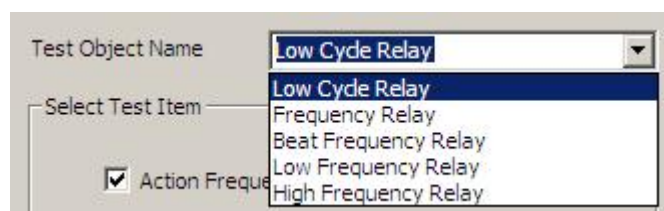
menu is as the diagram shows:

■ Testing Parameters

- **Time Delay before Variety of Frequency**

    During each changing process of variable, the device will firstly output the rated power 50Hz, which will be maintained to the end of 'Time Delay before Variety of Frequency', then it begins to vary. For testing some protection this is very useful, which can be used for releasing block after the frequency protection is blocked.

- **Test Interval**

    After completing one test the device will stop output till the end of 'Test Interval', and then it outputs to do next test.

- **Setting Value**

    There is inputting box of setting value in every page of test function. Most of these setting values do not work during the test, which only has a function of reference and contrast after the test. You can set the 'Error Allowance' if need. After contrasting the 'Test Value' got from test with the 'Setting Value', a relative error will be obtained for reflecting performance of protection.

■ Action Frequency

- **Frequency Test Range**

    During the test, frequency varys from original value to final value in the test range, the original and final value should be set so that the action frequency is placed between them; When Varying from original value to final value frequency should stride over the setting action value so that the protection can act.
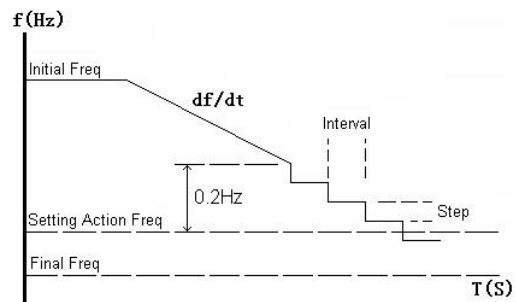
Test mode of action frequency: Frequency will vary in two stages during the test: At the beginning, it output the origin frequency. After delaying the time before the variety, it will firstly slip down (or up) evenly according to df/dt to the frequency 0.2Hz higher (or lower) than setting action value. Then, it will descend (or rise) the frequency step by step in certain time interval according to setting step size. If the protection acts during this process, the action value will be obtained. Otherwise, it will consider that the protection won't act and end this test item when frequency varys to the final value.

The time interval of step-by-step frequency varying is confirmed automatically according to setting action time, and this time interval is 0.2s longer than setting action time. So the setting action time must be set correctly in order to ensure that the protection has enough time to act in the time interval of variety. Similarly, the setting action frequency also must set correctly in order

that the protection can act in the stage frequency varying step-by-step.

For example: known low frequency action value is 48.5 Hz, the test range should be set 50 — 48Hz, and the step size is 0.05Hz, the testing final value should not be set too lower (normally higher than 45Hz), otherwise, the protection maybe will block.

■ Action time

Test mode of action time: frequency slips down (or up) from original value (normally 50Hz) to final value and waiting for action. This final value should be lower than frequency action value for ensuring action of protection. But the timer for testing action time begins to time it from 'Setting Action Frequency'.
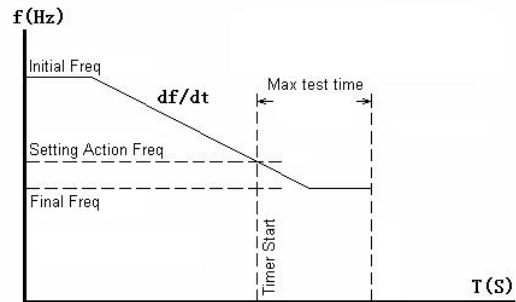
So if the setting value has deviation, it will influence the time measuring precision. For process of test, please see the right diagram.

■ df/dt Block

- **df/dt Test Range**

When testing the 'df/dt block value', it will do tentative test point by point in the test range. The frequency will slip down (or up) from original value to final value every time. The df/dt value slipping down (or up) will vary point by point in this range. When the protection acts in certain time test, the boundary value of df/dt block at that time will be tested out.

Since the protection is blocked when the df/dt value is larger than setting value, the original value of df/d should be higher and the final value should be lower than the setting block value of protection, which means during the test from protection no action to action, the dv/dt block value will be tested out.

- **Range of Frequency Variety**

In each period, testing frequency slips down (or up) from original value to final value. The original value is normally 50 Hz, and the final value is lower (or higher) than setting action frequency.

Attention：

Time delay before frequency variety when doing this test could not be too shorter in order that there are enough times for protection to release block.

■ dv/dt Block

This testing item is very similar to 'df/dt block' mentioned in the above paragraph. Their

difference is that the variable in each test period is dv/dt value. We only introduce their differences in the following paragraph.

- **dv/dt Test Range**

It will do tentative test point by point in this range when testing 'dv/dt block value'. Voltage will slip down from original value to final value when doing the test every time. The dv/dt value slipping down will be varied point by point in test range. When the protection acts in certain period of tentative test, the boundary value of dv/dt block will be tested out.

Since the device is in the block state when the dv/dt is higher than the setting block value, normally the original value should be set higher than the setting block value, and the final value should be set lower than the block value. Which means during the test from protection no action to action, the dv/dt block value will be tested out.

- **Varying Range of Voltage**

For simulating the process of voltage's descension, normally the 'Original Value of Variety' of voltage should be set higher than the 'Final Value of Variety'. Meanwhile, for avoiding the low frequency protection from being blocked due to low voltage, the 'Final Value of Variety' of voltage set should be higher than the setting low-voltage block value of the protection.

- **df/dt value in testing**

Frequency in this testing item always varies along according to gived df/dt, so df/dt should be set lower than the setting df/dt block value of the protection.

■ Low Voltage Block

This item is similar to 'df/dt block' and 'dv/dt block' in above paragraph. We introduce their difference as follows:

- **Test Range of Voltage**

Voltage will do tentative testing point by point in test range. In every period of test frequency will vary but voltage will be fixed to certain value. Voltage increases from the original value to final value step-by-step. When it is increased to certain value, the device release block to act, so this value is the boundary value of low voltage block.

Since the protection is blocked when voltage is lower than the block value, normally the original value of voltage should be lower and the final value be higher than the block value. Which means during the test from protection no action to action, the dv/dt block value will be tested out.

■ Low Current Locking

This testing page is very similar to 'Low Voltage Block'. Please refer to the instruction for

'df/dt block', 'dv/dt block' and 'low voltage block'.

Segment 2   Guidance for Test

We only take the 'Test of Low Frequency Action Value' as example, to explain the test method in details.

■ Connecting Mode

Connecting three phase voltage UA, UB and UC of tester with three phase voltage of relay; connecting UN of tester with UN of relay; connecting digital input A and B of tester respectively with the trip terminal of primary and secondary stage load-reduction of relay, and connecting common end of digital input of tester with the trip common terminal of relay, then turn on the power supply of relay. (If the relay needs DC power supply, the power can be lead out from the Aux DC power supply on the rear panel of tester.)

■ Option

In the "Frequency and High-Low Circle Protection' testing module, select the 'Action Frequency' test item and testing object of 'Low Circle Protection';

■   Set

Switch to 'Action Frequency' test interface to set testing data, like the right diagram shows:

- **Setting Action Frequency**

Set this item according to the settings list of relay or actual action valued by protection. This setting item is only for reference during the test and do not influence test result.

- **Setting Action time**

Set this item according to the settings list of relay. The inteval of frequency varying step by step in the second stage is 0.2s longer than this value. If it is too short, the relay may has not enough time to act, so this value should be set correctly.

- **Test Range of Action Frequency**

'Initial Frequency' must be higher than the action frequency set by protection, and 'Final Frequency' must be lower than it, that means action frequency should be placed between them.

- **Step Size of Variety of Frequency**

'Variety Step Size' should be set according to the precision required by the test, normally it can be set in 0.05Hz defaulted.

- **df/dt Value When doing the Test**
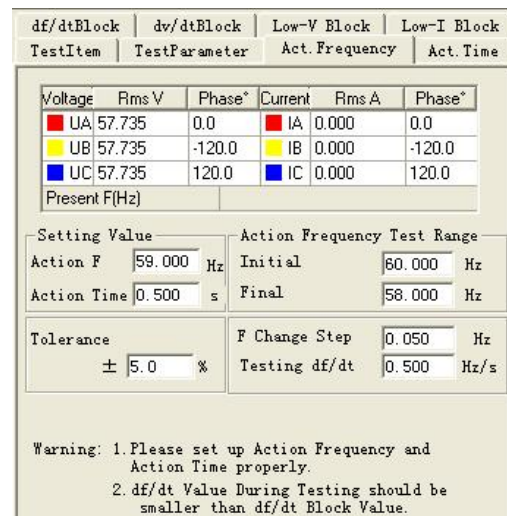
It stands for the speed of evenly frequency conversion in the first stage during the process of descending frequency, and df/dt value should be lower than the locking value set by protection.

■ Button for Starting the Test

After confirming all testing parameters are correct, the test can be started. During the test, current real-time frequency output by tester can be observed through the column of 'Current Frequency Hz'. When the tester does not output voltage, the 'Abnormity' lamp on protection will light up. When output frequency of tester is lower than the 'Start-up Value', the 'start-up' lamp on protection will light up, that is to start up low circle action components.

Process of test is as follows: output 50Hz voltage-current, after delaying time before variety—— frequency slips down evenly in the speed of df/dt to 'Original Value of Test' —— press 'Step Size of Variety' to reduce frequency in the time interval of 'Setting action time + 0.2 seconds' step by step, and also record whether the protection acts.

Chapter 9   Power Direction & Impedance Test

The Power direction and impedance test module is mainly used for testing the protections related to 'direction', such as power direction protection, negative sequence power direction, zero sequence power direction, phase-phase power direction, reverse power direction, phase-phase impedance, grounding impedance, etc. It tests their action boundary, the sensitive angle, and action value of voltage and current, action time and action impedance. We only take 'Power Direction Protection' as example to introduce all testing item of this module. Its main interface shows as the following diagram:

- It includes not only all kinds of test items for power direction protection, but also the test of phase-phase and grounding impedance protection.

- Software introduces the option of 'Enable Abrupt Variable' for satisfying the testing requirements of some protections which need abrupt variable to start protection

- Adopting two vectorgraph display modes to make the test process more conveniently to observe visually.

- In boundary test, the two action boundaries line can be drawn automatically and the sensitive angle can be computed and drawn on the graph automatically.
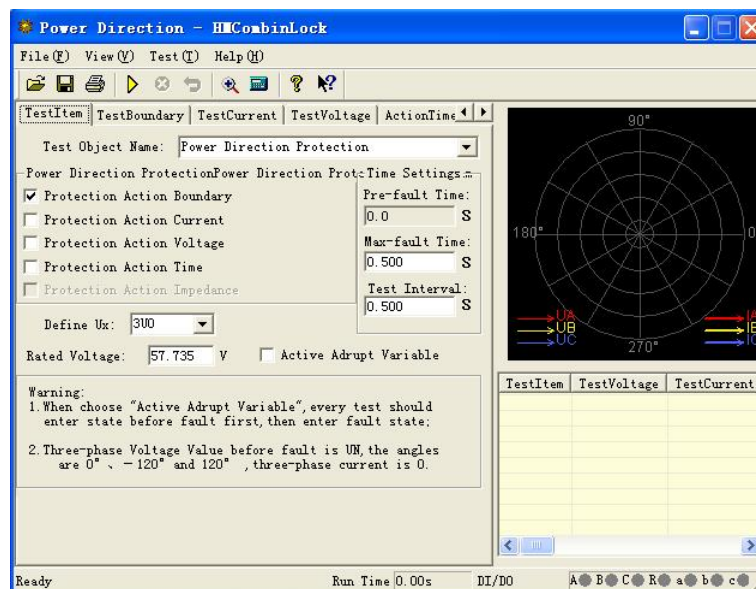
Section 1   Interface Instruction

■ Test item

### ● Name of Testing Object

There are many types of protection device available, it includes 'power direction protection', 'negative sequence power protection', 'negative sequence power direction', 'zero sequence power', 'zero sequence power direction', 'phase-phase power direction', 'reverse power protection', 'phase-phase impedance' and 'grounding impedance'.

● Abrupt Variable Start up Protection

When 'Enable Abrupt Variable' is selected, the tester will firstly output the voltage and current of state before fault every time during the test, then output the voltage and current set on the interface. For satisfying the demands of abrupt variable starting up protection of some protection relay, the 'Time before Fault' must be set at that time. If you do not select the 'Enable Abrupt Variable', the 'Time before Fault will be invalid (automatically be 0). It will output directly the voltage and current set every time during the test, which will vary continuously.

Take 'Test Voltage' as example, the meaning of abrupt variable can be showed as the right diagram. After clicking the 'Start Test' button, the tester will output firstly normal voltage, and maintain it till the end of 'Time before Fault'; then, the tester will output 'Fault Voltage 1' (the fault voltage set on the interface), and maintain it till the end of the 'Max Fault Time'; then, the tester will stop output for the test interval time (if the 'Test Interval' is not 0).

After that, tester will output again normal voltage, and maintain it till the end of 'Time before Fault'; then, output 'Fault Voltage 2' (the voltage after varying one step size), and maintaining it till ending the 'Max Fault Time'; then, the tester will stop output for the test interval time. The test will progress periodically like that, every cycle the voltage always vary from normal voltage to fault voltage abruptly.
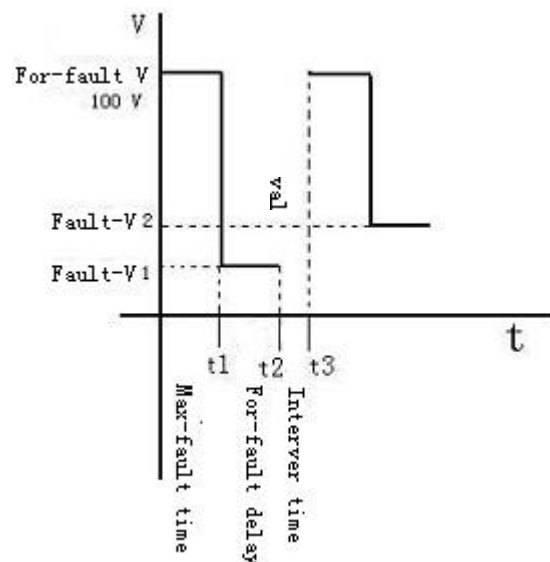
■ Test Action Boundary

It tests automatically two action boundaries of power direction protection, and calculate the

sensitive angle automatically. In the mode of 'Display vectorgraph of action angle', you can observe visually two boundary lines and the sensitive angle line from the diagram on the right of main interface.

- **Testing Parameters**

Selecting one voltage and one current output, its angle Φ（U，I）varies in given range measure left and right action boundaries.

Considering that protection is normally connected in the way of 90° connection, so we normally adopt line voltage and phase current of the third phase, such as adopt voltage UAB and Current IC. Sometimes you can also select single phase voltage and single phase current to do test, but normally the line current is not selected. Please pay attention that, the selected voltage and current are set value, but the voltages of unselected phases are equal to rated voltage and symmetrical, and the currents of those phases are 0.

When setting the searching range of Φ（U，I）, you should firstly know the setting value of the 'Sensitive Angle' of protection and ensure the searching range set can cover two actual action boundaries of protection. That means original value and final value of searching should all be set outside the action zone, and tester will search from the 'Non Action Zone' to 'Action Zone'.

Protection does not act when starting the search at the original angle. It acts when angle varies to certain value and one action boundary angle is found, and then lined the diagram. Then, it reverse the searching direction immediately to search another boundary angle (notes: now tester will search from the final angle set to original angle). When the second action boundary is found, it will be lined again. Then the Sensitive Angle can be calculated and lined on the diagram automatically.

- **Definition of Action Angle**

Select the action angle as 'Test Phase Angle', '（U0，I0）' or '（U2，I2）' according to protection type tested. If it is power direction or impedance relay, select the 'Test Phase Angle', that is the angle between testing voltage and current selected. If it is zero or negative sequence protection, you should select （U0，I0）or（U2，I2）.

- **Vectorgraph Display**

When 'Display the vectorgraph of 3 phase voltage and current' is selected, it displays the vectorgraph of each phase voltage and current in the graph.

When 'Display the vectorgraph of action angle' is selected, only the components of voltage and current of the action angle selected are displayed in the graph. If （U2，I2）is selected, it will only display the value and angle between U2 and I2. This display mode is convenient for observing visually the searching process of action boundary.

■ Testing Current

Mode for testing operating current is: Fix voltage and the angle between voltage and current, increase current step by step from low to high till the protection acts and test out action current value. During the test, angle Φ（U，I）should be normally set the sensitive angle of protection. shown as the right diagram.

When doing the test, select a line voltage to be fixed and the third phase current to be variable. The variety range of current should includes setting action current of protection. When voltage leading current , the angle is positive. So please pay attention to the positive angle and negative angle when setting angles. Normally, when the setting angle is equal or near sensitive angle, the protection acts the most sensitively, and the action current tested also is the mose exact. When the setting angle is deflected too much, the action current tested may be larger or even relay may not act.

■ Testing Voltage

Mode for testing operating voltage is: Fix current and the angle, increase voltage from low to high step by step till the protection acts and test out action voltage value. During the test, angle Φ（U，I）should be normally set to be the sensitive angle of protection.

When doing the test, selecting one phase current to be fixed and the line voltage of other two phases to be variable. Variety range of voltage should include setting action voltage of protection. The angle is equal to the sensitive angle.

■ Testing Action time

Mode for testing action time is: Directly set a voltage and a current which can make protection acts, when action occurs, recorde the action time.

■ Testing Impedance

Mode for testing action impedance is very similar to 'Testing Voltage' and "Testing Current' above, it also make the protection act through changing solely voltage or current. The difference is: this unit records action impedance value of protection but not operating voltage or operating current. As the following diagram shows:

The angle Φ（U，I）should certainly be in the action zone of protection, and we normally set it equal to the sensitive angle.

Impedance value is calculated according to voltage and current when protection acts. Please pay attention that: when testing grounding impedance, zero sequence compensating coefficient should be considered and set correctly. The default value is 0.667.

Section 2   Guidance for Test

■ Definition of Angle Made by Microcomputer Protection

Normally, the definition of angle made by microcomputer protection is: direction of voltage leading current is positive. On the contrary, it is negative. In addition, it often default the angle of voltage to be 0°, which means voltage is the reference for angle of current. Right diagram shows the active characteristics of certain power directional protection. Its largest sensitive angle is －45°. Two action boundaries are respectively －135°≤Φ≤45°, which is just opposite to the angle concept in x/y coordinate.

The shadow parts in the diagram stands for action zones of protection, which is corresponding to two action boundaries: 45° and－135°. When setting testing parameters, you should ensure two searching boundaries are respectively larger than 45° and smaller than －135°, which means they are in the non-action zone. Then it will search from non-action zone to action zone.

■ Searching Action Boundaries

When it is at the largest sensitive angle of testing protection, if you do not know its actual action boundary, you can adopt the following mode to search:

Set the 'Searching Range Collection of Φ（U，I）' in the page of

'Testing Boundary' to be 0°, then start the test. If the protection does not act, set this parameter to be 30°. By analogy, suppose the protection does not act when Φ（U，I）is 20°, which means one action boundary of protection is between 0°～20°. Finding rough range of another boundary of protective action by using the same mode, supposing it is between −130°～−120°.

When setting searching angle on the software interface, please pay your attention to that the software always begin to increase in step size from the angle of 'Φ（U，I）Searching Range Collection'. After measuring one action boundary, it begins to reduce in step size from the angle of 'Arrival'. So supposing 'Φ（U，I）searching step size' is set to be 1° (positive value), we take the above data as example, 'Φ（U，I）searching range collection' should be set to be -130°, and the 'Arrival' should be set to be 20°.
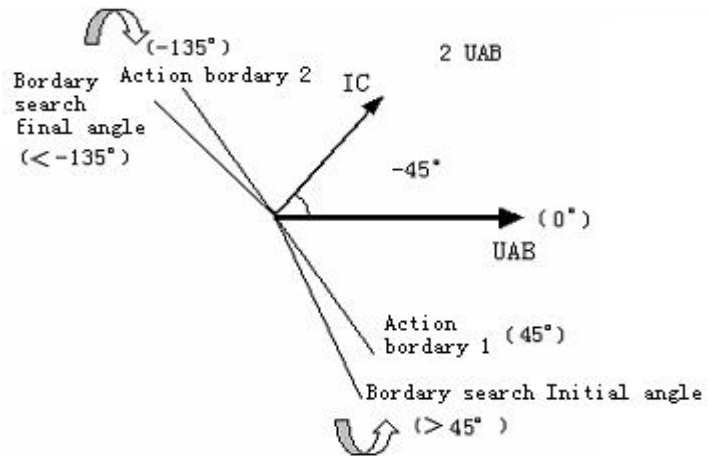
Chapter 10   Synchronization Test

This test module is used for testing quasi-synchronization device, and it can also be used for testing some protections which detect synchronization or nonvoltage to reclose.

- It can test synchronization various action value, voltage locking value, frequency locking value, leading angle and leading time, pulse width of voltage regulation and frequency regulation.

- Can do the automatic regulating test of automatic quasi-synchronization device.

- Can test automatic quasi- synchronization device, and also can test all kinds of synchronous relays

- Can test line protection reclose with synchronization or nonvoltage detection

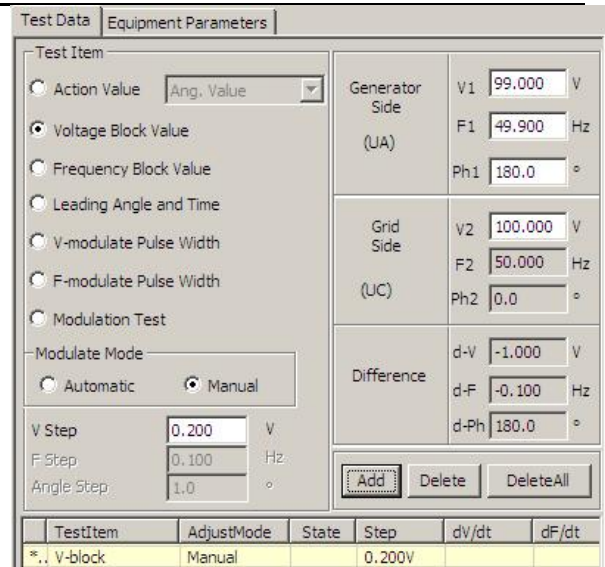- Can test automatically, and also can test by hand.
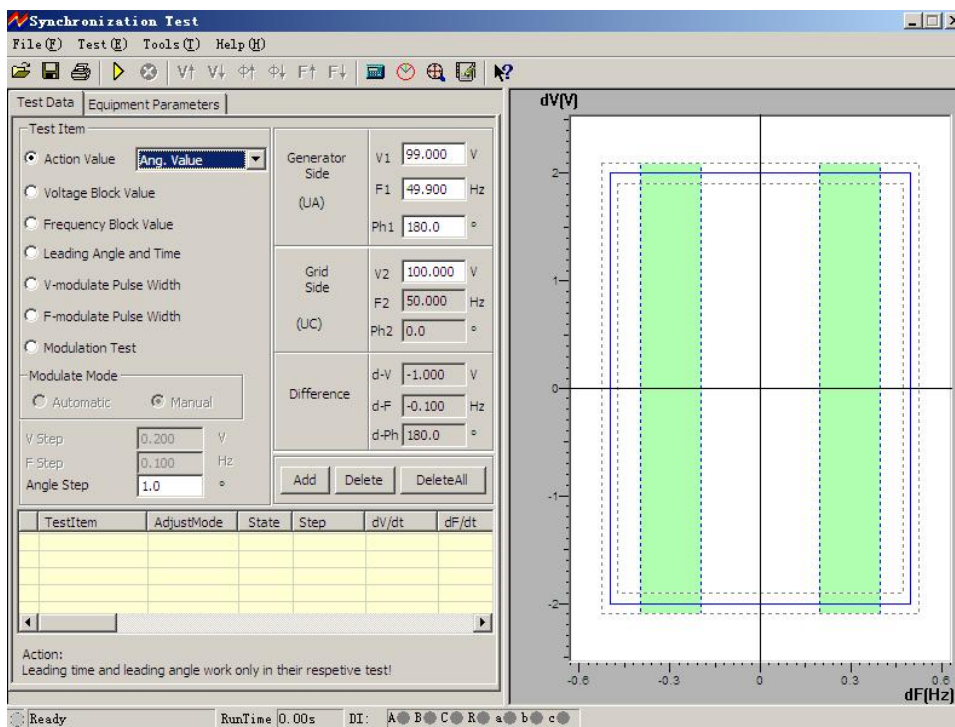
Section 1   Interface Instruction

■ Test item

- **Synchronization Action Value**

For testing action values of synchronous voltage difference, frequency difference, angle

difference. There are three options of 'Adjust voltage', 'Adjust angle' and 'Adjust frequency' in the pulldown menu on the right side. After one option is selected, set the 'Voltage (Frequency or Angle) Change Step'. You can start the test, then increase or decrease the variable step by step by hand till synchronization divice acts. Then, the corresponding synchronous action value will be tested out. You can also test the line protection reclose with synchronization or nonvoltage detection by using this function.

When any one of the above-mentioned parameters needs to be tested, you should always make other two parameters to satisfy synchronization condition in advance. Through changing value of parameters needs to be tested to make the synchronous device to act finally after satisfying fully synchronization requirements.

We hereby take the test of synchronization voltage value as example for explaining the mode of test:

Set firstly 'Adjust Voltage', set generator side voltage V1 to be 90V, and it does not satisfy synchronization condition. Set generator side frequency F1 and phase Φ1 to satisfy synchronization condition (F1 can be set to be 49.9Hz that is very close to the grid side frequency; arbitrary phase, and can also be set to be equal 50Hz and the phase to be equal 0°), and set certain 'Voltage Change Step'. Clicking 'Add' button to add the parameters set into testing data area. After starting the test, pressing 'increase ▲ (or decrease▼)' key by hand to change voltage till synchronization device acts.

During the test, you can observe the continous change of angles in columns of 'generator side' and 'difference' if frequency is different. If pressing the 'synchronization indicator' button in buttons column, you can even observe from the synchronization window opened that voltage vector of generator side rotates continously and its length varies at the same time. If frequencys of both sides are equal, the voltage vector of generator side won't rotates, and only its length varies. When three conditions --- voltage, frequency and phase angle all satisfy synchronization requirements (two voltage vectors of both side are close to the allowable range), synchronization device will send out close-switch signal. Tester will record the voltage difference, frequency

difference and angle difference when it acts.

Attention：

　　Mode for changing generator side voltage and angle value manually is to press ▲ and ▼key on the keyboard. Mode for changing generator side frequency manually is to press key ◄ and ► on the keyboard. There will be hints when moving cursor to the button column.

　　Frequency of grid side in software is fixed to be 50Hz, angle be 0°, the default voltage of grid side is 100V but can be adjusted. Generator side voltage is output by UA of tester, and grid side voltage by UC of tester.

- **Voltage Locking Value**

　　Before the test, firstly set voltage and frequency of generator side for satisfying synchronization conditions but voltage and frequency has certain difference so that the angle difference can recede or close periodically. After starting the test, since voltage and frequency of two sides satisfy synchronization condition, the synchronization device will send out the close-switch signal whenever the angle put into the action range (it can be observed from the action indicating lamp of device). Increase or decrease the generator side voltage manually or automatically till synchronization device is locked (it will no longer act in angle action range). When it changes automatically, the tester changes generator side voltage towards the direction of increasing voltage difference each time, which make voltage difference to be increased gradually till synchronization device will no longer act (action locked), then the voltage difference locking value is tested out.

- **Frequency Locking Value**

　　Before the test, firstly set voltage and frequency of side for satisfying synchronization conditions but frequency has certain difference so that the angle difference can recede or close periodically. After starting the test, since voltage and frequency of two sides satisfy synchronization condition, the synchronization device will send out the close-switch signal whenever the angle put into the action range. Increase or decrease the generator side frequency manually or automatically till synchronization device is locked (it will no longer act in angle action range). When it changes automatically, the tester changes generator side frequency towards the direction of increasing frequency difference each time, which make frequency difference to be

increased gradually till synchronization device will no longer act (action locked), then the frequency difference locking value is tested out.

- **Leading Angle and Leading Time**

Set voltages of two side to be equal before the test, and the frequency does not satisfy synchronization condition. After starting the test, synchronization device does not send out close-switch signal during angle rotation due to larger frequency difference. Increase or decrease frequency of generator side manually or automatically. When frequency is on the critical allowable action value, and when angle puts into the action range, synchronization device will act to send out close-switch signal first time. Tester will calculate and record the leading angle and leading time when frequency just satisfies the synchronization condition.

The following relation exists between leading angle and leading time:

$$\triangle \Phi = \triangle t \ / \ Tw \cdot 360^{\circ} \qquad\qquad Tw = 1 \ / \left| f1\text{-}f2 \right|$$

Among which：$\triangle \Phi$ is leading angle $\qquad\qquad \triangle t$ is leading time

f1 is frequency of generator side $\qquad$ f2 is frequency of grid side

In the state of automatic test, the tester always examine whether closing pulse is transmitted from the synchronization device in every period. If the tester does not receive closing pulse in one period, it will change automatically the frequency of generator side towards the direction of decreasing frequency difference. It adjusts like that in each period till the synchronization device signals. Software will calculate and record leading angle and leading time at that time.

- **Pulse Width of Voltage Regulating or Frequency Regulating**

When voltage difference and frequency difference do not satisfy synchronization conditions, the automatic quasi-synchronous device can transmit pulse width signals of increasing/ decreasing voltage or frequency automatically. The pulse width and period of this signal can be measure by this function.

Testing Mode of Pulse Width of Voltage Regulating：

Before the test, set the voltage of generator side not to satisfy synchronization condition (lower or higher than grid side voltage), set frequency of generator side to satisfy the condition but not to equal to the other in order that the angel difference can recede and close periodically. Connecting signals of increasing or decreasing voltage of synchronous device respectively with tester digital input A and a. When doing the test, the device won't transmit the closing signal due to voltage does not satisfy synchronization condition but it transmits 'Voltage increase (or decreasing)' signal periodically. Tester can measure the pulse width and period of voltage

regulating under this voltage difference. The pulse width of voltage adjusting is normally linear relation with voltage difference.

Testing Mode of Pulse Width of Frequency Adjusting：

Before the test, set the voltage of both sides to satisfy synchronization condition, but set frequency not to satisfy the condition (lower or higher than grid side frequency). Connect signals of increasing or decreasing frequency of synchronization device respectively with tester digital input B and b. When doing the test, the device won't transmit the closing signal due to frequency does not satisfy synchronization condition, but it transmits 'Frequency increase (or decreasing)' signal periodically. Tester can measure the pulse width and period of frequency regulating under this frequency difference. The pulse width of frequency adjusting is normally linear relation with frequency difference.

- **Adjusting Test**

Before the test, set the voltage and frequency of generator side differ largely from those of system side, which could not satisfy synchronization condition. During the test, the synchronization device will transmit signals of 'increase voltage', 'decreasing voltage', 'increase frequency' or 'decreasing frequency', tester adjusts automatically generator side voltage and frequency towards the direction of 'satisfying synchronous condition' according to signals received at the variety ratio set. It won't be stopped until the synchronization device transmit closing order in the situation of voltage, frequency and angle all satisfying the synchronization condition. Tester will record the difference of voltage, frequency and angle when closing switch.

During the test, the voltage difference eligible lamp or frequency difference eligible lamp on synchronization device lights up when voltage difference or frequency difference satisfy the condition; if the angle difference also satisfy the condition, synchronous device will transmit closing signal at once. The above is the necessary three conditions of synchronization actions: frequency and voltage of both side is basically equal, and angle difference is smaller than certain value.

■ Other parameters

- **Adjusting Mode & Step Size**

In all test items, the software set different adjusting modes. When test items of 'synchronous action value', 'pulse width of voltage adjusting', 'pulse width of frequency adjusting', etc., the software only needs to be adjusted by hand. That is OK no matter several other items is adjusted by "hand operation" or 'automation'. In the adjusting way of "Hand Operation", it is required to

change output of variable through press ▲▼ and ◄► key on keyboard or press corresponding buttons on software's interface during the test; In the adjusting way of 'Automation', tester adjusts automatically output of variable according to signals of adjustment transmitted from synchronous device.

- **Add, Delete and Delete All**

You can complete all tests in one time when setting well several items. The basic operational process is as follows: Select test item——set all parameters required for testing this item—— click the 'add' button after confirming all parameters are correct, and add this item into the listing box—— click the button of 'start test' to start the test, and it will test in sequence of items added. If you would like to delete certain item in test item list, select it through the mouse, then, click 'delete' button. If you would like to delete all items in the list, directly click 'delete all' button.

- **Synchronous Window**

Setting values of $\triangle V$ 、 $\triangle F$ 、 $\triangle Fmin$ 、 $\triangle Fmax$ and $\triangle \varphi$ according to setting value of synchronous device. These values are only for your reference during the test, which do not influence the test. After completing the set, you can observe visually corresponding effect graph through the right graph. You will watch the testing track during the test.

- **Two Sides Fixed Angle Difference**

It is the combination of all fixed angle difference including wiring angle difference, transformer Y/△ angle difference, etc. of two sides. The software will compensate this angle automatically during the test.

- **Closing Time of Circuit Breaker**

Closing time delay of circuit beaker: Time delay closing of circuit breaker after simulating synchronous device to issue the closing order.

- **Time of input flutter-proof**

For eliminating the influence on test due to contact flutter of protective relay during the test. For microcomputer synchronous device, it is normally set to be 5ms; for relay, it is normally set to be 20－40ms.

- **Synchronous Indicator**

Clicking the 'synchronous indicator' button to open the synchronous indicator during the test, then you can observe the variety vestorgraph of voltage amplitude value, frequency and phase angle of generator side and system side during the test.
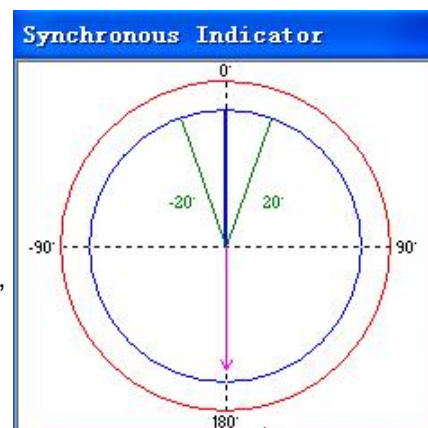
Section 2   Guidance for Test

■ Connection of Test

● Voltage Connection

Connecting the generator side voltage U1 with UA of tester; connecting system side voltage U2 with UC of tester; connecting common wire UN with UN of tester.

● Input connection：

Connecting the output signals of 'increase voltage', 'reduce voltage', 'increase frequency' and 'reduce frequency' of synchronous device respectively with input A, a, B and b of tester; connecting the export signal of closing action with input R of tester; short connecting another end of above-mentioned signals of synchronous device; connecting them to the public end (red end) of input of tester. If each output of protection is active contacts, please do connect positive power supply of each output contact with the public end of input of tester.

| Attention： |

When doing synchronous test, you should press the Start button of synchronous device firstly. Please check the input end of synchronous starting signal on the device for leading out two wires. After starting the test, firstly short connect them with start synchronous device. In addition, some synchronous device can be set synchronous time. During the test, if synchronous process is beyond this time, the device will lock out this time synchronous closing, and transmit alarm signal. You should press the synchronization start button or short connect the above-mentioned two wires for restarting synchronization.

Chapter 11   Full Group Test Ⅰ & Ⅱ

Overall test is equal to the static simulation test of relay protection tester. It simulates all kinds of faults of instant and nonvolatile single-phase earthing, phase to phase short circuit or convertibility for doing full group test for distance, zero sequence protective tester and action of reclosing or for verifying setting value. We hereby take the 'Overall Test Ⅰ' as example to introduce briefly to its operating mode. The software interface is as the diagram:

- Testing the protection for overcurrent, zero sequence and distance of the full group, doing full group transmission test.
- Can test the action of reclosing and after acceleration under the condition of having or having not the synchronization detection and detecting non-voltage.
- Can simulate convertibility fault and negative direction.
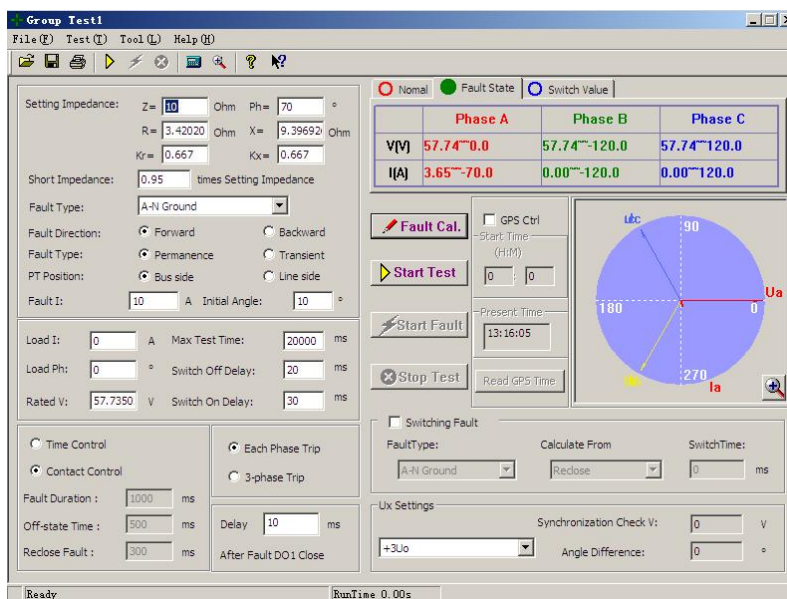
Section 1   Interface Instruction

■ Setting Component of Fault

● Type of Fault

You can set it to be the fault of Type AN、BN、CN、AB、BC、CA、ABN、BCN、CAN、ABC.

● Setting Impedance

According to the impedance setting mode given by the setting value list, the fault impedance can be input in the Z or Φ mode or be output in R or X mode. When inputting it in one mode, software will work out automatically the value of another mode.

● **Multiple of Short Impedance**

It is $n \times$ 'Setting Impedance'. Take this value to be impedance on short circuit point for doing the simulation. Normally it does the test in 0.95 or 1.05 times of setting value. If it could not be satisfied, you can also do the test in 0.8 or 1.2 times of setting value. It is the testing limit to 'Tolerance'. If the protection still could not be operated correctly, please examine whether there are other reasons exist.

● **Zero Sequence Compensating Factor**

$Ko = (Z0 / Z1 - 1) / 3$

If the Zro Squence Impedance Angle $\Phi(Z1)$ is not equal to the Zero Sequence Impedance Angle $\Phi(Z0)$, Ko will be a plurality. Then normally Kor、Kox will be used for calculation.

$Kor = (R0 / R1 - 1) / 3$ $Kox = (X0 / X1 - 1) / 3$

For some protections that is calculated in the mode of Ko、Φ (such as Series 901), if $\Phi(Z1)$ $=\Phi(Z0)$, then PS1=PS0, so Ko will be a real number. You should set Kor＝Kox＝Ko at that time.

● **Fault Direction**

It protection has directivity, please do select correct fault direction.

● **Character of Fault**

Difference of option 'instantaneity' and option 'permanence' is: in the testing mode of 'Time Control', when the 'instantaneity' fault is selected, the tester will stop output fault and enter next state when it acknowledges the action signal of protection though the fault time still has not been ended at that time; however, in the testing mode of 'permanence', the component of fault will still exist till the 'fault standing time' is up even though the tester acknowledges the action signal of protection. Which means fault output time of the tester is only controlled by the 'fault standing time' when it is in the mode of 'permanence' fault. So doing test in the mode of 'permanence' fault leads to the action of after acceleration protection easily, which also leads to that the reclosing could not be reclosingd. So we suggest that you select normally the fault mode of 'instantaneity'.
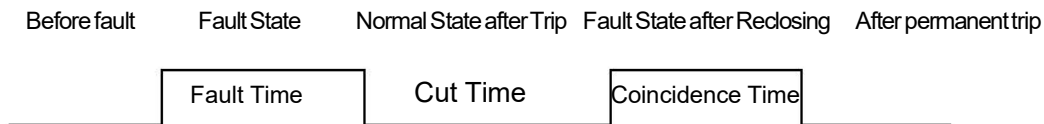
● **Fault Current**

Only short circuit impedance is set above. If you tell software certain fault current furtherly, the software will work out corresponding fault voltage automatically, and the tester will output corresponding fault voltage and current to protection. The fault current set should satisfy the following requirements: 1. Larger than pickup current of protection; 2. Product of fault current and short circuit impedance should not be larger than 57.7V.

● **Time Control/ Contact Control**

When 'Contact Control' is selected, the testing state will be controlled by signals of trip,

reclosing and permanent trip contact displacement of protection received by tester, which will decide that the tester outputs current and voltage at corresponding state.

When 'Time Control' is selected, the tester will output all kinds of component including 'before fault', 'during the fault', 'trip', 'reclosing', 'after permanent trip' in sequence according to the time sequence set, and the it only record time but do not change output process of all kinds of component when the protection trips.

Before fault	Fault State	Normal State after Trip	Fault State after Reclosing	After permanent trip
	Fault Time	Cut Time	Coincidence Time	

- **Fault Time, Cut Time and Reclosing Time**

  The mode of time control is used for controlling the standing time of output of failure component, the standing time of output of normal component after cutting the fault, and the standing time of re-output of failure component of reclosing as the above graph shows. It does not work in the mode of contact control.

- **Convertible Fault / Non-convertible Fault**

  Being used for setting convertible fault. Beginning from the start of fault, it will all trip the breaker and enter the state of 'fault after conversion' no matter the protection acts or not as soon as the convertible time is up. But the voltage-current of trip phase does not influenced by the state of convertibility fault. Its voltage V＝57.7V（PT is set on the bus side）or OV (PT is set on the line side), and I=0A. The Fault Convertible Time stands for the time calculated from the beginning of the first fault.

- **Fault Type after Conversion**

  It can be set to be Type AN、BN、CN、AB、BC、CA、ABN、BCN、CAN、ABC. Normally we set the fault type after conversion to be different form the first fault type, which is more tally with the actual situation.

- **Convertible Original Moment and Convertible Time**

  It can be set to begin calculation from starting the first fault, or after tripping of protection, or after coinciding the gate for deciding when the fault conversion happens.

- **Original Angle of Fault**

  It is the original angle of voltage when the fault happens. Since phases of three phases voltage-current are different, switch-on angle relates to the fault type. Normally it calculates according to reference phase of this type of fault: for single phase, it calculates according to fault phase; for two-phase short circuit or two-phase earthing, it calculates according to non-fault phase; for three-phase short circuit, it calculates according to Phase A.

- **PT Mounted Position**

Deciding where the primary side voltage transformer should be mounted, bus side or line side. When PT is mounted on bus side, after this phase is cut off, current of fault phase is zero, and voltage gets back to normal phase voltage （V＝57.7V，I=0A）; When PT is mounted on line side, after the fault phase is cut off, current and voltage of this phase will all be zero （V＝0V，I=0A）.

- **Split Phase Trip/ Three-phase Trip**

Being used for defining input A, B and C three terminals, regarding them as Terminal 'Trip A', 'Trip B' and 'Trip C' or Terminal 'Three Trip'? If it is set to be 'Split Phase Trip', it can simulate the situation of only tripping fault phase when it is single phase fault. Which means which signal among 'Trip A', 'Trip B' and 'Trip C' arrives first, it will simulate the trip of those corresponding phases.

- **Breaker off/on Delay**

For simulating off/on time of breaker. After acknowledging off/on signals of protection, it will wait switch's off/on delay for a while, then, switching voltage-current to the state after switching off or on.

- **Output 1 delayed closing time after fault**

Output 1 will delay this time closing after outputting component of fault. This function can be used for: simulating the 'offside signal collecting input' of receiver and transmitter by using 1 given when testing high frequency protection.

- **Output 2**

Output 2 varies by tracking the state of breaker. Which means Output 2 cuts off when the protection trips; output 2 will close when the protection reclosings. So output 2 can be used as analog breaker.

■ Setting Synchronization Detection Reclosing & Ux

- **Ux Option**

Ux is a special phase that can be set for outputting +3U0, -3U0, $\sqrt[4]{3} \times 3U0$, $\sqrt{3} \times 3U0$, Synchronizatios Detection Ua, Synchronization Detection Ub, Synchronization Detection Uc, Synchronization Detection Uc, Synchronization Detection Ubc, Synchronization Detection Uca and Synchronization Detection Uab.

For the first four kinds of 3U0 situtions, output value of Ux is obtained by 3Uo combined by Ua with Ub and Uc output currently being multipled by all factors, and it will vary along with them.

If selecting it to be equal to the extract voltage value of certain synchronization detection, Ux will be used for simulating the extract voltage of line side when the testing line is protecting reclosing of synchronization detection. Take the Synchronization Detection Ua as example, Ux output value is always equal to bus side Ua (but the numerical value is 100V) in the state of closing breaker; Ux value will be equal to the amplitude value and phase angle of synchronization detection voltage set in the state of cut-off after the protection trips, and this value can be set as the Ua numerical value or differed phase at that moment for testing the synchronization detection reclosing when the protection is in the situation that two sides voltage differs.

■ Instruction to Full Group Test Ⅱ

Function of Full Group Test II is basically as same as the one of Full Group Test I. In Full Group Test I, all fault situations are set according to impedance modes for protecting full group test. But it could not acknowledge the fault impedance but only have fault voltage and current for certain protection, such as zero sequence protection or 35 KV line protection. At that time, you can use Full Group Test II to do the test.

- **Type of Fault**

  It can be set as AN、BN、CN、AB、BC、CA、ABC type fault.

- **Fault Voltage U**

  For single phase fault and three-phase fault, the Fault Voltage U is the value of fault phase voltage; for phase to phase fault, the Fault Voltage U is the line voltage value of two phases of fault.

- **Setting Current I**

  It is the setting current value for protecting certain segment.

- **Multiple of Short Circuit Current**

  Short circuit current is the 'Setting Current' of Test Multiple nX, it will do analog test by regarding this value as short circuit point current.

Attention：

1. In the full group test, all fault data will be completed by computer. Every phase of short circuit voltage obtained by calculating the fault current and fault impedance set by computer should not be larger than rated voltage (57.7V). If it is too large, the fault current value will be reduced automatically for satisfying the condition of Vf ≤ rated

voltage (57.7V).

2. If the fault impedance is smaller, you should normally set heavier fault current; if the fault impedance is heavier, you can set smaller fault current so as to give suitable fault voltage, which is also in accordance with actual operation. Otherwise, it may influence the testing result.

Other options and testing process are all completely as same as the Full Group Test 1.

Section 2   Test Instruction

■ Explanation of Process of Full Group Test

Complete the data set, press '▷ Start Test ', the tester will output symmetrical component of every phase of 'Normal State'. All phase voltage is the rated voltage (57,7V) and current is load current at that time. Press the ' ⚡Start Fault' button or connect 'Input c', the tester will get into fault state, output fault current, and add it to the protective tester. After the protection trips, the tester will output component of state after tripping. After the protection coinciding the gate, the tester will output normal component (each phase voltage is 57.7V, current is load current) if it is the instant fault; If it is the permanent fault, the tester will output the component of fault again till protection trips for the second time (permanent trip), then, resuming output normal component.

● **Tester enters the fault state automatically when 'Input c' is switched on**

It has two functions: 1. It can accelerate to trip after it arrives at the fault line by simulating the manual closing mode. It can measure action time conveniently. Detail operation is to connect the manual contact or TWJ contact with 'Input c', the contact action tester will output the component of fault when closing it by hand, which can test the action of protection. 2. The fault can be started by contacts of GPS tester for simulating synchronous fault on two sides of line.

During the test, whenever you press the 'Stop' key, the testing process will be terminated and it will escape.

After completing the test, computer will file automatically the testing result in the testing record area under the subdirectory 'Test Report\Full Group Test\' in text formatting, and it can also be displayed or printed by the 'Printing' button, or it can also be copied for being edited or amended.

■ GPS Control Test

Process of full group test can be controlled by GPS for simulating the simultaneous and synchronous test of the protection on two sides of double power supply circuit, which means

these two testers on two sides will be started simultaneously and synchronously by GPS controller to enter the state before fault and the state of fault. Loading the protection for each side given by component of fault for testing the simultaneous action of two sides' protection.

- **GPS Pulse Output：**

The pulse export of GPS tester will output two lines of pulse, one is PPS pulse that will be transmitted every second; another is PPM pulse that will be transmitted every minute. Every time when PPS or PPM pulse is transmitted, a PPS indicating lamp and a PPM indicating lamp on faceplate will twinkle. We hereby do test by using PPM pulse. Output of pulse is terminal output.

- **Outputting GPS Clock Signals**

There is RS232 out let in GPS tester for outputting clock. Out let is Type D 9 needle socket. Connecting this out let with RS232 port of PC, and PC machine will read GPS time.

- **Connection between GPS Tester and Tester Tester：**

By using the special GPS connecting wire provided by us, connecting the pulse output terminal and clock output Rs232 port of GPS tester with the GPS communication port on backplate of tester.

  ○ **Comparing the time with GPS tester：**

For ensuring test's synchronization, click 'read GPS clock' on the 'Full Group Test' interface of PC machine to implementing the synchronous clock with GPS tester. If comparing the time with it is successful, a hint will be displayed.

  ○ **Start Test：**

Tick the option of 'GPS control begins to test' on the interface of 'Full Group Test', and click 'Read GPS Clock' to implement the clock synchronization with GPS tester. Then, two sides' operators all set the 'Start Test Time' to be the same time (this time must be later than current time). When 'Start Test Time' is up, two sides testers start the current-voltage before the synchronous output fault at the moment when PPM twinkles, and enter the fault state and output component of fault synchronously at the moment when next PPM twinkles. The whole process is as the following graph:
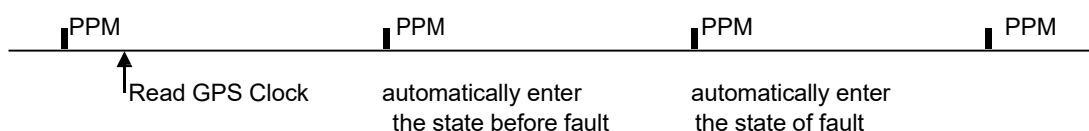
Chapter 12   Distance & Zero Sequence Protection

In 110KV and above line protection, normally distance and zero sequence protection is set as main protection of line, and they often concentrate in a set of protective tester. The testing module of distance and zero sequence protection is a software developed aiming at this situation, which can complete automatically all kinds of earthing distance, phase to phase distance and zero sequence protection.

- Can automatically complete verification of all fault setting value of several segments direction and zero sequence protection.

- Can test the time when protective three-phase trips synchronously or not in the same fault.

- Can set permanent falut, test the time of reclosing and permanent trip.

- Not only can adopt Mode Z、Φ, but also can adopt Mode R、X to set impedance setting value.

- Through setting the mode of 'pressing key for trigger', you can control output of component of fault by hand.
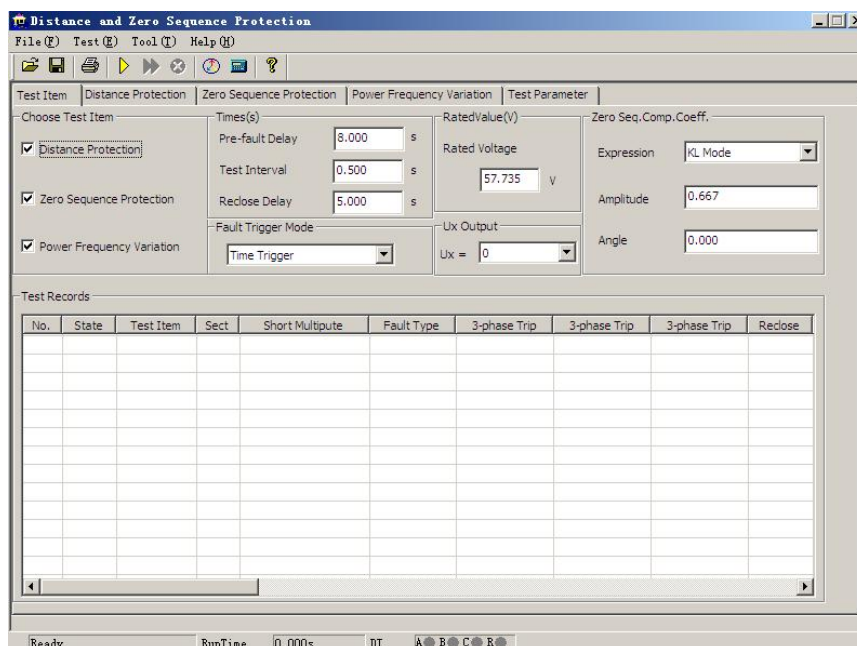
Section 1   Interface Instruction

■ Test items

'Distance Protection', "Zero Sequence Protection' and 'Power Frequency' three test items are available, which can be selected separately, and also can be selected simultaneously.

- **Time Parameter**

Time Delay before Fault This time is often used for waiting full group revert of protection after each time action, or disappear of "TV break of conductor' signal, or waiting for charging of reclosing. If it is only used for testing protective setting value but not been put into reclosing, this time is normally set 2~10s. If doing synchronously the reclosing test, it will be normally 15~25s. Every time when doing the fault test, tester will firstly enter the state of 'Time delay before fault', outputting three-phase rated voltage 57.7V, three-phase current is 0, and then entering the fault state again for outputting the component of fault set.

Off-hours of Test Every time when the fault test is ended, tester will stop output, it will wait for revert of protective contacts at this time state, normally setting it to be 0.5s is OK, and can also be set as 0.

The largest delay of reclosing If putting it into reclosing, doing reclosing test synchronously every time when doing fault test, the waiting for signals of reclosing within this time. This time should be larger than the time delay of setting reclosing.

- **Mode for triggering fault**

There are four kinds of triggering mode from the state of 'before fault' to state of 'fault': time control, key trigger, input c trigger and GPS trigger.

Time Control In this triggering mode, standing time of the state of 'before fault' will be confirmed by 'time delay before fault'. When time is up, it will enter the state of fault automatically. Under the control of time, the tester will do test automatically. You only need to switch shunt corresponding platen during the test.

Key-press Trigger In the state of 'before fault', press any key on keyboard of faceplate, or click the trigger key on software by mouse, it will enter the state of fault. The key-press trigger mode implements the process of manpower controlling test conveniently, which is convenient for

observing message of protection or printing testing result during the test.

Input c trigger   Input c of tester will enter the state of fault as soon as acknowledging the signal of displacement. This function can be used for doing tests for many testers synchronously.

GPSTrigger Connect GPS signal with communication port on backplate, doing combined adjusting test for two testers in different interspace through PPM pulse of GPS. It will enter the fault state when PPM pulse arrives

- **Zero Sequence Compensating Factor**

Providing KL、Kr/Kx、Z0/Z1 totally three kinds of expressing modes. For detail instruction, please refer to the instruction in the chapter of 'Intercommunicate Experience'. When doing earthing distance test, you must set correctly zero sequence compensating factor.

■ Distance Protection

Only when the test item of 'Distance Protection' is selected, this page will be at the active state, and it will allow setting corresponding parameters as shown on the right diagram:

- **Phase to phase Short Circuit Impedance & Earthing Distance Impedance**

1、You can tick ' √ ' for selecting the protection tests you needs to do.

2、Input directly the setting value of protection in the box of impedance data. You can select to input setting value in Mode Z-Φ or Mode R-X.

3、Each segment of current set must be larger than the inrush current of protection. Also the product of its impedance and current should better to be in the range of 20－40V during the phase to phase distance test, which must not be over 57v; During the earthing distance test, you'd better set the product of its impedance and current to be about in the 20－30V, that must not be over 57V. Normally you should also abide by the principle of the smaller the impedance (or reactance) is, the heavier the current will be, then you can ensure the test to be more accurate.

4、Every segment of 'Testing Time' set must be larger than the setting action time of this

segment. For example, suppose the action time of Segment I is 0s, then the one of Segment II is 0.5s, and the one of Segment III is 1.0s. Considering that trip of the protection itself has certain setting time delay, you can set the testing time of Segment I, II and III respectively to be 0.2s, 0.7s and 1.2s as the above diagram shows. So the ideal result of test will be: local segment acts when it is 0.95 times; local segment does not act when it is 1.05 times; it could not act if the next segment of time is not enough. You can also set three segments of times above-mentioned all to be larger than the third segment of action time. So the ideal result of test will be: local segment acts when it is 0.95 times; local segment does not act when it is 1.05 times.

5、Input all segments of setting action time in the box of 'setting time', and this time parameter is only used for reference, that won't influence the test result.

6、Clicking in the column of 'direction', you can switch between 'forward direction' and 'reverse' so as to test conveniently some distance protections of directivity.

7、Finally selecting the fault type needs to be test, among which the single phase earthing fault is used to verify earthing distance impedance; two-phase short circuit and three phase short circuit are used to verify phase to phase distance impedance. If you want to do earthing distance test, the zero sequence compenstating factor should be input correctly.

- **Multiple of Testing Impedance**

According to normal requirements for protective verification, the software provides 0.8 times, 0.95 times, 1.05 times and 1.2 times four kinds of default verifying multiple, and its numerical value can be amended. If the protection does not act in 0.95 times or 1.05 times, you can select 0.8 times or 1.2 times at that time, and you also can define the multiple by yourself to do test.

■ Zero Sequence Protection

Only when the test item of 'zero sequence protection' is selected, this page will be at the active state for allowing set of corresponding parameters as shown on the right diagram. Set of testing parameters for zero sequence protection is basically the same as the set of testing parameters for distance protection. When setting it, please refer to the instruction of above paragraph.

- **Calculating Mode of Short Circuit**

  Mode for making voltage to be constant

  For directly setting fault phase voltage in this mode. During the test, the fault phase voltage

output by tester will maintain unchanged whatever how heavy the fault current is. 'Fault Phase Voltage Angle' stands for the included angle of fault voltage and fault current.

Mode for making impedance to be constant

In this mode, the fault phase voltage will be calculated by fault current and fault impedance during the test.

■ Verifying setting value of power frequency variable impedance component

This test item is used for testing the action behavior of power frequency variable impedance relay, and it can verify the setting value of power frequency variable distance protection of certain lines as shown on the right diagram:

This mode allows verifying two segments of setting value at the same time, and simulating all types of fault once. When doing the test, you only need to tick the test item needs to be test, then setting parameters of all kinds of setting value in sequence according to the setting value list.

M has 0.9 and 1.1 two kinds of value in the default situation. Normally, the protection does not act reliably when M=0.9; the protection should be act reliably when M=1.1. You can measure the action time of protection when setting M=1.2

The parameter of 'short circuit current' should be set larger, 10~20 A is suggested. Since the short circuit current is too low, voltage calculated according to the above-mentioned formula may be a negative value. When doing the test, the 'distance protection' platen should be used.

Setting of the testing parameters is basically the same as setting of protection. Please refer to its instruction.

■ Vectorgraph

Click the 'vectorgraph' button during the test, you can observe actual vectorgaph of amplitude value and phase of voltage and current vector from the vectorgraph window opened. As shown on the right diagram:
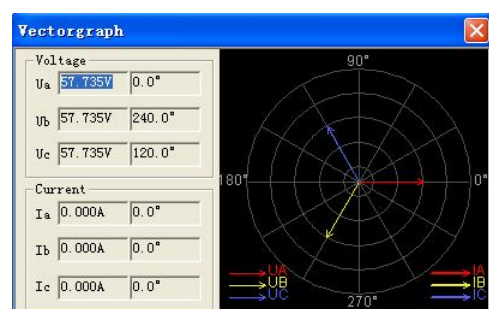
Section 2   Guidance for Test

Correct Connecting

When split phase trips, connecting Trip A, Trip B, Trip C and reclosing signal of protection with input terminal A, B, C and R; When the third trip happens, putting the trip signal in any terminal of A, B and C, and connect reclosing with R terminal.

Put-in or recede platen

Please input the protective platen corresponding to the item tested.

Select the test item, and set parameters of all items. For normal trigger mode, it will be set as the 'Time Control' mode.

Software will go back to the first page after the test, and doing tests in the sequence of testing data in list as shown on the right picture.

If you test synchronously earthing distance and zero sequence protection, the software will drop a hint of 'please recede zero sequence protective plate, and input distance protective plate' during doing the test of earthing distance protection; software will drop a hint of 'please recede distance protective platen, and input zero sequence protective plate' when doing the test of zero protection.

After ending the test, please save the test report according to the hint.

0.95 times and 1.05 times are two testing boundary points defaulted. When 0.95 times is selected, the local segment of distance protection should act reliably, and the local segment of zero sequence protection should not act reliably; when 1.05 times is selected, the local segment of distance protection should not act reliably, and zero protection should act reliably. In addition, Option 0.8 times and 1.2 times are available for reducing requirements for protective action when tests of 0.95 times and 1.05 times could not satisfy requirements of the above-mentioned action, those are tests of 'tolerance'. If it still could not act correctly, please check reasons of protection and contact with protection manufacturer for settling this problem.

During the test, if Segment II or Segment III should act, but you find that the action time recorded by tester is the action time of Segment I, please check whether the after acceleration of reclosing mis-operates. If so, please recede the after accelerate platen of reclosing or control words, then to do the test again.

When doing the test, if Trip A, B and C of protection is connected with Input A, B and C of tester, and you always hear that the tester sounds long 'woo' for alarming occasionally, but actually the tester could not record the action time of protection. Then, please check the fault phase always relates to which phase. For example, this situation occured while the AC phase to phase fault, and it also occured while BC phase to phase fault, so you can determine preliminarily that tester did not receive the signal of switching displacement transmitting from Protection Trip C. Please check whether the Protection Side Trip C is connected well. You can also short connect three signal lines of Protection Trip A, B and C, and connecting them together with Input A of tester.

If you want to make the protection to be under the multiple of certain setting value, make next segment of protection to act when local segment of protection does not act. Please set the 'largest fault time' of this segment to be larger than next segment of protective action time, 0.2s or above.

Attention：

1. The setting value of some protections such as the parallelogram characteristic protection of the Sifang Company is given in the way of reactance XX1－XX4、XD1－XD4, you only need to set the component of Reactance X, its compoent of Impedance R should be set as 0.

2. If you do the test of earthing distance protection, please set correctly zero sequence compensating factor according to the zero sequence compensating type and numerical value given by the setting setting value list.

Chapter 13　Characteristic of Impedance

This testing module is mainly used for searching the boundary of impedance action of distance protection aiming at its characteristic of action. It can search the boundary of impedance action of circular characteristic, polygon characteristic, arc, beeline and other characteristics. This testing module provides two different searching methods, 'Unidirectional Search' and 'Bidirection Search' as the following diagram shows:

- searching the characteristic graph of circle, polygon and other impedance.

- Setting parameters according to hints; software can draw graph approximately and can be compared with the searching graph conveniently.
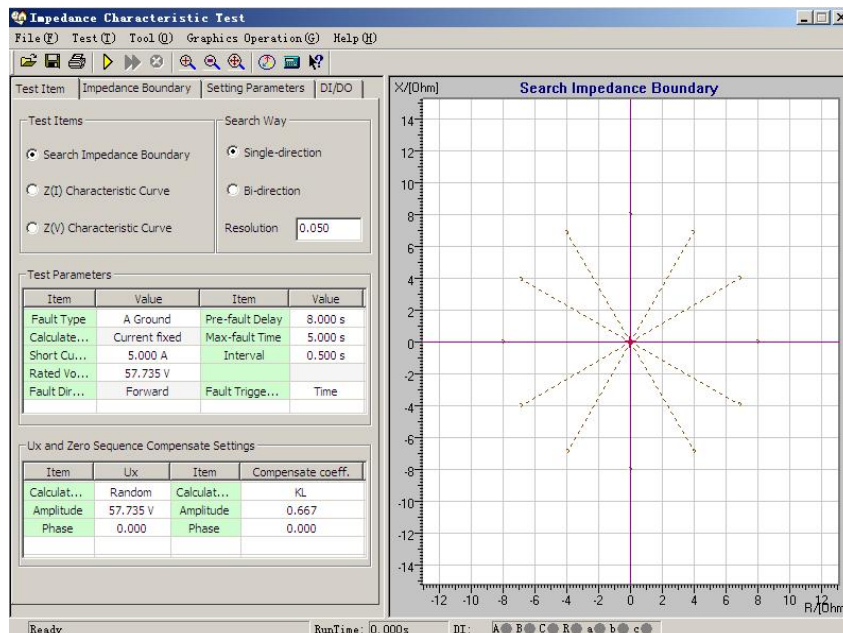
Section 1　　Interface Instruction

■ Test item

For every test, only one item of 'impedance boundary search', 'Z (I) characteristic curve' or 'Z (V) characteristic curve' should be selected.

　● **Fault Type** All kinds of fault types are available for testing all kinds of distance protections. For earthing type distance relay, single-phase earthing fault should be selected; for phase to phase type distance protection, the phase to phrase fault should be selected.

　●**Calculation Model** Two kinds of Calculation models, 'Constant Current' and 'Constant

Voltage, are available. When 'Constant Current' is selected, short circuit current can be set in the following box. The software will work out corresponding short circuit voltage according to short circuit current and short circuit impedance; when 'Constant Voltage' is selected, short circuit voltage can be set in the following box. The software will work out corresponding short circuit current according to short circuit voltage and short circuit impedance.

● **Searching Mode** Two kinds of modes are available, 'Unidirection Search' and 'Bidirectional Search'. For detail introduction, please refer to corresponding instruction on the chapter of 'Differential Protection'. The resolution is only effective for 'Bidirectional Search', and it decides the testing precision of bidirectional searching mode.

● **Mode of Fault Triggering** In the triggering mode of 'Time Control', software will test circularly in the sequence of 'time delay before fault' — 'the largest fault time' — 'interval of test'. For detail instruction, please refer to corresponding instruction on 'Line Protection'.

● **Direction of Fault** Setting it according to the setting value menu of protection, which is suitable for protection of directivity impedance.

● **Zero Sequence Compensating Factor** If you do the test of earthing distance relay, please do set correct zero sequence compensating factor. Please refer to corresponding instruction on 'Line Protection'.

■ Searching Boundary of Impedance

When the test item of 'searching boundary of impedance' is selected, radial scanning beam needs to be set as shown on the right diagram. For setting the scanning beam, please refer to the following mode:

● **Scanning Centre** The scanning centre should be set around the central position of characteristic graph of theoretical impedance of protection. You can put data directly in scanning centre, and also can click for selecting the scanning centre by the mouse. After the scanning center is revised, the coordinate axis will be adjusted automatically for ensuring that the scanning circle is always in the central position of graph, which means the scanning centre should be in the centre

Center Parameters		
Items	Center Position	Mouse Position
Z(Ohm)	0.000	15.532
Ph(°)	0.000	146.378
R(Ohm)	0.000	-12.933
X(Ohm)	0.000	8.600

Test Parameters

Items	Value	Items	Value
Radius	8.000	Start Angle	0.000
Step	1.000	End Angle	360.000
Range	100.000 %	Angle Step	30.000
		Line Number	12

Test Records

No.	State	Current	Setting Impedance	Set

of graph.

● **Scanning Radius** The Scanning radius should be larger than half of the setting value of protective impedance for ensuring that scanning circle covers all action boundaries of protection. Scanning will begin from the non-action area (points outside scanning beam) . During the test, if you find that the protection acts when it is scanning the outside point of certain search track, it represents that this scanning beam does not go beyond actual impedance's boundary, which means the whole search beams are in the active area, which does't conform to the principle of 'part of every search beam should be in the active area, but other part should be outside the active area'. At that time, please increase the 'scanning radius' properly.

●**Scanning Step Size** It is only effective for the mode of 'Unidirection Search', which influences directly the testing precision when the mode of 'Unidirection Search' is selected.

● **Scanning Range** It scans in one hundred percentage range in the condition of default. Setting suitable scanning range can normally avoid misoperation of other segment of impedance. For example, setting the scanning range to be 80%, searching beam is shown as the right diagram:
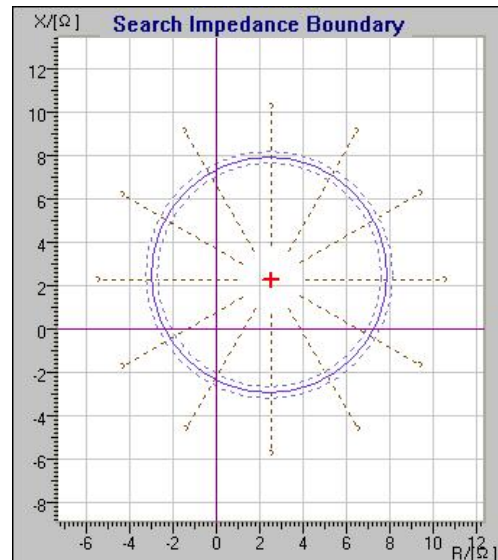
● **Searching Angle** Setting a series of searching beam through setting start angle, end angle and step size of angle. If the step size of angle is set very small, though it finds out many points that are favorable to increase precision of boundary search, the testing time will also be increased largely. So please select suitable step size of angle when you do actual test.

● **Automatically setting scanning parameters** On the the parameters setting page, after finishing impedance value setting, the software will automatically work out scanning central position and empiric value of scanning radius according to impedance value setting . If this value is still not appropriate, you can adjust it based on above operation.

■Setting Parameters

You can do the test without drawing the boundary graph of theoretical impedance on the interface of 'Setting Parameters', however, the user can determine more easily the central point of search and length of searching beam if the theoretical graph is available, which is also

convenient for comparing the testing results. We explain the drawing method in the following paragraph.

Drawing Polygon Select the characteristic of polygon, and select Data Input Mode 'R-X' or 'Z-Φ', then set the coordinate (R1，X1) of the first point of the angle in the column of 'angle point'. Usually the first point of the angle should be set as (0, 0). After completing the setting, click the 'add' key, and set the second point of the angle in the same way.The right diagram shows that these two points construct a line. Add several points in sequence according to setting parameters of protection. When setting parameters, R and X can all be set as negative numbers. Click the 'drawing' button after completing the addition.then the software will draw the curve of theoretical impedance boundary and corresponding error curve (as the dashed shows),you can move the cursor to central position of diagram, then click the left key of mouse to set scanning central point as the right diagram shows.
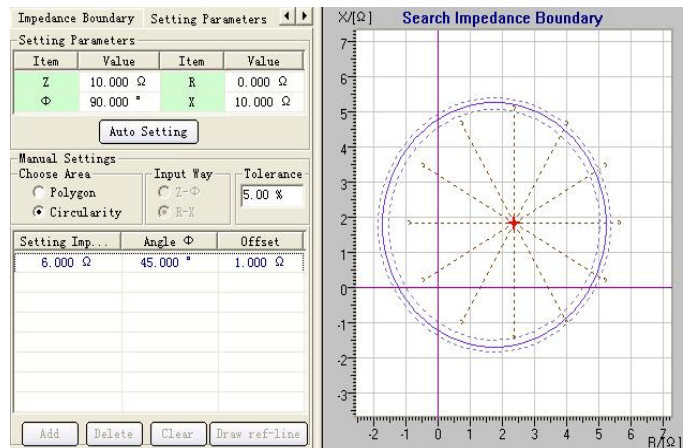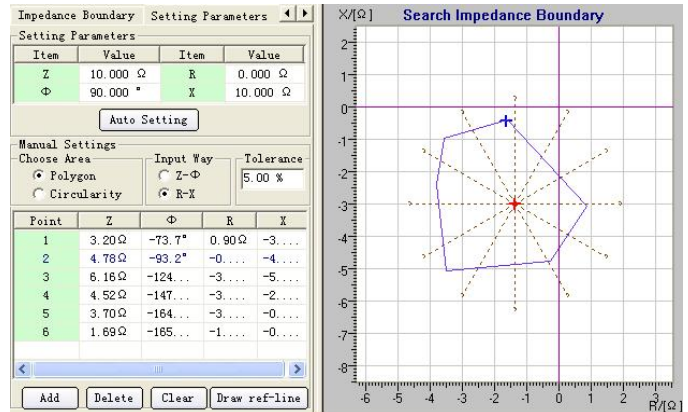
Drawing Circle Select Characteristic 'Circle' in above diagram, and set parameters such as 'setting impedance', 'angle of impedance' and 'offset' quantity' in the following diagram. The right interface will display its real-time figure. Click the centre of diagram by mouse, and set enough large scanning radius and corresponding step size on the interface of 'search impedance boundary' as the right diagram shows.
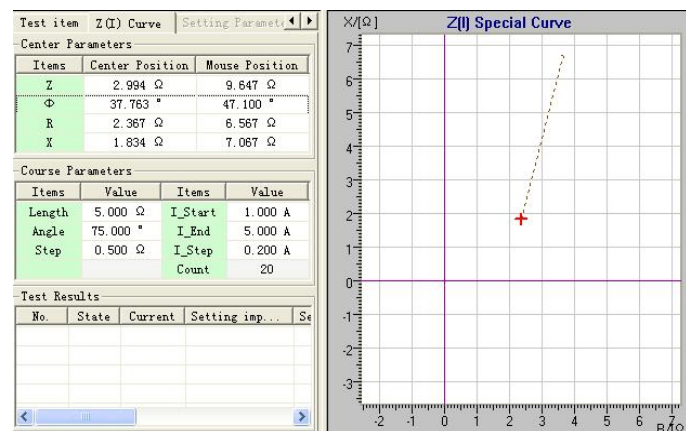
■ Characteristic Curve

Select the test item of 'Z (I) characteristic curve' on the interface of 'test item' for testing relation between current and impedance. Please refer to the

diagram above.

Parameters Set On the interface of 'Z (I) characteristic curve', set origin point, length and angle of searching beam, and original value and final value of current according to hints and setting value list. Afterwards you can observe actual effect diagram.

The process of this test resembles that of differential relay. If we can consider the impedance here as the 'differential current' of differential test, the current here is equivalent to the 'operating current'. When doing the test, the original value of impedance is 0 that will be increased in certain step size of search. It tests the operating current of protection of every impedance value. After completing the test, software will draw corresponding curve automatically. For 'Z (V) Characteristic Curve', please refer to 'Z (I) characteristic curve'.

Chapter 14   Differential Protection

The unit of differential protection is designed according to the characteristics of micro-computer type or integrate circuit type transformer, generator and differential protection of Motor. It is used for testing automatically its characteristics of ratio control, harmonic control, action time, etc.

Different from the 'characteristic test of differential relay control', this module does not do the test by directly loading action current and brake current on test, but loading primary current and secondary current on differential protective tester by simulating them，then it will combin action current and brake current by the protection.
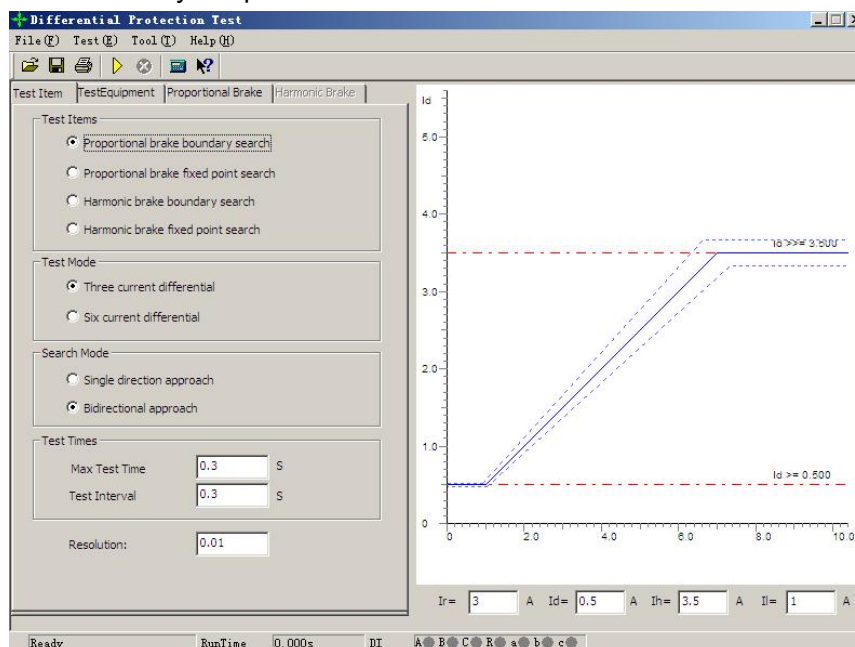
- Automatically searching characteristic curve of ratio control and harmonic control;
- Setting points for doing ratio restraint control test and harmonic restraint control test by will, and it can test action time;
- Drawn the theoretical characteristic curve of ratio restraint and harmonic restraint test in advance and estimate error range;
- Setting many kinds of arithmetic of brake current and action current controlled of ration restraint and harmonic restraint test;
- Secondary current verification of TA can be implemented by high side adjustment, low side adjustment or internal connecting adjustment (selecting the 'do not adjust' in the

software);

- For harmonic control, you can select 2~7 order harmonic;
- Fundamental wave and harmonic can be output separately from two sides, and also can be superposed to output from one side;
- Directly setting balance

coefficient, and it can

automatically finish calculation according to parameters of transformer. It can be used for testing differential protection of per unit value.

- Can output three channels current for doing single-phase differential test, and also can output six channels for doing high-low side full 6 phases differential test.

Section 1   Interface Instruction

■ Test item

The software provides four kinds of test items, they are 'Ratio Control Boundary Search', 'Ratio Restraint Setting Point Search', 'Harmonic Restraint Boundary Search' and 'Harmonic Restraint Setting Point Search'. 'Ratio Restraint Boundary Search' stands for that all action boundary of whole differential protection will be found out, which is the search of the whole action curve of protection; 'Ratio Restraint Setting Point Search' stands for that searching the action state of certain important point ,observing whether the action of this point is correct;the search aim of 'Harmonic Restraint Boundary Search' and 'Harmonic Restraint Setting Point Search' are the same as that of 'Ratio Control Setting Value Search', which includes searching the boundary of the whole action of harmonic and the protective action of certain setting point.

- **Testing Method**

'Three-channel Current Differential' and 'Six-channel Current Differential' are available for seclection. The differential testing unit can control the output of three-channel current when doing single-phase differential test, and it also can control the output of six-phase current for doing full six phases differential test on high-low voltage side. The function of three-phrase current differential test is included in Tester 'Relaystar-' and Tester 'Relaystar- 1000/1600', but the test of six-phase current differential only included in Tester 'Relaystar- 1000/1600'. Six channels current can simplify the connecting and parameters setting of transformer differential test.

Attention:

1. **When adopting the 'Three-phrase Current Differential test', IA of tester is**

permanently connected with the current output end on the high voltage side of differential protective tester; IB with current input end on the low (or middle) voltage side of protection; IC will be used for compensating current. When the phase of high voltage side be adjusted,IC is used for the compensating current on high voltage side,IC is also used for low (or middle) voltage side compensating current when the phase of low (or middle) voltage side is adjusted.For detail connection, please see the appendix.

2. When 'Six Phases Differential' is selected, IA, IB and IC should be permanently connected with Current input ends A, B and C on the high voltage side and connecting settingly Ia, Ib and Ic with current input ends of non-uniform low (or middle) a, b and c three phases of protection.

3. For 'Relaystar-', only 'Three-Channel Differential' can be selected; for 'Relaystar-1000/1600', both 'Three-Channel Differential' and 'six phases current Differential ' can be selected.

- **Way of Search**

Two ways of 'Unidirectional Approaching' and 'Bidirectional Approaching' are available for selection

Unidirectional approaching：   Beginning from the starting point, searching step by step from the direction of original value to the direction of final value. When it searches out certain point and the protection acts, this point is regardes as the action point. After recording this point, it will start searching for another line.

Bidirectional approaching：   It is dichotomizing search. After detecting the action of starting point (in non-action area) and final point (in the action area), you can do the test by taking the middle point between two points. If it acts, replacing the end point with this point; if it does not act, replacing the staring point with this point, then, continuing to take the middle points between starting point and terminal point. Approaching like this till the value of differential between the last two testing points is in the range of 'Resolution Ration', then we think the action boundary point is found. By using bidirectional approaching search, more accurate action boundary point will be found, and the searching speed will be quicker.

No matter which mode is selected, the starting point should usually be set in the non-action area, and the final point should be set in the action area.

Resolution：   It is only effective in the mode of 'Bidirectional approaching'. The smaller the resolution is, the higher the searching precision will be, but it takes longer time.

- **Testing Time**

The longest testing time:It means the longest fault time of every step output by tester.Usually it

should be set longer than setting action time of protection.

Interval: It represents the time between one fault and next fault protection output . The tester won't output any status quantity within this time.

■ Testing Equipment

Main parameters of transformer are set on this interface.

● Connecting Mode

For high voltage side, Style Y and Style Y0 can be selected; for low voltage side, four kinds of connecting modes can be selected, they are △-11, △-1, Y and Y0. For three-coil transformer, you should respectively do the test by taking two sides every time. For example, 'High－Low' and 'Low-High' connecting mode of the parameters selected should be the same as the one of corresponding transformer

● Setting Mode of Equilibrium Factor

Three kinds of setting modes are available for selection: setting equilibrium factor directly, calculating by

rated voltage and CT variable ratio, calculating by primary rated current and calculating by secondary rated current. The equilibrium factor has significant influence on the test, so its concrete setting mode should be done according to local condition .If the equilibrium factor of protection is given in the setting value of protection, we can select 'setting equilibrium factor directly', and input the equilibrium factor of high voltage side and low voltage side respectively . If the equilibrium factor is not given in the setting value of protection, we can select other three kinds of modes to set it. But please note that the mode of calculating equilibrium factor given in some protection instruction may be different from the setting mode of our program, we recommend that you calculate equilibrium factor firstly, and then selecting the mode of 'setting equilibrium factor directly' for directly inputting the equilibrium factor of high-low voltage side.

● Mode of Phase Adjustment

1、When the connection type of the transformer is Y/Y, two sides possess the same phase. TA connection type is normally Y/Y. Selecting 'not adjust phase'.

2、When connection type of transformer is Y/△, two sides possess the different phrase, and the TA connection type of microcomputer protection is normally Y/Y. If the protection is

designed to compensate by internal phase of high voltage side, selecting 'High Voltage Side Phase Adjustment'; If the protection is designed to compensatee by internal phase of low voltage side (such as the Type RCS-978 Protection of the Nanrui), selecting 'Low Voltage Side Phase Adjustment'. If the protection is designed for compensating by non-internal phase, it will be compensated by outside connection of TA, then selecting 'do not adjust'.

- **Ir、Id Calculating Formula**

1、 When 'General Differential' is selected, setting high side current (IA) as action current and low side current (IB) as brake current: Ir = Il, Id = Ih, you can set angle difference Φ（Id、Ir）.

2、 When 'Microcomputer Difference' is selected, Id = Ih + Il (vector sum of high-low side current is difference current). For Ir, many kinds of formula can be selected as the right diagram shows.
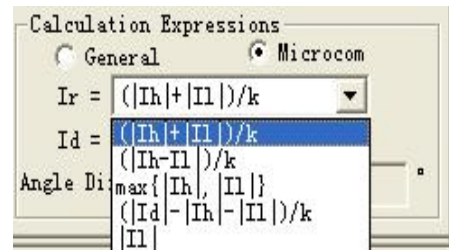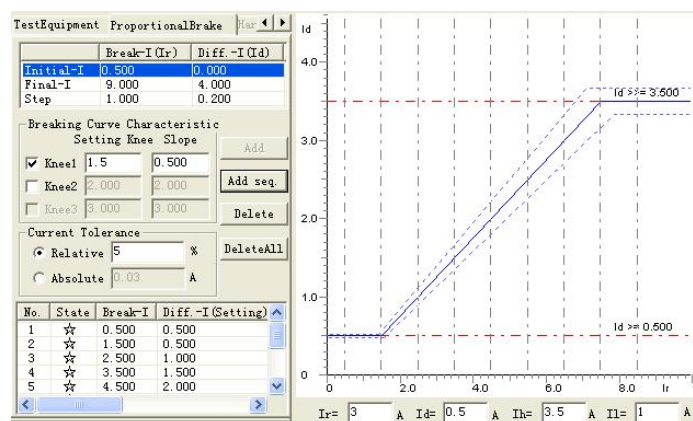
■ Proportional Restraint

On this interface, you can set the range of characteristic search of proportional restraint and parameters of theoretical characteristic curve.

- **Searching Range**

Original value, final value and step size of brake current decide the position of search beam, and they are required to be higher than the differential current corresponding to the current of protection. If it is unknown, you can set it to be the max output current of tester in order to ensure that it can search out the whole curve.

Original value and final value of difference current determine the length of search line, which is required to be slightly smaller than threshold value of differential current, and the final value should be slightly larger than quick break value of differential current. Step size of differential current is only effective in the mode of unidirectional approaching, but it is not effective in the mode of bidirectional approaching. Set step size of difference current

according to the precision of protection. If high precision is required, the step size should be set smaller.

After completing the set of searching range, selecting 'Add Sequence' or "Add" for putting the data of search line in the testing data list. Then selecting 'start the test'. Selecting 'delete' or 'output all' for deleting all single or the whole search lines selected.

- **Definition of Characteristic Curve**

Setting brake current of all knee points and slope of all segments of broken line (proportional control factor), combining the differential current value and differential quick break current value in previous interface, it can draw theoretical control characteristic curve. Set the setting values of all knee points according to setting value of protection. If knee point value is not given by the protective setting value, you can set it by referring to action graph of protection on the protection instruction. If there are many segments of curve, several knee points should be set. We can tick the box in front of Knee 2 for setting the second knee. Then, the theoretical curve of three segments of curve can be drawn. At present, the program can only set three knee points at most, which means it can only draw 4 segments of curve at most.

■ Harmonic Restraint

On this interface, the range of characteristic search of harmonic suppression and parameters of theoretical characteristic curve can be set.

- **Range of Search**

Original value, final value and step size of differential current decide the position of search line. Original value, final value of Ixb / Id decides the length of search line. Normally original value is required to be larger than setting value of harmonic controlling coefficient. Step size of Ixb / Id is only effective in the
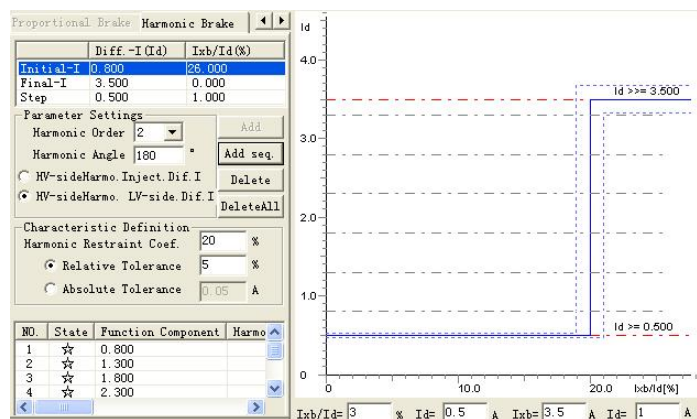
mode of 'Unidirectional Approaching', and it does not work in the mode of 'Bidirectional Approaching'. When setting parameters of the search line,the search lines should be distributed evenly between two horizontal lines, and also every search line should cover action area and non-action area. After completing the set of search range, you should select 'Add Sequence' or 'Add' for filling data of search lines in the testing data list. Selecting 'start the test' for starting the

test. Selecting 'delete' or 'output all' for deleting search line.

- **Definition of Characteristic Curve**

Completing the setting of harmonic restraint coefficients, and combining difference current value and differential quick break current value in the previous page,the characteristic curve of theoretical harmonic restraint can be obtained

Section 2   Guidance for Test

■ Connecting Mode of Six-Phase Current Difference

Connecting mode of six-phase current difference is very simply. No matter what kind of connecting mode is adopted by the transformer, the connecting modes are as following: connecting the first group three-phase Current IA, IB and IC of tester with Input terminals IA, IB and IC of high voltage side; connecting the second group of three-phase current Ia, Ib and Ic with input end Ia, Ib and Ic of low (middle) voltage side current of protection. The connecting mode is very simple.

■ Connecting Mode of Three-Phase Current Difference

1、Y（Y0）/ Y（Y0）Connecting Mode：
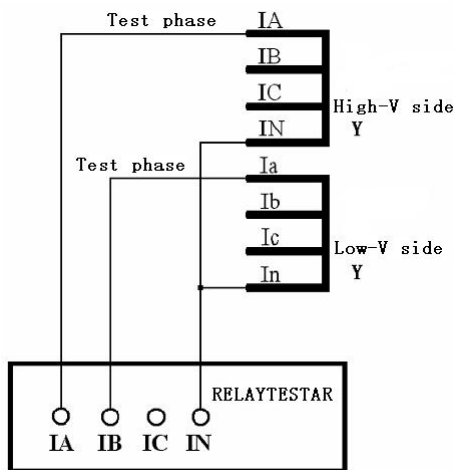

There is phase adjustment on two side,
but not zero sequence adjustment
Two sides should all be connected in the
mode of single phase short circuit.
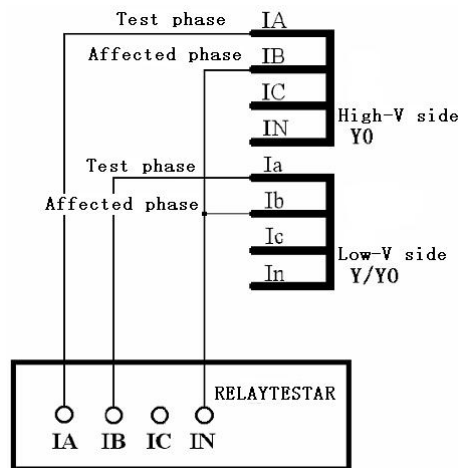
There is not phase adjustment on two sides, but zero
sequence adjustment.
For both sides, connecting testing phase with zero sequence
adjusting phase in the mode of   phase to phrase short circuit.

2、Y（Y0）/ △-11Connecting Mode：
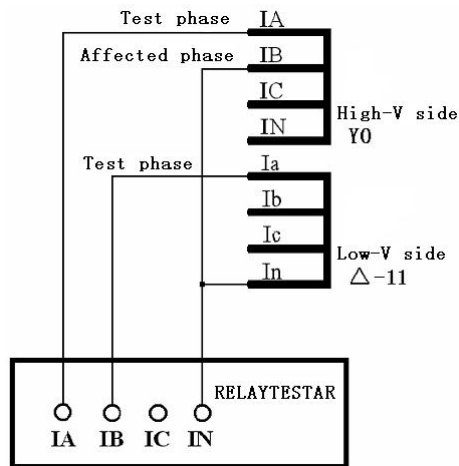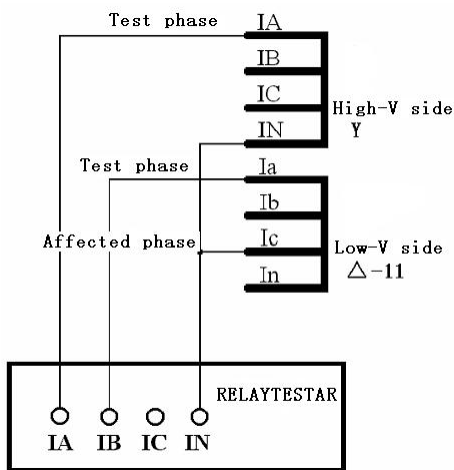
Y side has phase adjustment, not zero sequence single phase circuit mode.

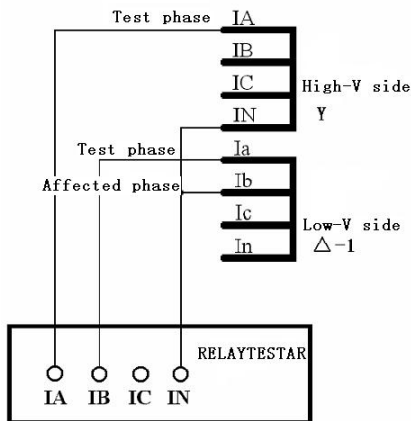△ side has phase adjustment, connecting in single phaseadjustment, connection in single phase short circuit mode.

Y side has phase adjustment, connecting in single phase short circuit mode.

$$IA'=IA-IB \quad IB'=IB-IC \quad IC'=IC-IA$$

Connecting the testing phase on △side with the phase influenced in phase to phrase short circuit mode.

$$Ia'=Ia-Ic \quad Ib'=Ib-Ia \quad Ic'=Ic-Ib$$

Y0 side has zero sequence adjustment. Connecting the testing phase on Y side with the phase influenced in phase to phrade short circuit mode.

3、Y（Y0）/ △-1 Connecting Mode：

Y side has phase adjustment, not zero sequence. connecting in single phase short circuit mode.

$$IA'=IA-IC \quad IB'=IB-IA \quad IC'=IC-IB$$

Connecting the testing phase on △side with the phase the influenced in phase to phrase short circuit mode.

△ side has phase adjustment, connecting in single phase short circuit mode.

$$Ia'=Ia-Ib \quad Ib'=Ib-Ic \quad Ic'=Ic-Ia$$

Y0 side has zero sequence adjustment. Connecting the testing phase On Side Y with the phase influenced in phase to phrase short circuit mode.
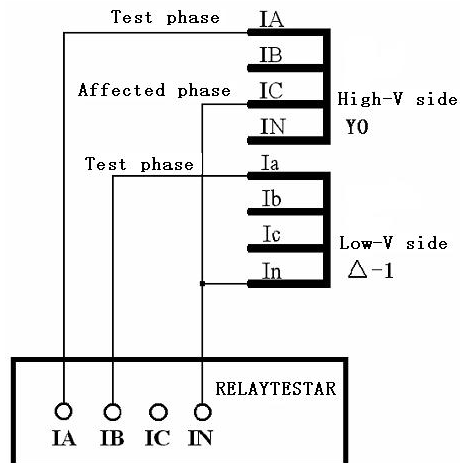
Attention：

Microcomputer differential protection is a relative complex protection, so you can't avoid coming across some problems during debugging. Generally the following points have significant influences on test result:

1、Setting equilibrium factor. Wrong equilibrium factor may lead to a large deviation between the curve tested and setting curve.

2、Selection of restraint formula. Wrong selection of restraint formula results in the testing curve and restraint coefficient calculated deviating from the setting value of protection, even completely wrong.

3、When doing the test by three-phase current, if compensating current does not be included, generally speaking ,if the first action point acts correctly, action points following it will act immediately after current is added. In this case, though the testing phase does not satisfy the condition of differential action, the differential current of compensating phase will exceed the setting value of differential action, so the protection will act quickly.

■Instruction on parameters setting of several kinds of microcomputer's differential protection

The differential module can be tested not only by three-channel current but also by six-phase current. If you do the test by Model tester, it can be done only by three-channel current. If the test is done by Model 1000/1600, both three-channel current but also six-channel current can be employed. When three phase current is adopted, the largest output of every phase current can achieve 40A; when six-channel current is adopted, each phase current of Model 1600 can achieve 30A (the one of Model 1000 can achieve 20A)

- As for three-channel current difference,please refer to the instruction on the connection in the chapter of 'Differential Protection";for six-channel current difference, connecting the first group IA, IB and IC of tester with three-phase current input terminals on high voltage side of protection; respectively connecting the second group Ia, Ib and Ic with three-phase current terminals on low (middle) voltage side of protection. When doing the test of six-channel current difference in 'AC Test', the phase difference and the connection type of the transformer are as the following form shown:

Connection type of Transformer	Phase of the Current on High Voltage Side	Phase of the Current on Low Voltage Side
Y/Y-12	0º	180º
Y/△-11	0º	210º
Y/△-1	0º	150º

Most of Parameters Setting Values of protection give the current value directly. For example,

the value of differential threshold is 2A, the unit is A. However, the setting values given by some protection are not current value but a coefficient. For example, the value of differential threshold is 0.3 without an unit. Actually, it is the setting value of protection given in the mode of 'Per Unit Value'. You can convert per unit value to actual current as the following formula: Actual current value = per unit value × rated current on high voltage side.

- Calculating method of Rated current:

$$Ie1=Sn / （1.732 * U1n * CT1）$$
$$Ie2=Sn / （1.732 * U2n * CT2）$$

In which:

$Ie1$、$Ie2$ — transformer I、II side secondary rated current

Sn — the largest rated capacity of transformer

$U1n$、$U2n$ — transformer I、II side primary rated voltage

$CT1$、$CT2$ — CT ratio respectively on the primary side and on secondary side

Note ： Some protections have calcualtion function themselves,in this case , $Ie1$ 、 $Ie2$ are calculated without considering 1.732 mentioned in above formula. For example, calculating $Ie1$, directly according to the formula: $Ie1= Sn / （1.732 * U1n * CT1）$ .The reason is that the equilibrium factor includes 1.732 when calculating the differential and brake current.

Take connection of transformer Y/Y/△-11 as example, calculating mode of each side's equilibrium factor is as follows:

$$K1=1/1.732=0.577$$
$$K2=U2n * CT2/（1.732 * U1n * CT1）\quad K2=U3n * CT3/（U1n * CT1）$$

If setting equilibrium factor on high voltage side to be 1, and convert other sides to high voltage side, its calculation formula is as follows:

$$K1=1$$
$$K2=U2n * CT2/（U1n * CT1）\quad K2=1.732 * U3n * CT3/（U1n * CT1）$$

Calculating equilibrium factor in terms of current is as following:

$$K1=1$$
$$K2=Ie1/Ie2$$
$$K2= Ie1/Ie3$$

In which：

K1、K2、K3 — equilibrium factor on Transformer I、II、III side $Ie1$、$Ie2$、

$Ie3$ — secondary rated current on Transformer I、II、III side $U1n$、$U2n$、

$U3n$ — primary rated voltage on Transformer I、II、III side CT1、CT2、CT3

— CT transformation ratio on Transformer I、II、III side

Note ：

Equilibrium factor of differential protection are not all the same, the calculating mode of some protections may not be the same as the above-mentioned one. Please refer to corresponding instruction when doing the test.

Chapter 15 Differential Harmonic

This module is intended for testing the characteristic of harmonic control of differential protection, and it also can be used for testing other harmonic protections. It can test not only differential relay but also the differential protection of microcomputer. It outputs the differential current of harmonic superposition not only in one channel, but also in two channels by pressing the mode of 'one side differential current, another side harmonic'. It can output 9th harmonic at most, which satisfying basically the requirements of normal harmonic tests.

- Style of software interface is similar with the one of 'AC Test' for simply operation of test.
- It can arbitrarily superposition component of 9th harmonic at most, and the amplitude value or phase of every harmonic can be set arbitrarily.
- It can directly amend amplitude value, phase and step size of verification of current in the testing state of not stopping the output, or change phase of variable.
- You can select arbitrarily the varatioal mode of variable in hand movement or automatic increase and reduce for controlling flexibly.
- Displaying real-time waveform of two-way superposition in graph form so as to observe the testing process directly.
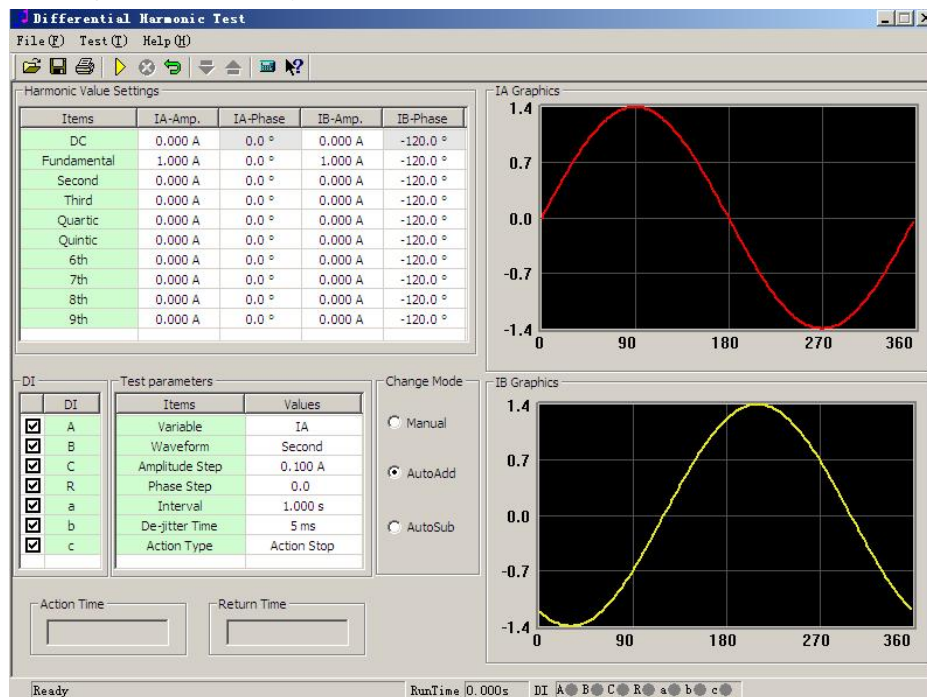
Section 1　　Interface Instruction

■ Setting Parameter

Before doing the test, you should set original values of every channel on the interface. The component of needless harmonic should be set as 0. There will be output definitely in the channels whose values are in the interface. So, If you do not hope any output happended in certain channel, you should set all amplitude value of every waveform to be 0, or do not connecting with this channel.

When doing normal tests, phases of fundamental wave and harmonic are synclastic, such as all being set as 0°. It is can also set as reverse. This phase decides initiative angle of this waveform output by the tester when test is started. If initiative angles of all waveforms superpositioned are different or reverse, which may influence the test.

When doing the test in the mode of differential harmonic control, it can not only output harmonic by IA to high voltage side of protection, and outputting fundamental wave by IB to low voltage side of protection, but also outputting by reversing IA and IB, which won't influence normal testing.

■ Variable Option

Software only allows selecting one channel of IA and IB as variable. Select the channel at first, then, select certain harmonic component of this channel in pull-down menu below as variable. Which means only certain waveform component of one current (IA or IB) channel will vary during the test, and others are all 'constant'.

If you need to reset variable without stopping output during the test, you can select the mode of 'Hand Movement' in the column of vary modes, most of parameters on the interface can be amended at that time. After completing the amendment, data can be read in by pressing the 'confirmation' key on small keyboard on the tester or the 'enter' key on notebook computer. After that, the tester will output according to new data. The tester can also read in new data through switching current mode of 'HM test' to other automatic modes by the mouse. The effect is the same.

■ Action Mode

The following two kinds of modes are only effective to variational modes of 'automatically increase' or 'automatically reduce'.

Action Stop If this mode is selected, the tester will stop test as soon as receiving action signals of protection. This mode can only test actional value of protection. If you do the relay test, the 'flutter-proof time' should be set as 20ms or above for reducing the influence on test caused by 'flutter' of relay.

Action return When this mode is selected, supposing current variable varies according to the mode of 'automatically increase', the tester will transfer direction automatically to the mode of 'automatically reduce' as soon as it receives actional signals of protection. This mode not only can test the action value of protection but also can test automatically the return value. If doing relay test, you should also set 'flutter-proof time' to be 20ms and above.

■ Input Option & Action Display

All seven inputs on the default interface of software can be selected together, which are all effective. If you need to cancel the influence of certain input on the action signals of protection, you can cancel this option by mouse before the test.
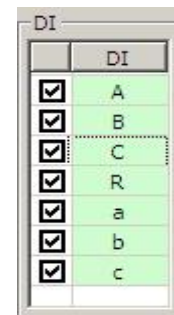
Section 2　　Test Guidance

■ Setting Parameter

- When doing the characteristic test of harmonic control of transformer, it can be loaded not only on high voltage side but also on low voltage side if single-phase current is selected for outputting differential current of harmonic superposition. When outputting it by adopting two-phase current synchronously, it loads the harmonic output by IA on high voltage side, and loading the fundamental wave output by IB on low voltage side. On the contrary, it can load fundamental wave on high voltage side by IA, and loading harmonic output by IB on low voltage side.

- For testing mode, you can fix fundamental wave, and adjusting harmonic from large to small in step size (harmonic should be set as variable at that time); or fixing the harmonic, and adjusting the fundmental wave from small to large in step size (fundamental wave should be set as variable at tht time). The testing effects are basically the same.

■ Testing Mode

Before the test, you can amend the connecting mode of transformer of differential protection to be Y（Y0）／Y, and setting equilibrium factor of low (middle) voltge side to be 1, which will simplify the test. When doing the test, no matter only loading current on high voltage side or loading current on high and low voltage sides at the same time, its principle is as follows:

1、Component of fundamental wave output must be larger than the action threshold current set by protection;

2、Output initial harmonic content must be protected by reliable lock-out, which means it must be larger than the coefficient of harmonic control set by the protection.

If the connecting type of transformer of differential protection is Y（Y0）／△, and the equilibrium factor of high and low voltage side are all not 1, how to test the ratio control coefficient of protection under the condition of not amending settings?

- **Outputting in the state of 'differential current of harmonic superposion on high voltage side'**

Since component of harmonic and component of fundamental wave are all added on high voltage side, component of two kinds of waveforms influenced by equilibrium factor of high voltage are the same, they will be counteracted mutually. So its testing mode is as same as the statement of above paragraph. Please refer to it.

- **Outputting in the state of 'harmonic on high voltage side, differential current on low voltage side'**

You must consider respectively the equilibrium factor of high and low voltage sides.

For being convenient to explanation, we hereby suppose the equilibrium factor of high and low voltage sides are respectively Kh and K1, differential threshold value is Ido, and harmonic control coefficient is Kxb, then:

a) The output component of fundamental wave (suppose it is output by IB) must be larger than $Id_0／Kl$；

b) The output initial harmonic content (suppose it is output by IA) must be larger than $Id_0＊Kxb＊Kh$.

Start the test, and reduce harmonic in step size till differential action acts. Suppose the harmonic current and fundamental wave current output by tester is respectively IA1 and IB1 at that time, then the formula of computing the coefficient of harmonic control:

$Kxb＝Ixb／Ijb＝（IA1／Kh）／（IB1＊Kl）$

Chapter 16 Comprehensive Test of Line Protection of 6-35 KV Microcomputer

This testing module concentrates most parts of test items of microcomputer line protection of low voltage, which is suitable for testing line protection of insulated system on 6~35KV neutral point. In whole testing process, we select the testing mode of 'Two Way Approaching' mostly, which enhance work efficiency of test.

- After all wires are connected, it can test completely all items in one time without human intervention.

- You need not to recede from other segments, just verifying settings of three segments of overcurrent protection in one time.

- Whole module adopts the testing mode of 'Two Way Approaching' mostly, which saves time and enhances test's effective.

- Gathering almost all kinds of testing functions of line protection of central point insulated system.

- Simple and clear interface. You only need to set a small quantity of testing coefficients. Some of them only need to input settings.

- In the test item of 'Power Direction', it blurs the positive and negative concepts of 'Sensitive Angle' on purpose. It can do the test correctly by inputting positive angle or negative angle.
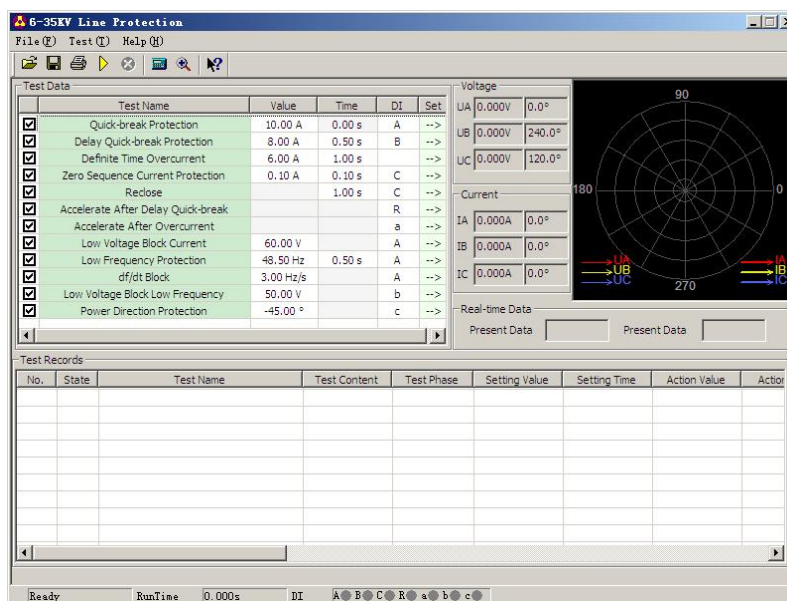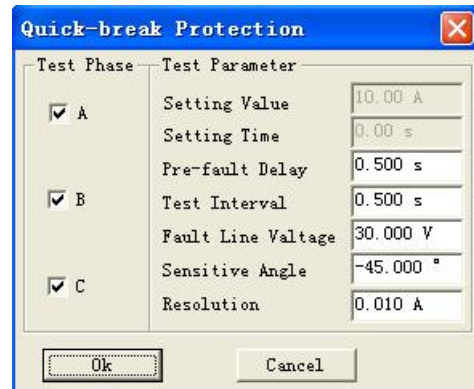
Section 1   Interface Instruction

■ Triple-segment type overcurrent protection: quick break, time delay quick break and time overcurrent limiting

These items are used specially for testing triple segments of overcurrent protection. After inputting correctly all segments of settings (including action value and action time) according to settings list, you can do one test without receding other segments.

When doing the test, select respectively the test item needs to be test, and set 'settings' and 'setting time' of all segments of actions. Then, click the '→' button by mouse. After that, set other testing parameter in a dialog box ejected. We hereby take 'quick break protection' as the example for detail explanation. See the right diagram:

Attention:

The 'settings' and 'setting time' required for output on the interface must be filled correctly according to actual settings set, otherwise, it may influence the result, and may even lead to unsuccessful test.

- **Test Phase**

The test is done through loading current on split phase, so Phase A, B and C is available for option. You can select single phase or several phases synchronously for testing, the software will do the test in sequence. When doing certain phase test, only this phase current has output, but other phase current is zero.

- **Fault Line Voltage**

For the protection having the function of 'low voltage lockout', triple current needs to be loaded. Only when line voltage is smaller than the settings of low voltage, it open overcurrent protection; otherwise, it will close down for protection, and it won't act even the current is very large. In this situation, it is required that this parameter should be smaller than the settings 'low voltage lockout' of protection. No matter you test which phase during the test, triple phase all has output, and UBA, UBC and UCA are all

equal to setting fault line voltage.

During the test, you can observe clearly the amplitude value of current and phase output by current voltage and current channel from software's interface. When doing the test of low circle unloading item, you can also supervise frequency of output voltage as the right diagram shows:

- **Sensitive Angle**

Sensitive angle of power direction. For inputting power directional element, you should set correctly sensitive angle. Normally just do it according to default value.

- **Resolution**

This parameter decides precision of testing value. 0.01 resolution defaulted already can meet normal testing requirements of microcomputer's protection.

■ Zero Sequence Current Protection

The zero sequence current of lines of small earthing system is larger, so the protection also has functions of zero sequence current trip or alarming.

Setting mode of testing parameters on the interface is similar to the one of above-mentioned triple overcurrent. Please refer to it. The difference is: 'column of 'test phase' in the dialog box ejected is not opened. Since the protection only has individual phase zero sequence, zero sequence current is output settingly by IA phase of tester for doing the test. When doing the test, connect IA of tester with input end of zero sequence current of protection regarding as zero sequence current of protection.

■ Reclosing

This item is used for simulating action of triple phase primary automatic reclosing. Before the test, you must input the function of reclosing of protection firstly. During the test, set a fault current for making certain segment of overcurrent protection to act reliably. Tester will transfer to normal state for outputting at once. It will wait for success of coincidence within the time slightly longer than 'setting time reclosing'.
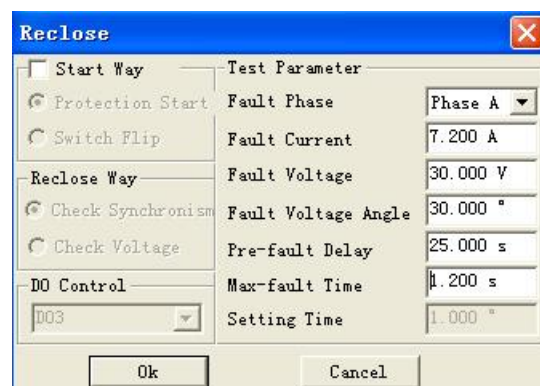
Attention: When switch is closed by hand or after reclosing acts, the reclosing discharges at once. The reclosing is in the locking state before fully charging again. Any faults will only trip without coinciding at that time. Charging time of reclosing is normally between 15s-25s. Parameters are as the right diagram shows:

The 'setting time' required by interface stands for the time of reclosing set by protection.

- **Fault Current, Fault Voltage and the Largest Fault Time**

Setting parameter of fault state before the protection coincides. This fault current and voltage should ensure reliable action of protection. 'Fault Current' is normally larger than certain segment of overcurrent setting value, and 'the Largest Fault Time' should be longer than the setting time of Period III, 0.2 or above, of overcurrent.

- **Time Delay before Fault**

If the reclosing does not charge fully, this parameter normally should be set between 15~25s so as to waiting for completely charging of reclosing. If the reclosing has charged fully before the test, this time can be set shorter in order to save testing time.

Attention：

Some protections require the switch to start reclosing only when it is on the switch-on position, which means it loads electric potential on the switching position end of protection for judging where the switch should be closed. During whole testing process, the Output 2 of tester outputs by simulating position of switch. It will open 2 closures in the state of 'before fault' and 'after coincidence', and will open 2 switch- off in the state of trip. So you can connect 'Output 2' with corresponding DC circuit in series for making the protection to distinguish switch's position correctly.

■ Acceleration after Time Delay Quick break & Acceleration after Overcurrent

These items are used for testing the process of trip of after-acceleration after the operation of reclosing in the state of permanent fault. When doing the test, tester will output again the same fault quantity as previous time after receiving action signals of reclosing of protection in order to wait for retrip of protection and testing of time of after-accelerated trip.

For doing the test, the following conditions need to be prepared:

1、Fault current, voltage, sensitive angle and fault time set in parameters should ensure correct action of the segment of overcurrent tested. (Please refer to relevant instruction to overcurrent protection of previous paragraph);

2、Providing protective functions of 'Acceleration After Time Delay Quick break' or 'Acceleration after Overcurrent' corresponding to this overcurrent segment;

3、Providing the function of reclosing (please refer to relevant instruction to reclosing of previous paragraph);

4、The protection of reclosing is started only when receiving signal of switching position. You should put in the contact signals of Output 2 correctly.

■ Low Voltage Latching Overcurrent

This item is used for testing the latching voltage value of protection of low voltage latching overcurrent, and this value is the line voltage value. You should put in the function of 'Low Voltage Latching' of protection of the segment of overcurrent waiting for test.

This item also does the test in three-phase successively. For example, when testing UAB, two phases of A and B are fault phases, Phase C is normal voltage, and UAB is fault voltage. No matter testing phase selects UAB, UBC or UCA, three-phase current all output current synchronously during the test. Amplitude values of three-phase current are all equal to the setting 'Fault Current', and they will be output in positive sequence phase
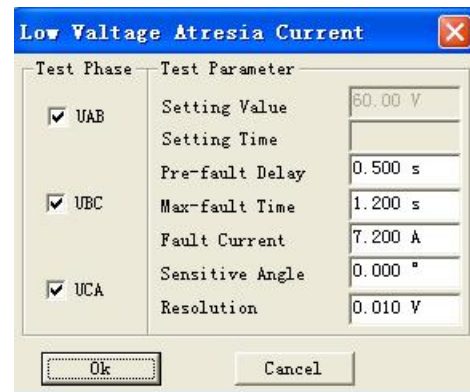
'Fault Current' and 'The Largest Fault Time' should be all respectively larger than corresponding setting value of the segment of overcurrent waiting for test. Please see the right diagram for reference.

For setting other parameters, please refer to relevant instruction to 'Triple Segments Type Overcurrent Protection' of previous paragraph.

■ Low Frequency Protection

This item is used for testing action frequency and action time of low or high frequency protection. Please see the right diagram for setting parameters.

• **Time Delay before Slip of Frequency**

Output firstly the voltage-current in initial frequency before doing the test every time. It can unlock low frequency protection through adopting 'Time Delay before Slip of Frequency', then, it begins to slip the frequency. This time parameter is used for unlock frequency by protection.
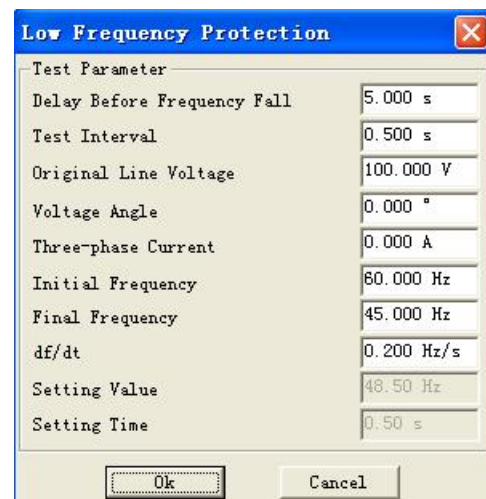
• **Initial Line Voltage and Three-phase Current**

Some protections have the function of 'Low Voltage Locks Low Frequency', so 'Initial Line

Voltage' should be larger than 'Latching Voltage' of protection. You can normally set it to be 100V defaulted.

Some protections require load current to open the function of low frequency. If there are not current or current is too small, the protection considers that it is no need to cut load, and then it will lock the low frequency function. So you should connect current testing lines in advance, then setting 'Three-phase Current' to be larger than 'Setting Value of Current' of protection. When doing the test, three-phase voltage and three-phase current will output at the same time, and it will change frequency synchronously.

- **Initial Frequency & End Frequency**

The basic principle of setting parameters is: Protection should not act reliably in initial frequency; protection should act reliably in end frequency.

For the protection having 'starting frequency', it is required that initial frequency must be larger than the value of 'starting frequency' of protection. 'Initial frequency' is normally set as 50Hz.

Normally end frequency should be at least 0.5Hz smaller than setting action frequency, but it also can't be set too small, otherwise protection may be locked. It should normally not lower than 45Hz.

- **Percentage Change df/dt of Frequency**

During the test, protection slips uniformly in setting df/dt at first. When it slips to the position of 'Setting Action Frequency ＋0.1Hz', tester will change it to converse frequency measure by measure in the rate of '0.01Hz/ each step time' till protection acts. The action frequency and action time will be measured. Here 'each step time' is equal to 'Setting time＋0.2s'.

■ Slip Latching

When frequency slips too quickly and df/dt is larger than the setting value of slip latching of protection, the protection will be locked without action; when df/dt is smaller than the setting value of slip latching, the protection will unlock it for allowing operation. If the protection is in the latching state originally, certain times will be needed for unlocking it from locking, so the 'Time Delay before Slip of Frequency' should be set enough large such as 5s. Meanwhile, low frequency has certain action delay, so end frequency should be set smaller than the action frequency set by protection such as 47Hz. Otherwise it may not act due to lack of sliding time. For the meanings and setting modes of parameters, please refer to the 'Low Frequency Protection mentioned in previous paragraph.

■ Low Voltage Latching Low Frequency

Different from the above-mentioned 'Slip Latching', here the low frequency protection locks when line voltage is lower than the latching voltage value set by protection. For modes of setting parameters, please refer to instructions to 'Low Freqeucy Protection' and 'Slip Latching' in previous paragraph.

■ Power Direction

Through this item, you can measure two boundaries of protection of power direction correctly and quickly, recording boundary angle and working out automatically the largest sensitive angle. Considering that differentiating positive pole from negative pole of the largest sensitive angle is difficult for some users on the spot, the technology for blurring output of setting
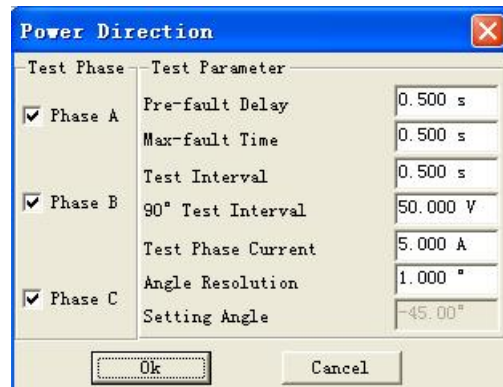
value of the largest sensitive angle has been used in the software. Suppose the largest sensitive angle of protection is −45°, no matter users input −45° or +45°, there ar not any influence on normaly test. The right diagram shows the dialog box for setting parameters.

In this item, tests are also done in three-phase successively. You can select single phase or all phases synchronously to be test phases. When testing certain phase, only this phase outputs current, and current of other phases is zero.

- **Off-hours of Test**

For meeting the testing requirements of certain protections needs to be started by 'Mutation Start', we hereby set this parameter. When it is a non-zero value, basic process of test is: output voltage and current in normal state (voltage is the rated value, current is 0), maintain them till 'Time Delay before Fault' ends—ouput preset voltage and current in the state of fault, maintain them till 'The Largest Fault Time' ends —stop outputting till the 'Off-hours of Test' ends—— output again voltage and current in normal state, maintain them till 'Time Delay before Fault' ends —— output mutatedly the fault voltage and current in another state till 'The Largest Fault Time' ends—— stop outputting till 'Off-hours of Test' ends. Outputting circulatedly like this till it tests a actional boundary of protection.

- **Line Voltage of 90° Connection**

This software can only test protection of the power direction connected in the mode of 90°.

When testing Phase A, Only IA can output current, and current of other phases is zero; only UB and UC output voltage, and voltage of other phases is zero. In addition, amplitude value of Current IA is equal to setting 'Test Phase Current', amplitude value of line voltage UBC is equal to setting 'Line Voltage of 90° connection'.

- **Resolution of Angle**

This parameter decides the precision of test. When the software finds the angle difference value of current output two times is smaller than 'Resolution of Angle', it will automatically stop outputting and end the test. We normally set it as default value ,1°.

Chapter 17　　Fault Review

fault Review is used for putting the data documents of current-voltage waveforms compiled in Data Format ANSI/IEEE C37.111-1991COMTRADE that is recorded by data recording equipment like fault waveform recorder in the tester, and its waveforms will be reviewed by tester for testing equipment like protection tester.

Each standard recording document consists of three kinds of documents. They are respectively pilot, configuration and data document. Names of these three kinds of documents are the same, which can be differed by different suffix names that are respectively .HDR, .CFG and .DAT. The review test can't be done unless three documents are complete.

Before the test, please open certain recording document at first. Recording document can be laid in any subentry that can be found in the dialog box of 'open the document'. The program will list all documents whose suffix name is .CFG after finding the subentry. After selecting certain document, the program will transfer automatically the .CFG and .DAT documents of this name, and display all voltage-current waveforms and name of channel on the screen. In addition, you can also check document's attribute, waveform discretion sampling point, etc. through the buttons in tool column.

Press the 'Test' key to enter a dialog of several pages testing options:

Page 1：　Select wave recording voltage and current line needs to be tested. You can select in the mode of whole group of voltage, whole circuit of current, and also can select separately and independently three-phase voltage or three-phase current.

Page 2：　Selecting the wave recording segment of time, starting-end points, needs to be reappeared. Basic unit of time point is according to numbers of waveform sampling point. You can input data on time point, and also can increase or reduce it by pressing the '↑' key and '↓' key on keyboard.

Page 3：　Outputting it in original ratio or outputting it after the change of PT and CT in transformation ratio. When outputting in transformation ratio, you should divide the data by this transformation ratio value. In addition, if data of certain phase needs to output after 180̊ revrse phase, you can set the transformation ratio to be a negative number such as '-1/1', then this phase will be output in original anti-phase ratio.

Page 4：　Transmitting automatically all selected data to the lower machine for waiting for reappearance output.

Page 5： Doing the reappearance test officially. The 'upper button' on this page makes the

tester to output circularly the first periodical waveform, and waiting for your pressing of 'lower button'; press the 'lower button', the tester will output all recording waveforms till the end point of reappearance time segment for reappearing whole process. You can also don't press 'up key' but press directly 'down key', it will reappear completely all waveforms from starting time segment to end time segment in one time.

After ending the test, computer will file the testing result in the subentry of 'test report\fault reappearance' in text format, and it can be displayed or printed by pressing the 'print' key. You can also copy it to be compiled or amended by compiling tools like WORD.