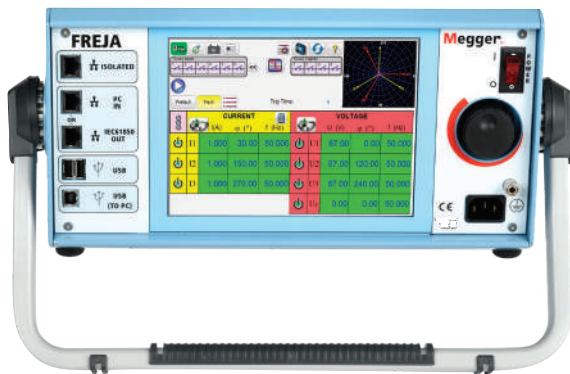


# FREJA 543 Relay Test System

**FREJA 543**  
Relay Test System



- Fully automated testing using FREJA Win software
- Stand-alone operation using intuitive high resolution graphic touchscreen, no PC required to operate
- 4 Voltage channels, 3 Current channels
- High current, high power output – up to 60 Amps / 300 VA rms per phase
- Dynamic GPS Satellite Synchronized End-to-End Testing Capability
- IEC 61850 Testing Capability

## DESCRIPTION

The FREJA 543 is a multipurpose, lightweight, field portable relay test set from Megger. The unit is operated via the built-in touchscreen user interface. The built-in user interface is Megger's second generation of automatic / semi-automatic manual user interface running the FREJA Local software. The large, easy to read Full Color high resolution, high definition, TFT LCD touch-screen display allows the user to perform manual, steady state and dynamic testing quickly and easily.

FREJA Local includes built-in preset test routines and relay test templates for automatic testing of protection relays and protection schemes. Menu screens and touch screen function buttons are provided to quickly and easily select the desired test function. Tests, and test results, can be saved in FREJA Local memory and downloaded to a USB memory stick for test data transfer or to print test reports. For full automatic testing on a PC, each FREJA unit comes with an install version of FREJA Remote. FREJA Remote is the FREJA Local software designed to run on a PC with Windows 10 operating system.

FREJA Win software is an optional software program for FREJA customers who want to continue to use the legacy FREJA Win software with a PC. The FREJA Win software includes a number of instrument programs to test virtually any protection.

## APPLICATIONS

The FREJA 543 is primarily designed for secondary testing of protection relays. Virtually all types can be tested.

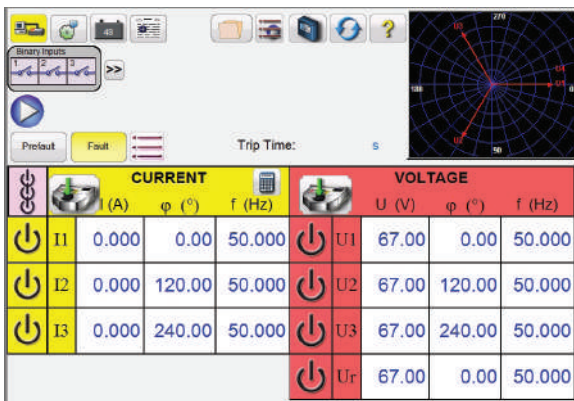
Examples of what FREJA can test	ANSI® / IEEE No.
Distance protection relay	21
Over fluxing relays	24
Synchronizing or synchronism-check relays	25
Under Voltage relays	27
Directional Power relays	32
Under Current or Under Power relays	37
Loss of field relays	40
Negative sequence overcurrent relays	46
Phase sequence voltage relays	47
Overcurrent-/ ground fault relays	50
Inverse time overcurrent-/ ground fault relays	51
Power factor relays	55
Overvoltage relays	59
Voltage or current balance relays	60
Directional overcurrent relays	67
DC overcurrent relays	76
Out-of-step protection relays	78
Automatic reclosing devices	79
Frequency relays	81
Carrier or pilot wire	85
Differential protection relays	87
Directional voltage relays	91
Voltage and power directional relays	92

**CURRENT AND VOLTAGE OUTPUTS**

Each current channel is rated for 32 A at 200 VA continuous, and can provide 60 A at 300 VA, for short durations. It has a unique flat power curve from 4 to 32 A that insures maximum compliance voltage to load at all times. With all three currents in parallel the unit provides 180 Amperes at 900 VA rms for testing all instantaneous overcurrent relays. With a maximum compliance voltage of 50 Vrms per phase, with just two channels in series provides 100 Vrms of compliance voltage to test high impedance earth fault type relays. Three voltage channels provide variable outputs of 0 to 300 V at 150 VA of output power, and have a unique flat power curve from 30 to 150 V insuring maximum output power to the load at all times. A fourth Uref voltage can provide a synchronizing reference voltage, or serve as a battery simulator.

**FREJA LOCAL – WITHOUT PC**

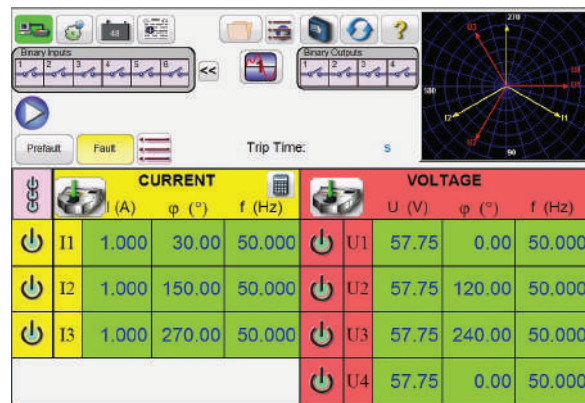
The most significant feature of the FREJA Local Software is its ability to provide the user with a very simple way to manually test, for both commissioning and maintenance, from the simple overcurrent relay to the most complex relays manufactured today. Manual operation is simplified through the use of a built-in computer operating system and the touch screen. The FREJA Local eliminates the need for a computer when testing virtually all types of relays. Enhanced graphics, intuitive menu screens, and touch screen icon buttons are provided to quickly and easily select the desired test function. The FREJA Local includes non-volatile built-in data storage for saving tests and test results. A USB port is provided for transferring test results by memory stick to your PC.



FREJA Local Basic Manual User Interface Screen

**Manual Test Screen**

In the Manual Test screen the pre-selected outputs are set using the touch screen. Power-up preset default values maybe automatically set from the user defined configuration screen. The user can select from a variety of test options including manual control using the control knob, a dynamic sequence of tests to include trip and reclose operations, an automatic ramp, pulse ramp, or pulse ramp binary search to determine pickup or drop out of relay contacts, or perform relay specific timing tests.

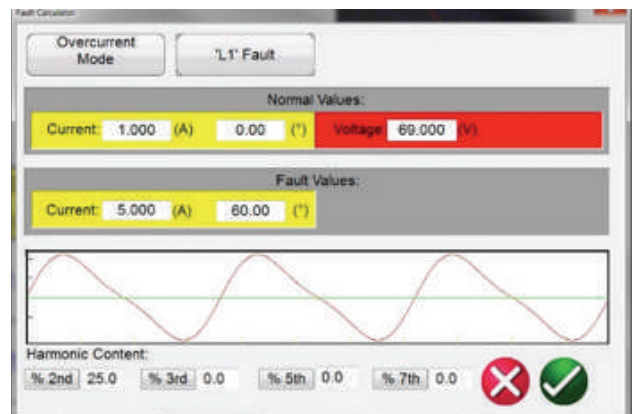


**Color Accents when Selected Outputs are on**

A vector graph indicates the relative phase angles of all the outputs, or the user can select to see the positive, negative, and zero sequence vectors displayed. The user may select to have all output amplitudes metered to provide real time verification of all of the selected outputs, or have setting values displayed. In the Manual Test Screen the user can set Prefault and Fault values. The user can toggle back and forth between the two values to monitor contact activity. To do a simple timing test the user can set Prefault time duration in seconds, and then press the Blue Play button. The Prefault values will be applied for the Prefault time, then change to the Fault values and start the Timer running. When the relay trips, it will stop the timer, and may turn selected outputs off depending on the user defined Auto-Off configuration. The test results may be saved to the internal memory to download later into a larger database for record keeping.

**Fault Calculator**

The Fault Calculator is available in the Manual and Sequencer test screens. The Fault Calculator provides the user with seven different modes of operation. They are Overcurrent, Voltage, Frequency, Impedance, Symmetrical (Component), Power Swing and Fault Location. Each mode offers a different set of fault calculators depending on the type of relay to be tested. For example, the Impedance Mode offers many of the same test features found in the Click-on-Fault test (see Click-on-Fault feature) where fault amplitudes and angles are automatically calculated and entered into the test screen ready of use. In addition, the user can create harmonic waveforms using the Fault Calculator to sum the default 1 (Fundamental), plus a % 2nd harmonic, plus a % 3rd, % 5th, and % 7th harmonics normally used in the testing of harmonic restrained relays.



In addition to the Fault calculator 2nd, 3rd, 5th, and 7th harmonics, the user can create other harmonics using the Waveform Button in the manual test screen. Here the user can define up to four waveforms, the default 1 (Fundamental), plus a Second (2nd), Third (3rd) and Fourth (4th) harmonic frequency. The frequencies selected do not have to be harmonics of the fundamental. All four waveforms will be summed together to create a harmonically distorted waveform.

**Smooth Ramp, Step Ramp, Pulse Ramp and Pulse Ramp Binary Search Features**

The FREJA Local Software may be used to automatically determine pickup or dropout of various types of relays. Pressing the Ramping button presents four choices; Smooth Ramp, Step Ramp, Pulse Ramp, and Pulse Ramp Binary Search.



**Smooth Ramp, Step Ramp, Pulse Ramp and Pulse Ramp Binary Search Selection Bar**

The first selection is the Smooth Ramp and will ramp the output by applying a value based upon entry of an increment value / second. The second selection, Step Ramp, will ramp the output by applying a value and then waiting a specific amount of time before incrementing. For example, to automatically ramp output current the user will select the channel to be ramped, input Start and Stop Amplitudes, an Increment (A), and a Delay time in Cycles (B).

Pulse Ramp will start at user defined predefault condition, increment up or down returning to the predefault condition between each increment. Instead of Delay time the user sets the Pulse Cycles time, which applies the fault value to the relay for the specified time. The user can select a 2nd, 3rd and 4th ramp if desired, changing the size of the increment with each ramp. This feature is most used when doing instantaneous pickup tests. The output current, or voltage, can be incremented in large steps getting to the pickup point quickly, and then reduce the size of the increment to zero-in on the pickup value. This reduces the test time, heating of the relay under test, and provides a very accurate test result. This feature is also used when testing multi zone distance relays using three phase voltage and currents. Set the Pulse Cycles duration just long enough for the intended zone to operate. If you are not sure exactly where the pickup value of the relay is, you can use the Pulse Ramp Binary Search feature.

**Timing Test Feature**

Built-in timing tests are provided for a wide variety of protective relays, including Overcurrent, Voltage, and Frequency relays. To make it even easier and faster, FREJA Local has ANSI, IEC, BS142, and IEEE Standards time curve algorithms built-in. FREJA Local also includes time curves and time curve algorithms for hundreds of specific relays. The user can select from a pull-down list of different manufacturers (over 20 different manufacturers and growing), then select the relay model number, and/or curve shape (inverse, very inverse, definite time etc.). The list includes relay manufacturer's digitized log-log, and semi-log, electromechanical relay time curves.

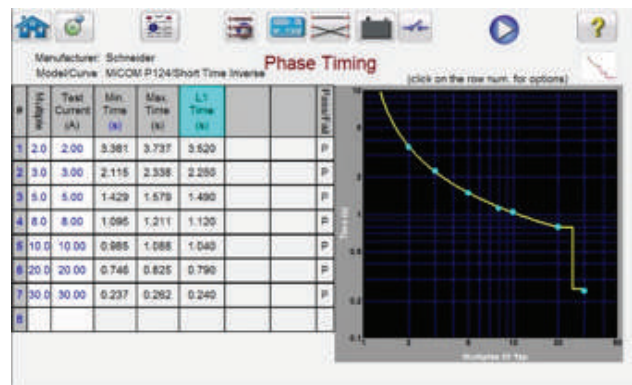
**Overcurrent Test Feature**

The Overcurrent test feature can perform all tests associated with electromechanical and microprocessor based overcurrent relays such

as;

- Phase Pickup
- Ground Pickup
- Neutral Pickup
- Phase Instantaneous
- Ground Instantaneous
- Neutral Instantaneous
- Phase Directional
- Ground Directional
- Neutral Directional
- Phase Timing (L1, L2, L3, L1-L2, L2-L3, L3-L1, and L1 L2-L3)
- Neutral Timing (L1, L2, L3)
- Ground Timing

In the following example, the Schneider MiCOM P124, Short Time Inverse curve relay with a 1 Amp Pickup, 25 Amp Instantaneous, and a number 2 Time Dial.



**Timing P124 Overcurrent Relay**

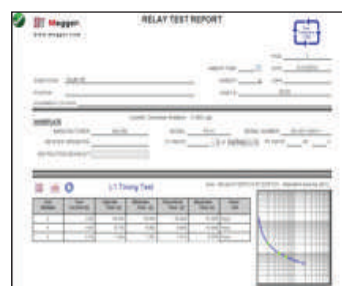
By entering the appropriate values in the setting screen, when the timing test is conducted, the test results will automatically be plotted and compared to the theoretical values from the relay specific time curve that was selected, and will automatically provide Pass/Fail assessment of the results. Up to 15 test points may be selected. If the test Multiple is changed, the appropriate theoretical trip time will change automatically.

**Timing Schneider MiCOM P123 Overcurrent Relay**

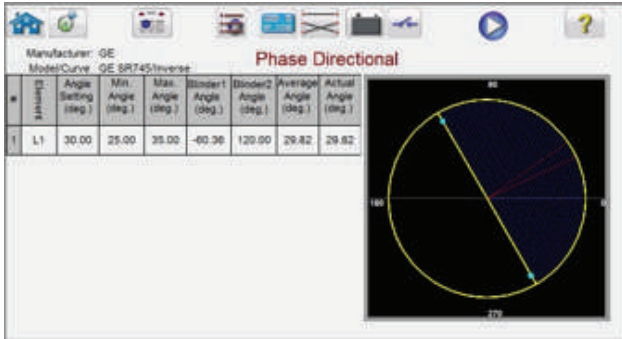
By entering the appropriate values in the setting screen, when the timing test is conducted, the test results will automatically be plotted and compared to the theoretical values from the relay specific time curve that was selected. Up to 8 test points may be selected. If the test Multiple is changed, the appropriate theoretical trip time will change automatically.

**View Test Reports**

To view the test result, press the Add Results to Report and View button. The user can now enter appropriate information relative to the test in the Test Report header. See the following example report.



Tests can be performed in any sequence such as phase pickup, phase directional, phase timing etc. and all test results are automatically recorded in that sequence, and added as additional pages to the report. See the following example report, page 2 Phase Overcurrent Directional Test for the GE SR745 relay



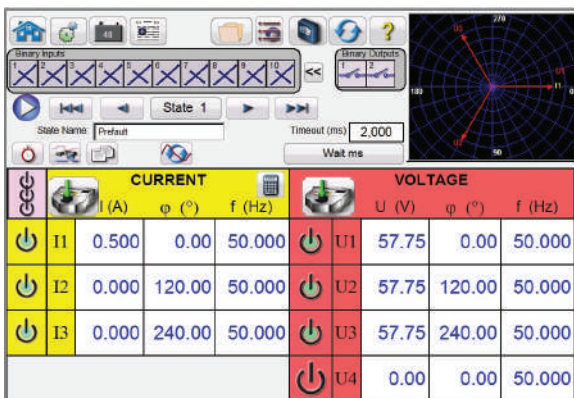
Page 2 Phase Directional Test Report

**Test Report MiCOM P123 IEC Inverse Timing Test**

Note that the software automatically compared the Operating Time to the theoretical and made a Pass/Fail determination based upon the manufacturer's time curve characteristic. If the recorded test point(s) is out of specification it appears red in color. If it is within specification it will be green in color. This provides excellent visual As Found reporting. If the data is imported into a PC, reports can be generated that summarize the comments and failures of every test you perform for future reporting requirements.

**State Sequence Timing Test Feature**

Pressing the State Sequence button on the test menu list takes the user to the Sequence Timing Test Screen. There are up to 15 programmable steps available in the Sequencer Test Screen.



**Multi-State Sequence Test Screen**

By default, 9 states are already labeled as Prefault, Trip1, Reclose 1, etc. up to Lockout in step 9. Therefore, it is initially setup for a four shot trip, reclose to lockout scenario. The user is free to change the labels, or use the default labels. With each state the user may input values of voltage, current, phase angle, frequency and set the Binary Input sensing for each state. Both single pole and three pole trip can be simulated. There are default values and binary settings for a single phase trip and reclose scenario already programmed in. The user can either use the defaults or change them to suit the application. The Total Time to Lockout is also included in the setting and indicates where the total timer starts and stops. This allows for 1, 2, 3, or 4 shots to lockout including

trip and reclose times. The user can set conditional settings such as Wait IRIG time setting (for End-to-End tests), Wait milliseconds, Wait cycles, Wait any contact (OR), and Wait all contacts (AND). The user can set the Binary Outputs to simulate the breaker 52a and/or 52b contacts.

Once all of the Binary Inputs, Outputs, Prefault, Fault and Reclose settings are completed, the user can then press the Preview button to get a visual representation of the voltage and current outputs, as well as a visual of the binary inputs and outputs for each stage of the simulation. The following figure illustrates a sample sequence.



Sample Sequence Voltage, Current, Binary Inputs and Outputs

**Impedance Relay Click-On-Fault**

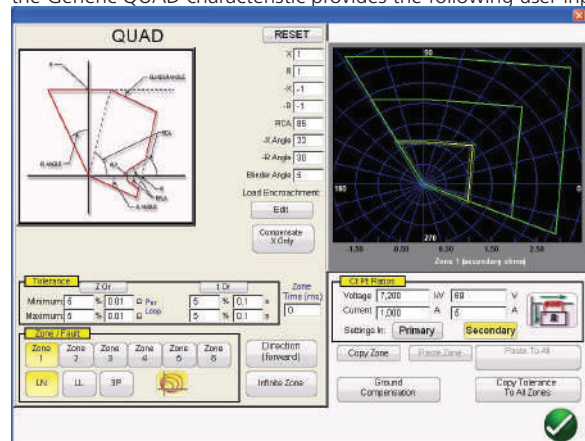
The all new Click-On-Fault (COF) is one of the choices in the test menu list. The new COF provides automatic tests of Impedance (distance) relays. It includes Pulse Ramp, Pulse Ramp Binary Search, and Shot test capabilities.

**Selection of Relay Operating Characteristics**

Select from one the predefined generic relay characteristics of MHO, Half MHO or QUAD (Quadrilateral), or import a RIO file supplied by a number of relay manufacturers, or select from the relay specific Relay Library files. The Relay Library currently includes distance relays from ABB, ALSTOM, AREVA, GE, MICOM, SEL, PROTECTA, SIEMENS, SIFANG, NARI, and TOSHIBA. There are numerous other library test files which are still being tested and field evaluated. Therefore, as new relay library files become available a new version of the software will be posted to the website for download and field upgrades.

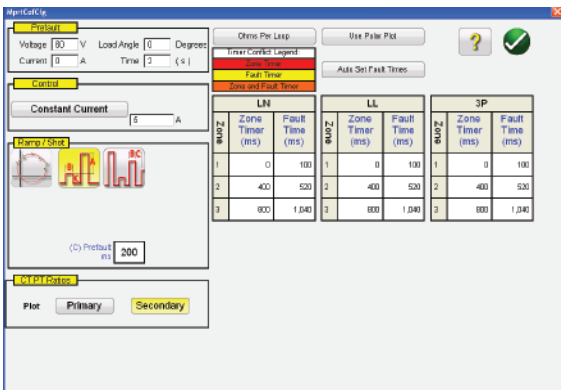
**Definition of Operating Characteristic and Tests**

There are several new innovations in the new COF that make testing distance relays easier and faster. For example, selecting the Generic QUAD characteristic provides the following user input



**Generic QUAD Setting Screen**

Here the user selects which Zone (up to 20 zones may be defined), type of fault, direction, tolerance values, inputs the reach, max torque (line) angle; any offset, or load encroachment settings. For phase to earth faults there are three types of compensation factors to choose from depending on the type of impedance characteristic. The software draws the operating characteristic(s) of the relay defined by the user settings. The user may select to view single zone or multiple zones. Pressing the green check button takes the user to the COF test setup screen, as shown in the following figure.



**Generic QUAD Test Setup Screen**

From this screen the user can select:

**Test Method-**

- Pulse Ramp
- Pulse Ramp Binary Search
- Shot

**Timing of Fault -**

- Phase to Ground
- Phase to Phase
- Three Phase

**Test Source Models -**

- Constant Voltage
- Constant Current
- Constant Source Impedance

**Displayed Values -**

- Primary Values
- Secondary Values

**Creating Search Lines or Shot Test Points**

The user can easily define up to 10 search lines or test points per fault type, per zone. Test options include;

The Independence Test option provides maximum freedom to the user to select any test line, at any angle, around the operating characteristic.

The Origin Test option the user clicks a point outside the operating characteristic, and the test line will be drawn to the origin or the intercept of the R and X axis.

The Shots Test Points option is used to create one or more test points, each to replicate a fault at a particular magnitude and angle. This type of test provides a quick GO, NO/GO test of the relay after a settings change.

The user does not even have to draw the test lines. There are two Quick Test Options the user may select. The first option draws three test lines for any of the selected Quick Test solutions. The second Quick Test the user may select the desired number of test points by pressing the Test Points button and select from the list.

If none of the standard test points or phase rotations meets the user's needs, they can enter the desired values in the window provided.

**IEC 60255 Test Option**

To comply with regulations which require testing to the IEC 60255 standard, the IEC 60255 option is also provided. All defined test lines will automatically be drawn perpendicular to the relay operating characteristic.

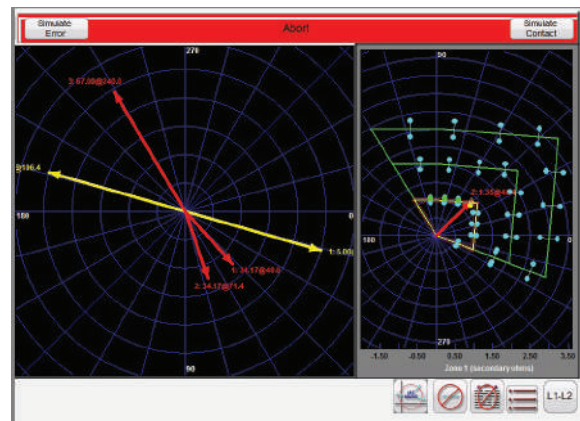
**Prefault Settings**

For testing relays which require a prefault load condition, the user can set the prefault load voltages and currents. This is normally used when testing accelerated tripping or dynamic over-reach characteristics

**Performing Tests**

The user then simply presses the blue Play button and the test begins. To save even more time the user can select the Play All button and the software will automatically test all define zones and faults in sequence. Based upon the user input the software will calculate all of the fault values and angles for each defined test point, and then make PASS/FAIL determination of the test results.

A real-time test screen will display the relay operating characteristic with the defined test lines in the right half of the screen, with the test vector moving in the impedance plane. In the left half it will display either the test vectors of voltage and currents being applied in real-time, or it will display the Positive, Negative and Zero Sequence vectors being applied, see the following example.

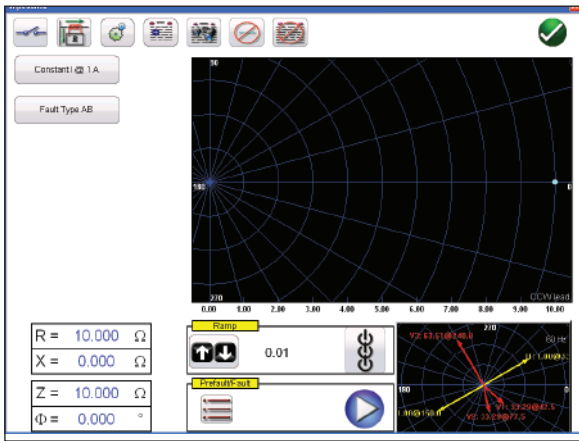


**Generic QUAD Real-Time Test Screen**

In the above figure a Zone 1, Pulse Ramp, Phase A-B fault is being performed. Note the real-time test amplitudes and angles are displayed in the left half, with the test results displayed in the right half.

**Easy Z Impedance Relay Test**

The FREJA Local Easy Z provides a quick approach to testing an impedance relay. The following is the Easy Z Impedance Test Screen. All tests are performed from this one screen.



**Easy Z Test Screen**

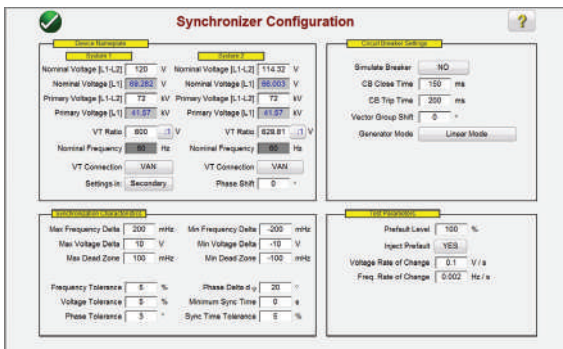
CT Polarity Directional button sets the phase angle of the output currents either into or out of the zone. Constant Source button provides the user with a selection of different methods to perform the tests. Some manufacturers require Constant Voltage and ramp current, some require Constant Current and ramp voltage.

Fault Type selection button provide the user with the Fault Type selection window. The user can select Three Phase Fault, Phase to Phase fault, or Phase to Ground fault. Note there is no ground compensation in the Easy Z test screen. For tests using ground compensation calculations see the Click On Fault test.

In the Ramp selection window the user can ramp outputs in terms of Z, R, X or the angle Phi. The increment of the ramp is also selected in this window. For example, the user desires to ramp impedance Z in 0.01 Ohms as shown above.

**New Synchronizer Test Feature**

The all new Synchronizer Test Feature provides automatic tests of synchronizing and sync-check type relays.



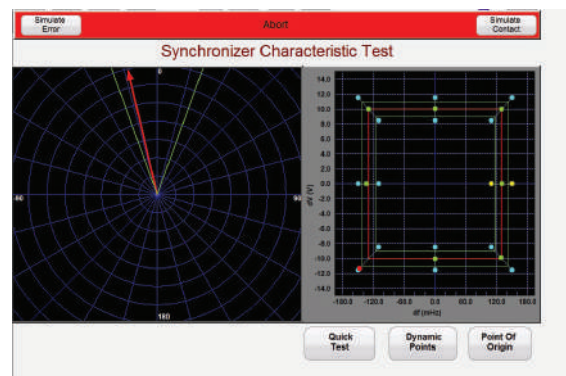
**Synchronizing Configuration Screen**

In the Device Nameplate section the user inputs information associated with System 1 and System 2, which includes Phase – Neutral or Phase - Phase Primary and Secondary voltage information. In the Synchronizing Characteristic section the user inputs the Voltage and Frequency Delta values as well as the tolerance values of the relay under test. In the Circuit Breaker section the user inputs values associated with the Closing and Trip times of the Circuit Breaker for breaker simulation. In the Test

Parameters section the user inputs the desired Rate of Change for the Voltage and Frequency changes.

**Creating and Performing Tests**

There are three options available to the user regarding the selection of test lines. Selection of the Quick Test, the software will automatically draw 4 test lines with two Delta Voltage lines and two Delta Frequency lines. Selection of the Dynamic Points, as shown below, draws eight test lines, with two Delta Voltage, two Delta Frequency, and four Dynamic test lines where both Frequency and Voltage are run in Delta. If either of these two options does not meet the user’s needs, the user is free to select their own test points by touching or clicking on the test screen points outside and inside the characteristic similar to the Click-on-Fault for Impedance relays.



**Dynamic Synchronizing Test Screen**

In the left side of the test screen the user can observe the synchroscope as the test voltage rotates, while in the right side the user can observe the dynamic test point closing in on the close characteristic for the relay in real time. When the relay close is captured the test results are shown similar to the above where the green dots indicate a passing test result.

**New Frequency Relay Test Feature**

The all new Frequency Relay Test feature provides automatic tests of Under/Over Frequency and df/dt type relays.

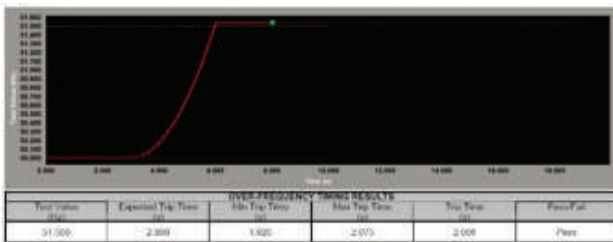


**Frequency Relay Configuration Screen**

In the Frequency Test Configuration screen the user selects the type of relay to be tested, Under, Over or df/dt. For three phase test applications the user can select how the VT’s and the Relay inputs are connected Star, Delta, and Open Delta. The user inputs the Prefault Voltage(s), Current(s), System Frequency and Duration Time of the default values before starting the test. For Pickup tests the

user can select a single ramp down or up depending on the relay type, or select a double ramp to determine pickup and dropout for dual setting relays.

For timing tests the user can select the classic timing mode where a step function is used, or use the ramp feature and start the timing test at a specific set point. The Timing test records the Prefault Frequency, the frequency ramp up or down depending on the type of relay test, the recorded Fault Frequency and the recorded operating time with Pass/Fail indication see the following example.

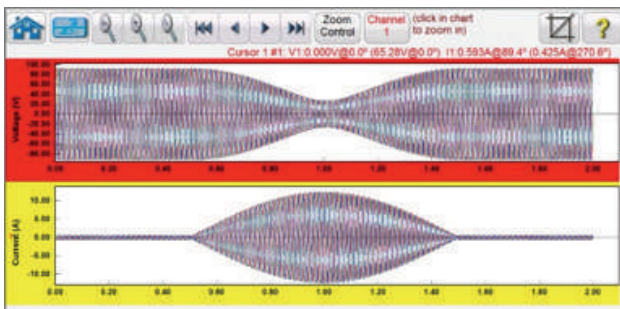


**Over Frequency Timing Test**

Note the frequency ramp up to a value slightly above the relay set point. The green dot indicates the relay operation was a pass. A red dot would indicate a fail.

**COMTRADE Viewer and Playback**

The COMTRADE test feature supports the IEEE C37.111 and IEC 60255-24 file formats. This test feature provides the capability for the FREJA 500 series of units to test relays with transient waveforms captured from digital fault recorders, or simulated faults using EMT/ATP type programs. The COMTRADE test feature includes extending the prefault data so that relays that require the prefault for proper polarizing will function properly under transient test conditions. This especially important when performing end-to-end tests using the COMTRADE playback feature. Timing may be started in conjunction with the fault application, thus timing the replay event



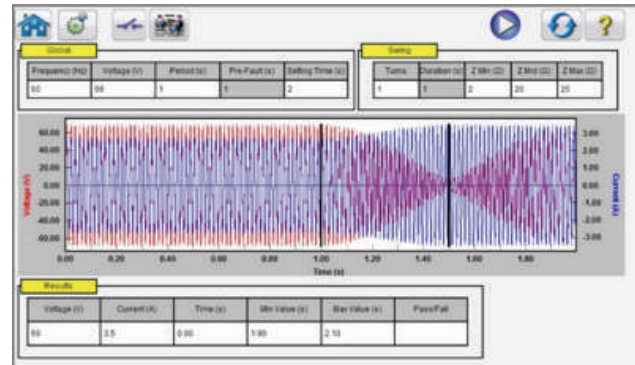
**Power Swing COMTRADE Simulation**

End-to-End test capability is provided, and allows GPS triggering of DFR files to be played back directly from the interface using either a programmable pulse on a binary input, or an IIRIG-B time signal from a GPS unit. Other tools are provided for review and evaluation of the waveforms such as zoom control. Displayed values include, Cursor #, Sample #, Voltage Channel Selected, RMS Magnitude, RMS Angle, (Peak Magnitude, Phase Angle), Current Channel Selected, RMS Magnitude, RMS Angle, (Peak Magnitude, Phase Angle), Cursor to Cursor difference time in ms. In addition, the

Iterations window provides the capability to cycle the relay through several iterations of the same fault.

**Power Swing Simulator Tool**

The Power Swing simulation tool provides realistic testing of power swing blocking elements in today's modern relays. In addition to power swing block, it can also perform Out-Of-Step tests. See the Power Swing input-setting screen in the following figure.

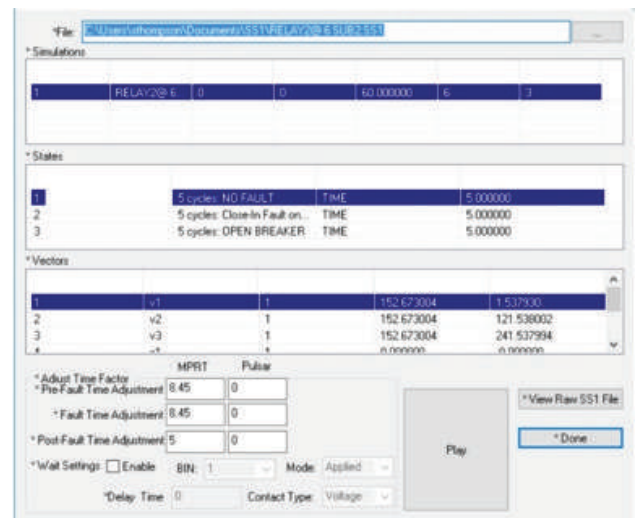


Power Swing Input Setting Screen

**Power Swing Waveform** – The Graphic window displays the power swing waveforms that will be played. If more than 1 Turn is specified the display will include each turn.

**SS1 File Converter**

SS1 files are generated using Power System Simulation software programs by Electrocon® CAPE™ or Aspen One-liner®. By modeling the power system and using the SS1 files, the relay can then be tested dynamically using realistic system test scenarios. The SS1 File Converter will read the SS1 file and create a dynamic state sequence playback file. This file can be used in two ways. The first method of use is as a standard dynamic test. One application is the testing of impedance relays. By modeling the power system using simulation software like CAPE or One-Liner, the relay can then be tested dynamically using realistic system test scenarios using actual line load conditions. The dynamic test can be used stand-alone or as part of a more complex test module. The other application is as an End-to-End playback file, similar to a COMTRADE playback file.



Example of the SS1 File Converter

**IEC 61850 Megger GOOSE Configurator**

The Megger GOOSE Configurator (MGC) provides mapping of the binary inputs and outputs of the FREJA 500 test set to the desired GOOSE messages. The GOOSE messages are read from available SCL (Substation Configuration Language) files or may be automatically detected by scanning the substation network in search of available published GOOSE messages. This scanning process is known as GOOSE "sniffing". The MGC also provides advanced network troubleshooting tasks such as comparing the GOOSE messages available on the network with the GOOSE messages described in the SCL files with GOOSE MERGE/ COMPARE functionality; this is also a powerful tool for validating the horizontal communication description (GOOSE) in the supplied SCD file at Factory Acceptance Tests (FAT) in IEC 61850 substations. This type of verification is also known as GOOSE Consistency Check.

An SCL file is an XML (Extensible Markup Language) file that describes the IEDs available in one IEC 61850 substation (SCD file) or can just describe only one single IEC 61850 device (ICD, CID files). In the SCL file there are several IEC 61850 information available (logical nodes in the IEDs, GOOSE messages sent by the IEDs, GOOSE messages received by IEDs, Reporting information to SCADA etc.).

**IEC 61850 Relay Testing – General Description**

The FREJA 500 relay test system is connected to the IEC 61850 station bus (or directly to the Ethernet port of the relay) and is programmed to map the trip GOOSE message from the tested IED to a chosen binary input. The mapped binary input is programmed to stop the timer of the SMRT test set. This last action is done from RTMS software. For testing IEC 61850 relay applications, where the protection relay needs an external signal to allow protection functions (e.g. external direct inter-trip command, or external auto-recloser start, or breaker failure start), it is necessary to "energize" the IEC 61850 relay with a GOOSE message. The FREJA 500 relay test set, which is connected to the IEC 61850 station bus, is now programmed to map a binary output to a defined GOOSE message that is published by the FREJA 500 unit. The test set activates its binary output when the test requires it, which means that the GOOSE message changes its status from "0" (false) to "1" (true). In a practical situation both applications (publishing of a GOOSE message and subscription of a GOOSE message), are often used simultaneously.



Figure 2 MGC 'My GOOSE' with Assigned Binary Inputs and Outputs

After the appropriate assignments of binary inputs and outputs have been made, the My GOOSE test file can be saved for reuse. Use basic test tools or standard test features in FREJA Local to perform automatic tests. The MGC provides mappings of Boolean and Bit Strings and/or simulation of STRuct, Integer/Unsigned, Float and UTC datasets. The FREJA 500 units meet the IEC 61850-5 standard, Type 1A, Class P 2/3, for high speed trip and reclose simulations.

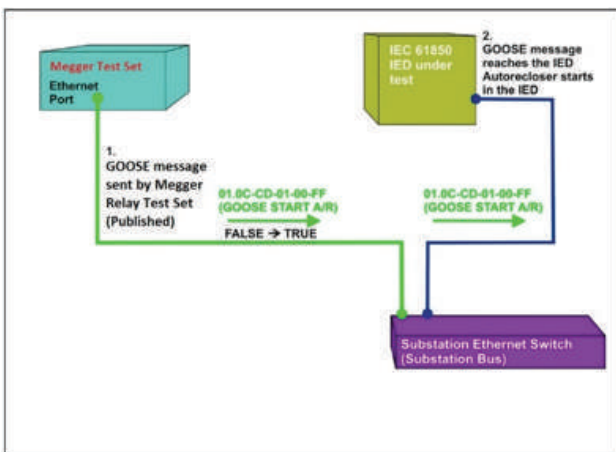


Figure 1 External energization (auto-recloser start) test of an IEC 61850 IED



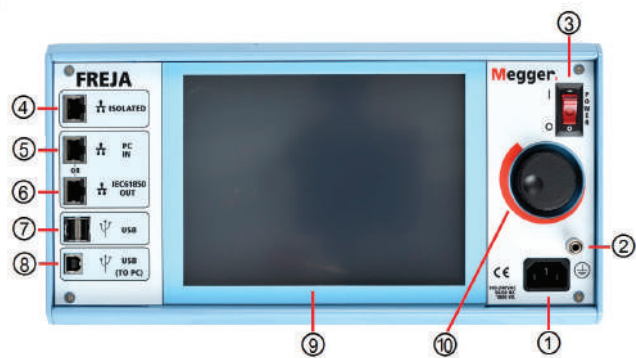
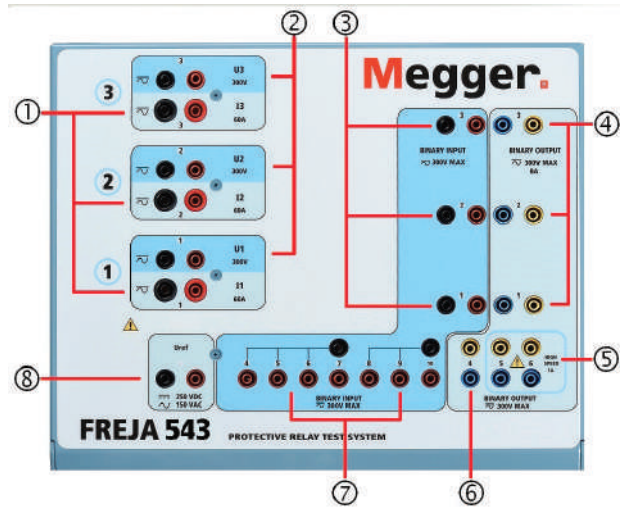
**FEATURES AND BENEFITS**

**Top Panel**

1. **Current Outputs**- 3 phases (3 x 60 A)
2. **Voltage Outputs**- 3 x 300 V at 150 VA
3. **Binary Inputs 1, 2 and 3** – Rated 5 to 300 V AC/DC
4. **Binary Outputs 1, 2 and 3** – Rated 300 V AC/DC, 8 A
5. **Binary Outputs 5 and 6** – High Speed, 400 V AC/DC peak, 1 Ampere
6. **Binary Output 4** – Rated 300 V AC/DC, 8 A
7. **Binary Inputs 4,5,6,7,8,9,10** - Rated 5 to 300 V AC/DC
8. **AC/DC Supply** – Variable 0 to 250 V DC, 100 Watts/3.33 Amps, or 0 to 150 V AC, 100 VA

**Front Panel**

1. **Mains Inlet Socket** – 100 to 240 V, 50/60 Hz
2. **Protective Earth Terminal**
3. **Power ON/OFF Switch** – Illuminates when power is on
4. **Isolated Ethernet Port** – For connecting to IEC 61850 Substation Bus
5. **PC / IN Ethernet Port** – Primary PC connection Port for automated testing. Also used when chaining to other FREJA units for multi-phase testing.
6. **IEC 61850 / OUT Port** – Used when testing IEC 61850 devices. Also used to chain to other FREJA units for multi-phase testing.
7. **USB Ports** - Two type A ports available. This port is used to update the firmware and software in the FREJA unit. It may also be used to download test results from the FREJA for download into a PC for storage or printing.
8. **USB (TO PC) Interface** – The (TO PC) USB Interface requires a Type B “downstream” connector, and is a communication and control port when used with a PC and Megger software for automated relay testing.
9. **Local HMI** – TFT LCD, full color touch screen.
10. **Control Knob**



	# Current Generators	# Voltage	Operating Modes
<b>FREJA 543</b>	3	4	4 Voltages (3 x 300 V) + 1 x 150 V 3 Currents (3 x 60 Amps)
			4 Voltages (3 x 300 V + 1 x 150 V) 2 Currents (1 x 120 A + 1 x 60 A)
			4 Voltages (3 x 300 V + 1 x 150 V) 1 Current (180 Amps)

**FREJA WIN**

In FREJA™ Win, the all-round General instrument program serves as a convenient, easy to understand, user-friendly toolbox. On the Connect page, you can enter information about how to connect the relay, including pictures if so desired.

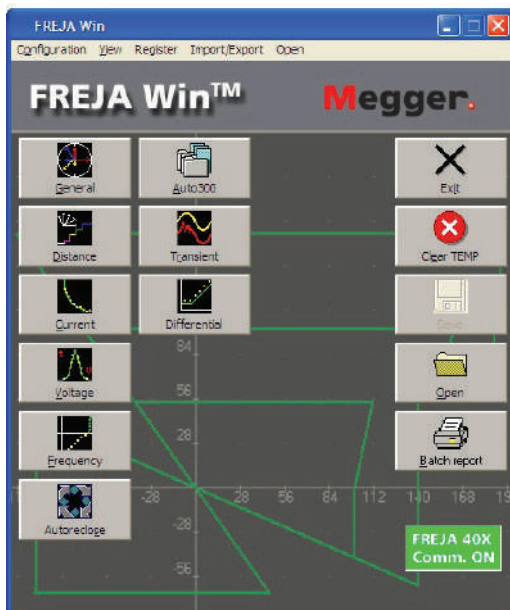
On the Sequence page, you can vary all generator parameters independently. You can have up to 25 different states (prefault, fault1, prefault, fault2, prefault, fault3 etc.). This is useful when testing auto-reclose relays or motor protection. It's also possible to generate up to the 25th harmonic.

On the Ramp page, you can ramp all generator parameters independently. Amplitudes and angles are shown on a vector diagram, and values can be set using the knob on FREJA or the PC keyboard and mouse, on-line as well.

**Distance instrument**

**Configuration page**

The Distance instrument program is designed to test distance relays. On the Configuration page, you enter the number of zones that are to be tested and also the time and impedance tolerances, thereby creating an automatic test. No programming is needed. Later, when you recall this object via the Control center, all settings are re-established so that you can start testing immediately.



Control Center

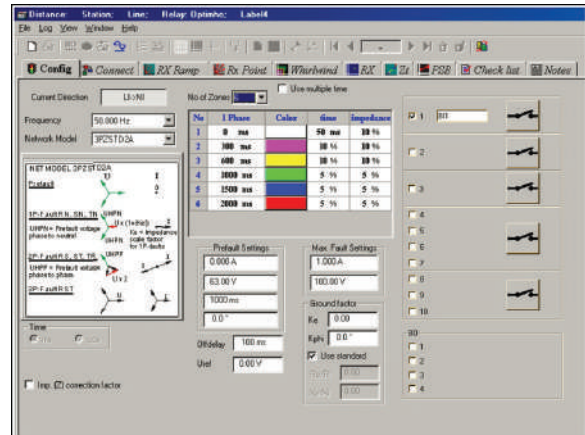
**Connect page**

On the Connect page you enter information about how to make connections to the relay, including pictures if so desired. Since this information is saved together with the object in the Control center, it can be displayed again the next time you want to test this relay.

**Zt page**

The Zt page is designed for time testing of a distance relay. Normally, you test one type of fault at a time when testing relays. With FREJA Win, however, you can test all seven fault types automatically if so desired. All you have to do is press the <Start> button. FREJA will test all seven fault types automatically and then compare the readings with the theoretical values that you entered

on the Configuration page. If the readings are OK, a green lamp lights. If not, a red lamp lights. If you want to check the reverse direction, the test can start below zero ohms in the 3rd quadrant.



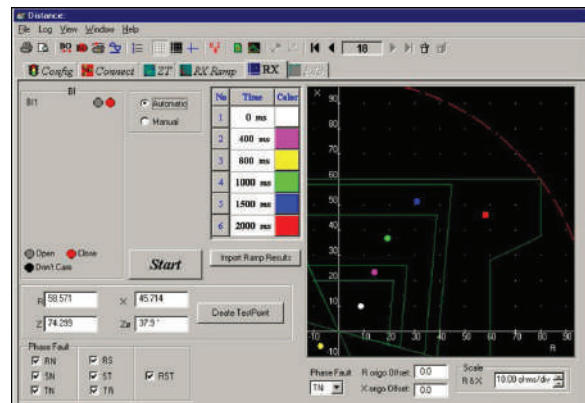
Distance, Configuration

**RX-ramp page**

The RX-ramp page, which is part of the Distance instrument program, is designed to test the reach of a distance relay. First, you define the start and stop angles and the delta phi between the ramps. Then press the <Start> button and relax. FREJA will automatically test all seven types of faults using the time saving "search-half" method. You can also define your own ramps, using the mouse to specify starting and ending points wherever desired. If you have defined a theoretical reference graph, the program will compare the actual test result with your graph and check for any deviations from the tolerances entered on the Configuration page. If the results are OK, a green lamp lights, if not, a red lamp lights.

**RX page**

The RX page enables you to define test points manually. You can define different points on the oscilloscope using the mouse or keyboard. Select the automatic mode and press the <Start> button. FREJA will test all points for the selected fault types. The points will be assigned different colors, depending on the trip time. If you select the manual mode, you can use the dial to search for a boundary.



Distance, Rx

**Reference graphs**

Efficient testing and performance analysis require well-defined reference values. FREJA can automatically create the IEC and IEEE® standard curves for overcurrent relays. It is also possible to create reference graphs in the impedance plane using the

included library of distance relays made by major manufacturers and/or create other characteristics using the standard circular lens and linear elements (including mho, quadrilateral and ice-cream cone shapes). The cut and paste buttons make it easy to take copies of the first zone and then edit these copies by inserting zone 2 and zone 3 values.

Some relay manufacturers can create a RIO-file with the settings of the relay. Using the FREJA RIO-converter you can create reference graphs based on these settings.

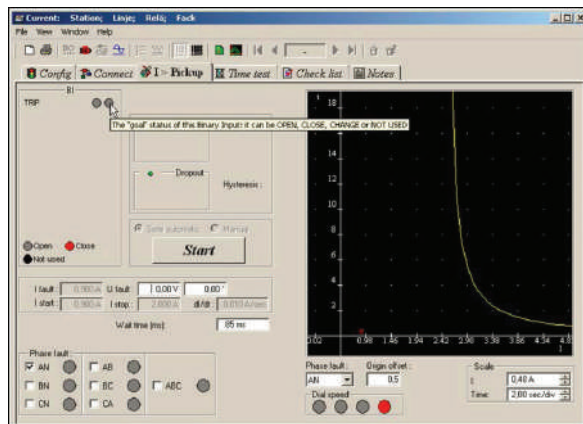
A feature is the ready-made current curves available for many relay types.

**Current instrument**

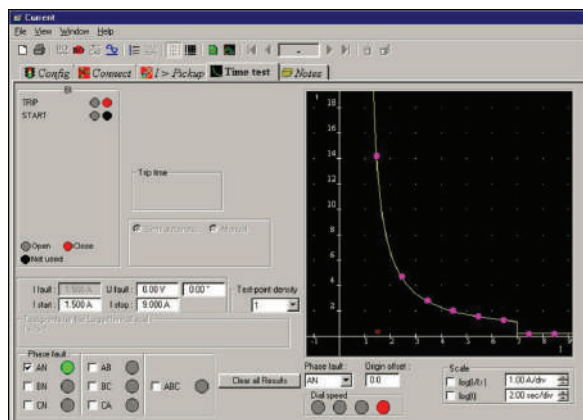
The Current testing instrument is designed to test all types of current relays, from electro-mechanic with or without an induction disc to modern numerical relays.

The Config page is where the relay settings will be entered.

In the Pick-up page the system will not just get the pick-up value (start current) but also the drop out and it will also calculate automatically the hysteresis.



Current Instrument, Pick-up



Current Instrument, Time test

The time test, check the trip time at different current values, will be done in the Time test page. A reference curve can be created in the same way as in Distance, by choosing the corresponding time curve and entering the settings. The time test can be run also in a logarithmic scale, time, current or both.

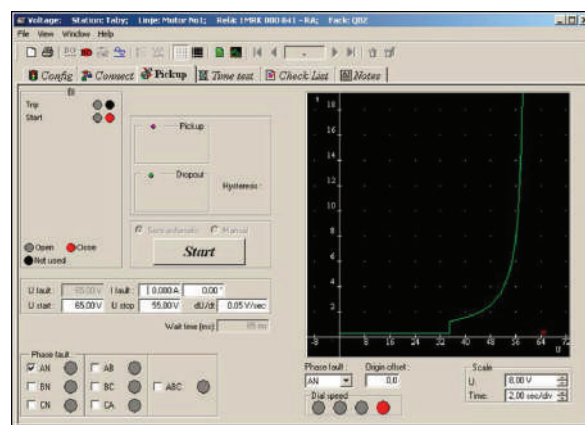
**Voltage instrument**

The Voltage testing instrument is designed to test all types of voltage relays, from electro-mechanic to modern numerical relays.

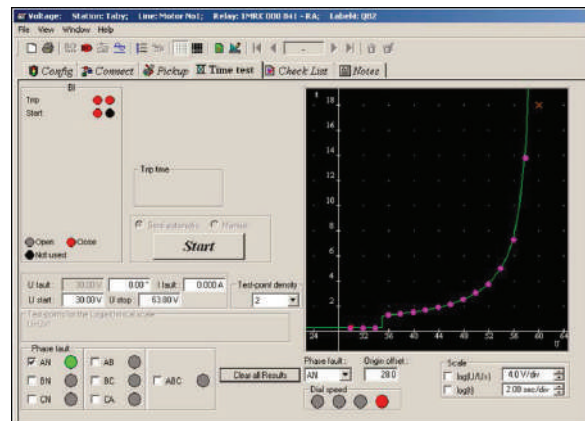
The Config page is where the relay settings will be entered.

In the Pick-up page the system will not just get the pick-up value (start voltage) but also the drop out and the hysteresis will be calculate automatically.

The time test, check the trip time at different voltage values, will be done in the Time Test page. A reference curve can be created in the same way as in Distance, by choosing the corresponding time curve and entering the settings. The time test can be run also in a logarithmic scale, time, current or both.



Voltage instrument, Pick-up

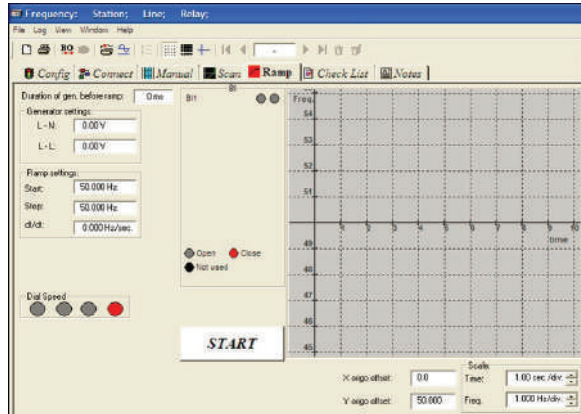


Voltage instrument, Time test

**Frequency instrument**

In the Frequency instrument a pre-fault an fault frequency can be generated manually in Manual page as well as an automatic sequence of pre-fault, fault, from a set start value to set stop value to Scan the trip time at different frequency values, useful for relays with two stages.

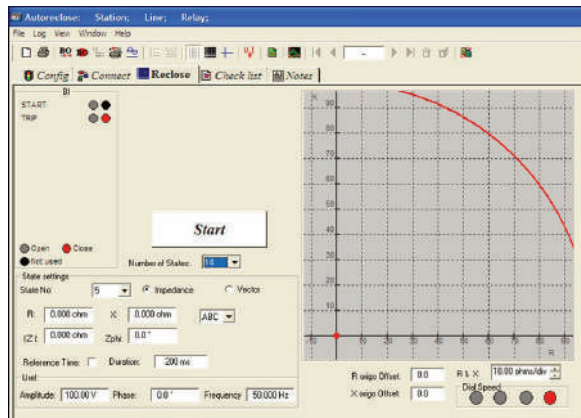
The Ramp mode will find the set fault frequency.



Frequency Instrument, Ramp

**Auto-reclose instrument**

The Auto-reclose instrument is a combination between Sequence in General and RX in Distance. This is just because it is easier to simulate pre-fault, energizing and dead times as vectors and in the same way it is easier to simulate a fault in a impedance plane. This instrument will test any auto-recloser function on today's modern relays.

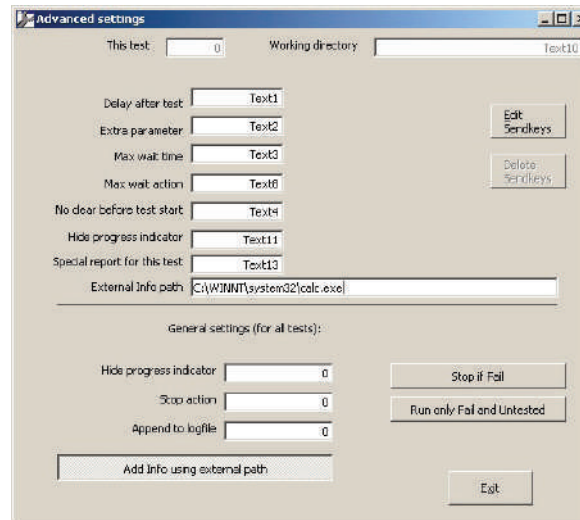


Autoreclose instrument

**Auto 300**

If we take as an example a modern distance relays has several functions activated, besides the distance elements.

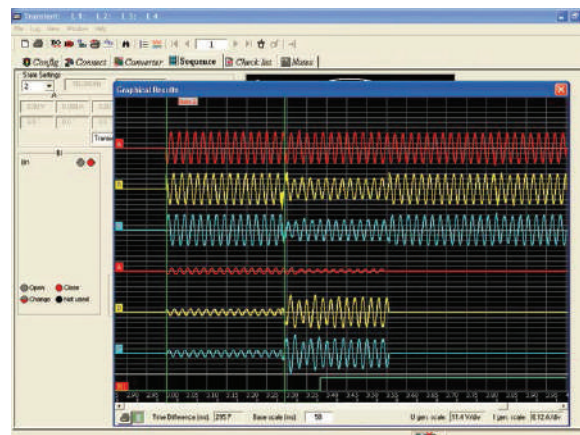
By using Auto 300 we can link together different tests made in different instruments, to create an automatic test sequence, so at the end we will have on test containing elements from Distance, Current, Sync and Voltage, for example.



Auto 300

**Transient instrument**

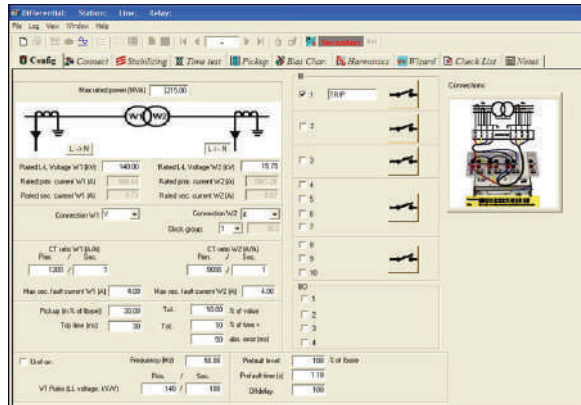
With the help of Transient, FREJA will generate (playback) a waveform recorded by a disturbance recorder. The file formats supported by Transient are COMTRADE, ASCII, EMTF WAX, EMTF PC and Inductic 65.



Transient instrument

**Differential instrument**

The Differential instrument is designed to test transformer protection relays and works with FREJA 549, as it makes use of 6 current generators.



Differential instrument

It can be used to test multi winding transformer protection relays, by testing a pair of windings at a time.

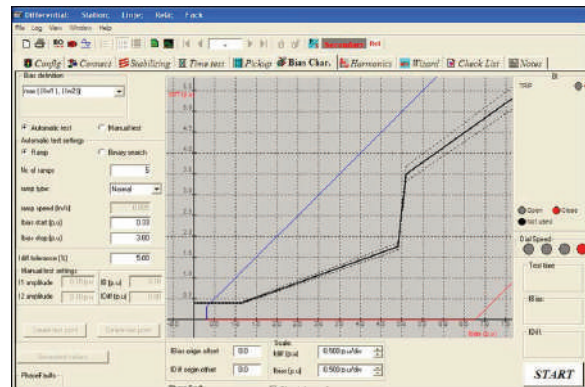
FREJA Differential can also be used to test differential generator protection relays and line differential protection relays. The data for the protected power transformer are entered in a very intuitive way that cannot be misunderstood by the user. This is done by using buttons and icons that immediately show to the user the effect of his choices. The injected currents are shown both in primary and secondary values, depending on the entered current transformers information and star point earthing.

The Stabilizing page has the purpose of verifying that the connections and settings in FREJA are correct by generating external faults and verifying that the relay is stable. The operator is also requested to read the measured values by the relay and enter them in the test page. The values will then be reported in the final report.

The Time Test page allows to verify the operate time of the differential relay. Several fault injections can be programmed and the page reports the statistics of the measured operate times (minimum, maximum and average values).

The Pick-up page allows the test of the minimum operating current of the differential relay for each winding, which is a test on the sensitivity of the relay. This test also makes use of pseudo-continuous ramp injections.

In the page Bias Characteristic it is possible to test the operating relay characteristic by running pseudo-continuous ramps (for testing the static accuracy of the relay) or ramps done by sequences of prefault and fault steady state simulations, called as "binary search", more suitable for commissioning tests. The characteristic can be tested with or without making use of the reference graph.

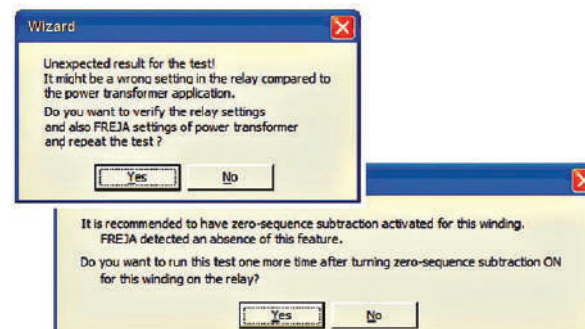


Differential Instrument, Bias Characteristic

The Harmonics page verifies the relay capability of not issuing the trip signal for faults in the trip area of the restrained characteristic, when a certain level of harmonics is present in the fault currents, for each winding of the power transformer. The purpose of this feature is to keep the relay stable during transformer energizing or during transformer overexcitation.

A very important test, introduced by Programma for the first time, is called Wizard. It will help discovering wrong settings for the differential transformer relays that might cause unwanted trip for external ground faults.

The Wizard will ask important and clear application questions to the relay engineer and will perform some simple tests on the relay in a semi-automatic manner. Depending on the application information entered by the user, the Wizard will report if the relay seems to be correctly set or not with a clear information to the user.



Differential Instrument, Wizard

**IEC 61850 GOOSE**

The FREJA with the GOOSE enabled, in conjunction with the Megger GOOSE Configurator (MGC) software, can be used in the testing or commissioning of IEC 61850 compliant devices.

**SPECIFICATIONS**

Specifications are valid for resistive load, nominal voltage supply and ambient temperature +25°C ±3°C, (77°F ±5.4°F) after 30 minutes warm up time. All hardware data are for full scale values. Specifications are subject to change without notice.

**Environment**

Application field	For use in high-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (32°F to +122°F)
Storage & transport	-25°C to +70°C (-13°F to +158°F)
Humidity	5% – 90% RH, non-condensing
Altitude (operational)	3000 m Full duty cycle up to 2000 m. Duty cycle limitation based on internal over temperature protection for altitudes >2000 m.

**CE-marking**

EMC	EN 61326:
LVD	EN/IEC 61010-1:2001 (Second Edition)

**Conformance Standards**

Shock	EN/IEC 60068-2-27
Vibration	EN/IEC 68-2-6
Transit Drop	ISTA 1A
Free Fall	EN/IEC 60068-2-32
Drop / Topple	EN/IEC 60068-2-31

**General**

Mains input	100 - 240 Volts AC, 50/60 Hz
Power consumption	1800 VA
Dimensions	337 W x 172 H x 273 D mm 13.25 W x 6.75 H x 10.75 D in.
Weight	13.2 kg (29.35 lb.)
Display	TFT LCD Touch Screen
Available	
Languages	English, French, German, Spanish
Communication	
Interfaces	(3) Ethernet Ports (2) USB "A" Ports (1) USB "B" Port Bluetooth

**Measurement Section**

Measured output quantities such as AC Amperes, AC Volts, DC Volts or DC Amperes, and Time may be simultaneously displayed on the touch screen. Preset AC and DC outputs display the approximate voltage/current output prior to initiation. This provides a fast, easy method for preset of outputs. Other values that may be displayed, depending on which test screen is in view, are phase angle, frequency, Ohms, Watts, VA, and Power Factor. All Accuracies stated are from 10 to 100% of the range at 50/60 Hz.

**AC Voltage Amplitude**

Accuracy:	±0.05 % reading + 0.02 % range typical, ±0.15 % reading + 0.05 % range maximum
Resolution:	0.01
Measurements:	AC RMS
Ranges:	30, 150, 300V

**AC Current Amplitude**

Accuracy:	±0.05 % reading + 0.02 % range typical, ±0.15 % reading + 0.05 % range maximum
Resolution:	0.001/0.01
Measurements:	AC RMS
Ranges:	32, 60A

**DC Voltage Amplitude**

Accuracy:	0.1 % range typical, 0.25% range maximum
Resolution:	0.01
Measurements:	RMS
Ranges:	30, 150, 300V

**DC Current Amplitude**

Accuracy:	±0.05 % reading + 0.02 % range typical, ±0.15 % reading + 0.05 % range maximum
Resolution:	0.001/0.01
Measurements:	RMS
Ranges:	32A

**Phase Angle**

Ranges: 0.00 to 359.99 degrees, Counter Clock Wise, or Clock Wise rotation, or 0.00 to ±180.00 degrees  
Accuracy: ±0.02° typical, ±0.25° max at 50/60 Hz

**Frequency**

The output modules provide a variable frequency output with the following ranges and accuracy.

Ranges	DC
	0.001 to 1000.000 Hz
Output amplifiers can provide transient signals with a range of DC to 10 kHz for transient playback using COMTRADE files.	
Resolution*:	.0001/.001 Hz
Frequency Accuracy:	2.5 ppm typical
	25 ppm 0° to 50° C, at 50/60 Hz

**DC IN Inputs (Optional Transducer Feature)**

**DC IN Volts**

Range:	0 to ±10 V DC
Accuracy:	±0.001% reading + 0.005% range Typical ±0.003% reading + 0.02% range Max
Resolution:	0.001
Measurements:	Average

**DC IN Amperes**

Range:	0 to ±1 mA DC 4 to ±20 mA DC
Accuracy:	±0.001% reading + 0.005% range Typical ±0.003% reading + 0.02% range Max
Resolution:	0.001
Measurements:	Average

**Timer**

The Timer-Monitor Input is designed to monitor and time-tag inputs, like a sequence of events recorder. In addition, the binary input controls enable the user to perform logic AND/OR functions, and conditionally control the binary output relay to simulate circuit breaker, trip, reclose and carrier control operation in real-time. The Timer function displays in Seconds or Cycles, with the following range and resolution:

- Seconds: 0.0001 to 99999.9 (Auto Ranging)
- Cycles: 0.01 to 99999.9 (Auto Ranging)
- Accuracy: ±0.001% of reading, typical. ±2 least significant digit, ±0.005% of reading from 0 to 50° C maximum

**Binary Inputs – Start/Stop/Monitor gate**

To monitor operation of relay contacts or trip SCR, continuity light is provided for the input gate. Upon sensing continuity the lamp will glow. In addition to serving as wet/dry contacts the Binary Inputs may be programmed to trigger binary output sequence(s). Input Rating: up to 300 V AC/DC

**Binary Output Relays**

Independent, galvanically isolated, output relay contacts to accurately simulate relay or power system inputs to completely test relays removed from the power system. The binary output simulates normally open, or normally closed, contacts for testing breaker failure schemes. The binary output can be configured to change state based on binary input logic.

**High Current Output Relays 1 to 4:**

- AC Rating: 400 V max., I<sub>max</sub>: 8 Amps, 2000 VA max.
- DC Rating: 300 V max., I<sub>max</sub>: 8 Amps, 80 W
- Response Time: <10ms

**High Speed Output Relays 5 and 6:**

- AC/DC Rating: 400 V peak, I<sub>max</sub>: 1 amp
- Response Time: <1ms typical

**GENERATION SECTION**

All outputs are independent from sudden changes in line voltage and frequency. All outputs are regulated so changes in load impedance do not affect the output. Each output module consists of one voltage amplifier, and a current amplifier. The voltage amplifier may be converted to a current source. Therefore, one amplifier module may be used to test single phase current differential relays, including harmonic restraint.

**Output Current Sources**

The FREJA 543 can provide three current sources 0 – 32 Amps continuous, with a max output current of 60 Amps at 300 VA for 1.5 seconds. The per channel output current and power ratings are specified in AC rms values and peak power ratings.

**Per Channel Output**

Output (AC)	Power	Max V
1 Ampere	15 VA	15.0 Vrms
4 Amperes	200 VA (282 peak)	50.0 Vrms
15 Amperes	200 VA (282 peak)	13.4 Vrms
32 Amperes	200 VA (282 peak)	6.67 Vrms
60 Amperes	300 VA (424 peak)	5.00 Vrms

**Output (DC)**

Output (DC)	Power
0 – 32 A	200 Watts

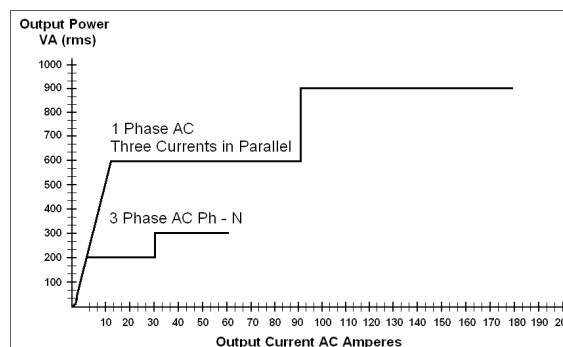
**Duty Cycle:** 32 Amps Continuous, 60 Amps 1.5 seconds

**Three Currents in Parallel:**

Output Current	Power	Max V
12 Amperes	600 VA (848 peak)	50.0 Vrms
50 Amperes	600 VA (848 peak)	13.4 Vrms
96 Amperes	600 VA (848 peak)	6.67 Vrms
180 Amperes	900 VA (1272 peak)	5.00 Vrms

**Two Currents in Series**

With two currents in series, the compliance voltage doubles to provide 4.0 Amperes at 100 Vrms.



**Current Output Power Curve for FREJA 543**

**Current Amplifier - Extended Power Range**

The FREJA 500 series current amplifier provides a unique flat power curve from 4 to 32 Amperes per phase to provide testing to electromechanical high impedance relays, and other high burden applications.

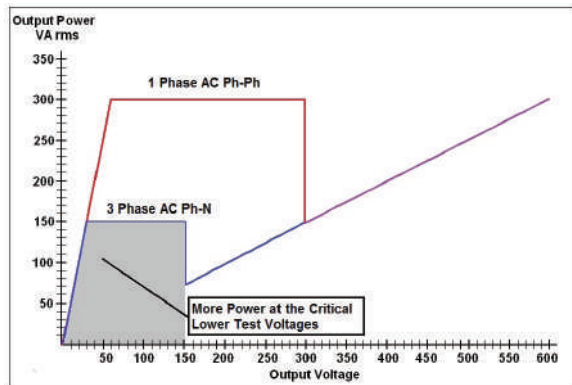
**Voltage Generators**

The FREJA 543 can provide three voltage sources 0 – 300 Volts AC/DC. The unit can provide a 4th AC/DC voltage source to serve as either a reference synchronizing voltage or as a battery simulator, see AC/DC Uref below.

Range (AC)	Power	Max I
50 Volts	150 VA	5 A
150 Volts	150 VA	Variable
300 Volts	150 VA	0.5 A

**Range (DC)**

Range (DC)	Power
0 – 300 V	150 Watts



**Voltage Output Power Curve**

“PowerV™” Voltage Amplifier-Extended Power Range

The FREJA 500-SERIES voltage amplifier provides a flat power curve from 30 to 150 Volts in the 150V range to permit testing of high current applications such as panel testing, and older electromechanical distance relays which demand a higher power voltage source to properly test.

**AC / DC Uref Supply**

The Uref AC/DC voltage output can be either an AC variable voltage source to use as a polarizing or synchronizing voltage source, or a battery simulator with a variable DC output voltage.

<u>Range (AC)</u>	<u>Power</u>	<u>Max I</u>
30 Volts	100 VA	3.33 A
150 Volts	100 VA	0.67 A

<u>Range (DC)</u>	<u>Power</u>
50 Volts	100 Watts
250 Volts	100 Watts

**Total Harmonic Distortion**

Less than 0.1% typical, 2% maximum at 50/60 Hz

**Waveform Storage**

Each output channel can store waveforms for playback on command. End-to-end playback of stored waveforms is possible, when triggered externally by a GPS receiver. Each channel can store up to 256,000 samples.

**Protection**

Voltage outputs are protected from short circuits and prolonged overloads. Current outputs are protected against open circuits and overloads.

**Enclosure and Transit Cases**

The unit comes mounted in a robust metal enclosure for field portability. Optional soft-sided and hard-sided transit cases are available. The soft-sided case has approximately 2.5 cm of padding, which provides moderate protection against rain, dust, vibration and shock. The robust design of the optional hard-sided transit case provides protection when transporting the unit over rugged terrain and long distances.

<sup>1</sup> PowerV™ voltage amplifier output current varies depending on the voltage setting on the 150 Volt range, see curve.





Style Number	Description
<b>F543-30P2C111T1</b>	FREJA 543 Standalone: Includes: International power cord, IEC 61850 test capability, Transducer test capability, and test leads.
<b>F543-30P2C111S1</b>	FREJA 543 Standalone: Includes: International power cord, with IEC 61850 test capability, and test leads. Excludes: No transducer test capability
<b>F543-30P2C110T1</b>	FREJA 543 Standalone: Includes: International power cord, Transducer test capability, and test leads. Excludes: no IEC 61850 test capability
<b>F543-30P2C110S1</b>	FREJA 543 Standalone: Includes: International power cord, and test leads. Excludes: no IEC 61850 test capability, no transducer test capability
<b>F543-30P2C110T0</b>	FREJA 543 Standalone: Includes: International power cord and Transducer test capability. Excludes: no IEC 61850 test capability, no test leads
<b>F543-30P2C111S0</b>	FREJA 543 Standalone: Includes: International power cord, with IEC 61850 test capability. Excludes: No transducer test capability, no test leads
<b>F543-30P2C110S0</b>	FREJA 543 Standalone: Includes: International power cord. Excludes: no IEC 61850 test capability, no transducer test capability, no test leads





Description of Software Options	Part Numbers
<b>Included Software</b> – Every unit comes with the PC version of the FREJA Local software called <b>FREJA Remote</b> .	<b>84835</b>
<b>Optional Software</b>	
<b>FREJA Win</b>	<b>84673</b>

**Included Standard Accessories**

Description	Part Number
Power Cord - Depending on the style number, the unit will come with one of the following,	
Line cord, NEMA .....	90015-267
Line cord, Continental Europe with CEE 7/7 Schuko Plug.....	90015-268
Line cord, International color coded wire.....	90015-269
Line cord, United Kingdom .....	90015-270
Ethernet cable for interconnection to PC, 210cm (7 ft.) long (Qty. 1 ea.) .....	90003-594
Instruction manual (digital copy).....	84624



**Optional Test Leads and Accessories**

The following quantities of Test Leads and Accessories are supplied with the selection of the Test Leads Option. Test Leads and Accessories can be ordered individually, see part numbers and descriptions below.

	Optional Accessories Descriptions	Test Leads Option
	<b>Accessory Carry Case:</b> Use to carry power cord, Ethernet cable, Optional STVI and test leads.	Qty. 1 ea. Part No. 2003-725
	<b>Sleeved Pair of Test Leads:</b> Sleeved Test Leads, one red, one black, 200 cm (78.7") long, 600 V, 32 Amperes CAT II	Qty. 7 pr. Part No. 2008-539
	<b>Cable/Spade Lug Adapter (Small):</b> Small lug fit most new relay small terminal blocks. Lug adapter, <b>red</b> , 4.1 mm, rated up to 1000 V/ 20 Amps CAT II	Qty. 15 ea. Part No. 684004
	Lug adapter, <b>black</b> , 4.1 mm, rated up to 1000 V/ 20 Amps CAT II.	Qty. 15 ea. Part Number 684005
	<b>Jumper Lead:</b> Jumper lead, black, 12.5 cm (5") long, use with voltage / current outputs, 600 V, 32 Amps CAT II	Qty. 4 ea. Part Number 2001-573
	<b>4x6 Sleeved Combination Voltage Leads with Retractable Shrouds:</b> Keeps the test leads from getting entangled. Three common leads connect to the test set, which are interconnected down to one black common to connect to the relay under test. Sleeved Three Phase Test Leads, 200 cm (78.7") long, 600 V, 32 Amperes CAT II.	Qty. 1 ea. Part Number 2008-540
	<b>6x6 Sleeved Combination Voltage Leads with Retractable Shrouds:</b> Keeps the test leads from getting entangled. Three pairs of leads connect to the test set, with three pairs to connect to the relay under test. Sleeved Three Phase Test Leads, 200 cm (78.7") long, 600 V, 32 Amperes CAT II	Qty. 1 ea. Part Number 2008-541






**Test Leads and Accessories (Transducer Option)**

The following quantities of Test Leads and Accessories are supplied with the selection of the Transducer Option. Test Leads and Accessories can be ordered individually, see part numbers and descriptions below.






Descriptions of Optional Test Leads and Accessories	
	<p><b>Sleeved Pair of Test Leads:</b> Sleeved Test Leads, one red, one black, 200 cm (78.7") long, 600 V, 32 Amperes CAT II.</p> <p>Qty. 2 pr., Part No. <b>2008-539</b></p>
	<p><b>Cable / Spade Lug Adapter (Small):</b> Small lug fit most new relay small terminal blocks. Lug adapter, red, 4.1 mm, rated up to 1000 V/ 20 Amps CAT II</p> <p>Qty. 2 ea., Part No. <b>684004</b></p> <p>Lug adapter, black, 4.1 mm, rated up to 1000 V/ 20 Amps CAT II</p> <p>Qty. 2 ea., Part Number <b>684005</b></p>

**Additional Optional Accessories (Not Included in the FREJA 500-SERIES Optional Test Lead and Accessories)** - Additional Optional Test Leads and Accessories can be ordered individually, see description and part numbers below. The following accessories and part numbers are in quantities of 1 each. Order the appropriate number as required.

**Description**

	<p><b>RLC, Relay Lead Connector:</b> Excellent for easily connecting three phase voltage and current leads to the test system.</p> <p>Two sets of test leads (one for voltages and one for currents), sleeved, 4 mm (0.16 in.) terminals with retractable safety shrouds, color coded red, yellow, blue, black, 200 cm long (78.7") 600 V/ 32 Amps CATII.....<b>RLC</b></p>
	<p><b>Individual (Non-Sleeved) Test Leads:</b> Excellent for separated individual terminal test connections.</p> <p>Test Lead, red, use with voltage/current output, or binary I/O, 200 cm long (78.7") 600 V/ 32 Amps CAT II..... <b>620143</b></p> <p>Test Lead, black, use with voltage/current output, or binary I/O, 200 cm long (78.7") 600 V/ 32 Amps CAT II..... <b>620144</b></p>
	<p><b>Extra-Long Individual (Non-Sleeved) Test Leads:</b> Excellent for widely separated individual terminal test connections.</p> <p>Test Lead, red, use with voltage/current output, or binary I/O, 360 cm long (144") 600 V/ 32 Amps CAT II..... <b>2003-173</b></p> <p>Test Lead, black, use with voltage/current output, or binary I/O, 360 cm long (144") 600 V/ 32 Amps CAT II..... <b>2003-174</b></p>
	<p><b>Jumper Lead:</b> Used to common returns together externally when paralleling current channels (not required when using the sleeved combination current leads 2001-396).</p> <p>Jumper lead, black, 12.5 cm (5") long, use with voltage / current outputs, 600 V, 32 Amps CAT II ..... <b>2001-573</b></p>
	<p><b>Flexible Test Lead Adapter:</b> Use with rail-mounted terminals or screw clamp connections where spade lugs and crocodile/alligator clips cannot be used.</p> <p>Flexible test lead adapter, black, 1.8 mm male pin, use with test leads up to 1000 V/ 32 Amps CAT III..... <b>90001-845</b></p>

**Additional Optional Accessories (Not Included in the FREJA 500-SERIES Optional Test Lead and Accessories) Continued:**

	<p><b>Flexible Test Lead Adapter with Retractable Insulated Sleeve:</b> Use for connection to old style non-safety sockets with retractable protective sleeve on one end.</p> <p>Retractable Sleeve Test Lead, red, 50 cm (20") long, use with test leads up to 600 V, 32 Amperes CAT II .....<b>90024-781</b>                  Retractable Sleeve Test Lead, black, 50 cm (20") long, use with test leads up to 600 V, 32 Amperes CAT II .....<b>90024-780</b></p>
	<p><b>Parallel Test Lead Adapter:</b> Used when paralleling up to three current test leads together to a common test point. Usually used when connecting to a test paddle or relay terminal.</p> <p>Parallel test lead adapter, use with test leads up to 600 V/ 32 Amps CAT II .....<b>1002-286</b></p>
	<p><b>GPS unit with accessories</b></p> <p>GPS unit with all-weather antenna, power supply, and 15 meter cable ..... <b>MGTR-II-50</b>                  GPS unit with all-weather antenna, power supply, and 30 meter cable ..... <b>MGTR-II-100</b></p>
	<p><b>Soft-Sided Carry Case:</b> The soft-sided carry case protects the unit from light rain and dust. The padded sides provide moderate protection while in transit.</p> <p>Soft-sided carry case (1ea) .....<b>2006-066</b></p>
	<p><b>Hard-Sided Transit Case:</b> Includes custom designed foam inserts for the FREJA 543 unit, and accessories. Transit case includes retractable handle, built-in wheels, twist and lock-down latches, spring loaded fold-down handles, with O-ring seal.</p> <p>Rugged, hard-sided transit case (1ea) .....<b>1007-364</b></p>

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