F6TesT™

Advanced Visual Protection Testing Software for F6000 Power System Simulators

F6TesT software offers the ultimate in easy, fast, automated testing of stand-alone relays and complete protection schemes. F6TesT takes advantage of the power and versatility of the F6000-series power system simulators – F6TesT automatically controls the instrument from a standard PC. F6TesT is a protection application-centric software with graphical user interface and pre-configured test modules that make testing impedance, differential, current, voltage, directional, frequency, volts-per-hertz, sync-check, reclosing and all other relays very easy. It is also easily customizable for special, complex-scheme testing requirements.

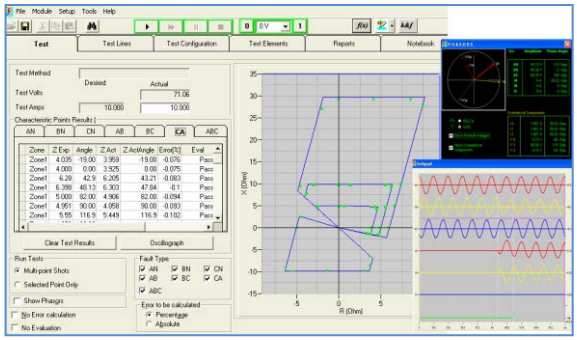
The highly-automated approach of F6TesT reduces user intervention and manual errors, improving the accuracy and repeatability of your tests, resulting in more reliable protection system performance. In addition, F6TesT provides a powerful database and reporting capabilities that give you better control and management of your commissioning and maintenance programs. With F6TesT you have the ease-of-use and power that you need to gain greater productivity and improve the quality of your protection maintenance program.

Benefits of automated testing with F6TesT

- Enjoy easy-to-use graphical modeling of protection characteristics for impedance, differential and other functions
- Start up quickly using pre-configured test modules
- Reduce learning time and start testing right away
- Model complex characteristics easily and create test plans quickly with the included library of relays
- Improve accuracy and repeatability with less manual intervention and automated calculation of complex quantities
- Perform more realistic dynamic testing with power system network models
- Standardize test practices with automated templates and increase productivity
- Verify your entire protection scheme with GPS-synchronized end-to-end testing
- Import of relay setting files in various formats – csv, txt, urs, xml, xrio
- Employ full relay templates with settings, protection functions, characteristics and test plans adapt automatically to the settings
- Use the flexibility of mathematical and logical formulas to support any special calculation requirements
- Test your protection at the in-service settings, avoiding changes to relay settings or remapping of input/output signals
- Test IEC 61850-based protection and automation systems using GOOSE and GSSE messages
- Test protection schemes that use IEC 61850 9-2 LE sampled values of voltages and currents
- Test devices that use Rogowski low-level inputs
- View test quantities in either primary or secondary values
- Prepare for regulatory compliance audits and manage your maintenance program with a historical database and reporting features

F6TesT is a menu- and mouse-driven program that runs under Microsoft Windows®. F6TesT displays protection data in a tree-view hierarchy and list-view folders in the familiar Microsoft Windows-Explorer-style interface. F6TesT includes copy and paste features to make it even easier to add new relays, relay functions, test plans, and tests.

F6TesT features a point-and-click graphical user interface to display relay characteristics, add and select test points, display test data and results, and a tabular format, as well. The graphical interface provides a visual presentation of the test points before, during and after the test. You can customize the color scheme of the graphs to suit your requirements for viewing and printing.



Settings, Functions and Test Modules

Test automation is achieved using relay templates of settings, protection functions and test modules. The protection functions and characteristics are calculated based on the settings. Settings and functions support multiple setting groups. Test modules are based upon the selected functions and elements to be tested, display characteristics and the test quantities. The test modules employ algorithms that calculate the expected operating values such as impedance, current, voltage, and time; and evaluate the relay performance.

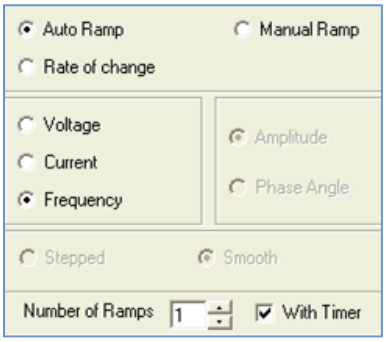
All test modules apply prefault and fault conditions, wherein the amplitudes and phase angles of all voltages and currents change simultaneously between states, simulating realistic dynamic fault conditions. It also allows control of the logic outputs to simulate other devices during the test such as circuit breaker and auxiliary switch contacts, a teleprotection permissive signal, an IEC 61850 GOOSE blocking signal, and others.

Defining the main test quantities in relative terms (e.g., test current in multiples of pickup setting, impedance test point such as 95% of Zone1 at 80 degrees line angle) allows any existing relay and test modules to be used as a template when creating new relays and tests modules. The user simply needs to copy an existing relay, change the settings or import a new settings file and apply the new settings. F6TesT recalculates and updates automatically the existing protection functions, characteristics, and test points. Disabled functions and associated test can be hidden and displayed as desired. The entire existing test plans and test modules under the relay template can now be used for testing. This avoids the need to create brand-new test plans and test modules and dramatically speeds test-plan preparation.

F6TesT employs flexible formulas that use logical and mathematical expressions for automatic calculation of characteristics, test quantities, and control of selection checkboxes.

Ramp

Ramp tests provide testing of relay pickup and dropout of current, voltage, frequency, phase angle and V/Hz relays by automatically ramping the test quantities (voltage/current amplitude, frequency or phase angle) up or down at a user-specified rate. The test quantity can be varied linearly in steps, or pulsed.



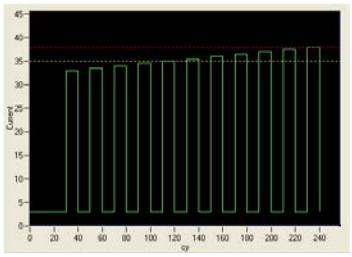
Ramp type selection

A pulsed ramp tests the pickup of high-set instantaneous overcurrent relays by going back to an offset value between pulses, as shown in the graph, to prevent thermal damage to relay input windings. A double ramp tests both dropout and pickup.

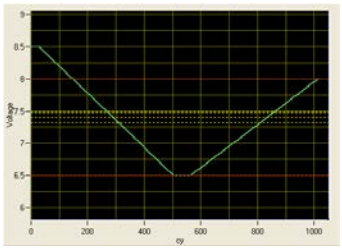
You can test inrush restraint in differential relays by ramping the amplitude of the harmonic restraint current.

For the frequency ramp a timer can be started when the frequency drops to a user-specified frequency for a timing test of rate-of-change-of-frequency (ROCOF) relays.

In addition F6TesT can automatically search for the pickup for the rate-of-change-of-frequency protection function, as well as rate-of-change of current and voltage.



Pulsed Ramp of Current

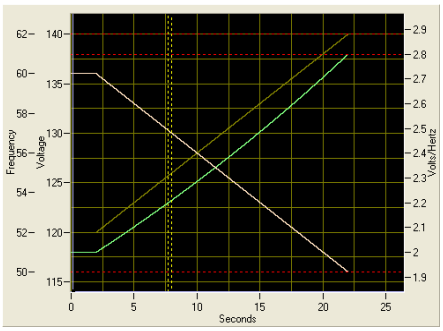


Double Ramp of Voltage Amplitude

VpHzRamp

This is a special ramp module dedicated for testing volts-per-hertz protection functions. It simultaneously ramps both the voltage amplitude and frequency, to more realistically simulate real-world system conditions. It tests the pickup and dropout of volts-per-hertz relays.

Prefault		
Duration	2.00	s
Voltage	120.00	V
Frequency	60.000	Hz
V / f	2.0000	V/Hz
Ramp Parameters		
delta t	0.010	s
delta V	0.01	V
dV/dt	1.000	V/s
V Limit	140.00	V
delta f	-0.005	Hz
df/dt	-0.5000	Hz/s
f Limit	50	Hz
V/f Limit	2.8000	V/Hz
Max. Duration	20.000	s

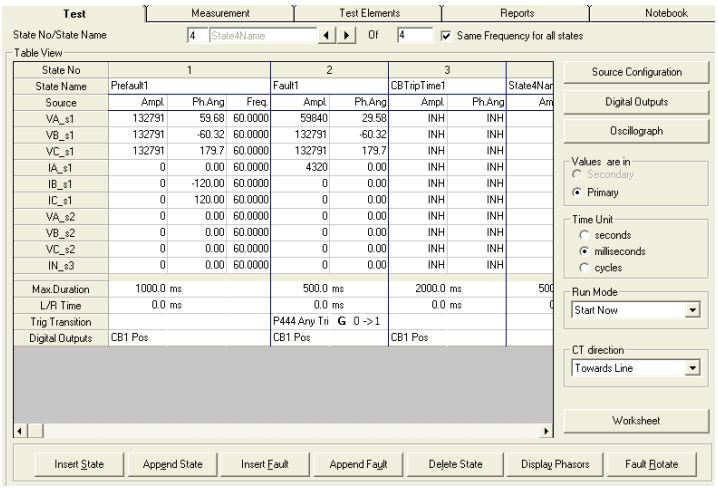


State Simulation

The state simulation (SSIMUL) test module provides full control of F6000 voltage sources, current sources, and logic outputs. A sequence of power-system states such as pre-fault, fault, post-fault, synchronizing, and autoreclose conditions can be simulated for dynamic state testing of the protection system. Decaying transient dc offset current can be simulated by specifying the L/R time constant for each state. Virtually any protection system test can be performed using SSIMUL including switch-onto-fault, evolving fault, current reversals, teleprotection schemes, and breaker failure.

State simulation serves as the basic foundation for all test modules described below, for more realistic testing of relays.

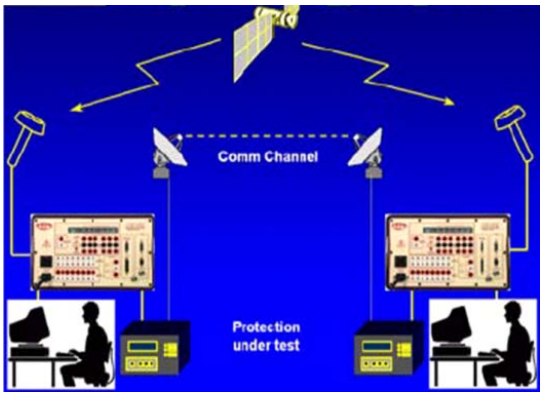
F6TesT imports SS1 and SS2 files that are created by third-party, fault-analysis and protection-coordination programs.



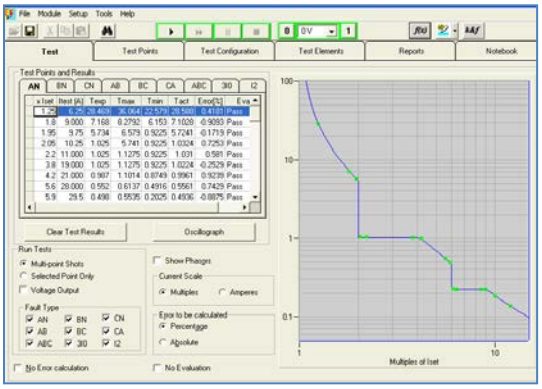
Faults based on the relay zone-impedance characteristics can be added using the graphical interface for Z-Time, described below.

SSIMUL has spreadsheet-like features and worksheets that support complex formulas. This feature makes SSIMUL even more powerful, allowing automatic calculation of test voltages and currents based on settings and test conditions.

State simulation with GPS synchronized, end-to-end testing lets you test and evaluate the complete line protection scheme including the teleprotection system and circuit breakers, and gives you confidence in the reliability of your overall protection system.



I-Char

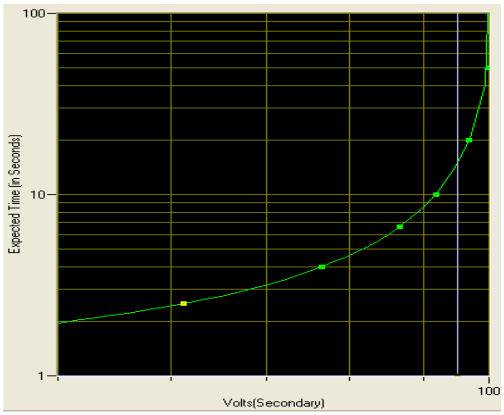


The I-Char module tests the current-time characteristics of overcurrent relays. Test points are specified in multiples of pickup setting or in amperes.

The expected operating time and the tolerance limits are automatically calculated based on the selected relay characteristics and settings. The picture shows the results of a test using the I-Char test module. The test module includes features that allow testing, in a single module, of multiple elements of different types (phase, zero-sequence, negative-sequence) for different fault types (Ph-N, Ph-Ph, 3Ph, 3I0, I2). Thus, you can use a single, common output contact, simulating proper values of currents and voltages and controlling the values of symmetrical-component quantities. This allows targeting the element under test while preventing other elements from operating.

VF-Char

The VF-Char test module tests the time characteristics of overvoltage, undervoltage, overfrequency, underfrequency, and volts per hertz protection functions. Test the relay functions by changing the voltage only, or the frequency only, or both voltage and frequency simultaneously. The interface is similar to the overcurrent test described above and you can test multiple levels and combine definite-time and inverse-time characteristics with ease.

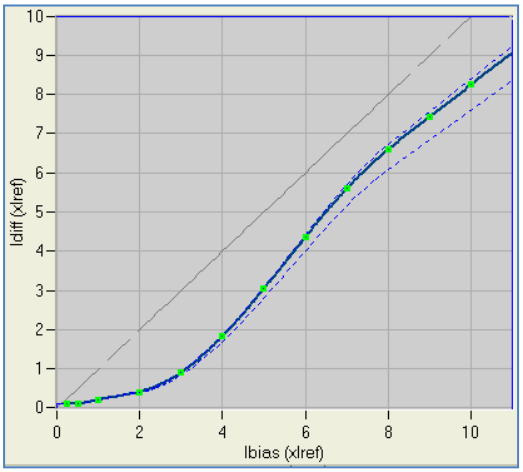


Diff-Char

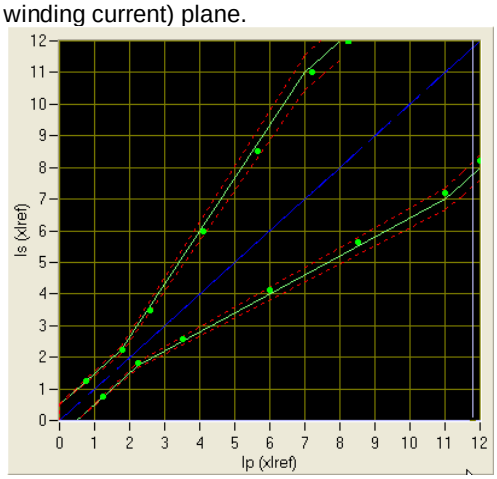
In the Diff-Char test module F6TesT can model all known differential relay restraint and bias equations. Characteristics can be modeled and displayed in the following coordinate systems

- bias current vs. differential current
- Primary-winding current vs. secondary-winding current

Single-phase and three-phase relays can be tested easily using in-service settings, selecting the actual relay settings for the bias equation, ratio compensation or tap setting, and phase or vector compensation. F6TesT uses the settings to calculate the test currents, avoiding the need to change settings to equal ratios or tap settings and simplifying the phase-angle compensation to zero to test three-phase relays.

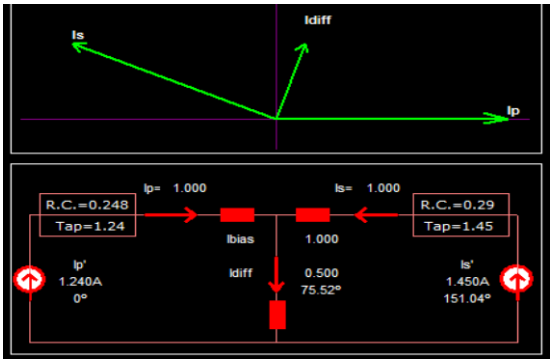


The Diff-Char test module tests the characteristics of current-differential relays using a binary search technique. When testing in the Ibias vs. Idiff plane, for each Ibias-Idiff point, the primary and secondary relay winding three-phase currents are recalculated taking into account all the bias equation and settings mentioned above. Testing can also be performed in the Ip vs. Is (primary vs. secondary winding current) plane.



Ip vs. Is plane.

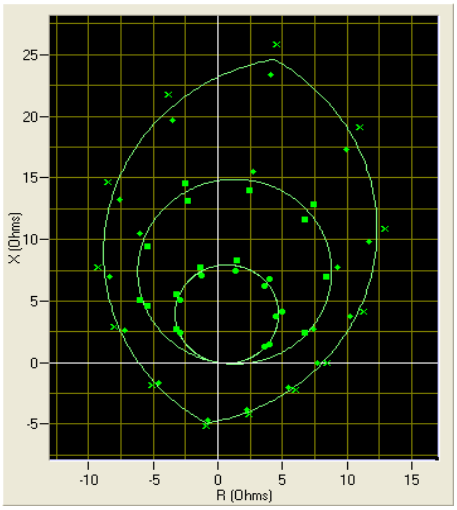
You can also test the relay by varying the phase angles of the secondary-winding current.



The differential test module also includes a phasor diagram of the currents into the relay windings as well as a tabular display of the current amplitudes and phase angles.

Z-Time

The Z-Time module tests the relay impedance characteristic boundaries and tolerances, just inside and just outside the reference characteristic for a single zone and for multiple zones in the R-X plane. The module calculates and adds multiple test points automatically. You can add more test points in a number of ways, including double-clicking on the graph. The relay trip time is compared against expected values and plotted using the appropriate zone symbol and green/red color for pass/fail. By selecting a few points you can quickly confirm the characteristic during routine testing.

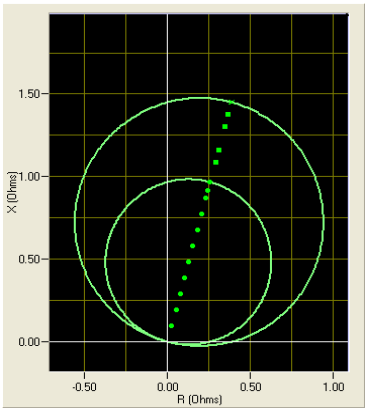


Boundary or tolerance testing

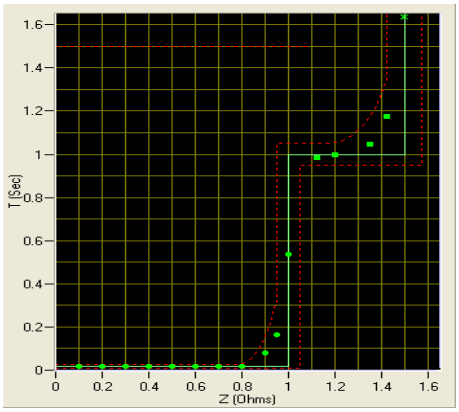
The special Spiral test plots numerous points on the R-X diagram. The test starts at the center of the R-X diagram and spirals out to fill the graph will test points. The test points will have different symbols and colors representing the zone and whether it passed or failed the test. This test can be used for checking relays with unknown characteristics. When used with a constant-impedance model it can be used for verifying that there are no blind spots and areas of misoperation. This provides a comprehensive tool for investigating some relay problems and in evaluating distance-relay performance.

You can enter a number of test points on the R-X plane along any fixed angle, such as the line angle. Then switching to the Z-time plane allows testing and plotting of the points for the actual operating time as shown.

This provides a very convenient tool for testing the operating time performance of distance relays for different points along the line under dynamic conditions when using a constant-source impedance test.



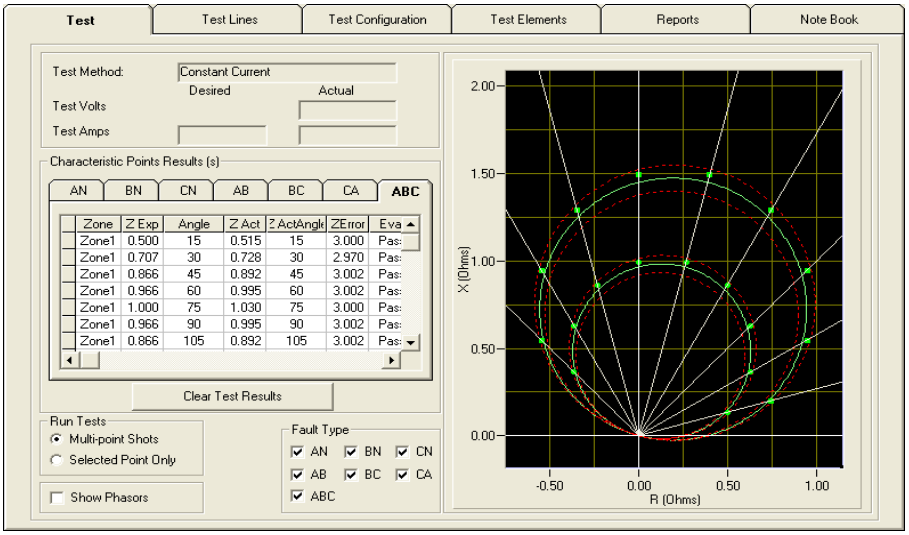
R-X Plane

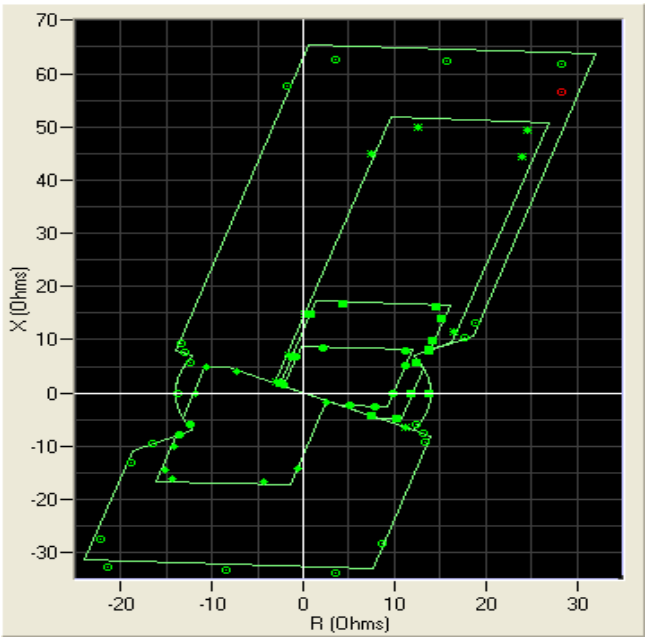


Z vs. Time Plane

Z-Char

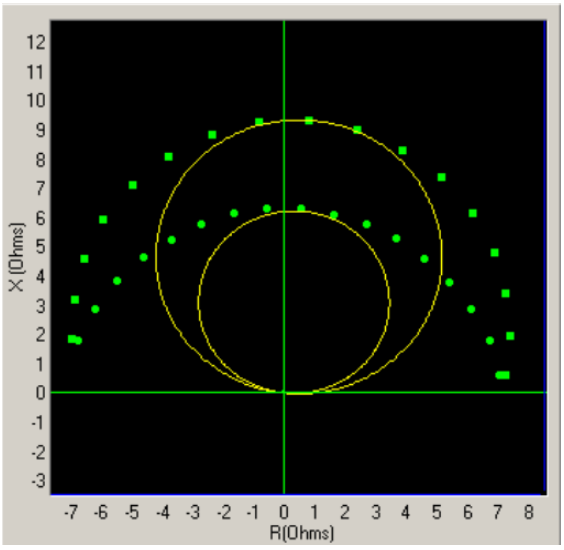
The Z-Char test module searches for the actual relay-impedance characteristics along test lines by using the binary-search technique and applying a series of test shots until the difference in impedance between two successive test shots is less than the specified search accuracy. Test lines can be radial, emanating from the origin or from a user-specified origin, or from several user-drawn lines. Z-Char can even find unknown characteristics. Test points are plotted and move on the diagram while test is ongoing, providing a visual sense on how the test is progressing.



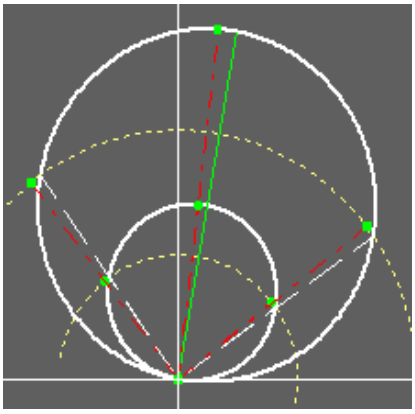


Polygon characteristics with load encroachment tested with user-drawn test lines

When the constant source-impedance test model is used for Z-Char testing, the dynamic expansion of a Mho characteristic can be tested and plotted as shown below.



Mho characteristic dynamic expansion



Z-MTA

The Z-MTA test module determines the characteristic angle or maximum torque angle of Mho characteristics. F6TesT performs a binary search along test arcs by applying a series of test shots until the difference in the angle between successive shots is less than a specified search accuracy angle. As in all impedance test modules a single module can test multiple zones as well as all the fault loops AN, BN, CN, AB, BC, CA and ABC.

Directional

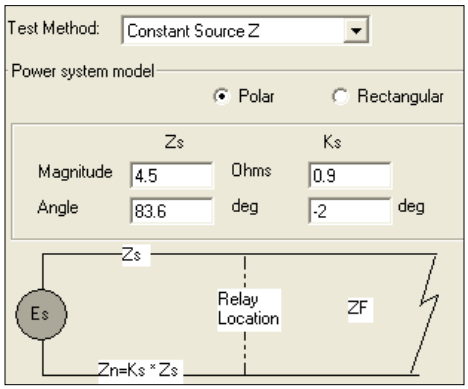
The Directional test module determines the characteristic angle of various types of directional functions including zero-sequence, negative-sequence, and user-selectable operating and polarizing quantities.

Testing of each element such as Phase A can include all fault loops. Likewise, zero- and negative-sequence elements are tested using pure zero-sequence and pure negative-sequence quantities in addition to these fault loops.

Impedance Network Models

Test modules Z-Time, Z-Char and Z-MTA employ the following test methods:

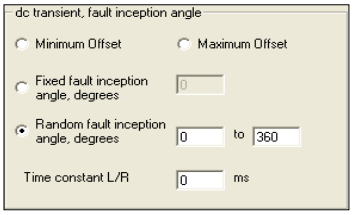
- Constant Test Current maintains the specified fault currents for all test shots and calculates fault voltages
- Constant Test Voltage maintains the specified fault voltage and calculates fault currents
- Constant Source Impedance calculates the voltages and currents for each fault test point

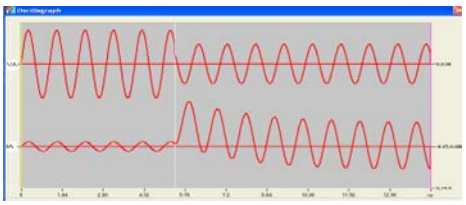


Complete three-phase fault quantities are calculated depending on the test method and the fault type (AN, BN, CN, AB, BC, CA or ABC).

For ground distance elements, F6TesT models the residual compensation using three modes – KN magnitude and angle, Z0/Z1 magnitude and angle, and ratios RN/RPh and XN/XPh. F6TesT also allows correct testing of distance-relay characteristics that measure arc resistance separately from the reactance measurement.

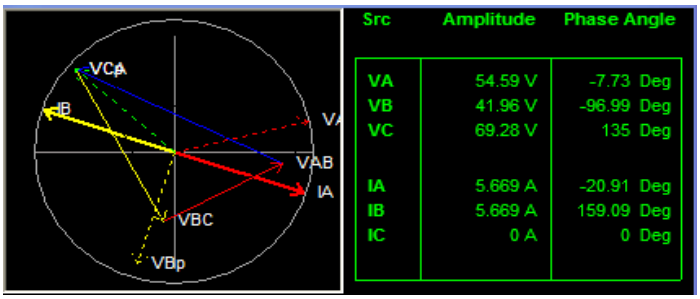
F6TesT provides automatic calculation of the fault inception angle for minimum and maximum dc transient as well as random, and user-control of the fault inception angle. Entering a value for the L/R time constant simulates the decaying dc transient.



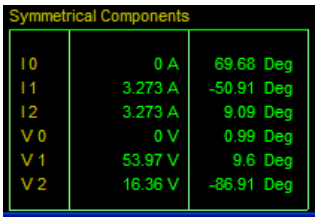


Phasor Diagram

The Phasor Diagram displays the actual prefault and fault voltages and currents in both graphical and tabular form for each test point before, during and after testing. All test modules have some form of phasor diagram.



The symmetrical-component quantities of voltages and currents are also calculated and can be displayed in a table, as well as in the phasor diagram.

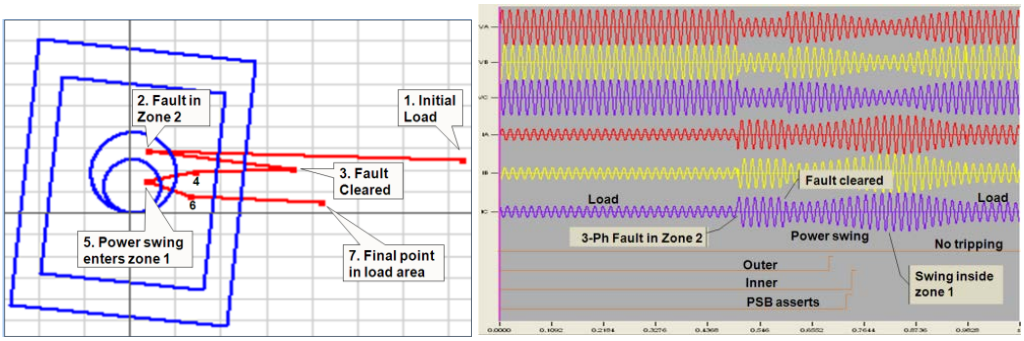


Oscillography

The waveforms and logic inputs and outputs are displayed for each of the test points in most modules.

WaveSim

WaveSim test module makes it very easy to simulate more realistic power oscillations and faults and makes it possible to test more advanced power-swing blocking and out-of-step tripping functions. It supports the classical two-machine system model and user-specified points and smooth rate-of-change-of-impedance, using mouse clicks on the impedance graph.



WaveSim module also simulates transient ground faults for testing this type of protection function.

Run Multiple Tests Automatically (Auto Run)

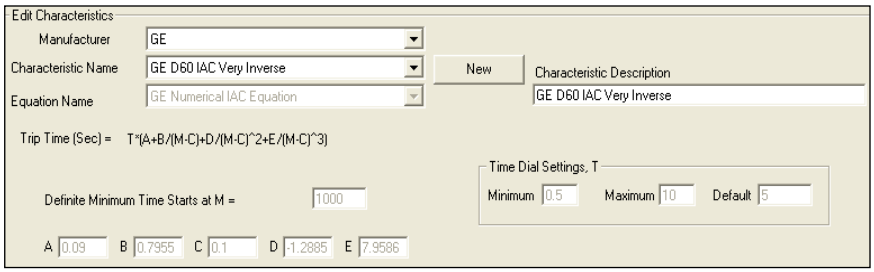
The Auto Run feature allows a series of test modules to be run non-stop, reducing the test time while increasing the consistency of a test by avoiding user intervention. You simply select the test(s) that you want to run and click on the Autorun button. F6TesT compares Test Results with expected values and tolerance limits to record pass/fail evaluation. F6TesT saves Test Results with test time and date information.

The **Extern** module allows external programs and scripts to be executed during an Auto Run sequence. This allows reading relay internal measurements, mapping a relay element to the output contacts, and changing relay settings, if required.

Relay Reference Characteristics

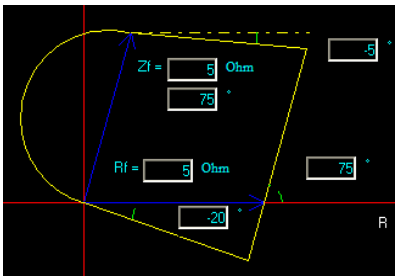
Accurate testing of protective relays and evaluation of test results requires correct reference or expected values. F6Test displays the reference graphs to provide a visual aid to the user during the preparation of tests, during testing, and viewing the test results. F6TesT employs reference characteristics to calculate automatically test quantities like current, voltage, impedance, frequency, phase angle and time.

F6TesT features a versatile interface for selecting and creating relay characteristics to reflect the relay settings. Equations and lookup tables model overcurrent, voltage and frequency relay characteristics; differential relay characteristics use lookup tables.



Modeling of numerical relay characteristics is based on IEC and IEEE standard equations. Non-standard equations that are specific to manufacturers and relays are modeled as easily as standard ones, such as the equation shown.

Electromechanical characteristics that do not have a suitable equation are modeled using lookup tables. Lookup tables support importing data from Excel and .CSV files as well as Windows copy and paste from any table. After creating a new characteristic you can view it graphically and compare it with other existing curves.



Distance relay characteristics such as mho, offset mho, quadrilateral, bullet, lens, and tomato are modeled easily by simply entering the applicable relay settings like forward reach, offset, characteristic angle, reactive reach, resistive reach, directional angle, reactive reach tilt angle, and aspect ratio.

Virtually any modern impedance relay characteristic can be modeled using a combination of straight-line and circular-arc segments (in polar form or Cartesian form) using a tabular interface and a graphical interface for visualizing the characteristic.

In addition F6TesT can also import functions and characteristics from files with .rio and .xrio extension exported by some relay settings software.

Library of Relays

F6TesT makes the modeling of protection functions and characteristics even easier with a library of impedance and differential relay models from various relay manufacturers.
The relay parameter settings are displayed in a similar way as is in the actual relay software. The settings automatically calculate the relay reference characteristics and are displayed graphically.
Then, a single click adds the new function to the relay, or updates an existing function if a setting is changed.

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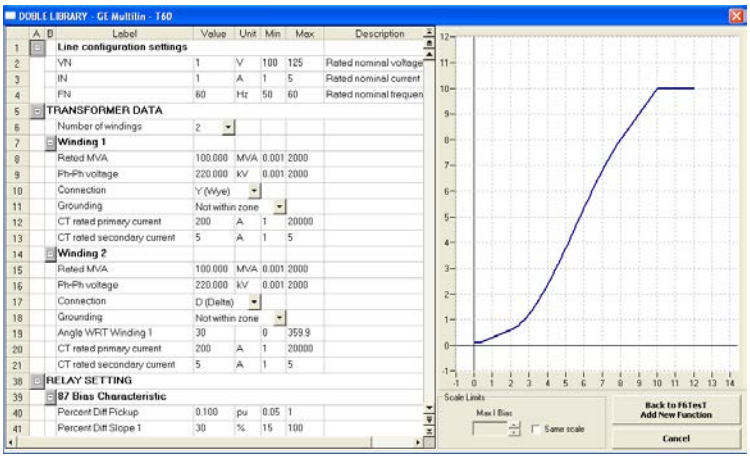
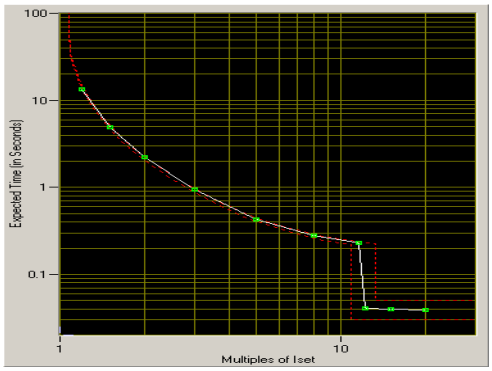
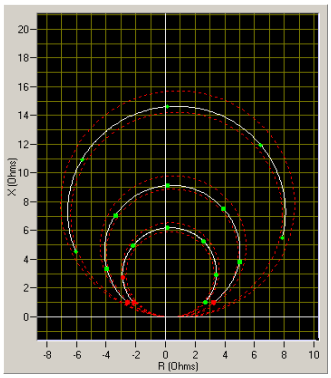


Plotting Actual Relay Characteristics

After conducting a characteristics test such as I-Char, Diff-Char, or Z-Char the actual composite characteristics can be plotted either alone or alongside the reference and tolerance characteristics for comparison.

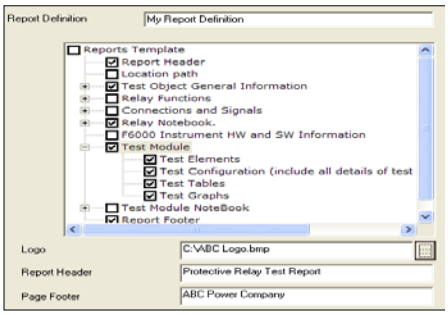




Ready-to-use Report Templates

F6TesT makes report creation as easy as clicking a mouse. The software includes a variety of ready-to-use report templates that preview, print and export test reports. You can easily customize reports to include all important information, including relay specifics, graphs, test configurations and test results by selecting only the corresponding checkboxes. The use of filters makes it easy to select relays, test plans and tests to include in a report.

You can add your company logo and company name to the report template. The user can also export a report in RTF format and edit it in MS Word® or other equivalent software.



A Database of Relays, Test Plans and Test Results

F6TesT uses the Microsoft Access® database system that stores historical test parameters and results for all protection throughout your power system. You can easily document and report all your relay settings, relay characteristics, test methods and maintenance test history. The historical database and reporting features help you in your maintenance program and in getting ready for regulatory compliance audits

Maintenance Scheduling and Alerts

F6TesT keeps track of maintenance test schedules and tests performed. It alerts you when a scheduled maintenance is getting close. This allows you to manage your maintenance resources and avoid missing scheduled tests.

Test Plan Library

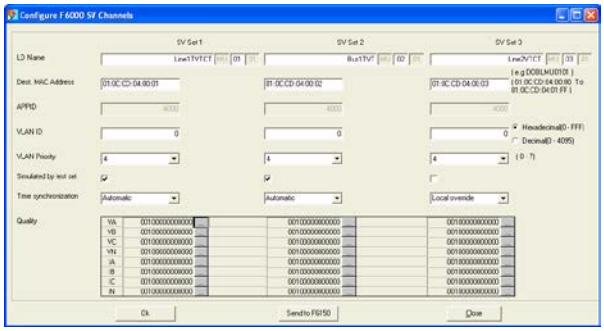
You can create a new database from any existing F6TesT database. This allows you to create a standard database that contains relays and test plans that you normally use. You can easily customize your template database. These standard databases can be used as libraries that contain relays and complete test plans. Doble customers can access and download test plans for various relay models that are continually updated.

IEC 61850 9-2 LE Sampled Values

F6TesT supports the enhanced F6150sv Power System Simulator that can create sampled values of voltages and currents over copper and fiber-optic Ethernet networks in accordance with IEC 61850 9-2 LE implementation guidelines. All test modules support testing with sampled values. A simple user interface in F6TesT makes configuration of the sampled value streams very easy. With three output streams of 9-2 LE, each with 4 voltages and 4 currents, you can easily perform functional test involving multiple IEDs.

IEC 61850 sampled values sources

Sources	Merging units	Voltage				Current				Enable
SV 1	XL01MU0101	VA_s1	VB_s1	VC_s1	VN_s1	IA_s1	IB_s1	IC_s1	IN_s1	☑
SV 2	XB01MU0101	VA_s2	VB_s2	VC_s2	VN_s2	IA_s2	IB_s2	IC_s2	IN_s2	☑
SV 3	XL02MU0101	VA_s3	VB_s3	VC_s3	VN_s3	IA_s3	IB_s3	IC_s3	IN_s3	☑



The test system supports Edition 2 requirements for simulation/test bits and time synchronization. It also allows testing in mixed mode using a combination of conventional voltages and currents as well as sampled values. An example is a transformer differential relay that uses sampled-value currents on one side and conventional currents of the other side.

Low-Level Sources

Certain devices use current sensors that convert the primary voltages and currents to low-level (Rogowski) voltages as inputs to the device. F6TesT can display the high-level primary values and scale these to the required low-level voltages.