F6TesT

VISUAL PROTECTION TESTING SOFTWARE
FOR F6000 POWER SYSTEM SIMULATORS

The ultimate software for the automated testing of individual relays and complete protection schemes

F6TesT software offers the ultimate in automated testing of individual relays and complete protection schemes. Designed to take advantage of the power and versatility of the F6000 series power system simulators, F6TesT automatically controls the instrument from a standard PC. F6TesT makes testing impedance, differential, voltage, current, and frequency relays simpler than ever before. Even complex protection schemes are easy to test with F6TesT’s graphical interface and pre-configured test templates.

The highly automated approach of F6TesT reduces user intervention and manual errors, improving the accuracy and repeatability of your tests. This results in a more reliable protection system performance. In addition, F6TesT provides a powerful database with 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 you need to gain higher productivity – which will improve the quality of your protection maintenance program.
Benefits of automated testing with F6TesT:

- Reduce learning and training time
- Increase test productivity
- Improve accuracy due to limited manual intervention and automated calculation of complex quantities.
- Start up quickly using pre-configured test modules
- Evaluate and improve test procedures with historical database
- Standardize test practices with automated templates
- Verify your entire protection scheme with GPS satellite synchronized end-to-end testing

F6TesT is a menu-driven program that runs under Microsoft Windows™. F6TesT displays protection data in a tree view hierarchy and lists folders in Microsoft Windows Explorer style interface.

F6TesT features a point and click graphical user interface to display relay characteristics, add and select test points, display test data and results, in addition to a tabular format. The graphical interface provides a visual presentation of the test points before, during and after the test. F6TesT includes copy and paste features to make it even easier to add new relays, relay functions, test plans, and tests.

Test Modules

Test automation is achieved using test modules or templates. These modules display characteristics and test quantities and employ algorithms that: calculate the expected operating values such as impedance, current, voltage, or time; calculate the equivalent voltages and currents required for test injection; control the voltage/current sources and the logic outputs of the test instrument; sense the response from the protection to measure its operating point or operate time; and evaluate the relay's performance. All test modules apply prefault and fault conditions, wherein the amplitudes and phase angles of all voltages and currents change simultaneously between the two states, simulating more realistic fault conditions.

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) allows any existing relay and test modules to be used as a template when creating new relays and test modules. The user simply needs to copy an existing relay, change the settings, apply the new settings, and existing test points are automatically recalculated and updated. The entire existing test plan and test modules under the relay can now be used for testing. This avoids the need to create new test plans and test modules and dramatically speeds up the preparation of test plans.
Ramp

Allows 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 may be varied linearly in steps or pulsed. You can test Inrush restraint of differential relays by ramping the amplitude of the harmonic restraint current.

<table>
<thead>
<tr>
<th>Ramp Type</th>
<th>Smooth</th>
<th>Pulsed</th>
<th>Number of Ramps</th>
<th>With Timer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
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<td></td>
</tr>
<tr>
<td>Current</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amplitude</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase Angle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pulsed ramp allows testing the pickup of high-set instantaneous current relays by going back to an offset value between pulses, as shown in the graph, in order to prevent thermal damage to relay windings.

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

VpHzRamp

This is a special ramp module dedicated for testing Volts per Hertz relays. It simultaneously ramps both the voltage amplitudes and frequency to more realistically simulate real-world system conditions. It tests the pickup and dropout of Volts per Hertz relays.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>200 s</td>
</tr>
<tr>
<td>Voltage</td>
<td>120.00 V</td>
</tr>
<tr>
<td>Frequency</td>
<td>60.000 Hz</td>
</tr>
<tr>
<td>V/Hz</td>
<td>2.0000 V/Hz</td>
</tr>
<tr>
<td>Tht</td>
<td>0.010 s</td>
</tr>
<tr>
<td>Vt</td>
<td>1.000 V/s</td>
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<tr>
<td>V Limit</td>
<td>140.00 V</td>
</tr>
<tr>
<td>Tht</td>
<td>0.005 Hz</td>
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<tr>
<td>V Limit</td>
<td>50 Hz</td>
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<tr>
<td>V/Hz Limit</td>
<td>2.8000 V/Hz</td>
</tr>
<tr>
<td>Max Duration</td>
<td>20,000 s</td>
</tr>
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</table>
State Simulation

Virtually any protection system test can be performed using State Simulation including evolving fault, current reversals, teleprotection schemes, autoreclosing, and breaker failure.

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

State simulation with GPS synchronized end-to-end testing lets you 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.

State simulation is made using the SSIMUL test module that provides full control of F6000 voltage sources, current sources, and logic outputs. A sequence of power system states like pre-fault, fault, post-fault, synchronizing and autoreclose conditions can be simulated for dynamic state testing of the protection system. Transient dc offset current can be simulated by specifying the L/R time constant for each state.

I-Char

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 below shows the results of a test using the I-Char test module.

V-Char

Tests the voltage-time characteristics of undervoltage and overvoltage relays. The interface is similar to an overcurrent test.

F-Char

Tests the frequency-time characteristics of under-frequency and over-frequency relays.

V-Char and F-char may be used to test V/Hz inverse characteristics.
**Diff-Char**

F6TesT can model all known differential relay restraint or bias equations. Characteristics can be modeled and displayed in the following coordinate systems: bias current vs. differential current or primary winding current vs. secondary winding current coordinates. Single-phase and three-phase relays can easily be tested using in-service settings by selecting the actual relay settings for the bias equation, ratio compensation or tap setting, and phase or vector compensation. There is no need to change settings to equal ratios or simple zero phase angles in order to test three-phase differential protection.

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

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

**Z-Time**

Z-Time tests the relay impedance characteristic boundaries or tolerances, just inside and just outside the reference characteristic for a single zone or multiple zones in the R-X plane by automatically calculating and adding multiple test points. You can also 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 basic points very quick testing can be performed for routine testing.

Entering a number of test points on the R-X plane along any fixed angle, and then selecting the Z-time plane allows testing and plotting of the impedance vs. time characteristics, as shown below.

A special test called Spiral tests 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 with test points. The test points will have different symbols and colors that represent the zone and whether it passed or failed the test. This test may 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 the performance of a distance relay.
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 R-X diagram origin or from a user-specified origin, or test lines may be several user-drawn lines. ZChar can even find unknown characteristics. Test points are plotted and move on the diagram while the test is ongoing, providing a visual sense on how the test is progressing.

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.
Run Multiple Tests Automatically

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 that you want to run and click on the auto run 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.

Relay Reference Characteristics

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

F6TesT features a versatile interface for the selection and creation of relay characteristics to reflect the setting of the relay. Overcurrent, voltage and frequency relay characteristics are modeled using equations and lookup tables; differential relay characteristics use lookup tables. This allows modeling of numerical relay characteristics based on IEC or 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 in the figure above. 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, tomato are easily modeled 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, which can be 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 extension that some relay settings software export.

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 can also calculated and displayed.
Plotting of Actual Relay Characteristics

After conducting a characteristics test such as Ichar, Diffchar, or Zchar, the actual 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 can be used to preview, print, or export test reports. You can easily customize reports to include whatever information is important, including relay information, graphs, test configurations, and test results by checking only the needed checkboxes. 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 test results

F6TesT includes a powerful database system that allows you to store historical test parameters and results for all the protection throughout your power system. You can easily document, report all your relay settings, relay characteristics, test methods, and test result history.

You can create a new database based on any existing F6TesT database. This allows you to create a standard database that contains relays that you normally use and allows you to customize your test plans.

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