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Mentor12 EN v3_SMC fichas 09/08/13 15:09 Página 1

ALL-IN-ONE RELAY TEST SET

▶ **MENTOR 12**



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MENTOR 12

“All in One” System for electromechanical, electronic, and numerical protection relay testing



INNOVATION

The new Mentor 12 universal platform revolutionizes the traditional relay testing concepts. With more than 25 years in designing and developing test equipment, EuroSMC has launched a product which exceeds the expectations of the most demanding professionals in this field.

The Mentor 12 has everything you need to test relays of any type, including the routine procedures and results saved in memory by the user for later repetition and reference. No external computer is required, except for existing and upcoming remote control applications that are not part of the built-in software. Also incorporated is an auxiliary voltage supply source to energize the relay under test when required.

Based on the success obtained from the PTE family of relay testing products, EuroSMC has equipped the Mentor 12 with a fast, powerful yet simple manual control interface that allows the expert user to verify the response of any relay in seconds. For the more complex or repetitive jobs, however, a full set of pre-defined, fully configurable test tools will assist the operator for an efficient, safe and error-free testing.

Your Mentor 12 will never become obsolete because all its functional elements are completely programmable. You can upgrade its software over the internet and install plug-and-play hardware options with no external assistance.

Ultra-compact output amplifiers, energy saving system, self-regulated ventilation, automatic auto-resetting protections with dynamic status reports, safety indicators, etc., we have charged the Mentor 12 with state-of-the-art features to keep it in perfect shape and ready at all times.



Swivel Touch-Sensitive 800x600 TFT. Built-in Windows CE® computer .

Rotary encoder for adjustment of test values and sliders.

Ergonomic custom case with anti-slip coating and transport handles.



EASY TO USE

The Mentor 12 is controlled via a touch screen panel and a rotary selector. An external mouse and keyboard can also be used if desired. The entire test process and test results are immediately displayed in numerical and graphic forms, with a complete set of feedback indicators and a real-time representation of power vectors.

You only need turn on the Mentor 12, connect it to the relay, and select the desired test on the menu. You will see the process and the results on the screen. Now, name it and save it so you can repeat the test or examine the results in the future.

If you have a COMTRADE file stored on a USB pen drive, just plug it into the Mentor 12 and it will reproduce the signal onto the relay in a matter of seconds.

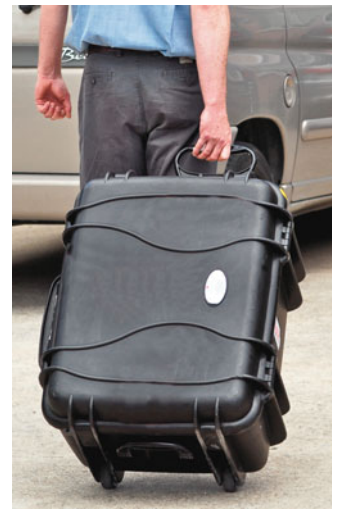


The VGA connector can be used to hook up external monitors or projectors for a larger viewing surface or for training purposes.

Mentor 12 is supplied with standard 10 Years Warranty, without additional cost. The Mentor 12 is designed and built to assure a very long life cycle, both in terms of updateable hardware and firmware, as in a rough electromechanical construction and high quality manufacturing process.



Small foot print, easy access to all connections and adjustable screen



UNIQUE FEATURES

STAND-ALONE FUNCTIONALITY, WITHOUT PC

EASY AND INTUITIVE TOUCH SCREEN

UP TO 12 CURRENTS AND UP TO 6 VOLTAGES

MODULAR CONCEPT, ADAPTED TO USER NEEDS

VOLTAGES CONVERTIBLE TO CURRENT

ADVANCED BUILT-IN TEST TOOLS

IEC 61850 TESTING CAPABILITIES

LOWER MAINTENANCE COST

10 YEARS WARRANTY

Fuse-protected AC power input.

Programmable Auxiliary DC supply with electronic protection.

Two three-channel bays for up to six voltage amplifiers with independent neutral, reversible to current mode.

12 binary inputs with automatic dry/voltage contact detection. Software-configured logical processing.

High-accuracy voltage / current measurement input.

8 binary outputs. Software-configurable relay or open collector modes.

Two three-channel bays for up to six isolated current amplifiers with independent neutral.

Connectivity set with 6 low level signal outputs, GPS antenna, digital expansion port, Centronics, RS-232, Ethernet LAN, 2xUSB, VGA, Mouse, Keyboard.

- Single-box solution for testing all types of relays and protection schemes.
- Modular construction, User-replaceable Plug & Play amplifier modules.
- Field upgradeable from 6 up to 12 power outputs, at any time, to test any type of protection scheme.
- Manual as well as automated testing, stand alone testing without PC.
- Voltage channels are convertible to current for differential relay testing.
- Intuitive and easy to use touch screen interface, for fast testing, no need for special training.
- Built-in advanced test tools, with graphical templates.
- Powerful Relay Test and device management software - ROOTS.
- State of the art amplifier technology.
- Fully isolated amplifiers with independent neutral.
- Software-controlled combination of channels, in serial or parallel, to meet higher current, voltage and power requirements.
- 3-kHz bandwidth transient testing from USB memory in COMTRADE format.
- Ethernet, USB and RS-232 communications.
- Free lifetime software upgrades via internet.
- End-to-end testing with GPS synchronization.

MENTOR 12



Low Level Outputs, USB and Ethernet connections

POWER

A state-of-the-art, fully programmable digital waveform generation engine constitutes the heart of the Mentor 12. It is able to control twelve independent low-level signal paths to the output section, producing extremely accurate signals with a 3-kHz bandwidth. These signals are driven to the output amplifiers for a stable, distortion-free 100 VA testing power. Prior to being amplified, these signals are also available at the low-level output connectors to test and calibrate transducers, energy meters and sensor- or Rogowski coil-based protective relays, as well as to be externally amplified for applications that require greater current or voltage limits.

The output amplifiers of the Mentor 12 deliver a stable and efficient output, with a power curve adapted to the most demanding test conditions. The unit can be charged with up to 6 current and 6 voltage amplifiers, each of which supply top-quality 100 VA/W permanent power simultaneously. The resulting 1,200 VA power allows for the complete three-phase testing of two relays at the same time, including the logical scheme and messaging functions, simulated and recorded by the 8 binary outputs and 12 inputs available in the Mentor 12.

FLEXIBILITY

You might not need twelve channels right now. Start with a smaller configuration and add more channels when you need them. The Mentor 12's amplifiers are plug and play. You just remove the unit's side cover, slide the amplifier(s) in, turn the unit on and continue working. The new amplifiers will be recognized and added to all the test and configuration screens by the Mentor 12 automatically.



POWER OUTPUTS CONFIGURATION

Regardless the number of amplifiers in your Mentor 12, you can also combine them in series and in parallel to attain greater voltage and current levels. The output configuration screen displays a menu with all the possible combinations and a visual guide to help you at connecting the relay. There is no need to calculate partial current, voltage or phase angle values as the Mentor 12 manages and shows each group of combined channels as if it were a single "virtual" one.

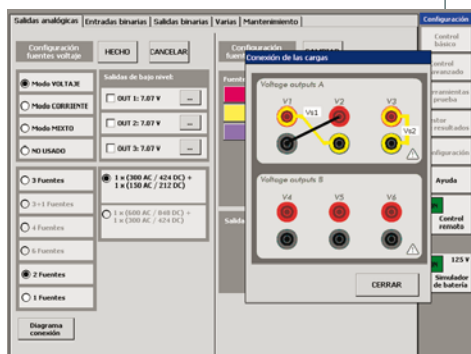
Furthermore, each voltage amplifier can be switched to current mode by a simple touch on the configuration screen. This feature allows, for example, to convert a Mentor 12 3v3i (3 voltage + 3 current channels) to a six-current test set when the need for testing three-phase differential relay arises.

Low Level Outputs and superimposed harmonics for every source can also be activated in this control. You can accurately measure the output from a transducer, an energy meter or any other measurement device by connecting it to the analogue or binary inputs while injecting known quantities with the Mentor 12.

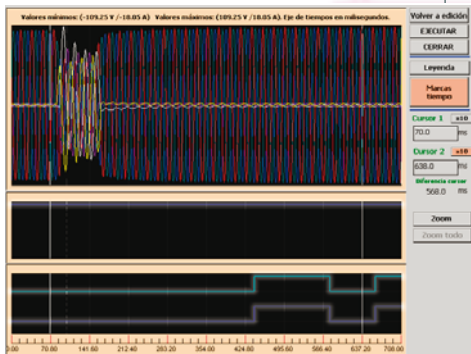
PRODUCTIVITY

The Mentor 12's human interface is organized to complete the job safely and accurately in the shortest possible time. Locating the necessary controls and the relevant test information will take just a few seconds to the untrained expert. The Basic Control panel has been designed especially for him. Adjusting a few values and testing a handful of trip points in the relay is a snap, thanks to the touch-sensitive panel and the rotary knob. There is no need to even look at the relay, as its response is displayed on the control screen in real time.

The Mentor 12 includes the transient fault Playback as standard. You only need to copy your COMTRADE files into a USB pendrive, plug it into the unit and press Playback. If you want, you can assign each current and voltage signal in the recording to specific current and voltage channels for the playback. You can map the recorded binary information and the response of the relay to any of the binary outputs and inputs in the Mentor 12. You can also discard the unneeded signal's sections or adjust the best transformation ratio for the playback. Press Playback to examine the streamed signals and the relay's reactions in the screen.



Combining two voltage channels in series



COMTRADE transient playback

COMPLETE CONTROL

The MENTOR 12 is the most advanced three-phase relay test set available for type and field testing of electromechanical and digital protections of any kind, in traditional or IEC-61850 based substations, providing the most complete and straightforward Manual Control of the market.

The optimized Basic Control Panel refers to the control of the equipment in Manual Mode for total control over all its functions:

- Power source controls: Current source/ Voltage source, Amplitude, phase angle, low level outputs, harmonic content, channel selection, on/off activation, channel combination, frequency control (2 Frequency Buses).
- Measurement display: multifunction timer, countdown timer, analogue input measurement, binary input pulse counter and frequency measurement.
- Function keys: channel selection, memory and Dynamic fault shortcuts.
- Battery simulator: Auxiliary DC supply setting for relay powering.
- I/O states: monitoring of power sources, binary inputs, binary outputs activation/status.
- On-screen access to Alarms reports.
- Output Power trimmer: Energy saving system with auto-adjustment to load and regulation of working cycle.
- Fine/coarse tuning.
- Real-time representation of power vectors.
- Timer operation/trip setup and preferences, binary I/O setting.
- Event Logger, with event description and time of the event. Automatic recording for all events, such as sources switching and I/O states.
- External measurement configuration, for testing of transducers, energy meters and sensors.
- Hardware configuration and maintenance, with internet upgrading capacity.

- Remote control activation/setup.
- Results Manager, and storage of results.
- STT: Importing RIO files and ROOTS test, execution of tests with no need of PC, just a USB pendrive.
- Advanced built-in Test Functions: Fault, Ramp, Double Ramps, Pulse Ramps, Binary Search, State Sequencer, Fault Playback.

The MENTOR 12's standard equipment build up one of the most advanced basic configurations available on the market for quick, simple and easy testing, for both commissioning and maintenance, without the need of any PC.

MODULARITY

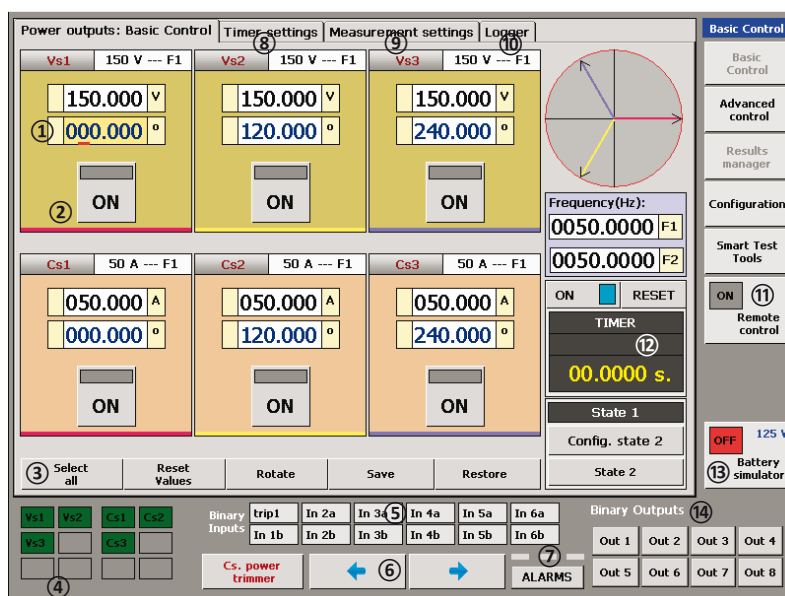
One of the biggest advantages of the MENTOR 12 is the "plug & play" modularity. New amplifiers connected by the user are automatically recognized and added to all the test and configuration screens by the MENTOR 12, with no software adjustment. User can start with a basic 6-channel unit –or even lower- and add more channels later on. The plug and play technology makes adding or replacing channels an easy operation, with no need to return the unit to the factory. It allows to have spare amplifiers, to be inserted in MENTOR 12 equipment with smaller channel configurations, or exchanged among units, providing at the same time a lower maintenance cost. Regarding replacement modules, contact us for more details on our unique Mentor Express Service.

The outstanding number of power outputs available in the Mentor 12 allow for endless combinations, which along with the serial or parallel connection of the output channels, extends the application field of the test set even to great power demanding electromechanical type relays.

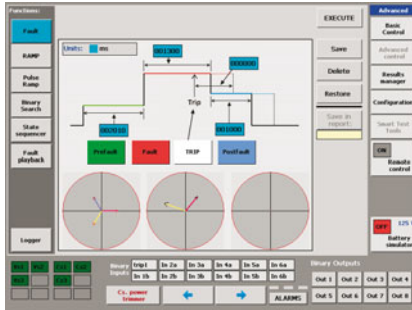
Mentor works on a Windows® CE platform which is configured to preserve the applications and data against the typical maintenance and security problems of personal computers, avoiding its disadvantages, but also keeping the unit up to date, with automatic and safe internet upgrading.

Intuitive Touch Screen

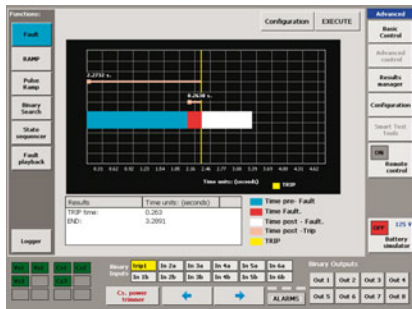
- Adjustment of test quantities, phase angles and frequencies
- Control panel for voltage and current outputs
- Channel selection, memory and dynamic fault shortcuts
- Output On/off indicators
- Binary inputs status indicators
- Adjustment digit selection
- Indicator / access to the alarm reports



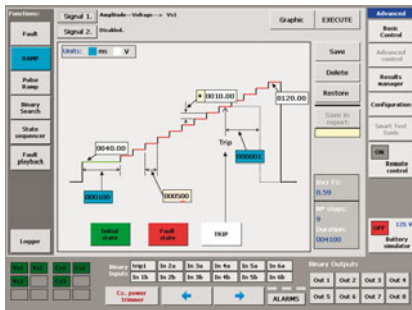
- Timer operation setup and preferences
- External measurement configuration
- Event logger
- Remote control activation / setup
- Multifunction display (timer, pulse, analogue, etc.)
- Auxiliary DC supply control / setup
- Binary outputs activation /status



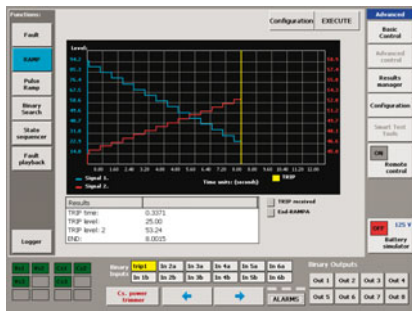
Fault Function



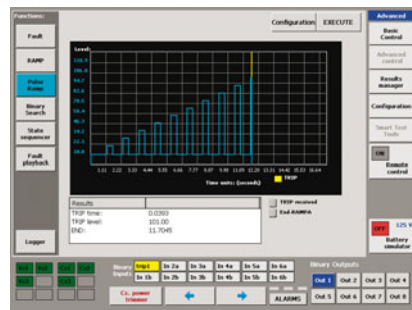
Fault Execution



Ramp Setup



Dual Ramps execution



Pulse Ramp function

ADVANCED TEST FUNCTIONS

The most complete Built-in Test functions, with on-screen graphic configuration, to carry out typical test for protection relays and protection schemes. These tests allows determining the state of the relay and obtaining readings and results of different relay parameters under different test conditions, configured by the user. A Logger is available for all functions, to carry out an in-depth study of the performance of the relay tested throughout the function.

Fault function: This three-state binary function allows the user to set a complete simple fault and execute the pre-fault, fault and post-fault values, including duration of the states, logic I/O states, and trip conditions. The fault execution displays the progress timeline and test results in graphical and numeric mode, including the trip time and end function time.

Ramp function: Single and Double Ramps, upward or downward ramps, of any output parameter on the MENTOR 12 can be programmed and executed. Ramp function operation is provided for finding limiting values, such as pick-up and drop-off. The linear ramp is the best way of handling parameters such as the Phase Angle, Voltage and Frequency, especially the latter, as the real performance of these parameters can be reproduced with great precision.

The flexibility of this module allows two synchronized simultaneous ramps of different variables, each one applied to different types of output quantities. For example, one ramp moving the Voltage and the other moving the Current (Impedance ramp), or applied to the same selected output source. For example one ramp moving the voltage and the other moving the frequency at the same time (V/Hz variation ramp).

After ramp and trip conditions are set, the test progress is displayed in an oscillographic fashion, with electrical values evolving along the ramp and trip events being stamped on the timeline as they take place. Relay trip time, trip value and duration of the test are displayed, and test repetition can also be performed if desired, or with different conditions. At the end of a test, user can type a name and a brief description and save it for future use. Since storage takes place on removable USB pendrives, the capacity is unlimited, and it also provides a way to create a collection of automatic test routines.

Pulse Ramp function: It is a way of carrying out a Fault ramp, each state with its pre-fault and its fault. The basic difference is that instead of continuously increasing the magnitude, a preset condition state occurs between consecutive pulses. This function is preferably used when instantaneous or defined time values are sought in Overcurrent elements, as it enables to inject a high current value during a specified time and return to low current conditions or even non-existing current conditions between each programmed pulse, thus eliminating the possibility of damaging the relay tested.

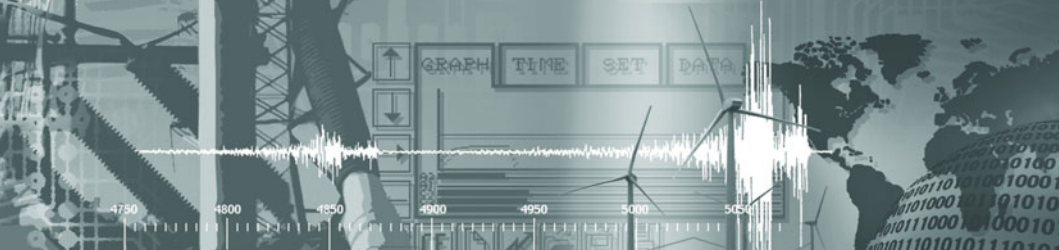
It is also very useful to verify trip setting values in protection zones, as we can enter the zone for a defined time and exit it without causing the other slower zones to trip.

The information about the number of steps (increases) and the total function length (in milliseconds) appears automatically calculated in the screen, as in the ramp function.

Binary Search function, unlike the ramps, the Binary Search does not use a fixed increase value, as it adapts to different values to make an effective search. The Binary Search function is designed to cover the circumstance when you do not know the trip value or even, to verify a known trip value carrying out the test in a different way.

State Sequencer function: The State Sequencer is a very flexible test module to test protection schemes, since it allows programming a sequence of all the outputs available on the MENTOR, analog or binary, as you desire, in a logical sequence of states. The State Sequencer is used to test protection functions that are closely connected to times and actions dependent on each other, such as reclosing cycles, protection schemes with segregated or selective trips, sending orders and signals to other protections, communication schemes, etc. To use this function it is important to study the data contained in the Logger in detail as well as their correlation with the changes in state, depending on what the protection or scheme tested are expected to do under the injected conditions.

Within one state, all configured test signals (voltage and current outputs) of the test device can be set independently in amplitude, phase, and frequency.



Fault Playback: This function allow the playback of COMTRADE fault description files, both binary and ASCII, according to IEEE STD C37.111-1999. This is very useful to analyze the protection's behavior against a previously recorded fault, or a simulated fault (from network simulation programs), reproducing this transient faults recordings at a specific sampling frequency.

COMTRADE files can be directly read from a USB pendrive, select the section to be played and analyze the response of the relay at the binary inputs in the MENTOR 12. User can edit and discard the unneeded signal's sections or adjust the best transformation ratio for the playback.

This makes it possible to check if the relay's reaction differs between the recording and its behavior during playback, and also to analyze how other protection device operates under the same conditions. If the GPS option is installed, it is possible to synchronize the file playback through this external time reference.

OTHER SOFTWARE ELEMENTS

Results Manager: This module allows saving both the test results and configuration of Advanced test functions, so that they can be repeated as desired. Results are saved in a USB pendrive.

The system can save as many tests as needed in Report files, being a way to automate tests for specific relays. The reports can be displayed on the PC, exported and/or printed, using the Report Viewer for Windows, which is included as standard in every MENTOR.

After any advanced function test, we can add the results to any existing report, with a new name for this test and a description. The test is recorded with date and time and the function type. The saved collection of user-defined and customized test routines will provide a valuable asset of ready-to-use test tools for each relay type and protective function. The user only needs to choose one from the list in the Results Manager and press Execute.

Binary Inputs Configuration: The MENTOR 12 has 12 (Logic) Binary Inputs grouped together in 6 isolated pairs, in order to be able to detect the behavior of the logic outputs of the relay or protection scheme that is being tested. The Binary Inputs can be configured to detect both Dry Contact operation signals, or Wet Contacts, that is, a signal with voltage applied to them (1.5 or 15V threshold up to 400V pk ac or dc). Each Binary Input can be programmed to be active High or Active Low (NO, NC).

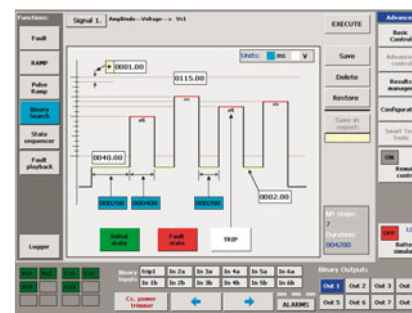
Binary Outputs Configuration: There are 8 Binary (Logic) Outputs in the MENTOR 12, in order to be able to program their behavior so the action of devices in the protection scheme that is being tested can be simulated. Each Binary Output can be configured as: Relay /Open Collector, and NO/NC mode.

Binary I/O Monitor: The MENTOR 12 is permanently monitoring the Binary Inputs states, and reflecting any change at both the screens of test results and in the Logger; furthermore, the user can also monitor on-screen any status change of all the Binary Inputs at any time, which facilitate testing and verifying the relay's reaction during the test execution.

Similarly, Binary Outputs status is displayed on the screen, monitoring the pre-programmed activity of them at any of the functions; besides that, the user can also activate or deactivate manually any of the Binary Outputs, if required by the simulated protection scheme, from the Binary Outputs control on the main screen.

Meter & Measuring: Measurement configuration section to configure the settings for analog and binary measurement. This functionality, specifically designed to test transducers with analog output in VDC or mA DC or counters with analog or digital output by pulses, makes the conversion from the magnitude measured at the input (V, mA, Pulses) to the units that are assumed to be the nominal ones of the element to be tested (V, A, KVA, Kw, Kvar, Kw, time, etc) entering the ratio between both. Optical scanning heads for capturing pulses emitted by the energy meters (non-visible infrared LED and visible) are optional accessories available. The multifunction display in the main control panel shows the values measured in the analog input and binary input in real time.

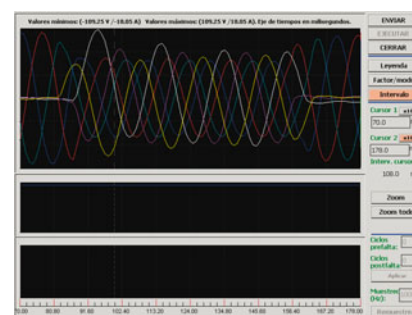
Logger: Automatic recording available in MENTOR 12, where any event is registered, such as the activation of the outputs, and changes at the binary inputs and outputs. The events listing are displayed with the time recorded for each, to correctly analyze the performance of the relay.



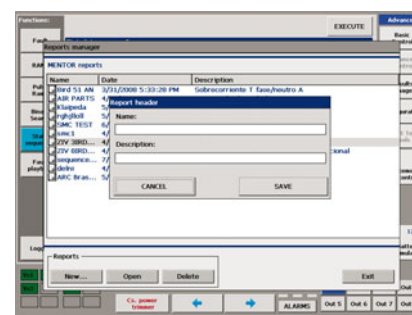
Binary Search



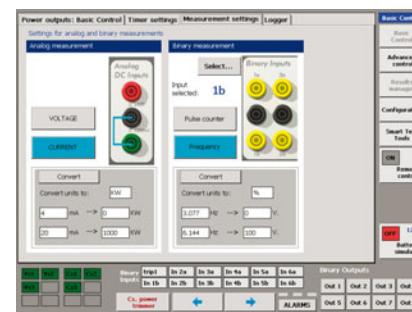
State Sequencer function



COMTRADE transient playback

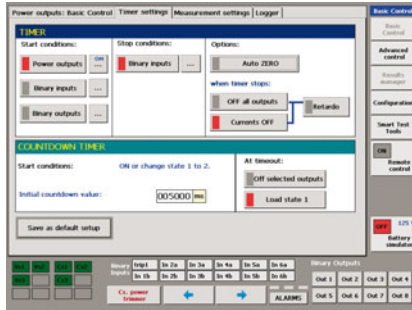


Results Manager

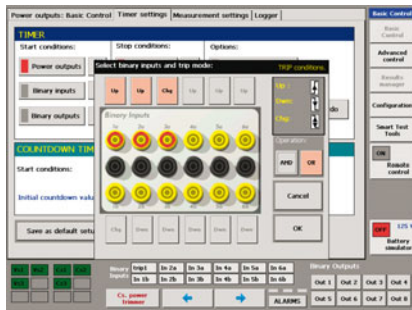


Measurement settings

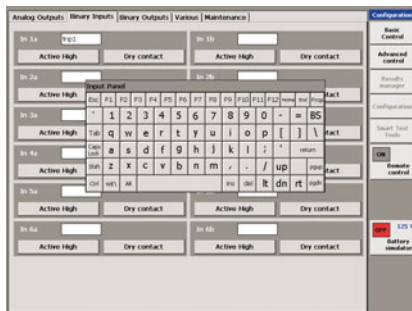
MENTOR 12



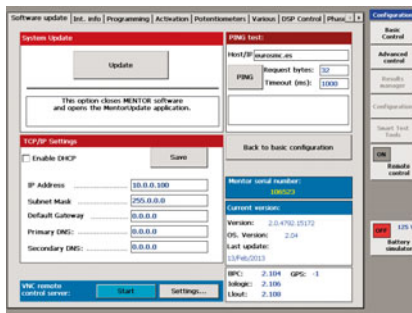
Timer Settings



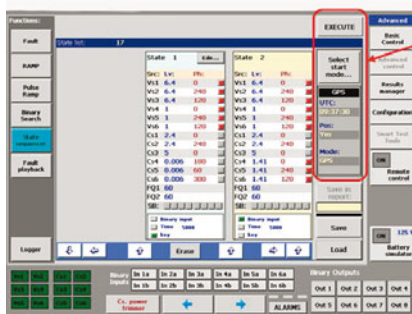
Binary input selection and trip mode



Binary inputs configuration



Internet upgrading



States sequence with GPS

Timer Settings: Timer start and stop conditions can be quickly adjusted to the test needs. The timer can be programmed to start by the status changes in the Power Outputs, by the action of a Binary Input combination, or by the status change of any Binary Output. Timer stops by the trip action at the Binary Input logic, which setting is straightforward selected. After the stop of the timer, voltage and/or current outputs can be immediately switched off or delayed to simulate switch time.

A countdown timer can also be programmed to stop the outputs or to load the previous state with the desired time in milliseconds.

Battery Simulator: The MENTOR 12 has a built-in battery simulator up to 250 Vdc, which must be used to supply the relays being tested and which require an auxiliary power supply. The Battery Simulator control is available in all the accessible function screens.

Internet upgrading and Maintenance: the MENTOR 12 will never become obsolete because all its functional elements are completely programmable. The user can upgrade its software over the internet and install plug-and-play hardware options with no external assistance. All hardware and software configurations can be updated by internet. The user enjoys free updates of new features and modules made by EuroSMC.

Harmonics: set of controls to easily regulate different harmonics contents in the voltage and/or current channels. The control allows selecting the desired Harmonic (2 to 33 in 60 Hz base frequency and 2 to 40 in 50 Hz base frequency) for the channel group. On each channel it is possible to regulate both the harmonic content in percentage and the angle where it is going to be inserted into the fundamental waveform. The possibility to work with the two parameters makes possible to generate with the desired Crest Factor (also called Form Factor), which is important mainly in testing old electromechanical and electronic analog relays, which are sensitive to this parameter.

Cape Test files converter: Now all the EuroSMC's MENTOR 12 users may convert the Cape SS1 files into a file directly readable from a USB pendrive by the MENTOR 12 test set, and perform the test in few seconds by using the EuroSMC's CAPE SS1 to MENTOR converter software, which allow the user to directly download the sequence values into the States Sequencer and perform the test immediately. The States Sequencer may be triggered either manually or through the GPS or IRIG-B time synchronized options available for the MENTOR 12 unit, making an ideal tool for End-to-End testing. The Cape software is a popular program for network simulation and shorrcircuit analysis, which allow the user to calculate the fault values in a network point and make possible to obtain a file which contains all the information of the prefault, fault and post fault values and the duration of each state. It is also possible to obtain a full states sequence corresponding to a reclosing cycle.

IEC-61850- GOOSE module: MENTOR 12 is IEC-61850 compatible. The option MENTOR IEC 61850 is a GOOSE Messages Interface Board which consists in a plug & play electronic board that installs into the Control Bus of any MENTOR 12. The configuration software tool is included in the MENTOR 12 internal software, avoiding the use of an external computer, and allows to subscribe/publish the GOOSE messages.

This option works through the RJ-45 connector, which connects with the IEC-61850 bus and use the information contained in the GOOSE messages as logic inputs and also it is able to broadcast GOOSE messages that acts as logic outputs, exactly in the same way that the current MENTOR 12 electrical I/O works, but avoiding the wiring of the I/O to the relay inputs and outputs.

The IEC 61850 option can be installed in any existing or future MENTOR 12.

MENTOR-GPS/IRIG-B: The MENTOR 12 equipment allows for this synchronism by the use of two alternatives of very precise time reference inputs: GPS and IRIG/B. It requires the installation of the corresponding Printed Circuit Board. GPS and IRIG/B boards are plug & play; once the hardware has been detected and the signal is received, the unit is in disposition to initiate a state sequence or execute a COMTRADE file in a previously defined instant with a precision of microseconds. User can upgrade the MENTOR 12 with these optional boards at any time by themselves, without needing to send back the unit to factory.

SMART TEST TOOL FOR MENTOR 12

The Smart Test Tool (STT) for the Mentor is an Automatic Stand-alone Testing tool. Any MENTOR 12 can be equipped or upgraded at any time with this optional software called Smart Test Tools. Among the advanced test features provided by this component, the possibility of executing ROOTS-originated test batches is possibly the most outstanding, because it avoids the connections and preparation overhead usually associated to an external computer.

Any number of relay entries, each one containing a batch of different tests, can be stored from ROOTS onto a USB removable memory and then read and executed by the MENTOR 12. It is also possible to modify the test settings and even the test points before running the pre-defined tests. In the fault settings, the user can also modify and select the binary inputs of the MENTOR 12 and trip mode required for the test. When the test is performed, the test point lists are injected sequentially, each one with its pre-fault, fault and postfault values. The results are displayed graphically and numerically in the test point table. The reaction of the relay is automatically assessed, comparing the result to the specified nominal settings, and clearly indicated as successful or failed.

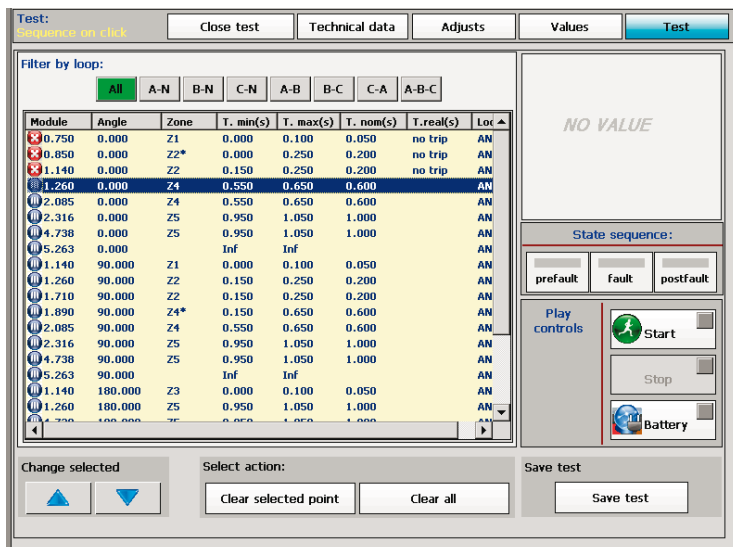
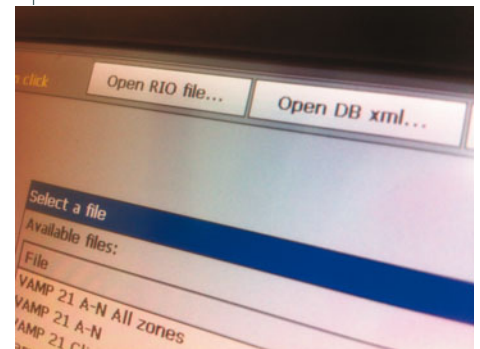
The results are automatically appended to each test point and saved back into a new file in the USB memory. Later on, ROOTS will retrieve the complete test records from the USB and will associate them all to the corresponding relays in the original database, for future reference and / or immediate reporting. The general functionality of the STT module provides a usability not known so far for non-experienced users and a very powerful tool for the expert.

True touch & test paradigm

Another useful feature in STT is the RIO file import. This can save you the time of defining your relay's operation characteristic. Once a RIO file has been read from your USB removable drive onto the STT, you only need to enter the values of as many points you want to test in the impedance plane or, even easier, add test points by just touching at different spots on the displayed characteristic's graphics, and run the test. A zoom is available to facilitate data input. It is also possible to change and adjust the test settings, test method, and technical data before running the test. Test points can be defined for the several fault loops at the same time (A-N, B-N, C-N, A-B, etc) or separately. Test points results can be cleared and repeated individually if desired, not being necessary to run again the complete test.

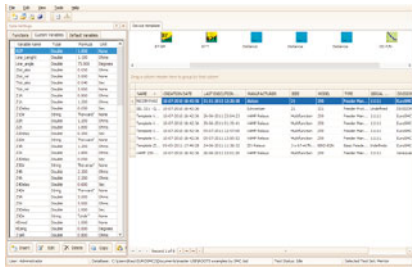
The Mentor STT effectively leverages the outstanding power of ROOTS by allowing you to put your test plan inside your pocket, execute it with no manual intervention and no external computer on the field, and produce as many reports as you need once back in your desk.

ROOTS and the STT are supplied as standard with every new MENTOR 12. New users can try these products for 90 days and, if eventually decide to purchase a license, all the test routines defined and test results saved so far will continue to be indefinitely operative in the database.

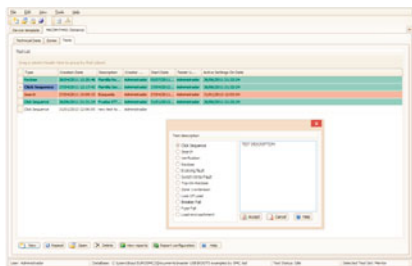


ROOTS

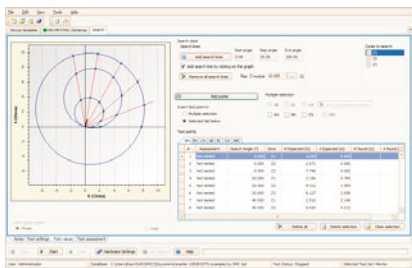
ROOTS RELAY TESTING SOFTWARE



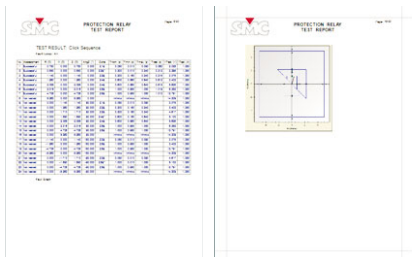
Device Panel



Test List Screen



Test Screen



Test Report

ROOTS (Relay Object-Oriented Test System) provides the best solution to the testing of today's multifunctional IEDs by performing accurate fault calculation, sequential test execution, and reporting automatically.

ROOTS is an optional product for PC-operation of SMC's **MENTOR 12** and **TRES** relay test sets.

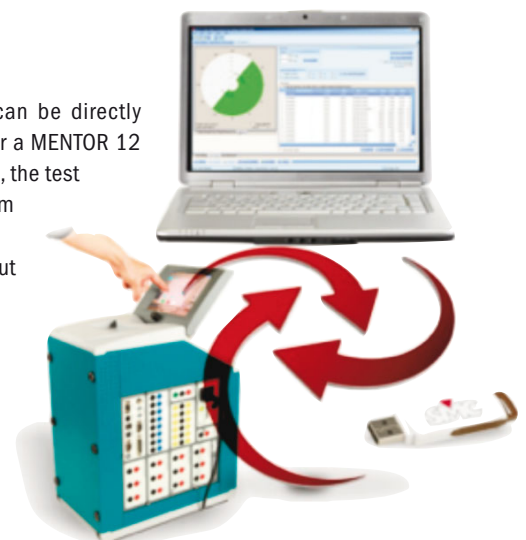
ROOTS is developed using the latest Microsoft .NET® technology and is available for 32-bit and 64-bit Windows XP, or later platforms.

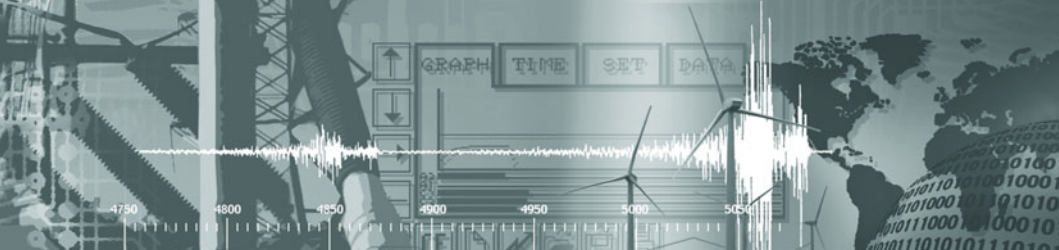
ROOTS implements a friendly, intuitive interface, for the quick and accurate configuration of all equipment features, device settings, test modules, test results, reports, and the permanent storage in a database. Test routines and report definitions are saved according to a simple hierarchy that is flexible and easy to understand. The user can create any number of test databases and each database is organized by Devices (IED); several Test Modules can be added to every Device, protection-specific modules, such as Distance or Overcurrent, or RIO files modules. Each module contains a test kit with test routines (click sequence, search, reclosing, breaker failure, etc) that can be used right off-the-box or quickly and easily customized to the user's needs. In summary, substation/s overall test procedures can easily be built, can be repeated for maintenance testing, and also used as templates for similar substations with minimum adjustments, which saves considerable time.

MAIN FEATURES

- The best solution to the testing of today's **multifunctional IEDs**.
- Spans the testing from the relay to its interactions with the whole **protection scheme**.
- Accurate **fault calculation** and sequential test execution.
- Automatic, customized and exportable **Reporting**.
- Roots storage files are self-contained **databases**: relay data, characteristics, custom formulas, test routines and report definitions.
- Database management functions for the **import/export** of device (relay), test definitions and results between databases.
- Ability of using **formulas** instead of fixed values when entering test values, settings, options or other data.
- Direct import of **RIO** relay description files supplied by a number of relay manufacturers.
- Intuitive graphical zone and elements **Characteristics Editor**, with pre-defined Templates.
- **Modular architecture**, different optimized test modules for each protection function.
- **Modular pricing**, ROOTS can be purchased with one or more functional modules, providing a price-optimized solution.
- **Free updates**, No other product in its class offers free lifetime updates and the possibility of being upgraded (in software and in hardware) by the user himself.

Test procedures defined within ROOTS can be directly executed on a connected SMC test set. For a MENTOR 12 equipped with the Smart TestTools module, the test procedures can also be transferred from ROOTS to an USB pendrive that can be read and executed by the MENTOR 12 without the need of an external computer.





OVERCURRENT MODULE

The **Overcurrent** test module is used to automatically test the performance of protective devices that implement any combination of the 50, 50N, 51, 51N, 67, 67N, 46 and 49 protection functions. It includes tests of operating values, and the external scheme tests related to these protective functions.

The module's functionality is distributed in the following sections, among others:

Technical data: general parameters that affect all the tests contained in the Overcurrent module, such as: work with primary values, elements used for phase-ground faults, ground CT data, sensitive ground CT data, Current, time and angle tolerances, directional settings, grounding characteristics and transformer connection.

Element list: the test module supports any number of phase, neutral, negative sequence, ground and sensitive ground elements. Different element characteristics can be selected, added and activated in the Element List, and different settings can be adjusted for each one. A Graphical View of the Relay curve is available for Non Directional and Directional Relays (Forward Curve, Reverse Curve and Operation/No Operation zone view).

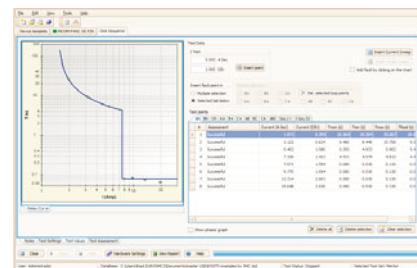
Characteristics Template: access to the edition of the different inverse time characteristics that Roots contain. Groups of pre-defined Characteristics are available depending on specific equations (IEC, IEEE, ANSI, U.S.), user-defined formulas, and curves in tabular form. Each one can be edited through modification of the associated variables. The user can also easily create new curves from scratch.

Test Screen: with flexible access and configuration of the various test elements:

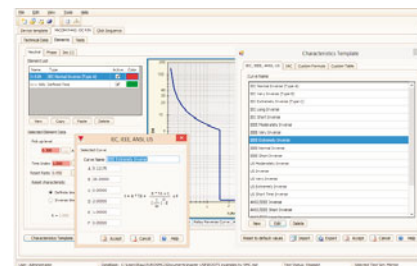
- Test Settings (prefault, fault and postfault).
- Test Points: table of test points for each Fault type loop with the set values. With several methods to define and insert test points, individually, interactively clicked right onto the characteristic's drawing or a number of time-saving tools can be used to automatically generate series of test points, supporting separate or multiple fault loops selection (A-N, B-N, C-N, A-B, ABC, etc).
- Test Result Assessment, automatic and manual.
- Test Graph of the protection element: For directional relays, the graph shows three views, relay curve for forward and backward faults, and an angular view, indicating the operating area by colors.
- Phasor Graph: allow to view the phasor diagram of every point being tested.
- Hardware Settings: map the test set I/O and power connections to the relay, configuration of operating options of the test set for Binary I/O (Relay/Open Collector, NO, NC, Dry/Voltage).
- Report and Report Configuration: automatic report generation with user selection of data to be shown. The report can be produced in PDF format or other data interchange like XML. Reports are saved along with the results in the database.
- Test execution: automatic sequential injection of test settings for every test point, comparing the operating time measurement with the allowable current and time tolerances in technical data, assessing the result as correct or incorrect and printing it both in the test point table and the test graph. The test sequence can be stopped at any time by the operator, and then resumed from the first non-tested point. The user may also decide to reset the tested points and restart the entire test from the beginning, or to repeat the test only for a selection of the points in the list without affecting the other test points.

Test List: Multiple tests can be selected and attached to the device under test from a wide choice of test types including scheme-oriented tests like reclosing or CB failure:

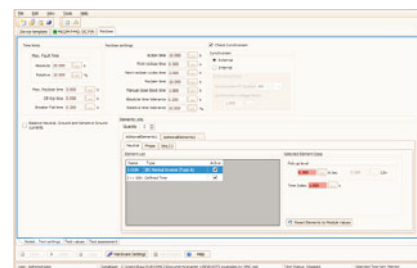
- | | |
|-----------------------------|--------------------|
| - Click Sequence | - Pick up/drop out |
| - Reclose | - Cold Load |
| - SOTF (Switch On To Fault) | - I2/I1 Ratio |
| - Breaker Fail | - Fuse Failure |
| - SOL (Selective OC Logic) | - Reset Time |



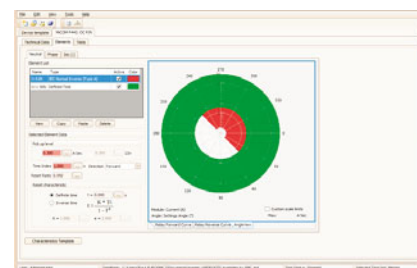
Click Sequence Test



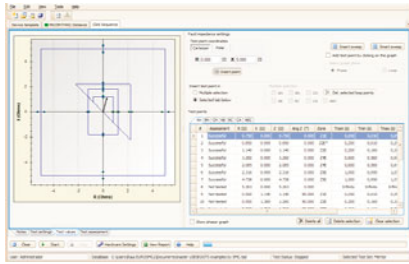
Element list and characteristic templates



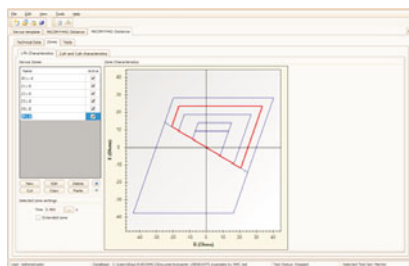
Test Settings



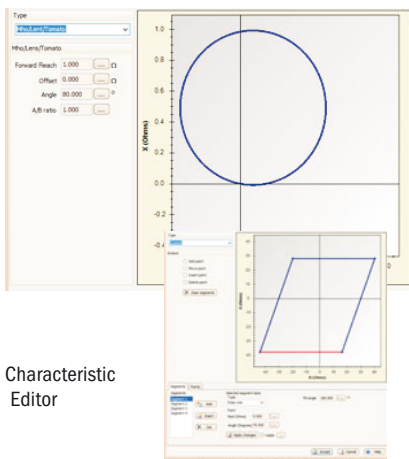
Angle View



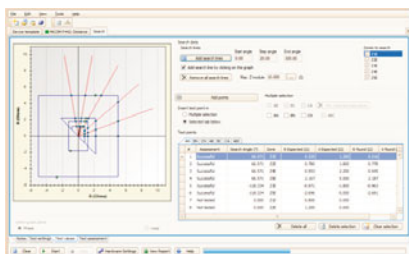
Click Sequence Test



Distance Zones



Characteristic Editor



Search Test

DISTANCE MODULE

Distance test module is used to test all functions related to protection function IEEE number 21. It includes not only the tripping characteristic tests but also external scheme tests related to this protection function. The module's functionality is distributed in the following sections, among others:

Technical data: general parameters that affect all the tests contained in the Distance module, such as: Line data (line impedance, line angle, ground compensation factor), Impedance and Time Tolerance (both absolute and as a percentage), Transformer connection, and performance parameters of the specific distance relay model.

Distance Zones: Zones defined in the relay are listed grouped by single-phase, phase-to-phase or three-phase characteristics, which the user can activate, edit and adjust the operating time for each zone. Also, as standard key feature in ROOTS, the direct import of RIO files with relay characteristics and settings, reduces the data entry process to minor modifications.

Graphical Characteristic Editor: ROOTS features an intuitive and powerful interactive graphical editor for geometrical definitions of protective characteristics and impedance zones. Lines and curves can be drawn in free hand mode and/or adjusted using numerical values and coordinates. The user can use MHO, Lens and Tomato characteristics shapes or create a customized characteristic as complex as desired.

Test Screen: with flexible access and configuration of the different test elements:

- Test models: fault simulation models of constant test current, constant test voltage, and constant impedance source.
- Test Settings (prefault, fault and postfault).
- Test Points: table of test points for each Fault type loop with the set values. With several methods to define and insert test points, by individual coordinates, by clicking on the graph or with automatic generation of test points, supporting separate or multiple loop plane selection (A-N, B-N, C-N, A-B, ABC, etc). With the Smart sweep function, test points are automatically set at the tolerance boundaries at each side of each zone, and with the Insert Sweep function test points are created along impedance directions, according to the sweep angle and reach defined. The calculated fault parameters are displayed for each point. Test points list can be listed or made visible by any parameter criteria.
- Test Result Assessment, automatic and manual.
- Test Graph of the protection element: show the characteristics of the active zones in the relay, for each selected fault type (single phase fault, phase to phase and three phase fault), and the length and angle of the protected line.
- Phasor Graph: allow to view the phasor diagram of every point and injection values per phase and its angles.
- Hardware Settings: map the test set I/O and connections to the relay, and configuration of operating options in the test set for Binary I/O (Relay/Open Collector, NO, NC, Dry/Voltage).
- Report and Report Configuration: automatic report generation with user selection of data to be shown. The report can be produced in PDF format or other data interchange like XML. Reports are saved along with the results in the devices database.
- Test execution: The entire test sequence will be injected and operation time results will be obtained for each test point. The trip time at each test point is compared with the theoretical value calculated taking into account the tolerances for impedance and the preset time specified in the settings, qualifying the result as Successful or Failed on the table of test points, and in the subsequent test report. If, at the end of a test, the user wants to repeat the execution of some test points, without affecting the others, he just select the test points to be redone and re-test them.
- Test notes and message to the operator, to show at start test, is also available.

Test List: Multiple tests can be attached to the module from a wide choice of test types, including scheme-oriented tests:

- | | | |
|-------------------|--------------------|----------------------|
| - Click Sequence | - Search | - Verification Test |
| - Reclose | - Evolving Fault | - Switch On To Fault |
| - Trip on Reclose | - Zone 1 extension | - Loss of Load |
| - CB Failure | - Fuse Failure | - Load Encroachment |



DIFFERENTIAL MODULE

The set of differential test modules is used to test the operation of protective devices that implement the IEEE function 87 and includes the following four modules.

CLASSIC DIFFERENTIAL 87C: The module is distributed in the following sections, among others:

Technical Data: To set up the general parameters associated with the data of the protected object, the characteristics of the protective device and the applied settings: number of windings, tap settings, restraint current calculation, current and time tolerances.

Differential Operating Characteristic: For configuration of the characteristic and the operating times of the relay, as well as defining the parameters for the harmonics restrain. In tests designed for harmonic restrain in differential relays, ROOTS allows to add a certain component of a harmonic to the fundamental frequency value. Although the common practice is to work with the 2nd harmonic (Inrush Blocking) and 3^o or 5^o (Blocking by over excitation), harmonics from the second to the eighth can be manipulated.

TRANSFORMER DIFFERENTIAL 87T: Designed for testing numerical relays for differential protection of transformers.

Technical Data: an extensive modeling of the protected device and the relay data gathers all the data for the calculations required to facilitate testing, suitable for transformer differential schemes with up to 3-windings and up to nine currents to be injected.

The automatic calculation of the test currents eliminates the most time consuming and error-prone manual tasks.

The Relay Data gathers all the data defining the operation of the protective relay: reference current, restraint current calculation, phase reference winding, maximum test current, current and time tolerances, remove zero sequence settings, etc.

Differential Operating Characteristic: Configure the characteristic and the operating times of the relay, as well as defining the parameters for the harmonics restrain. It includes single slopes, double continuous and discontinuous slopes and user-defined curves, with easy programming of pickup thresholds, slope of segments, change points and offset.

GENERATOR/MOTOR DIFFERENTIAL 87GM: Designed for testing rotating machines differential relays.

Technical Data: the setting of Generator/Engine Data gather all relevant data from the protected machine and from the current transformers used by the differential protection. Reference current, I_{bias} calculation, and time and current tolerances are set in the relay data.

Verification Test: The Verification test provides a method to check the consistence between the protected device, the relay settings, the Differential module's setup, and the test connections. This test simulates load conditions and/or external faults under which the relay's differential element should not operate. The assessment of each test point consists of verifying that the differential element did not operate and that the quantities measured by the relay fall inside the tolerance threshold set.

Click Sequence Test: Allows the user to verify the accuracy of the relay at determining if a fault falls inside or outside the protected zone. This test generates test sequences from test points defined by the user in the test window. Each test point will include pre-fault, fault and post-fault stages.

Search Test: This tool provides a method to locate the boundaries of the relay's characteristic. A series of consecutive faults are injected that gradually enter the searched zone. This method reveals the actual accuracy of the relay.

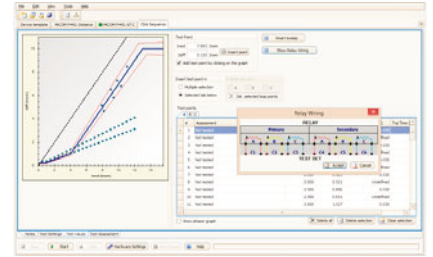
BUSBAR DIFFERENTIAL 87B: Designed for testing busbar differential relays.

Technical Data: Up to 6 feeders connected to the busbar can be configured, with the corresponding setting of the CT data for each feeder. Directional blocking technique used by some relay manufacturers can also be activated in this module.

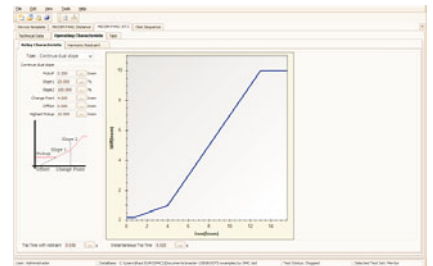
Operating Characteristic: ROOTS allows editing of the relay characteristic in a simple way by choosing from a set of predefined types or by custom building one when necessary.

Test List: Multiple tests can be attached to each differential module from the test types:

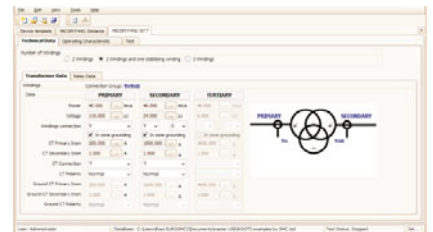
- Click sequence
- Search
- Verification
- Harmonic restraint, etc.



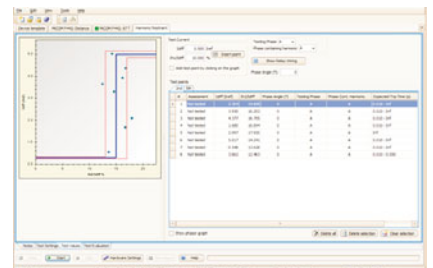
Differential shot test



Differential relay characteristic editor



Technical data



Harmonic Restraint Test

MENTOR 12

MENTOR 12 SOFTWARE ELEMENTS

SOFTWARE/ MODULES	FUNCTIONALITY	MENTOR 12	ROOTS OVERCURRENT	ROOTS DISTANCE	ROOTS DIFFERENTIAL
Full Basic Control	Powerful, fast and easy manual testing, no PC needed	■			
Configuration Control	Easy control of all Power sources combination, Binary I/O configuration, visual guide connection	■			
Advanced Control	The most complete Built-in Test functions, with on-screen graphic configuration, to carry out typical test for protection relays and protection schemes.	■			
Fault	Three-state Fault function, pre-fault, fault and post-fault configuration	■			
Ramp	Single or double Ramps, upward or downward, of any MENTOR 12 parameter	■			
Pulse Ramp	Pulse ramping with preset condition state, of any output parameter	■			
Binary Search	Effective search of trip values through adaptive ramps	■			
State Sequencer	A simple programmable multi-step tool to test protection schemes and logical sequences.	■			
Fault Playback (Comtrade)	Playback and processing of COMTRADE files and similar, for transient fault analysis and relays reaction	■			
Results Manager	Results and Test saving in USB pendrive, semi-automatic routines tests collection.	■			
Remote Control	Local mode or remote control, through serial or Ethernet connection	■			
Battery Simulator	Auxiliary DC supply setting for relay powering	■			
Harmonics	Control to select the desired Harmonic content and angle in each channel	■			
Meter & Measuring	Testing of transducers, counters, measuring devices, analogue and binary measurement	■			
Logger	On-screen event list, automatic recording for all events, such as sources switching and I/O status change.	■			
Smart Test Tools* STT	Importing RIO files and ROOTS test, execution of tests with no need of PC, just a USB pendrive, and storage of results	■		■	
IEC-61850 – GOOSE **	Testing with GOOSE according to IEC 61850, with configuration tool and no need of PC	■			
Power Saving Trimmer	Energy saving system with auto-adjustment to load and regulation of working cycle	■			
Internet Upgrading & Maintenance	All MENTOR 12 elements can be upgraded via internet, update and diagnostics	■			
Cape Test Files Converter	SS1 CAPE converter and execution of this network simulation program files	■			
Binary I/O Monitor & Configuration	On-screen display of all binary I/O status and flexible configuration	■	■	■	■
Free Lifetime Updates	SMC free unlimited updates, new releases and modules	■	■	■	■
Devices Configuration & Test List	Data settings and Devices template configuration. Several Test Modules added to every device, each module with its specific relay's settings, protective elements and Test List.		■	■	■
Automatic Reporting & Report Configuration	Immediate reporting in PDF format or XML, with selection of data to display		■	■	■
Database Management	Administration of Databases of Devices with relay definitions, test values, test routines, results and reports.		■	■	■
Rio Files Import	Direct import of RIO files , relay definitions and settings		■	■	■
Characteristics Editor & Templates	Powerful Graphic Editor for protective areas and curves, with pre-defined templates		■	■	■
Formulas	User-programmable test engine in Visual Basic.Net language. Function definition window		■	■	■
Fault Calculation & Sequential Test Execution	Accurate fault calculation and Test Assessment for the specified settings in every test point sequence.		■	■	■
Click Sequence (Shot Test)	Automatic sequential injection of test points, with pre-fault, Fault and Post-Fault conditions, and assessing of results.		■	■	■
Pick Up/Drop Out	Finding of the pickup and dropout values of the active elements in the relay under test		■		
Reclose	Verification of the relays reclose function, with any number of reclosing cycles		■	■	
Cold Load	Evaluation of protection devices that support the cold load function		■		
Sotf (Switch On To Fault)	Performance of the relay during a SOTF condition		■	■	
I2/I1 Ratio	Generation of faults to evaluate relays with this function		■		
Cb Failure	Circuit Breakers failure scheme evaluation		■	■	■
Fuse Fail	Test elements behavior during the Fuse Fail condition		■	■	
Selective Overcurrent Logic	Verify the correct logic behavior of the protective devices on signal reception with forward faults and reverse faults		■		
Reset Time	Testing of reset timing function		■		
Distance Search	Impedance element evaluation to find the boundary values of distance zones in selected directions.			■	
Distance Verification	Impedance element evaluation without zone geometry			■	
Evolving Fault	Evaluation of relay's behavior under evolving fault conditions during a single-phase recloses cycle.			■	
Trip On Reclose	Test to evaluate the relay's trip acceleration function during a reclose cycle.			■	
Zone 1 Extension Test	Evaluation of the relay when this clearing-fault function is active			■	
Loss Of Load	Test module to evaluate LOL function in diverse circumstances (also called Remote End Opened)			■	
Load Encroachment	Module to verify the proper operation of a distance relay under heavy load conditions.			■	
Differential Verification	Test to check the consistence between the protected device, the relay settings, the Differential module's setup, and connections.				■
Differential Search	Test to find the boundary trip values which corresponds with the characteristic of the relay				■
Diff. Harmonics Restraint	Evaluates the response of the relay to the harmonic content variation in measured current signals				■
Set Of Differential Modules	Differential 87C Classic; Differential 87T Transformer; Differential 87GM Generator / Motor; Differential Bar 87B				■

* Smart Test Tools - Optional license required.
** Optional Plug & Play Board required.



TYPICAL MENTOR 12 HARDWARE CONFIGURATIONS

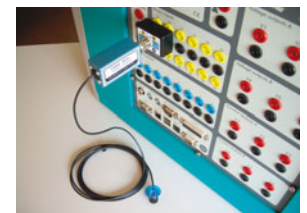
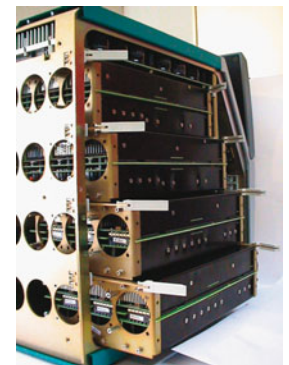
MODEL'S NAME	OUTPUT CHANNELS		TYPICAL APPLICATIONS
3v 3i	6	3 voltage (0-150 V or 0-5 A) + 3 current channels (0-25 A), with 100 VA each.	Single- and three-phase testing of any type of relay, transducers and meters. Up to 600 VA total output power. Full-range transient playback. Provides 6 currents.
4v 3i	7	4 voltage (0-150 V or 0-5 A) + 3 current channels (0-25 A), with 100 VA each.	Adequate for synchronizing relays. Direct three-phase testing with neutral voltage elements and a current up to 5 A. Capable for testing three phase differential relays.
4v 4i	8	4 voltage (0-150 V or 0-5 A) + 4 current channels (0-25 A), with 100 VA each.	A fourth current supply up to 25 A for devices with neutral element. Single phase test up to 100 A with 400 VA of power. Testing single phase differential relays with up to 25 A.
3v 6i	9	3 voltage (0-150 V or 0-5 A) + 6 current channels (0-25 A), with 100 VA each.	Three- phase electromechanical relays. Direct testing of differential relays with triple windings, maintaining the connection class. Up to 50A current per channel.
6v 3i	9	6 voltage (0-150 V or 0-5 A) + 3 current channels (0-25 A), with 100 VA each.	Calibration of low voltage measurement converters and energy meters. Fault tests of high impedance relays, directional detection of differential neutral with high voltage setting and moderate current setting.
4v 6i	10	4 voltage (0-150 V or 0-5 A) + 6 current channels (0-25 A), with 100 VA each.	Single- and three-phase testing with high current settings Differential relay testing. Provides up to 10 currents.
6v 6i	12	6 voltage (0-150 V or 0-5 A) + 6 current channels (0-25 A), with 100 VA each.	Testing of 2 relays simultaneously. Three-phase transformer differential testing on quadruple windings. High current and high power output needs. Two full line endings to perform end to end testing.

OPTIONAL SOFTWARE

ROOTS	ROOTS Software, with optional licensed modules: Overcurrent, Distance, Differential, new modules
MENTOR STT	Smart Test Tools license for MENTOR 12

OPTIONAL ACCESSORIES

MENTOR IEC-61850	IEC 61850 Compliant Test Interface
MENTOR GPS	GPS board, antenna, extension cable
MENTOR-IRIGB	IRIG-B adapter for MENTOR 12
MENTOR-MD1V	Additional Voltage Amplifier
MENTOR-MD1C	Additional Current Amplifier
MENTOR-MD3V	3-voltage amplifier module
MENTOR-MD3C	3-current amplifier module
MENTOR-IR	Optical pickup for non-visible infrared LED with BNC connector
MENTOR-VIS	Optical pickup for visible light with BNC connector
MENTOR-DSK	Induction disk sensor with suction mount
BAG 06	Lightweight bag for MENTOR 12. Ideal option for short-distance transportation. 20-mm padding for adequate protection inside the car's trunk, adding no significant weight to the equipment. The screen, connections panel and ventilation grid can be uncovered, so there is no need to extract the Mentor 12 from the bag for testing.



SUPPLIED ACCESSORIES

Complete set of test leads, 4 mm shrouded / straight stackable banana plugs (28-40 cables)
1 power cord 250 V/ 16 A
2-m / 6.5 ft. twisted-pair Ethernet cable
RS-232 (ActiveSync®) cable
1 set of assorted spare fuses (19-32)
1 PS2 adapter for keyboard and mouse
2 adapters for low level outputs
1 USB Pen Drive
1 soft organizer bag for cables and accessories
1 User's manual
Certificate of calibration
Sturdy ABS transport case with wheels and extensible handle



MENTOR 12 TECHNICAL SPECIFICATIONS

POWER OUTPUT

VOLTAGE AMPLIFIERS		CURRENT AMPLIFIERS
Capacity	1 - 6	1 - 6
Output ranges per channel	0 - 150 V AC / 0 - 5 A AC / 0 - 212 V DC / 0 - 5 A DC	0 - 25 A AC and DC
Outputs configurations	Up to 6 x (150 V AC 100 VA / 212 DC) Up to 3 x (300 V AC 200 VA / 424 DC) Up to 1 x (600 V AC 400 VA / 848 DC) + 1 x (300 V AC 200 VA / 424 DC) As current mode: Up to 6 x (5 A AC 100 VA / 5 DC) Up to 3 x (10 A AC 200 VA / 10 DC) Up to 1 x (20 A AC 400 VA / 20 DC) + 2 x (5 A AC 100 VA / 5 DC)	Up to 6 x (25 A AC 100 VA / 25 DC) Up to 3 x (50 A AC 200 VA / 50 DC) Up to 1 x (100 A AC 400 VA / 100 DC) + 1 x (50 A AC 200 VA / 50 DC) Up to 1 x (150 A AC 600 VA / 150 DC)
Power per channel	100 VA continuous @ 37.5 - 150 V AC, 100W	100 VA @ 9.5 A AC, 100 W
Adjustment resolution	5 mV / 0.5 mA	0.5 mA
Reversibility	Yes	No
Accuracy	0.1% of the value ± 0.03% of the range (20-30°) @ 50-60 Hz	
Distortion	0.1 % @ 50-60 Hz (resistive load) / 2 % @ 50-60 Hz (maximum inductive load)	
Isolation	Yes (from mains and between all channels)	
Combined output	Series and Parallel	
Frequency	Adjustment range: 0.0 - 2000 Hz / Bandwidth: 3000 Hz / Resolution: 5 µHz / Accuracy: 1 ppm	
Phase angle	Range: 0.0 - 359.9° / Accuracy: 0.1° / Resolution: 0.001°	

LOW LEVEL OUTPUTS

NUMBER	TYPE	LEVELS	RANGES	ISOLATION	RESOLUTION	ACCURACY	DISTORTION
6	V	0-10 Vpk (1 mA max.)	1	No	250 µV	0.07 %	0.05 %

TIMERS

NUMBER	RESOLUTION	RANGES	ACCURACY
4	0.1 ms	00000.0001 - 99999.9999 sec.	0.001 % +/- 0.1 ms

BINARY INPUTS

NUMBER	TYPE	THRESHOLDS	RANGES	ISOLATION	RESOLUTION	COUNTER FUNCTION
12	Dry or voltage	1.5, 15 V	+/-400 V (p-p)	6 groups of 2	0.1 ms	Up to 3 kHz. (width: 150 µs) 100 kHz. in 1 group

BINARY OUTPUTS

NUMBER	TYPE	LEVELS	ISOLATION	TIME RESOLUTION
8	Relay or <i>Open Collector</i>	300 Vdc / 300 Vac / 8 A 2000 VA / 240 W	Yes	100 µs

EXT. MEASUREMENT

Vdc MEASUREMENT INPUT	Idc MEASUREMENT INPUT	ACCURACY
± 10 V	± 20 mA	0.02 %

AUXILIARY DC SUPPLY

RANGES	POWER	ACCURACY	RIPPLE
48, 125, 250 Vdc	60 W	5 %	0.2 %

GENERAL

Dimensions	422 x 254 x 511 mm. / 16.6" x 10" x 20.1"
Weight	22.5 kg. / 49.6 lb(6 ch.) - 29.8 Kg / 65.6 lb (12 ch.)
Casing	Custom
Consumption	Max. 1600 VA. 100 - 260 V AC, 40 - 70 Hz
Compliance/CE Marking	IEC-61010 / EMC-50081-2 / EN-50082-2
Working Temperature	0° to 50° C // 32° F to 122° F
Storage temperature	-40° to +70° C // -40° F to 158° F
Humidity	Up to 95% (non condensating)
Display	Color TFT 800 x 600
Control	Touch panel + rotary encoder
Communications	RS-232, 2 x USB, Ethernet, Centronics, PS2, VGA

DISTRIBUTED BY

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