Switchgear/ Relay and Circuit Breaker Test Equipment

MULTI-TEK INTERNATIONAL

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Megger (Formerly AVO Group), Programma, LL, TTI, MTE/EMH/EDI Group Exporter

V 2014

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SECTION A
Secondary Injection/ Relay test sets

Item	Description
1	**Secondary Injection Test Set/ Universal relay test set type SVERKER780, complete with test lead set, carrying case and built in phase shifter and frequency generator**
2	**Complete Three phase relay testing system type FREJA300 (CF-19091) with built in digital display complete with FREJA WIN software, test lead set, calibration box (CF-90100) and hard transport case** **Note: full version software is inclusive of :** **FrejaWin Standard** **Current Instrument** **Voltage Instrument** **Frequency Instrument** **Autoreclose Instrument** **Auto300 instrument** **Diferential Instrument** **Transducer Instrument** **Auto21 instrument** **Transient Instrument**

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3 **Relay test system type FREJA400 series**

4 **Advance high power Megger relay test system type SMRT410, complete with 4 voltages and up to 10 currents and AVTS software**

5 **Multi-Function Digital Phase Angle Meter type PAM420, complete with test lead set and transport case (2 channels voltage, current with frequency meter and timer)**

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SECTION B
Primary Injection test sets/ Circuit breaker test equipment

Item	Description
6	Multi-function Primary Current Injection Test set type INGVAR (BH-72490), up to 5 KA, with digital display and CT testing, complete with standard accessories Secondary Injection Test Set/ Universal relay test set type SVERKER780, complete with test lead set, carrying case and built in phase shifter and frequency generator
7	Primary current injection test set type ODEN AT series
8	Circuit Breaker and Overload Relay Test Set type MS-2A
9	Circuit breaker and over load relay test set/ Primary Current injection Test Set type CB-845
10	Circuit breaker test set type DDA-3000 series
11	Circuit breaker test set type DDA-6000 series
12	Advanced 200 A light weight Micro Ohm Meter in the world market type MOM2 (BD-59090) with Kelvin probes
13	200A High Current Digital Low Resistance Ohmmeter type DLRO200 with RS-232, software and all standard accessories

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Switchgear/ Relay and Circuit Breaker Test Equipment

14 **600A Digital Low Resistance Ohmmeter type DLRO600 complete with standard accessories**

15 **Electrical Circuit Breaker Vacuum test set type VIDAR complete with permanently mounted cable set 5 m (16 ft), ground cable and transport case**

16 **Circuit breaker analysing system Type TM1700 series, Soft case, Test cables and clamps, Protective earth (ground) cable, Mains cable, Bag for cables, USB memory stick Ethernet cable, CABA Win software**

17 **Circuit Breaker Analyzer System type TM1800 Standard complete with 1 control module, 1 Timing M/R module(6 channels + 6PIR), two Analogue Modules (each three channels) and all standard accessories including CABA WIN Software**

Section A

ITEM 1

SVERKER 750/780
Relay Test Sets

- **The engineer's toolbox for all single phase relay testing**
- **Stand-alone functionality**
- **Rugged and reliable for field use**

Description

The SVERKER 750/780 Relay Test Set is the engineer's toolbox. The control panel features a logical layout, still SVERKER 650 users will find it comfortably familiar and will be able to start work right away.

The SVERKER 750/780 features many functions that make relay testing more efficient. For example, its powerful measurement section can display (in addition to time, voltage and current) Z, R, X, S, P, Q, phase angle and cos φ. The voltmeter can also be used as a 2nd ammeter (when testing differential relays for example). All values are presented on a single easy-to-read display.

You can also test directional protective equipment efficiantly by means of the built-in variable voltage source. In SVERKER 780 this has a continuous phase shift function and adjustable frequency as well. Automatic reclosing devices can also be tested – just as easily.

Designed to comply with EU standards and other personal and operational safety standards, SVERKER 750/780 is also equipped with a serial port for communication with personal computers and the PC software SVERKER Win. Since the compact SVERKER weighs only 18 kg (39 lbs), it's easy to move from site to site.

Two or more SVERKER units can also be synchronized, which allows the user to operate a basic 3-phase test set.

Application

Relay Testing

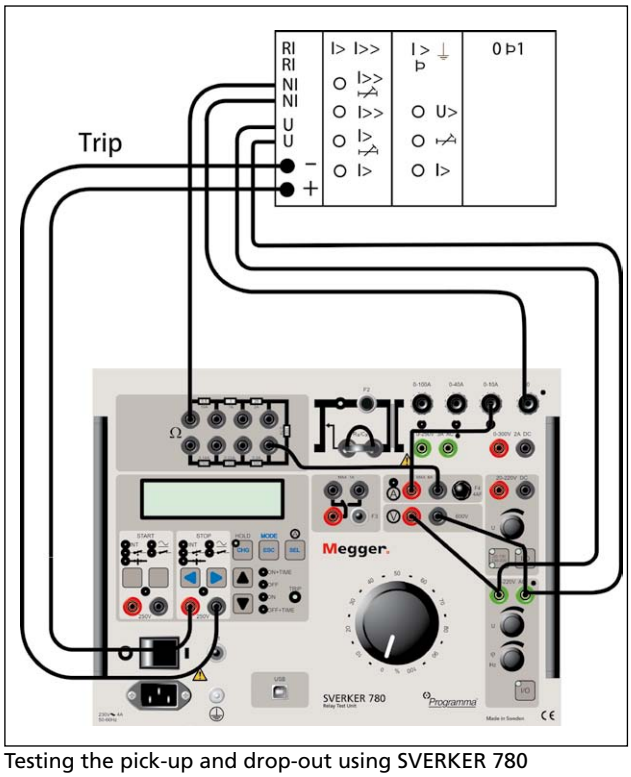
SVERKER 750/780 is intended primarily for secondary testing of protective relay equipment. Virtually all types of single-phase protection can be tested. You can also test three-phase protection that can be tested one phase at a time, and also a number of protective relay systems that require phase shifting. Moreover, automatic reclosing devices can be tested.

SVERKER 780 can test voltage relays with a frequency range from 15 Hz up tp 550 Hz.

Examples of what SVERKER can test	ANSI® No.
Overcurrent relays	50
Inverse time overcurrent relays	51
Undercurrent relays	37
Ground fault relays	50N, 51N
Directional overcurrent relays	67
Directional ground fault relays	67N
Overvoltage relays	59
Undervoltage relays	27
Directional power relays	32
Power factor relays	55
Differential protection (differential circuits)	87
Distance protection equipment (phase by phase)	21
Negative sequence overcurrent relays	46
Motor overload protection	51/66
Automatic reclosing devices	79
Tripping relays	94
Voltage regulating relays	
Underimpedance relays	21
Thermal relays	49
Time-delay relays	
Frequency relays (SVERKER 780)	81

Other fields of application

- Plotting excitation curves
- Current and voltage transformer ratio tests
- Burden measurement for protective relay test equipment
- Impedance measurement
- Efficiency tests
- Polarity (direction) tests
- Injection
  - Maintained
    - Injection continues without any time limitation.
  - Momentary
    - Injection continues only as long as the button is kept depressed.
  - Max. time
    - Injection stops automatically when the preset maximum time is reached.
- Filtering
  - When filtering is selected, five successive readings are averaged. The following can be filtered: Current, Voltage and Extra items that are measured.
- Off delay
  - The turning off of generation can be delayed after tripping throughout a specified time interval that is expressed in mains frequency cycles.



Testing the pick-up and drop-out using SVERKER 780

Application example

IMPORTANT!
Read the User's manual before using the instrument.

Testing the pick-up and drop-out using SVERKER 780

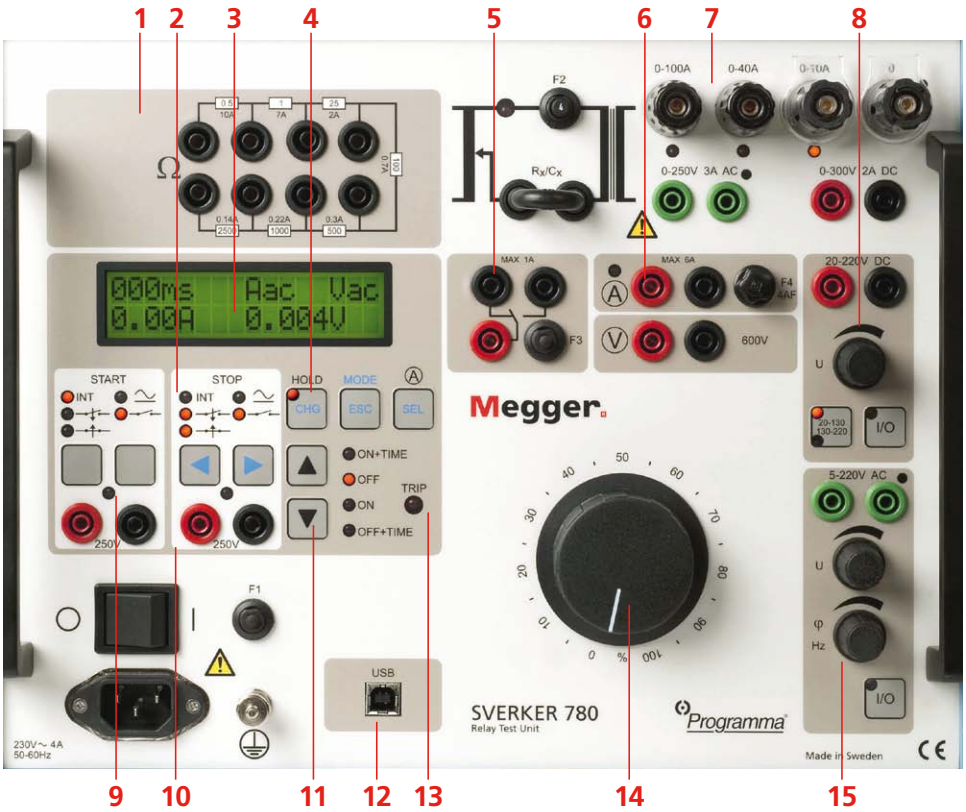
1. Connect as shown in the diagram.
2. Select stop conditions, dry or wet contact.
3. Select HOLD to freeze the current reading.
4. Press button SEL/ A until you get a red light at the built-in ammeter.
   Note: Maximum allowed current through the separate ammeter used in this connection example is 6 A. The other measurement points do not have this limitation.
5. Press the MODE button.
6. Use the key ▼ to select Ω, φ, W, VA...
7. Press CHG (Change)
8. Select φ (°, Iref) or (°, Uref) by using the key ▼.
9. Press SEL (Select)
10. Press ESC
11. Set the voltage amplitude with the upper small knob.
12. Make sure the main knob is set to 0.
13. Turn on the SVERKER output by activating ON using the start switch ▼.
14. Set the phase-angle. Use the lower knob for fine adjustment, and the middle knob for step of 90°.
    Note: A small current flowing in the circuit is required to measure the phase angle.

Testing the operation time

15. Increase the current to 1.5 times the pick-up value.
16. Invoke the ON+TIME state by means of the start switch. The outputs will now remain turned on until the protective relay equipment operates.
17. Read the time from the display. Check also the high current setting using the same procedure.

Features and benefits

1. **Set of resistors**
   Fine regulation of current and voltage thanks to the built-in set of resistors.
2. **Start and stop conditions**
   The timer's start and stop inputs respond to changes, voltage or contact closing/openings. The timer's start input is also used when testing auto-reclosing relays, to synchronize two or more SVERKER units and to start generation with an external signal.
3. **Display**
   Presents time, current, voltage and other entities. Also used to make settings, after you enter the setting mode by pressing button marked MODE.
4. **Freeze function (HOLD)**
   This makes it possible to measure voltages and current as short as a quarter of a mains-voltage period by immobilizing the reading on the display. Voltage and current readings are frozen when the timer stops. If the timer does not stop, the reading present when the current was interrupted is frozen on the display.
5. **Make/break contact**
   Changes state automatically when a test is started. Can be used (for example) to synchronize two or more SVERKER units, other external equipment or to switch the voltage applied to the protective relay equipment back and forth between non-faulty and faulty.
6. **Ammeter and voltmeter**
   Current and voltage are measured by the built-in ammeter and voltmeter. Resistance, impedance, phase angle, power and power factor can also be measured. Readings appear on the display. These instruments can also be used to take measurements in external circuits. The voltmeter can also be used as a 2nd ammeter (when testing differential relays for example, using CSU20A). Current and voltage can be displayed either as amperes and volts or as percentages of a given current or voltage (the present settings of the protective relay equipment for example).
7. **Current source**
   Provides 0-250 A AC, 0-250 V AC or 0-300 V DC, depending on the output that is being used. Settings are made using the main knob. The readings of current, voltage and other entities appear on the display. The start switch is used to turn the current source on and off. When time is being measured, this is done in synchronization with the timer.
8. **Auxiliary voltage source**
   Provides 20-220 V DC in two ranges. Equipped with overload protection and separated from the other outputs. Used frequently to supply the object being tested.
9. **Status indicator**
   The timer's start and stop inputs are each equipped with indicator lamps which, when lighted, indicate a closed circuit (useful for detecting contact closings/openings) or the presence of voltage. These indicator lamps make it possible (for example) to check circuits before starting a measurement cycle.
10. **Timer inputs**
    The timer has separate start and stop inputs, and it can be used to measure both external cycles and sequences initiated by SVERKER. The measured time appears on the display. Each input can be set to respond to the presence or absence of voltage (AC or DC) at a contact.
11. **Start switch**
    Controls the turning on and off of the current source and timer. Can be set to one of four states. ON+TIME. Starts generation and timing simultaneously. Used to test over... relays (...means current, voltage or some other entity). Generation continues a) until the protective relay equipment operates and stops the timer or b) until the maximum time expires or the start switch is released if time-limited generation has been selected. OFF. Turns off the current source, whereupon generation is interrupted. ON. Turns on the current source in the generating state. OFF+TIME. Interrupts generation and starts the timer simultaneously. Used when testing under ...relays (...means current, voltage or some other entity). The timer is stopped when the protective relay equipment operates. When automatic reclosing is to be tested, SVERKER can be set so that new generation will start when the timer's start input is activated by the closing command.
12. **Computer communication interface USB**
    SVERKER is equipped with a serial port for communication with personal computers and the PC software SVERKER Win.
13. **Tripping indicator**
    Lights when a stop condition is fulfilled to indicate operation of the protective relay equipment. If the test being conducted incorporates timing, this indicator starts to blink when relay operation occurs.
14. **Main knob**
    Used to set current output from the current source.
15. **AC voltage source**
    Since the AC voltage source is separated from other outputs, it is set independently of the current source. The AC voltage source is intended primarily for the relay protection equipment's voltage input..



SVERKER Win

PC software for SVERKER 750/780

The SVERKER Win software makes fieldwork easier while providing neater reports. The SVERKER Win software enables you to control the SVERKER from a PC. The SVERKER is connected to the PC's serial port. Test results can be reported either directly with table and graph, or from an external program, e.g. Microsoft® EXCEL.

SVERKER Win enables customised reports in an easy way. Very useful are the reference graphs, together with the current/voltage graph presentation for each test point during the test. The graph can of course be printed out on the test report if you like.

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

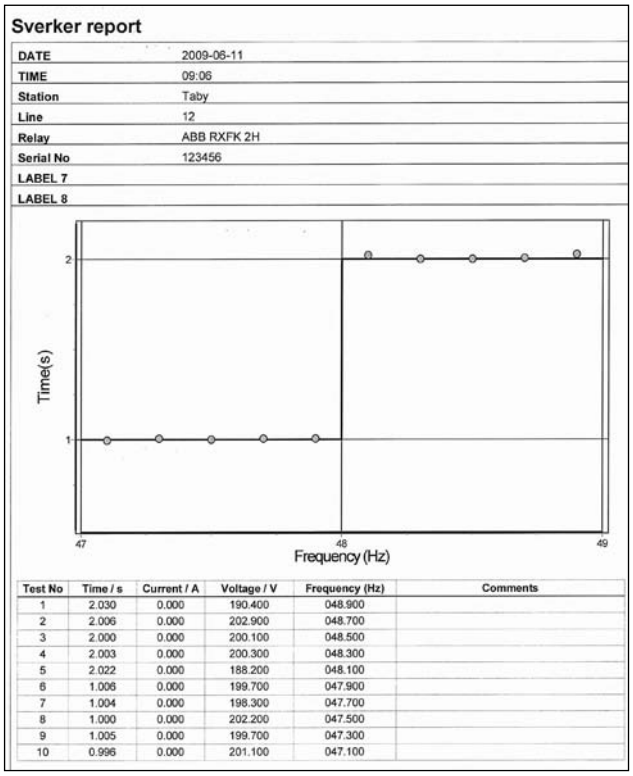
During relay testing, each measured value is stored in a log list. In this list you can add comments to each test point. When the entire test is finished, you can save everything as a data file. Later, you can print out the test results. You save time by not having to write your report in the field. All report writing can be done conveniently back at the office.

The SVERKER Win software provides easy access to connection instructions, test instructions and the like, which you prepare in advance. These instructions, which can contain both text and graphics, can be prepared using standard word processing packages.

The settings you make on SVERKER are also saved in a file, so that the next time you want to test the same or similar protective relay equipment, all you have to do in order to set-up the SVERKER, is to open the file.

Specifications SVERKER Win

The SVERKER Win software comprises a 32-bit program written to run under Windows® 95/98/2000/NT/XP. The amount of space needed to save reports and settings will depend on how many protective systems that are to be tested. Roughly estimated, you will thus need a total of about 20-100 MB of free space on the hard disk. Languages in SVERKER Win are: Czech, English, French, German, Spanish and Swedish.

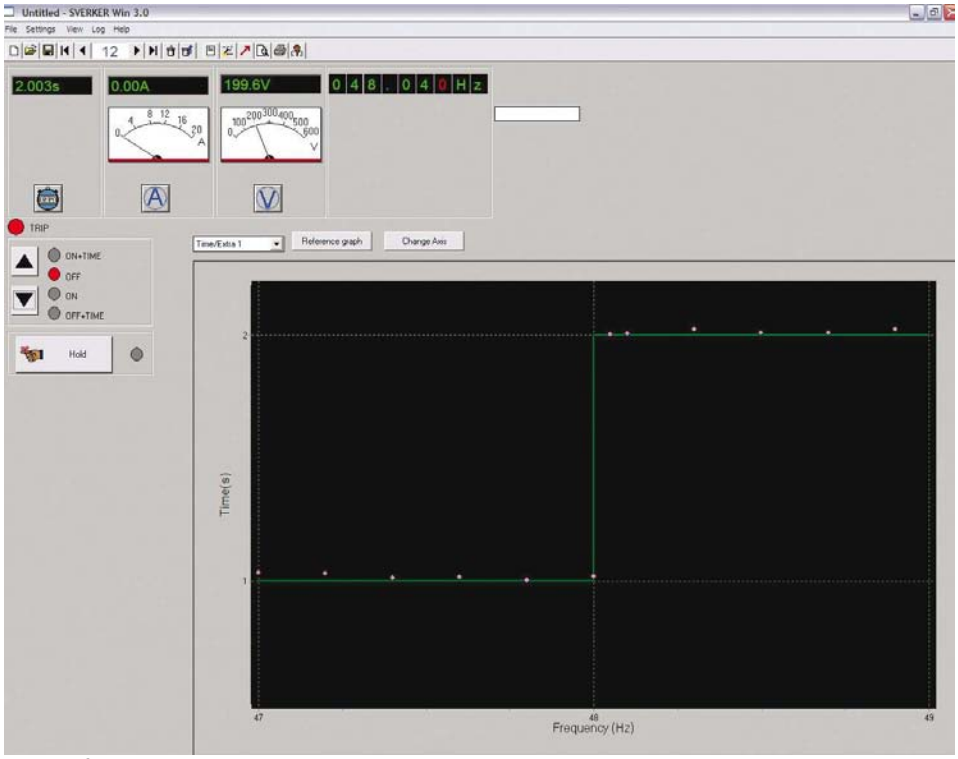


Sverker report

DATE	2009-06-11
TIME	09:06
Station	Taby
Line	12
Relay	ABB RXFK 2H
Serial No	123456
LABEL 7	
LABEL 8	

Test No	Time / s	Current / A	Voltage / V	Frequency (Hz)	Comments
1	2.030	0.000	190.400	048.900	
2	2.006	0.000	202.900	048.700	
3	2.000	0.000	200.100	048.500	
4	2.003	0.000	200.300	048.300	
5	2.022	0.000	188.200	048.100	
6	1.006	0.000	199.700	047.900	
7	1.004	0.000	198.300	047.700	
8	1.000	0.000	202.200	047.500	
9	1.005	0.000	199.700	047.300	
10	0.996	0.000	201.100	047.100	

Frequency relay test report



Testing frequency relay with SVERKER 780

Specifications SVERKER 750/780

Specifications are valid at nominal input voltage and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

Environment

Application field	The instrument is intended for use in high-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (32°F to +122°F)
Storage & transport	-40°C to +70°C (-40°F to +158°F)
Humidity	5% – 95% RH, non-condensing

CE-marking

LVD	Low Voltage Directive 2006/95/EC
EMC	EMC Directive 2004/108/EC

General

Mains voltage	115/230 V AC, 50/60 Hz
Power consumption (max)	1380 W
Protection	Thermal cut-outs, automatic overload protection
Dimensions	
Instrument	350 x 270 x 220 mm (13.8" x 10.6" x 8.7")
Transport case	610 x 350 x 275 mm (24.0" x 13.8" x 10.8")
Weight	
SVERKER 750	17.3 kg (38.1 lbs) 26.3 kg (58 lbs) with accessories and transport case
SVERKER 780	18.1 kg (39.9 lbs) 27.1 kg (59.7 lbs) with accessories and transport case
Test lead set, with 4 mm stackable safety plugs	2 x 0.25 m (0.8 ft), 2.5 mm² 2 x 0.5 m (1.6 ft), 2.5 mm² 8 x 2.0 m (6.6 ft), 2.5 mm²
Test leads with spade tongue connectors	2 x 3.0 m (9.8 ft), 10 mm²
Display	LCD
Available languages	Bulgarian, Czech, English, French, German, Russian, Spanish, Swedish, Turkish

Measurement section

Timer

Time can be displayed in seconds or in mains-frequency cycles.

Range	Resolution	Inaccuracy
000-9.999 s	1 ms	±(1 ms + 0.01%)*
10.00-99.99 s	10 ms	±(10 ms + 0.01 %)*
100.0-999.9 s	100 ms	±(100 ms + 0.01 %)*
* For the OFF+TIME start condition in INT mode, 1 ms shall be added to the above measurement error.		

Range	Resolution	Inaccuracy
0.0-999.9 cycles	0.1 cycles	±(0.1 cycles + 0.01%)
1000-49999 cycles at 50 Hz 1000-59999 cycles at 60 Hz	1 cycle	±(1 cycle + 0.01 %)

Ammeter

Measurement method	AC, true RMS DC, mean value
Ranges	
Internal	0.00 – 250.0 A
External	0.000 – 6.000 A
Inaccuracy	
Internal range [1]	
0–10 A AC	±(1% + 20 mA)
0–40 A AC	±(1% + 40 mA)
0–100 A AC	±(1% + 200 mA)
External range [1]	
0–0.6 A AC	±(1% + 20 mA)
0–6 A AC	±(1% + 20 mA)
0–0.6 A DC	±(0.5% + 2 mA)
0–6 A DC	±(0.5% + 20 mA)
Resolution	
Internal range	10 mA (range <100 A) 100 mA (range >100 A)
External range	1 mA

Voltmeter

Measurement method	AC, true RMS DC, mean value
Range	0.00 – 600.0 V
Inaccuracy [1]	AC, ±(1% + 200 mV) Max. value DC, ±(0.5% + 200 mV) Max. value Values are range depending

Extra measurements

Power factor and phase angle measurements

	Range	Resolution	Inaccuracy
Power factor cos φ	-0.99 (cap) to +0.99 (ind)	0.01	±0.04
Phase angle φ (°)	000 – 359°	1°	±2°

Impedance and power measurements

AC	Z (Ω and °), Z (Ω), R and X (Ω and Ω), P (W), S (VA), Q (VAR)
DC	R (Ω), P (W)
Range	Up to 999 kX (X= unit)
Make/Break contact	
Max. current	1 A
Max. voltage	250 V AC or 120 V DC
Reclosing test	
Items measured	Tripping and reclosing times
Display	After test is finished a list of all times appears in display
Breaker state feedback	The Make/Break contact can be used to feed back the breaker state
Max. number of reclosings	49
Max. testing time	999 s

Sets of resistors and a capacitor

Resistors	0.5 Ω to 2.5 kΩ
Capacitor [2]	10 µF, max voltage 450 V AC

1) Measurement intervals longer than 100 ms
2) SVERKER 750

Outputs

Current outputs – AC

Range	No-load voltage (min)	Full-load voltage (min)	Full-load current (max)	Load/unload times On (max)/Off (min)
0 – 10 A	90 V	75 V	10 A	2/15 minutes
0 – 40 A	25 V	20 V	40 A	1/15 minutes
0 – 100 A	10 V	8 V	100 A	1/15 minutes
0 – 100 A	10 V	-	250 A* 200 A**	1 sec/5 minutes

* Mains voltage 230 V AC
** Mains voltage 115 V AC

Voltage outputs – AC/DC

Range	No-load voltage (min)	Full-load voltage (min)	Full-load current (max)	Load/unload times On (max)/Off (min)
0 – 250 V AC	290 V AC	250 V AC	3 A	10 min/45 min
0 – 300 V DC	320 V DC	250 V DC	2 A	10 min/45 min

Separate AC voltage source SVERKER 750

Range	No-load voltage (min)	Full-load voltage (min)	Full-load current (max)
0 – 60 V AC	70 V	60 V	0.25 A
60 – 120 V AC	130 V	120 V	0.25 A
Both ranges are divided into voltage steps of 10 V that are steplessly variable.			

Separate AC voltage source SVERKER 780

Range	No-load voltage (min)	Full-load voltage (min)	Full-load power (max)
5 – 220 V AC minimum step 0.1 V	240 V AC	220 V AC at 33 W 200 V AC at 46 W	33 W continuously. 46 W 1 minute

Phase angle	Resolution	Inaccuracy
0 – 359°	1°	±2°

Frequency	Resolution	Inaccuracy
15 – 550 Hz	1 mHz	±0.1%

Auxiliary DC output

Range	Voltage	Max. current
20 – 130 V DC	20 V DC 130 V DC	300 mA 375 mA
130 – 220 DC	130 V DC 220 V DC	325 mA 400 mA

Optional accessories

Power source CSU20A

CSU20A is a small light-weight current and voltage source primarily intended to work together with the SVERKER 750/780 Relay Testing Unit when testing differential relays. Using the CSU20A together with SVERKER 750/780 gives the user two independent current sources, and the timer/measurement section in SVERKER 750/780 is used both for measuring the two outputs as well as measuring the trip time of the relay.

Besides testing differential relays the unit can be used as a multi-purpose AC/DC source. The CSU20A features one AC current/voltage output, one fully rectified DC output and one half-wave rectified DC output for harmonic restraint testing.

Other features are a current measurement shunt, selectable current/voltage ranges and an AC mains input/output. Connecting the SVERKER 750/780 mains to the mains output of the CSU20A gives an in-phase synchronization of the two units.

Specifications CSU20A

Specifications are valid at nominal input voltage and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

Operating temperature	-20°C to +50°C (-4°F to +122°F)
Mains voltage	115/230 V AC, 50/60 Hz
Thermal protection	Built-in
Dimensions	280 x 178 x 246 mm (11" x 7" x 9.7")
Weight	5.9 kg (13 lbs) excl. transport case
Current measurements	Current shunt 0.1 A / 1 V, ± 2%

Output, AC

20 A setting	Output voltage (min)	Load time
Idle/non-load	26 V	Continuous
5 A	25 V	Continuous
10 A	22 V	Continuous
20 A	18 V	2 min
10 A setting		
Idle/non-load	52 V	Continuous
3 A	50 V	Continuous
5 A	47 V	Continuous
10 A	41 V	10 min

Output, DC

DC current	As above, less the voltage drop over the rectifying diodes

CSU20A

Phase selector switch PSS750

The Phase Selector Switch PSS750 is specifically designed to work with SVERKER 750/780 when testing three-phase relays. It is connected between SVERKER 750/780 and the relay inputs and allows the user to easily select which phase to test.

The PSS750 handles both the current and voltage sources and single-phase or phase-phase testing can be selected. Together with the output-input switching the unit also contains a variable resistor that can be used together with the built-in capacitor in SVERKER 750/780. This feature gives the user the possibility to create a variable phase shift at a decreased amplitude of the test voltage.

The design is passive which makes it very general. You may for example use any of the inputs for current or voltage as long as you do not exceed the specification. It is also possible to connect the measuring inputs of the SVERKER 750/780 to the PSS750 and use the switch for selecting measurement signals.

The PSS750 simplifies phase switching, selecting type of fault, phase reversing and gives a possibility to create a variable phase shift..

Specifications PSS750

Specifications are valid at nominal input voltage and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

Max input voltage	250 V AC / 3 A
Max input current	6 A / 250 V AC
Max resistor loading	200 V AC / 200 mA (0.5 A during 5 seconds)
Dimensions	200 x 120 x 85 mm (7.9" x 4.7" x 3.3")
Weight	1.3 kg (2.9 lbs)

PSS750

Application example with PSS750

IMPORTANT!
Read the User's manual before using the instrument

1. Connect the current and voltage outputs of SVERKER 750/780 to the PSS750 inputs.
2. Connect the current and voltage inputs of the relay to the PSS750 outputs.
3. Select which phase to test and type of test (phase-to-ground or phase-phase) with the selector switch.
4. Proceed with the test for each phase and fault type.
5. To create a phase shift, connect the 10 µF capacitor in SVERKER 750/780 in series between the voltage output and the PSS750 input, and connect the variable resistor in parallel with the PSS750 input.
6. Set the SVERKER 750/780 for phase (and impedance) measurement. Connect the voltage measurement input to the PSS750 input.
7. Start the test with the resistor in maximum position. Gradually decreasing the resistor gives increasing phase shift in the voltage signal. The test voltage/impedance will decrease at the same time so an adjustment of the test current might be necessary to get the correct impedance. Please observe that the phase shift depends on the input resistance and may vary between different relays. Some relays may also have a low voltage limit where the relay will not operate. For additional 180 degrees phase shift use the phase reversal switch.

Megger

Test lead set GA-00030

Ordering information

Item	Art. No.
SVERKER 750	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: English, French, German, Spanish, Swedish	
115 V Mains voltage	CD-11190
230 V Mains voltage	CD-12390
SVERKER 750	
Incl. Test lead set GA-00030 and IP65 HD-case	
Language: English, French, German, Spanish, Swedish	
115 V Mains voltage	CD-13190
230 V Mains voltage	CD-13390
SVERKER 750	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: Czech, English, German, Swedish, Turkish	
230 V Mains voltage	CD-12392
SVERKER 750	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: English, French, German, Russian, Swedish	
230 V Mains voltage	CD-12394
SVERKER 750	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: Bulgarian, English, French, German, Swedish	
230 V Mains voltage	CD-12396

Item	Art. No.
SVERKER 780	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: English, French, Spanish	
115 V Mains voltage	CD-31190
230 V Mains voltage	CD-32390
SVERKER 780	
Incl. Test lead set GA-00030 and IP65 HD-case	
Language: English, French, Spanish	
115 V Mains voltage	CD-33190
230 V Mains voltage	CD-33390
SVERKER 780	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: English, German, Swedish	
230 V Mains voltage	CD-32392
SVERKER 780	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: Bulgarian, English, Turkish	
230 V Mains voltage	CD-32394
SVERKER 780	
Incl. Test lead set GA-00030 and Transport case GD-00182	
Language: Czech, English, Russian	
230 V Mains voltage	CD-32396

Optional

SVERKER Win PC Software	
Please specify the SVERKER serial number when ordering. SVERKER Win contains software, a copy-protection key and cables (RS232 and USB) for connecting the PC to SVERKER. **Note** that the software key can be installed on a single SVERKER. The software itself, however, can be installed on an unlimited number of PCs.	CD-8102X
SVERKER Win Upgrade	CD-8101X

Optional accessories

CSU20A	
Incl. Cables and Transport case	
115 V Mains voltage	BF-41190
230 V Mains voltage	BF-42390
PSS750	CD-90020
Cable organizer	
Velcro straps, 10 pcs.	AA-00100

ITEM 2

FREJA 300
Relay Test System

- **Manual and PC remote control**
- **Easy to use**
- **Excellent software provides great visuals and simple setup**
- **Lightweight and portable**
- **User can calibrate the unit**

Description

The FREJA™300 relay testing system is a computer-aided relay testing and simulation system. The weight of FREJA 300 is only 15 kg. The rugged hardware design is built for field use over a wide temperature range, with the possibilities of intelligent software to perform rapid testing.

FREJA 300 can be operated with or without a PC. After being put into the Local mode, FREJA 300 can be used stand-alone without a PC. Using the Local mode is easy. The function of each key is described on the display, which also presents the settings and measured values.

The very accurate (typically 0.01%) low level analogue inputs are designed for transducer measurements. The high level inputs can be used as a normal volt- and ammeter. FREJA 300 can generate 4x150 V (82 VA) and 3x15 A (87 VA) or 1x45 A (250 VA). Each output can be varied independently. Both static and dynamic testing can be performed, such as prefault and fault generation, simultaneous ramping of several quantities and wave form editing.

FREJA 300 can also be used as a disturbance simulator and create and generate simulated disturbances, or import actual recorded disturbances from e.g. EMTP or COMTRADE files.

With use of the GPS receiver accessory, GPS200 – MGTR, several FERJA 300 can be synchronized to perform end-to-end testing with the test sets allocated in different substations.

A FREJA 300 can be upgraded to a FREJA 306.

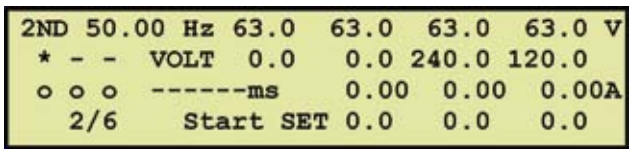
Application

FREJA 300 is intended primarily for secondary testing of protection relays. Virtually all types of protection relays can be tested.

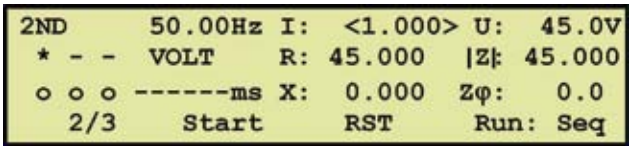
Examples of what FREJA 300 can test	ANSI® No.
Distance protection relay	21
Synchronising or synchronism-check relays	25
Undervoltage relays	27
Directional Power relays	32
Undercurrent or underpower relays	37
Negative sequence overcurrent relays	46
Overcurrent-/ ground fault relays	50
Inverse time overcurrent-/ ground fault relays	51
Power factor relays	55
Overvoltage relays	59
Voltage or current balance relays	60
Directional overcurrent relays	67
DC overcurrent relays	76
Phase-angle measuring or out-of-step protection relays	78
Automatic reclosing devices	79
Frequency relays	81
Differential protection relays	87
Directional voltage relays	91
Voltage and power directional relays	92

Local Mode - without PC

Using the dial by turning and clicking it is easy to make the settings. All settings are saved automatically when you exit, but if you prefer you can assign the settings a name and save them separately for convenient access when you conduct your next test. The display can also show the measured value that is being generated. This feature is equivalent to three voltmeters and three ammeters that present RMS values for all generators.



Local Mode General



Local Mode Rx (I)

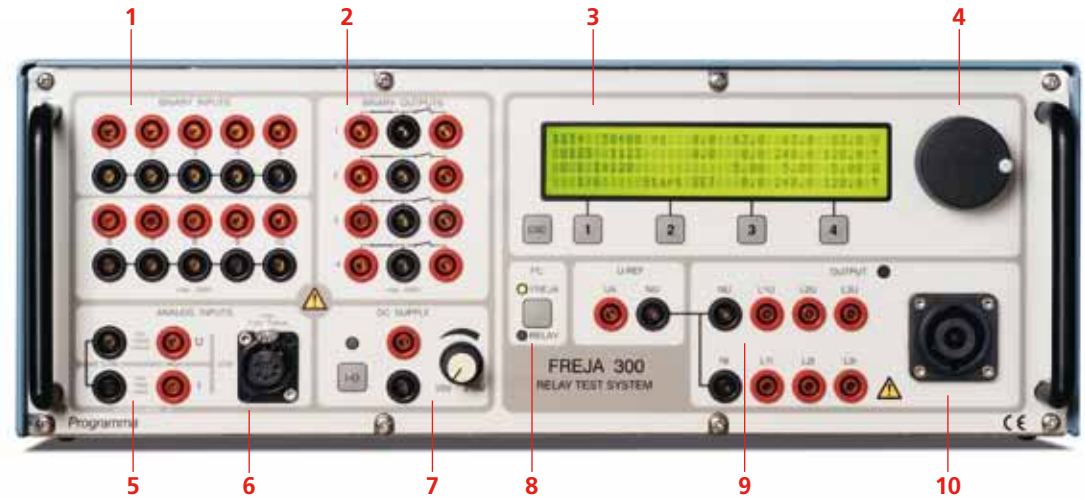
With a PC - FREJA Win

There are a number of instrument programs. You start the different programs at the Control center, where you also save and recall results. Since the test set-ups/results are saved via a regular Microsoft® Explorer display, you can create your own test object structures.

For FREJA Win there is no longer any license file needed and no license keys for the FREJA test sets. Once installed on your PC you can freely control any FREJA test set.

Features and benefits

1. Binary inputs – Response-time compensated
2. Binary outputs – Operating-time compensated
3. Display and buttons used in the Local Mode.
4. Dial, press to Enter.
5. Analog inputs, HIGH, for volt- and ammeter
6. Analog inputs, LOW, for measurement transducers
7. DC-supply, connect to (5) to read the values
8. Switch, PC to FREJA 300 or relay
9. Current and voltage outputs.
10. Multiconnector for voltage (L1U, L2U, L3U, NU) and current (L1I, L2I, L3I, NI)..



FREJA Win

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

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

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

Distance instrument

Configuration page

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

Connect page

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

Zt page

The Zt page is designed for time testing of a distance relay. Normally, you test one type of fault at a time when testing relays. With FREJA Win, however, you can test all seven fault types automatically if so desired. All you have to do is press the <Start> button. FREJA will test all seven fault types automatically and then compare the readings with the theoretical values that you entered on the Configuration page. If the readings are OK, a green lamp lights. If not, a red lamp lights. If you want to check the reverse direction, the test can start below zero ohms in the 3rd quadrant.

RX-ramp page

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

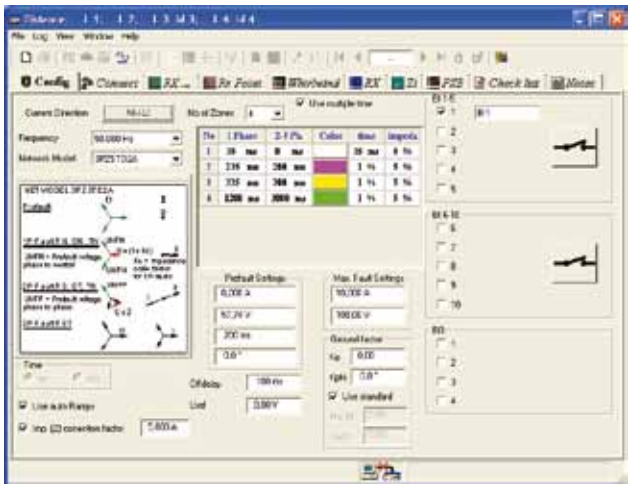
RX page

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

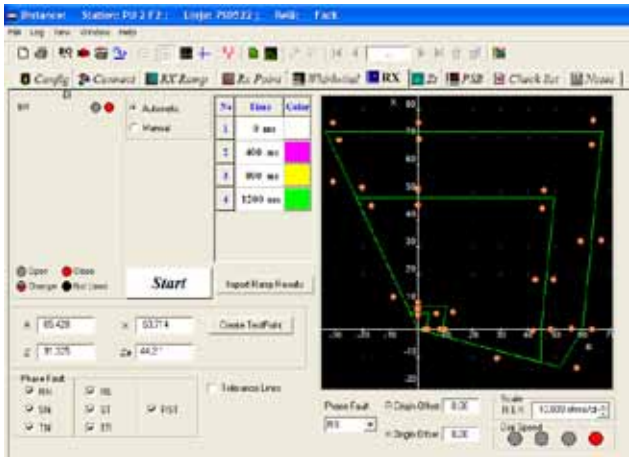
Reference graphs

Efficient testing and performance analysis require well-defined reference values. FREJA can automatically create the IEC and

Control center



Distance, Config



Distance, Rx

IEEE® standard curves for overcurrent relays. It is also possible to create reference graphs in the impedance plane using the included library of distance relays made by major manufacturers and/or create other characteristics using the standard circular lens and linear elements (including mho, quadrilateral and ice-cream cone shapes).

The cut and paste buttons make it easy to take copies of the first zone and then edit these copies by inserting zone 2 and zone 3 values.

State-of-the-art distance relays having sophisticated impedance characteristics and several setting groups require many parameter settings. The optional ProGraph feature enables you to import the parameter settings from a master selectivity plan prepared in Microsoft® Excel. This eliminates manual transfer errors, and the FREJA software creates the reference graph automatically.

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

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

Current instrument

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

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

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

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

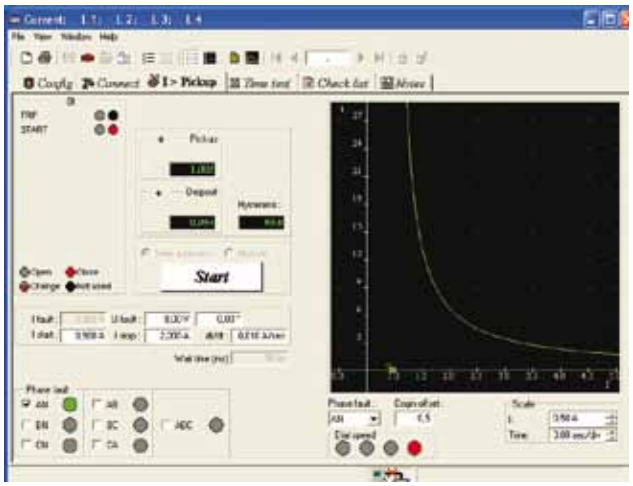
Voltage instrument

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

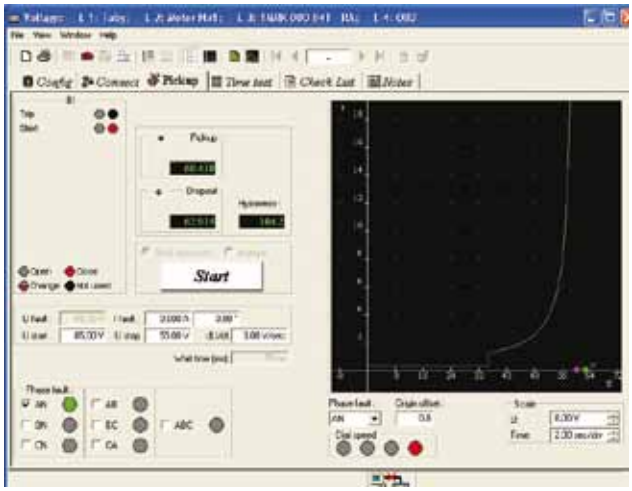
The Config page is where the relay settings will be entered.

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

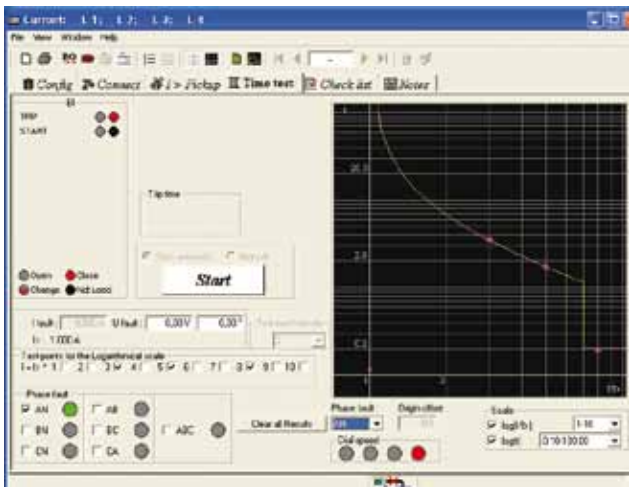
The time test, check the trip time at different voltage values, will be done in the Time Test page. A reference curve can be created in the same way as in Distance, by choosing the corresponding time curve and entering the settings. The time test can be run also in a logarithmic scale, time, current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



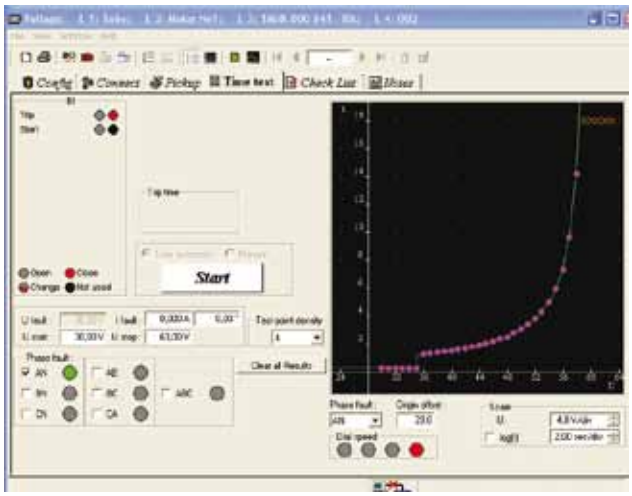
Current instrument, Pick-up



Voltage instrument, Pick-up



Current instrument, Time test



Voltage instrument, Time test

Frequency instrument

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

The Ramp mode will find the set fault frequency.

Autoreclose instrument

The Autoreclose instrument is a combination between Sequence in General and RX in Distance. This is just because it is easier to simulate pre-fault, energizing and dead times as vectors and in the same way it is easier to simulate a fault in a impedance plane.

This instrument will test any autorecloser function on today's modern relays.

Auto 300

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

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

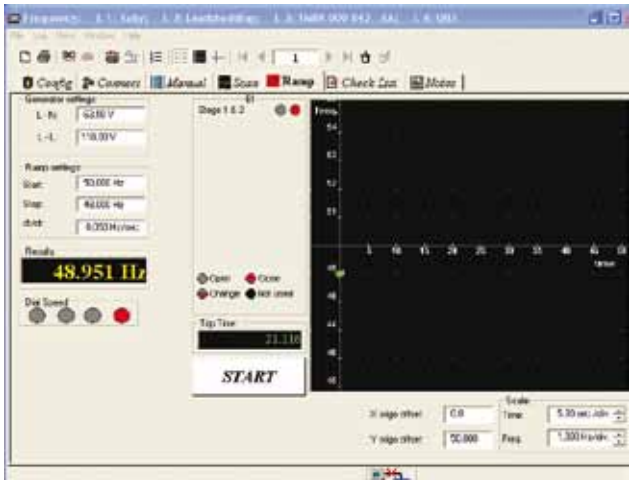
Transducers instrument

The Transducers instrument will test any transducers by checking the output of the transducers and compare it to the settings made in Config.

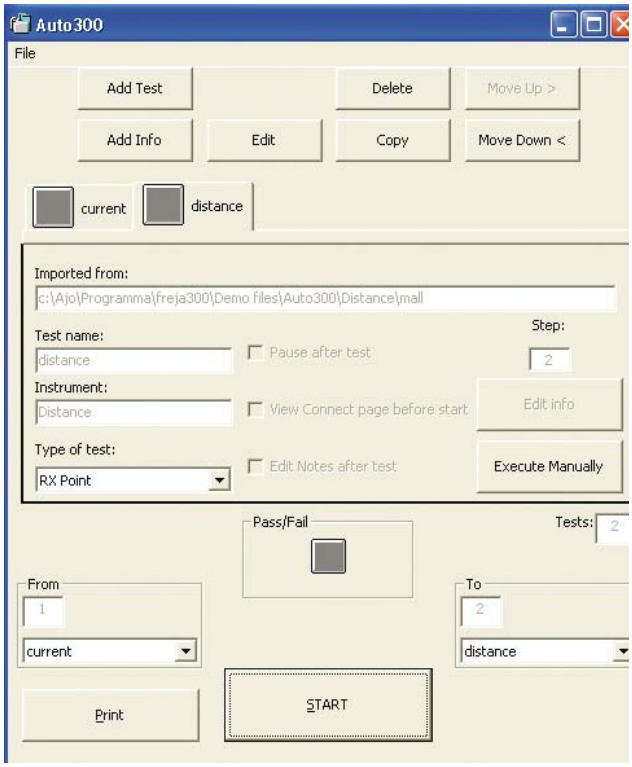
The result will be showed in linear format, full scale, relative and absolute error.

Transient instrument

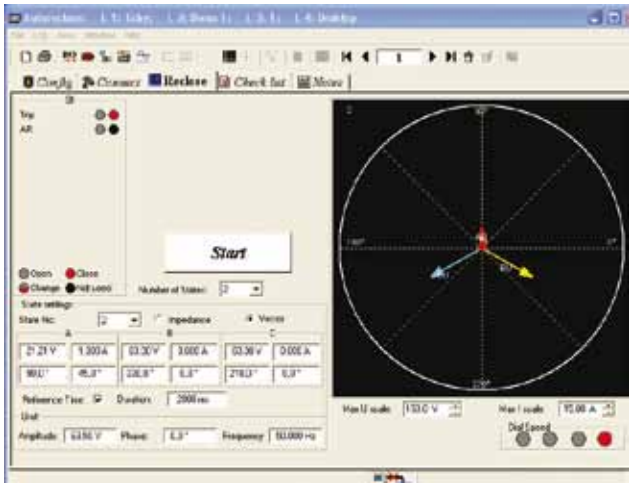
With the help of Transient, Freja will generate (playback) a waveform recorded by a disturbance recorder. The file formats supported by Transient are COMTRADE, ASCII, EMTP WAX, EMTP PC and Inductic 65.



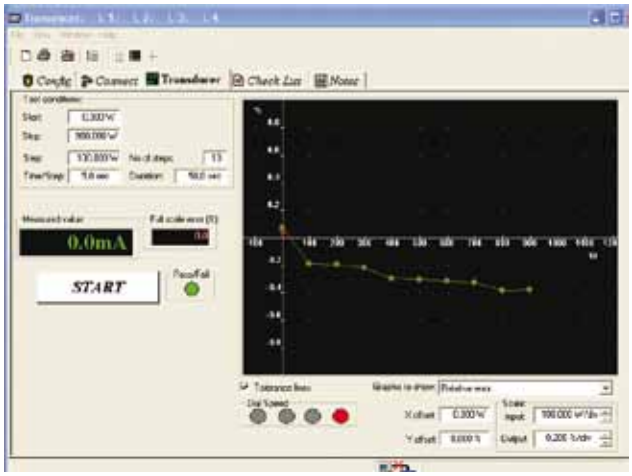
Frequency instrument, Ramp



Auto 300



Autoreclose instrument



Transducers instrument

Auto 21

Auto 21 is a converter that will convert old test plans made with Freja 21/21D and using Freja DOS software, to a Windows compatible format that ken be used together with FrejaWin and Freja.

Sync instrument

U-f Min & Max

The U-f Min & Max part of the Sync instrument program is designed especially to test voltage and frequency boundaries for a synchronizing relay. This test is carried out automatically. Simply press the <Start> button, whereupon the program itself searches for the boundaries.

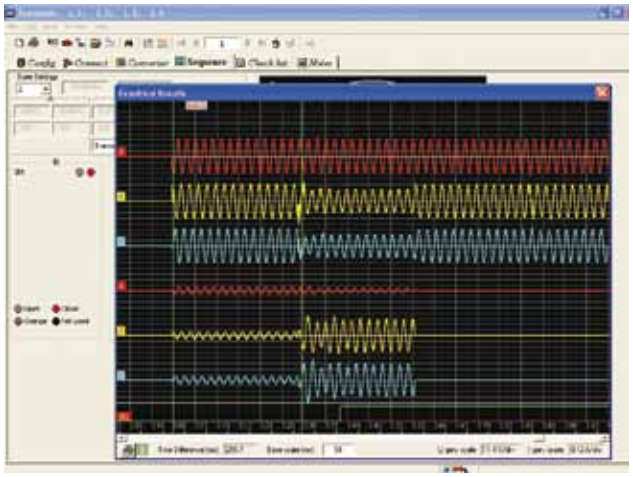
Synchronizing page

The Synchronizing page is designed to measure lead-time. It also enables you to measure the pulses sent out from the synchronizing relay.

Synchro Check page

The Synchro Check page is designed to test synchrocheck relays.

First set the phase angle to +20° (or some other starting point). Then change the phase angle until you reach the boundary. You press the <Save> button to store the result. Now test on the other side, starting at -20°, change the phase angle until you reach the other boundary.



Transient instrument

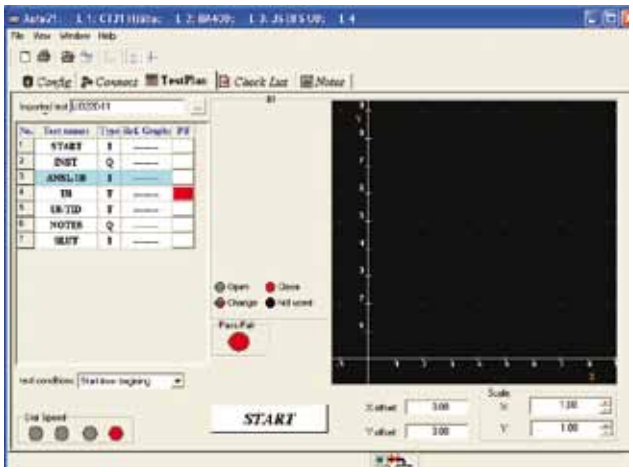
Differential instrument

The Differential instrument is designed to test transformer protection relays and works with FREJA 306 or with FREJA 300 together with external amplifiers CA30 or CA3, as it makes use of 6 current generators.

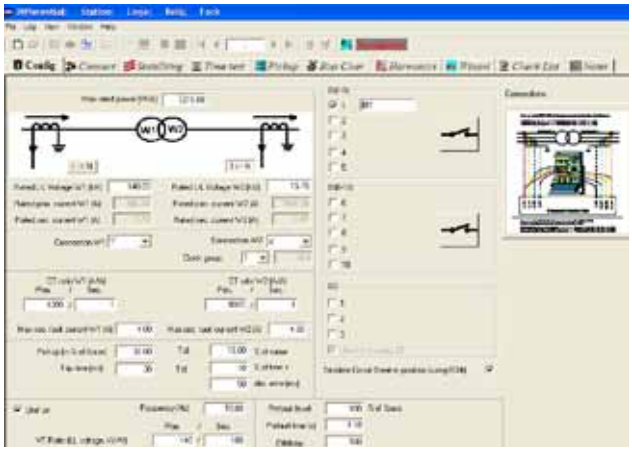
It can be used to test multi winding transformer protection relays, by testing a pair of windings at a time.

FREJA Differential can also be used to test differential generator protection relays and line differential protection relays.

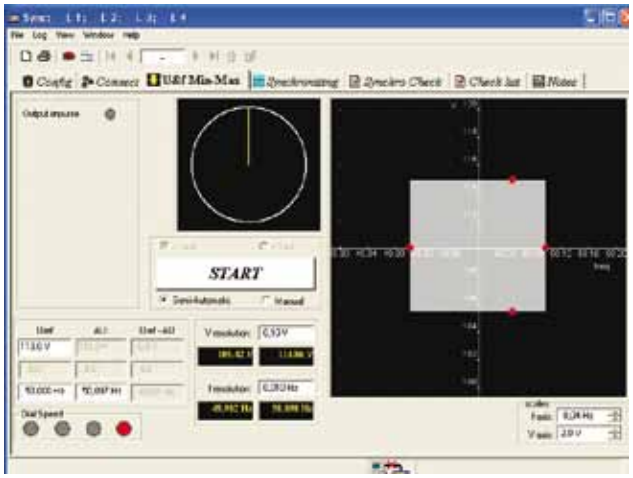
The data for the protected power transformer are entered in a very intuitive way that cannot be misunderstood by the user. This is done by using buttons and icons that immediately show to the user



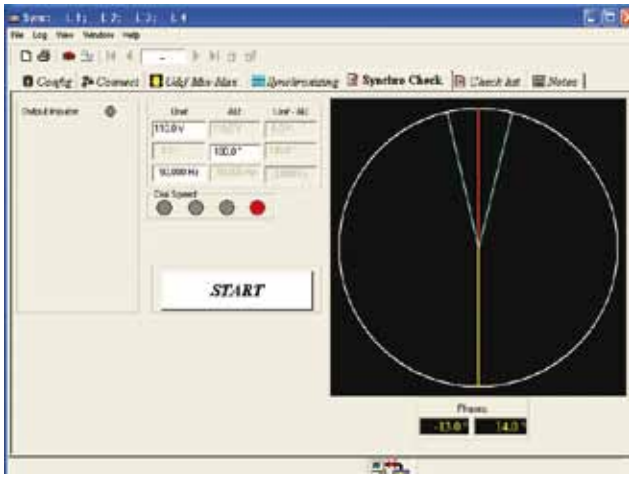
Auto 21 instrument



Differential instrument



Sync, U-f Min & Max



Sync, Synchro Check

the effect of his choices. The injected currents are shown both in primary and secondary values, depending on the entered current transformers information and star point earthing.

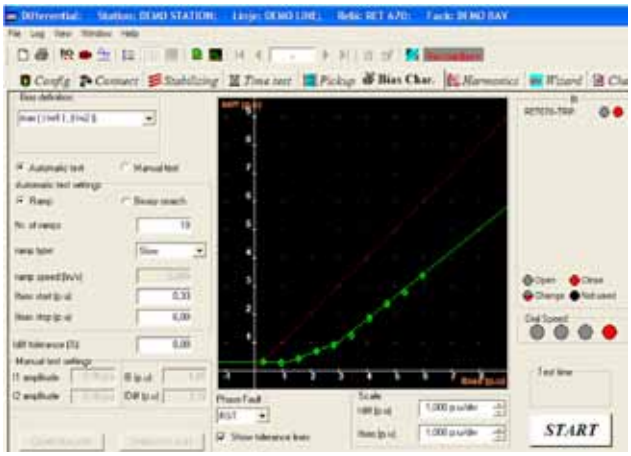
The Stabilizing page has the purpose of verifying that the connections and settings in FREJA are correct by generating external faults and verifying that the relay is stable. The operator is also requested to read the measured values by the relay and enter them in the test page. The values will then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

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

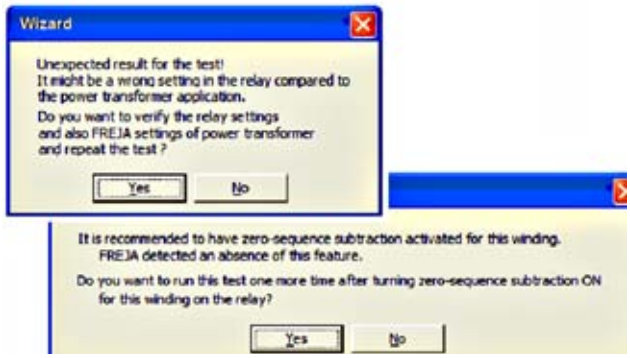
The Pick-up page allows the test of the minimum operating current of the differential relay for each winding, which is a test on the sensitivity of the relay. This test also makes use of pseudo-continuous ramp injections.

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

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



Differential instrument, Bias Char.



Differential instrument, Wizard

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

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

Specifications FREJA 300

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

Environment

Application field	For use in high-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (32°F to +122°F)
Storage & transport	-40°C to +70°C (-40°F to +158°F)
Humidity	5% – 95% RH, non-condensing
Altitude (operational)	3000 m Full duty cycle up to 2000 m. Duty cycle limitation based on internal over temperature protection for altitudes >2000 m.

CE-marking

EMC	2004/108/EC
LVD	2006/95/EC

General

Mains input (nominal)	100 – 240 V AC, 50–60 Hz
Power consumption	1200 VA (max)
Dimensions	
Instrument	450 x 160 x 410 mm (17.7" x 6.3" x 16.1")
Transport case	560 x 240 x 575 mm (22" x 9.5" x 22.6")
Weight	
Instrument	15 kg (33.1 lbs)
Transport case	7.5 kg (16.5 lbs)
Display	LCD
Available languages	English, French, German, Spanish, Swedish

Measurement section

Binary inputs

Number	10 Inputs (2 groups of 5 independent)
Type	Dry or wet contacts 275 V DC, 240 V AC Response-time compensated
Internal resolution time	50 µs
Galvanic isolation	Galvanically separated from the amplifier section. Two galvanically separated groups: 1 to 5 and 6 to 10
Max measuring time	15264 h (636 days)

Range	**Resolution**
0 - 9.9 ms	0.1 ms
10 ms - 60 min	1 ms
1 h - 15264 h	1 s

DC current measuring input, LOW

Measuring range	±20 mA
Resolution	SW 0.1 µA HW 0.6 µA
Inaccuracy	0.01% typical, 0.03% guaranteed (= 6 µA)

DC voltage measuring input, LOW

Measuring range	±10 V
Resolution	SW 0.1 mV HW 0.3 mV
Inaccuracy	0.01% typical, 0.03% guaranteed (= 3 mV)

AC / DC current measuring input, HIGH [1]

Measuring range	±14 A DC, 10 A AC_{RMS}
Inaccuracy	DC <0.1%, AC <0.3%

AC / DC voltage measuring input, HIGH [1]

Measuring range	±220 V DC, 150 V AC_{RMS}
Inaccuracy	DC <0.05%, AC <0.2%

Measurement, internally generated values

Inaccuracy	
Voltage AC / DC	<1% ±1digit
Current AC / DC	<2% ±2digit

Binary outputs

Number	2 x 4 (NO & NC)
Type	Zero-potential contacts, controlled via software Response time compensated
Break capacity AC	240 V AC, max 8 A, max load 2000 VA
Break capacity DC	275 V DC, max 8 A, max load 240 W

Low level outputs (Rogowski option)

Setting range	
LLU	3 X 0...2 V_{RMS}
LLI	3 X 0...2 V_{RMS}
Max. output current	5 mA
Inaccuracy	<0.1% typ. (<0.2% guaranteed)
Resolution	250 µV
Distortion (THD+N) [2]	<0.05% typ. (<0.1% guaranteed)
Max. generating time	5 minutes

Generator section

Voltage outputs

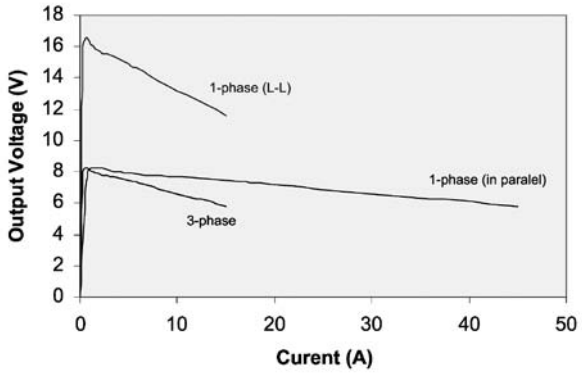
Range	
4-phase AC	4 x 150 V
1-phase AC (L-L)	2 x 300 V
DC (L-N)	180 V
Power	
3-phase AC	3 x 82 VA at 150 V
1-phase AC (L-L)	1 x 140 VA at 300 V
DC (L-N)	87 W
Resolution	
SW	10 mV
HW	6.5 mV
Inaccuracy [3] *(guaranteed)*	(±0.01% of range) + (±0.05% of reading)
Distortion (THD+N) [4]	0.02% typical (0.04% max)

Current outputs

Standard outputs – L1I, L2I, L3I

Range	
3-phase AC	3 x 15 A
1-phase AC [2)]	1 x 45 A
DC (L-N)	15 A
3-channel DC	–
Power	
3-phase AC	3 x 87 VA
1-phase AC [2)]	1 x 250 VA
DC (L-N)	3 x 87 W (max)
Resolution	
SW	1 mA
HW	0.65 mA
Inaccuracy [3)] *(guaranteed)*	(±0.01% of range) + (±0.3% of reading)
Distortion (THD+N) [4)]	0.1% typical (0.2% max)

FREJA 300 current generators



Generators, general

Frequency range	
Continuous signals	DC – 2000 Hz
Transient signals	DC – 3.5 kHz
Frequency resolution	1 mHz
Frequency inaccuracy	0.01%
Phase angle range	0 – 360°
Phase resolution	0.1°
Phase inaccuracy [3)]	±0.1°
Connection (Amplifier outputs)	4 mm stackable safety plugs or 8-pin amplifier multiconnector

All seven generators are continuously and independently adjustable in amplitude and phase. No switching of range is necessary. All current and voltage outputs are fully overload- and short-circuit-proof and protected against external high voltage transient signals and overtemperature.

Note! To allow continuous generation of high DC current (12–15 A), a minimum load impedance of 0.2 Ohm is required. For lower load impedances, e.g. short-circuit, the time is limited to 1 minute.

DC auxiliary voltage output

Range	20 – 210 V DC
Output power	75 W at 210 V

Other

On-line measurement of the current and voltage output, presented on the built-in display.

Calibration check when the temperature is changed. Full calibration can be conducted a any time using the FREJA calibration box. This means you do not need to send away FREJA for calibration. Only the calibration box needs to be sent for calibration once per year.

Connection to IBM compatible PC (minimum Pentium II 266 MHz, 32 Mb RAM, Win 95/98/2000/XP, NT 4.0) via the serial port.

1) 50 or 60 Hz AC + harmonics only.

2) THD+N: Values at 50/60 Hz, at max amplitude, 50% power and resistive load. Measurement bandwidth 22 Hz – 22 kHz.

3) For sinusoidal signals at 50/60 Hz.

4) Parallel connection.

5) Values at max amplitude, 50% power and resistive load.

6) THD+N: Values at 25 A, 125 VA.

Optional accessories

Multi cable

GPS200 – MGTR GPS unit with accessories

Test lead set

Calibration box

Ordering information

Item	Art. No.
FREJA 300 Complete with: FREJA Win, Two test lead sets, Hard transport case	CF-19091
Same as above but with soft transport case	CF-19090
FREJA 300 basic unit Incl. FREJA Win	CF-19000
FREJA 300, LLA Rogowski option Complete with: FREJA Win, Two test lead sets, Hard transport case	CF-19095
Same as above but with soft transport case	CF-19094
FREJA 300 Basic Unit, LLA Rogowski option Incl. FREJA Win	CF-19004
FREJA 300 Expert Same as CF-19091 + IPS RELEX (data base)	CF-19098
FREJA 300 Expert, LLA **Rogowski option** Same as CF-19095 + IPS RELEX (data base)	CF-19099
Optional	
Rebuild FREJA 300 to FREJA 306	CF-90090
FREJA Win upgrade	CF-8282X

Item	Art. No.
Optional accessories	
FREJA Multi-cable Shortens hookup time considerably. Consists of a multi-pole connector that connects to FREJA's three voltage and three current outputs, and a number of banana plugs that connect to the protection relay that is to be tested.	GA-00103
Test lead set With touch-proof contacts. 2 x 0.25 m (0.8 ft) / 2.5 mm^2, 2 x 0.5 m (1.6 ft) / 2.5 mm^2, 8 x 2 m (6.5 ft) / 2.5 mm^2. Weight**:** 0.8 kg (1.8 lbs). Normally you need two sets.	GA-00032
Calibration box	CF-90100
GPS200 – MGTR The GPS receiver GPS200 – MGTR makes it possible to synchronize two or more FREJA to conduct end-to-end testing. End-to-end testing provides quick, reliable results showing how two or more protection relay systems interact. The unit comes with a 15 m (50 ft) cable and an all-weather antenna. Longer cables can be ordered.	CF-90150
Cable organizer Velcro straps, 10 pcs.	AA-00100

ITEM 3

FREJA 400-series
Relay Test System

- **Fully automated testing using FREJA Win software**
- **PC operated or stand alone using the intuitive graphic touch screen**
- **High current, high power output (60 A / 300 VArms) per phase**
- **FREJA 409 provides 3 x 120 A in three-phase configuration mode**
- **FREJA 406 provides 6 currents, and FREJA 409 provides 9 currents for transformer differential testing**
- **IEC 61850 test capabilities**

Description

The FREJA 400-series is a new member of the relay testing equipment from Megger, quick and easy to use. The rugged hardware design is built for field use over a wide temperature range, with the possibilities of intelligent software to perform rapid testing.

The instruments have the "smart" combination of high compliance voltage and high current to test all electromechanical, solid-state and numerical-based overcurrent relays, including voltage controlled, voltage restraint and directional overcurrent.

With three current generators and four voltage generators the instruments provides a complete three-phase test system for commissioning of three phase protection systems. The FREJA 406 can provide 6 current generation and FREJA 409 can provide 9 current generation by converting the voltage channels to currents. The generators also provide high power in both the voltage and current channels to test virtually all types of protection relays.

The FREJA 400-series test system has the ability to be manually controlled from the FREJA local, available as touch screnn interface. The local HMI, with its large, full color, high resolution, TFT LCD touch screen allows the user to perform manual, steady-state and dynamic testing quickly and easily using the manual test screen, as well as using built-in preset test routines for automatic testing. Menu screens and touch screen function buttons are provided to quickly and easily select the desired test function. Tests results can be saved in FREJA local memory and downloaded to a USB memory stick for transfer or print test reports.

For full automatic testing the FREJA Win software will be used with a PC. There are number of instrument programs to test any protection. Since the test set-ups/results are saved via regular Microsoft Explorer display, you can create your own test object structure.

Application

FREJA 400-series is intended primarily for secondary testing of protection relays. Virtually all types of protection relays can be tested.

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

Current and voltage outputs

Each current channel is rated for 30 A at 200 VA continuous, up to 60 A at 300 VA for short durations. It has a unique flat power curve from 4 to 30 A that insures maximum compliance voltage to load at all times. Three currents in parallel provide up to 180 A at 900 VA for instantaneous operation tests. With a maximum compliance voltage of 50 V per phase, with just two channels in series provides 100 V of compliance voltage to test high impedance relays.

Each voltage channel can provide variable outputs of 0 to 300 V at 150 VA of output power, and has a unique flat power curve from 30 to 150 V insuring maximum output power to the load at all times. With the voltage channel converted to current, a FREJA 406 can provide 6 currents and a FREJA 409 can provide 9 currents for testing three phase current differential relays, including harmonic restraint transformer differential relays.

FREJA Local - without PC

The most significant feature of the Local HMI is its ability to provide the user with a very simple way to manually test, for both commissioning and maintenance, from the simple overcurrent relay to the most complex relays manufactured today. Manual operation is simplified through the use of a built-in computer operating system and the touch screen.

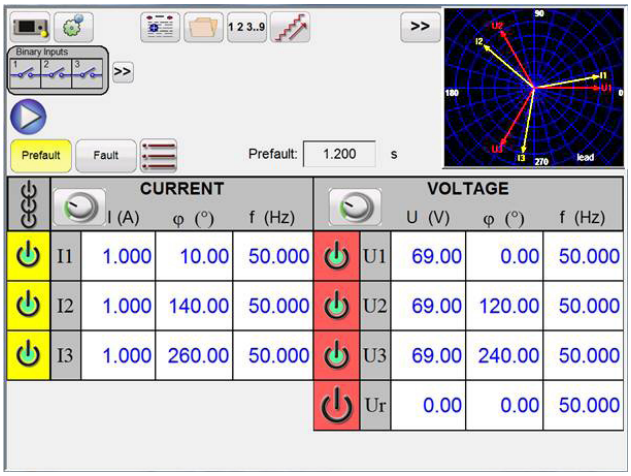
The FREJA Local eliminates the need for a computer when testing virtually all types of relays. Intuitive menu screens and touch screen buttons are provided to quickly and easily select the desired test function. The FREJA Local includes non-volatile built-in data storage for saving tests and test results. An USB port is provided for transferring test results by memory stick from your PC

Manual test screen

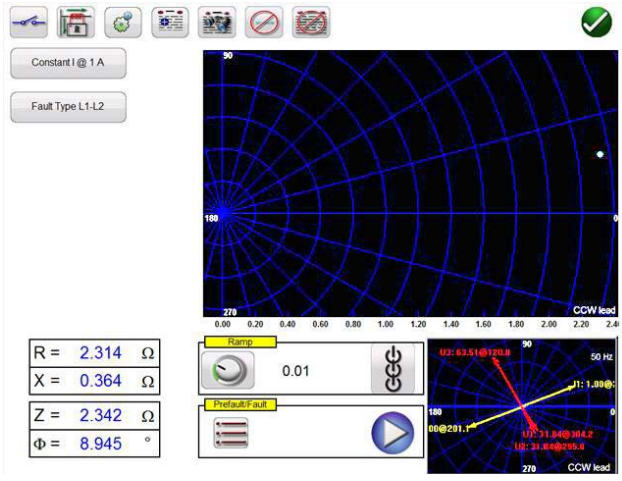
In the following manual test screen the pre-selected outputs are set using the touch screen, or power-up preset default values maybe automatically set from the user defined configuration screen. The user can select from a variety of test options including manual control using the control dial, a dynamic sequence of tests to include trip and auto reclose operations, an automatic ramp, pulse ramp, or pulse ramp binary search to determine pickup or drop out of relay contacts, or perform relay specific timing tests. By pressing the ON button, the selected output indicators will change colors indicating which outputs are energized.

A vector graph indicates the relative phase angles of all of the outputs. The user may select to have all output amplitudes metered to provide real time verification of all of the selected outputs, or have setting values displayed.

In the manual test screen the user can set prefault and fault values. The user can toggle back and forth between the two values to monitor contact activity. To do a simple timing test the user can set prefault time duration in seconds, and then press the blue play button. The prefault values will be applied for the prefault time, then change to the fault values and start the Timer running. When the relay trips, it will stop the timer, and may turn selected outputs off depending on the user set post-fault time.



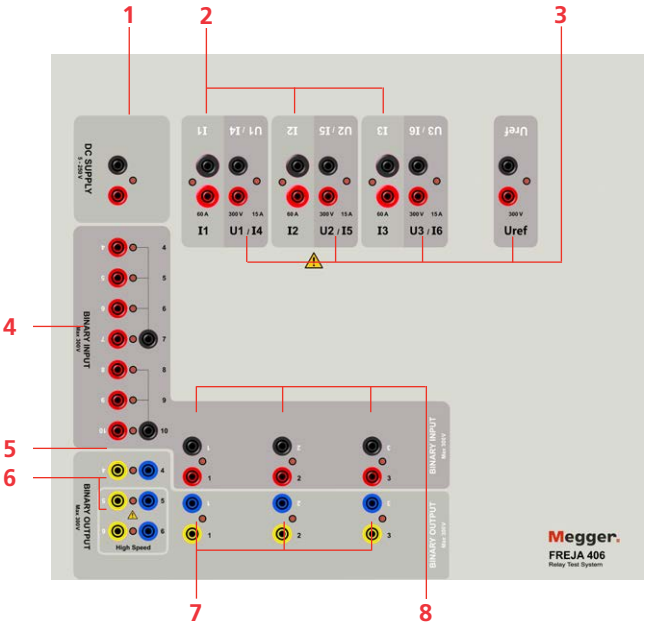
FREJA Local – Interface manual test screen, prefault – fault.

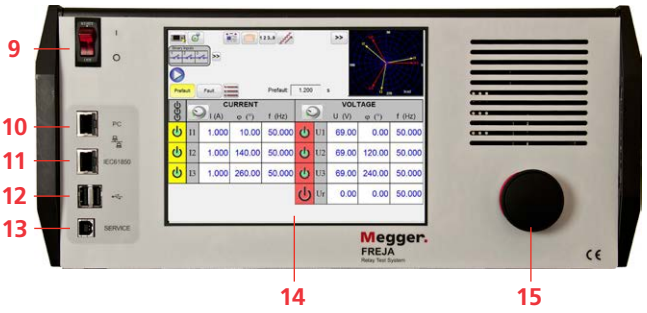


FREJA Local – Impedance menu

Features and benefits

1. **DC supply** Variable 5 to 250 V DC output at 100 W (4 A maximum).
2. **Current outputs**
   - FREJA 403
     Up to three channels 60 A at 300 VA per phase.
   - FREJA 406
     Up to 6 channels (3 x 60 A and 3 x 15 A).
   - FREJA 409
     Up to 9 channels (6 x 60 A and 3 x 15 A).
3. **Voltage outputs**
   - FREJA 403/406/409
     Up to four channels 300 V at 150 VA
   - FREJA 406/409
     Three channels convertible to currents 15 A at 120 VA per phase.
4. **Binary inputs 4, 5, 6, 7, 8, 9, 10.** Provides seven additional monitor circuits.
5. **Binary output 4** Rated for 300 V AC/DC, 8 A
6. **Binary outputs 5 and 6** High speed, AC/DC voltage rating of 400 volts peak, 1 ampere.
7. **Binary outputs 1, 2 and 3** Rated for 300 V AC/DC, 8 A
8. **Binary inputs 1, 2 and 3** Rated 5 to 300 V AC/DC.
9. **POWER ON/OFF switch** Illuminates when power is on.
10. **Ethernet port** The primary PC connection port.
11. **IEC61850** This port may also be used for connecting to the IEC 61850 substation bus for testing IEC 61850 devices.
12. **USB ports** Upgrade and retrive test report from local HMI.
13. **SERVICE port**
14. **Local HMI** TFT LCD , full color touch screen.
15. **Dial**
16. **Mains inlet socket** 100 to 240 V, 50/60 Hz.
17. **Protective earth terminal**





Generator configuration

	Current generators	Voltage generators	Operation modes
FREJA 403	3	4	4 voltages 3 currents (3 x 60 A)
			4 voltages 1 current (180 A)
FREJA 406	3 (6)*	4 (1)*	4 voltages 3 currents (3 x 60 A)
			4 voltages 1 current (180 A)
			1 voltage 6 currents (3 x 60 A + 3 x 15 A)
FREJA 409	6 (9)*	4 (1)*	4 voltages 6 currents (6 x 60 A)
			4 voltages 3 currents (3 x 120 A)
			4 voltages 2 currents (2 x 180 A)
			1 voltage 9 currents (6 x 60 A + 3 x 15 A)

* Three voltage channels converted to current (by configuration setting in local HMI)

FREJA Win

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

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

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

Distance instrument

Configuration page

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

Connect page

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

Zt page

The Zt page is designed for time testing of a distance relay. Normally, you test one type of fault at a time when testing relays. With FREJA Win, however, you can test all seven fault types automatically if so desired. All you have to do is press the <Start> button. FREJA will test all seven fault types automatically and then compare the readings with the theoretical values that you entered on the Configuration page. If the readings are OK, a green lamp lights. If not, a red lamp lights. If you want to check the reverse direction, the test can start below zero ohms in the 3rd quadrant.

RX-ramp page

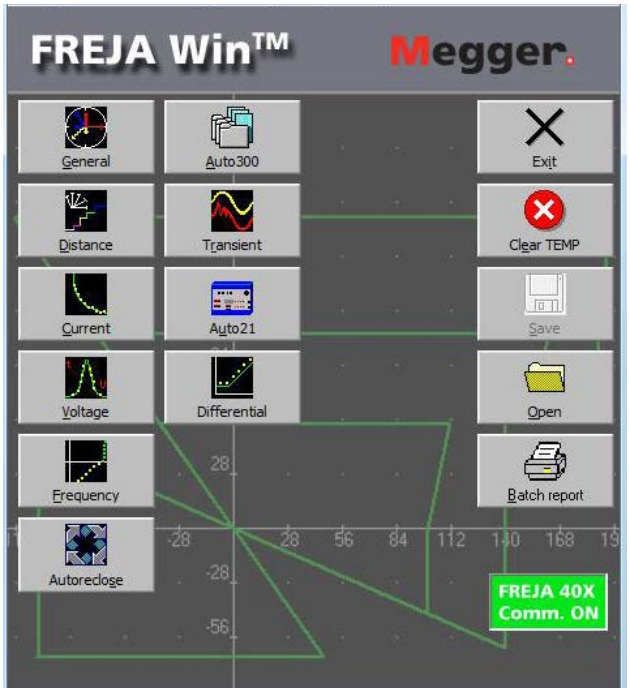
The RX-ramp page, which is part of the Distance instrument program, is designed to test the reach of a distance relay. First, you define the start and stop angles and the delta phi between the ramps. Then press the <Start> button and relax. FREJA will automatically test all seven types of faults using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

RX page

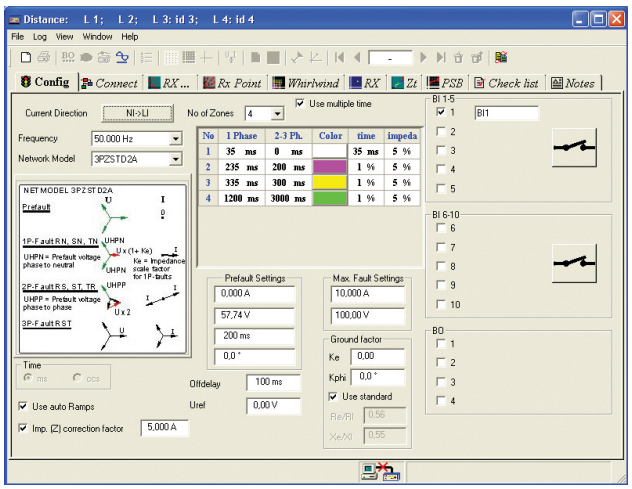
The RX page enables you to define test points manually. You can define different points on the oscilloscope using the mouse or keyboard. Select the automatic mode and press the <Start> button. FREJA will test all points for the selected fault types. The points will be assigned different colors, depending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

Reference graphs

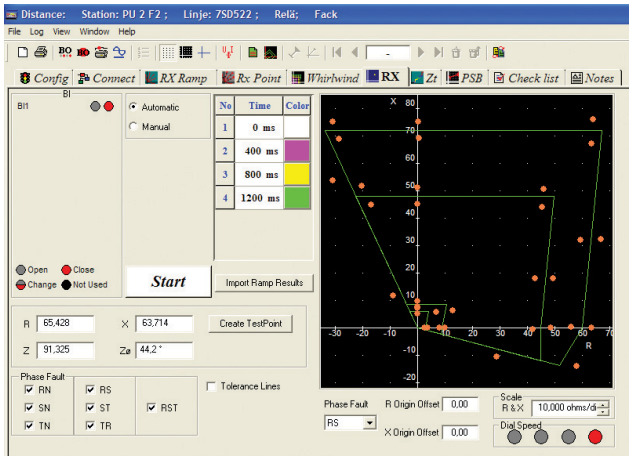
Efficient testing and performance analysis require well-defined reference values. FREJA can automatically create the IEC and IEEE® standard curves for overcurrent relays. It is also possible to create



Control center



Distance, Config



Distance, Rx

reference graphs in the impedance plane using the included library of distance relays made by major manufacturers and/or create other characteristics using the standard circular lens and linear elements (including mho, quadrilateral and ice-cream cone shapes).

The cut and paste buttons make it easy to take copies of the first zone and then edit these copies by inserting zone 2 and zone 3 values.

State-of-the-art distance relays having sophisticated impedance characteristics and several setting groups require many parameter settings. The optional ProGraph feature enables you to import the parameter settings from a master selectivity plan prepared in Microsoft® Excel. This eliminates manual transfer errors, and the FREJA software creates the reference graph automatically.

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

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

Current instrument

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

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

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

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

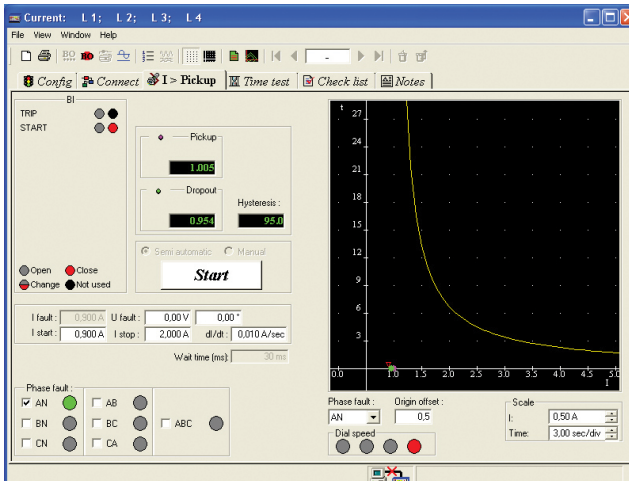
Voltage instrument

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

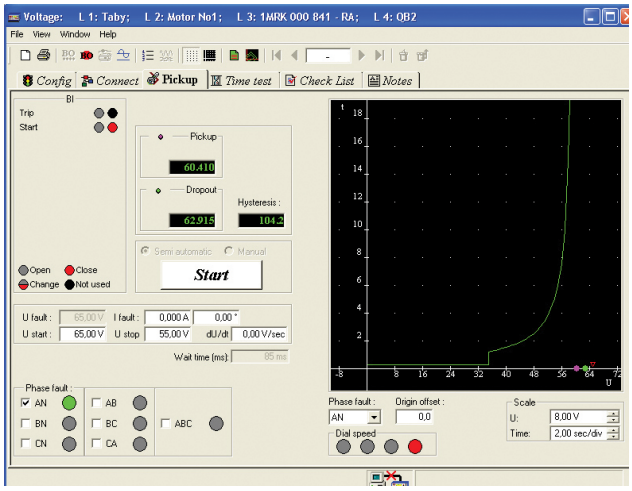
The Config page is where the relay settings will be entered.

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

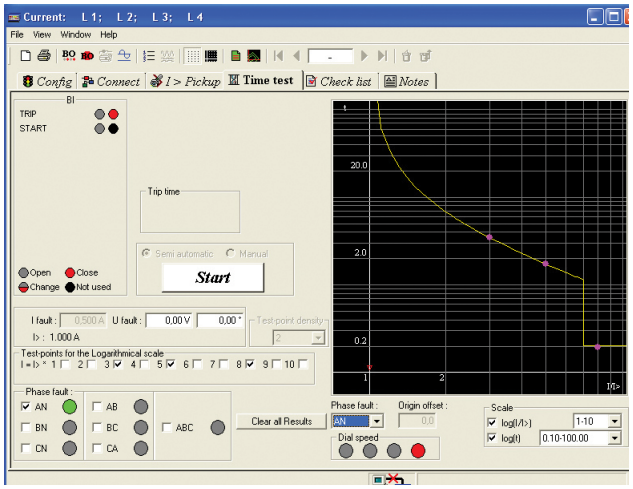
The time test, check the trip time at different voltage values, will be done in the Time Test page. A reference curve can be created in the same way as in Distance, by choosing the corresponding time curve and entering the settings. The time test can be run also in a logarithmic scale, time, current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



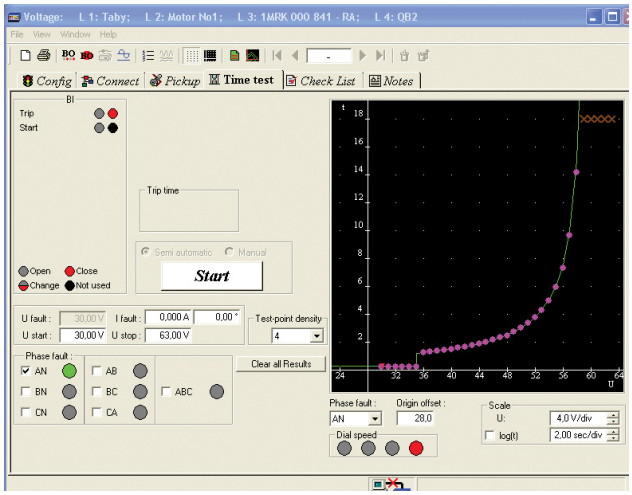
Current instrument, Pick-up



Voltage instrument, Pick-up



Current instrument, Time test



Voltage instrument, Time test

Frequency instrument

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

The Ramp mode will find the set fault frequency.

Autoreclose instrument

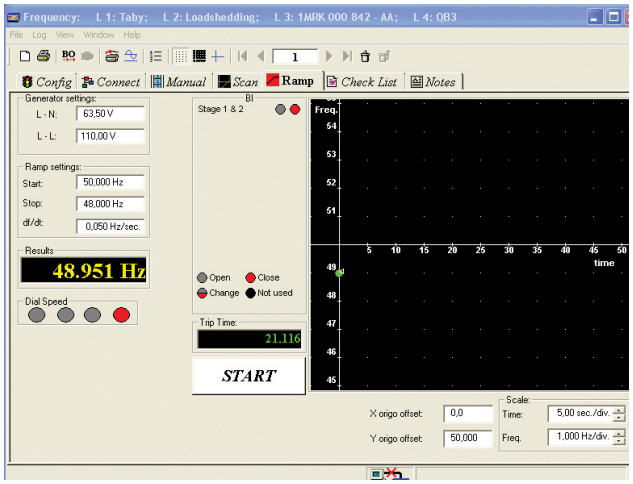
The Autoreclose instrument is a combination between Sequence in General and RX in Distance. This is just because it is easier to simulate pre-fault, energizing and dead times as vectors and in the same way it is easier to simulate a fault in a impedance plane.

This instrument will test any autorecloser function on today's modern relays.

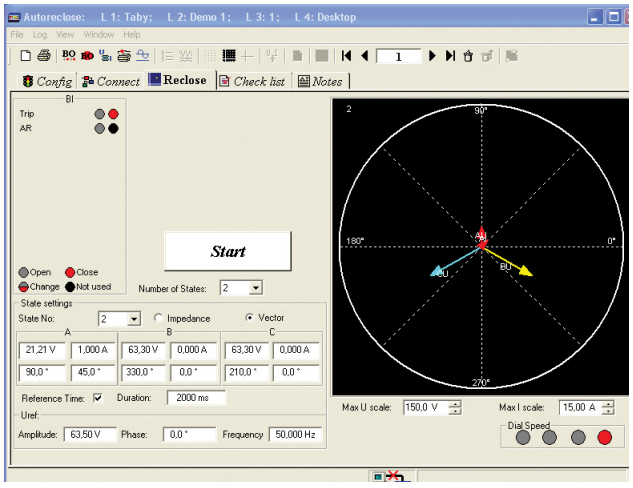
Auto 300

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

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



Frequency instrument, Ramp



Autoreclose instrument

Transducers instrument

The Transducers instrument will test any transducers by checking the output of the transducers and compare it to the settings made in Config.

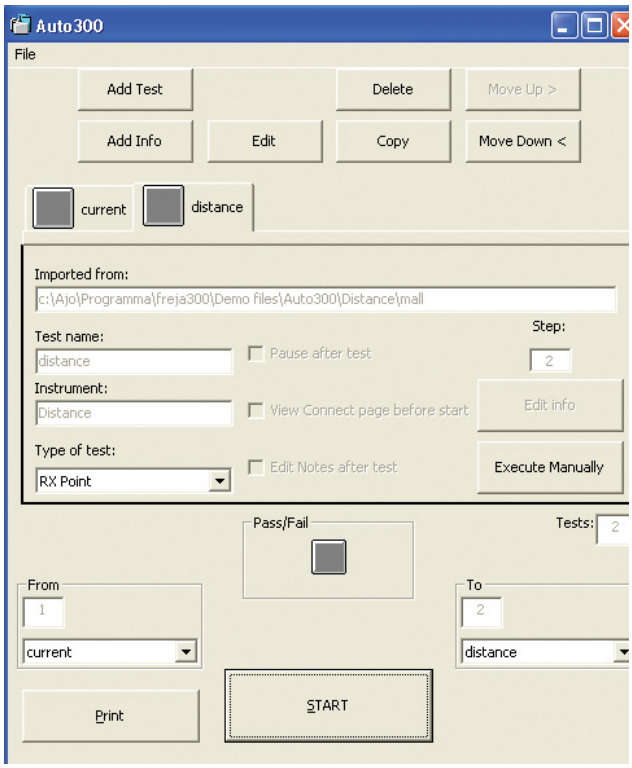
The result will be showed in linear format, full scale, relative and absolute error.

Transient instrument

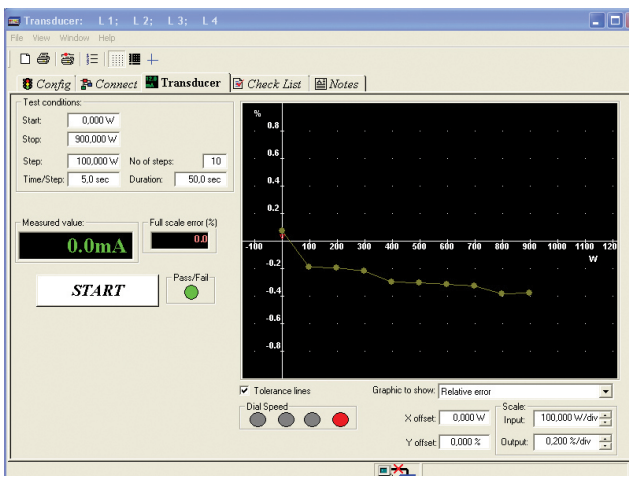
With the help of Transient, FREJA will generate (playback) a wave-form recorded by a disturbance recorder. The file formats supported by Transient are COMTRADE, ASCII, EMTP WAX, EMTP PC and Inductic 65.

Auto 21

Auto 21 is a converter that will convert old test plans made with FREJA 21/21D and using FREJA DOS software, to a Windows compatible format that ken be used together with FREJAWin and FREJA.



Auto 300

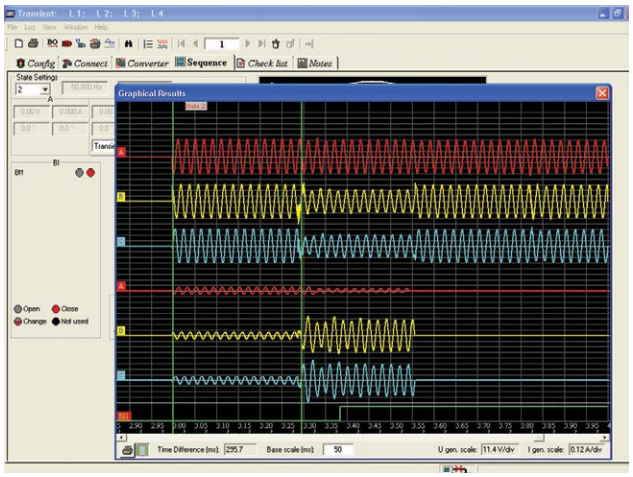


Transducers instrument

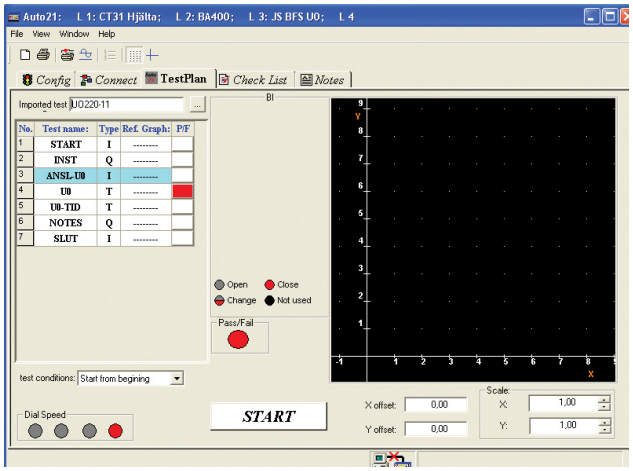
Sync instrument

U-f Min & Max

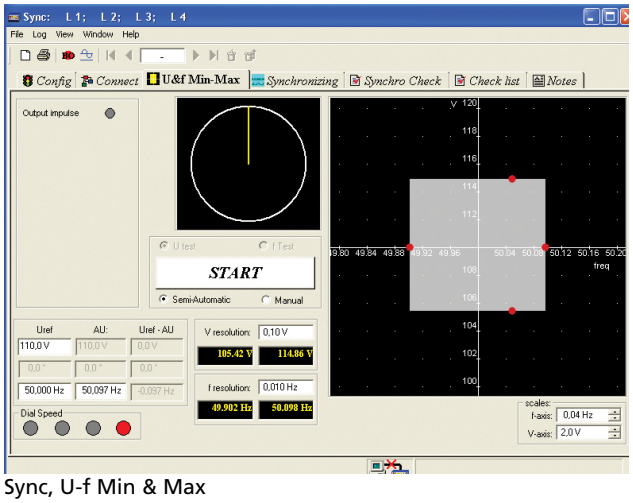
The U-f Min & Max part of the Sync instrument program is designed especially to test voltage and frequency boundaries for a synchronizing relay. This test is carried out automatically. Simply press the <Start> button, whereupon the program itself searches for the boundaries.



Transient instrument



Auto 21 instrument



Sync, U-f Min & Max

Synchronizing page

The Synchronizing page is designed to measure lead-time. It also enables you to measure the pulses sent out from the synchronizing relay.

Synchro Check page

The Synchro Check page is designed to test synchrocheck relays.

First set the phase angle to +20° (or some other starting point). Then change the phase angle until you reach the boundary. You press the <Save> button to store the result. Now test on the other side, starting at -20°, change the phase angle until you reach the other boundary.

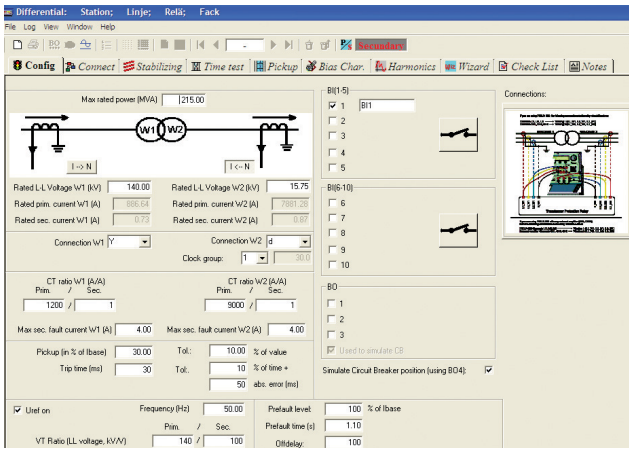
Differential instrument

The Differential instrument is designed to test transformer protection relays and works with FREJA 406, as it makes use of 6 current generators.

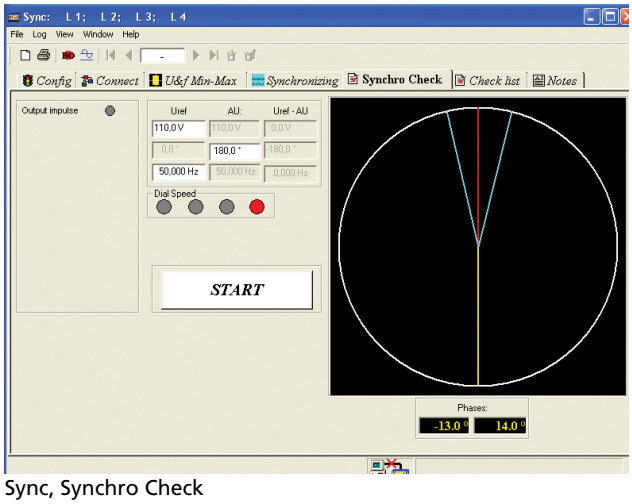
It can be used to test multi winding transformer protection relays, by testing a pair of windings at a time.

FREJA Differential can also be used to test differential generator protection relays and line differential protection relays.

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



Differential instrument



Sync, Synchro Check

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

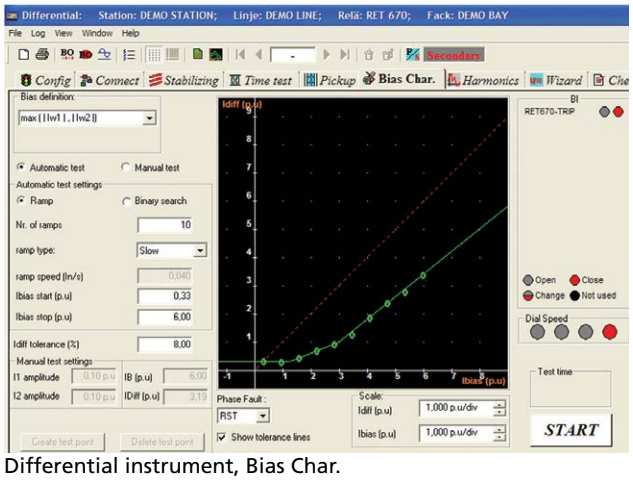
The Time Test page allows to verify the operate time of the differential relay. Several fault injections can be programmed and the page reports the statistics of the measured operate times (minimum, maximum and average values).

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

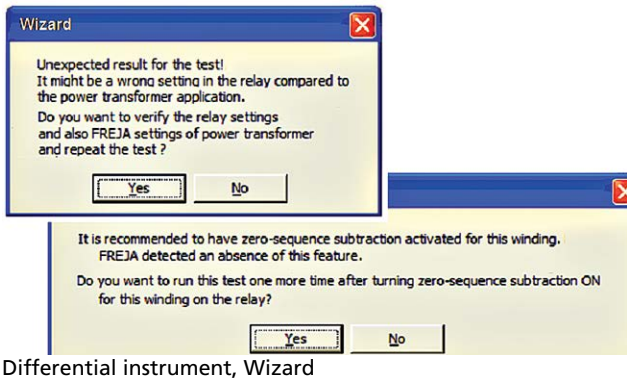
In the page Bias Characteristic it is possible to test the operating relay characteristic by running pseudo-continuous ramps (for testing the static accuracy of the relay) or ramps done by sequences of pre-fault and fault steady state simulations, called as "binary search", more suitable for commissioning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

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

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



Differential instrument, Bias Char.



Differential instrument, Wizard

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

IEC 61850 GOOSE

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

Specifications FREJA 400-series

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

Environment

Application field	For use in high-voltage substations and industrial environments.
Temperature	
Operating	0°C to +40°C (32°F to +104°F)
Storage & transport	-25°C to +70°C (-13°F to +158°F)
Humidity	5% – 90% RH, non-condensing
Altitude (operational)	3000 m Full duty cycle up to 2000 m. Duty cycle limitation based on internal over temperature protection for altitudes >2000 m.

CE-marking

EMC	EN 61326:2006
LVD	EN/IEC 61010-1:2001 (Second Edition)

General

Mains input	100 – 240 V AC, 50–60 Hz
Power consumption	2400 VA
Dimensions	
Instrument	400 x 175 x 420 mm (15.7" x 6.9" x 16.5")
Transport case	514 x 499 x 280 mm (20" x 19.7" x 11")
Weight	
Instrument (403, 406)	18 kg (39 lbs)
Instrument (409)	21 kg (46 lbs)
Transport case	10 kg (22 lbs)
Display	LCD
Available languages	English, French, German, Spanish,
Communication Interfaces	Ethernet

Measurement section

Binary inputs – Start/Stop/Monitor gate

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

Input Rating	< 300 V AC / DC

Timer

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

Seconds	0.0001 to 99999.9 (Auto Ranging)
Cycles	0.01 to 99999.9 (Auto Ranging)
Inaccuracy	
Typical	±0.001% of reading
Maximum	±2 least significant digit, ±0.005% of reading from 0 to 40°C

Binary outputs

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

High current output relays: Output 1,2 and 3.

AC Rating (maximum values)	400 V, 8 A, 2000 VA
DC Rating (maximum values)	300 V, 8 A, 80 W
Response Time	< 10ms

High speed output relays

AC/DC Rating	400 V peak, 1 A (max)
Response Time	< 1 ms typical

DC supply

The FREJA 406 includes a battery simulator with a variable DC output voltage ranging from 5 to 250 V at 100 W, 4 A max, providing capability to power up relays with redundant power supplies. Voltage output is controlled via FREJA Local

Generation section

Each output channel can generate a variety of output waveforms such as: DC; sine wave; sine wave with percent harmonics at various phase angles; half waves; square waves with variable duty cycles; exponential decays; periodic transient waveforms from digital fault recorders, relays with waveform recording capability or EMTP/ATP programs, which conform to the COMTRADE standard format.

Protection

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

Metering

Measured output quantities such as AC/DC V/A, and time may be simultaneously displayed on the large, color TFT LCD touch screen. The AC and DC outputs display the approximate voltage/current output prior to initiation of the outputs.

AC Voltage amplitude

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

AC Current amplitude

Inaccuracy	±0.05 % reading + 0.02 % range typical, ±0.15 % reading + 0.05 % range maximum
Resolution	0.001 / 0.01
Measurements	AC RMS
Ranges	30, 60 A

DC Voltage amplitude

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

DC Current amplitude

Inaccuracy	
Typical	*±0.05 % reading + 0.02 % range*
Maximum	*±0.15 % reading + 0.05 % range*
Resolution	*0.001 / 0.01*
Measurements	*RMS*
Ranges	*30 A*

Convertible source in AC Current mode

Inaccuracy	
Typical	*±0.05 % reading + 0.02 % range*
Maximum	*±0.15 % reading + 0.05 % range or ±12.5 mA whichever is greater*
Resolution	*0.001*
Measurements	*ACrms*
Ranges	*5 A, 15 A*

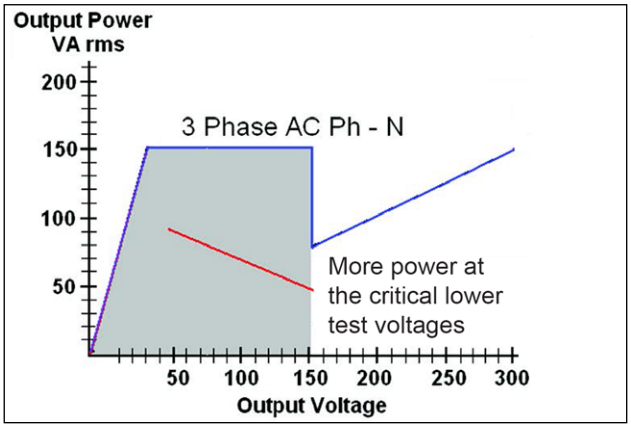
Outputs

All outputs are independent from sudden changes in mains voltage and frequency, and are regulated so changes in load impedance do not affect the output. All amplifier outputs are isolated or floating.
FREJA 406 with 3 convertible voltage to current generators can provide up to six current sources; three high current/high power, and three convertible channels providing lower current/high power.

Voltage outputs

Range (AC)	*Power (VA)*	*Current (max)*	*Duty Cycle*
30 V	150 VA	5 A	Continuous
150 V	150 VA	Variable*	Continuous
300 V	150 VA	0.5 A	Continuous
Range (DC)	*Power (W)*		*Duty Cycle*
0 – 300 V	150		Continuous

* PowerV™ voltage amplifier output current varies depending on the voltage setting on the 150 Volt range, see curve.



"PowerV" Voltage amplifier output power curves

PowerV™ Voltage amplifier - Extended power range

The FREJA voltage amplifier provides a flat power curve from 30 to 150 V in the 150 V range to permit testing of high current applications such as panel testing.

Voltage amplifier in current mode (FREJA 406/409)

The voltage amplifier is convertible to a current source with the following output capability. Output power ratings are specified in rms values and peak power ratings.

Output (A)	Power (VA)	Voltage (max)	Duty cycle
5	150 (212 peak)	30.0 Vrms	Continuous
15	120	8.0 Vrms	90 Cycles

Phase angle

Range	*0.00° to 359.99° counter clock wise, or clock wise rotation or 0.00° to ±180.00°*
Inaccuracy (at 50/60 Hz)	*±0.02° typical ±0.25° max*

Frequency

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

Ranges

DC	0.001 to 1000.000 Hz

Output amplifiers can provide transient signals with a range of DC to 10 kHz for transient playback using COMTRADE files.

*Resolution**	0.0001/0.001 Hz
Frequency inaccuracy 0° to 40°C, at 50/60 Hz	*Typical 2.5 ppm Maximum 25 ppm*
Total harmonic distortion at 50/60 Hz	*< 0.1% typical 2% maximum*

Current outputs

The per channel output current and power ratings are specified in ACrms values and peak power ratings.

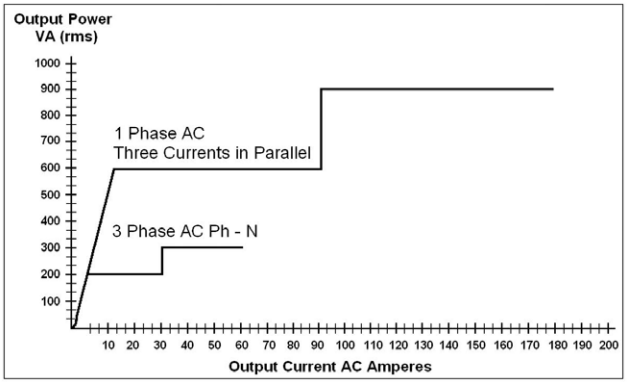
Output (AC)	*Power (VA)*	*Vrms (max)*	*Duty Cycle*
1 A	15	15.0	Continuous
4 A	200 (282 peak)	50.0	Continuous
15 A	200 (282 peak)	13.4	Continuous
30 A	200 (282 peak)	6.67	Continuous
60 A	300 (424 peak)	5.00	90 cycles
120 A*	600 (848 peak)	5.00	90 cycles
Output (DC)	**Power (VA)**		**Duty Cycle**
0 – 30 A	200 W		Continuous

With three currents in parallel

Output (A)	Power (VA)	Vrms (max)	Duty Cycle
12	600 (848 peak)	50.0	Continuous
45	600 (848 peak)	13.4	Continuous
90	600 (848 peak)	6.67	Continuous
180	900 (1272 peak)	5.00	90 cycles

With two currents in series

The compliance voltage doubles to provide 4.0 A at 100 Vrms.



Current amplifier output power curve

Current Amplifier - Extended Power Range

The FREJA current amplifier provides a unique flat power curve from 4 to 30 A per phase to permit testing of electromechanical high impedance relays, and other high burden applications, with an extended operating range up to 60 A at 300 VArms.

* 3 x 120 A only for FREJA 409

Optional accessories

Test lead set, GA-00033

GPS200 – MGTR GPS unit with accessories

Ordering information

Item	Art. No.
FREJA 403 Standalone Excl. FREJA Win, excl. soft case, excl. test leads	CF-39000
FREJA 403 (with soft case) Incl. FREJA Win, soft case, test leads (GA-00033)	CF-39090
FREJA 403 (with flightcase) Incl. FREJA Win, flightcase, test leads (GA-00033)	CF-39091
FREJA 406 Standalone Excl. FREJA Win, excl. soft case, excl. test leads	CF-49000
FREJA 406 (with soft case) Incl. FREJA Win, soft case, test leads (GA-00033)	CF-49090
FREJA 406 (with flightcase) Incl. FREJA Win, flightcase, test leads (GA-00033)	CF-49091
FREJA 409 Standalone Excl. FREJA Win, excl. soft case, excl. test leads	CF-59000
FREJA 409 (with soft case) Incl. FREJA Win, soft case, 2x test leads (GA-00033)	CF-59090
FREJA 409 (with flightcase) Incl. FREJA Win, flightcase, 2x test leads (GA-00033)	CF-59091
Optional	
FREJA Win Software	CF-8203X
FREJA Win upgrade	CF-8282X
MGC IEC 61850 Megger GOOSE configuration software	CF-8401X

Item	Art. No.
Optional accessories	
Multicable	GA-00105
Flight case	GD-00265
Soft case	GD-00315
Test lead set With touch-proof contacts. 4 x 0.25 m (0.8 ft) / 2.5 mm^2 2 x 0.5 m (1.6 ft) / 2.5 mm^2 10 x 2 m (6.5 ft) / 2.5 mm^2 Weight**:** 1 kg (2.2 lbs).	GA-00033
GPS200 – MGTR The GPS receiver GPS200 – MGTR makes it possible to synchronize two or more FREJA to conduct end-to-end testing. End-to-end testing provides quick, reliable results showing how two or more protection relay systems interact. The unit comes with a 15 m (50 ft) cable and an allweather antenna. Longer cables can be ordered.	CF-90150
Cable organizer Velcro straps, 10 pcs.	AA-00100

Registered to ISO 9001 and 14001
Subject to change without notice.
Art.No. ZI-CF05E • Doc. CF0900BE • 2012
FREJA 406_DS_en_V02
www.megger.com

ITEM 4

SMRT410
Megger Relay Test System

SMRT410 with 6 x 60 Amps

- **Small, rugged, lightweight and powerful**
- **Operate with or without a computer**
- **Intuitive manual operation with Smart Touch View Interface**
- **High current, high power output (60 Amps/300 VA rms) per phase**
- **Flexible output design provides up to four-phase voltage and up to ten-phase current**
- **Network interface provides IEC 61850 test capabilities**
- **Fully automated testing using AVTS Software**

DESCRIPTION

The SMRT410 test system may be customized by adding the number of Voltage-Current, "VIGEN", modules needed for specific test applications. The SMRT410 has the "smart" combination of high compliance voltage and high current to test all electromechanical, solid-state and microprocessor-based overcurrent relays, including voltage controlled, voltage restraint and high impedance directional ground overcurrent.

The SMRT410 provides a complete multi-phase test system for commissioning of protection systems. With up to 4 voltage channels a 6 high currents, the SMRT410 meets every testing need. The SMRT410 VIGEN modules also provide high power in BOTH the voltage and current channels to test virtually all types of protective relays.

The SMRT410 test system has the ability to be manually controlled with Megger's new Smart Touch View Interface™ (STVI). The STVI, with its large, full color, high resolution, TFT LCD touch screen allows the user to perform manual, steady-state and dynamic testing quickly and easily using the manual test screen, as well as using built-in preset test routines for most popular relays.

STVI with SMRT410

The STVI eliminates the need for a computer when testing virtually all types of relays. Menu screens and touch screen function buttons are provided to quickly and easily select the desired test function. Tests results can be saved to the STVI for download to a memory stick to transfer or print test reports.

For full automatic testing the SMRT410 may be controlled by Megger Advanced Visual Test Software (AVTS). AVTS is a Microsoft® Windows® XP®/Vista™/7 compatible software program designed to manage all aspects of protective relay testing using the new Megger SMRT.

APPLICATIONS

Each current channel is rated for 30 Amps @ 200 VA continuous, up to 60 Amps @ 300 VA for short durations. It has a unique flat power curve from 4 to 30 Amps that insures maximum compliance voltage to load at all times. With only 3 currents in parallel the unit provides up to 180 Amps @ 900 VA for instantaneous tests. With a maximum compliance voltage of 50 Volts per phase, with just two channels in series provides 100 Volts of compliance voltage to test high impedance relays.

Each voltage channel can provide variable outputs of 0- 30/150/ 300 Volts at 150 VA of output power, and has a unique flat power curve from 30 to 150 Volts insuring maximum output power to the load at all times. With the

voltage channels converted to current, a five channel unit can provide 10 currents.

Using the Ethernet ports, the SMRT410 is literally a "plug-and-play" unit, where voltage and current outputs can be seamlessly synchronized with other SMRT units outputs for testing more complex test applications such as back-to-back tests.

FEATURES AND BENEFITS

Constant Power Output – New higher powered Voltage-Current amplifiers. The current amplifier delivers maximum compliance voltage to the load constantly during the test, and range changing is done automatically under load. This insures better test results, and saves time by not having to turn the outputs off to change ranges. Constant power output in many cases eliminates the need to parallel or series current channels together to test high burden relays.

High Output Current – Provides up 30 Amps at 200 VA per phase continuous, or up to 60 Amperes at 300 VA with a 1.5 second duty cycle. With only three current amplifiers in parallel the SMRT410 provides 180 Amperes at 900 VA, for testing all instantaneous overcurrent relays.

New PowerV™ Voltage Amplifier High Power Output – The SMRT provides a new higher VA power output on the voltage channel at the lower critical test voltages (from 30 to 150 Volts). Customers who want to test a panel of relays at one time find it impossible using lower VA rated voltage.

Convertible Voltage Channels – With a 5 channel SMRT410 unit, convertible channels in conjunction with the main current channels, provides 10 currents for testing multi-phase current differential relays.

High resolution and accuracy – Metered outputs provides extremely high accuracy needed for testing a wide variety of devices. With metered values, what you see is what you get.

Steady-State and Dynamic testing capability – The SMRT410 provides, either through manual control or computer control, both steady-state and dynamic testing of protective relays. This includes programmable waveforms with dc offset and harmonics.

Output current and voltage sine waves are generated digitally – Outputs do not vary with sudden changes in input voltage or frequency, which increases test accuracy and reduces testing time.

Digital binary inputs and outputs – The programmable binary inputs, and programmable outputs provide timing and logic operations in real-time with the output voltage and currents. Binary Inputs can be programmed, using Boolean logic, for more complex power system simulations. This provides a low cost, closed loop, power system simulator.

Circuit breaker simulator – Binary outputs provide programmable normally closed and normally open contacts to simulate circuit breaker operation for testing reclosing relays. Sequence of operation, timing, and lockout are easily tested.

Performs transient tests – Perform acceptance or troubleshooting tests by replaying digitally recorded faults or EMTP/ATP simulations in the IEEE- C37.111, COMTRADE Standard format.

Perform End-to-End tests – Using AVTS software and a portable GPS satellite receiver, the SMRT performs satellite-synchronized end-to-end dynamic multi-state or playback transient COMTRADE files either for commissioning or troubleshooting tests.

Wide-ranging output frequency – The output frequency of the current and voltage channels can be set for any frequency from dc to 1 kHz. Popular test frequencies such as 16.66, 25, 33, 50, 60, 100,120, 125, 150, 180, 250, 300 and 400 Hz are easily set and controlled. Multi-purpose test system saves time and money.

USB 2.0 interface port – The USB port provides a PC interface for automated control of the SMRT unit. Also provides secure isolation when testing IEC 61850 devices (for customers who require secure isolation from their IEC 61850 substation bus).

Three Ethernet ports – PC/OUT Ethernet Port is the primary PC connection port. The IN/IEC61850 Ethernet Port provides interface to multiple SMRT units, and may be used to connect to the IEC 61850 substation bus. The OUT Ethernet Port is primarily used to interconnect multiple SMRT units together for synchronous multi-unit operation. The STVI PoE (Power over Ethernet) port and is used to connect to the STVI.

Bluetooth – Optional Bluetooth provides more flexibility. A wireless interface between the PC and SMRT, in conjunction with the SMRT IEC 61850 Ethernet port, provides the isolation required for a secure substation access interface between the SMRT and the IEC 61850 substation network.

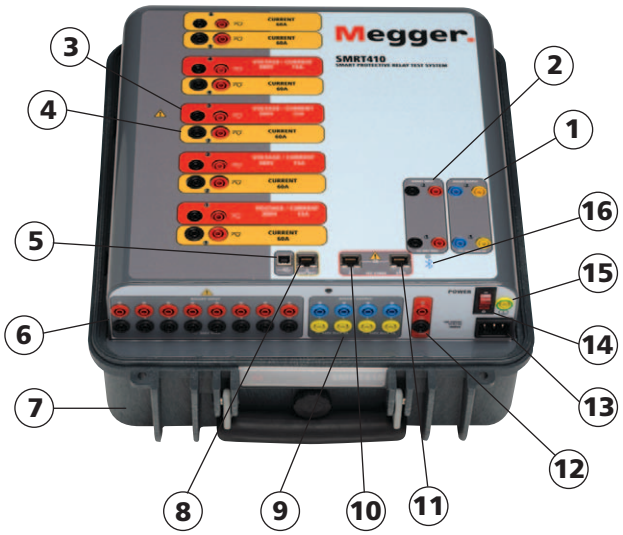
Universal input voltage – Operation from 90 to 264 Vac, 50/60 Hz, the SMRT can use virtually any standard source in the world.

Immediate error indication – Audible and visual alarms indicate when amplitude or waveforms of the outputs are in error.

Modular design – Output modules plug-in and out easily for system re-configuration and maintenance.

IEC 61850 – Optional integrated interface provides testing using the IEC 61850 GOOSE protocol.

SMRT410 RELAY TESTER



APPLICATIONS SELECTION GUIDE

1. **Binary Outputs 1 and 2:** Rated for 300 V at 8 Amps.
2. **Binary Inputs 1 and 2:** Rated 5 to 300 V AC/DC
3. **Voltage Outputs:** Up to 4 channels 300 V at 150 VA, convertible to currents 15 A at 120 VA per phase.
4. **Current Outputs:** Up to 6 channels 60 Amps at 300 VA per phase.
5. **USB 2.0 Interface:** Communication and control port.
6. **Additional Binary Inputs:** Provides 8 additional monitor circuits.
7. **Rugged Case:** Fiberglass reinforced plastic.
8. **PC/OUT:** Ethernet Port is the primary PC connection port. Ethernet Port used to chain multiple SMRT units together for synchronous multi-unit operation.
9. **Additional Binary Outputs:** Adds 4 outputs. Binary Outputs 3 and 4 are rated for 300 V AC/DC, 8 amperes. Binary Outputs 5 and 6 are high speed and have an AC/DC voltage rating of 400 volts peak, 1 ampere.
10. **IN/61850:** This port may also be used for connecting to the IEC 61850 substation bus for testing IEC 61850 devices.
11. **STVI:** Ethernet Port is a PoE (Power over Ethernet) port and is used to connect to the STVI for manual control.
12. **Battery Simulator:** Variable 5 to 250 Volts DC output at 100 Watts (4 amperes maximum).
13. **Incoming Power/Line Cord Socket:** 100 to 240 V, 50/60 Hz.
14. **POWER ON/OFF Switch:** Illuminates when power is on.
15. **Protective Earth Ground Jack.**
16. **Bluetooth:** Bluetooth© provides wireless control.

APPLICATIONS SELECTION GUIDE

Protective Relays by IEEE Device #		SMRT410 Three Channels	SMRT410 Four Channels
2	Time Delay	■	■
21	Distance Single Phase	■	■
21	Distance Three Phase Open Delta	■	■
21	Distance Three Phase wye	■	■
24	Volts/Hz	■	■
25	Synchronizing	■	■
27/59	Under/Over Voltage	■	■
32	Directional Power Single Phase	■	■
32	Directional Power Three Phase	■	■
37/76	DC Under/Over Voltage/Current	■	■
40	Loss of Field	■	■
46	Phase Balance Current	■	■
46N	Negative Sequence Overcurrent	■	■
47	Phase Sequence Voltage	■	■
50	Instantaneous Overcurrent	**Up to 225 Amps**	**Up to 300 Amps**
51	Time Delay Overcurrent	**Up to 105 Amps**	**Up to 140 Amps**
55	Power Factor	■	■
60	Voltage/Current Balance	■	■
67	Directional Overcurrent	■	■
67N	Ground Directional Overcurrent	■	■
78	Out of Step	■	■
79	Reclosing	■	■
81	Frequency	■	■
85	Carrier or Pilot Wire	■	■
87	Differential	■	■
91	Voltage Directional	■	■
92	Voltage and Power Directional	■	■
94	Tripping	■	■

SPECIFICATIONS[1]

Input Power
100 to 240 Volts (± 10%) AC, 1Ø, 50/60 Hz, 1800 VA

Outputs[2]
All outputs are independent from sudden changes in mains voltage and frequency, and are regulated so changes in load impedance do not affect the output. All amplifier outputs are isolated or floating. The SMRT units can be ordered with the amplifier common returns tied to chassis ground as an option.

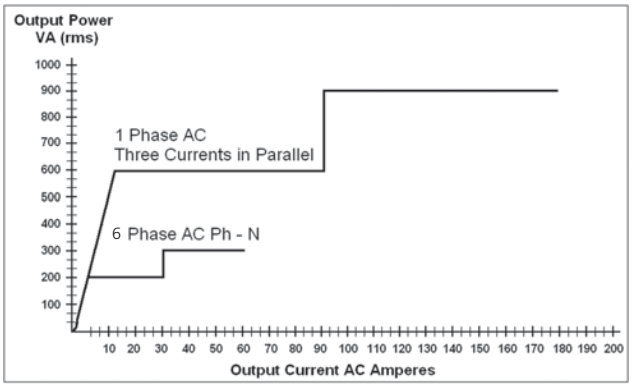
Output Current Sources
The SMRT410 with five modules can provide up to ten current sources; six high current/high power[3], and four convertible channels providing lower current/high power. The per channel output current and power ratings are specified in AC rms values and peak power ratings.

Output Current	Power	Max V/Duty Cycle
1 Ampere	15 VA	15.0 Vrms Continuous
4 Amperes	200 VA (282 peak)	50.0 Vrms Continuous
15 Amperes	200 VA (282 peak)	13.4 Vrms Continuous
30 Amperes	200 VA (282 peak)	6.67 Vrms Continuous
60 Amperes	300 VA (424 peak)	5.00 Vrms 90 Cycles
DC 200 Watts		

With three currents in parallel:

Output Current	Power	Max V/Duty Cycle
12 Amperes	600 VA (848 peak)	50.0 Vrms Continuous
45 Amperes	600 VA (848 peak)	13.4 Vrms Continuous
90 Amperes	600 VA (848 peak)	6.67 Vrms Continuous
180 Amperes	900 VA (1272 peak)	5.00 Vrms 90 Cycles

With two currents in series:
The compliance voltage doubles to provide 4.0 Amperes at 100 Volts rms.



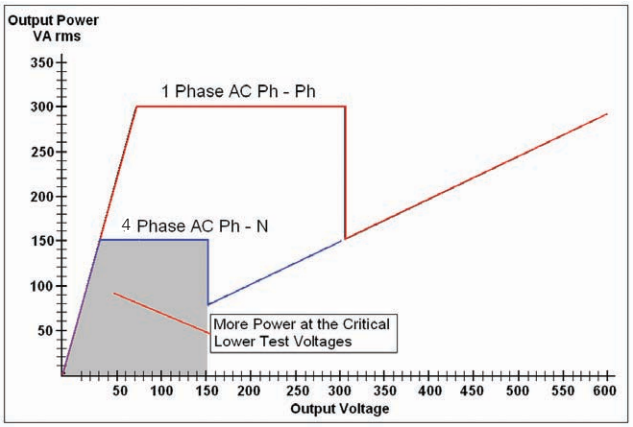
Current Amplifier Output Power Curve

Current Amplifier - Extended Power Range
The SMRT current amplifier provides a unique flat power curve from 4 to 30 Amperes per phase to permit testing of electromechanical high impedance relays, and other high burden applications, with an extended operating range up to 60 Amperes at 300 VA rms.

AC Voltage Output
Outputs are rated with the following Ranges:

Output Volts	Power	Max I
30 Volts	150 VA	5 Amps
150 Volts	150 VA	Variable[4]
300 Volts	150 VA	0.5 Amps
DC 150 Watts		

Duty Cycle: Continuous



"PowerV" Voltage Amplifier Output Power Curves

"PowerV™" Voltage Amplifier - Extended Power Range
The SMRT voltage amplifier provides a flat power curve from 30 to 150 Volts in the 150V range to permit testing of high current applications such as panel testing.

Voltage Amplifier in Current Mode:
The voltage amplifier is convertible to a current source with the following output capability. Output power ratings are specified in rms values and peak power ratings.

Output Current	Power	Max V	Duty Cycle
5 Amperes	150 VA (212 peak)	30.0 Vrms	Continuous
15 Amperes	120 VA	8.0 Vrms	90 Cycles

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

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

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

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

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[1] Megger reserves the right to change product specifications at any time.

[2] For 4 or 5 channel units operating at input voltages below 220 VAC a derating of the simultaneously available total output power of the voltage/current amplifiers and battery simulator will occur. The maximun output power of a single amplifier is not affected.

[3] Six high current/high power channels require optional DIGEN, Double Current Generation, see Ordering Information for details.

[4] PowerV™ voltage amplifier output current varies depending on the voltage setting on the 150 Volt range, see curve.

Timer

The Timer-Monitor Input is designed to monitor and time-tag inputs, like a sequence of events recorder. In addition, the binary input controls enable the user to perform logic AND/OR functions, and conditionally control the binary output relay to simulate circuit breaker, trip, reclose and carrier control operation in real-time. The Timer function displays in Seconds or Cycles, with the following range and resolution:
Seconds: 0.0001 to 99999.9

(Auto Ranging)

Cycles: 0.01 to 99999.9

(Auto Ranging)

Accuracy: ±0.001% of reading, typical. ±2 least significant digit, ±0.005% of reading from 0 to 50° C maximum

Binary Input – Start/Stop/Monitor Gate

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

Binary Output Relays

SMRT410 has independent, galvanically isolated, output relay contacts to accurately simulate relay or power system inputs to completely test relays removed from the power system. The binary output simulates normally open / normally closed contacts for testing breaker failure schemes. The binary output can be configured to change state based on binary input logic.
High Current Output Relays: The first two VIGEN Modules have 1 each and the P option add 2 more.
AC Rating: 400 V max., Imax: 8 amps, 2000 VA max.
DC Rating: 300 V max., Imax: 8 amps, 80 W
Response Time: <10ms
High Speed Output Relays: SMRT410 P Option adds 2
AC/DC Rating: 400 V peak, Imax: 1 amp
Response Time: <1ms typical

Battery Simulator

The SMRT410 with the P (Plus) option includes a battery simulator with a variable DC output voltage ranging from 5 to 250 Volts at 100 Watts, 4 Amps max, providing capability to power up relays with redundant power supplies. Voltage output is controlled via the Smart Touch-View Interface, or through AVTS software. The SMRT410 with the N option does not include a battery simulator.

Waveform Generation

Each output channel can generate a variety of output waveforms such as: DC; sine wave; sine wave with percent harmonics at various phase angles; half waves; square waves with variable duty cycles; exponential decays; periodic transient waveforms from digital fault recorders, relays with waveform recording capability or EMTP/ATP programs, which conform to the IEEE C37.111 COMTRADE standard format.

Metering

Measured output quantities such as AC Amperes, AC Volts, DC Volts or DC Amperes, and Time may be simultaneously displayed on the large, color TFT LCD touch screen. The AC and DC outputs display the approximate voltage/current output prior to initiation of the outputs. All accuracies stated are from 10 to 100% of the range at 50/60Hz.

AC Voltage Amplitude

Accuracy: ±0.05 % reading + 0.02 % range typical,
±0.15 % reading + 0.05 % range maximum
Resolution: .01
Measurements: AC RMS
Ranges: 30, 150, 300V

AC Current Amplitude

Accuracy: ±0.05 % reading + 0.02 % range typical,
±0.15 % reading + 0.05 % range maximum
Resolution: .001/.01
Measurements: AC RMS
Ranges: 30, 60A

DC Voltage Amplitude

Accuracy: 0.1% range typical,
0.25% range maximum
Resolution: .01
Measurements: RMS
Ranges: 30, 150, 300V

DC Current Amplitude

Accuracy: ±0.05 % reading + 0.02 % range typical,
±0.15 % reading + 0.05 % range maximum
Resolution: .001/.01
Measurements: RMS
Ranges: 30A

Convertible Source in AC Current Mode

Accuracy: ±0.05 % reading + 0.02 % range typical,
±0.15 % reading + 0.05 % range or ±12.5 mA whichever is greater
Resolution: .001
Measurements: AC RMS
Range: 5, 15A

Environmental

Operating Temperature: 32 to 122° F (0 to 50° C)
Storage Temperature: -13 to 158° F (-25 to 70° C)
Relative Humidity: 5 - 90% RH, Non-condensing

Unit Enclosure

The SMRT unit comes housed in a rugged, virtually indestructible, lightweight and ergonomic enclosure. It features a large oversized rubber cushioned handle, and removable lid for use in tight spaces.

Dimensions

With the lid on:
14.2 W x 7.6 H x 16.25 D in.
(360 W x 194 H x 413 D mm)
With the lid off:
14.2 W x 7.2 H x 16.25 D in.
(360 W x 180 H x 413 D mm)
IEC Enclosure Rating: IP20

Weight

With the transit lid on: 39.5 lb. (17.76 kg)
With the transit lid off: 36.5 lb. (16.4 kg)

Conformance Standards

Safety: EN 61010-1
Shock: MIL-PRF-28800F (30g/11ms half-sine)
Vibration: MIL-RFP-28800F (5-500Hz, 2.05 g rms)
Transit Drop: MIL-RFP-28800F (10 drops, 46 cm)

Protection

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

Communication Interfaces

Ethernet (2)
USB 2.0
Bluetooth (optional)

Megger

OFTWARE

AVTS – STVI Basic

Every unit comes with **AVTS Basic** software and the PC version of the **STVI Basic** software packages. AVTS Basic version includes Online Vector control (for single and multi-state timing tests), Online Ramp control (for automatic ramping of voltage, current, phase angles or frequency) and Online Click-On-Fault (for dynamic tests of impedance relays). Test results may be exported directly to Microsoft Word. AVTS software includes a database for saving test results, which can also provide the necessary information needed for system reliability audits. See **AVTS** bulletin for more information.

The PC version of the STVI software includes the ability to bring all STVI test data (from other STVI units) into file folders for retrieval, review and printing whenever needed. See **STVI** bulletin for more information.

AVTS Advanced

The AVTS Advanced version includes all the feature in AVTS Basic plus the powerful Test Editor, Dynamic Control (includes dynamic end-to-end testing capability, and waveform recording capability), ASPEN OneLiner™ or Electrocon CAPE™ SS1 File Converter for dynamic testing, and easy to use programming Tools for creating and editing test modules. See **AVTS** bulletin for more information.

AVTS Professional

The AVTS Professional version includes all of the features of the Basic and Advanced versions plus some other powerful test tools and features. It includes the DFR Waveform Viewer, One-Touch™ Test for fully automatic tests, Modbus communication test capability, and Waveform Digitizer to digitize scanned waveforms of electromechanical over current time curves. See **AVTS** bulletin for more information.

IEC 61850 GOOSE

The SMRT with the GOOSE enabled, in conjunction with the Megger GOOSE Configurator (MGC) software, can be used in the testing or commissioning of IEC 61850 compliant devices. See **AVTS** bulletin for more information.

ITEM 5

PAM420
Multi Function Meter

- **Phase Angle Meter**
- **2 channels: voltage, current and frequency meter**
- **Timer**
- **Compact and lightweight**
- **Local calibration**
- **Rechargeable batteries**
- **Easy to use**

Description

The PAM420 is specifically designed for measurements on electrical power systems. It is capable of displaying phase angle, voltage, current, frequency and timing.

The phase angle is calculated from the relationship between two power signals, which can be two currents, two voltages or any combination.

Currents up to 25 A and voltages up to 500 V can be applied directly to the instrument. The current input range can be extended by using external current transformers.

Application

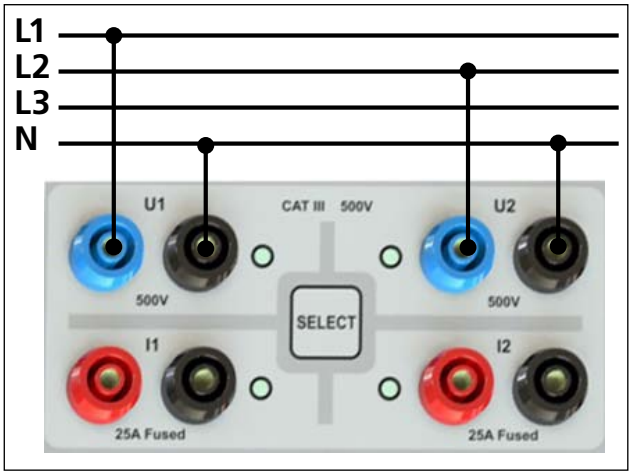
The PAM420 is suited for checking polyphase metering installations, testing protective relays, make comparative test in electrical substations, and verifying the phase angle deviation on power transformers.

Features and benefits

- Direct digital reading to tenths of a degree (0.1°) – does not require calculation or interpretation.
- Designed for use in substation or industrial environments – transport case provided for rugged protection.
- Phase angle calculated from of any combination of two power signals to be measured giving broad application capability.
- Timer with high accuracy for contact or voltage trig.
- Local calibration.

φ	180.0	°
U1	228.1	V
F1	50.01	Hz
U2	230.2	V
F2	49.99	Hz

Example of measured values shown on display



Application example of the PAM420

Specifications PAM420

Specifications are valid at nominal input voltage and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

Environment

Application field	The instrument is intended for use in high-voltage substations and industrial environments.
Temperature	
Operating	-10°C to +50°C (14°F to +122°F)
Storage & transport	-40°C to +70°C (-40°F to +158°F)
Humidity	5% – 95% RH, non-condensing
Altitude	< 2000 m above sea level

CE-marking

EMC	2004/108/EC
LVD	2006/95/EC

General

Measurement category	CAT III 500 V CAT IV 300 V
Enclosure class	IP21
Power supply	Rechargeable batteries
Mains adapter	100–240 V AC, 50/60 Hz
Adapter output voltage	9 V DC
Output connector	Ø 5.08 mm with Ø 2.54 centre pin (+)
Power consumption	10 W (max)
Dimensions	
Instrument	260 x 140 x 55 mm (except handle) (10.2" x 5.5" x 2.2")
Transport case	390 x 300 x 140 mm (15.4" x 11.8" x 5.5")
Weight	1.2 kg (2.6 lbs) 3.5 kg (7.7 lbs) with accessories and transport case
Test lead set, with 4 mm stackable safety plugs	Black 2 x 2 m (6.6 ft), 2.5 mm² Red 2 x 2 m (6.6 ft), 2.5 mm²
Display	Alpha numerical LC display with backlighter

Measurement section

Current – Inputs I1 and I2

Measurement category	CAT III 500 V CAT IV 300 V
Input range	0 – 25 A AC
Inaccuracy	0.5% of reading
Resolution	0.1 A
Protection	Built-in 25 A fuse

Voltage – Inputs U1 and U2

Measurement category	CAT III 500 V CAT IV 300 V
Input range	0 – 500 V AC true RMS
Inaccuracy	0.15 % of reading + 0.03% of range (± 0.15 V)
Resolution	0.1 V

Phase angle

Range	0 – 359.9°(2–500 V and 0.15–25 A)
Type of phase angle measurement	Current-current, voltage-voltage and current-voltage
Waveform	Sinusoidal
Resolution	0.1°
Inaccuracy	±0.5° at >10% of voltage/current range ±1° at 2–10% of voltage/current range ±2° at 1–2% of voltage/current range

Frequency

Note: Frequency component in voltage component only

Range	15 – 75 Hz
Inaccuracy	0.1%
Resolution	0.01 Hz

Timer

Measurement category	CAT II 250 V
Range	0-999.999 s
Resolution	1 ms
Inaccuracy	±0.02% + 2 digits of displayed value
Max input voltage	250 V AC/DC
Input debouncing filter	1 ms

Voltage mode

Parameter	Min	Max	Unit
Trig AC	9	250	V AC
Trig DC	11	250	V DC

Contact mode

Parameter	Min	Max	Unit
Closed contact detection	0	1	kΩ
Open contact detection	4	-	kΩ

Ordering information

Item	Art. No.
PAM420 Incl. Test lead set, mains adapter (battery charger) and transport case	BP-39093

Section B

ITEM 6

INGVAR
Primary Current Injection Test System

- **Most Advanced Primary Current Injection Test System to simplify all types of switchgear and CT commissioning, ground grid, circuit breaker testing and more**
- **Two units, each of about 20 kg (44 lbs), simplifies transportation**
- **Unique I/30 function allows the current to be pre-set using low current to prevent test sample heating, thus eliminating corruption of test result**

Description

This powerful test system is designed for primary injection testing of protective relay equipment and circuit breakers. It is also used to test the turns ratio of current transformers and for other applications that require high variable currents.

The system consists of a control unit and a current unit. The two parts are portable, and INGVAR can be quickly assembled and connected.

The control unit has many advanced features – a powerful measurement section for example, that can display turns ratio as well as time, voltage and current. A second measurement channel can be used to test an additional current or voltage. Current transformer turns ratio, impedance, power, power factor (cos φ) and phase angle are calculated and shown in the display. Current and voltage can be presented as percentages of nominal value. The fast-acting hold function freezes short-duration readings on the digital display when the voltage or contact signal arrives at the stop input, the object under test interrupts the current or injection is stopped

Application

- **Primary current injection testing and breaker testing**

These tests require high currents and the ability to measure very short duration, current flow. INGVAR has been designed especially to meet these needs. No extra contacts are needed to measure the operating time of a low-voltage breaker. Testing stops at the instant when the main breaker contacts open to interrupt the current. Output current initiation is synchronized with the currents zero-crossover point to ensure good repeatability and minimized DC offset.

- **Testing current transformers**

For turns ratio testing, the primary current and either the secondary current or the turns ratio are displayed simultaneously. Since the turns ratio is displayed directly as the nominal value (1000/5 for example), no further calculation is needed. Burden of secondary circuits can be measured and presented in VA.

- **Polarity testing**

The currents phase displacement is shown, and the polarities of the outputs are clearly marked.

- **Heat runs**

INGVAR is ideal for performing heat runs. Current can be applied continuously or through programmable intervals. The times can be shown in minutes and hours which facilitates long-term testing capability.

- **Automatic reclosers and sectionalizers**

INGVAR can also be set to test circuit breakers with reclosing relays. Operating limits, partial times, total times and the number of operations before lockout can be measured. User-selectable reclosing sequences can be programmed for testing sectionalizers.

Testing integrity of ground grids and safety-ground devices

One way to test ground grids is by injecting current between a reference ground and the ground to be tested and measuring the voltage drop and the percentage of current flowing through the ground grid.

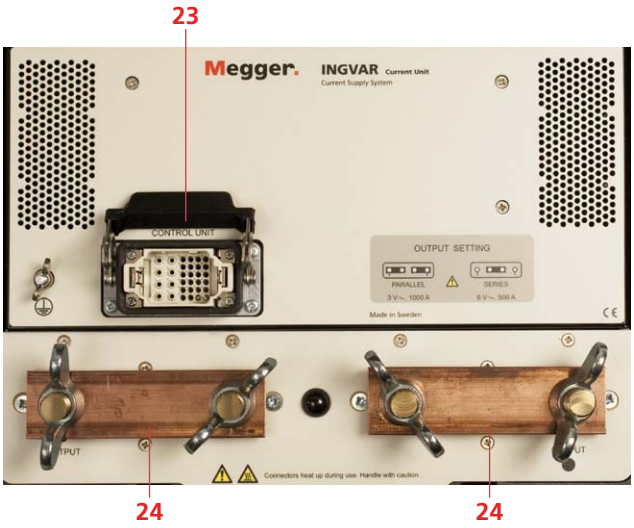
Megger

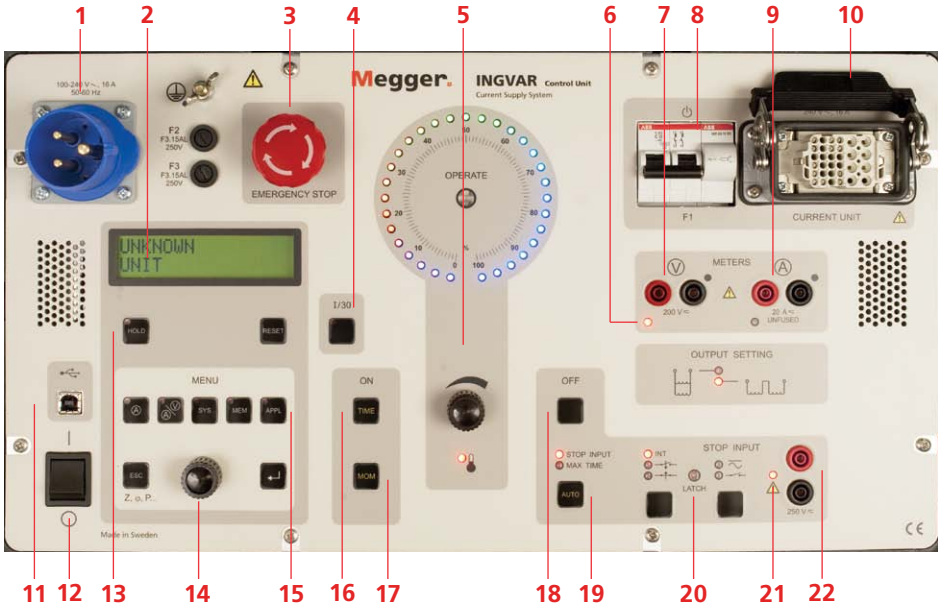
INGVAR

Primary Current Injection Test System

Features and Benefits

1. **Mains inlet**, 3 pin CEE connector (16 A)
2. **Display.** The display presents time, output current, voltage, current shown on ammeter 2 and phase angle. You can scroll through entities Z, P, Q, R, X, S, power factor (cos φ) and I max.
3. **Emergency stop button.**
4. **Current reduction button.** Used during setting to reduce the output current to 1/30. Useful in order to avoid for example unintentional tripping and overheating.
5. **Current adjustment knob.**
6. **Indicator lamps.** Indicate whether ammeter 2 or the voltmeter is enabled.
7. **Input for voltmeter.** Used to measure voltage and other quantities.
8. **Miniature circuit breaker used for current output.** Interrupts output current. Can also be actuated manually for safe disconnection of load.
9. **Input for ammeter 2.** Used to measure current in an external circuit (in a current transformer's secondary winding for example).
10. **Multiconnector** for interconnection of control and current units.
11. **USB port**, type B
12. **ON/OFF** switch
13. **Hold function.** This function freezes readings on the display.
14. **Selection/setting knob.** Selects the desired menu option (shown in the display window). Also used to change numerical values.
15. **Setting buttons.** Personnel unfamiliar with INGVAR can use the pre-defined settings very effectively, while experienced users can make their own basic settings.
    - **Ammeter.** Used to set the main current-output ammeter. You can select the desired range or select autoranging.
    - **V/A Meter.** Toggles between the voltmeter and ammeter 2. Also used to select the desired range or select autoranging.
    - **System.** Used for general settings.
    - **Memory.** Used to save or recall settings to or from the ten INGVAR memories. One of these memories contains the default (pre-defined) settings that are invoked when INGVAR is powered up.
    - **Application**. Used to invoke the desired measurement mode: a) automatic recloser, b) sectionalizer. INGVAR can also be set to generate pulse trains with user-selectable pulse and pause times.
16. **Injection.** Starts current injection and timing.
17. **Momentary Injection.** When this button is used, injection continues only as long as it is pressed. Useful in order to avoid for example overheating.
18. .**Manual shut-off.** Injection and timing are stopped when this button is pressed.
19. **Automatic injection stop.** Generation stops after a user-specified interval or when condition at the input is met. The diodes show the selected OFF condition.
20. **Stop-condition indicator.** Indicates that the stop condition is fulfilled.
21. **Status indicator.** Indicates if a contact connected to the input is closed or if voltage is present.
22. **Stop input.** Used to freeze a reading or stop injection. Activated when current is interrupted by the object being tested, when an external contact is actuated or when a voltage is applied or removed.
23. **Multiconnector** for interconnection of current and control units.
24. **Current bars** for parallel or serial connection of the outputs.





Specifications INGVAR

Specifications are valid for an ambient temperature of +25°C and nominal input voltage. The specifications are subject to change without notice.

System designation

An INGVAR-system consists of a Control Unit an one Current Unit.

Environment

Application field	The instrument is intended for use in medium-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (+32°F to +122°F)
Storage & transport	-25°C to +55°C (-13°F to +127°F)
Humidity	5% – 95% RH, Non-condensing
Altitude (operational)	<2000 m
Pollution degree	2

CE-marking

EMC	2004/108/EC
LVD	2006/95/EC

General

Measurement category	CAT I Rated transient overvoltage: 2200 V
Mains voltage	100 – 240 V AC, 50/60 Hz
Mains inlet	IEC 60309-1, -2. 16 A
Input current	Output current x open circuit voltage / input voltage
Protection	The output transformer has a built-in thermal cut-out, and the primary side is protected by a miniature circuit breaker
Dimensions	
Control Unit	546 x 347 x 247 mm (21.5" x 13.7" x 9.7")
Current Unit	410 x 340 x 205 mm (16.1" x 13.4" x 8")
Weight	
Control Unit	20 kg (44 lbs)
Current Unit	20 kg (44 lbs)
Data transfer	USB Type B Female

Display

Type	LCD
Available languages	English, German, French, Spanish, Swedish.

Measurement section

Ammeters

Measurement method	AC 50/60 Hz, DC RMS
Inaccuracy	1% of range ±1 digit
Ammeter 1	
Ranges	
Serial Low	0 – 1.00 kA
Serial High	0 – 2.00 kA
Parallel Low	0 – 3.25 kA
Parallel High	0 – 6.50 kA
Resolution	
0-999 A	1 A
1.00 – 6.50 kA	10 A
Ammeter 2	
Ranges	0 – 2 A / 0 – 20 A
Maximum current	20 A (The input is not protected by a fuse)

Voltmeter

Measurement method	AC 50/60 Hz, DC RMS
Ranges	0 – 0.2 V, 0 – 2 V, 0 – 20 V, 0 – 200 V, AUTO
Inaccuracy	1% of range ±1 digit
Input resistance (Rin)	240 kΩ (range 0 – 200 V) 24 kΩ (other ranges)
Dielectric withstand	2.5 kV

Timer

Presentation	In seconds, mains frequency cycles or hours and minutes
Ranges	0.000 – 99999.9 s 0 – 9999 cycles
Inaccuracy	±(1 digit + 0.01% of value) For the stop condition in INT-mode 1 ms shall be added to the specified measurement error.

Stop input

Max. input voltage	250 V AC / 275 V DC
Phase angle	
Range	0 – 359°
Resolution	1°
Inaccuracy	±2° (For voltage and current readings higher than 10% of the selected range)

Z, P, R, X, S, Q and power factor (cosφ)

The result is calculated using U, I and φ

Imax

Stores highest current value that exists ≥100 ms

INT-level

Threshold indicating that current is interrupted, can be set to approx. 0.5 or 2% of range for Ammeter 1

Outputs

Outputs in parallel, 240 mains voltage

Maximal current	*Maximum generation time*	*Minimum rest time*[1)]	*Load voltage*
700 A	continuously	–	2.6 V
1000 A	30 min	5 min	2.3 V
2000 A	3 min	10 min	2.2 V
3000 A	1 min	12 min	2.0 V
5000 A	2 sec	3 min	1.3 V
Outputs in series, 240 mains voltage			
350 A	continuously	–	5.1 V
500 A	20 min	15 min	5.0 V
1500 A	2 min	12 min	3.6 V

1) Time to reset the thermal protection.

Megger

Optional accessories

HCP2000— High Current Probe

The high current probe, HCP2000, is a tool that makes it possible to test Molded Case Circuit Breakers (MCCB), without removing/uninstalling the circuit breaker. The high current probe operates from 16 A up to 1500 A trip current.

Current transformer switchbox

The Current Transformer (CT) Switchbox for INGVAR is a tool that is used to facilitate CT testing. The secondary windings on the CT are connected to the CT Switchbox inputs and the CT Switchbox output is connected to INGVAR Ammeter 2 terminals. The switch on the CT Switchbox is used to select which secondary winding on the CT that should be measured. The windings that aren't measured are short-circuited. The CT Switchbox can handle up to 5 secondary windings.

Application example

MCCB testing using the HCP2000

Ordering information

Item			Art.No.
INGVAR			BH-72490
Including:			
GA-12700	Interconnection cable 3 m (10 ft)	1	
GA-12051	Current cable 2 m (6.5 ft) 120 mm^2	2	
04-00087	Mains cable 3 m (10 ft)	1	
GA-00204	Grounding cable 5 m (16 ft)	1	
Optional accessories			
HCP2000, High Current Probe			AA-90165
Current Transformer Switchbox			BH-90130
Extension interconnection cable INGVAR, 5 m (16 ft)			GA-12705
Extension interconnection cable INGVAR, 10 m (32 ft)			GA-12710
Multi-cable high current cable sets			
Length	***Impedance (Twisted-pair cables)***		
Cross section area: 240 mm^2 (2x120)			
2 x 0.5 m (1.6 ft)	0.21 mΩ		GA-12205
2 x 1 m (3.3 ft)	0.32 mΩ		GA-12210
2 x 1.5 m (4.9 ft)	0.42 mΩ		GA-12215
2 x 2 m (6.6 ft)	0.53 mΩ		GA-12220
Cross section area: 360 mm^2 (3x120)			
2 x 0.5 m (1.6 ft)	0.18 mΩ		GA-12305
2 x 1 m (3.3 ft)	0.25 mΩ		GA-12310
2 x 1.5 m (4.9 ft)	0.32 mΩ		GA-12315
2 x 2 m (6.6 ft)	0.39 mΩ		GA-12320
Cable set, 2 x 5 m (16 ft) Cross section area: 120 mm^2 Weight: 15.2 kg (33.5 lbs) Impedance: 2.2 mΩ			GA-12052

Registered to ISO 9001 and 14001
Subject to change without notice.
Art.No. ZI-BH03E • Doc. BH0713DE • 2011
INGVAR_DS_en_V04

ITEM 7

ODEN AT
Primary Current Injection Test System

- **Most Advanced Primary Current Injection Test System to simplify all types of switchgear and CT commissioning, ground grid, circuit breaker testing and more**
- **Modular design to permit optimal user configuration of output current vs. unit size**
- **Compact transport cart facilitates portability into switchgear rooms with limited space**
- **Unique I/30 function allows the current to be pre-set using low current to prevent test sample heating, thus eliminating corruption of test result**

Description

This powerful test system is designed for primary injection testing of protective relay equipment and circuit breakers. It is also used to test the turns ratio of current transformers and for other applications that require high variable currents.

The system consists of a control unit together with one, two or three current units. There are three versions of the current unit: S, X and H. The S and X current units are identical except that the X unit has an additional 30/60 V output. The H unit is rated for even higher current. This makes it possible to configure an ODEN AT system in a suitable way. All parts are portable, and ODEN AT can be quickly assembled and connected.

The control unit has many advanced features – a powerful measurement section for example, that can display turns ratio as well as time, voltage and current. A second measurement channel can be used to measure an additional current or voltage. Current transformer turns ratio, impedance, resistance, power, power factor (cos φ) and phase angle are calculated and shown in the display. Current and voltage can be presented as percentages of nominal value. The fast-acting hold function freezes short-duration readings on the digital display when the voltage or contact signal arrives at the stop input, the object under test interrupts the current or injection is stopped

Application

- **Primary current injection testing and breaker testing**

These tests require high currents and the ability to measure very short duration, current flow. ODEN AT has been designed especially to meet these needs. No extra contacts are needed to measure the operating time of a low-voltage breaker. Testing stops at the instant when the main breaker contacts open to interrupt the current. Output current initiation is synchronized with the currents zero-crossover point to ensure good repeatability and minimized DC offset.

- **Testing current transformers**

For turns ratio testing, the primary current and either the secondary current or the turns ratio are displayed simultaneously. Since the turns ratio is displayed directly as the nominal value (1000/5 for example), no further calculation is needed. Burden of secondary circuits can be measured and presented in VA.

- **Polarity testing**

The currents phase displacement is shown, and the polarities of the outputs are clearly marked.

- **Heat runs**

ODEN AT is ideal for performing heat runs. Current can be applied continuously or through programmable intervals. The times can be shown in minutes and hours which facilitates long-term testing capability.

- **Automatic reclosers and sectionalizers**

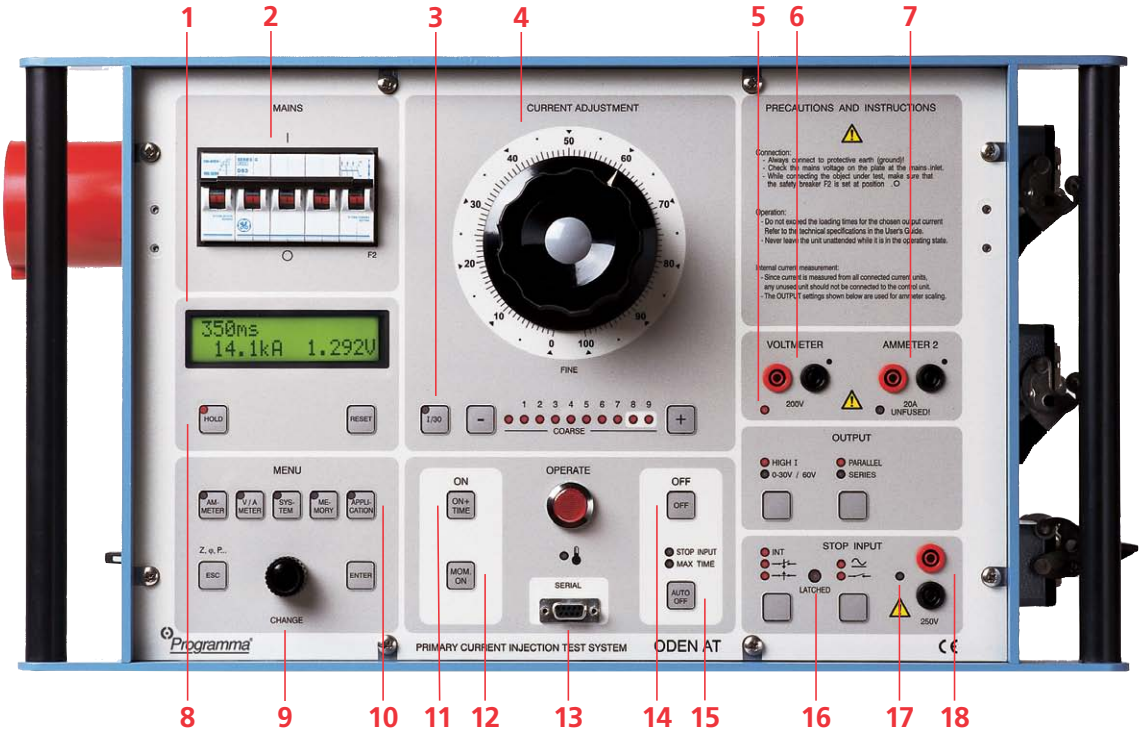
ODEN AT can also be set to test circuit breakers with reclosing relays. Operating limits, partial times, total times and the number of operations before lockout can be measured. User-selectable reclosing sequences can be programmed for testing sectionalizers.

- **Testing integrity of ground grids and safety-ground devices**

One way to test ground grids is by injecting current between a reference ground and the ground to be tested and measuring the voltage drop and the percentage of current flowing through the ground grid. The type X current unit included with ODEN AT is designed for this type of application. Personal safety grounds must be tested at rated current, a task for which ODEN AT is well suited.

Features and Benefits

1. **Display.** The display presents time, output current, voltage, current shown on ammeter 2 and phase angle. You can scroll through entities Z, P, Q, R, X, S, power factor (cos φ) and I max.
2. **Miniature circuit breaker used for current output.** Interrupts output current. Can also be actuated manually for safe disconnection of load.
3. **Current reduction button.** Used during setting to reduce the output current to 1/30. Useful in order to avoid for example unintentional tripping and overheating.
4. **Fine adjustment knob.** Knob for fine adjustment of current and +/- buttons for coarse adjustment.
5. **Indicator lamps.** Indicate whether ammeter 2 or the voltmeter is enabled.
6. **Input for voltmeter.** Used to measure voltage and for microhmmeter measurement.
7. **Input for ammeter 2.** Used to measure current in an external circuit (in a current transformer´s secondary winding for example).
8. **Hold function.** This function freezes readings on the display.
9. **Selection/setting (CHANGE) knob.** Selects the desired menu option (shown in the display window). Also used to change numerical values.
10. **Setting buttons.** Personnel unfamiliar with ODEN AT can use the pre-defined settings very effectively, while experienced users can make their own basic settings.
    • **Ammeter.** Used to set the main current-output ammeter. You can select the desired range or select autoranging.
    • **V/A Meter.** Toggles between the voltmeter and ammeter 2. Also used to select the desired range or select autoranging.
    • **System.** Used for general settings.
    • **Memory.** Used to save or recall settings to or from the ten ODEN AT memories. One of these memories contains the default (pre-defined) settings that are invoked when ODEN AT is powered up.
    • **Application**. Used to invoke the desired measurement mode: automatic recloser, sectionalizer or microhmmeter.
    ODEN AT can also be set to generate pulse trains with user-selectable pulse and pause times.
11. **Injection.** Starts current injection and timing.
12. **Momentary Injection.** When this button is used, injection continues only as long as it is pressed. Useful in order to avoid for example overheating.
13. **RS232 for computer.** ODEN AT is equipped with a serial port for communication with PC (for transfer of test data for example).
14. **Manual shut-off.** Injection and timing are stopped when this button is pressed.
15. **Automatic injection stop.** Generation stops after a user-specified interval or when condition at the input is met. The diodes show the selected OFF condition.
16. **Stop-condition indicator.** Indicates that a stop condition is met, voltage or contact triggered.
17. **Status indicator.** Indicates if a contact connected to the input is closed or if voltage is present.
18. **Stop input.** Used to freeze a reading or stop injection. Activated when current is interrupted by the object being tested, when an external contact is actuated or when a voltage is applied or removed.



Specifications ODEN AT

Specifications are valid at nominal input voltage and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

System designation

An ODEN AT-system consists of a control unit and one, two or three current units. There are three different versions of the current units: S-unit (standard), X-unit (extra 30/60 V outlet) and H-unit (high current). The system designation indicates the number and version of current units included.

Example: ODEN AT/2X
2 = Number of current units
X = Version of current unit (S, X or H)

Environment

Application field	The instrument is intended for use in high-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (+32°F to +122°F)
Storage & transport	-25°C to +55°C (-13°F to +127°F)
Humidity	5% – 95% RH, non-condensing

CE-marking

LVD	2006/95/EC
EMC	2004/108/EC

General

Mains voltage	240/400 V AC, 50/60 Hz 480 V AC / 60 Hz
Mains inlet	IEC 60309-2, 63 A
Input current	Output current x open circuit voltage / input voltage
Protection	The output transformer has a built-in thermal cut-out, and the primary side is protected by a miniature circuit breaker.
Dimensions	
Control unit AT	570 x 310 x 230 mm (22.4" x 12.2" x 9")
Current unit S, X H	570 x 310 x 155 mm (22.4" x 12.2" x 6")
Complete with cart	690 x 350 x 860 mm (27.2" x 13.8" x 33.9")
Weight	
Control unit AT	25 kg (55 lbs)
Current unit S	42 kg (92.6 lbs)
Current unit X	45 kg (99.3 lbs)
Current unit H	49 kg (108 lbs)
Cart	11 kg (24.3 lbs)
Display	LCD
Available languages	English, German, French, Spanish, Swedish.

Measurement section

Ammeters

Measurement method	AC, true RMS
Inaccuracy	1% of range ±1 digit
Ammeter 1	
Ranges	0 – 4800 A / 0 –15 kA 0 – 9600 A / 0 – 30 kA 0 – 960 A / 0 – 3 kA
Ammeter 2	
Ranges	0 – 2.000 A / 0 – 20.00 A
Maximum current	20 A (The input is not protected by a fuse)

Voltmeter

Measurement method	AC, true RMS
Ranges	0 – 0.2 V, 0 – 2 V, 0 – 20 V, 0 – 200 V, AUTO
Inaccuracy	1% of range ±1 digit
Input resistance (Rin)	240 kΩ (range 0 – 200 V) 24 kΩ (other ranges)
Dielectric withstand	2.5 kV

Timer

Presentation	In seconds, mains frequency cycles or hours and minutes
Ranges	0.000 – 999.9 s 0 – 9999 cycles 0.001 s – 99 h 59 min
Inaccuracy	±(1 digit + 0.01% of value) For the stop condition in INT-mode 1 ms shall be added to the specified measurement error.

Stop input

Max. input voltage	250 V AC / 275 V DC

Phase angle

Range	0 – 359°
Resolution	1°
Inaccuracy	±2° (for voltage and current readings that are higher than 10% of the selected range)

Z, P, R, X, S, Q and power factor (cos φ)

For these measurements the result is calculated using U, I and sometimes φ.

Imax

Stores highest current value that exists ≥100 ms

INT-level

Threshold indicating that current is interrupted. Can be set to 0.7% or 2.1% of Ammeter 1 range.

Outputs

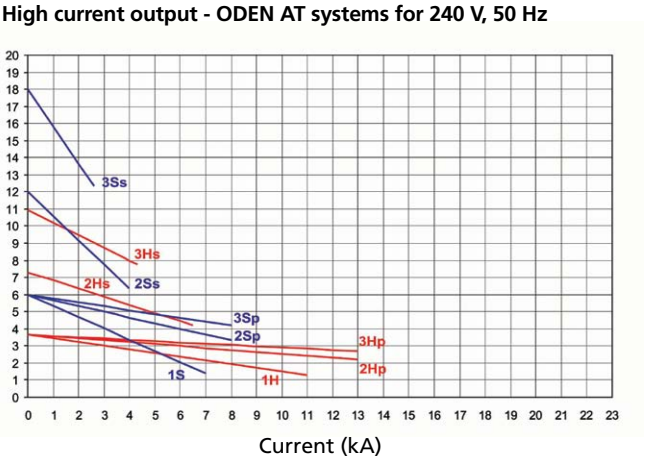
ODEN AT, 240 V mains voltage, 50 / 60 Hz					
		Open circuit voltage	Max. continuous current [3]	Max. current, 3 minutes [3]	Max. current, 1 sec [3]
ODEN AT/1S					
		6 V	1000 A	2000 A	7000 A
ODEN AT/2S					
	1)	6 V	1680 A	3600 A	8000 A
	2)	12 V	1000 A	2000 A	4000 A
ODEN AT/3S					
	1)	6 V	2500 A	5200 A	8000 A
	2)	18 V	840 A	1700 A	2600 A
ODEN AT/1X					
High current output		6 V	1000 A	2000 A	7000 A
Output 0 – 30/60 V					
30 V range		30 V	160 A	300 A	1200 A
60 V range		60 V	80 A	150 A	600 A
ODEN AT/2X					
High current output	1)	6 V	1680 A	3600 A	8000 A
	2)	12 V	1000 A	2000 A	4000 A
Output 0 – 30/60 V					
30 V range	1)	30 V	320 A	600 A	1600 A
30 V range	2)	60 V	160 A	300 A	800 A
60 V range	2)	120 V	80 A	150 A	400 A
ODEN AT/3X					
High current output	1)	6 V	2500 A	5200 A	8000 A
	2)	18 V	840 A	1700 A	2600 A
Output 0 – 30/60 V					
30 V range	1)	30 V	480 A	900 A	1600 A
30 V range	2)	90 V	160 A	300 A	520 A
60 V range	2)	180 V	80 A	150 A	260 A
ODEN AT/1H					
		3.6 V	1250 A	2600 A	11 kA
ODEN AT/2H					
	1)	3.6 V	2500 A	5500 A	13 kA
	2)	7.2 V	1250 A	2800 A	6500 A
ODEN AT/3H					
	1)	3.6 V	3800 A	8000 A	13 kA
	2)	10.7 V	1250 A	2800 A	4300 A

ODEN AT, 400 V mains voltage, 50 / 60 Hz					
		Open circuit voltage	Max. continuous current [3]	Max. current, 3 minutes [3]	Max. current, 1 sec [3]
ODEN AT/1S					
		6 V	1000 A	2000 A	7000 A
ODEN AT/2S					
	1)	6 V	1900 A	4000 A	13 kA
	2)	12 V	900 A	2000 A	6000 A
ODEN AT/3S					
	1)	6 V	1900 A	4000 A	13 kA
	2)	18 V	600 A	1400 A	4400 A
ODEN AT/1X					
High current output		6 V	1000 A	2000 A	7000 A
Output 0 – 30/60 V					
30 V range		30 V	160 A	300 A	1200 A
60 V range		60 V	80 A	150 A	600 A
ODEN AT/2X					
High current output	1)	6 V	1900 A	4000 A	13 kA
	2)	12 V	900 A	2000 A	6000 A
Output 0 – 30/60 V					
30 V range	1)	30 V	320 A	600 A	2500 A
30 V range	2)	60 V	160 A	300 A	1200 A
60 V range	2)	120 V	80 A	150 A	600 A
ODEN AT/3X					
High current output	1)	6 V	1900 A	4000 A	13 kA
	2)	18 V	600 A	1400 A	4400 A
Output 0 – 30/60 V					
30 V range	1)	30 V	380 A	850 A	2600 A
30 V range	2)	90 V	120 A	290 A	880 A
60 V range	2)	180 V	60 A	145 A	440 A
ODEN AT/1H					
		3.6 V	1250 A	2600 A	11 kA
ODEN AT/2H					
	1)	3.6 V	2500 A	5300 A	21 kA
	2)	7.2 V	1250 A	2500 A	10.9 kA
ODEN AT/3H					
	1)	3.6 V	3800 A	7700 A	21.9 kA
	2)	10.7 V	1250 A	2600 A	7200 A

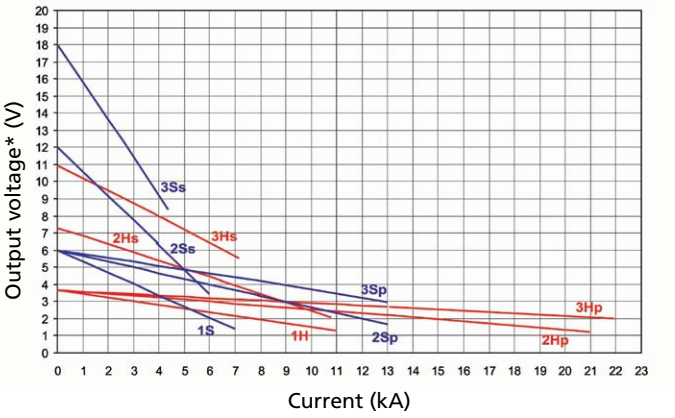
ODEN AT, 480 V mains voltage, 60 Hz					
		Open circuit voltage	**Max. continuous current 3)**	**Max. current, 3 minutes 3)**	**Max. current, 1 sec 3)**
ODEN AT/1S					
		7.2 V	1000 A	2000 A	7000 A
ODEN AT/2S					
	1)	7.2 V	1900 A	4000 A	13 kA
	2)	14.4 V	900 A	2000 A	6000 A
ODEN AT/3S					
	1)	7.2 V	1900 A	4000 A	13 kA
	2)	21.6 V	600 A	1400 A	4400 A
ODEN AT/1X					
High current output		7.2 V	1000 A	2000 A	7000 A
Output 0 – 30/60 V					
30 V range		36 V	160 A	300 A	1200 A
60 V range		72 V	80 A	150 A	600 A
ODEN AT/2X					
High current output	1)	7.2 V	1900 A	4000 A	13 kA
	2)	14.4 V	900 A	2000 A	6000 A
Output 0 – 30/60 V					
30 V range	1)	36 V	320 A	600 A	2500 A
60 V range	1)	272 V	160 A	300 A	1200 A
60 V range	2)	144 V	80 A	150 A	600 A
ODEN AT/3X					
High current output	1)	7.2 V	1900 A	4000 A	13 kA
	2)	21.6 V	600 A	1400 A	4400 A
Output 0 – 30/60 V					
30 V range	1)	36 V	380 A	850 A	2600 A
30 V range	2)	108 V	120 A	290 A	880 A
60 V range	2)	216 V	60 A	145 A	440 A
ODEN AT/1H					
		4.3 V	1250 A	2600 A	11 kA
ODEN AT/2H					
	1)	4.3 V	2500 A	5300 A	21 kA
	2)	8.7 V	1250 A	2500 A	10.9 kA
ODEN AT/3H					
	1)	4.3 V	3800 A	7700 A	21.9 kA
	2)	13.0 V	1250 A	2600 A	7200 A

1) Current units connected in parallel
2) Current units connected in series
3) Maximum possible current is also limited by the impedance in the test circuit. The current value can not exceed output voltage / impedance value.

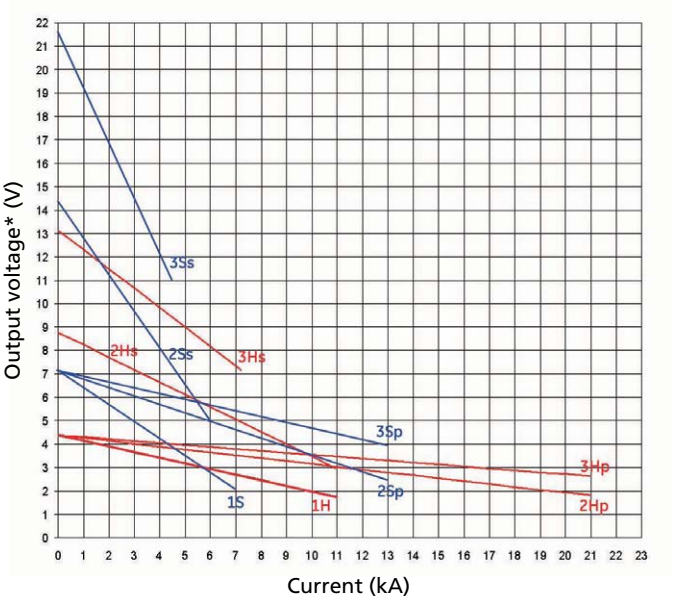
High current output - ODEN AT systems for 240 V, 50 Hz



High current output - ODEN AT systems for 400 V, 50 Hz



High current output - ODEN AT systems for 480 V, 60 Hz



S or X units
H units
p = units in parallel, s = units in series
*) Voltage between output terminals

Optional accessories

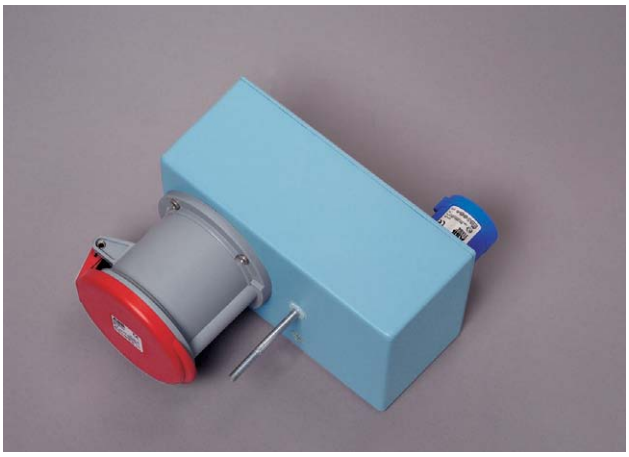
HCP2000 — High Current Probe
The high current probe, HCP2000, is a tool that makes it possible to test Molded Case Circuit Breakers (MCCB), without removing/uninstalling the circuit breaker. The high current probe operates up to 2000 A trip current.

High current serial bar
For serial connecting of ODEN current units.

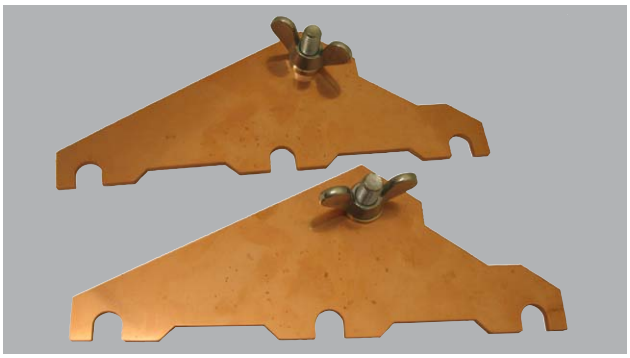
Current transformer switchbox
The Current Transformer (CT) Switchbox for ODEN AT is a tool that is used to facilitate CT testing. The secondary windings on the CT are connected to the CT Switchbox inputs and the CT Switchbox output is connected to ODEN AT Ammeter 2 terminals. The switch on the CT Switchbox is used to select which secondary winding on the CT that should be measured. The windings that aren't measured are short-circuited. The CT Switchbox can handle up to 5 secondary windings.

Multi-cable high current cable sets
Low-impedance multi-cable sets for higher output current. Available with 2, 3, 4 or 6 parallel cables, and in lengths of 0.5, 1.0, 1.5 or 2 meters.

Cable sets
See Ordering Information.



Input power adapter 240/400V
Used to run a 400 V ODEN AT at 240 V.



High current parallel bars
The parallel bars can be used when up to three current units are connected in parallel.

Ordering information

Item	Art.No.
A cart (Art.No. 50-00092) is always included with purchase of a complete ODEN system. The cable set(s) for connection to the object under test must however be stated as a separate item in the order. High current serial bar for connecting current units in series is included with purchase of two current units.	
ODEN AT/1S	
240 V Mains voltage	BH-62411
400 V Mains voltage	BH-64011
480 V (60 Hz) Mains voltage	BH-64811
ODEN AT/2S	
240 V Mains voltage	BH-62412
400 V Mains voltage	BH-64012
480 V (60 Hz) Mains voltage	BH-64812
ODEN AT/3S	
240 V Mains voltage	BH-62413
400 V Mains voltage	BH-64013
480 V (60 Hz) Mains voltage	BH-64813
ODEN AT/1X	
240 V Mains voltage	BH-62421
400 V Mains voltage	BH-64021
480 V (60 Hz) Mains voltage	BH-64821
ODEN AT/2X	
240 V Mains voltage	BH-62422
400 V Mains voltage	BH-64022
480 V (60 Hz) Mains voltage	BH-64822
ODEN AT/3X	
240 V Mains voltage	BH-62423
400 V Mains voltage	BH-64023
480 V (60 Hz) Mains voltage	BH-64823
ODEN AT/1H	
240 V Mains voltage	BH-62431
400 V Mains voltage	BH-64031
480 V (60 Hz) Mains voltage	BH-64831
ODEN AT/2H	
240 V Mains voltage	BH-62432
400 V Mains voltage	BH-64032
480 V (60 Hz) Mains voltage	BH-64832
ODEN AT/3H	
240 V Mains voltage	BH-62433
400 V Mains voltage	BH-64033
480 V (60 Hz) Mains voltage	BH-64833

Item		Art.No.
Optional accessories		
HCP2000		AA-90165
Current Transformer Switchbox		BH-90130
High Current Serial Bar		BH-90102
High Current Parallel Bars, 2 pcs Weight: 3 kg		BH-90171
Mains Adapter 240/400V Note: Can only be used together with an ODEN AT prepared for this feature. Contact Megger Sweden.		BH-90120
ODEN-Select Software tool for finding the best ODEN AT configuration. Free-ware, can be downloaded from the Megger ftp server.		
Multi-cable high current cable sets		
Length	***Impedance (Twisted-pair cables)***	
Cross section area: 240 mm^2 (2x120)		
2 x 0.5 m (1.6 ft)	0.21 mΩ	GA-12205
2 x 1 m (3.3 ft)	0.32 mΩ	GA-12210
2 x 1.5 m (4.9 ft)	0.42 mΩ	GA-12215
2 x 2 m (6.6 ft)	0.53 mΩ	GA-12220
Cross section area: 360 mm^2 (3x120)		
2 x 0.5 m (1.6 ft)	0.18 mΩ	GA-12305
2 x 1 m (3.3 ft)	0.25 mΩ	GA-12310
2 x 1.5 m (4.9 ft)	0.32 mΩ	GA-12315
2 x 2 m (6.6 ft)	0.39 mΩ	GA-12320
Cross section area: 480 mm^2 (4x120)		
2 x 0.5 m (1.6 ft)	0.16 mΩ	GA-12405
2 x 1 m (3.3 ft)	0.21 mΩ	GA-12410
2 x 1.5 m (4.9 ft)	0.27 mΩ	GA-12415
2 x 2 m (6.6 ft)	0.32 mΩ	GA-12420
Cross section area: 720 mm^2 (6x120)		
2 x 0.5 m (1.6 ft)	0.14 mΩ	GA-12605
2 x 1 m (3.3 ft)	0.18 mΩ	GA-12610
2 x 1.5 m (4.9 ft)	0.21 mΩ	GA-12615
2 x 2 m (6.56 ft)	0.25 mΩ	GA-12620
Cable set, 2 x 5 m (16 ft), 120 mm^2 Cross section area: 120 mm^2 Weight: 15.2 kg (33.5 lbs) Impedance: 2.2 mΩ		GA-12052
Cable set, 2 x 5 m (16 ft), 25 mm^2 Cross section area: 25 mm^2 For the 30/60 V output of current unit X. Weight: 4 kg (8.8 lbs)		GA-02052

MULTI-TEK INTERNATIONAL
140-144 Freston Road,
London W10 6TR, England
Tel: +44 20-73133190
Fax: +44 20-73133191
E-Mail: mti@multitekintl.com

ITEM 8

MS-2A
Circuit Breaker and Overcurrent Relay Test Set

- **Light Weight, Portable Primary Injection Test Instrument**
- **Overcurrent Relay Testing**
- **Ground Fault Performance Testing for NEC 230.95**
- **Circuit Breaker Testing**

DESCRIPTION

The Megger MS-2A test set is used around the world by several thousand utility companies, industrial plants and electrical service organizations.

Model MS-2A is a self-contained test set that incorporates a variable high-current output and appropriate control circuitry and instrumentation for testing thermal, magnetic or solid-state motor overload relays, molded-case circuit breakers, ground-fault trip devices and overcurrent relays.

APPLICATIONS

Model MS-2A is capable of testing the time-delay characteristics of overcurrent relays, motor overload relays and molded-case circuit breakers rated up to 125 amperes, when following the recommended test procedure of testing the time delay of these devices at three times their rating.

Higher currents are available for the short durations required to test an instantaneous trip element. For example, the test set will provide a maximum short-duration output of 750 amperes through a typical, 125 ampere, molded-case circuit breaker.

The MS-2A is ideal for testing ground fault protection devises with window CT's. The NEC 230.95C requires specific ground fault devices be performance tested when initially installed.

The MS-2A is commonly used by many utilities and service organizations as a economical light weight overcurrent relay test system.

Additional applications include verifying the ratio of current transformers and testing panelboard ammeters and voltmeters.

FEATURES AND BENEFITS

- **Rugged and lightweight:** Unit weighs only 33 lb (15 kg) and is tough enough to withstand daily field or plant use.
- **Digital memory ammeter:** High-accuracy, direct-reading instrument has read-and-hold memory for measurement of short-duration currents. Ideal for testing ground fault devices, overcurrent relays and molded case circuit breakers.
- **Digital, multirange timer:** Crystal-controlled, high-accuracy instrument with autoranging measures operating time to 1 millisecond.
- **High-current output:** Provides instantaneous currents up to 750 amperes through a 125 ampere breaker in a small 33lb (15kg) package

SPECIFICATIONS

Input

Input Voltage (specify one): 120 V **OR** 240 V, 50/60 Hz, 1ϕ

Output

Output Ranges: The output is continuously adjustable in four ranges to accommodate a variety of test-circuit impedances:
0 to 5 A at 120 V max.
0 to 25 A at 24 V max.
0 to 120 A at 6 V max.
0 to 240 A at 3 V max.

Output Capacity: The output circuit is designed to permit short-duration overloads and the output ranges will provide several times their current rating, provided the output voltage is sufficient to push the desired current through the impedance of the test circuit.
The test set is capable of testing the time-delay characteristics of devices rated up to 125 A using a test current of three times their rating (375 A). Additionally, to perform an instantaneous trip test, it will provide 750 A through a typical, 125 A, molded-case circuit breaker connected with the test leads provided with the test set.
Overload Capability: To increase use of the test set, it is designed so that the current ratings may be exceeded for short durations. Because the magnitude of the output current is determined by the impedance of the load circuit, the voltage rating must be sufficient to push the desired current through the device under test and the connecting test leads.

Percent Rated Current	Maximum Time On	Minimum Time Off
100 (1x)	30 min	30 min
200 (2x)	3 min	8 min
300 (3x)	30 s	4 min

Output Initiate Circuit: The test set uses a solid-state output initiating circuit. To increase reliability and eliminate contact maintenance, this circuit uses a triac instead of a contactor to initiate the output. The initiating circuit provides momentary and maintained modes to control output duration. The momentary mode is used whenever the output is to be on for a short duration, such as when performing instantaneous trip tests, or to avoid damage or overheating of the device under test while setting the test current. In the maintained mode, the output remains energized until manually turned off or, when performing timing tests, until the device under test operates — which both stops the timer and de-energizes the output.

INSTRUMENTATION

Ammeter

Operating Modes (switch-selected)
Memory
Normal

Display
$3^{1}/_{2}$ digit, extra-bright LED display with 0.3 in. (7.62mm) numerals

Ranges (switch-selected)
0 to 1.999/19.99/199.9/750 A

ContinousAccuracy (overall ammeter system)
±1% of reading, ±1 digit on three high ranges
±1% of range, ±1 digit on low range

Timer

Display
5-digit, extra-bright, LED display with 0.3 in. (7.62mm) numerals

Ranges (switch-selected)
0 to 99.999 s
0 to 999.99 s
0 to 99999 cycles

Accuracy
±0.005% of reading, ±1 digit

Timer Control Circuit

This circuit automatically starts the timer when the output is energized and automatically stops the timer and de-energizes the output when the device under test operates. This circuit accommodates the following test conditions by simple switch selection of the appropriate mode:
Current Actuated: Used to test a device that has no auxiliary contacts to monitor, such as a single-pole circuit breaker. The timer stops when the output current is interrupted.
Normally Closed: Used to test a device with normally closed contacts. The timer stops and the output is de-energized when the contacts open.
Normally Open: Used to test a device with normally open contacts. The timer stops and the output is de-energized when the contacts close.

Enclosure

The test set is housed in a high strength, molded, suitcase-type enclosure with carrying handle and removable cover. Storage space is provided for test leads.

Standards

CE
EN 61326-2-1
EN 61010-1
EN 61010-031

Dimensions

9.9 H x 14 W x 11 D in.
(25 H x 35 W x 28 D cm)

Weight

33 lb (15 kg)

ORDERING INFORMATION

Item (Qty)	Cat. No.
Model MS-2A	
115 volt input	MS-2A-115
230 volt input	MS-2A-230
Included Accessories	
Test Lead, red, 200cm, [2]	620143
Test Lead, black, 200cm [2]	620144
Alligator clip, red, [2]	684006
Alligator clip, black, [2]	684007

Item (Qty)	Cat. No.
Test and maintenance record cards	
Green [50]	2239
Buff [50]	2238
No. 2 high-current leads, 2 ft (0.6 m) [2]	620155
Fuses	
0.125 A, 250 V, MDL [5]	981
Instruction manual [1]	750026

ITEM 9

CB-845
Circuit Breaker Test Set

- **Digital memory ammeter**
- **Digital, multirange timer**
- **Lightweight and portable**
- **High-current output**
- **Solid-state output initiate circuitry**

DESCRIPTION

The Model CB-845 test set is a high-current circuit breaker test set consisting of a control unit that incorporates the latest in solid-state metering, control technology and a high-current output unit.

The lightweight, two-section design of Model CB-845 enables the user to easily transport the unit into areas previously inaccessible to high-current test equipment such as elevated or subsurface load centers, shipboard power panels, elevator machinery rooms and other isolated locations.

APPLICATIONS

Model CB-845 is suitable for a wide variety of testing requirements including molded-case circuit breakers; thermal, magnetic or solid-state motor overload relays and other overcurrent protective devices. Additional applications include verifying the ratio of current transformers and testing ground-fault trip devices.

The time-delay characteristics of motor overload relays and molded-case circuit breakers rated up to 500 amperes can be tested with Model CB-845, when following the recommended test procedure of testing the time delay of thermal devices at three times their rating. Instantaneous trip elements can be tested with the higher currents required for these tests. For example, the test set will provide short-duration output of 5000 amperes through a typical 500 ampere, molded-case circuit breaker.

FEATURES AND BENEFITS

- **Digital memory ammeter:** High-accuracy, direct-reading instrument features read-and-hold memory for measurement of short-duration currents.
- **Digital, multirange timer:** Crystal controlled, high-accuracy instrument measures operating time to 1 ms.
- **Lightweight and portable:** Two-section unit has a total weight of only 175 lb (80 kg).
- **High output current:** Provides instantaneous current up to 5000 amperes through a 500 ampere circuit breaker.
- **Solid-state output initiate circuitry:** Solid-state output circuit switching eliminates need for contact maintenance.
- **Protection:** Overload and short- circuit protection is incorporated.
- **Enclosure:** The test set is housed in two stackable, interlocking, rugged, metal enclosures with convenient carrying handles. The control unit comes with a lid for protection of the controls during transportation. The unit is easily transported by and/or on a standard hand truck.

SPECIFICATIONS

Input

Input Voltage (switch-selected)
208 and 240 V, 1ϕ, 30 A

Input Frequency (specify one)
50 Hz **OR** 60 Hz

Output

Output Range
The output is continuously adjustable to accommodate a variety of test circuit impedances: 0 to 1200 A at 6 V max.

Output Capacity
The output circuit is designed to provide short-duration overloads. The above output range will provide several times its current rating, provided the output voltage is sufficient to push the desired current through the impedance of the test circuit.
The test set is capable of testing the time-delay characteristics of devices rated up to 500 A using a test current of three times their rating (1500 A). Additionally, to perform an instantaneous trip test, it will provide 5000 A through a typical 500 A, molded-case circuit breaker connected with the 4 ft (1.2 m) test-leads provided.

Overload Capability
To increase use of the test set, it is designed so that the current ratings may be exceeded for short durations. Because the magnitude of the output current is determined by the impedance of the load circuit, the voltage rating must be sufficient to push the desired current through the device under test and the connecting test leads.

Output Initiate Circuit
The test set uses a solid-state output initiating circuit. To increase reliability and eliminate contact maintenance, this circuit uses a triac instead of a contactor to initiate the output.

Output Initiate Control Circuit
The initiating control circuit provides momentary and maintained modes to control output duration. The momentary mode is used whenever the output is to be on for a short duration. An example is an instantaneous trip test, or to avoid damage or overheating of the device under test while setting the test current. In the maintained mode, the output remains energized until manually turned off, or when performing timing tests, until the device under test operates—which both stops the timer and de-energizes the output.

Instrumentation

Ammeter
To measure the output current, the test set incorporates a solid-state digital instrument with multiple ranges and a read-and-hold memory to measure short-duration currents.

Operating Modes (switch-selected)
Memory
Normal

Digital Display
3½ digit, extra-bright LED display with 0.3 in. (7.62 mm) numerals

Ranges (switch-selected)
0 to 19.99/199.9/1999 A/10 kA

Continuous Accuracy (overall ammeter system)
±1% of reading, ±1 digit on three high ranges, ±1 digit on low range

Timer

A solid-state digital timer measures the elapsed time of the test in either seconds or cycles. It uses a crystal controlled oscillator and therefore, its accuracy is independent of the line frequency.

Display

5-digit, extra-bright LED display with 0.3 in. (7.62 mm) numerals

Ranges (switch-selected)
0 to 99.999 s
0 to 999.99 s
0 to 99999 cycles

Accuracy

±0.005% of reading, ±1 digit

Timer Control Circuit

This circuit automatically starts the timer when the output is energized and automatically stops the timer and de-energizes the output when the device under test operates. This circuit accommodates the following test conditions by simple switch selection of the appropriate mode:

Current Actuated
Used to test a device that has no auxiliary contacts to monitor, such as a single-pole circuit breaker. The timer stops when the output current is interrupted.

Normally Closed
Used to test a device with normally closed contacts. The timer stops and the output is de-energized when the contacts open.

Normally Open
Used to test a device with normally open contacts. The timer stops and the output is de-energized when the contacts close.

Dimensions

Control Units
11.25 H x 21.75 W x 17.5 D in. (29 H x 55 W x 44 D cm)

Output Unit
11.25 H x 21.75 W x 19.5 D in. (29 H x 55 W x 49 D cm)

Weight

Control Unit:
69.25 lb (31.4 kg)
Output Unit
(50 Hz): 123 lb (55.8 kg)
Output Unit
(60 Hz): 103 lb (46.8 kg)

ORDERING INFORMATION

Item (Qty)	Cat. No.
Model CB-845, 50 Hz application	CB-845-50
Model CB-845, 60 Hz application	CB-845-60

Included Accessories

Timer leads, 5 ft (1.5 m) [1 set]	1282
Current leads No. 4, 5 ft (1.5 m) [1 set]	2265
Current leads 4/0, 4 ft (1.2 m) [1 set]	9311
Input connector, 3W 20 A [1]	1402

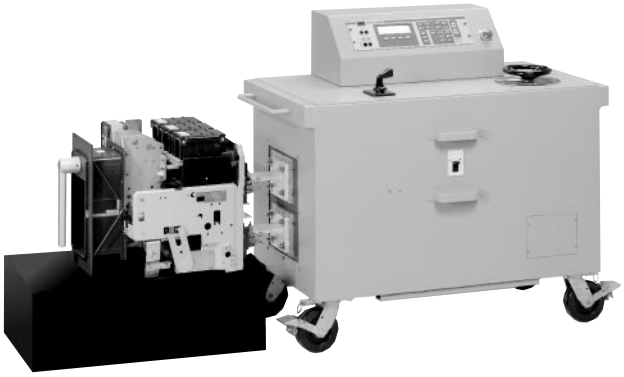
Item (Qty)	Cat. No.
Fuses	
0.125 A, 250 V, MDL [5]	981
30 A, 250 V, FNW [5]	9880
Interconnect cable, 4 ft (1.2 m) [1]	9487
Instruction manual [1]	9820

Optional Accessories

Interconnect cable, 10 ft (3 m) [1]	9688

ITEM
10 & 11

DDA-3000 and DDA-6000
Universal Circuit Breaker Test Sets



- **Model DDA-1 Digital Data Acquisition Instrumentation and Control System**
- **High-current output: 60,000 A for Model DDA-6000; 35,000 A for Model DDA-3000**
- **Digital signal processing (DSP) technology**
- **Variable pulse time and firing angle output current control**
- **Compliant with NEMA AB-4 test guidelines**

DESCRIPTION

Incorporating the latest technological advancements, Models DDA-3000 and DDA-6000 Series are designed specifically to test low-voltage power and molded-case circuit breakers equipped with thermal, magnetic or solid-state trip devices. The units are fully compliant with NEMA AB-4 test guidelines.

Tests are performed by simulating an overload or fault condition. Each test set is an integrated test system that provides a variable, high-current output. The test sets incorporate all control circuitry and instrumentation necessary to test direct-acting circuit breakers accurately, efficiently and safely.

The unique transformer and circuit design results in a very high-capacity test set in a very compact size. Advanced digital control and instrumentation provides exact testing capacity.

APPLICATIONS

Universal in application, the test sets will test virtually all low-voltage, molded-case and metal-clad, direct-acting ac circuit breakers produced by General Electric, Westinghouse, Federal Pacific, Square D, Gould, ABB, ITE, Siemens and other manufacturers.

Model DDA-3000 is rated for testing breakers up to 3000 amperes. Model DDA-6000 is rated for testing breakers up to 6000 amperes. Rugged and reliable, Megger circuit breaker test sets will provide years of trouble-free operation.

The test sets also may be used for other high-current applications, such as verifying the ratio of current transformers and performing heat runs or primary injection testing of high-voltage breakers and their associated protective relays.

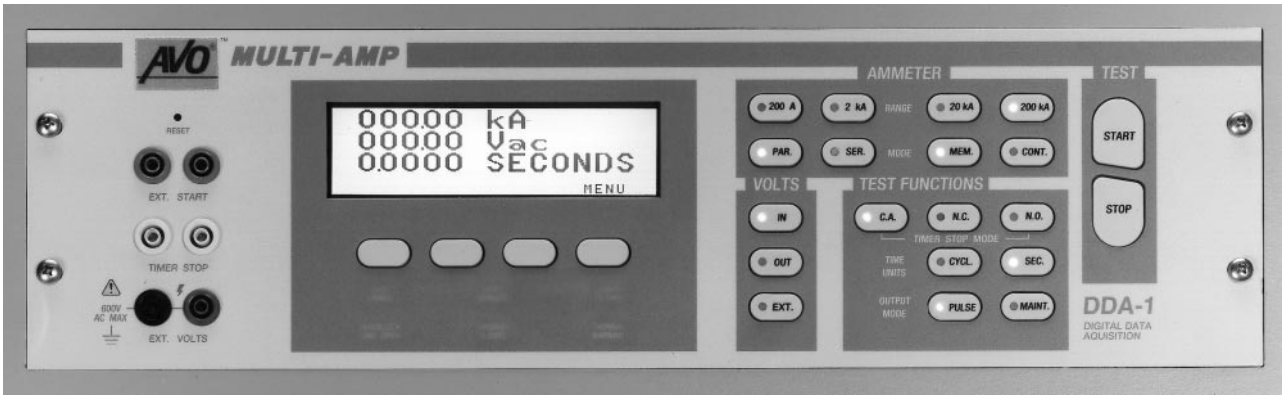
All Model DDA-3000 and DDA-6000 test sets have identical features, instrumentation and operational characteristics. The only changes in the specifications among the units are their size, weight and maximum output-current capacity.

FEATURES AND BENEFITS

- **Initiating control circuit:** Fully digital initiating control circuit provides both pulsed and maintained control modes of output duration. The pulsed mode automatically pulses the output to any programmed pulse duration. This provides additional testing capabilities for electromechanical and solid-state trip devices. A short pulse duration also limits the preheating of the breaker under test while setting the test current.

  In the maintained mode, the output remains energized until manually turned off or, during timing test, until the device under test operates, which both stops the timer and de-energizes the output.

- **Zero dc offset:** Use of digitally controlled SCRs instead of a contactor to initiate the output of the test set eliminates closing-time error and thereby ensures precise initiation at the zero crossover point of the output current waveform every time. Initiation at the zero crossover point ensures symmetrical output current by eliminating dc offset in the current waveform. Therefore accurate, repeatable test results are assured even with currents of very short duration, as when conducting tests of instantaneous or short-time delay trip elements.



The Model DDA-1 control panel digitally samples the output current and mathematically calculates the current supplied to the breaker under test.

The digital control of the SCRs also allows the unit to initiate at any point within 90 degrees of the zero crossover point of the output-current waveform. This will allow the intentional insertion of a dc offset into the waveform for a complete investigation of a breaker's operation.

- **Compact enclosure:** Improvements in transformer and circuit design have resulted in a very high-capacity test set in a single, relatively small enclosure. For safety and mobility, the test set is housed in a single, rugged, sheet metal enclosure with a low center of gravity, tow ring, lifting eyes and large, locking swivel casters with brakes.

  To increase maneuverability, all four casters swivel; however, they also can be locked into a fixed position easily. The compact size of test sets permits easy movement through narrow doors. Controls and instrumentation are positioned so that the operator can simultaneously observe the circuit breaker under test.

- **Construction:** Built for years of trouble-free, reliable operation, the test sets include rugged instrumentation and controls designed to withstand the vibration and shock of frequent transportation. They need never be removed from the enclosure .

- **Protection:** Fuse, circuit breaker and overload protective devices are incorporated. The output-initiating SCRs are forced-air cooled, and temperature sensors provide protection from overheating. Emergency stop pushbutton is provided to de-energize all input power to the test set.

- **Ground safety interlock:** An interlock circuit ensures that the test set chassis is connected to system ground before the output of the test set can be energized.

- **Accessory outlet:** A ground-fault-protected, 120 volt outlet with a capacity of 1.2 kVA is provided for convenient connection of accessory equipment. Other voltages are available internally for customer-installed outlets.

INSTRUMENTATION AND CONTROLS

Model DDA-1: The Digital Data Acquisition instrumentation and control system was designed and accurate metering of the breaker under test.

Model DDA-1 uses the latest in digital signal processing (DSP) technology. This technology provides complete digital control of the SCRs and digitally samples the output current for high-accuracy measurements.

Digital ammeter: Model DDA-1 samples the output current digitally and mathematically calculates the current that is supplied to the breaker under test. This process increases the accuracy of the ammeter systems and provides extreme flexibility in what current value is displayed. For example, when the test set is delivering a continuous current, the digital ammeter is continuously sampling the output waveform and can display a true rms value of the current.

For measuring short-duration currents, Model DDA-1 can calculate the output current in the following ways via selection from the soft control buttons on the panel:

1. For any output current greater than half a cycle, Model DDA-1 can calculate the true rms value of the output current pulse. For any output less than half a cycle, a true rms measurement is invalid.

2. For any current pulse, Model DDA-1 can measure the peak current and calculate an anticipated rms value of the current from the peak current.

This multiple-current calculation feature is also useful when testing different styles of solid-state trip devices. This feature allows the test set to simulate a similar type of current calculation that is being used by the various solid-state trip devices.

Digital timer: Thanks to digital signal processing technology, Model DDA-1's system knows exactly when current is present and when the breaker under test opens. This provides high-accuracy timing even when testing the instantaneous trip function on fast-acting breakers. In addition, the digital timer can display the breaker trip time in cycles or seconds.

A completely digital, solid-state circuit starts the timer automatically when the output current starts to flow and stops it when the device under test operates. This circuit will accommodate a variety of test conditions including:

The DDA Series offers high capacity in a single, relatively compact enclosure that can be easily maneuvered.

1. When testing a circuit breaker or a device which has no auxiliary contact to monitor (e.g., a single-pole circuit breaker), the timer starts when the output current starts to flow and stops when the output current is interrupted.

2. When testing a device and monitoring normally closed contacts, the timer starts when the output current starts to flow and stops when the contacts open.

3. When testing a device and monitoring normally open contacts, the timer starts when the output current starts to flow and stops when the contacts close.

Digital voltmeter: Model DDA-1 can be used to measure the input voltage to the test set or the output voltage from the test set. It also can be used as a diagnostic tool to evaluate contact condition by measuring the voltage drop across breaker contacts while subject to high current.

Panel indicators: Panel lamps incorporated for operator safety and convenience, indicate:

1. Output of the set ENERGIZED
2. Thermal WARNING or SHUTDOWN
3. GROUND INTERLOCK open
4. OVER RANGE of ammeter

External initiate circuit: Allows initiation of the test set from a remote location when desired.

SPECIFICATIONS

Input

Model No.	Input Voltage (single-phase)	Input Frequency	Input Current
DDA-3000	460 V ±5%	60 Hz	200 A
DDA-3001	380 V ±5%	50 Hz	200 A
DDA-3002	415 V ±5%	50 Hz	200 A
DDA-6000	460 V ±5%	60 Hz	350 A
DDA-6001	380 V ±5%	50 Hz	350 A
DDA-6002	415 V ±5%	50 Hz	350 A

Because Model DDA-3000/-6000 is used all over the world to test low-voltage circuit breakers, there are a number of test sets designed to contend with the many different input voltages and frequencies.
When ordering, select the test set which best suits the power system available. The standard input power requirements for the DDA-3000 and DDA-6000 series are as follows:

Output

Output Circuit: The output of the test set is easily adjustable from zero to the maximum current available through the impedance of the device under test. Two output ranges are provided to accommodate a variety of load circuit impedances.
For high impedance devices, the output can be connected in series (with the series bar provided) to double the output voltage at a reduced maximum current.
The maximum current available from the test set is determined primarily by the impedance of the load circuit.
The duration of the available current is determined primarily by thermal conditions within the test set.
Output Connections: To provide maximum utilization of the output available from the test set, each set is equipped with a Megger stab adapter board and stab sets Model CBS-1 and Model CBS-2 for use with drawout style, metal-clad breakers. The stabs eliminate the significant losses that occur if leads are used to connect the breaker under test to the test set. Cables must be used when testing molded-case breakers or other devices which will not connect directly to the stabs.
Duty Cycle: The test set will supply the rated continuous current indicated for 30 minutes, followed by 30 minutes off.
Maximum Output Current: Model DDA-3000/-6000 Series will produce the following outputs at rated input voltage:

Model No.	Output Current		
	Maximum Continuous Current	Maximum Current Through a Circuit Breaker	Maximum Current Through a Short Circuit
DDA-3000	4500 A	35,000 A	60,000 A
DDA-3001	4446 A	28,000 A	48,000 A
DDA-3002	4446 A	28,000 A	48,000 A
DDA-6000	6250 A	60,000 A	100,000 A
DDA-6001	6175 A	50,000 A	80,000 A
DDA-6002	6175 A	50,000 A	80,000 A

Model No.	WEIGHT		DIMENSIONS	
	lb	kg	H X W X D (in.)	H X W X D (cm)
DDA-3000 Series	1000	454	46 X 46 X 28 in.	117 X 117 X 71 cm
DDA-6000 Series	1200	545	46 X 55 X 28 in.	117 X 140 X 71 cm

Instrumentation

Digital Ammeter

Operating Mode
Memory
Continuous
Digital Display: 5-digit display with 0.281 in. (7 mm) numerals
Ranges: 200/2000/20,000/200,000 A

Overall Ammeter System Accuracy
Continuous ±1% of reading
Peak Pulse ±2% of reading
RMS Pulse ±1.5% of reading

Digital Timer

Digital Display: 5-digit display with 0.281 in. (7 mm) numerals

Ranges
0.0001 to 99999 seconds
0.0001 to 99999 cycles
Accuracy: ±1% of reading

Digital Voltmeter

Operating Mode
Input voltage
Output voltage
External voltage
Digital Display: 5-digit display with 0.281 in. (7 mm) numerals
Ranges: 0 to 600 V
Accuracy: ±1% of reading

OPTIONAL ACCESSORIES

Protective Cover

A tough cover made of heavyweight, reinforced, vinyl-coated nylon is available for protecting the test set from oil, dust or other particulate matter during storage.
It conforms to Mil-C-43006D and passes Mil-C-20696B test for oil and hydrocarbon resistance. It will withstand continuous exposure to temperatures ranging from -40 to +180° F (-40 to +82° C), and the fire-retardant material is treated with fungal and ultraviolet ray inhibitors.

Input Autotransformer

If the nominal input voltage for the test set is not available, or if use at different locations requires the use of a variety of input voltages, an autotransformer may be used.

The multitapped autotransformer is equipped with a power on/off switch, appropriate sockets, plugs, interconnect and tap selector cables. It is housed in a rugged sheet-metal enclosure with casters and handles.
All voltages are single-phase with a tolerance of ±5%. Input taps of 240 volts and below are not recommended for obtaining maximum output of the test set. For other combinations of input and output voltages, contact Megger.

Model No.	WEIGHT		DIMENSIONS	
	lb	kg	H X W X D (in.)	H X W X D (cm)
DDA-3000 Series	1000	454	46 X 46 X 28 in.	117 X 117 X 71 cm
DDA-6000 Series	1200	545	46 X 55 X 28 in.	117 X 140 X 71 cm

ORDERING INFORMATION

Item (Qty)	Cat. No.
Model DDA-3000	DDA-3000
Model DDA-3001	DDA-3001
Model DDA-3002	DDA-3002
Model DDA-6000	DDA-6000
Model DDA-6001	DDA-6001
Model DDA-6002	DDA-6002
Included Accessories	
Standard stab sets	CBS-1 and CBS-2
Leads	
Timer leads,12 ft (3.7 m) [2]	2997
Input leads, 15-ft (4.5-m), 4/0 cable [2]	17163
Fuses	
Fuse 500 V, 6 A [2]	9377
Fuse 250 V, 1.5 A [5]	950
Stab series bar [1]	5532
Instruction manual [1]	17176
Optional Accessories	
Input autotransformer	AT-1, AT-4
Leads included with input autotransformer	
Interconnect leads, 10-ft (3-m), 4/0 cable [2]	17164
Jumper lead [1]	17527
Protective cover	PC-1
Model CBS-3 stabs	Contact Technical Sales

ITEM 12

MOM2
Microhmmeter

- **Up to 220 A**
- **Battery supplied**
- **Lightweight – 1 kg**
- **Safe test – DualGround™**
- **Auto range: 1 µΩ to 1000 mΩ**
- **Bluetooth® PC communication**
- **Complies with IEEE and IEC standards**

Description

The MOM2 is designed to measure the resistance of circuit breaker contacts, bus-bar joints and other high-current links. This product is designed with safety, ease of use and versatility in mind.

The microhmmeter can be used anywhere to measure a low resistance value with high accuracy.

MOM2 uses an ultra capacitor to generate the high output current. The ultra capacitor is able to store a huge amount of energy compared to conventional capacitors and can deliver very high current during the discharge thanks to its very low internal resistance.

While testing, the capacitor is discharged through the test object and the voltage drop across- and the current flow through the test object are continuously and synchronously sampled. The resistances calculated from the individual samples are then averaged to obtain the final value.

With MOM2 it is possible to make measurements according to the DualGround™ method. This means that the test object will be grounded on both sides throughout the test giving a safer, faster and easier workflow.

The ruggedness and lightweight makes MOM2 a handheld instrument very suitable for field work, such as in substations. The unit comes with a strong rubber holster accessory which makes it extra durable. MOM2 is dimensioned to make a full day's work of testing without recharge. It can store 190 test values and transfer test data to a PC via Bluetooth.

Applications

MOM2 test system is designed to serve a number of applications. The most common are contact resistance measurements of low-, medium- and high-voltage breakers and also at bus-bar joints, and other high current links.

If the contact resistance is too high this will lead to power loss and temperature rise, which often leads to serious trouble. To avoid such problems, it is necessary to check the resistance at regular intervals.

The following table demonstrates how important low resistance is at high currents:

Current	Contact resistance	Power loss
10 kA	1 mΩ	100 kW
10 kA	0.1 mΩ	10 kW
1 kA	1 mΩ	1 kW
1 kA	0.1 mΩ	100 W

At 10 kA a contact with the resistance 0.1 mΩ gives a power loss of 10 kW. This power loss in one single point will definitely confer a temperature rise, which may result in overheating and possibly premature failure.

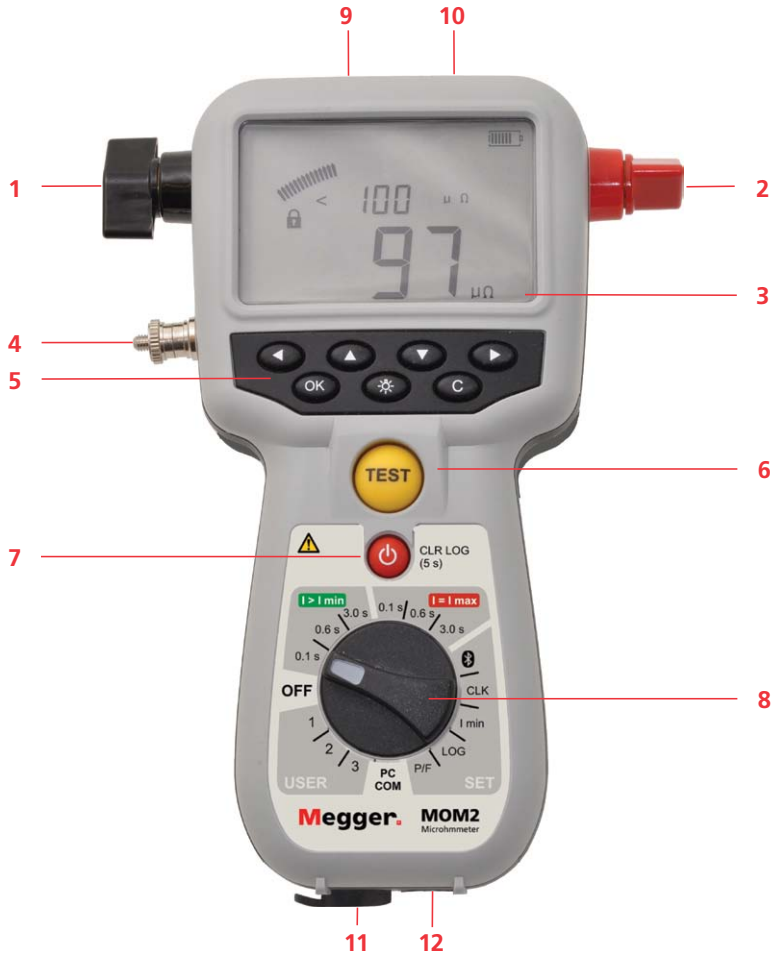
Features and benefits

1. Current output terminal (-)
2. Current output terminal (+)
3. Display
   The display offers a combination of analogue arc and a dual digital readout:
   - Analogue arc:
     Indicates level of the capacitor charge.
   - Dual digital display:
     Large main digital readout for good visibility of all main measurement results
     Second digital display for additional data.
4. Ground (earth) terminal
5. Keys for navigation and to make settings in the display
6. TEST-button
7. Stand-by/Wake up (Press shortly to toggle)
   Clear log (Press and hold for 5 seconds)

8. Function selector

OFF		
I > I min	**0.1 s**	Measurement time with minimum current guarantee
	0.6 s	
	3 s	
I = I max	**0.1 s**	Measurement time with max. charge
	0.6 s	
	3 s	
SET	Bluetooth	Bluetooth "pair units"
	CLK	Set date and time Set volume for the internal loudspeaker Discharge the MOM2 internal capacitor
	I min	Minimum current guarantee setting
	LOG	Data log setings
	P/F	Pass/Fail settings
PC COM		PC communication (dump data to PC)
USER	**1**	Stored settings. Set from PC, MOM2 Win
	2	
	3	

9. Connector for the voltage (–) sense lead
10. Connector for the voltage sense (+) lead and the trig function
11. Connector for the battery charger
12. Battery charger indicator



Application examples

Circuit Breaker testing

- Test of circuit breaker contacts
- Test of the connections to the breaker

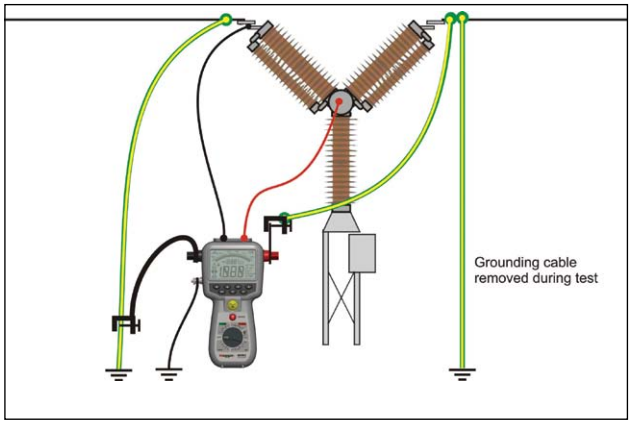
Testing of Bus-bar

- Test of Bus-bar joints
- Test of connections

Everywhere you need to test a low resistance/ high current connection

- Switches
- Disconnecting devices
- Safety ground connections
- Welding points
- Fuses
- Cables

Hold probes / attach Kelvin clamps to CB and press trig / TEST button. A signal indicates whether test was pass or fail and result is logged in unit for later dump to PC.



Traditional measurement from ground. Injection is done through existing grounding cable (earthing). Optional cable kit is needed. Available kits have 5, 10 or 15 m cables.

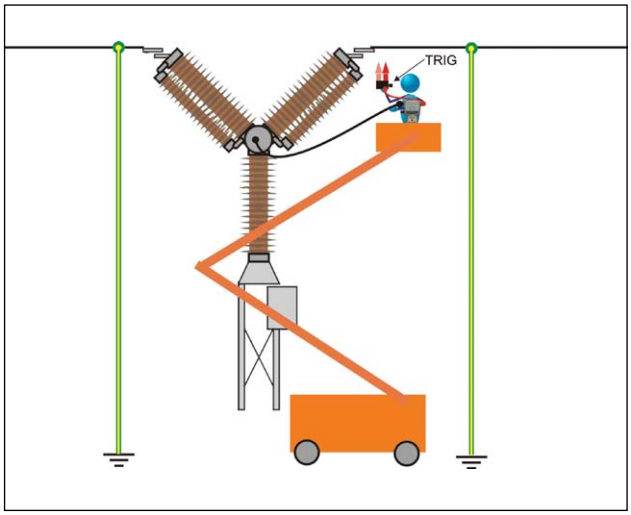
Both Sides Grounded

Many utilities require safety grounds to remain in place during station outages, therefore, the MOM2 was designed with this field safety constraint in mind. DualGround means that the test object will be grounded on both sides throughout the test giving a safer, faster and easier workflow. Minimum time shall be spent in the substation and focus shall be on the test rather than the equipment.

Conventional vs. DualGround	
Site preparation (isolate work area, apply safety ground, issue permit to work)	Site preparation (isolate work area, apply safety ground, issue permit to work)
Hook up test equipment. Issue sanction for test	Hook up test equipment. Issue sanction for test
Authorised person removes the ground	Risky step left out
Perform testing	Safe testing with both sides grounded
Authorised person applies ground	Risky step left out
Cancel sanction for test. Disconnect test equipment	Cancel sanction for test. Disconnect test equipment
Site closing (cancel permit to work, disconnect ground)	Site closing (cancel permit to work, disconnect ground)

DualGround™ Testing

Equipment and methods that supports DualGround™ testing are associated with the DualGround symbol. This symbol certifies the use of groundbreaking technology and methods that enables a safe, fast and easy workflow with both sides grounded throughout the test.



Measurement on CB with both sides grounded, DualGround.

Specifications MOM2

Specifications are valid at fully charged batteries and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

Environment

Application field	For use in high-voltage substations and industrial environments.
Temperature	
Operation	-20°C to +50°C (-4°F to +122°F) *)
Storage	-40°C to +70°C (-40°F to +158°F)
Relative humidity %RH	5%-95%, non condensing
Pollution degree	2
Shock	IEC 60068-2-27
Vibration	IEC 60068-2-6
Transport	ISTA 2A

*) Battery operation temperature 0°C to +50° (32°F to +122°F)
Battery charging temperature +10°C to +40° (50°F to +104°F)

CE-marking

EMC	2004/108/EC
LVD	2006/95/EC

General

Battery power	Five AA (HR6) 2700 mAh NiMH cells
Recharge time	< 12 h
Typical recharge time at 25°C	3 h
Battery charger	
Mains voltage	100-250 V AC, 50 / 60 Hz
Power consumption	60 W
Protection	Against wrong battery type, low/high temperature.
Real time clock battery life	≥10 years
Audible feedback	Different buzzer sounds
User presets	3
Field calibration	Yes
Encapsulation	IP54
Dimensions (excl. binding posts)	217 x 104 x 72 mm 8.5 x 4.1 x 2.8 in.
Weight	1.0 kg (2.2 lbs) instrument only 5.0 kg (11 lbs) with accessories and carrying case

Measurement section

Minimum current guarantee	Selectable 50 A / 100 A Valid at resistance ≤2mΩ
Pass / Fail	Settable from 1 µΩ to 1999 mΩ
Number of measurements on fully charged batteries	typ. 2200 at I min = 50 A and 0.1 s typ. 800 at I min = 100 A and 0.1 s
Interference suppression	Yes
Range	0 - 1000 mΩ
Range selection	Auto
Resolution	
0 – 999 µΩ	1 µΩ
1.0 – 9.99 mΩ	0.01 mΩ
10.0 – 99.9 mΩ	0.1 mΩ
100 – 1000 mΩ	1 mΩ
Inaccuracy	
0 – 1999 µΩ	±1 % of reading ±1 digit
2 – 1000 mΩ	±2 % of reading ±1 digit

Outputs + / –

Range	> 100 A DC (R < 2 mΩ)
Output voltage (max)	2.5 V DC
Generation duration	Selectable: 0.1 s, 0.6 s, 3 s

	Recovery time at I min set to 100 A and load 100 µΩ	
Generation time	Max	Typ
0.1 s	10 s	8 s
0.6 s	20 s	16 s
3 s	130 s	100 s

Inputs

SENSE + / –	
Connector	4 mm banana jack
Voltage	±3 V DC
Trigger input	Threshold 8 V DC
DC IN	12 – 24 V DC, 2 A max

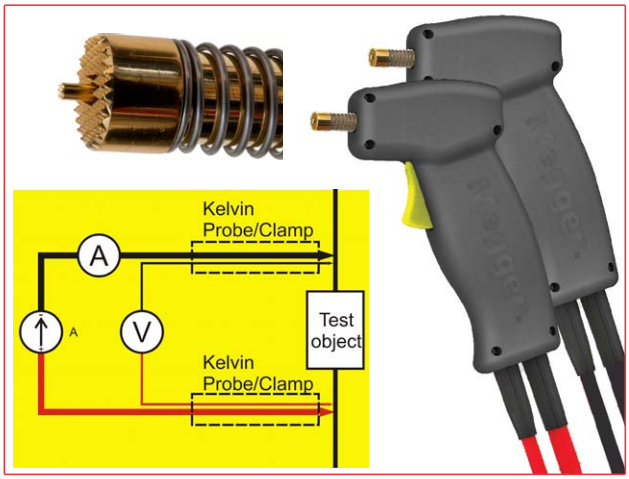
Logger

Logger, Data	Label. Timestamp, I max, I min, I Limit, Resistance, Meas.time, P/F limit
Labeling schemes	Circuit breaker oriented or running numbers
Capacity	190 measurements

Wireless communication

Headset	Bluetooth
PC communication	Bluetooth

Megger



Ordering information

Item	Art. No.
MOM2 *Including:* 2 x 1.3 m (4 ft) test cables with Kelvin probes (one with trig button) Transport case, Charger, Rubber holster, Carrying strap, Belt clip, MOM2 Win	BD-59090
MOM2 *Including:* 1.3 m (4 ft) test cable red with Kelvin clamp 3 m (10 ft) test cable black with Kelvin clamp Transport case, Charger, Rubber holster, Carrying strap, Belt clip, MOM2 Win	BD-59092
Optional accessories	
Test cables with Kelvin probes 2 x 1.3 (4 ft) m (one with trig button)	GA-90000
Test cables with Kelvin clamps 1.3 m (4 ft) red, 3 m (10 ft) black	GA-90001
Cable kit 5 m Current cable 0.5 m (1.6 ft), Connection plate and sense cables 5 m (16 ft), Ground cable	GA-00380
Cable kit 10 m Current cable 0.5 m (1.6 ft), Connection plate and sense cables 10 m (33 ft), Ground cable	GA-00382
Cable kit 15 m Current cable 0.5 m (1.6 ft), Connection plate and sense cables 15 m (49 ft), Ground cable	GA-00384
Bluetooth kit Bluetooth headset and dongle for PC	XC-06000
Calibration kit	BD-90002
Soft carrying case For MOM2, Charger and Cables	

ITEM 13

DLRO 200
Digital Microhmmeter

- **Small and weighs less than 15kg (33 lbs)**
- **Test currents from 10A to 200 A d.c.**
- **0.1 μΩ best resolution**
- **On board memory for up to 300 test results and notes**
- **RS232 port to download stored results or for real time output to a printer**
- **Supplied complete with 5m (16.4 ft.) test leads and download software**
- **Smooth, continuous applied curent eleminates magnetic transients capable of inductively tripping breaker controls (115 V version)**

DESCRIPTION

Megger DLRO200 measures resistances between 0.1 $\mu\Omega$ and 1 Ω, at high currents.

This versatile instrument can provide test currents from 10 amps up to 200 amps subject to the load resistance and supply voltage. A large liquid crystal display provides all the information needed to perform a test; all test parameters and measurement results are displayed.

The unique design allows the weight and size of DLRO200 to be kept to a minimum; the instrument weighs less than 15kg. This small size makes DLRO200 equally at home in the workshop, on the production floor or in the field. The high current capability and compact design make DLRO200 suitable for testing circuit breaker contacts, switch contacts, busbar joints or other applications where high current is needed.

300 sets of results may be stored in DLRO200's on board memory for later download to a PC or may be output directly to a printer via the RS232 port. You may also add notes to any stored result by using the on board alphanumeric keypad, thereby making later identification of results straightforward.

As well as adding notes to stored results, the alphanumeric keypad allows you to set the test current directly by typing in the value required. DLRO200 will check the continuity of the test circuit, and will quickly ramp the test current up to the desired level. The keyboard is also used to set upper and lower limits for the result and to prevent the use of excessive currents by setting an upper limit to the allowable test current.

DLRO200 uses a four terminal measurement technique to cancel the resistance of the test leads from the measurement.

DLRO200 operates in one of three modes, which are simply selected from the on screen menu.

CONTINUOUS mode is provided for users who wish to monitor a resistance over a period of time. Connect the test leads, select the test current and press the TEST button. DLRO200 will pass a current continuously, and measure the resulting voltage at 2-second intervals, until the test button is pressed to stop the test or the test circuit is interrupted.

In NORMAL mode you connect the leads, select the test current and press the TEST button. The test current will ramp up to the desired level, hold for 2 seconds and then ramp down. The whole process takes approximately 10 seconds.

In AUTO mode select the desired current, connect the current leads and press the TEST button. The TEST lamp will flash to show that the DLRO200 is ready to carry out a test. As soon as the potential leads are connected, a test will start. To repeat a test, simply break contact with the voltage probes and remake contac.

Measuring individual joints in a busbar is a good example of the convenience to be gained by using AUTO mode. The two current leads are connected to the ends of the busbar. They will remain connected here until all tests have been completed. When the voltage leads make contact across a joint, DLRO200 detects that all four leads are connected, carries out a test and stops. When you move to the next joint DLRO detects the new completed circuit automatically and carries out the next test, and so on until all joints have been tested. The results may be stored automatically and may be recalled to the display or downloaded for review.

SPECIFICATIONS

Measurement:
Range: 0.1 μΩ to 999.9 mΩ
(Subject to supply voltage and leads used)

Accuracy:

Voltage	±0.5% ± 0.1 mV
Current	±0.5% ± 0.1 A
Resistance:	Better than 1% from 300 μΩ to 100 mΩ
	Better than ±2% from 100 μΩ to 300 μΩ

Current Lead Resistance (Megger supplied leads)

2 x 5 m 25 mm^2 current leads	8 m
2 x 5 m 50 mm^2 current leads	4 mΩ
2 x 10 m 70 mm^2 current leads	5.4 mΩ
2 x 15 m 95 mm^2 current leads	6 mΩ

Maximum Continuous Test Time
More than 60 seconds at 200 A @ 20ºC ambient.

Power Supply for DLRO200
for full output (unsmoothed d.c.)

100 to 265 V 50/60 Hz with a load
less than 19 mΩ (supply >207 V rms), or
11 mΩ (115 V rms) including current leads

Power Supply for DLRO200-115 V
for full output (additional smoothing)

100 to 130 V 50/60 Hz with a load
less than 11 mΩ including current leads

Test Modes:	Manual, Auto, Continuous.
Test Time:	10 seconds NORMAL /AUTO mode. Refreshed every 2 seconds in CONTINUOUS mode
Display:	Large, high resolution backlit liquid crystal display
Warnings	Current flowing: - LED. Other warnings are shown on the lcd display
Data Transfer	Real time or batch download via RS232 using Download Manager.
Storage Capacity:	300 result sets and memo, battery backed for 10 years.
Memo field:	160 characters max.

Test Current	
Range:	10 A to 200 A d.c. *
Accuracy:	±2% ±2 A
Voltmeter input impedance:	>200 kΩ
Hum rejection:	5 V rms 50 Hz/60 Hz

Temperature	
Operation:	-10 to +50ºC (-14 to +122ºF)
Storage:	-25 to +65ºC (-13 to 149ºF)
Calibration:	20ºC
Co-efficient:	<0.05% per ºC

Max. Humidity:	95% RH non-condensing
Maxi Altitude:	2000 m
Safety:	IEC61010-1
EMC:	IEC61326-1
Dimensions:	410 x 250 x 270 mm (16.4 x 9.84 x 10.63 ins)
Weight:	14.5 kg (excluding test leads) (31.97 lbs)

ORDERING INFORMATION

STANDARD VERSIONS WITH TEST LEADS

Item (Qty)	Order No.
DLRO200 High Current Digital Low Resistance Ohmmeter (English QWERTY keyboard)	DLRO200-EN
DLRO200 High Current Digital Low Resistance Ohmmeter (French AZERTY keyboard)	DLRO200-FR
DLRO200-115 High Current Digital Low Resistance Ohmmeter 115 V with additional output smoothing (English QWERTY keyboard)	DLRO200-115
Included Accessories	
DLRO200-EN, DLRO200-FR	
5 m (16.4 ft.) Lead set set comprising 2 x 50 mm² current leads with clips and 2 potential leads with clips	6220-755
DLRO200-115	
5 m (16.4 ft.) Lead set in bag comprising: 2 x 25 mm² current leads with clamps and 2 x potential leads with clips	6220-787
Download Manager	6111-442
User Guide on CD-ROM	6172-763
RS232 download cable	25955-025
Quick Start Guide (English)	6172-782
Quick Start Guide (French)	6172-783
Warranty card.	6170-618

VERSIONS WITHOUT TEST LEADS

Item (Qty)	Order No.
DLRO200 High Current Digital Low Resistance Ohmmeter (English QWERTY keyboard)	DLRO200-EN-NLS
DLRO200 High Current Digital Low Resistance Ohmmeter (French AZERTY keyboard)	DLRO200-FR-NLS
DLRO200-115 High Current Digital Low Resistance Ohmmeter 115 V with additional output smoothing (English QWERTY keyboard)	DLRO200-115-NLS
Included Accessories	
Download Manager	6111-442
User Guide on CD-ROM	6172-763
RS232 download cable	25955-025
Quick Start Guide (English)	6172-782
Quick Start Guide (French)	6172-783
Warranty card.	6170-618

NOTE:
For further test lead information refer to datasheet DLRO_TL_DS_en_V01.pdf

TEST LEAD INFORMATION

6220-755 5m Lead set (600 A)
2 x 50 mm² current leads with clamps and 2 x potential leads with clips.

6220-787 5m Lead set (200 A)
as above but 25mm² cable fitted.

Description
Lead set consists of pair of flexible high current capacity leads, together with a separate pair of lightweight potential leads.
Current leads are fitted with heavy duty sprung clamps (60 mm jaw capacity).
Potential leads fitted with smaller HD crocodile clips 22 mm jaw capacity).

Note:
6220-755 supplied as standard with DLRO200-EN and DLRO200-FR
6220-787 supplied as standard with DLRO200-115

6220-756 10m Lead set
2 x 70mm² current leads with clamps and 2 x potential leads with clips.

6220-757 15m Lead set
2 x 95mm² current leads with clamps and 2 x potential leads with clips.

Description
Lead set consists of pair of flexible high current capacity (600 A cont.) leads, together with a separate pair of lightweight potential leads.
Current leads are fitted with heavy duty sprung clamps (60 mm jaw capacity).
Potential leads fitted with smaller HD crocodile clips 22 mm jaw capacity).

ITEM 14

DLRO 600
Digital Microhmmeter

- **Small and weighs less than 15kg**
- **Test currents from 10A to 600 A d.c.**
- **0.1 μΩ best resolution**
- **On board memory for up to 300 test results and notes**
- **RS232 port to download stored results or for real time output to a printer**
- **Supplied complete with 5m test leads and download software**

DESCRIPTION

Megger DLRO600 measures resistances between 0.1 $\mu\Omega$ and 1 Ω, at high currents.

This versatile instrument can provide test currents from 10 amps up to 600 amps subject to the load resistance and supply voltage. A large liquid crystal display provides all the information needed to perform a test; all test parameters and measurement results are displayed.

The unique design allows the weight and size of DLRO600 to be kept to a minimum; the instrument weighs less than 15kg. This small size makes DLRO600 equally at home in the workshop, on the production floor or in the field. The high current capability and compact design make DLRO600 suitable for testing circuit breaker contacts, switch contacts, busbar joints or other applications where high current is needed.

300 sets of results may be stored in DLRO600's on board memory for later download to a PC or may be output directly to a printer via the RS232 port. You may also add notes to any stored result by using the on board alphanumeric keypad, thereby making later identification of results straightforward.

As well as adding notes to stored results, the alphanumeric keypad allows you to set the test current directly by typing in the value required. DLRO600 will check the continuity of the test circuit, and will quickly ramp the test current up to the desired level. The keyboard is also used to set upper and lower limits for the result and to prevent the use of excessive currents by setting an upper limit to the allowable test current.

DLRO600 uses a four terminal measurement technique to cancel the resistance of the test leads from the measurement.

DLRO600 operates in one of three modes, which are simply selected from the on screen menu.

CONTINUOUS mode is provided for users who wish to monitor a resistance over a period of time. Connect the test leads, select the test current and press the TEST button. DLRO600 will pass a current continuously, and measure the resulting voltage at 2-second intervals, until the test button is pressed to stop the test or the test circuit is interrupted.

In NORMAL mode you connect the leads, select the test current and press the TEST button. The test current will ramp up to the desired level, hold for 2 seconds and then ramp down. The whole process takes approximately 7 seconds.

In AUTO mode select the desired current, connect the current leads and press the TEST button. The TEST lamp will flash to show that the DLRO600 is ready to carry out a test. As soon as the potential leads are connected, a test will start. To repeat a test, simply break contact with the voltage probes and remake contact.

Measuring individual joints in a busbar is a good example of the convenience to be gained by using AUTO mode. The two current leads are connected to the ends of the busbar. They will remain connected here until all tests have been completed. When the voltage leads make contact across a joint, DLRO600 detects that all four leads are connected, carries out a test and stops. When you move to the next joint DLRO detects the new completed circuit automatically and carries out the next test, and so on until all joints have been tested. The results may be stored

automatically and may be recalled to the display or downloaded for review.

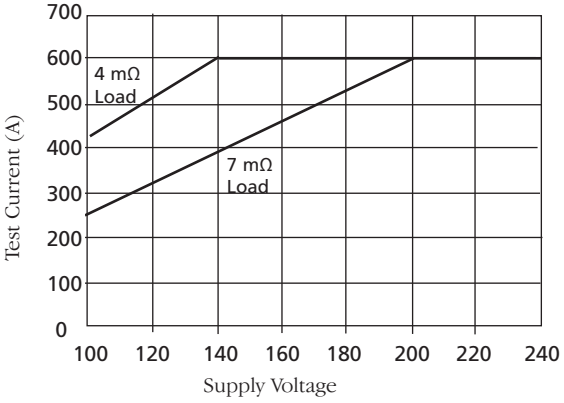
SPECIFICATIONS

Measurement:

Range: 0.1 μΩ to 999.9 mΩ
(Subject to supply voltage and leads used)

Accuracy:

Voltage	±0.5% ± 0.1 mV
Current	±0.5% ± 0.1 A
Resistance:	Better than 1% from 100 μΩ to 100 mΩ



Output Current:
The chart above shows the maximum output current available at different supply voltages with a 4 mΩ load (i.e. standard 5 m current leads only) and with a 7 mΩ load

Current Lead Resistance (Megger supplied leads)

2 x 5 m 50 mm2 current leads	4 mΩ
2 x 10 m 70 mm2 current leads	5.4 mΩ
2 x 15 m 95 mm2 current leads	6 mΩ

Maximum Continuous Test Time
More than 60 seconds at 600 A @ 20°C ambient.

Power Supply for: See chart.

full output:	207 to 265 V 50/60 Hz with a load less than 7 mΩ including current leads
reduced output:	Down to 100 V 50/60 Hz.
Test Modes:	Manual, Auto, Continuous.
Test Time:	7 seconds NORMAL /AUTO mode. Refreshed every 2 seconds in CONTINUOUS mode
Display:	Large, high resolution backlit liquid crystal display
Warnings	Current flowing: - LED. Other warnings are shown on the lcd display.
Data Transfer	Real time or batch download via RS232 using Download Manager.
Storage Capacity:	300 result sets and memo, battery backed for 10 years.
Memo field:	200 characters max.
Test Current Range:	10 A to 600 A unsmoothed d.c. in 1 A steps
Accuracy:	±2% ±2 A
Voltmeter input impedance:	>200 kΩ
Hum rejection:	5 V rms 50 Hz/60 Hz
Temperature Operation:	-10 to +50°C
Storage:	-25 to +65°C
Calibration:	20oC
Co-efficient:	<0.05% per °C
Max. Humidity:	95% RH non-condensing
Maxi Altitude:	2000 m
Safety:	IEC61010-1
EMC:	IEC61326-1
Dimensions:	410 x 250 x 270 mm
Weight:	14.5 kg (excluding test leads)

ORDERING INFORMATION

STANDARD VERSIONS WITH TEST LEADS

Item (Qty)	Order No.
DLRO600 High Current Digital Low Resistance Ohmmeter (English QWERTY keyboard)	DLRO600-EN
DLRO600 High Current Digital Low Resistance Ohmmeter (French AZERTY keyboard)	DLRO600-FR
Included Accessories	
5 m (16.4 ft.) Lead set set comprising 2 x 50 mm² current leads with clips and 2 potential leads with clips	6220-755
Download Manager	6111-442
User Guide on CD-ROM	6172-763
RS232 download cable	25955-025
Quick Start Guide (English)	6172-782
Quick Start Guide (French)	6172-783
Warranty card.	6170-618

VERSIONS WITHOUT TEST LEADS

Item (Qty)	Order No.
DLRO600 High Current Digital Low Resistance Ohmmeter (English QWERTY keyboard)	DLRO600-EN-NLS
DLRO600 High Current Digital Low Resistance Ohmmeter (French AZERTY keyboard)	DLRO600-FR-NLS
Included Accessories	
Download Manager	6111-442
User Guide on CD-ROM	6172-763
RS232 download cable	25955-025
Quick Start Guide (English)	6172-782
Quick Start Guide (French)	6172-783
Warranty card.	6170-618

NOTE:
For further test lead information refer to datasheet DLRO_TL_DS_en_V01.pdf

TEST LEAD INFORMATION

6220-755 5m Lead set (600 A)

2 x 50 mm² current leads with clamps and 2 x potential leads with clips.

Description

Lead set consists of pair of flexible high current capacity leads, together with a separate pair of lightweight potential leads.

Current leads are fitted with heavy duty sprung clamps (60 mm jaw capacity).

Potential leads fitted with smaller HD crocodile clips 22 mm jaw capacity).

Note:
6220-755 supplied as standard with DLRO600-EN and DLRO600-FR

6220-756 10m Lead set

2 x 70mm² current leads with clamps and 2 x potential leads with clips.

6220-757 15m Lead set

2 x 95mm² current leads with clamps and 2 x potential leads with clips.

Description

Lead set consists of pair of flexible high current capacity (600 A cont.) leads, together with a separate pair of lightweight potential leads.

Current leads are fitted with heavy duty sprung clamps (60 mm jaw capacity).

Potential leads fitted with smaller HD crocodile clips 22 mm jaw capacity).

MULTI-TEK INTERNATIONAL
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London W10 6TR, England
Tel: +44 20-73133190
Fax: +44 20-73133191
E-Mail: mti@multitekintl.com

Registered to ISO 9001:2000 Cert. no. Q 09290
Registered to ISO 14001-1996 Cert. no. EMS 61597

ITEM 15

VIDAR
Vacuum Interrupter Tester

- **Tests the integrity of vacuum interrupters quickly, safely and easily**
- **User defined voltage selection**
- **Extensive voltage range**
- **Easy to operate. Follows ANSI/IEEE standardized DC test methods**
- **Lightweight and portable**

Description

When a vacuum circuit breaker is commissioned or undergoes routine tests, it is very important to be able to ascertain whether or not the Vacuum Interrupter (VI) is intact before putting it back into operation.

VIDAR enables you to check the integrity of the vacuum interrupter quickly and conveniently by means of the known relationship between the flashover voltage and the vacuum interrupter. A suitable test voltage (DC) is applied to the breaker, and the result is known immediately.

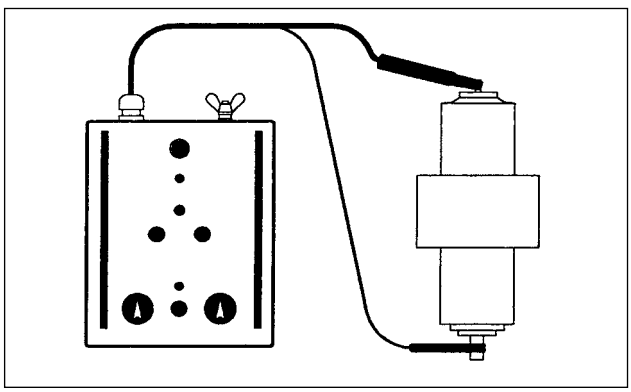
VIDAR permits you to select among test voltages from 10 to 60 kV DC. One of these voltages is customized and specified by the customer when ordering. A green lamp indicates approval of the VI. A red lamp indicates that it is defective. Two-hand control and a high-voltage warning lamp enhances safety.

VIDAR has been developed in close collaboration with leading manufacturers of vacuum circuit breakers. It weighs only about 6 kg (15 lbs), and it is easy to use since interrupters do not have to be dismounted for testing. VIDAR is therefore ideal for use in the field or shop floor applications.

Applications

The VIDAR vacuum tester is used to test the ability of the VI in a vacuum circuit to inhibit flashover. The rugged, lightweight, compact and portable VIDAR is ideal for field work and shop floor applications.

The VI in vacuum breakers do not last forever. Leakage starts after years or decades and the interrupters fill with air making the breaker unreliable. In most cases, the leakage process is rapid once it has started. In addition to leakage, dirt on the poles and on the exterior surface of the interrupter can make it unsafe during operation. The mechanics of the breaker can become misaligned so that the distance between the poles no longer is adequate. VIDAR, introduced in 1985, uses high voltage DC to test the integrity of vacuum breakers.

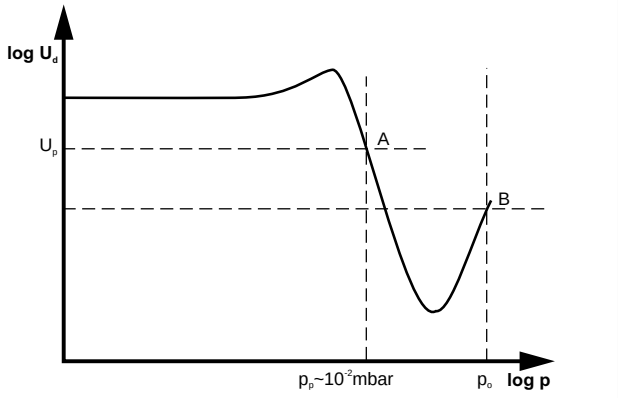


Connection diagram for the VIDAR

Flashover Threshold Voltage

The curve shown in Fig. 1 illustrates the relationship between the VI's internal pressure and its ability to inhibit flashover. This relationship permits the vacuum to be checked indirectly by measuring the voltage threshold. One special advantage of this method is that you do not need to disassemble the circuit breaker in order to test it.
The voltage shall be selected so that test point A is sufficiently far from point B (when the chamber is filled with air). However, the electric stress in the chamber must not be too high. In normal situations, the pressure is less than 10^{-2} mbar.

For guidance on test voltage refer to IEC 694 and ANSI C37-06 standards

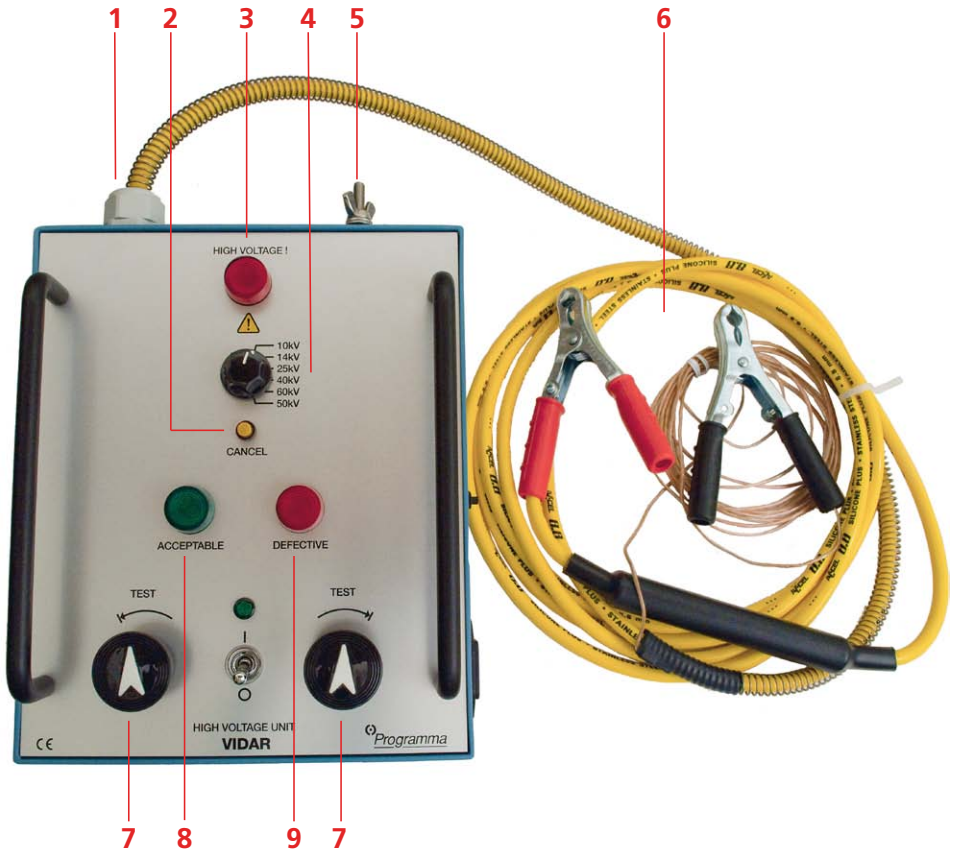


p	Interrupter pressure	U_d	Breakdown voltage
p_o	Atmos. pressure	U_p	Test voltage
P_p	Max. pressure on passing voltage test		

Fig. 1: Flashover threshold voltage plotted against pressure in vacuum interrupter.

Features and Benefits

1. **High voltage cable**. For connection of the test voltage and ground to the vacuum breaking chamber.
2. **CANCEL lamp**. Lights up when:
   - the test interval has exceeded one minute.
   - you try to conduct a one minute test less than two minutes after the latest test.
   - the HIGH-VOLTAGE indicator malfunctions.
3. **HIGH-VOLTAGE warning lamp**. Shows that the high voltage is applied.
4. **Test voltage selector.** 10 to 60 kV DC. One of these voltages is customized and specified by the customer when ordering.
5. **Protective earth** (ground) terminal.
6. **Large test clip connectors** – provides for quicker connection and more efficient testing process
7. **TEST Safety control knobs**. Both knobs must be turned simultaneously to apply high voltage to the test object.
8. **ACCEPTABLE green lamp.** Lights up when the breaking chamber test result is positive.
9. **DEFECTIVE red lamp.** Lights up when the breaking chamber test result is negative, when the flashover threshold voltage is too low.



Megger

Specifications VIDAR

Specifications are valid at nominal input voltage and an ambient temperature of +25°C, (77°F). Specifications are subject to change without notice.

Environment

Application field	The instrument is intended for use in medium and high-voltage substations and industrial environments.
Temperature	
Operating	0°C to +50°C (32°F to +122°F)
Storage & transport	-40°C to +70°C (-40°F to +158°F)
Humidity	5% – 95% RH, non-condensing

CE-marking

LVD	2006/95/EC
EMC	2004/108/EC

General

Mains voltage	115/230 V AC (switchable), 50/60 Hz
Power consumption	69 VA (max)
Protection	Overload cut-out
Dimensions	
Instrument	250 x 210 x 125 mm (9.8" x 8.3" x 4.9")
Transport case	460 x 430 x 210 mm (18.0" x 17" x 8.3")
Weight	6.9 kg (15.5 lbs) 10.7 kg (23.6 lbs) with accessories and transport case

Measurement section

Indicators

Green lamp	Indicates an approved breaking chamber
Red lamp	Indicates a defect breaking chamber, lights up if the current exceeds 0.3 mA
Yellow lamp	Indicate that the test was interrupted

Output

Standard voltages, switchable	10, 14, 25, 40 and 60 kV DC
Customized voltage	Between 10 and 60 kV DC. Determined at the factory. Default voltage is 50 kV.
Ripple	Max 3%

Ordering information

Item	Art. No.
VIDAR	
Included accessories:	
Permanently mounted cable set 5 m (16 ft), ground cable and transport case (GD-00030)	BR-29090

MULTI-TEK INTERNATIONAL
140-144 Freston Road,
London W10 6TR, England
Tel: +44 20-73133190
Fax: +44 20-73133191
E-Mail: mti@multitekintl.com

ITEM 16

TM1700-series
Circuit Breaker Analyzer System

- **Provides reliable and accurate test results in noisy high voltage substations**
- **Four standard models. Full stand-alone functionality or data acquisition models without user interface.**
- **Fast and safer with DualGround™ testing, both sides of breaker grounded**
- **On-screen assistance with connection diagrams and test template Wizard**
- **All models can be controlled via computer**

Description

The TM1700 series circuit breaker analyzers utilizes some of the ground breaking technology from the top of the line version TM1800. There are four models starting from PC-remote controlled to fully stand-alone. All models can be controlled from a computer using the well proven data management and analyzing software CABA Win.

The robust design offers powerful technology that assists the user to achieve efficient and reliable circuit breaker testing. All inputs and outputs on the instrument are designed to withstand the challenging environment in high-voltage substations and industrial environments. Galvanically isolated inputs and outputs makes it possible to perform all relevant measurements in one test, eliminating the need for new setup and re-connections.

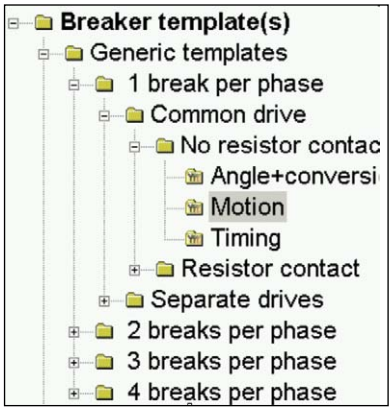
The patented DualGround™ method makes the testing safe and time saving by keeping the circuit breaker grounded on both sides throughout the test.

The timing measurement inputs are using a patented Active Interference Suppression algorithm to ensure correct timing and accurate PIR (Pre-Insertion Resistor) values even at high capacitively coupled interference currents.

The adaptive and easy-to-use software allow the user to perform the test by simply turning the test switch without the need for settings. The operator is only one click away from advanced help functions such as connection diagrams. The 8" color touch screen, with on-screen keyboard, allows the user to efficiently operate this high-level interface.

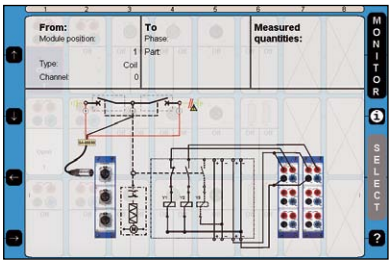
Select – Connect – Inspect

Working with TM1700 means fast and easy testing. Testing is done with a three-step process.



Select

First step is to select a suitable template from the template library depending on number of contacts per phase, motion or not, resistor contacts and more.



Connect

Second step is to connect the test leads according to the graphical help screen. Separate help screens for each cable.

Inspect

Third step is to turn the "Measure" knob. The measurement is performed, analyzed and the results displayed on the screen. Magnification and compare functions are available..

Testing with DualGround

Electricity deregulation changes the business environment for utilities, switchgear owners and service companies. Deregulation has been shown to lead directly to increased emphasis on efficiency of operations, maintenance and service levels. Internationalization of business brings new challenges: substantial investments by global corporations will bring with them sharper or new requirements for increased emphasis on health, safety and environmental compliance. Experience has also shown there is less time for testing because the switchgear is less and less available to be taken out of service.

The safety aspect

Network operators and service companies need to maintain and develop their industry safety record. Eminent International bodies including the IEEE® and IEC®, National Safety agencies and Trade Unions increases the demands on safety. During the deregulation safety regulations have been clarified and the application of existing rules has been tightened. Keeping a good safety record is becoming a crucial asset to attract investors and customers.

In all substations the capacitive coupling from live high voltage conductors induce harmful/lethal currents in all parallel conductors. Grounding both sides of the test object will lead the induced current to earth and provide a safe area for the test personnel. See diagrams below.

Both sides grounded

The best way to provide safety in circuit breaker testing is to keep both sides of the circuit breaker grounded throughout the test. This will also make the test faster and easier. Testing personnelshould spend the minimum time in the substation and their focus should be the test rather than the equipment.

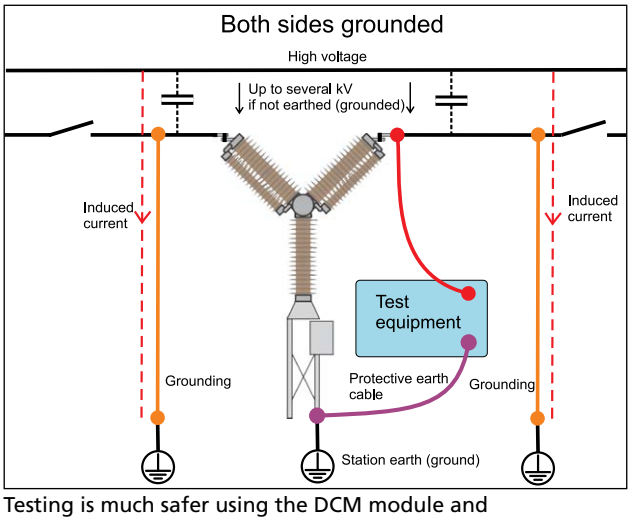
The DualGround™ testing method is available for all tests on all circuit breakers.

Conventional vs. DualGround	
Site preparation (isolate work area, apply safety ground, issue permit to work)	Site preparation (isolate work area, apply safety ground, issue permit to work)
Hook up test equipment. Issue sanction for test	Hook up test equipment. Issue sanction for test
Authorised person removes the ground	Risky step left out
Perform testing	Safe testing with both sides grounded
Authorised person applies ground	Risky step left out
Cancel sanction for test. Disconnect test equipment	Cancel sanction for test. Disconnect test equipment
Site closing (cancel permit to work, disconnect ground)	Site closing (cancel permit to work, disconnect ground)

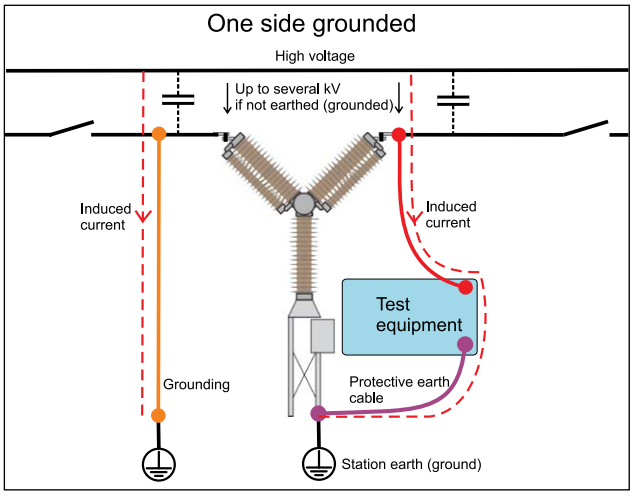
DualGround™ Testing

- Contact resistance — **MJÖLNER / SDRM202**
- Timing — **TM1700 with DCM**
- Motion — **TM1700**
- SDRM — **TM1700 with SDRM202**
- Vibration — **CABA Win Vibration / SCA606**

Equipment and methods that support DualGround™ testing are associated with the DualGround symbol. This symbol certifies the use of ground-breaking technology and methods that enable a safe, fast and easy workflow with both sides grounded throughout the test.



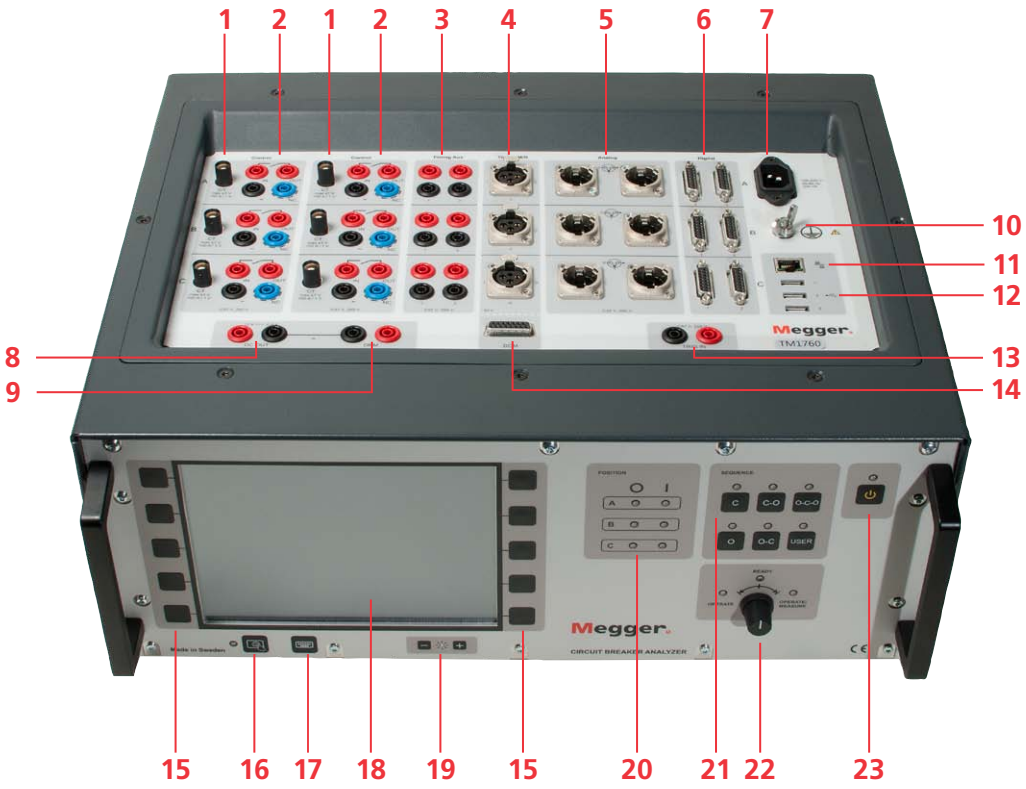
Testing is much safer using the DCM module and DualGround.



With only one side grounded the induced current can reach values high enough to be harmful or lethal for humans.

Features and benefits

1. Input for external clamp-on CT
2. Control section
   - Three independent contact functions
   - Pre-programmed sequences C, O, C–O, O–C, O–C–O
   - Timing of a and b auxiliary contacts
   - Coil current, voltage and resistance
3. Timing Aux section
   - Six galvanic isolated channels
   - Polarity insensitive
   - Dry and wet auxiliary contacts
4. Timing M/R section
   - Six inputs
   - High resolution 15µV and up to 40 kHz sampling
   - Main and parallel resistor contact timing
   - Resistance value of parallel resistors
5. Analog section
   - Six channels (three optional)
   - Supports industrial analog transducers
   - Insulated channels, measure up to 250 V whithout volt. div.
   - High resolution 0.3 mV, sampling rate 40 kHz
6. Digital section
   - Six channels
   - Incremental transducers with RS422
   - Up to ±32000 pulses resolution
   - Up to 40 kHz sampling
7. Mains input
8. DC out
   - General voltage source ,12 V
9. DRM
10. Earth (ground) terminal
11. Ethernet port
12. USB ports
13. Trig IN
    - Used for external trig of the unit. Contact make / break or voltage signal.
14. DCM interface
15. Navigation buttons
    - Works in parallell with the touch screen buttons.
    - Most of the CABA Local functions are controlled by the ten navigation buttons.
16. Touch screen On/Off
17. On-screen keyboard On/Off
18. Display (touch screen)
    - High brightness for good visibility in direct sunlight.
19. Brightness setting
20. POSITION
    - Indicates the position of the circuit breaker main contacts if the coil circuit is connected to the control section.
21. SEQUENCE
    - Indicates the next operation of the circuit breaker. If Auto-detect breaker state is enabled in CABA Local or CABA Win, only possible sequences for the circuit breaker are selectable.
22. OPERATE/MEASURE
    - Initiates the selected operation sequence and makes the measurement. Green "READY" LED must be lit before turning the rotary switch. The yellow "OPERATING" LED is lit as long as the sequence is performed.
23. On/Off switch



Application examples

First trip measurement

When a fault occurs on a transmission or distribution line, it is the circuit breaker's job to fast and efficiently clear the fault by opening the circuit, or to trip, and isolating the fault from the power source. A quick trip limits the damage caused to expensive equipment by the high fault currents, or in worst case, kill someone. This is why it is so important to test the circuit breakers so you know they are functioning properly.

Why capture first trip?

Testing breakers can be done in many ways, but one of the most common is timing of the main contacts, which gives a direct indication of the trip time. A typical procedure for performing a timing test on a circuit breaker that is in service is:

1. Open the breaker
2. Disconnect the breaker by opening the disconnect switches
3. Ground the breaker
4. Perform timing test

The timing tests will now show the correct trip times, right? Not necessarily! Consider a breaker that has been in service without operating for months, even years, before it was taken out of service for testing. It might be suffering from a lack of grease and maybe corrosion in its bearing. These problems can, and most probably will, slow down the first operations.

The problem with this procedure is the breaker has been operated at least once before the testing procedure begins. This operation might be all it takes to "shake off" any corrosion problems or sticky bearings and bring the breaker's trip time up to standard. So when the actual timing test is performed, no problem exists and the service engineer thinks the breaker is in good shape and no further service is needed. A few months down the road, the corrosion is back and when a fault occurs and the breaker does not trip fast enough, or at all!
This is why it is so important to capture the first operations, so any problems with the breaker will be revealed.

Methods

The "First Trip" measurement is a part of on-line testing, which means that the circuit breaker is in service. We will focus on three measurements; coil currents, control voltage and contact timing. However, other measurements that are possible on-line are auxiliary contact timing, vibration, motor currents and motion.

The coil currents are measured to give indication of any lubrication problems inside the main bearings or in the trip latch. By analyzing the coil currents, indication of changes in resistance can also be detected. They are caused by short-circuited windings, burnt coils etc. The coil currents can be measured with either current clamps or with the analyzers control module, if the utility allows a local breaker operation.

The control voltage is measured during the operation to give an indication of a weak battery bank. The station's battery voltage before an operation might be in order, and is monitored by the charging units. However, during the operation the power demand might be too great for the bank.

- **If the voltage drop is greater than 10% of the nominal voltage, it might be a sign of a failing battery bank.**
- **If the circuit breaker has three operating mechanisms, the coil currents and control voltages should be measured in each mechanism.**

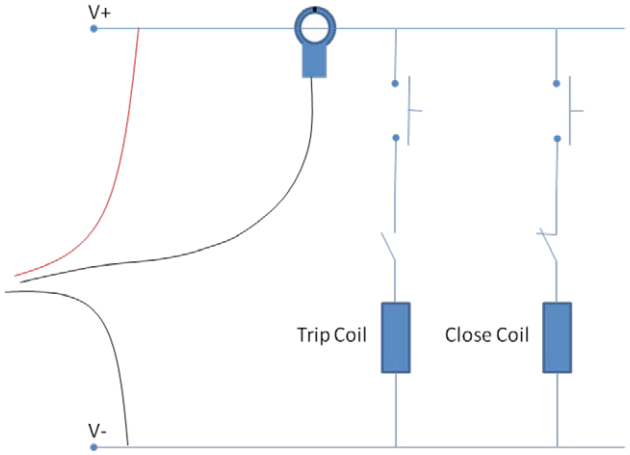


Figure 1 Point for measuring coil current and control voltage

Since the breaker is in service, the conventional way of measuring the times of the main contacts with timing leads across the interrupter cannot be used. Instead of timing leads, three current clamps are used. These current clamps are used on the secondary side of the current transformer for each phase. These show the current flowing through each phase and by looking for the instant when the current stops flowing, the breakers trip time is revealed.

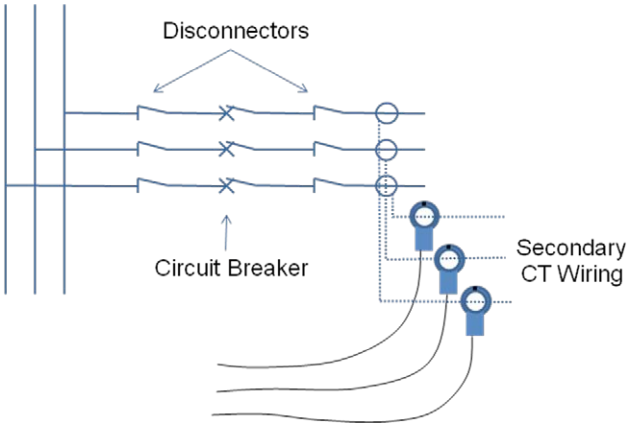


Figure 2 Point for measuring the line currents

Figure 3 Control cabinet with current clamps

Equipment

The equipment needed for a first trip measurement depends on the configuration of the circuit breaker. A common denominator for all measurements is the three current clamps for the line current are needed to capture the timing of the individual phases. These do not need to be able to measure DC currents, since they will only measure the alternating line currents. For the coil current, either one

or three clamps are needed depending on the number of operating mechanisms. These need to be able to measure both AC and DC to cover all types of coils, however DC coils being the most common.

Analysis

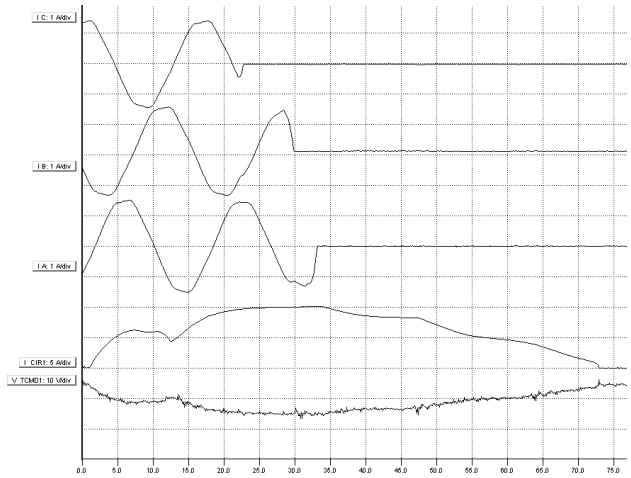


Figure 4 Example of measurement result

In figure 4, we see an example of a measurement that covers the three phases, one coil current and the control voltage.

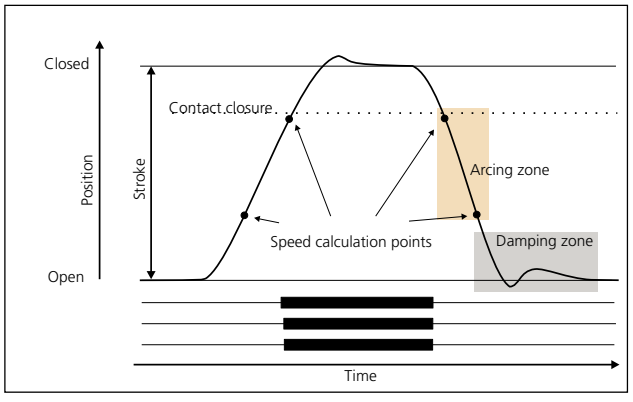
Timing measurements

Simultaneous measurements within a single phase are important in situations where a number of contacts are connected in series. The breaker becomes a voltage divider when it opens a circuit. If the time differences are too great, the voltage becomes too high across one contact, and the tolerance for most types of breakers is less than 2 ms.

The time tolerance for simultaneous measurements between phases is greater for a 3-phase power transmission system running at 50 Hz since there is always 3.33 ms between zero-crossovers. Even so the time tolerance is usually specified as less than 2 ms for such systems. It should also be noted that breakers that perform synchronized breaking must meet more stringent requirements.

There are no generalized time limits for the time relationships between main and auxiliary contacts, but it is important to understand and check their operation. The purpose of an auxiliary contact is to close and open a circuit. Such a circuit might enable a closing coil when a breaker is about to perform a closing operation and then open the circuit immediately after the operation starts, thereby preventing coil burnout.

The "a" contact must close well in advance of the closing of the main contact. The "b" contact must open when the operating mechanism has released its stored energy in order to close the breaker. The breaker manufacturer will be able to provide detailed information about this cycle.



Motion diagram and timing graphs for a close-open operation

Motion measurements

A high-voltage breaker is designed to interrupt a specific short-circuit current, and this is required to operate at a given speed in order to build up an adequate cooling stream of air, oil or gas (depending on the type of breaker). This stream quenches the electric arc sufficiently to interrupt the current at the next zero-crossover. It is important to interrupt the current in such a way that the arc will not re-strike before the breaker contact has entered the so-called damping zone.

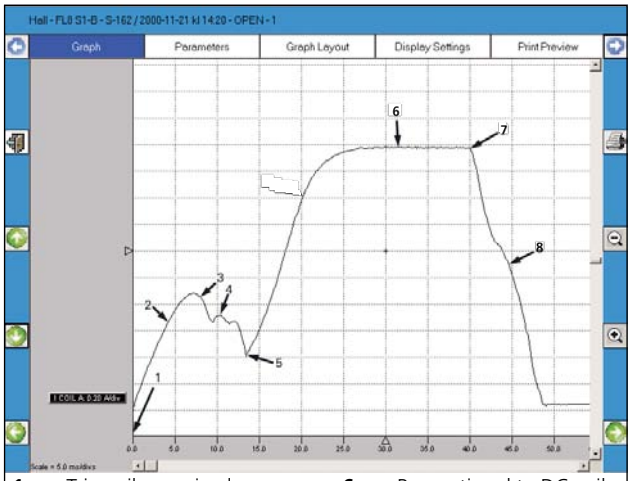
Speed is calculated between two points on the motion curve. The upper point is defined as a distance in length, degrees or percentage of movement from a) the breaker's closed position, or b) the contact-closure or contact-separation point. The lower point is determined based on the upper point. It can either be a distance below the upper point or a time before the upper point. The time that elapses between these two points ranges from 10 to 20 ms, which corresponds to 1-2 zero-crossovers.

The distance throughout which the breaker's electric arc must be extinguished is usually called the arcing zone. From the motion curve, a velocity or acceleration curve can be calculated in order to reveal even marginal changes that may have taken place in the breaker mechanics.

Damping is an important parameter for the high energy operating mechanisms used to open and close a circuit breaker. If the damping device does not function satisfactorily, the powerful mechanical strains that develop can shorten breaker service life and/or cause serious damage. The damping of opening operations is usually measured as a second speed, but it can also be based on the time that elapses between two points just above the breaker's open position.

Coil currents

These can be measured on a routine basis to detect potential mechanical and electrical problems in the actuating coils well in advance of their emergence as actual faults. The coil's maximum



1	Trip coil energized	**6**	Proportional to DC coil resistance
2-5	Armature travel	**7**	Auxiliary contact opens
3-4	Armature operates trip latch	**8**	Current decay
4-5	Armature completes its travel		
5	Armature hits stop		

Example of coil current on circuit breaker

current (if the current is permitted to reach its highest value) is a direct function of the coil's resistance and actuating voltage. This test indicates whether or not a winding has been short-circuited.

When you apply a voltage across a coil, the current curve first shows a straight transition whose rate of rise depends on the coil's electrical characteristic and the supply voltage (points 1-2). When the coil armature (which actuates the latch on the operating mechanism's energy package) starts to move, the electrical relationship changes and the coil current drops (points 3-5). When the armature hits its mechanical end position, the coil current rises to the current proportional to the coil voltage (points 5-7). The auxiliary contact then opens the circuit and the coil current drops to zero with a current decay caused by the inductance in the circuit (points 7-8).

The peak value, of the first lower current peak, is related to the fully saturated coil current (max current), and this relationship gives an indication of the spread to the lowest tripping voltage. If the coil was to reach its maximum current before the armature and latch start to move, the breaker would not be tripped. It is important to note that the relationship between the two current peaks varies, particularly with temperature. This also applies to the lowest tripping voltage.

Dynamic resistance measurement (DRM)

A circuit breaker will have arcing contact wear from normal operation as well as from breaking short-circuit currents. If the arcing contact is too short or in bad condition the breaker soon becomes unreliable. Main contact surfaces can be deteriorated by arcing, resulting in increased resistance, excessive heating and in worst-case explosion.

The main contact resistance is measured dynamically over an open or close operation in DRM. With DRM measurement the arcing contact length can be reliably estimated. The only real alternative to finding the length of the arcing contact is dismantling the circuit breaker.

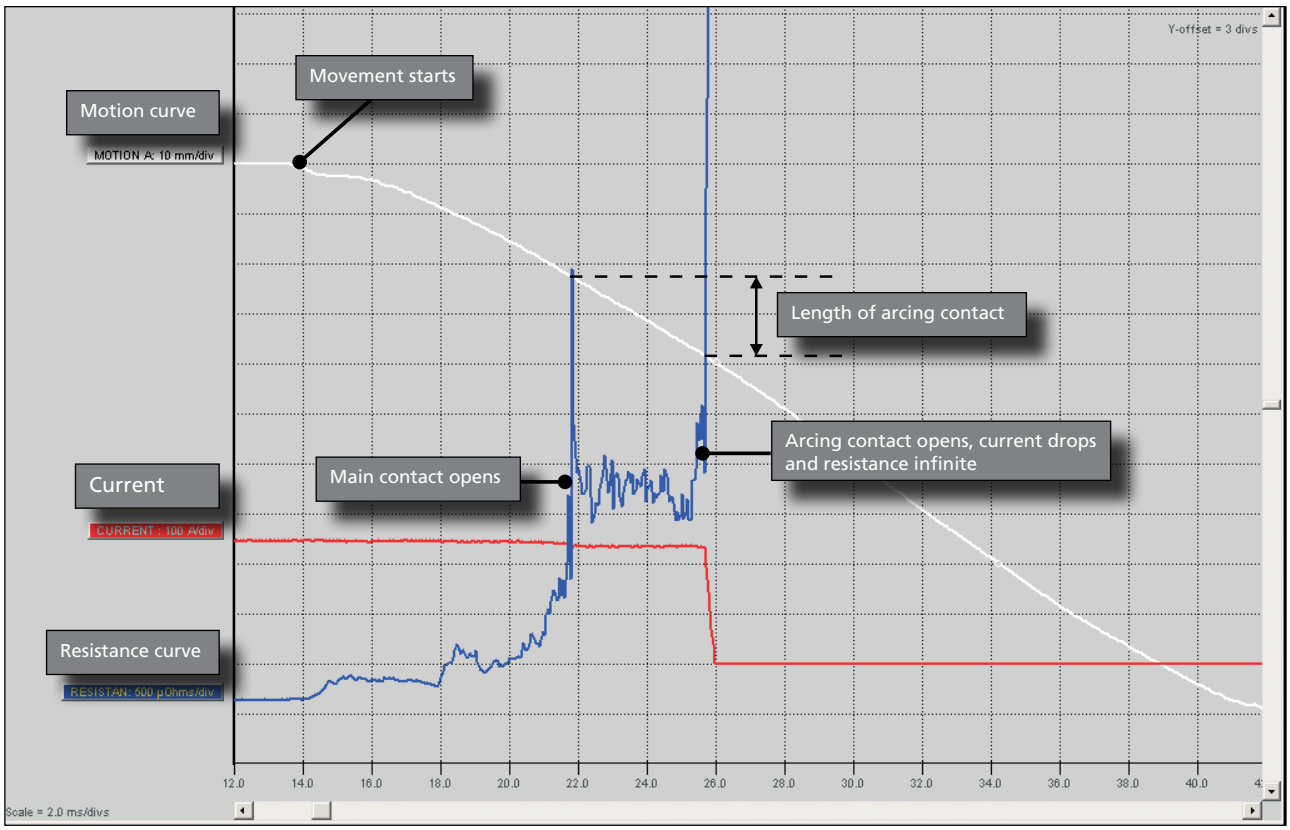
A reliable DRM interpretation requires high test current and a circuit breaker analyzer with good measurement resolution.

Vibration analysis

Vibration analysis is a non-invasive method using an acceleration sensor without moving parts. The breaker can stay in service during the test. An Open-Close operation is all that is required for the measurement. The first operation can be compared to the second and third and will vary due to corrosion and other metal to metal contact issues. Vibration is an excellent method to capture the first operation after long time in the same position.

The analysis compares the vibration time series with a previously recorded reference trace. The vibration method detects faults that can hardly be founded with conventional methods. But if conventional data such as contact time, travel curve, coil current and voltage are available in addition to the vibration data even more precise condition assessment is possible. The vibration data is stored together with available conventional data.

The Vibration method is published in CIGRÉ and IEEE® papers. For about 15 years it has been in the industry for testing all kind of breakers from 400 kV distribution to smaller industrial ones. The method was first established in Scandinavia. Vibration can be performed very safely for the test technician as both sides can be grounded throughout the test. Less climbing is required as no access to the breaker contact system is needed, the acceleration sensor is easily mounted on the breaker.



DRM is a reliable method to estimate the length/wear of the arcing contact. The SDRM202 provides high current and the TM1700 gives an accurate measurement with very good resolution. Besides, it is possible to use DualGround testing.

Specifications TM1700-series

General

Specifications are valid after 30 minutes warm up time.
System time base drift 0.001% per year.
Specifications are subject to change without notice.

Environment

Application field	For use in high-voltage substations and industrial environments
Temperature	
Operating	-20°C to +50°C (-4°F to +122°F)
Storage & transport	-40°C to +70°C (-40°F to +158°F)
Humidity	5% – 95% RH, non-condensing

CE-marking

EMC	2004/108/EC
LVD	2006/95/EC

General

Mains input (nominal)	100 – 240 V AC, 50/60 Hz
Power consumption	200 VA (max)
Dimensions	515 x 173 x 452 mm (20.3" x 6.8" x 17.8")
Weight	12 kg (26.5 lbs)

External input

TRIG IN

Voltage mode

Input range	0 – 250 V AC/DC
Threshold level	User configurable in software in steps of 1 V

Contact mode

Open circuit voltage	30 V DC ±15%
Short circuit current	10 – 40 mA
Threshold level	1 – 2 kΩ

External outputs

DC OUT

General voltage source	12 V ±10%, short circut protection 1.7 A

DRM only for SDRM202 and DRM1800

Voltage mode

Output Voltage	12 V DC ±10%
Short circuit protection	PTC 750 mA
Switching current	<750 mA, resistive load

Communication interfaces

USB	Universal Serial Bus ver. 2.0
Ethernet	100 base-Tx Fast Ethernet

HMI, Human-Machine interface

CABA Local	Circuit breaker analyzing software
Available languages	English, French, German, Spanish, Swedish. Translation kit available
Display	High brightness SVGA 800x600, Touch screen
Diagonal size	21 cm (8")
Keyboard	On screen

Control section (1 or 2)

General

No. of channels	3
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	40 kHz
Measurement time	200 s at 10 kHz sample rate,

Non-bouncing switch

Max current	80 A AC/DC, pulse ≤ 100 ms
Duration	User configurable in steps of 1 ms
Delay	User configurable in steps of 1 ms

Current measurement

Measurement range	0 to ±80 A AC/DC
Resolution	16 bits
Inaccuracy	±2% of reading ±0.1% of range

External current measurement

CT

Max input	±1 V
Scaling	100 A / 1 V
Range	±80 A V / ±0.8 V

Voltage measurement

Measurement range	0 – 250 V AC/DC
Resolution	12 mV
Inaccuracy	±1% of reading ±0.1% of range

Timing M/R section (1)

General

No. of channels	6
Time base inaccuracy	±0.01% of reading ±1 sample interval
Min. resolution	0.05 ms
Max. sample rate	40 kHz
Measurement time	200 s at 20 kHz sample rate

Timing of main and resistive contacts

Open circuit voltage	6 V or 26 V ±10% (Toggling at every second sample)
Short cicuit current	9.7 mA or 42 mA ±10%

Status threshold

Main	Closed < 10 Ω < Open
Main and Resistor	Main < 10 Ω <PIR < 10 kΩ < Open

PIR resistance measurement

Supported PIR types	Linear PIR
Measurement range	30 Ω – 10 kΩ
Inaccuracy	±10% of reading ±0.1% of range

Voltage measurement

Measurement ranges	±50 V_{peak}, ±15 V_{peak}, ±0.5 V_{peak}
Resolution	16 bits
Inaccuracy	±1% of reading ±0.1% of range

Analog section (none, 1 or 2)

General

No. of channels	3 isolated channels
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	40 kHz
Measurement time	200 s at 10 kHz sample rate
Transducer resistance	500 Ω – 10 kΩ at 10 V output

Output

Voltage output	10 V DC ±5%, 24 V DC ±5%
Max. output current	30 mA

Current measurement

Measurement range	±22 mA
Resolution	16 bits
Inaccuracy	±1% of reading ±0.1% of range

Voltage measurement

Input voltage range	0 – 250 V AC/DC
Measurement ranges	±10 V DC, 0 – 250 V AC/DC
Resolution	16 bits
Inaccuracy	
250 V range	±1% of reading ±0.1% of range
10 V range	±0.1% of reading ±0.01% of range

Digital section

General

No. of channels	6
Supported types	Incremental transducers, RS422
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	40 kHz
Measurement time	200 s at 10 kHz sample rate

Output

Voltage	5 V DC ±5% or 12 V DC ±5%
Max. output current	200 mA

Digital input

Range	±32000 pulses
Resolution	1 pulse
Inaccuracy	±1 pulse

Timing Aux section

General

No. of channels	6 isolated channels
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	40 kHz
Measurement time	200 s at 10 kHz sample rate

Voltage Mode

Input voltage range	0 – ±250 V AC/DC
Status threshold	±10 V
Inaccuracy	±0.5 V

Contact mode

Open circuit voltage	25 – 35 V
Short circuit current	10 – 30 mA
Status threshold	Closed < 100 Ω, Open > 2 kΩ

Optional accessories

Item	Description	Art. No.
Software and application kits		
CABA Win – Circuit Breaker analysis software		
CABA Win	incl. Ethernet cross-over cable	CG-8000X
CABA Win upgrade	Upgrade to latest version	CG-8010X
Vibration analysis		
Vibration kit	The Vibration kit extends TM1800 and CABA Win with the equipment and software required for recording and analyzing vibration signals at a circuit breaker. The kit includes the signal conditioning unit SCA606, the software CABA Win Vibration and one vibration channel. The vibration solution can be extended up to 6 channels.	BL-13090
Vibration channel	Additional vibration channel to be used together with the Vibration kit. Each Vibration channel includes accelerometer, accelerometer adapter, cables to SCA606 and cables to TM1700-series.	XB-32010
Synchronized Switching Relay test kit		
SSR kit	Incl. accessories, software and cables (delivered in transport case)	CG-91200
1:st trip kits	For single operating mechanism	BL-90700
	For three operating mechanisms	BL-90710
DCM (Dynamic Capacitance Measurement)		
DCM1700	The DCM1700 is used for timing using the DualGround™ method. Safe testing with both sides grounded.	
DCM1700 3 ch	Kit for 3-channels DualGround™ Timing	BL-59190
DCM1700 6 ch	Kit for 6-channels DualGround™ Timing	BL-59192
SDRM (Static and Dynamic Resistance Measurement)		
SDRM202	The SDRM202 uses new technology, patent pending, with ultra capacitors. The current output is up to 220 A from a box that weighs only 1.8 kg (4 lbs). The weight of the current cables is also low because the SDRM202 is placed very close to the circuit breaker. Timing M/R measurement can be done with the same hook-up	CG-90200
SDRM202 Pack of 3 units	Pack for CB with 2 Breaks / Phase	CG-90230
Extension cable SDRM202	7.5 m (24 ft)	GA-12815
	10 m (33 ft)	GA-12810
Transducers		
Linear – Analog		
TLH 500	500 mm (20") travel Incl. cable 0.5 m (20")	XB-30020
LWG 225	225 mm (9") travel Incl. cable 0.5 m (20")	XB-30117
TS 150	150 mm (5.9") travel Incl. cable 1.0 m (3.3 ft)	XB-30030

Item	Description	Art. No.
TS 25	25 mm (1") travel Incl. cable 1.0 m (3.3 ft)	XB-30033
Linear – Digital		
TP1 300	300 mm (11.8") travel Incl. cable 10 m (33 ft)	XB-39140
TP1 500	500 mm (17.7") travel Incl. cable 10 m (33 ft)	XB-39150
Link	300 mm (11.8") for position marker	XB-39193
The above transducers are also available in other lengths, please contact Megger for information.		
Rotary - Analog		
Novotechnic IP6501	Incl. cable 1 m (3.3 ft), 6 mm Flex coupling, Hexagon wrench	XB-31010
Flex coupling	For IP6501, shaft diam. 6 mm	XB-39030
Rotary – Digital		
Baumer	BDH16.05A3600-LO-B Incl. cable 10 m (33 ft), 10/6 mm Flex coupling, Hexagon wrench	XB-39130
Transducer mounting kits		
Universal kits		
Rotary transducer mounting kit	For transducers XB-31010 and XB-39130	XB-51010
Universal transducer mounting kit	For linear and rotary transducers	XB-51020
Circuit breaker specific kits		
LTB Kit (ABB)	Incl. mounting kit XB-51010, Software conversion table BL-8730X	XB-61010
HPL/BLG Kit (ABB)	Incl. mounting kit XB-51010, Software conversion table BL-8720X	XB-61020
AHMA 4/8 (ABB)	Incl. 3 transducers	XB-61030
HMB 4/8 (ABB)	Incl. 3 transducers	XB-61040
Ready-to-use kits – Rotary – Analog		
1-phase kit	Incl. transducer XB-31010, mounting kit XB-51010	XB-71010
3-phase kit	Incl. 3 x 1-pase kits XB-71010	XB-71013
Ready-to-use kits – Rotary – Digital		
1-phase kit	Incl. transducer XB-39130, mounting kit XB-51010	XB-71020
3-phase kit	Incl. 3 x 1-pase kits XB-71020	XB-71023
Transducer mounting accessories		
Universal support		XB-39029
Switch magnetic base		XB-39013
Thread adapter kit	Metric to Imperial TLH / TP1	XB-39036
Cables		
DCM 3-channel addition	3 DCM cables, 12 m (39 ft, 6 clamps (DualGround timing)	CG-19180
DCM 3-channel extension cable	3 DCM extension cables, 10 m (33 ft) GA-00999 (DualGround timing)	CG-19181

Item	Description	Art. No.
Cable reel 20 m (65.5 ft), 4 mm stackable safety plugs	Black	GA-00840
	Red	GA-00842
	Yellow	GA-00844
	Green	GA-00845
	Blue	GA-00846
Extension cables, XLR female to male	For analog input, 10 m (33 ft)	GA-01005
	For Timing M/R modules, 10 m (33 ft)	GA-00851
Open analog cable	For customized analog transducer connection	GA-01000
XLR to 4 mm safety plugs	For customized analog transducer connection	GA-00040
Digital transducer extension cable	RS422, 10 m (33 ft)	GA-00888
Open digital cable	For customized digital transducer connection	GA-00885
L & L digital cable	For using Leine & Linde 530 digital transducer	GA-00890
Baumer digital cable	For using Baumer digital transducer	GA-00895
Doble cable	Adapter for Doble transducer	GA-00867
Siemens cable	Adapter for Siemens transducer	GA-00868
Vanguard cable	Adapter for Vanguard transducer	GA-00869
TP1	Digital cable	GA-00889
Ethernet cable, network	Cable for connection to network/ LAN	GA-00960
Other		
LTC135	Load Tap Changer power supply	CG-92100
Current sensor	Current sensor kit 1 channel (Fluke 80i-110s incl. cable GA-00140)	BL-90600
	Current sensor kit 3 channels (Fluke 80i-110s incl. cables GA-00140)	BL-90610
Transport case		GD-00025
Cable organizer	Velcro straps, 10 pcs.	AA-00100

For more information about optional accessories please contact Megger Sweden AB

Rotary transducer, Novotechnic IP6501 (analog)

Rotary transducer, Baumer BDH (digital)

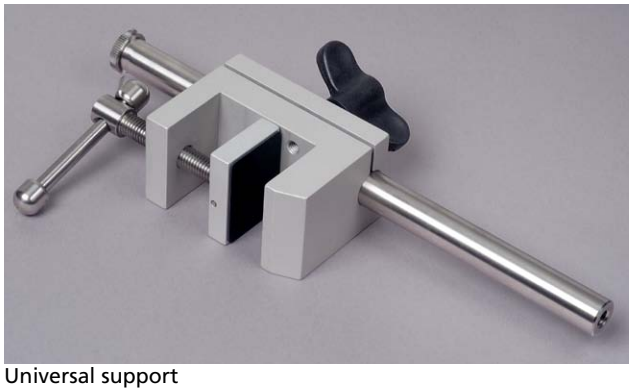
Linear transducer, LWG 150

Vibration kit, BL-13090 Includes: SCA606, CABA Win Vibration software and one Vibration channel

Linear transducer, TS 25

Switch magnetic base

Linear transducer, TLH 225



Universal support

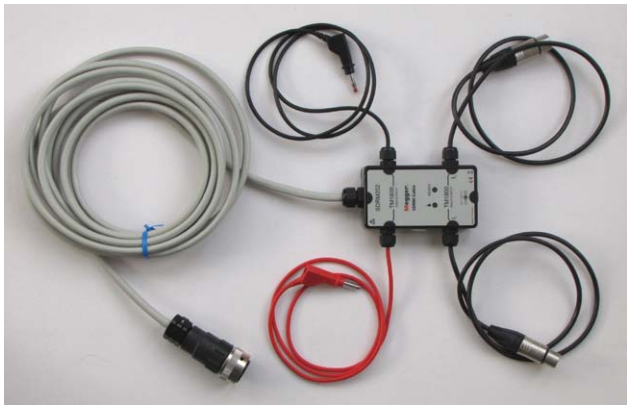
Linear transducer, **TP1 300** (digital)

Rotary transducer mounting kit, XB-51010

Cable reels, 20 m (65.5 ft), 4 mm stack-able safety plugs

SDRM202

LTC135, Load Tap Changer power supply



SDRM Cable

Cable XLR, GA-00760

Extension cable XLR, GA-01005

DCM1700, for timing using the DualGround™ method. Safe testing with both sides grounded.

TM1700 – Models

TM1710

Including:
- Control 3 ch. (Auxiliary 3 ch.)
- Timing M/R 6 ch.
- Digital 6 ch.
- CABA Win

Optional:
- Analog 3 ch., DCM 6 ch.

TM1720

Including:
- Control 6 ch. (Auxiliary 6 ch.)
- Auxiliary 6 ch.
- Timing M/R 6 ch.
- Digital 6 ch.
- CABA Win

Optional:
- Analog 3 ch., DCM 6 ch.

TM1750

Including:
- Control 6 ch. (Auxiliary 6 ch.)
- Auxiliary 6 ch.
- Timing M/R 6 ch.
- Digital 6 ch.

Optional:
- Analog 3 ch., DCM 6 ch.

TM1760

Including:
- Control 6 ch. (Auxiliary 6 ch.)
- Auxiliary 6 ch.
- Timing M/R 6 ch.
- Digital 6 ch.
- Analog 3

Optional:
- Analog 3 ch., DCM 6 ch.

Ordering information

Item	Art. No.
TM1710	BL-49090
With Analog option incl. analog cables	BL-49092
TM1720	BL-49094
With Analog option incl. analog cables	BL-49096
TM1750	BL-59090
With Analog option incl. analog cables	BL-59092
TM1760	BL-59094
With Analog option incl. analog cables	BL-59096

Included accessories

Soft case
Test cables and clamps
Protective earth (ground) cable
Mains cable
Bag for cables
USB memory stick
Ethernet cable
CABA Win
User's manual

Optional accessories

DCM1700 3 ch Kit for 3-channels DualGround™ Timing	BL-59190
DCM1700 6 ch Kit for 6-channels DualGround™ Timing	BL-59192
Keyboard	HC-01090
Flight Case TM1700-series	GD-00025

NEW Accessories

Digital Linear Transducer

TP1 300	XB-39140
TP1 500	XB-39150

Circuit breaker transducer kits

AHMA 4/8 (ABB)	XB-61030
HMB 4/8 (ABB)	XB-61040

First trip kits

For single operating mechanism	BL-90700
For three operating mechanisms	BL-90710
LTC135 Load Tap Changer power supply	

ITEM 17

TM1800
Circuit Breaker Analyzer System

- **Stand-alone functionality – one toolbox for all breaker testing**
- **Expandable modular concept**
- **Safer testing – DualGround™, test circuit breakers with both sides grounded**
- **Designed for off-line and on-line measurement**
- **Rugged and reliable for field use**

Description

The TM1800™ is the instrument platform for circuit breaker maintenance, based on more than 20 years' experience of over 4,000 delivered breaker analyzers. The modular construction makes it possible to configure the TM1800 for measurements on all known types of circuit breakers in operation on the world market.

The robust design contains powerful technology that streamlines circuit breaker testing. Sophisticated measurement modules enable great time savings as many parameters can be measured simultaneously, eliminating the need for new setup each time.

The patented DualGround™ testing using the new DCM module makes the testing safe and time saving, by keeping the circuit breaker grounded on both sides throughout the test. The DCM module uses a measuring technology called Dynamic Capacitive Measurement.

Timing M/R is using the patented Active Interference Suppression to obtain correct timing and accurate PIR (Pre-Insertion Resistor) values in high voltage substations.

An adaptive, easy-to-use software suite supports activities from timing, simply turning a knob without the need for presetting, to advanced help functions for hooking up to the test object. A full keyboard and 8" color screen is the front end of the high-level user interface. The Select-Connect-Inspect workflow guides you to fast results in three steps. Testing is made easier to learn and perform.

The system also offers full connection capability to the local network, printers etc.

Testing with DualGround

Electricity deregulation changes the business environment for utilities, switchgear owners and service companies. Deregulation has been shown to lead directly to increased emphasis on efficiency of operations, maintenance and service levels. Internationalization of business brings new challenges: substantial investments by global corporations will bring with them sharper or new requirements for increased emphasis on health, safety and environmental compliance. Experience has also shown demands for shorter time periods for testing, while the switchgear is less and less available to be taken out of service.

The safety aspect

Network operators and service companies need to maintain and develop their industry safety record. Eminent International bodies including the IEEE® and IEC®, National Safety agencies and Trade Unions increases the demands on safety. During the deregulation applicable safety regulations have been clarified and the application of existing rules has tightened. Keeping a good safety record is becoming a crucial asset in attracting investors and customers.

In all substations the capacitive coupling from live high voltage conductors induce harmful/lethal currents in all parallel conductors. Grounding both sides of the test object will lead the induced current to earth and provide a safe area for the test personnel. See figures below.

Both sides grounded

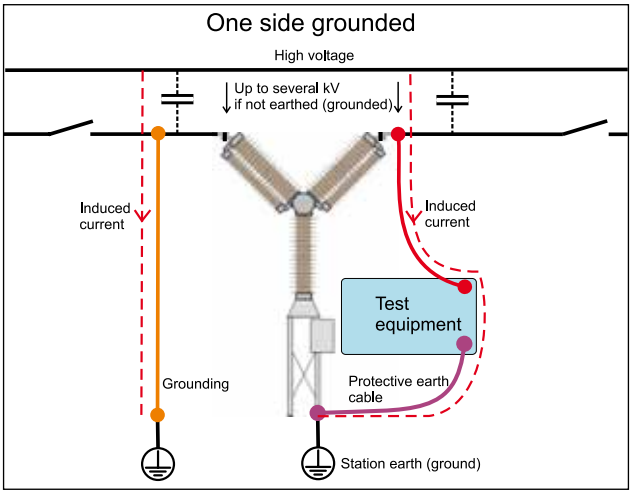
The best way to provide safety in circuit breaker testing is to keep both sides of the circuit breaker grounded throughout the test. This will also make the test faster and easier.

Minimum time shall be spent in the substation and focus shall be on the test rather than the equipment.

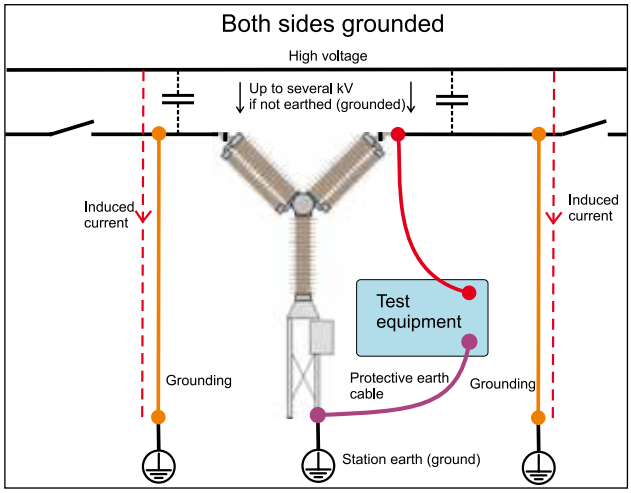
The DualGround™ testing method is available for all tests on all circuit breakers.

Equipment and methods that support DualGround™ testing are associated with the DualGround symbol. This symbol certifies the use of ground-breaking technology and methods that enable a safe, fast and easy workflow with both sides grounded throughout the test.

Contact resistance	**MJÖLNER / SDRM202**
Timing	**TM1800 with DCM**
Motion	**TM1800**
DRM	**TM1800 with SDRM202**
Vibration	**CABA Win Vibration / SCA606**



With only one side grounded the induced current can reach values high enough to be harmful or lethal for humans.



Testing is much safer using the DCM module and DualGround.

Conventional	vs. DualGround
Site preparation (isolate work area, apply safety ground, issue permit to work)	Site preparation (isolate work area, apply safety ground, issue permit to work)
Hook up test equipment. Issue sanction for test	Hook up test equipment. Issue sanction for test
Authorised person removes the ground	Risky step left out
Perform testing	Safe testing with both sides grounded
Authorised person applies ground	Risky step left out
Cancel sanction for test. Disconnect test equipment	Cancel sanction for test. Disconnect test equipment
Site closing (cancel permit to work, disconnect ground)	Site closing (cancel permit to work, disconnect ground)

Basic unit

The modularized design makes it very flexible to user needs and enables reconfiguration for new demands and upgrade with new functionality. You can configure TM1800 to a complete test set tailor made for your specific needs. The firmware, CABA Local, guides you to efficient circuit breaker testing.

All inputs and outputs on the TM1800 and the modules are designed to withstand the harsh environment in high-voltage substations and industrial environments.

With built-in protection circuits and software-designed protection the TM1800 has a good guard to influences and even failures caused by over-voltages generated in the environment.

The HDD module is a part of the basic unit and contains the hard drive with all data and software setup. It can easily be removed and changed.

- Eight user configurable slots for modules
- Temperature sensor connection
- Trig inputs and outputs
- Outputs for warning signal and DRM
- Earth (Ground) connection
- Communication interfaces (USB, Ethernet, etc)

The basic unit is only equipped with the HDD module. Add modules to the configuration that supports your needs.

Control module

Generates the selected circuit breaker operation sequences accurate and bounce-less. The Control module, with 9 analog channels (3 U + 6 I), also measures important parameters during the test. Coil current, control voltage, coil resistance and auxiliary contact timing are automatically measured for each phase without any additional test lead connections.

- Three independent contact functions per module
- Pre-programmed sequences C, O, C–O, O–C, O–C–O
- Timing of a and b auxiliary contacts
- Coil current, voltage and resistance

Including
3 cable sets, 5 m (16 ft)

Accessories
Standard cable sets are used as extension cables: GA-00877

Timing M/R module

The Timing M/R module uses one hook-up for testing all the important timing parameters of a contact without the need of reconnection or special set-ups. One timing M/R module, with 12 analog channels (6 U + 6 I), will time up to six main plus six PIR contacts and measure values of the Pre-Insertion Resistors. With the same hook-up Timing M/R can also perform static and dynamic resistance measurements (using SDRM202). The Timing M/R module is using patented Active Interference Suppression to obtain correct timing and accurate PIR values regardless of interference in high voltage substations.

- Six inputs per module
- High resolution 15µV and up to 40 kHz sampling
- Main and parallel resistor contact timing
- Resistance value of parallel resistors

Including
3 cable sets, 5 m (16 ft) total length, 2 m (6.5 ft) spread

Accessories
Extension cable,
10 m (33 ft): GA-00851

DCM module

The DCM module enables DualGround testing. This increases safety and also makes testing easier. Each pair of a Timing M/R and DCM module provides up to six channels. Each channel requires a special DCM cable with integrated electronics. The TM1800 system can be equipped with multiple DCM and Timing M/R module pairs that enable timing measurement on up to 18 contacts.

- Six channels per module
- Timing test using DualGround
- Safe, fast and easy testing
- Two breaks per phase
- GIS breaker testing

Including
DCM-cables, 12 m (39 ft)

Accessories
3-channel addtion: CG-19180
Extension cables,
10 m (33 ft): GA-00998

See Accessories pages for more details.

Analog module

The Analog module measures any analog entity from a transducer mounted on a circuit breaker. It enables measurements of motion, speed, current, voltage, pressure, vibration etc. A motion measurement of a circuit breaker is simple thanks to the flexible and easy to use interface. Universal transducers, specialized transducers and conversion tables are available for numerous circuit breakers. See the accessory section.

- Three channels per module
- Supports industrial analog transducers
- Insulated channels, measure up to 250 V whithout volt. div.
- High resolution 0.3 mV, sampling rate 40 kHz

Including
3 cable sets, 10 m (33 ft)

Accessories
Extension cables,
10 m (32.8 ft): GA-01005
Transducers (analog)
Currens sensor

See Accessories pages for more details.

Digital module

With digital transducers motion and other measurements become even more accurate, faster and easier. The Digital module enables use of incremental rotary or linear transducers, for measuring e.g. motion, velocity and damping characteristics of circuit breakers

- Six channels per module
- Incremental transducers with RS422
- Up to ±32000 pulses resolution
- Up to 20 kHz sampling

Accessories
Transducers (rotary digital)

See Accessories pages for more details.

Timing Aux module

Expands the TM1800 system with timing inputs for measuring any auxiliary contact on the circuit breaker. It measures timing, polarity insensitive, of both dry and wet contacts for example timing of spring charging motor, anti-pump relay etc.

- Six channels per module
- Polarity insensitive
- Dry and wet auxiliary contacts

Including
3 cable sets, 5 m (16 ft)

Accessories
Standard cable sets are used as extension cables: GA-00870

Printer module

The Printer module offers a convenient and practical way of making printouts of test results in the field. The printouts contain both numerical and graphical results and printer templates delivered pre-installed in the TM1800 are easy to adapt to suit specific needs for a clear and complete report of all tested parameters.

- Thermal printer sensitive line dot method
- Paper width 114 mm (4")
- Printing speed 50 mm/s (400 dot lines/s)

Including
Paper spool (Thermopaper)

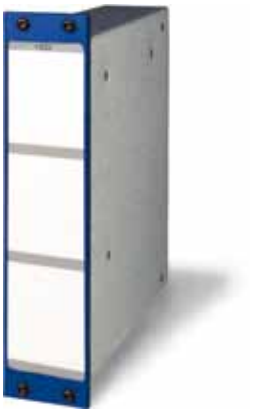
Accessories
Thermopaper: GC-00040

See Accessories pages for more details.

HDD module

The HDD module is a part of the Basic unit. Storage of all set-up, user customization and measurement data is done in the HDD module. The module is easily replaced e.g. when different users are sharing one TM1800 and want individual setups, data and configurations.

- Change set-up, user customization, measurement data by changing HDD module
- Easy to remove during transportation



Application

Timing measurements

Simultaneous measurements within a single phase are important in situations where a number of contacts are connected in series. Here, the breaker becomes a voltage divider when it opens a circuit. If the time differences are too great, the voltage becomes too high across one contact, and the tolerance for most types of breakers is less than 2 ms.

The time tolerance for simultaneous measurements between phases is greater for a 3-phase power transmission system running at 50 Hz since there is always 3.33 ms between zero-crossovers. Still, the time tolerance is usually specified as less than 2 ms, even for such systems. It should also be noted that breakers that perform synchronized breaking must meet more stringent requirements in both of the previously stated situations.

There are no generalized time limits for the time relationships between main and auxiliary contacts, but it is still important to understand and check their operation. The purpose of an auxiliary contact is to close and open a circuit. Such a circuit might enable a closing coil when a breaker is about to perform a closing operation and then open the circuit immediately after the operation starts, thereby preventing coil burnout.

The "a" contact must close well in advance of the closing of the main contact. The "b" contact must open when the operating mechanism has released its stored energy in order to close the breaker. The breaker manufacturer will be able to provide detailed information about this cycle.

Motion measurements

A high-voltage breaker is designed to interrupt a specific short-circuit current, and this requires operation at a given speed in order to build up an adequate cooling stream of air, oil or gas (depending on the type of breaker). This stream cools the electric arc sufficiently to interrupt the current at the next zero-crossover. It is important to interrupt the current in such a way that the arc will not re-strike before the breaker contact has entered the so-called damping zone.

Speed is calculated between two points on the motion curve. The upper point is defined as a distance in length, degrees or percentage of movement from a) the breaker's closed position, or b) the contact-closure or contact-separation point. The time that elapses between these two points ranges from 10 to 20 ms, which corresponds to 1-2 zero-crossovers.

The distance throughout which the breaker's electric arc must be extinguished is usually called the arcing zone. From the motion curve, a velocity or acceleration curve can be calculated in order to reveal even marginal changes that may have taken place in the breaker mechanics.

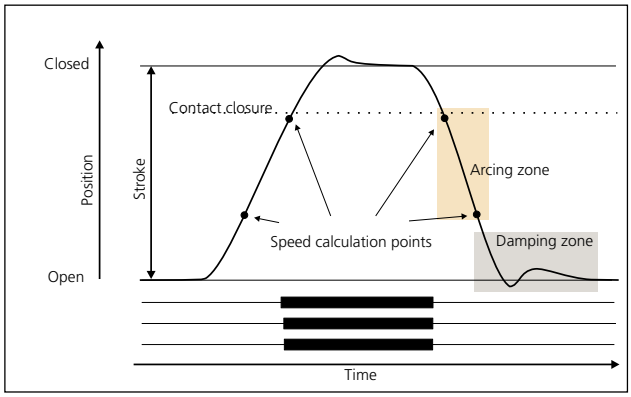
Damping is an important parameter for the high energy operating mechanisms used to open and close a circuit breaker. If the damping device does not function satisfactorily, the powerful mechanical strains that develop can shorten breaker service life and/or cause serious damage. The damping of opening operations is usually measured as a second speed, but it can also be based on the time that elapses between two points just above the breaker's open position.

Coil currents

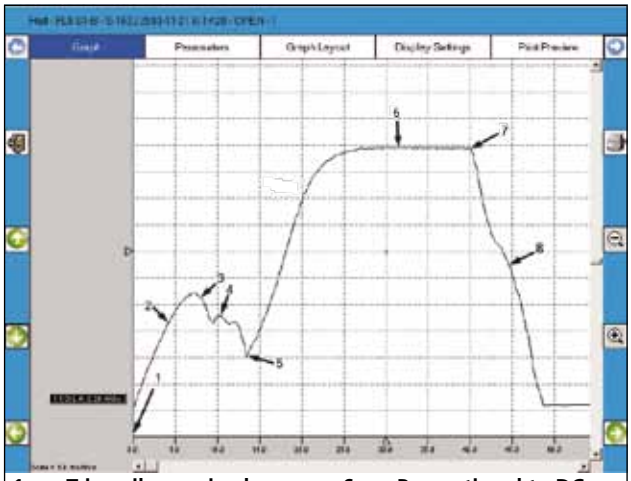
These can be measured on a routine basis to detect potential mechanical and/or electrical problems in actuating coils well in advance of their emergence as actual faults. The coil's maximum current (if current is permitted to reach its highest value) is a direct function of the coil's resistance and actuating voltage. This test indicates whether or not a winding has been short-circuited.

When you apply a voltage across a coil, the current curve first shows a straight transition whose rate of rise depends on the coil's electrical characteristic and the supply voltage (points 1-2). When the coil armature (which actuates the latch on the operating mechanism's energy package) starts to move, the electrical relationship changes and the coil current drops (points 3-5). When the armature hits its mechanical end position, the coil current rises to the current proportional to the coil voltage (points 5-7). The auxiliary contact then opens the circuit and the coil current drops to zero with a current decay caused by the inductance in the circuit (points 7-8).

The peak value, of the first lower current peak, is related to the fully saturated coil current (max current), and this relationship gives an indication of the spread to the lowest tripping voltage. If the coil was to reach its maximum current before the armature and latch start to move, the breaker would not be tripped. It is important to note, however, that the relationship between the two current peaks varies, particularly with temperature. This also applies to the lowest tripping voltage.



Motion diagram and timing graphs for a close-open operation



1	**Trip coil energized**	**6**	**Proportional to DC coil resistance**
2-5	**Armature travel**	**7**	**Auxiliary contact opens**
3-4	**Armature operates trip latch**	**8**	**Current decay**
4-5	**Armature completes its travel**		
5	**Armature hits stop**		

Example of coil current on circuit breaker

Dynamic resistance measurement (DRM)

A circuit breaker will have arcing contact wear by normal operation as well as when breaking short-circuit currents. If the arcing contact is too short or otherwise in bad condition, then the breaker soon becomes unreliable. Main contact surfaces can be deteriorated by arching, resulting in increased resistance, excessive heating and in worst-case explosion.

The main contact resistance is measured dynamically over an open or close operation in DRM. With DRM measurement the arcing contact length can be reliably estimated. The only real alternative in finding the length of the arcing contact is dismantling the circuit breaker.

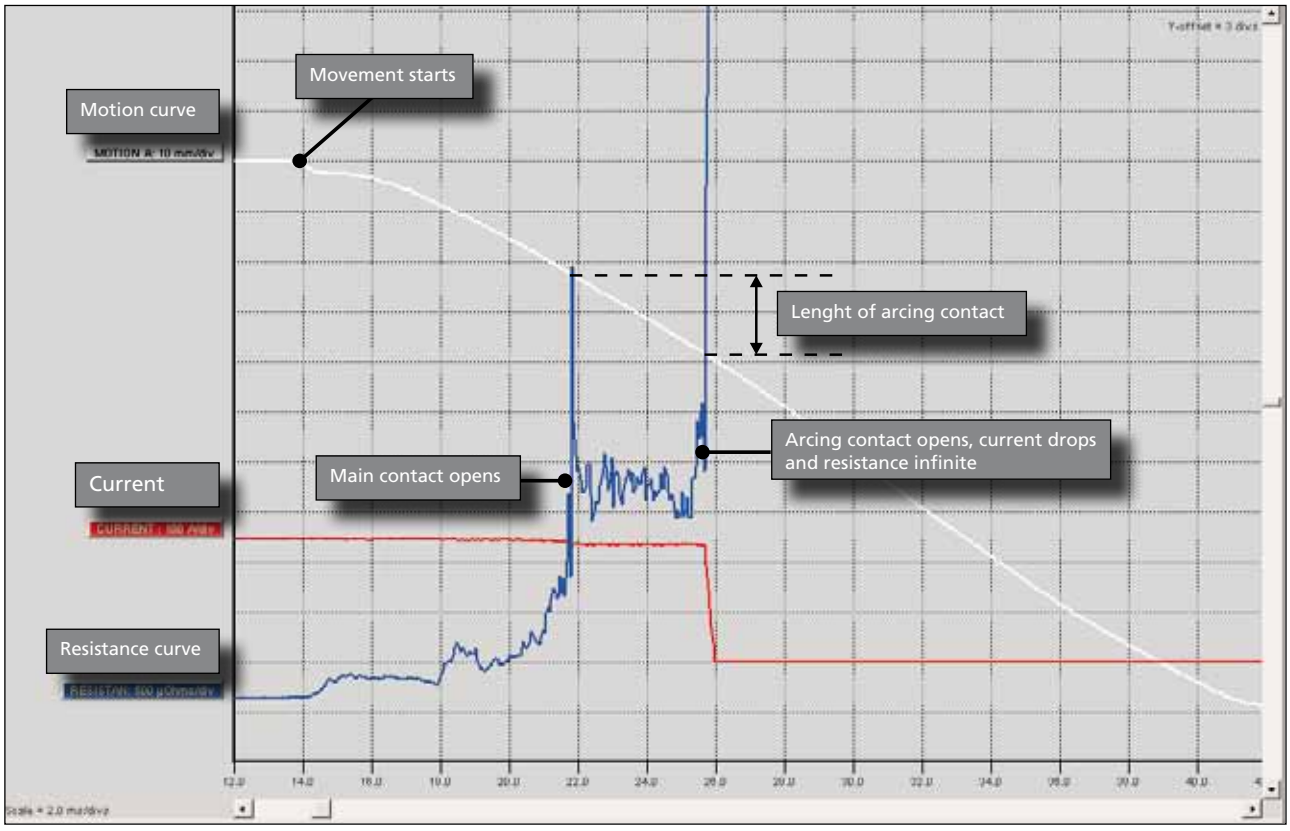
A reliable DRM interpretation requires high test current and a circuit breaker analyzer with good measurement resolution.

Vibration analysis

Vibration analysis is a noninvasive method using an acceleration sensor without moving parts. The breaker can stay in service during the test. An Open-Close operation is all that is required for the measurement. The first operation can be different compared to the second and third because of corrosion and other metal to metal contact issues. Vibration is an excellent method to capture the first operation after long time in the same position.

The analysis compares the vibration time series with earlier taken reference. The vibration method detects faults that can hardly be indicated with conventional methods. But if conventional data such as contact time, travel curve, coil current and voltage are available in addition to the vibration data even more precise condition assessment is possible. The vibration data is stored together with available conventional data.

The Vibration method is published in CIGRÉ and IEEE® papers. Since about 15 years is it utilized in the industry for testing all kind of breakers from 400 kV distribution to industrial sites. The method was first established on the Scandinavian market. Vibration can be performed under very safe manners for the test technician as both sides can be grounded throughout the test. Also less climbing is required since no access to the breaker contact system is needed, the acceleration sensor is easily mounted on the breaker.



DRM is a reliable method to estimate the length/wear of the arcing contact. The SDRM202 provides high current and the TM1800 gives an accurate measurement with very good resolution. Besides, it is possible to use DualGround testing.

Select – Connect – Inspect

Working with TM1800 means fast and easy testing. Testing is done with a three-step process.

First step is to select a suitable template from the template library depending on number of contacts per phase, motion or not, resistor contacts and more.

Second step is to connect the test leads according to the graphical help screen.

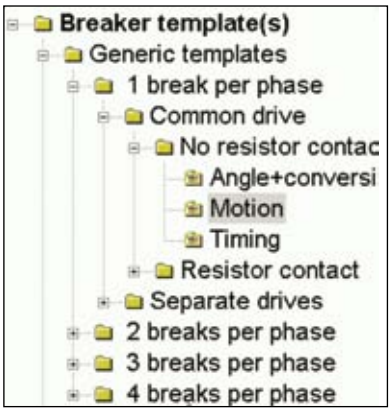
Third step is to turn the "Measure" knob. The measurement is performed, analyzed and the results will be displayed on the screen. Magnification and compare functions are available.

For more advanced setup there is still the opportunity to control all the details in the measurement. The large number of general purpose templates cover most circuit breakers found around the world. It is also possible to select a tailor made template with special adaptions. You can edit templates yourself or with assistance from our customer support. This is a very powerful tool to customize TM1800 for fast and easy work according to your needs in every detail. Increase the level of detail as you learn.

After the test it is possible to print a test report, either from the TM1800 printer module or using CABA Win on a PC. With CABA Win you can make a more advanced analysis of the data. CABA Win is also the archive for common test data and interface to CBEX. With CBEX the test is stored in a database.

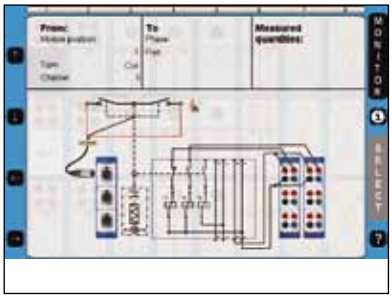
Select

Select the template suitable for the test and circuit breaker from the library.



Connect

Connect test leads and cables according to display. Separate help screen per cable.



Inspect

Turn the knob and the measurement is displayed on the screen ready for inspection.

Application examples

6 Timing and 3 Motion

Circuit breaker: Any CB with two contacts per phase and separate drives

TM1800 configuration: TM1800 Expert

1. **Select** breaker template: Generic templates / 2 breaks per phase / Separate drives / Two Control modules / No resistor contact / Motion
2. **Connect** cables according to "Analyzer view" in CABA Local. Turn the OPERATE/MEASURE knob.
3. **Inspect** the result on screen.

Note:
Coil current and auxiliary contacts are measured and displayed automatically.

If TM1800 is configured with a DCM module the test can be made using DualGround.

Specifications TM1800

General

Specifications are valid after 30 minutes warm up time.
System time base drift 0.001% per year.
Specifications are subject to change without notice.

Environment

Application field	For use in high-voltage substations and industrial environments
Temperature	
Operating	0°C to +50°C (32°F to +122°F)
Storage & transport	-55°C to +70°C (-67°F to +158°F)
Humidity	5% – 95% RH, non-condensing

CE-marking

EMC	EMC Directive 89/336/EEC am. by 91/263/EEC, 92/31/EEC and 93/68/EEC
LVD	Low Voltage Directive 73/23/ EEC am. by 93/68/EEC

Basic unit

General

Mains input (nominal)	100 – 240 V AC, 50/60 Hz
Power consumption	250 VA (max)
Dimensions	515 x 173 x 452 mm (20.3" x 6.8" x 17.8")
Weight	11.5 kg (25.4 lbs)

HDD module

Weight	0.6 kg (1.3 lbs)
Temperature, storage	-55°C to +70°C (-67°F to +158°F)

External input

TRIG IN

Voltage mode

Input range	0 – 250 V AC/DC
Threshold level	User configurable in software in steps of 1 V

Contact mode

Open circuit voltage	35 V DC ±20%
Short circuit current	10 – 40 mA
Threshold level	1 – 2 kΩ

External outputs

TRIG OUT

Pulse duration	1 – 999 ms, user configurable in steps of 1 ms

Voltage mode

Open circuit voltage	12 V DC ±5%
Voltage at 0.5 A	9 V DC ±10%
Max. short circuit current	1.5 A

Contact mode

Max. switching current	0.5 A at 12 V and resistive load
Voltage drop at 0.5 A	4.5 V DC ±10%
Max. short circuit current	1.5 A

DRM only for SDRM202 and DRM1800

WARNING

Relay	For lamp or horn
Pre-operation warning	0 – 999 s, user configurable in steps of 1 s

Voltage mode

Output Voltage	12 V DC ±10%
Short circuit protection	Fuse 1 A DC fast acting type (F1H250V)

Contact mode

Max. switching currrent	1 A at 12 V and resistive load

Communication interfaces

USB	Universal Serial Bus ver. 1.1
Ethernet	100 base-Tx Fast Ethernet
External screen	SVGA, up to 800 x 600 at 24 bit color, 32 MB SDRAM

HMI, Human-Machine interface

CABA Local	Circuit breaker analyzing software
Available languages	English, French, German, Spanish, Swedish. Translation kit available
Display	Transreflecting to increase visibility in direct sunlight
Diagonal size	21 cm (8")
Keyboard	Built-in

Modules

Control module

General

No. of channels	3
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	10 kHz
Measurement time	19 s at 10 kHz sample rate, 39 s at 5 kHz sample rate, 200 s at 10 kHz sample rate using data compression
Weight	1.0 kg (2.2 lbs)

Non-bouncing switch

Max current	60 A AC/DC, pulse ≤ 100 ms
Fuse	15 A DC
Duration	User configurable in steps of 1 ms
Delay	User configurable in steps of 1 ms

Current measurement

Measurement range	0 – 60 A AC/DC
Resolution	16 bits (15 bits at data compression)
Inaccuracy	±2% of reading ±0.1% of range

Voltage measurement

Measurement range	0 – 250 V AC/DC
Resolution	20 mV (40 mV at data compression)
Inaccuracy	±1% of reading ±0.1% of range

Timing M/R module

General

No. of channels	6
Time base inaccuracy	±0.01% of reading ±1 sample interval
Min. resolution	0.05 ms
Max. sample rate	40 kHz
Measurement time	16 s at 20 kHz sample rate, 32 s at 10 kHz sample rate, 200 s at 10 kHz sample rate using data compression Data compression is available at sample rates up to 20 kHz
Weight	0.8 kg (1.8 lbs)

Timing of main and resistive contacts

Open circuit voltage	6 V or 26 V ±10% (Toggling at every second sample at sample rates from 10 kHz and upwards.)
Short cicuit current	9.7 mA or 42 mA ±10%
Status threshold	
Main	Closed < 10 Ω < Open
Main and Resistor	Main < 10 Ω <PIR < 10 kΩ < Open

PIR resistance measurement

Supported PIR types	Linear PIR
Measurement range	10 Ω – 10 kΩ
Inaccuracy	±10% of reading ±0.1% of range

Voltage measurement

Measurement ranges	±50 V_{peak}, ±15 V_{peak}, ±0.5 V_{peak}
Resolution	16 bits
Inaccuracy	±1% of reading ±0.1% of range

DCM module

General

No. of channels	6
Weight	0.6 kg (1.3 lbs)

Output

Voltage	0 - 5 V rms AC
Current	0 - 70 mA rms AC

Analog module

General

No. of channels	3
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	40 kHz
Measurement time	10 s at 40 kHz sample rate, 20 s at 20 kHz sample rate, 200 s at 10 kHz sample rate using data compression
Transducer resistance	500 Ω – 10 kΩ at 10 V output
Weight	0.8 kg (1.8 lbs)

Output

Voltage output	10 V DC ±5%, 24 V DC ±5%
Max. output current	30 mA

Current measurement

Measurement range	0 – 20 mA DC
Resolution	16 bits (15 bits at data compression)
Inaccuracy	±1% of reading ±0.1% of range

Voltage measurement

Input voltage range	0 – 250 V AC/DC
Measurement ranges	±10 V DC, 0 – 250 V AC/DC
Resolution	16 bits (15 bits at data compression)
Inaccuracy	
250 V range	±1% of reading ±0.1% of range
10 V range	±0.1% of reading ±0.01% of range

Digital module

General

No. of channels	6
Supported types	Incremental transducers, RS422
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	20 kHz
Measurement time	16 s at 20 kHz sample rate, 32 s at 10 kHz sample rate, 200 s at 10 kHz sample rate using data compression
Weight	0.7 kg (1.5 lbs)

Output

Voltage	5 V DC ±5% or 12 V DC ±5%
Max. output current	200 mA

Digital input

Range	±32000 pulses
Resolution	1 pulse
Inaccuracy	±1 pulse

Timing Aux module

General

No. of channels	6
Time base inaccuracy	±0.01% of reading ±1 sample interval
Max. sample rate	20 kHz
Measurement time	15 s at 20 kHz sample rate, 30 s at 10 kHz sample rate, 200 s at 10 kHz sample rate using data compression
Weight	0.8 kg (1.8 lbs)

Voltage Mode

Input voltage range	0 – ±250 V AC/DC
Status threshold	±10 V
Inaccuracy	±0.5 V

Contact mode

Open circuit voltage	25 – 35 V
Short circuit current	10 – 30 mA
Status threshold	Closed < 100 Ω, Open > 2 kΩ

Printer module

General

Printer type	Thermal printer
Paper type	Thermal 114 mm
Storage and transport temperature	-20°C to +60°C (-4°F to +140°F)
Weight	0.8 kg (1.8 lbs)

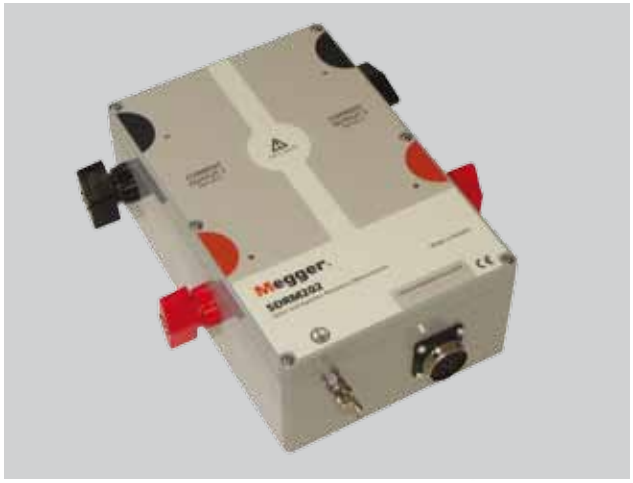
Accessories

Item	Description	Art. No.
Software and application kits		
CABA Win – Circuit Breaker analysis software		
CABA Win	incl. Ethernet cross-over cable	CG-8000X
CABA Win upgrade	Upgrade to latest version	CG-8010X
Vibration analysis		
Vibration kit	The Vibration kit extends TM1800 and CABA Win with the equipment and software required for recording and analyzing vibration signals at a circuit breaker. The kit includes the signal conditioning unit SCA606, the software CABA Win Vibration and one vibration channel. The vibration solution can be extended up to 6 channels.	BL-13090
Vibration channel	Additional vibration channel to be used together with the Vibration kit. Each Vibration channel includes accelerometer, accelerometer adapter, cables to SCA606 and cables to TM1800.	XB-32010
Synchronized Switching Relay test kit		
SSR kit incl. accessories, software and cables	SSR kit for TM1800 *(delivered in transport case)*	CG-91200
Static and Dynamic Resistance Measurement		
SDRM202	The SDRM202 uses new technology, patent pending, with ultra capacitors. The current output is up to 250 A from a box that weighs only 1.8 kg (4 lbs). The weight of the current cables is also low because the SDRM202 is placed very close to the circuit breaker. Timing M/R measurement can be done with the same hook-up	CG-90200
SDRM202 Pack of 3 units	Pack for CB with 2 Breaks / Phase	CG-90230
Extension cable SDRM202	10 m (33 ft)	GA-12810
Transducers		
Linear		
TLH 500	500 mm (20") travel Incl. cable 0.5 m (20")	XB-30020
LWG 225	225 mm (9") travel Incl. cable 0.5 m (20")	XB-30117
TS 150	150 mm (5.9") travel Incl. cable 1.0 m (39")	XB-30030
TS 25	25 mm (1") travel Incl. cable 1.0 m (39")	XB-30033
The above transducers are also available in other lengths, please contact Megger for more information.		
Rotary		
Analog		
Novotechnic IP6501	Incl. cable 1 m (39"), 6 mm Flex coupling, Hexagon wrench	XB-31010
Flex coupling for IP6501	For shaft diam. 6 mm	XB-39030
Digital		
Baumer		
	BDH16.05A3600-LO-B Incl. cable 10 m (33ft), 10/6 mm Flex coupling, Hexagon wrench	XB-39130
Transducer mounting kits		
Universal kits		
Rotary transducer mounting kit	For transducers XB-31010 and XB-39130	XB-51010
Universal transducer mounting kit	For linear and rotary transducers	XB-51020
Circuit breaker specific kits		
LTB Kit (ABB)	Incl. mounting kit XB-51010, Software conversion table BL-8730X	XB-61010
HPL/BLG Kit (ABB)	Incl. mounting kit XB-51010, Software conversion table BL-8720X	XB-61020
Ready-to-use kits – Rotary		
Analog		
1-phase kit	Incl. transducer XB-31010, mounting kit XB-51010	XB-71010
3-phase kit	Incl. 3 x 1-pase kits XB-71010	XB-71013
Digital		
1-phase kit	Incl. transducer XB-39130, mounting kit XB-51010	XB-71020
3-phase kit	Incl. 3 x 1-pase kits XB-71020	XB-71023
Transducer mounting accessories		
Universal support		XB-39029
Switch magnetic base		XB-39013
Cables		
TM1800 DCM 3-channel addition	3 DCM cables, 12 m (39 ft, 6 Clamps	CG-19180
TM1800 DCM 3-channel extension cable	3 DCM extension cables, 10 m (33 ft) GA-00998	CG-19181
Cable reel 20 m (65.5 ft), 4 mm stackable safety plugs	Black	GA-00840
	Red	GA-00842
	Yellow	GA-00844
	Green	GA-00845
	Blue	GA-00846
Extension cables, XLR female to male	For analog input, 10 m (32.8 ft)	GA-01005
	For Timing M/R modules, 10 m (32.8 ft)	GA-00851
Open analog cable	For customized analog transducer connection	GA-01000
XLR to 4 mm safety plugs	For customized analog transducer connection	GA-00040
Digital transducer extension cable	RS422, 10 m (33 ft)	GA-00888
Open digital cable	For customized digital transducer connection	GA-00885
L & L digital cable	For using Leine & Linde 530 digital transducer	GA-00890
Baumer digital cable	For using Baumer digital transducer	GA-00895
Ethernet cable, network	Cable for connection to network/LAN	GA-00960

Accessories

Item	Description	Art. No.
Other		
Current sensor	Current sensor kit 1 channel (Fluke 80i-110s incl. cable GA-00140)	BL-90600
	Current sensor kit 3 channels (Fluke 80i-110s incl. cables GA-00140)	BL-90610
Temperature sensor	With the temperature sensor the ambient temperature is automatically recorded with each measurement and stored together with the test result. The temperature becomes a parameter in CABA Win. The temperature sensor shall be placed in the shade. Suitable cable is the Analog cable, 10 m GA-01005. Range: -20°C to +50°C (-4°F to +122°F), Resolution: 0.5°C (0.9°F)	CG-90070
Thermopaper	114 mm, Ø 40 mm	GC-00040
Soft case	Made from sturdy nylon fabric	GD-00340
Cable organizer	Velcro straps, 10 pcs.	AA-00100

For more information about optional accessories please contact Megger Sweden AB



SDRM202

SDRM Cable

Rotary transducer, Novotechnic IP6501 (analog)

Rotary transducer, Baumer BDH (digital)

Linear transducer, LWG 150

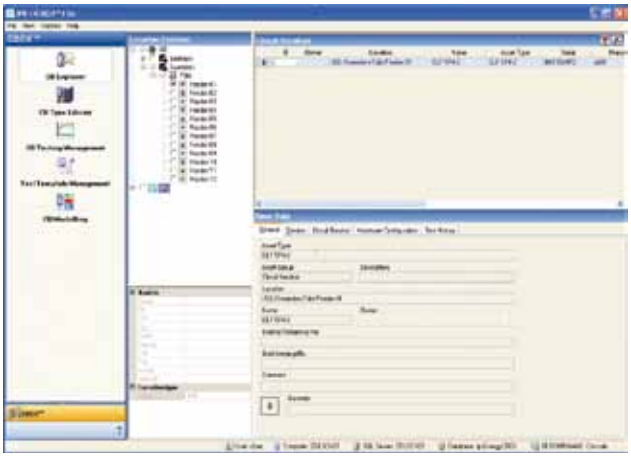
Linear transducer, TLH 225

Linear transducer, TS 25

Switch magnetic base

Vibration kit, BL-13090 Includes: SCA606, CABA Win Vibration software and one Vibration channel

Rotary transducer mounting kit, XB-51010



IPS-CBEX, database

Cable XLR, GA-00760

Extension cable XLR, GA-01005

Temperature sensor

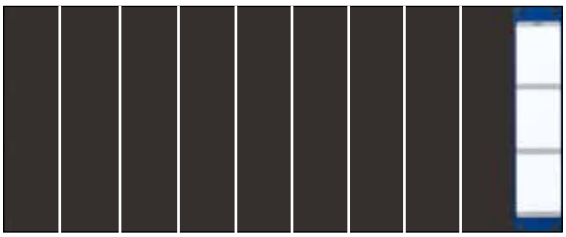
Universal support

Cable reels, 20 m (65.5 ft), 4 mm stack-able safety plugs

Soft case

TM1800 – Configurations

Art. No.

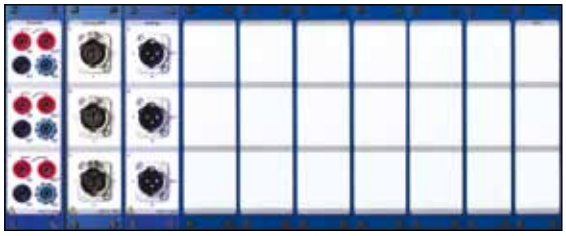


TM1800 Basic Unit

CG-19090

CB testing example

- No testing is possible. Modules has to be ordered separately.



TM1800 Standard

CG-19290

CB testing example

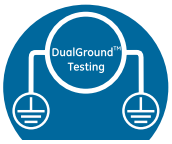
- One common operating mechanism
- Two breaks per phase
- One travel motion

TM1800 Standard – for DualGround

CG-19292

CB testing example

- With both sides grounded
  - One common operating mechanism
  - Two breaks per phase
  - One travel motion



DCM-cables x 6

TM1800 Expert

CG-19294

CB testing example

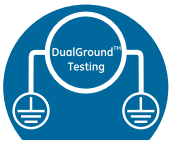
- Three operating mechanisms
- 6 auxiliary, 6 coil currents, 6 station battery voltages
- Four breaks per phase
- Three travel motions
- 6 independent auxiliary contacts

TM1800 Expert – for DualGround

CG-19296

CB testing example

- With both sides grounded
  - Three operating mechanisms
  - 6 auxiliary, 6 coil currents, 6 station battery voltages
  - Four breaks per phase
  - Three travel motions
  - 6 independent auxiliary contacts



DCM-cables x 12

Megger

Ordering information

Item	Art. No.
TM1800 – Separate items	
TM1800 Basic Unit Complete with: HDD module, CABA Local, Transport case, USB Memory	CG-19090
Control Module (3 independent contacts) Including: 3 cable sets, 5 m (16 ft), GA-00877	CG-19030
Timing M/R Module (6 channels + 6 PIR) Including: 3 cable sets, 5 m (16 ft) total length, 2 m (6.5 ft) spread, GA-00850	CG-19080
DCM Module Including: 3 DCM-cables, 12 m (39 ft)	CG-19190
DCM Module Including: 6 DCM-cables, 12 m (39 ft)	CG-19192
Analog Module (3 channels) Including: 3 cable sets, 10 m (33 ft), GA-01005	CG-19000
Digital Module (6 channels)	CG-19040
Timing Aux Module (6 channels) Including: 3 cable sets, 5 m (16 ft), GA-00870	CG-19060
Printer Module Including: Paper spool, GC-00040	CG-19050

Optional accessories

CABA Win
See separate datasheet for CABA Win.

IPS-CBEX
IPS CBEX is a database for circuit breakers and can be purchased as a stand alone SW or as a server version and also as a nice priced package together with TM1800 Expert.
For more information please visit our web site or contact customer service breaker department

Item	Art. No.
TM1800 – Configurations	
TM1800 Standard	CG-19290

Including:

CG-19090	TM1800 Basic Unit	1
CG-19030	TM1800 Control Module	1
CG-19080	TM1800 Timing M/R Module	1
CG-19000	TM1800 Analog Module	1
CG-8000X	CABA Win - TM1800	1

TM1800 Standard – for DualGround testing CG-19292

Including:

CG-19090	TM1800 Basic Unit	1
CG-19030	TM1800 Control Module	1
CG-19080	TM1800 Timing M/R Module	1
CG-19192	TM1800 DCM Module	1
CG-19000	TM1800 Analog Module	1
CG-8000X	CABA Win - TM1800	1

TM1800 Expert CG-19294

Including:

CG-19090	TM1800 Basic Unit	1
CG-19030	TM1800 Control Module	2
CG-19080	TM1800 Timing M/R Module	2
CG-19000	TM1800 Analog Module	1
CG-19060	TM1800 Timing AUX Module	1
CG-8000X	CABA Win - TM1800	1

TM1800 Expert – for DualGround testing CG-19296

Including:

CG-19090	TM1800 Basic Unit	1
CG-19030	TM1800 Control Module	2
CG-19080	TM1800 Timing M/R Module	2
CG-19192	TM1800 DCM Module	2
CG-19000	TM1800 Analog Module	1
CG-19060	TM1800 Timing AUX Module	1
CG-8000X	CABA Win - TM1800	1