ABB Network Partner

FREJA RTS 21D
Computer aided test system

1MRK 512 003-BEN
Page 1
November 1995
Changed since March 1992
Replaces 1MDB12005-EN
Data subject to change without notice

Features

- *Easy to carry, divided in two parts*
- Three-phase current and three-phase voltage output
- Current output *45* VA, outputs may be paralleled
- Voltage output *35* VA
- **Automatic calibration unit is included**
- **For test of distance, frequency, directional, current/voltage relays, *differential relays with harmonics, synchronizing relay***
- **Simple to use for manual testing**
- **High-speed automatic testing**
- *Auxiliary supply 20-220 V dc*
- *User-friendly knob on the panel ensures simple operation*
- Relay specific test plans are easily prepared by the test engineer *(Store manual tests)*
- Reliable testing - no settings on the relay have to be changed during the testing
- **No additional instruments are required**
- **Provided with test plug and contacts for banana plugs**
- **Optional software disturbance simulator is possible to include**

Application

FREJA is a unique relay test system primarily intended for field testing. It is therefore built up as a complete portable work station that is easy to transport. FREJA combines a computer with a test unit for manual and automatic testing. The test unit is controlled by a portable personal computer. No additional instruments are needed for testing or for test planning.

FREJA can be used for the testing of most types of relays. The test system provides three voltage and three current outputs that can be controlled individually or controlled with respect to each other. The test system is supplied from a single-phase source, *115*/230 V ac, 50/60 Hz. The output quantities of the test system are independent of the supply source, e.g. the test system can give out voltages with 16 $^{2}/_{3}$ Hz or 60 Hz frequency even when supplied from a 50 Hz source.

Display panels for the simulation of different types of faults are prepared for distance relays. For the testing of simpler types of relays such as overcurrent, voltage and directional relays a general display panel is available where the amplitude and phase angle for each current and voltage is controlled manually.

For test of a relay's performance to harmonics there is an extended general display available there the fundamental voltage and/or current can be superimposed by two harmonics. Displays are also available for test of frequency, synchrocheck and synchronizing relays.

When used for manual testing the test system operates as a conventional test set, but is much easier and faster to use.

The controls of a normal instrument panel are presented on the PC display, i.e. with a display panel. When testing a distance protection, the applied fault impedance is shown in an impedance diagram on the display. The test quantities can be varied and observed directly in the impedance diagram presented as an oscilloscope screen.

Application (cont'd)

The test system provides network models for simulating different types of faults, L1-N, L2-N, L3-N, L1-L2, L2-L3, L3-L1and L1-L2-L3. FREJA calculates the impedance and the fault impedance corresponding to the applied currents and voltages and indicates these in the diagram. Actual values of current, voltage and impedance are also shown on the display.

The impedance can be varied by turning a *knob* on the front of the FREJA. The direction of movement is either rectangular, Zr or Zx, or polar, |Z| or ZØ.

There are four different conditions available: "open", "*prefault*", "faulty", and "faulty/auto open". "*Prefault*" signifies the line in service, "faulty" the fault impedance and "open" a disconnected line with zero voltage and current. In position "faulty/auto open" the outputs will be disconnected when the condition of the digital inputs are fulfilled. The oscilloscope screen shows the "faulty" state. The output quantities for the "*prefault*" state can be changed from the default values, if so required.

In this way a "faulty" impedance can be selected on the display and then it is possible to jump to this point from a "*prefault*" or an "open" state at a defined fault inception angle. It is, of course, also possible to continuously vary the output quantities when the "faulty" state is activated.

Test positions can be permanently marked with the pass sign (+) or the fail sign (X).

A timer is always connected and it starts when a jump to or from "faulty" is initiated. The timer stops when the digital input signals are recorded as specified (DI goal).

The display contents or a complete report stating the set-up configuration and the results for all fault cases in tables and diagram plots can be printed out after completing the test.

The manual display panel also provides a computer-aided manual testing mode, the whirlwind. Computers can do the same task many times without being bored. This forms the basis for the whirlwind method where faulty impedance points are introduced in a spiral or whirlwind fashion from the centre of the impedance diagram and outward until the complete diagram is filled. Relay operation is marked for the different zones with different characters *and colours*. This gives a very good picture of the relay operating characteristic. If needed, the impedance range can be changed and another whirlwind test be made so that higher precision is obtained around the operating limits.

The whirlwind method is very useful when there is not enough time to prepare an automatic test or if the characteristic of the tested relay is not known.

After a whirlwind scan the characteristic of each zone can be defined and reference graphs consisting of lines and circle segments can be entered into the diagram. These reference graphs may be saved for later use, e.g. preparation of test plans for automatic testing. It is also possible to print out the screen contents.

The fastest and easiest way to test a distance protection is of course by using fully automated testing. The FREJA test system has been designed to make the test planning as easy as possible and is adapted to common test routines.

No large and complicated test programs for different types of protections are needed. FREJA works with one test plan for each device to be tested, which makes the test plans small and uncomplicated. The test system is supplied with examples of test plans and these are easily modified by the test engineer without any actual programming.

Test plans are prepared on the personal computer supplied with FREJA or on any other compatible computer available in your office.

The procedure for preparing a test plan can be as follows:

1. The relay characteristic is determined by the use of whirlwind testing, as described above, or taken from the relay manual.
2. To enable the relay characteristic to be shown in the impedance diagram during testing and to have it printed out in the report, the relay reference graphs are defined in the test template. The zone 1 characteristic for the protections shown in the illustration would be defined as follows:
   a. the resistive blinder is defined as a line from one impedance point to another point i.e. from (5.8,-0.7) to (7.8,9.4).
   b. the circle is defined as a segment from one point to another point via a point on the circle i.e. from (1.7, 10.2) to (0,0) via (-4.4, 5.1).
   c. the reactive blinder is defined in the same way as the resistive blinder i.e. from (1.7, 10.2) to (7.8, 9.4).
   d. The directional line is defined as from (0,0) to (5.8,-0.7).

   Up to *64* different graph segments can be defined in the form, which means that characteristics for any type of distance protections can be constructed. The graphs that can be made are lines and circles and combinations of these.
3. The impedance points to be tested are entered in the test plan. These can be in numerical values or by the use of formulas, i.e. $X = X_{set}$-% (tolerance).
   In this way a complete test plan is built up. The test plan is easily modified for relays with different settings.
   Tests for time measurement can also be included in the test plan.

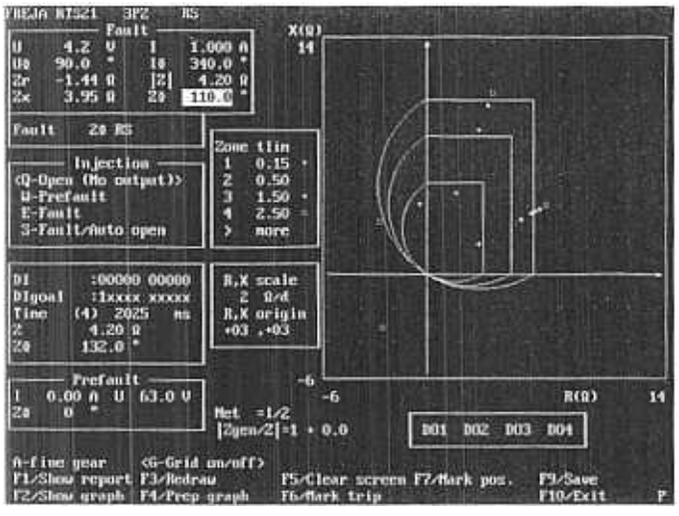


Fig. 1 Manual display panel

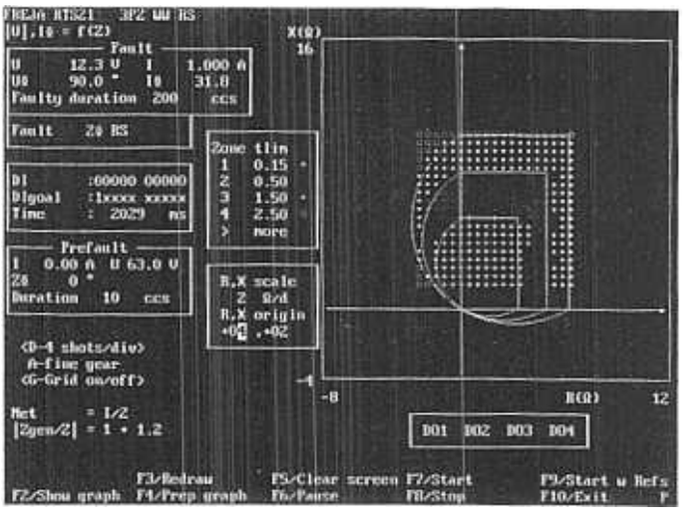


Fig. 2 Whirlwind testing

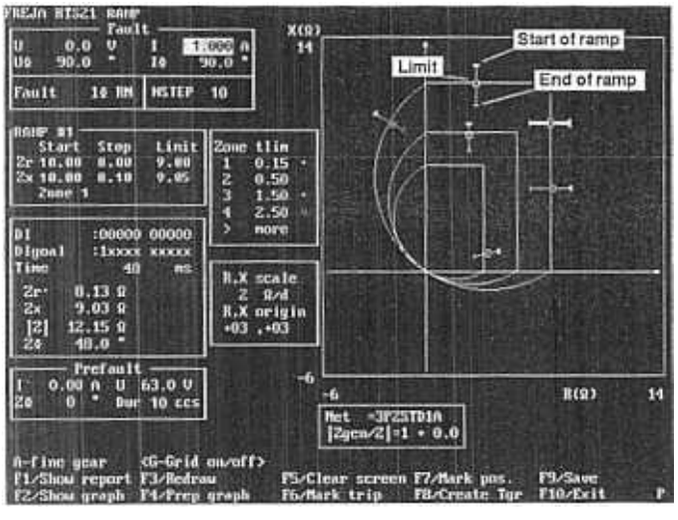


Fig. 3 The Test Plan Editor (TPE) provides a new, simple way to create test plans for automatic testing. No programming is needed. You indicate right on the screen how the tests are to be conducted. As a result you can, for example, measure zone limits for different distance relays easily and without using a tailor-made test plan. TPE is included as part of FREJA's standard software.

It is very easy to execute the automatic test. The test system starts up directly when switched on and information on how to connect the relay to be tested is shown on the display.

No settings on the relay have to be changed; the test is made with the timers for zone 2, 3 and the start zone connected. The test is executed by pressing a function key, as indicated in the menu on the display.

Test results can be printed out in the field or at a later time, as they are automatically stored in the memory.

The fastest way to make a complete automatic test is to use the highway technique. Highway testing is based on the fact that all relays have a defined characteristics with given tolerances. To determine that the relay operates correctly a number of test points are placed on the characteristic values, plus the tolerance and minus the tolerance respectively. No operation should occur on the outer limit and operation should occur on the inner limit. Between each test point the injected quantities represent a "*prefault*" condition in order to reset the relay between test shots. This also enables the timers to be connected during the test.

With the highway testing, a complete test of a four zone distance protection is done in less than ten minutes, including the time for connecting the object to the test system. The highway test performed on the protection shown in the illustration below used 40 test points and had a running time of 66 seconds.

The test results of a highway test are presented in the form of plots, where the tested points are marked and tabulated, with numerical values for all tested points.

The highway test can be combined with "ramped measurement" e.g. decreasing the impedance until the protection operates.

Application (cont'd)

A highway test is made first, in order to verify that the relay operates within the specified limits. A ramped measurement of the operating values is then made, with starting values on the outer limit of the highway test; as we already know that the operating values are inside this limit. In this way the normally slow ramped measurement method is speeded up considerably, as a much smaller impedance segment need be ramped.

Test results of a highway and ramped measurement test are presented in forms of plots were the actual operating value is indicated and in a table with numerical values. The tables show the starting values and/or the actual operating value.

Reports are made on paper on the printer, either in the field or at a later occasion. The amount of data to be presented can be determined by the test engineer preparing the test plans.

Test plans and test results are stored on diskettes. These are then used as a reference during following routine rests made on the same relay, so that results can easily be compared. The diskettes are also very useful as a basis for statistical reports for a region, substation or type of relay protection.

FREJA software can also be installed on a separate PC for test planning in the office without the use of FREJA generation part.

When testing simple types of relays such as overcurrent, voltage and directional relays the "general" display panel is used.

The display shows the amplitude and phase angle of all six current and voltages. By moving the cursor, each one of the quantities can be varied by turning the control knob or by inserting values from the keyboard. In this way fixed values can be given to eleven of the quantities while the twelfth is being varied.

When testing, e.g. a single-phase directional overcurrent relay, two of the voltages and two of the currents are set to zero.The third voltage is given fixed values for amplitude and phase angle as well as phase angle for the third current. The amplitude for the current is then varied until operation occurs. The actual current is given in a numerical value, below the "ruler".

Time measurement can be made by selecting a "faulty" condition and then with a function key activating the generators which initiate time measurement. The timer stops when the trip signal is recorded by FREJA. In this way the operating characteristic for e.g. inverse types of relays, can be recorded.

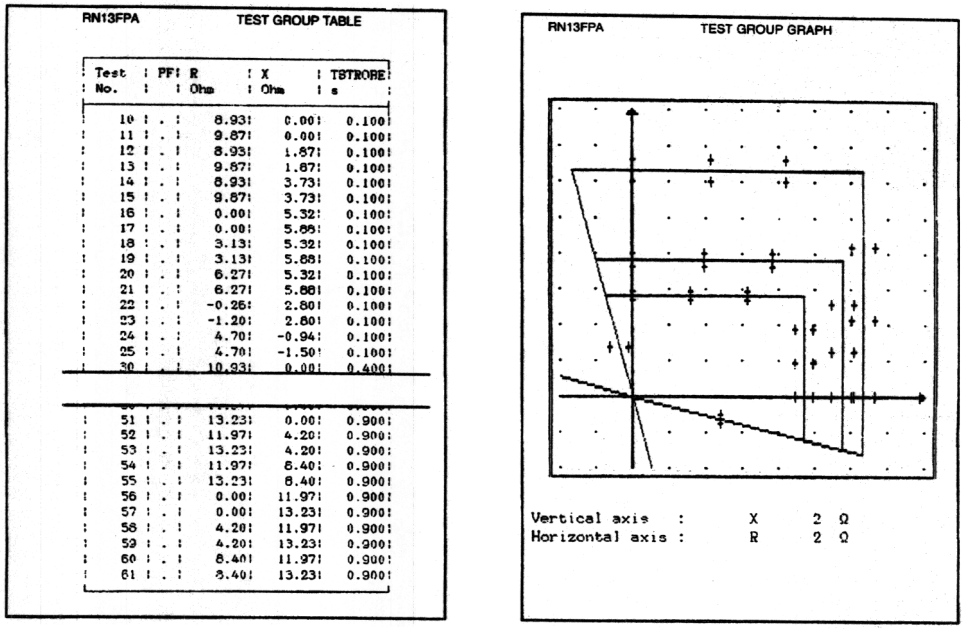
All measuring instruments should be calibrated regularly as the components are subject to changes due to temperature variations and ageing. FREJA is supplied with a unit that automatically calibrates the test system which means that it is never necessary to send in the test system itself for calibration.

The calibration unit consists of a small case with precision components. When connected to the test plug on the FREJA front panel the test system is automatically calibrated in less than two minutes.

Calibration is initiated by the test engineer in the field whenever required. We recommend to performance of an automatic calibration whenever the test system has been exposed to temperature changes larger than ±10°C.

The calibration units are interchangeable so that any FREJA can be calibrated by any unit and when the calibration unit might be at the laboratory the test system will still maintain high accuracy for months.

As the components in the calibrations unit are extremely stable, this unit does not need to be calibrated more often than every second year. The components are easily checked in a test laboratory with the aid of a high-performance multimeter.


RN13FPA TEST GROUP TABLE

Test No.	PF	R Ohm	X Ohm	TSTRORE s
10	.	8.93	0.00	0.100
11	.	9.87	0.00	0.100
12	.	8.93	1.87	0.100
13	.	9.87	1.87	0.100
14	.	8.93	3.73	0.100
15	.	9.87	3.73	0.100
16	.	0.00	5.32	0.100
17	.	0.00	5.65	0.100
18	.	3.13	5.32	0.100
19	.	3.13	5.68	0.100
20	.	6.27	5.32	0.100
21	.	6.27	5.68	0.100
22	.	-0.26	2.80	0.100
23	.	-1.20	2.80	0.100
24	.	4.70	-0.94	0.100
25	.	4.70	-1.50	0.100
30	.	10.93	0.00	0.400
51	.	13.23	0.00	0.900
52	.	11.97	4.20	0.900
53	.	13.23	4.20	0.900
54	.	11.97	8.40	0.900
55	.	13.23	8.40	0.900
56	.	0.00	11.97	0.900
57	.	0.00	13.23	0.900
58	.	4.20	11.97	0.900
59	.	4.20	13.23	0.900
60	.	8.40	11.97	0.900
61	.	8.40	13.23	0.900

Fig. 4 Highway testing

The following test display panels are included in FREJA:

General
The general display is used for test of current-, voltage- and directional relays in manual mode. Timer is included and relays for $16^2/_3$ Hz, 50 Hz or 60 Hz can be tested.

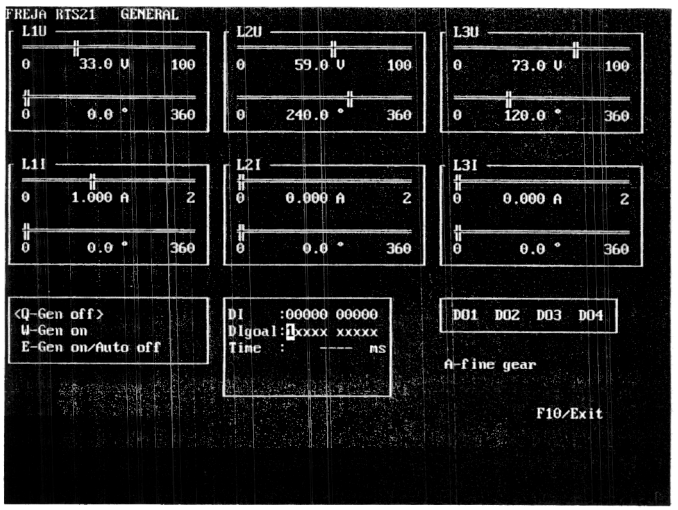


Fig. 5 General display panel

Extended general
From this display it is possible to set up a *prefault* and faulty three-phase system within the frequency range 15-65 Hz. Voltage, current phase angle or frequency can be ramped individual or together. Two harmonics for each generator is freely selectable to be superimposed to the fundamental frequency. Dc-voltage can also be generated. Timer is included.

Three-phase impedance
This display is used for test of distance relays in manual or the semiautomatic whirlwind mode. Timer and report facilities are included. Can supply $16^2/_3$ Hz, 50 Hz or 60 Hz.

Z, U or I versus time
This display can be used for semiautomatic time measurement of impedance voltage or current relays. Tests can be made in a sequence: open, healthy, faulty test values with either $16^2/_3$ Hz, 50 Hz or 60 Hz. Report facilities is included.

Frequency versus time
Display for test of frequency relays there the frequency can be increased automatic and the time is measured. Report facilities are included.

Synchrocheck
This is a display that can be used for test of synchronizing/syncrocheck relays. Amplitude, phase angle and frequency for two voltage generators can be set independently. Voltage, frequency limits can be measured as well as lead times and pulse length and cycles of pulses from the regulating functions for voltage and frequency. Report facilities are included.

FREJA SIM Disturbance Simulator
FREJA SIM disturbance simulator is used to evaluate protective relay equipment and chart its performance when a main disturbance occur. Information on diskettes from disturbance recorders *comtrade format*, simulation programs (EMTP) and network simulations are used as input for generation of the waveform to the amplifiers in FREJA.

FREJA Test Plans
Ready-to-use test plans for a number of distance relays are prepared. In a copy of these test plans is it easy to include actual settings for the distance relay to be tested and the test plan is ready to use.

FREJA is supplied in two parts:

The *hard* transport cases function as workbenche. The *cases are* supplied with wheels so that it is easy to move the test system in the substation. FREJA itself is supplied with handles. The optional Laptop and printer are delivered in an aluminium transport case having a metal lining that protects against disturbances.
Current Amplifier CA1, CA1H (New)

Current Amplifier CA1, which enhances FREJA RTS21 performance, is used when you need higher current and power.

CA1 can provide an output current of up to 60 A_{rms} (560 VA). If you need even higher current, two or more current amplifiers can be connected i parallel, thus bringing the output current up to 180 A_{rms} (1680 VA). CA1 is a single-phase current amplifier, but current in two or more phases can be amplified by using a separate CA1 for each phase.

CA1 can also be used in situations where more current generators are needed than three built into FREJA. Since CA1 can be controlled by both current and voltage, it can be connected to one of FREJA's voltage generators. The number of current generators can thus be increased to six, and they can be used for testing differential relay protection equipment.

*The **new** Current Amplifier CA1H is used when you need higher current and power. The CA1H provides higher voltage (30 V), and can provide currents ranging up to 20 A_{rms} (at 30 V, 600 VA). Since the voltage can be as high as 40 V at a current of 2 A, the CA1H can be used to test all known high-burden relays. Case dimensions have been changed to make this unit easier to carry.*

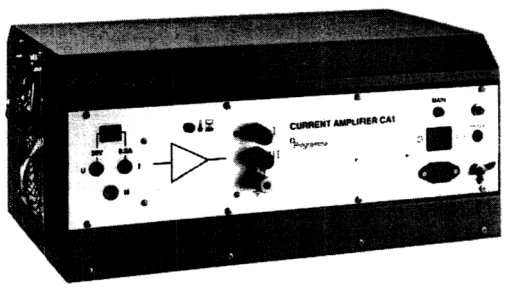


Fig. 6

Technical data

Table 1: Three-phase voltage output

Range	Rating, continuous
150 V	35 VA at 110 V
100 V	25 VA at 60 V
20 V	0,2 A at 100 Ω
2 V	0,2 A at 10 Ω
0-300 V if phase-phase	
Range	**Resolution**
150 V	0,1 V
100 V	0,1 V
20 V	0,01 V
2 V	0,001 V

Table 2: Current output

Ranges		
3-phase	**1-phase (parallel)**	**1-phase (phase-phase)**
10 A (4,5 V) 45 VA	30 A (4,5 V) 135 VA	10 A (10 V) 100 VA
2,4 A (9,5 V) 23 VA	7,2 A (9,5 V) 68 VA	2,4 A (21 V) 50 VA
0,24 A (9,5 V) 2 VA	0,72 A (9,5 V) 7 VA	0,24 A (21 V) 5 VA
Resistive load, max 2% distortion		
An external current amplifier (External Current Amplifier CA1) with 60 A, 600 VA, is available as an option.		
Range	**Resolution**	
30 A	0,01 A	
10 A	0,01 A	
2,4 A	0,001 A	
0,24 A	0,0001 A	

Table 3: Current and voltage outputs

Accuracy, Tcal ±5° C	
voltage output	±(0,5% of reading +0,2% of range)
current output	1% of range for 4-10 A, ±(0,5% of reading +0,2% of range)
Phase angle	0-360°
Phase accuracy:	
voltage output	±0,2°
current output	±0,4°
Phase resolution	0,1°
Frequency	15-65 Hz (and 1-10 harmonics)
accuracy	±0,01% (5 mHz at 50 Hz)

Table 4: Dc auxiliary voltage output

Range	Voltage	Max current
20-130 V	130 V	0,3-0,4 A
130-220 V	220 v	0,3-0,4 A

Table 5: Relay contact outputs

Outputs	4 independent
Rating	275 V dc, 240 V ac
Breaking capacity	10 W for I ≤0,5 A and L/R <40 ms and No. of operations >10 000
Voltage between any output and case	340 V peak, maximum, to be applied
Voltage withstand capability	2 kV, 1 min, remove voltage clamps

Table 6: Time interval measurement

Range	0-1000 s, 0-10 000 s in "Frequency vs time"
Resolution	1 ms
Accuracy	
Any output to any contact sensing input	±1,5 ms
Difference between	±0,5 ms any contact sensing input
Time base	±0,01% of reading

Table 7: Contact sensing inputs

Inputs	10 independent
Rating	275 V dc, 240 V ac
High level dc	>19 V or <-19 V
Low level dc	-3 V to 3 V
Input current, high	1-2 mA
Input current, low	<0,1 mA
High level ac	>60 V
Low level ac	<2 V
Small signal input impedance at 50 Hz	>500 k
Internal aux supply	48 ±10 v dc, 10 ±3 mA, common source for all selected inputs
Voltage between any input and case	340 V peak, maximum, to be applied
Voltage withstand capability	2 kV, 1 min, remove voltage clamps

Table 8: Computer periphals

Communication to standard serial port on personal computer type 386

Table 9: Voltage supply

Single phase	115 or 230 V ac ±10%, selectable range

Table 10: Weight

Instrument only	22,5 kg + 17,8 kg

Table 11: Dimensions

Instrument only	275 × 440 × 240 and 575 × 440 × 115 mm

During transport

Table 13: Relative humidity

Average relative humidity ≤75% 95% continuously on 30 days per year 85% occasionally on the remaining days

Table 14: Printer

Case (incl. PC and printer) Weight Dimensions	 10 kg 510 × 390 × 120 mm (20" × 15,3" × 4,7").

Table 15: Specifications CA1

Output current ac Continuous 12% intermittent duty 20% intermittent duty	 15 A_{rms} 60 A_{rms}, 5 A_{peak} (max 3 s) 50 A_{rms} (max 10 s)
Output power	500 VA (10 V_{rms} at 50 A)
Dimensions	500 × 300 × 245 mm (19,6" × 11,8" × 9,6")
Weight	20 kg (44 lbs), 29 kg (63,9 lbs) with transport case

Table 16: Specifications CA1H

Same for CA1 except for: Output current ac Continuous 12% intermittent operation (max 3 s)	 5 A_{rms} 20 A_{rms}, 28 A_{peak}
Output power	600 VA (30 V_{rms} at 20 A) and (40 V_{rms} at 2 A)

Table 17: FREJA SIM

No. of samples	2048
Sampling frequency	0,41-4,1 kHz
Bandwidth	Dc-2 kHz
File format	ASCII, Comtrade, EMPT, Inductic 65c

12

Ordering

Specify:
- Quantity
- Ordering number

Description		Ordering No.
FREJA RTS 21D	English	1MRK 000 884-AA
	Swedish	1MRK 000 884-BA
	German	1MRK 000 884-CA
	French	1MRK 000 884-DA

Ordering number for FREJA RTS 21D includes software and calibration box

Optional accessories

Current amplifier	CA1	RK 912 006-AA
	CA1H	1MRK 000 885-AA
Transport case for FREJA RTS 21D:	Hard transport case, upper unit	1MRK 000 886-AA
	Hard transport case, lower unit	1MRK 000 886-BA
	Soft transport case, upper unit	1MRK 000 886-CA
	Soft transport case, lower unit	1MRK 000 886-DA
Transport case for Current Amplifier Hard transport case, CA1H, CA1		1MRK 000 886-EA

Portable computer:
ABB has a number of different types of portable computers from which you can choose. Contact your ABB representative for more information.

Computer case with printer:
This case includes a printer (but no computer). this case is suitable for those who use their own computers.
(Dimensions: 510 x 390 x 120 mm (20" x 15,3" x 4,7"). Weight: 7,5 kg (16,5 lbs) — 1MRK 000 886-FA

FREJA cable model 1:
Shortens hook-up time considerably. Consists of a multi-pole connecter that connects to FREJA RTS21 and a number of banana plugs that connect to the protective relay equipment that is to be tested. — RK 912 010-AA

Disturbance simulator program FREJA SIM:
Software package that converts FREJA RTS21 to a simulator. — On request

GPIB program for FREJA:
This extra software converts FREJA to a GPIB instrument (English version) — On request

References

Test system COMBITEST	*1MRK 512 001-BEN*