OMICRON

FRAnalyzer

SWEEP FREQUENCY RESPONSE ANALYZER FOR POWER TRANSFORMER WINDING DIAGNOSIS

User Manual

Article Number VESD0662 - Manual Version: FRA.AE.8

The product information, specifications, and technical data embodied in this manual represent the technical status at the time of writing and are subject to change without prior notice.

We have done our best to ensure that the information given in this manual is useful, accurate and entirely reliable. However, OMICRON electronics does not assume responsibility for any inaccuracies which may be present.

The user is responsible for every application that makes use of an OMICRON product.

OMICRON electronics translates this manual from the source language English into a number of other languages. Any translation of this manual is done for local requirements, and in the event of a dispute between the English and a non-English version, the English version of this manual shall govern.

Contents

Using This Manual

This User Manual provides information on how to use the *FRAnalyzer* sweep frequency response analyzer safely, properly and efficiently. The FRAnalyzer User Manual contains important safety rules for working with the *FRAnalyzer*. It gets you familiar with operating the *FRAnalyzer*, and provides a typical application example. Following the instructions in this manual will help you to prevent danger, repair costs and possible down time due to incorrect operation.

All users of the *FRAnalyzer* must read this User Manual and observe the contained instructions. Make sure that the manual is always available to the *FRAnalyzer* operator.

Reading the FRAnalyzer User Manual alone does not release you from the duty of complying with all national and international safety regulations relevant to working on power transformers.

Operator Qualifications

Working on power transformers can be extremely dangerous. Testing with the *FRAnalyzer* must be carried out only by qualified, skilled and authorized personnel. Before starting to work, clearly establish the responsibilities. Personnel receiving training, instructions, directions, or education on the *FRAnalyzer* must be under constant supervision of an experienced operator while working with the equipment.

Safety Standards

Testing with the *FRAnalyzer* must comply with the EN 50110-1 (VDE 0105 Part 100) "Operation of Electrical Installations" safety standard. Moreover, follow additional relevant laws and internal safety standards as well as the safety rules in this User Manual (see "Safety Rules" on page 9).

Safety Rules

Before operating the *FRAnalyzer* sweep frequency response analyzer, read the following safety rules carefully. If you do not understand some safety rules, contact OMICRON electronics before proceeding. Observe the following safety rules when working with the *FRAnalyzer*.

General

Before connecting any test leads to a test object, always observe the five safety rules:

- Disconnect completely
- Secure from re-connection
- Verify that the installation is dead
- Carry out grounding and short-circuiting

  Note: Grounding and short-circuiting is a general precaution before starting to work on the high-voltage power equipment. During a measurement, follow the instructions in 2.4 "Connecting the FRAnalyzer to a Power Transformer" on page 28.

- Provide protection against adjacent live parts

Before handling the *FRAnalyzer* in any way, connect its equipotential ground terminal with a solid connection of at least 6 mm^2 cross-section to the ground terminal of the power transformer under test.

Do not open the *FRAnalyzer* housing.

Do not repair, modify, extend, or adapt the *FRAnalyzer* or any accessories.

Use only original accessories available from OMICRON electronics.

Use the *FRAnalyzer* and its accessories only in a technically sound condition and when its use is in accordance with the regulations. In particular, avoid disruptions that could in turn affect safety.

Operation

Before operating the *FRAnalyzer*, ground it as described in "General" earlier.

Make sure that the ground terminal of the power transformer is in good condition, clean and free of oxidation.

Additional Precautions

The FRAnalyzer User Manual or alternatively the e-book in PDF format has always to be available on the site where the *FRAnalyzer* is being used. It must be read and observed by all users of the *FRAnalyzer*.

The *FRAnalyzer* may be used only as described in this User Manual. Any other use is not in accordance with the regulations. The manufacturer and/or distributor is not liable for damage resulting from improper usage. The user alone assumes all responsibility and risk.

Full compliance with the regulations also includes following the instructions provided in this User Manual.

Disclaimer

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

1 Introduction

1.1 Frequency Response Analysis (FRA)

Power transformers are essential components of any power transmission and distribution system. The strong electrodynamic forces resulting from short-circuit faults in the power system and the high acceleration potentially emerging during transportation can give rise to severe deformations of the transformer windings and mechanical construction. Transformers can also be exposed to stress during installation and due to inrush current or seismic occurrences.

Consequently, the mechanical construction and the windings of power transformers are subject to high mechanical stress. Depending on the grade of the overstressing, this may cause mechanical deformation or defects of the transformer windings and magnetic core.

The equivalent circuit of the transformer winding includes the coil's resistance and inductance as well as parasitic capacitances between consecutive coils and between the winding and the tank wall and the core. Figure 1-1: "Equivalent circuit of the transformer winding" on page 12 shows the circuitry of discrete RLC elements. The frequency response of the particular transformer winding is a unique characteristic depending on the transformer's mechanical construction. Deformations of the transformer's mechanical construction cause altering the values of the RLC elements and, consequently, the frequency response of the transformer windings changes. By measuring the frequency response of the transformer windings in a wide frequency range, defects in the windings and magnetic core of power transformers can be diagnosed.

Figure 1-1:
Equivalent circuit of the transformer winding

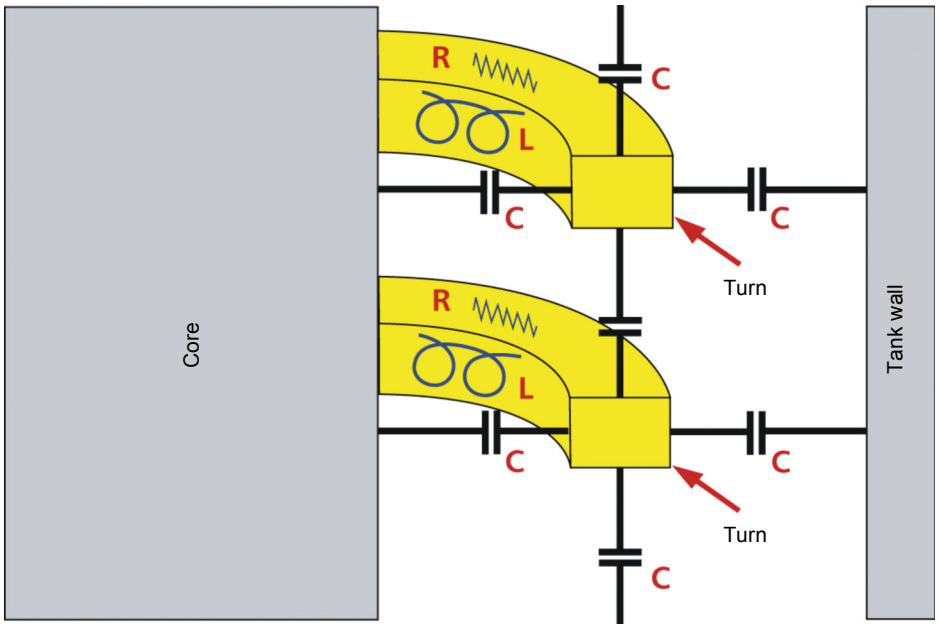
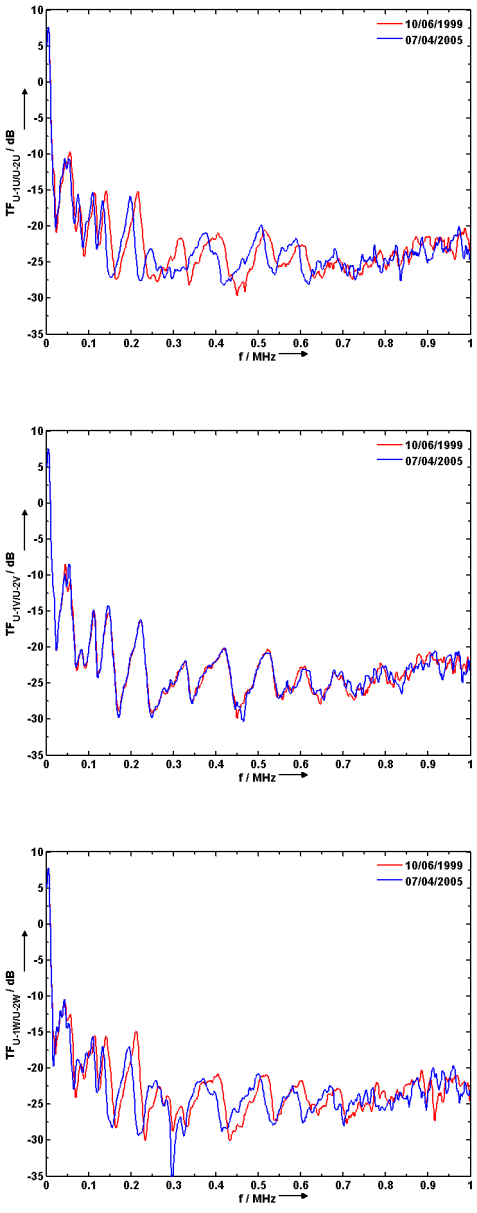


Figure 1-2: "FRA measurement results" compares the frequency responses of the phase U, V and W windings of a power transformer with those in a healthy condition. The deviations of the FRA measurement results indicate that the U and W phase windings might have a defect.

Figure 1-2:
FRA measurement results



The following figure shows the windings of the phase U and the radial displacements of the windings.

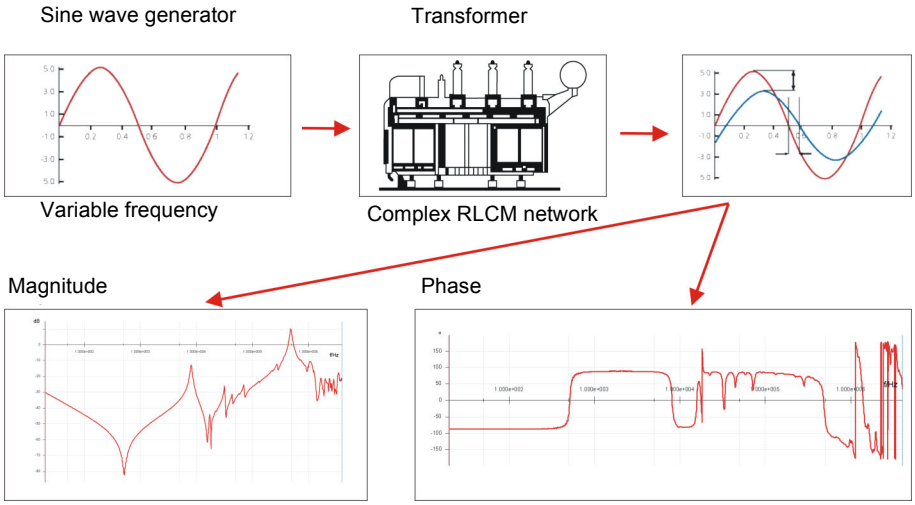
Figure 1-3:
Radial coil deformation

1.2 The *FRAnalyzer*

The *FRAnalyzer* is a sweep frequency response analyzer for power transformer core and winding diagnosis. Its concept – universal hardware controlled by software running on a computer – makes the *FRAnalyzer* an efficient and flexible solution for the diagnosis of power transformer windings and magnetic cores.

The *FRAnalyzer* evaluates the frequency response of the transformer windings by using the sweep frequency response analysis (SFRA) in the frequency domain. Figure 1-4: "Sweep frequency response analysis" shows the measurement procedure. A sinusoidal voltage with constant amplitude and variable discrete frequencies is applied to the winding under test and the frequency of the input signal is successively increased. The amplitude and phase of the output signal is measured against the frequency and the output-to-input amplitude ratio and the phase shift between the output and input signals are evaluated.

Figure 1-4:
Sweep frequency response analysis



The *FRAnalyzer* measures the frequency response of the transformer windings in a wide frequency range and compares it with that in a healthy condition. From the frequency response deviations, many different types of defects in the transformer winding and magnetic core can be diagnosed. These include:

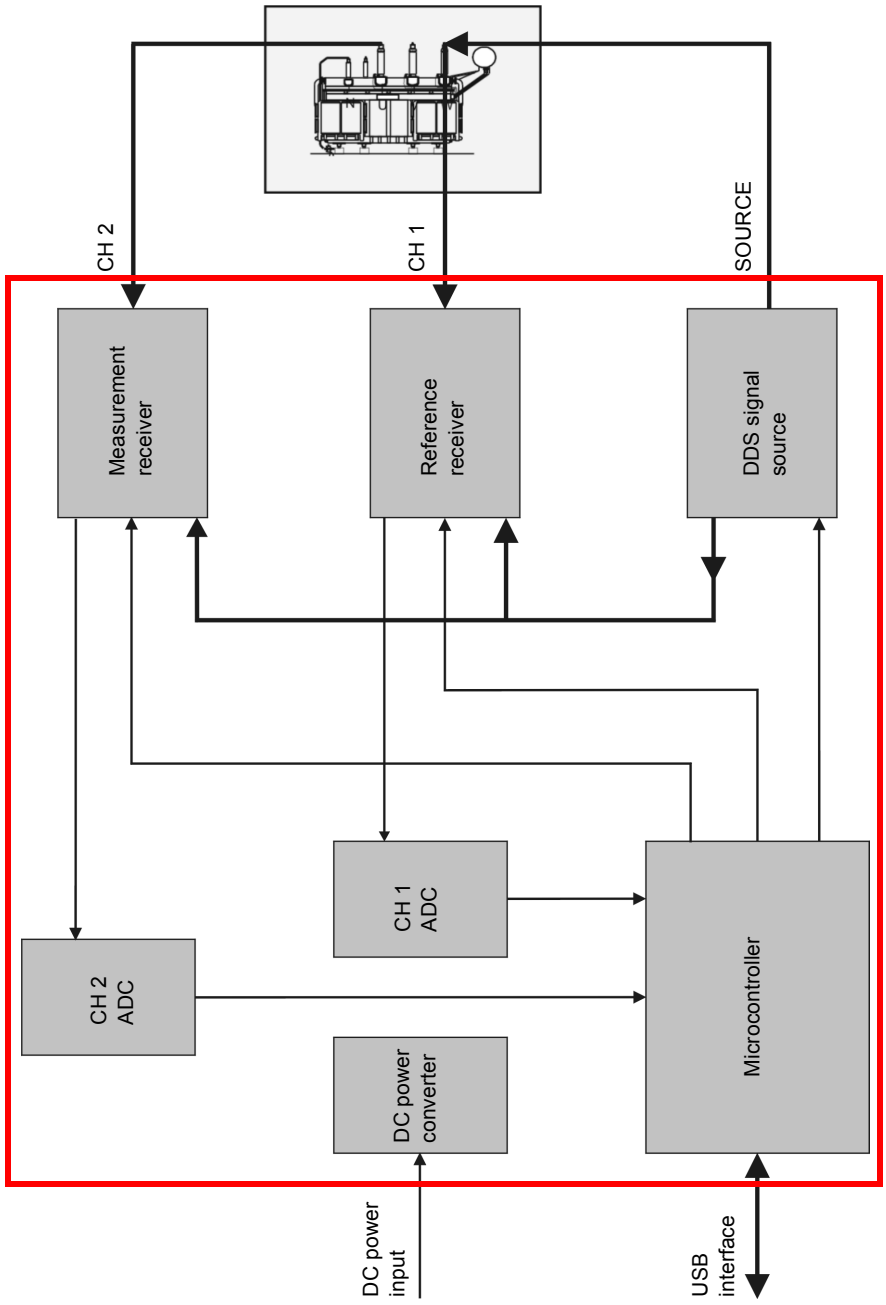
- Coil deformation – axial and radial
- Faulty core grounds
- Partial winding collapse
- Hoop buckling
- Broken or loose clamps
- Shorted turns and open windings
- Core deformation

With the *FRAnalyzer*, you can measure the magnitude and phase, the impedance and the admittance frequency responses of the transformer windings. The measurement results are available on your computer for further processing and/or documentation.

The *FRAnalyzer* includes a DDS (direct digital synthesis) signal source with constant level and variable frequency for excitation of the transformer winding, two receivers processing the winding's response and a microcontroller. A DC power converter generates voltages for powering the circuitry involved. The control software runs on a computer connected to the *FRAnalyzer* by USB interface. The *FRAnalyzer* is powered optionally from a battery or using an AC power supply.

1.2.1 Block Diagram

Figure 1-5:
Block diagram



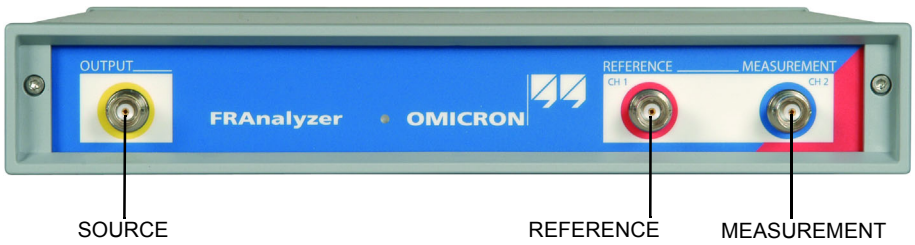
1.2.2 Connectors and Operating Controls

The *FRAnalyzer* provides the following connectors and operating controls.

On the front panel:

- SOURCE connector (signal source output)
- REFERENCE (CH 1) connector (reference channel input)
- MEASUREMENT (CH 2) connector (measurement channel input)

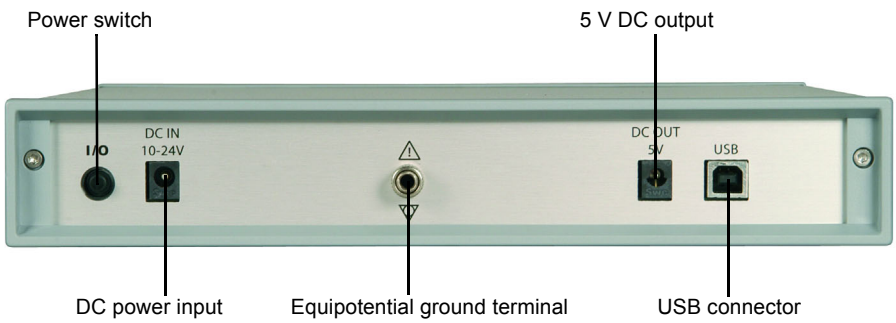
Figure 1-6:
Front view of the *FRAnalyzer*



On the rear panel:

- Power switch
- DC power input
- Equipotential ground terminal
- 5 V DC output
- USB connector

Figure 1-7:
Rear view of the *FRAnalyzer*



1.2.3 Standard Compliance

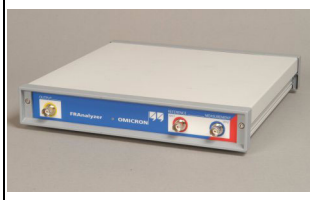
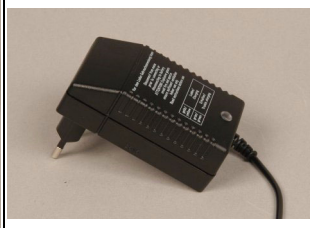
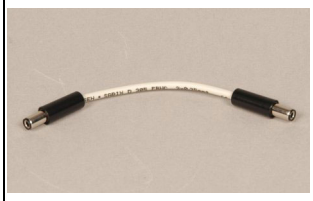
The *FRAnalyzer* complies with the following standards:

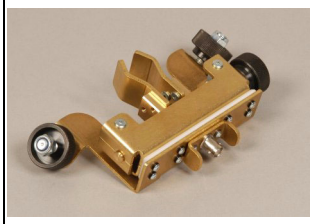
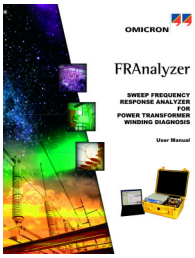
Table 1-1:
Standard compliance

Standard	Description
IEC 61326: Class B equipment Performance criterion B	EMC requirements
Universal Serial Bus (USB) Specification, Revision 1.1 and Revision 2.0	USB interface

1.2.4 Delivery

The *FRAnalyzer* delivery includes:

		
FRAnalyzer	Battery pack	AC power supply and battery charger (including international mains plug adapters)
		
Power cable	USB cable 50 cm/1.6 ft with power cable for optical USB converter	USB 2.0 A/A cable 1.8 m/6 ft
		
50 Ω coaxial cable 18 m/60 ft (yellow)	50 Ω coaxial cable 18 m/60 ft (red)	50 Ω coaxial cable 18 m/60 ft (blue)

		
Optical USB cable 20 m/65 ft	Grounding cable (GR/YE) 6 m/20 ft, 6 mm^2	4 × Aluminium braid 25 mm^2 roll
		
Insulation sleeve	BNC T adapter for calibration	BNC adapter set
		
2 × Bushing clamp	4 × Screw clamp	File
		
Transport case	*FRAnalyzer* CD-ROM	FRAnalyzer User Manual

Note: The FRAnalyzer User Manual is also available as eBook in the *Documentation* folder on the *FRAnalyzer* CD-ROM.

2 Installation

Before installing the *FRAnalyzer*, check the environmental and power requirements (see 6 "Technical Data" on page 105).

2.1 Installing the Software

For the minimum requirements your computer needs to run the *FRAnalyzer* software, see 6.2 "Computer Requirements" on page 106.

Note: Install the *FRAnalyzer* software before connecting the *FRAnalyzer* to the computer.

To install the *FRAnalyzer* software, put the delivered *FRAnalyzer* CD-ROM in the CD-ROM drive and follow the instructions on the screen.

2.2 Powering the *FRAnalyzer*

The *FRAnalyzer* is powered optionally with an AC power supply[1] or from a battery.

2.2.1 Powering with an AC Power Supply

To power the *FRAnalyzer* using the delivered AC power supply:

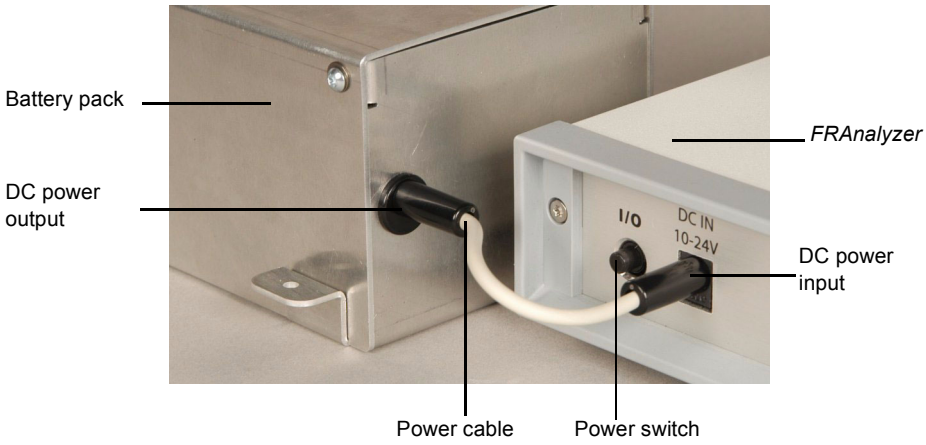
1. Plug the DC output connector of the AC power supply into the DC power input on the *FRAnalyzer* rear panel (see Figure 1-7: "Rear view of the FRAnalyzer" on page 18).
2. Fit the mains plug of the AC power supply to the power outlet, if necessary.
3. Connect the mains plug of the AC power supply to the power outlet.
4. Press the power switch on the *FRAnalyzer* rear panel.

2.2.2 Powering from a Battery

To power the *FRAnalyzer* from the battery:

1. Plug the power cable into the DC power output of the battery pack.
2. Plug the other end of the power cable into the *FRAnalyzer* DC power input.

Figure 2-1:Connecting battery pack to the *FRAnalyzer*



3. Press the power switch on the *FRAnalyzer* rear panel.

1. The delivered AC power supply is a battery charger for 12 V lead acid storage batteries. It is suitable for powering the *FRAnalyzer* directly, too.

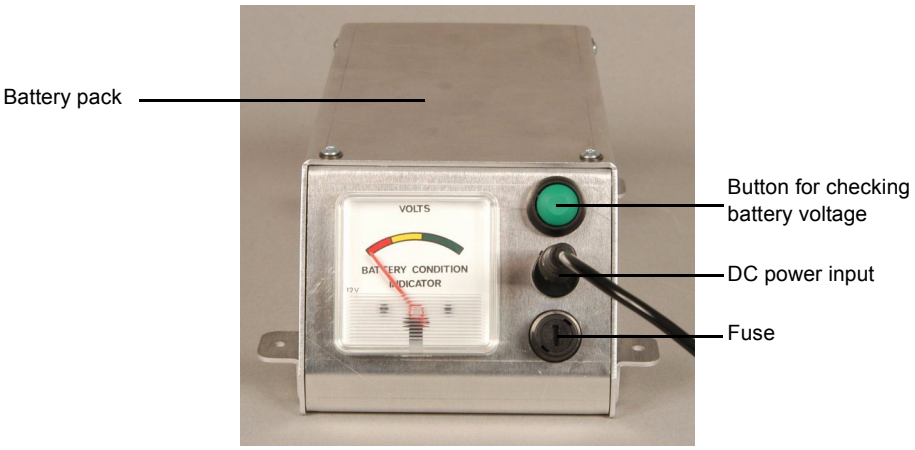
2.2.3 Charging the Battery

With the battery pack delivered with your *FRAnalyzer*, you can check the battery voltage and charge the battery even while the battery powers the *FRAnalyzer*. To check the battery voltage, press the green button on the battery pack. The needle within the green area indicates adequate battery voltage. If the needle is in the yellow zone, charge the battery immediately.

To charge the battery:

1. Plug the DC output connector of the AC power supply into the DC power input of the battery pack.

Figure 2-2: Connecting AC power supply to battery pack



2. Fit the mains plug of the AC power supply to the power outlet, if necessary.
3. Connect the mains plug of the AC power supply to the power outlet.

When the battery is finished charging, the green LED on the AC power supply lights. You can charge the battery even while powering the *FRAnalyzer* (see 2.2.2 "Powering from a Battery" on page 24).

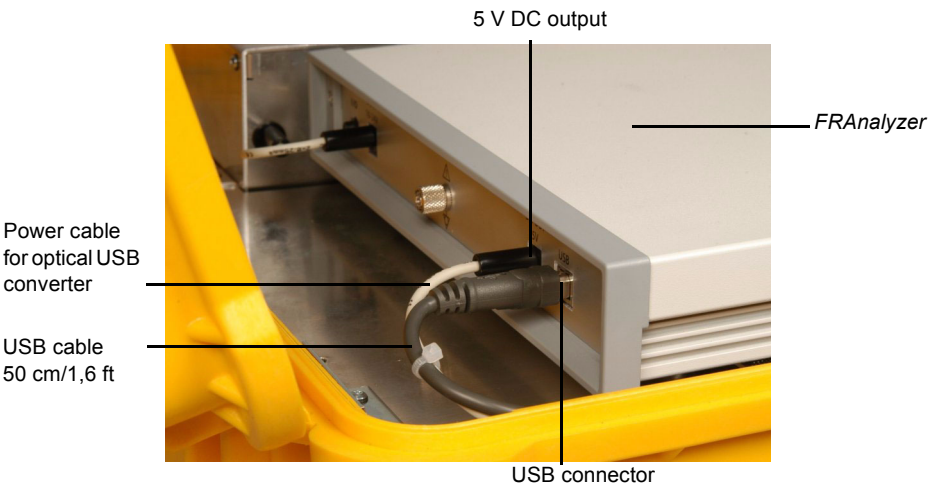
Note: When charging the battery while powering the *FRAnalyzer*, the red LED on the power adapter lights permanently.

2.3 Connecting the *FRAnalyzer* to the Computer

The *FRAnalyzer* communicates with the computer through the USB interface (see 6.2 "Computer Requirements" on page 106). To connect the *FRAnalyzer* to the computer:

1. Connect the USB cable 50 cm/1.6 ft to the *FRAnalyzer* USB connector.
2. Connect the power cable for the optical USB converter to the *FRAnalyzer* 5 V DC output.

Figure 2-3: Connecting the USB cable and power cable for the optical USB converter



3. Guide the USB cable with the power cable for the optical USB converter to the front of the transport case.

Note: Make sure not to crush the cables when closing the transport case.

4. Connect the USB cable on the front of the transport case to the USB connector of your computer using either the USB 2.0 A/A cable or the optical USB cable. If using the optical USB cable, connect the power cable for optical USB converter to the power connector of the optical USB cable.

Figure 2-4:
Connecting the *FRAnalyzer* with the computer using the USB 2.0 A/A cable

Figure 2-5:
Connecting the *FRAnalyzer* with the computer using the optical USB cable

2.4 Connecting the *FRAnalyzer* to a Power Transformer

Note: Before connecting the *FRAnalyzer* to a power transformer and performing measurements, it is recommended to calibrate the *FRAnalyzer* (see 3.11 "Calibrating the FRAnalyzer" on page 80).

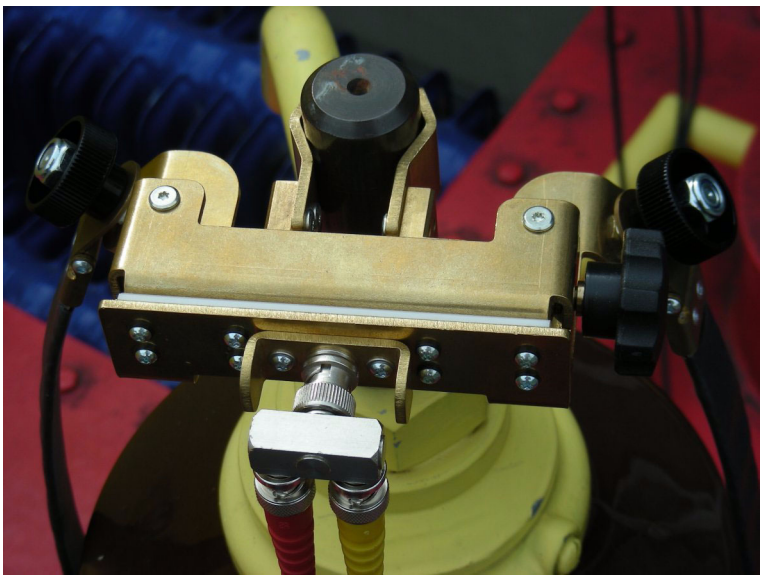
For testing a power transformer, connections are defined by the test (see 4.1 "Test Traces" on page 83). For each test trace, the *FRAnalyzer* assigns the SOURCE, REFERENCE and MEASUREMENT connectors to the transformer's terminal bushings. To perform a measurement, connect the *FRAnalyzer* to the power transformer under test as follows:

1. Fasten a bushing clamp to the transformer's terminal bushing that corresponds to the identifying name shown in the list next to the **Red** label (representing the REFERENCE terminal) in the **Test View** window (see 3.2 "Test View Window" on page 47).
2. Connect the yellow and red coaxial cables to the BNC connector on the bushing clamp by using a delivered BNC adapter.

3. Connect the aluminium braids to the bushing clamp using the screws on the bushing clamp and tighten the screws.
   If necessary, use the delivered insulation sleeve to prevent electrical contact between the aluminium braid and the bushing.

   Note: It is recommended to use two aluminium braids for grounding the bushings clamps, especially for long bushings. Prevent overbending of the aluminium braids and pull them carefully not to break the small strands.

Figure 2-6: Connecting the bushing clamp with the yellow and red coaxial cables



4. Connect the aluminium braids to the transformer's tank using the screw clamps. You can use the clamps in two different ways as shown in Figure 2-7: "Fastening the screw clamp" and Figure 2-8: "Alternative way of fastening the screw clamp" on page 30. Choose one of the two positions to connect the aluminium braid as near as possible to the ceramic isolation to reach a good grounding connection. Make sure that all clamps and braids are

screwed tight and that there is a good electrical contact between the clamps and the transformer's tank. If in doubt, remove the varnish with the delivered file.

Note: We recommend to test the quality of the contact with a multimeter.

Figure 2-7: Fastening the screw clamp

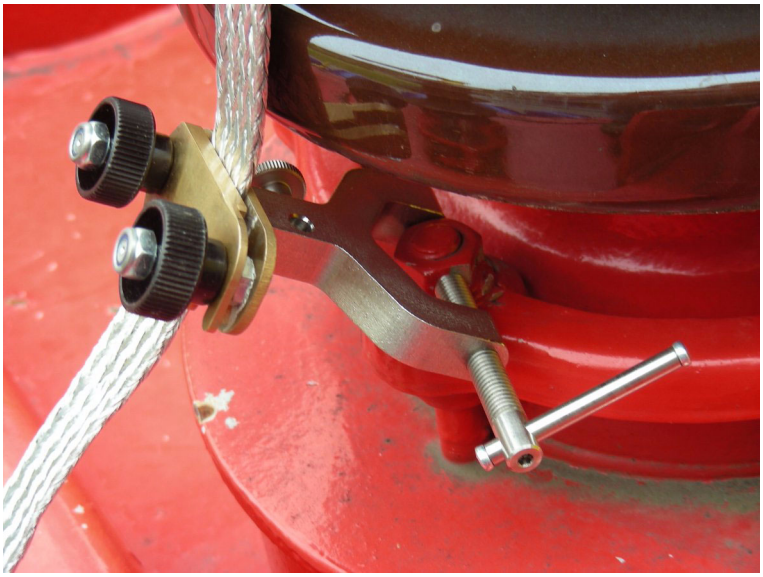
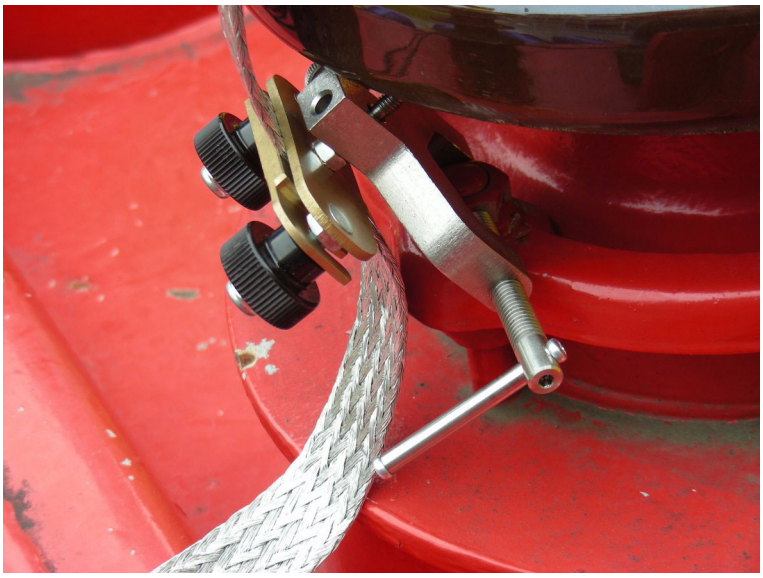
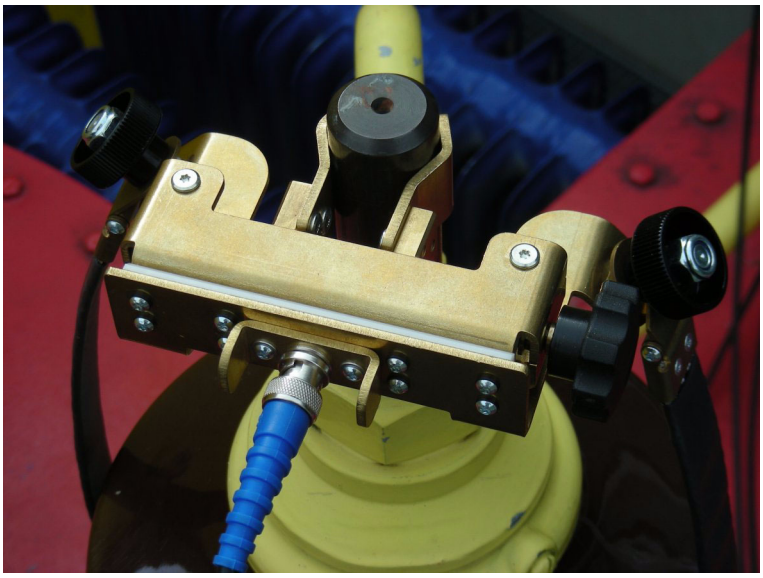


Figure 2-8: Alternative way of fastening the screw clamp



5. Fasten a bushing clamp to the transformer's terminal bushing that corresponds to the identifying name shown in the list next to the **Blue** label (representing the MEASUREMENT terminal) in the **Test View** window (see 3.2 "Test View Window" on page 47).
6. Connect the blue coaxial cable to the BNC connector on the bushing clamp.

Figure 2-9: Connecting the bushing clamp with the blue coaxial cable



7. To ground the bushing clamp, repeat steps 3 and 4.
8. If not already done, connect the other ends of the three BNC cables to the corresponding color-coded connector ports (SOURCE, REFERENCE, MEASUREMENT) on the front panel of the *FRAnalyzer*.

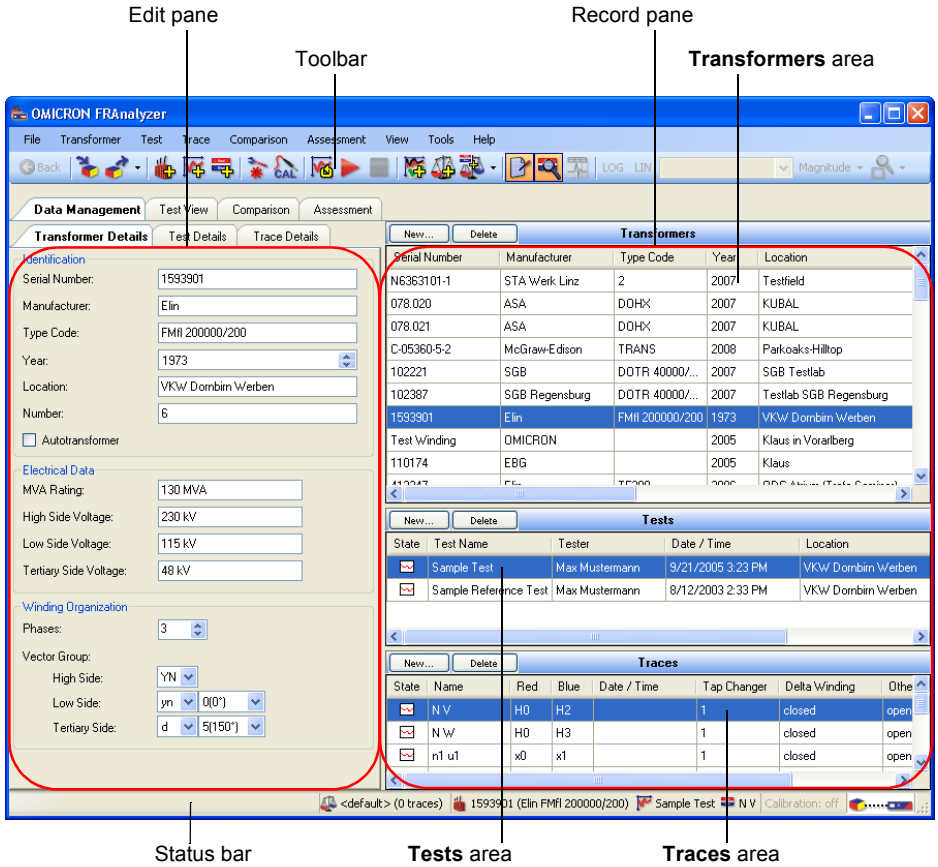
3 The *FRAnalyzer* Software

This section gets you familiar with the *FRAnalyzer* software. The *FRAnalyzer* software user interface has four windows for managing data, viewing and processing tests, comparing test traces and assessing measurement results. You can switch between the windows by clicking the respective tab.

3.1 Data Management Window

After starting the *FRAnalyzer* software, the **Data Management** window opens. In the **Data Management** window, you can manage the transformer, test and trace data. The **Data Management** window has two panes: the edit pane and the record pane. The record pane is divided into the **Transformers** area, the **Tests** area and the **Traces** area.

Figure 3-1:
Data Management window

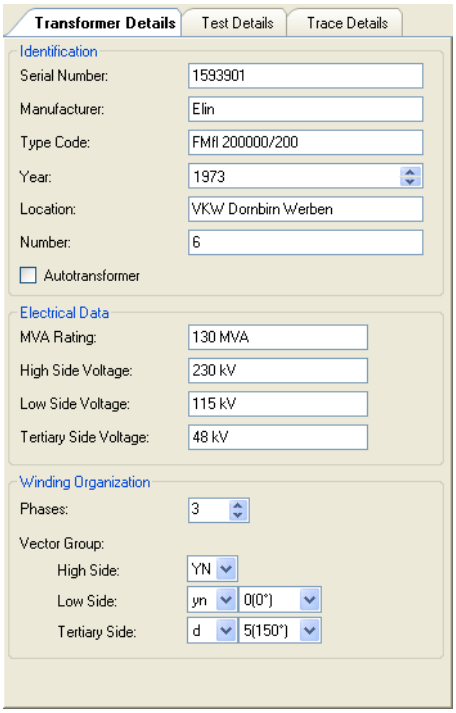


3.1.1 Data Management Window Edit Pane

The edit pane of the **Data Management** window has three tabbed pages for editing the transformer, test and trace data relevant to the respective record selected in the record pane. You can show and hide the edit pane by clicking the **Edit Pane** toolbar button or **Edit Pane** on the **View** menu.

On the **Transformer Details** tab of the edit pane, you can edit the data of the transformer record selected in the **Transformers** area.

Figure 3-2:
Edit pane: **Transformer Details** tab



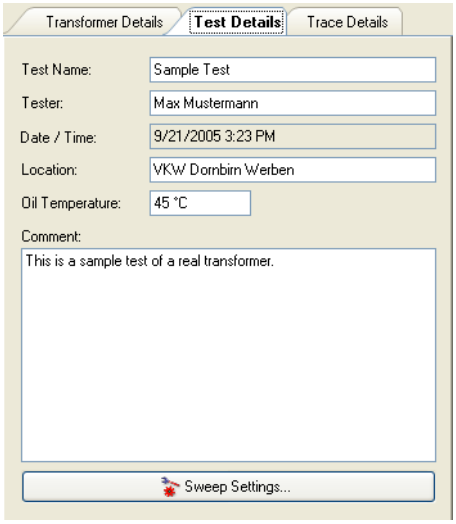
The transformer data is described in the following table.

Table 3-1:
Transformer data

Data	Description
Serial Number	Serial number of the transformer
Manufacturer	Name of the transformer's manufacturer
Type Code	Type code of the transformer's manufacturer
Year	Manufacturing year of the transformer
Location	Physical location of the transformer
Number	Transformer's number or user-defined inventory number
Autotransformer	Select the **Autotransformer** check box if the transformer is an autotransformer.
MVA Rating	Transformer's MVA rating in MVA
V High (kV)	Transformer's high side voltage in kV
V Low (kV)	Transformer's low side voltage in kV
V Tertiary (kV)	Transformer's tertiary side voltage in kV
Phases	Number of the transformer's phases
Vector Group	Vector group of the transformer's windings

On the **Test Details** tab of the edit pane, you can edit the data of the test record selected in the **Tests** area.

Figure 3-3:
Edit pane: **Test Details** tab



The test data is described in the following table.

Table 3-2:
Test data

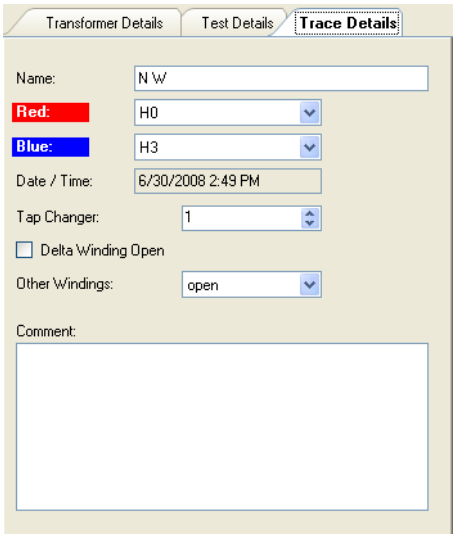
Data	Description
State[1]	State of the test (tested, not tested)
Test Name	Short description of the test
Tester	Name of the person who performed the test
Date	Date the test was performed (automatically set by the system)
Time	Time the test was performed (automatically set by the system)
Location	Physical location the test was performed
Oil Temperature	Temperature of the transformer's oil
Comment[2]	Comment on the test

1. Displayed in the record pane only
2. It is recommended to type here the test details, particularly the reason for the test.

By using the **Sweep Settings** button, you can set the frequency sweep parameters. For more information, see 3.8 "Sweep Settings" on page 75.

On the **Trace Details** tab of the edit pane, you can edit the data of the trace record selected in the **Traces** area.

Figure 3-4:
Edit pane:
Trace Details tab



The trace data is described in the following table.

Table 3-3:
Trace data

Data	Description
State[1]	State of the trace (tested, not tested)
Name	Trace name
Red	Transformer's terminal to be connected to the REFERENCE connector (red)
Blue	Transformer's terminal to be connected to the MEASUREMENT connector (blue)
Date/Time	Date and time of the trace record
Tap Changer	Tap changer setting of the transformer
Delta Winding Open	Select the **Delta Winding Open** check box if a transformer's delta winding is open.
Other Windings	Click **open**, **grounded**, **shorted**, or **shorted + grounded** if other transformer's windings are terminated respectively.
Comment[2]	Comment on the trace

1. Displayed in the record pane only
2. It is recommended to type here the test trace details for better data organization.

3.1.2 Data Management Window Record Pane

In the record pane of the **Data Management** window (see Figure 3-1: "Data Management window" on page 33), you can process transformer, test and trace records.

Note: For simplicity, the transformer, test and trace records (see 3.1 "Data Management Window" on page 33) are also called transformers, tests and traces if no ambiguity arises.

Transformers Area

In the **Transformers** area of the record pane, transformer records are displayed. A transformer record is a set of data relevant to a transformer. The transformer records are arranged in tabular form with rows corresponding to the transformers and columns displaying the transformer data.

By using the **Transformers** area shortcut menu, you can process the transformer records. To open the shortcut menu, right-click in the **Transformers** area.

Figure 3-5: **Transformers** area shortcut menu

Note: The **Transformers** area shortcut menu is identical to the **Transformer** menu in the menu bar.

Table 3-4: Commands on the **Transformers** area shortcut menu

Command	Description
Edit	Displays the **Transformer Details** tab for editing the transformer data.
New	Adds a new transformer and displays the **Transformer Details** tab for editing the transformer data.
Delete	Deletes the selected transformer.
Import	Imports the transformer data (see 3.9 "Importing and Exporting Data" on page 77).
Export	Exports the transformer data (see 3.9 "Importing and Exporting Data" on page 77).
Export in CIGRE Format	Exports the transformer data in CIGRE format (see 3.9 "Importing and Exporting Data" on page 77).

To add a transformer:

1. Do one of the following:
   - In the **Transformers** area, click the **New** button.
   - Click the **New Transformer** toolbar button  .
   - Right-click in the **Transformers** area, and then click **New**.
2. In the **New Transformer** dialog box, type the serial number of the transformer you want to add.
3. In the edit pane, enter the transformer data.

Note: The vector group can only be set if the transformer phase number is three.

To edit a transformer:

1. In the **Transformers** area, click the transformer you want to edit.
2. In the edit pane, edit the transformer data.

To delete a transformer, do one of the following:

- In the **Transformers** area, click the transformer you want to delete, and then click the **Delete** button or press the DEL key.
- In the **Transformers** area, right-click the transformer you want to delete, and then click **Delete**.

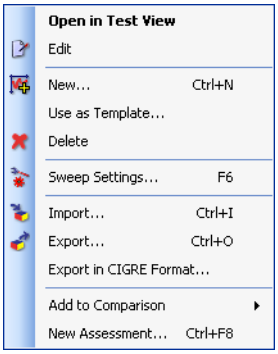
Note: By clicking the respective command on the **Transformer** menu, you can process transformer records even if any window is open or if the edit pane is hidden.

Tests Area

In the **Tests** area of the record pane, the test records available for the transformer selected in the **Transformers** area are displayed. A test record is a set of data relevant to a test. The test records are arranged in tabular form with rows corresponding to the tests and columns displaying the test data.

By using the **Tests** area shortcut menu, you can process the test records. To open the shortcut menu, right-click in the **Tests** area.

Figure 3-6: **Tests** area shortcut menu



Note: The **Tests** area shortcut menu is identical to the **Test** menu in the menu bar.

Table 3-5: Commands on the **Tests** area shortcut menu

Command	Submenu	Description
Open in Test View		Displays the selected test in the **Test View** window.
Edit		Displays the **Test Details** tab for editing the test data.
New		Adds a new test and displays the **Test Details** tab for editing the test data.
Use as Template		Adds a new test by using the selected test as template.
Delete		Deletes the selected test.
Sweep Settings		Enables you to specify the sweep settings (see 3.8 "Sweep Settings" on page 75).
Import		Imports transformer data (see 3.9 "Importing and Exporting Data" on page 77).

Command	Submenu	Description
Export		Exports transformer data (see 3.9 "Importing and Exporting Data" on page 77).
Export in CIGRE Format		Exports transformer data in CIGRE format (see 3.9 "Importing and Exporting Data" on page 77).
Add to Comparison	**Add All Traces**	Adds all traces of the selected test to a comparison (see 3.3 "Comparison Window" on page 54).
	Add All High Voltage Traces	Adds all high-voltage traces of the selected test to a comparison (see 3.3 "Comparison Window" on page 54).
	Add All Low Voltage Traces	Adds all low-voltage traces of the selected test to a comparison (see 3.3 "Comparison Window" on page 54).
	Add All Tertiary Voltage Traces	Adds all tertiary-voltage traces of the selected test to a comparison (see 3.3 "Comparison Window" on page 54).
	Add All Interwinding Traces	Adds all interwinding traces of the selected test to a comparison (see 3.3 "Comparison Window" on page 54).
New Assessment		Enables you to configure a new assessment (see 3.4 "Assessment Window" on page 59).

When adding a test, you can create test traces according to a standard or use an existing test as template. For more information on the test traces, see 4.1 "Test Traces" on page 83.

Note: A new test is always added to the transformer selected in the **Transformers** area.

To add a test:

1. In the **Transformers** area, select the transformer to which you want to add a test.
2. Do one of the following:
   - In the **Tests** area, click the **New** button.
   - Click the **New Test** toolbar button  .
   - Right-click in the **Tests** area, and then click **New**.
3. In the **New Test** dialog box, type the name of the test.
4. Select a standard for creating the default test traces.
5. Click **OK**.
6. In the **Traces** area, the default test traces according to the FRA testing recommendations are displayed.
7. In the edit pane, enter the test data.

To add a test by using a template:

1. In the **Transformers** area, select the transformer to which you want to add a test.
2. In the **Tests** area, select the test you want to use as template.
3. Right-click in the **Tests** area, and then click **Use as Template**.
4. In the **New Test** dialog box, type the name of the test.
5. Click **OK**.
6. In the **Traces** area, the default test traces specified by the test template are displayed.
7. In the edit pane, enter the test data.

To edit a test:

1. In the **Tests** area, click the test you want to edit.
2. In the edit pane, edit the test data.

To delete a test, do one of the following:

- In the **Tests** area, click the test you want to delete, and then click the **Delete** button or press the DEL key.
- In the **Tests** area, right-click the test you want to delete, and then click **Delete**.

Note: By clicking the respective command on the **Test** menu, you can process test records even if any window is open or if the edit pane is hidden.

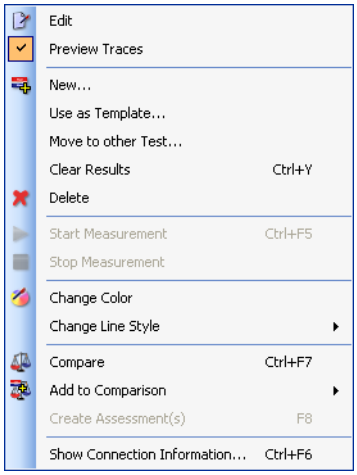
Traces Area

In the **Traces** area of the record pane, the trace records available for the test selected in the **Tests** area are displayed. A trace record is a set of data relevant to a trace. The trace records are arranged in tabular form with rows corresponding to the traces and columns displaying the trace data.

Note: To select more trace records, hold down CTRL or SHIFT and click the trace records you want to select.

By using the **Traces** area shortcut menu, you can process the trace records. To open the shortcut menu, right-click in the **Traces** area.

Figure 3-7:
Traces area shortcut menu



Note: The **Traces** area shortcut menu is identical to the **Trace** menu in the menu bar.

Table 3-6:
Commands on the **Traces** area shortcut menu

Command	Submenu	Description
Edit		Displays the **Trace Details** tab for editing the test data.
Preview Traces		Displays a preview of a trace when pointing to the trace record.
New		Adds a new trace and displays the **Trace Details** tab for editing the trace data.
Use as Template		Adds a new test trace by using the selected trace as template.
Move to Other Test		Moves the selected trace to another test.

Command	Submenu	Description
Clear Results		Clears the measurement results of the selected trace.
Delete		Deletes the selected trace.
Start Measurement		Starts measuring a trace.
Stop Measurement		Stops measuring a trace.
Change Color		Enables you to change the line color of the selected trace.
Change Line Style	**Line**	Sets the continuous line style for the selected trace.
	Dash	Sets the dash line style for the selected trace.
	Dash-Dot	Sets the dash-dot line style for the selected trace.
	Dash-Dot-Dot	Sets the dash-dot-dot line style for the selected trace.
Compare		Compares the selected test traces (see 3.3 "Comparison Window" on page 54).
Add to Comparison	Available comparisons	Adds the selected traces to a comparison (see 3.3 "Comparison Window" on page 54).
	Group Comparisons by Tags	Groups available comparisons by tags.
Create Assessment(s)		Enables you to configure a new assessment (see 3.4 "Assessment Window" on page 59).
Show Connection Information		Displays the connection of the *FRAnalyzer* to the transformer under test.

You can add an arbitrary test trace or use an existing trace as template. For more information on the test traces, see 4.1 "Test Traces" on page 83.

Note: The default test traces are created by the *FRAnalyzer* software according to the FRA testing recommendations. Change the default test traces only in well-founded cases.

Note: A new trace is always added to the test selected in the **Tests** area.

To add a new test trace:

1. In the **Tests** area, select the test to which you want to add a trace.
2. Do one of the following:
   - In the **Traces** area, click the **New** button.
   - Click the **New Trace** toolbar button  .
   - Right-click in the **Traces** area, and then click **New**.
3. In the **New Trace** dialog box, clear the **Generate name automatically** check box if you want to change the default trace's name.
4. In the **Red** list, click the transformer's terminal to be connected to the REFERENCE connector (red).
5. In the **Blue** list, click the transformer's terminal to be connected to the MEASUREMENT connector (blue).
6. Optionally, edit the trace's name.
7. Click **OK**.
8. In the edit pane, enter the trace data.

To add a new test trace by using a template:

1. In the **Tests** area, select the test to which you want to add a trace.
2. Right-click in the **Traces** area, and then click **Use as Template**.
3. In the **New Trace** dialog box, type the trace's name.
4. Click **OK**.
5. In the edit pane, enter the trace data.

To edit a test trace:

1. In the **Traces** area, click the trace you want to edit.
2. In the edit pane, edit the trace data.

To delete a test trace, do one of the following:

- In the **Traces** area, click the trace you want to delete, and then click the **Delete** button.
- In the **Traces** area, right-click the trace you want to delete, and then click **Delete**.

To set the test trace line color:

1. In the **Traces** area, right-click the trace whose color you want to set, and then click **Change Color**.
2. In the **Color** palette, specify the line color.

To set the test trace line style:

1. In the **Traces** area, right-click the trace whose style you want to set.
2. Point to **Change Line Style**, and then click the line style.

Note: By clicking the respective command on the **Trace** menu, you can process trace records even if any window is open or if the edit pane is hidden.

3.2 Test View Window

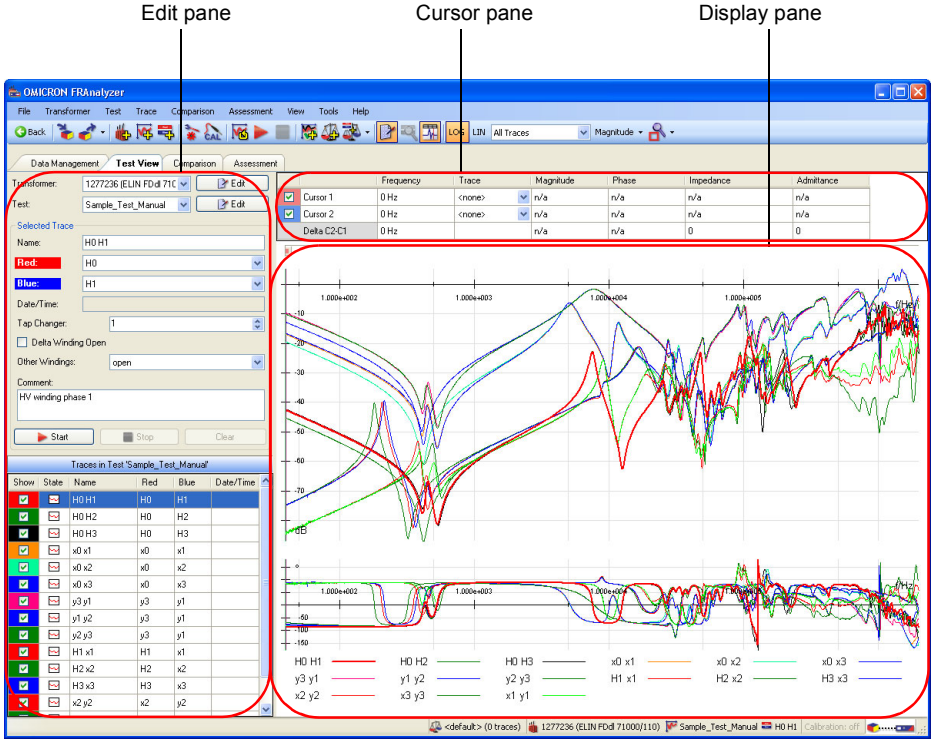
In the **Test View** window, you can view and process the transformer winding measurement results.

To open the **Test View** window, do one of the following:

- In the **Tests** area of the **Data Management** window, right-click a test record, and then click **Open in Test View**.
- In the **Tests** area of the **Data Management** window, double-click a test record.
- Click the **Test View** tab.
- On the **Test** menu, click **Open in Test View**.
- On the **View** menu, point to **Page**, and then click **Test View**.

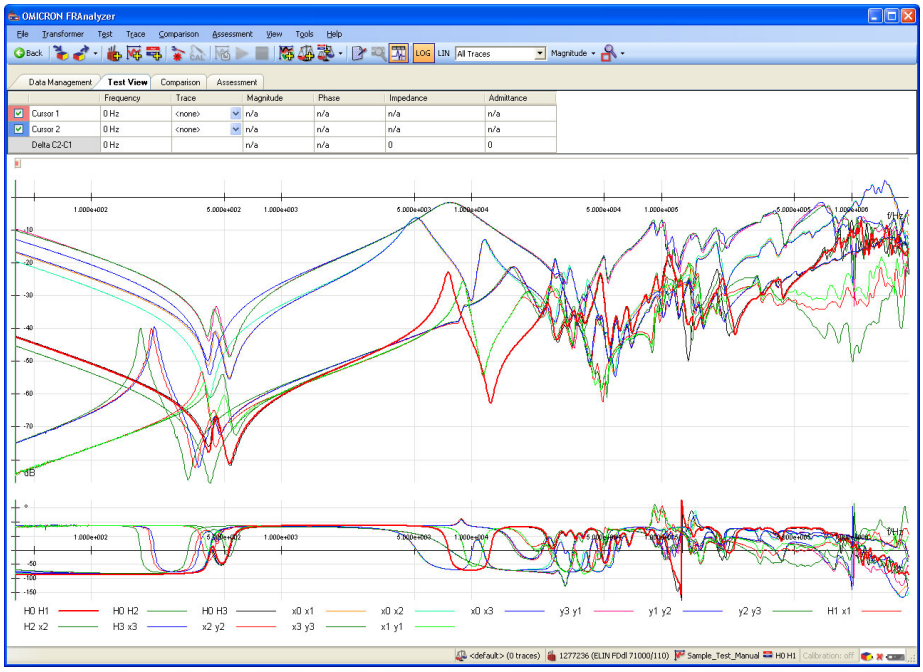
The **Test View** window has three panes: the edit pane, the display pane and the cursor pane.

Figure 3-8:
Test View window



By clicking the **Edit Pane** toolbar button or **Edit Pane** on the **View** menu, you can hide the edit pane to have a more detailed view of the diagram as shown in the following figure.

Figure 3-9:
Test View window with the edit pane hidden

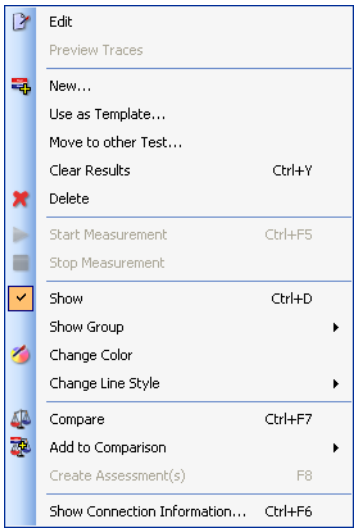


3.2.1 Test View Window Edit Pane

In the edit pane of the **Test View** window, you can specify the test traces to be displayed in the display pane and process them. You can show and hide the edit pane by clicking the **Edit Pane** toolbar button or **Edit Pane** on the **View** menu.

In the edit pane of the **Test View** window, you can process the traces analogously as in the **Traces** area of the **Data Management** window. To open the shortcut menu, right-click in the **Traces in Test '*Test Name*'** area.

Figure 3-10:
Traces in Test '*Test Name*' area shortcut menu



Note: The **Traces in Test '*Test Name*'** area shortcut menu is identical to the **Trace** menu.

For the commands available on the **Traces** area shortcut menu, see Table 3-6: "Commands on the Traces area shortcut menu" on page 43.

By using the **Show** command, you can display test traces individually.

To display test traces in the display pane:

1. In the **Transformer** list, click the transformer associated with the test you want to display.
2. In the **Test** list, click the test you want to display.
3. In the **Traces in Test '*Test Name*'** area, select the **Show** check box next to the trace you want to display or right-click the trace you want to display, and then click **Show**.

By using the **Show Group** command, you can display test traces grouped by the transformer's voltage side.

To display a group of test traces in the display pane:

1. Right-click in the **Traces in Test '*Test Name*'** area.
2. Point to **Show Group**, and then click **All Traces**, **All High Voltage Traces**, **All Low Voltage Traces**, **All Tertiary Voltage Traces** or **All Interwinding Traces** to display the respective test trace group.

After clicking the **Edit** button next to the **Transformer** box and the **Edit** button next to the **Test** box, you can edit the transformer and test data respectively. For more information, see 3.1.1 "Data Management Window Edit Pane" on page 34. Under **Selected Trace**, you can edit the data of the test trace selected in the **Traces in Test '*Test Name*'** area.

To add a new test trace:

1. In the **Transformer** list, click the transformer associated with the test you want to display.
2. In the **Test** list, click the test you want to display.
3. Click the **New Trace** toolbar button or right-click in the **Traces in Test '*Test Name*'** area, and then click **New**.
4. In the **New Trace** dialog box, clear the **Generate name automatically** check box if you want to change the default trace's name.
5. In the **Red** list, click the transformer's terminal to be connected to the REFERENCE connector (red).
6. In the **Blue** list, click the transformer's terminal to be connected to the MEASUREMENT connector (blue).
7. Optionally, edit the trace's name.
8. In the edit pane, enter the trace data.

To delete a test trace:

1. In the **Traces in Test '*Test Name*'** area, right-click the trace you want to delete.
2. Click **Delete**.

To set the test trace line color:

1. In the **Traces in Test '*Test Name*'** area, right-click the trace whose color you want to set.
2. Click **Change Color**.
3. In the **Color** palette, specify the line color.

To set the test trace line style:

1. In the **Traces in Test '*Test Name*'** area, right-click the trace whose style you want to set.
2. Point to **Change Line Style**, and then click the line style.

Note: By clicking the respective command on the **Trace** menu, you can process trace records if any window is open or if the edit pane is hidden.

3.2.2 Test View Window Display Pane

The display pane of the **Test View** window displays the frequency responses of the test traces specified in the edit pane. New test traces are displayed in the default color set in the **Options** dialog box (see 3.7 "Setting Options" on page 66). You can change the test trace color and style as described in 3.2.1 "Test View Window Edit Pane" on page 48.

By using the display pane shortcut menu, you can control the graphical display. To open the shortcut menu, right-click in the display pane.

Figure 3-11: Display pane shortcut menu

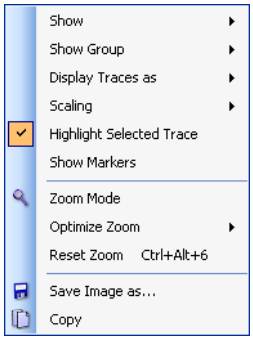


Table 3-7: Commands on the display pane shortcut menu

Command	Submenu	Description
Show	Available test traces	Displays the selected test traces.
Show Group[1]	**All Traces**	Displays all test traces.
	All High Voltage Traces	Displays all high-voltage traces.
	All Low Voltage Traces	Displays all low-voltage traces.
	All Tertiary Voltage Traces	Displays all tertiary-voltage traces.
	All Interwinding Traces	Displays all interwinding traces.
Display Traces As[1]	**Magnitude**	Displays the magnitude and phase frequency response of the test traces.
	Impedance	Displays the impedance frequency response of the test traces.
	Admittance	Displays the admittance frequency response of the test traces.

Command	Submenu	Description
Scaling	**Logarithmic**[1]	Displays the X-axis logarithmic scale.
	Linear[1]	Displays the X-axis linear scale.
Highlight Selected Trace		Displays the selected trace with a thicker line width.
Show Markers		Displays every measured point as a marker to provide information about the resolution of the measurement.
Zoom Mode		Enables you to display the diagram in the zoom area.
Optimize Zoom	**All**[1]	Sets the X-axis and Y-axis ranges to fit the measurement results.
	X-Axis	Sets the X-axis range to fit the measurement results.
	Y-Axis	Sets the Y-axis range to fit the measurement results.
Reset Zoom		Sets the X-axis and Y-axis to their full display range.
Save Image As		Saves the displayed diagram as a graphic.
Copy		Copies the displayed diagram to the clipboard.

1. Also available on the toolbar

3.2.3 Test View Window Cursor Pane

In the cursor pane of the **Test View** window, you can examine the measurement results in detail. For the test traces assigned to the cursors, the cursor pane displays the frequency and the measurement results at cursor positions. To assign a test trace to a cursor, select the check box next to the cursor, and then click the trace in the corresponding **Trace** list. You can show and hide the cursor pane by clicking the **Cursors Table** toolbar button or **Cursors Table** on the **View** menu.

Figure 3-12:
Test View window cursor pane

	Frequency	Trace	Magnitude	Phase	Impedance	Admittance
☑ Cursor 1	315.24 Hz	N V	-87.62 dB	15.8°	1.21 MΩ	838.69 nS
☑ Cursor 2	5.45 kHz	N W	-36.23 dB	-66.3°	3.24 kΩ	309.02 µS
Delta C2-C1	5.13 kHz	N W - N V	51.39 dB	-82°	-1.21 MΩ	308.18 µS

In the cursor pane, the measured magnitude and phase of the frequency response and the calculated values of the impedance and admittance are displayed. In the **Delta C2-C1** row, the differences between the values at the positions of cursor 2 and cursor 1 are displayed.

3.3 Comparison Window

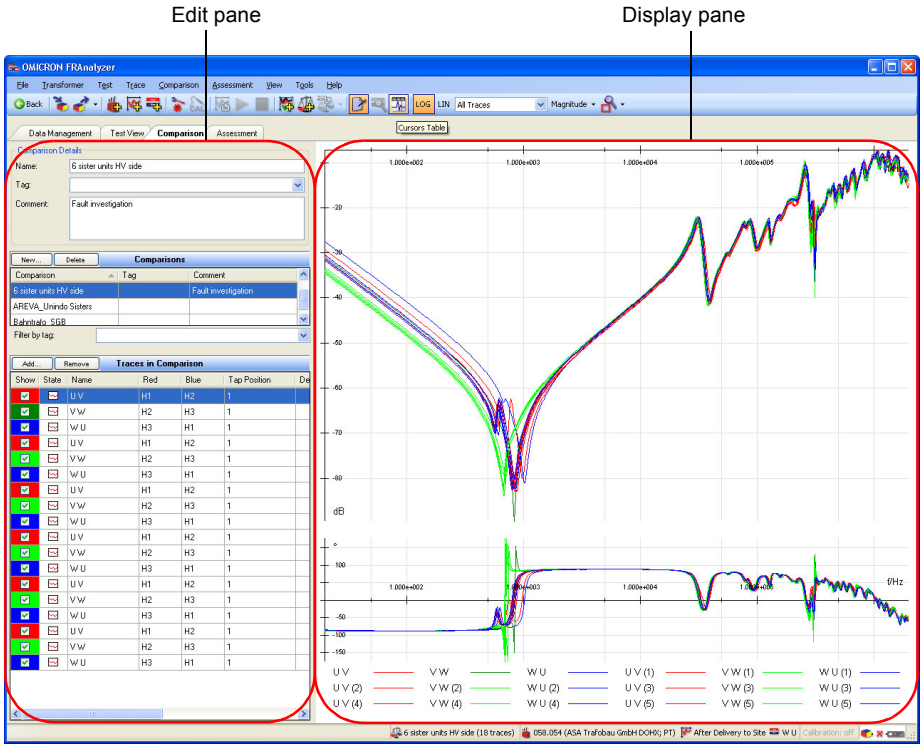
In the **Comparison** window, you can compare an arbitrary number of test traces. By using this tool, you can directly compare test traces of different tests by displaying them in one figure.

To open the **Comparison** window, do one of the following:

- Click the **Comparison** tab.
- On the **View** menu, point to **Page**, and then click **Comparison**.

The **Comparison** window has three panes: the edit pane, the display pane and the cursor pane. In the following figure, the cursor pane is hidden. You can display it by clicking the **Cursors Table** toolbar button or **Cursors Table** on the **View** menu.

Figure 3-13:
Comparison window



3.3.1 Comparison Window Edit Pane

In the edit pane of the **Comparison** window, you can process trace comparisons. A comparison is a collection of test traces you want to compare. You can show and hide the edit pane by clicking the **Edit Pane** toolbar button or **Edit Pane** on the **View** menu.

In the **Comparisons** area, the available comparisons are displayed. The *FRAnalyzer* software provides a **<default>** comparison as a trace container for trial comparisons which you do not want to save. After renaming it, the **<default>** comparison becomes a regular comparison which you can process as described later, and a new **<default>** comparison is added and stored.

By using the **Comparisons** area shortcut menu, you can process the comparisons. To open the shortcut menu, right-click in the **Comparisons** area.

Figure 3-14: **Comparisons** area shortcut menu

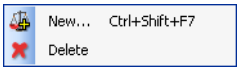
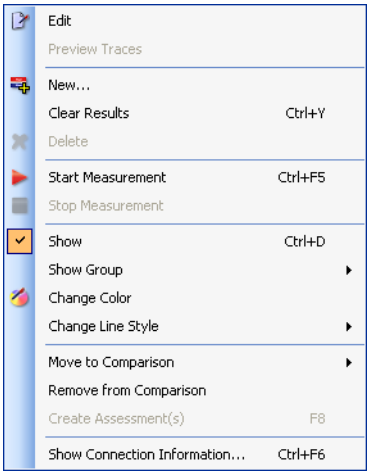


Table 3-8: Commands on the **Comparisons** area shortcut menu

Command	Description
New	Opens the **New Comparison** dialog box for adding a comparison.
Delete	Deletes the selected comparison.

In the **Traces in Comparison** area, the traces belonging to the selected comparison are displayed.

Figure 3-15: **Traces in Comparison** area shortcut menu



For the commands available on the **Traces in Test '*Test Name*'** area shortcut menu, see 3.2.1 "Test View Window Edit Pane" on page 48.

By using the **Move to Comparison** command, you can add test traces to a comparison.

By using the **Remove from Comparison** command, you can remove test traces from a comparison.

To add a comparison:

1. In the **Comparisons** area, click the **New** button or click the **New Comparison** toolbar button  .
2. In the **New Comparison** dialog box, type the comparison name.
3. In the **Traces in Comparison** area, click the **Add** button.
4. In the **Add Traces to Comparison** dialog box, configure the comparison as follows:
   - Select the test trace you want to add to the comparison, and then click the **Add Selected** button.

     Note: To add more test traces at once, hold down CTRL or SHIFT and click the traces you want to add.
   - Click the **Add All** button to select all traces available for the selected test and the associated transformer.
5. Repeat step 4 for all test traces you want to add to the comparison.

Under **Comparison Details**, you can edit the data of the selected comparison and assign a tag to the comparison. You can then group the comparisons by the tags.

To assign a tag to a comparison:

1. Under **Comparisons**, select the comparison to which you want to assign a tag.
2. Under **Comparison Details**, enter the tag name in the **Tag** list.
3. Press the ENTER key.

You can add grouped traces of a test or separate test traces to a comparison.

To add grouped test traces to a comparison:

1. In the **Comparisons** area of the **Comparison** window, select the comparison to which you want to add test traces.
2. Click the **Data Management** tab, and then do one of the following:
   - In the **Tests** area of the **Data Management** window, right-click the test including the traces you want to add to the comparison, point to **Add to Comparison**, and then click the test traces you want to add.
   - In the **Tests** area of the **Data Management** window, click the test including the traces you want to add to the comparison, point to **Add to Comparison** on the **Test** menu, and then click the test traces you want to add.

To add separate test traces to the selected comparison:

1. In the **Comparisons** area of the **Comparison** window, click the comparison to which you want to add test traces.
2. Click the **Data Management** tab.
3. In the **Traces** area of the **Data Management** window, select the traces you want to add to the comparison, and then click the **Add To Comparison** toolbar button  .

To add separate test traces to an arbitrary comparison:

1. In the **Traces** area of the **Data Management** window, select the traces you want to add to the comparison, and then do one of the following:
   - Click the arrow next to the **Add To Comparison** toolbar button  , and then click the comparison to which you want to add the traces.
   - Right-click in the **Traces** area, point to **Add To Comparison**, and then click the comparison to which you want to add the traces.

Alternatively, you can add test traces to a comparison analogously in the **Test View** window.

To remove a test trace from a comparison:

1. In the **Comparisons** area, click the comparison from which you want to remove a test trace.
2. In the **Traces in Comparison** area, do one of the following:
   - Click the trace you want to remove, and then click the **Remove** button.
   - Right-click the trace you want to remove, and then click **Remove from Comparison**.

To delete a comparison, do one of the following:

- In the **Comparisons** area, click the comparison you want to delete, and then click the **Delete** button.
- In the **Comparisons** area, right-click the comparison you want to delete, and then click **Delete**.

3.3.2 Comparison Window Display Pane

The display pane of the **Comparison** window displays the frequency responses of the compared test traces. For the shortcut menu commands, see 3.2.2 "Test View Window Display Pane" on page 51.

3.3.3 Comparison Window Cursor Pane

In the cursor pane of the **Comparison** window, you can examine the measurement results in detail. You can show and hide the cursor pane by clicking the **Cursors Table** toolbar button  or **Cursors Table** on the **View** menu. For more information, see 3.2.3 "Test View Window Cursor Pane" on page 53.

3.4 Assessment Window

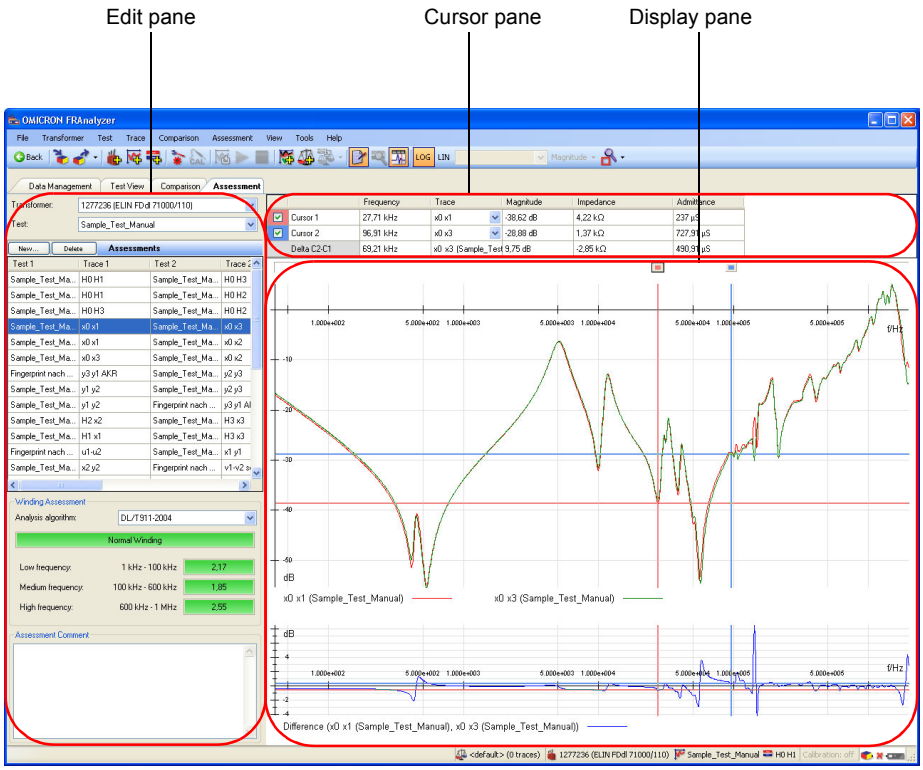
With the *FRAnalyzer*, you can assess the transformer windings by evaluating the difference between the frequency responses of *two* comparable test traces. For detailed information, see 4.5 "Analysis Algorithms" on page 88. You can configure and perform the winding assessment in the **Assessment** window.

To open the **Assessment** window, do one of the following:

- Click the **Assessment** tab.
- On the **View** menu, point to **Page**, and then click **Assessment**.

The **Assessment** window has three panes: the edit pane, the display pane and the cursor pane.

Figure 3-16:
Assessment window



3.4.1 Assessment Window Edit Pane

In the edit pane of the **Assessment** window, you can configure trace assessments. You can show and hide the edit pane by clicking the **Edit Pane** toolbar button or **Edit Pane** on the **View** menu.

In the **Assessment** area, the available assessments are displayed. By using the **Assessment** area shortcut menu, you can process the assessments. To open the shortcut menu, right-click in the **Assessment** area.

Figure 3-17: **Assessments** area shortcut menu

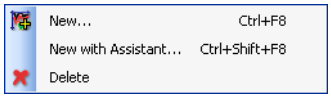


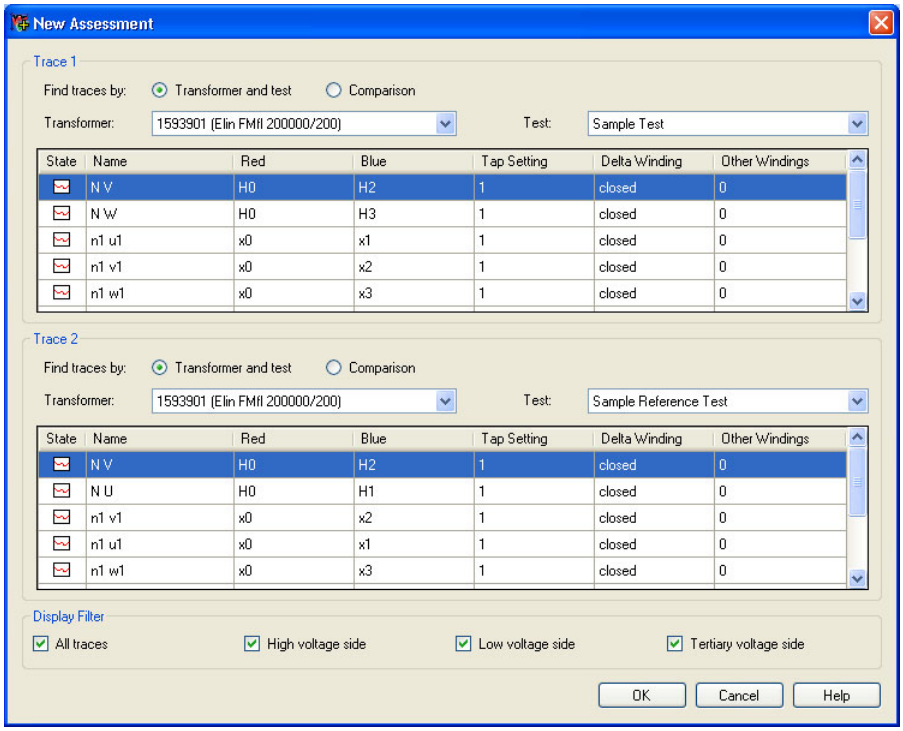
Table 3-9: Commands on the **Assessment** area shortcut menu

Command	Description
New	Opens the **New Assessment** dialog box for configuring an assessment.
New with Assistant	Facilitates generating all meaningful assessments for a test or two different tests.
Delete	Deletes the selected assessment.

To configure an assessment:

1. Under **Winding Assessment**, select the algorithm (see 4.5 "Analysis Algorithms" on page 88) you want to use for the assessment.
2. Do one of the following:
   - In the **Assessments** area, click **New**.
   - Click the **New Assessment** toolbar button .
   - Click **New** on the **Assessment** menu.

Figure 3-18:
New Assessment dialog box



3. In the **New Assessment** dialog box, select the test traces for the assessment.
   You can select the traces belonging to a test or to a comparison as described later.

4. Under **Trace 1**, do one of the following:
   - Click **Transformer and test**, and then click the transformer associated with the test in the **Transformer** list and the test including the trace you want to add to the assessment in the **Test** list.
   - Click **Comparison**, and then click the comparison including the trace you want to add to the assessment in the **Comparison** list.
5. In the list of traces available for the selection, click the trace you want to add to the assessment.
6. Under **Trace 2**, select the second trace you want to add to the assessment.
7. Click **OK**.

Under **Display Filter**, select the **All traces**, **High voltage side**, **Low voltage side** or **Tertiary voltage side** check box to display the respective traces in the list of traces available for the selection.

After clicking **OK** in the **New Assessment** dialog box, the assessment appears in the **Assessments** area and the calculated winding assessment factors for the low frequency, medium frequency and high frequency ranges as well as the overall winding assessment are displayed under **Winding Assessment**. To display the assessed test traces and the winding assessment factors of another assessment, click the assessment in the **Assessments** area.

By using the **New with Assistant** command on the **Assessment** menu, you can generate all meaningful assessments for a test or two different tests.

To generate all meaningful assessments for a test:

1. On the **Assessment** menu, click **New with Assistant**.
2. In the **Assessment Generation Assistant** dialog box, click **Generate assessments for traces of a single test**, and then click **Next**.
3. In the **Transformer** list, click the transformer associated with the test.
4. In the **Test** list, click the test including the traces for which you want to generate assessments.
5. Optionally, select the **High voltage traces**, the **Low voltage traces** or the **Tertiary voltage traces** check box to select the respective test traces, and then click **Next**.
6. Click **Finish**.

To generate all meaningful assessments for two different tests:

1. On the **Assessment** menu, click **New with Assistant**.
2. In the **Assessment Generation Assistant** dialog box, click **Generate assessments for traces from two different tests**, and then click **Next**.

3. Under **Test 1**, click the transformer associated with the former test in the **Transformer** list and the test including the traces for which you want to generate assessments in the **Test** list.
4. Under **Test 2**, click the transformer associated with the latter test in the **Transformer** list and the test including the traces for which you want to generate assessments in the **Test** list.
5. Optionally, select the **High voltage traces**, the **Low voltage traces** or the **Tertiary voltage traces** check box to select the respective test traces.
6. Optionally, select the **Generate only assessments for the corresponding traces** check box to generate only assessments for the traces including the same windings.
7. Click **Finish**.

3.4.2 Assessment Window Display Pane

The display pane of the **Assessment** window displays the frequency responses of the assessed test traces. For the shortcut menu commands, see 3.2.2 "Test View Window Display Pane" on page 51.

3.4.3 Assessment Window Cursor Pane

In the cursor pane of the **Assessment** window, you can examine the measurement results in detail. For the test traces assigned to the cursors, the cursor pane displays the frequency and measured values at cursor positions. To assign a test trace to a cursor, select the check box next to the cursor, and then click the trace in the corresponding **Trace** list. You can show and hide the cursor pane by clicking the **Cursors Table** toolbar button  or **Cursors Table** on the **View** menu.

3.5 Toolbar

The toolbar provides quick access to the frequently used commands. You can show and hide the toolbar by clicking **Toolbar** on the **View** menu.

Figure 3-19:
Standard toolbar

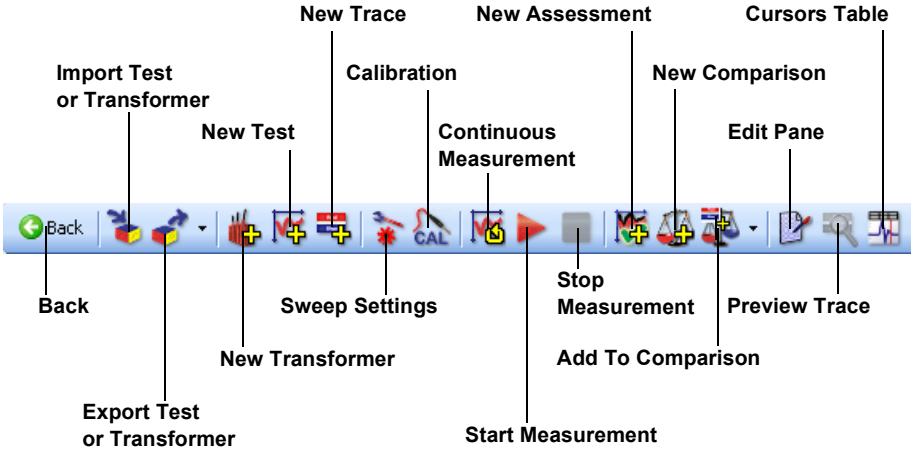
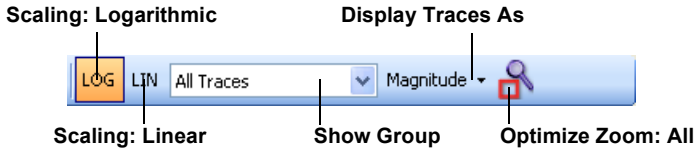


Figure 3-20:
Display Settings
toolbar



3.6 Status Bar

The status bar at the bottom of the windows shows the comparison, the transformer and the test selected and the measurement status.

Figure 3-21:
Status bar

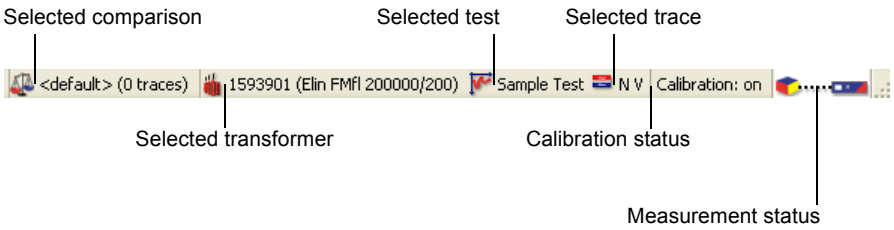


Table 3-10:
Measurement status

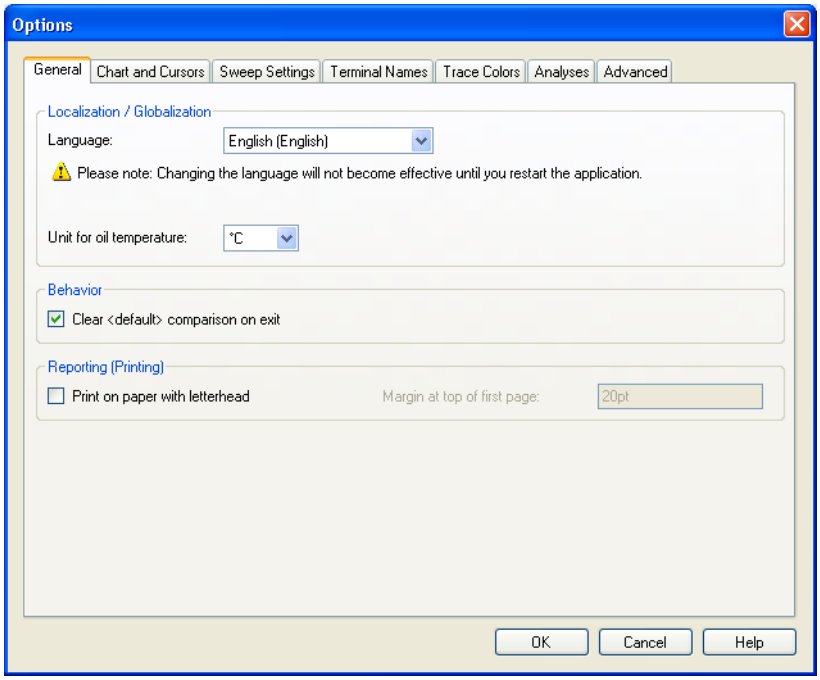
Measurement Status	Symbol	Description
Status busy		The *FRAnalyzer* performs internal calibration after it was connected to the computer.
Measurement running		The *FRAnalyzer* performs a measurement.
Status online		The *FRAnalyzer* is connected to the computer.
Status offline		The *FRAnalyzer* is not connected to the computer.

3.7 Setting Options

You can set general configuration options of the *FRAnalyzer* software in the **Options** dialog box. To open the **Options** dialog box, click **Options** on the **Tools** menu. After clicking the respective tab in the **Options** dialog box, you can set the general options, the chart and cursor options, the sweep settings options, the transformer's terminal names, the default colors of the transformer's terminals, the levels for the winding assessment factors, and the advanced measurement options.

On the **General** tab, you can set the user interface and reporting (see 3.10 "Reporting" on page 80) language, the oil temperature unit displayed by the *FRAnalyzer* software as well as some behavior options.

Figure 3-22:
General options



Under **Localization/Globalization**:

- In the **Language** list, select the language you want to use for the user interface and reporting.

  Note: After changing the language, restart the *FRAnalyzer* software.

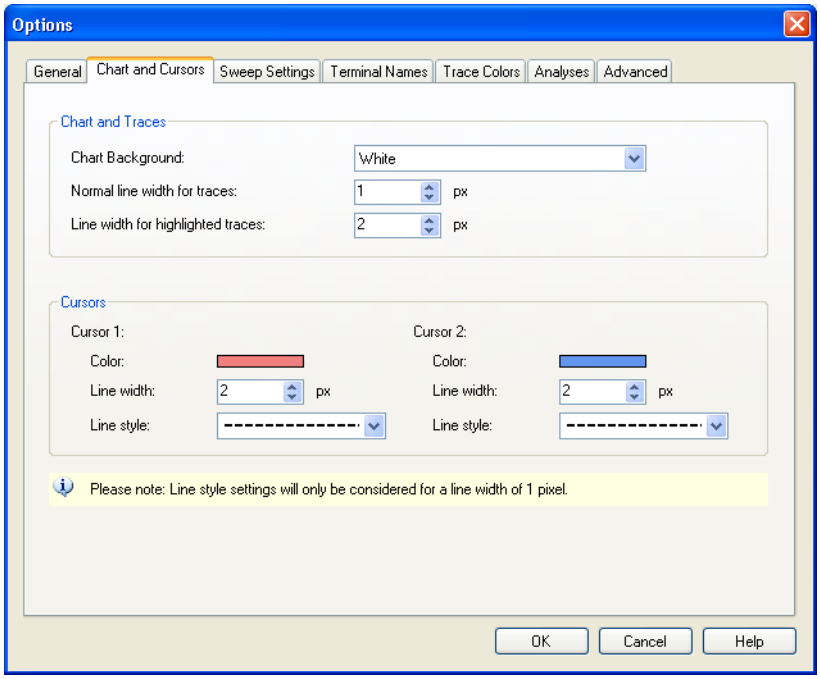
- In the **Unit for oil temperature** list, select the oil temperature unit you want to be displayed by the *FRAnalyzer* software.

Under **Behavior**, select the **Clear <default> comparison on exit** check box to clear the measurement results in the **<default>** comparison when exiting the *FRAnalyzer* software.

Under **Reporting (Printing)**, select the **Print on paper with letterhead** check box and enter the margin at the top of the first page to set the respective options for printing the reports.

On the **Chart and Cursors** tab, you can set the display properties of traces and cursors.

Figure 3-23:
Chart and cursors options



Under **Chart and Traces**:

- In the **Chart background** list, select the background color of the display panes.
- In the **Normal line width for traces** list, enter the normal line width.
- In the **Line width for highlighted traces** list, enter the line width of the selected traces.

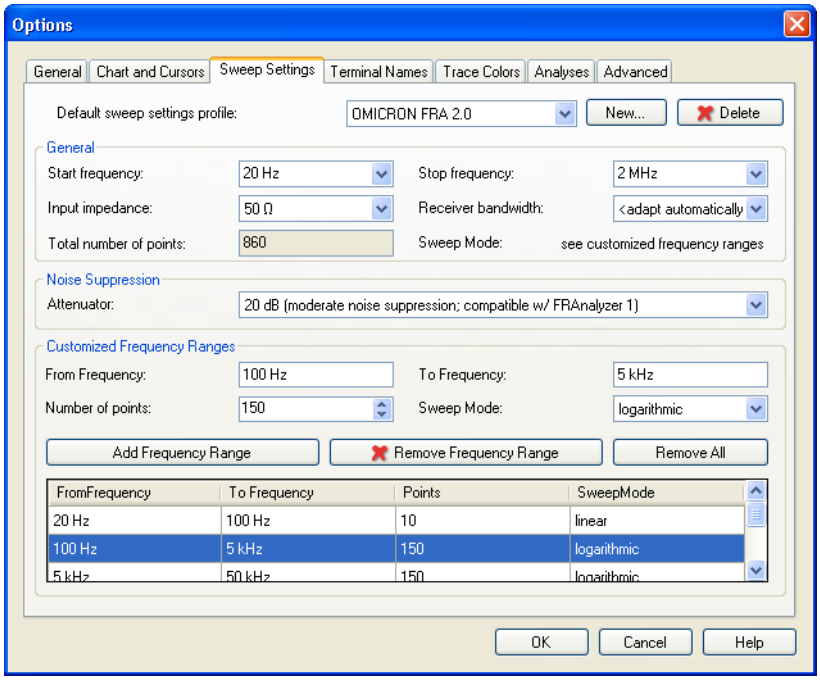
Under **Cursors**:

- Click in the **Color** bars, and in the **Color** palette, set the cursor colors.
- In the **Line width** boxes, enter the width of the cursor lines.
- In the **Line style** boxes, click the style of the cursor lines.

  Note: The style of the cursor lines is selectable only for the cursor line width of 1 pixel.

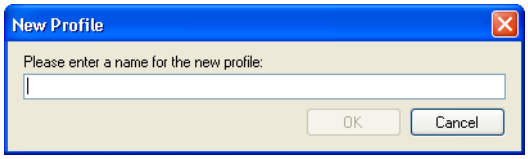
On the **Sweep Settings** tab, you can manage the sweep settings profiles. The *FRAnalyzer* software is delivered with non-editable profiles selectable in the **Default sweep settings profile** list. You can configure and save your own sweep settings profiles.

Figure 3-24:
Sweep settings options



To create your own sweep settings profile:

1. On the **Sweep Settings** tab, click the **New** button.



2. In the **New Profile** dialog box, type the profile name.
3. Click **OK** to get back to the **Options** dialog box.
4. Under **General**, enter:
   - Start and stop frequencies
   - Input impedance

     Note: The input impedance of 50 Ω is the standard setting for all default test traces and the recommended connection technique. Select the 1 MΩ input impedance only in well-founded cases, for example for measuring the transformation ratio or when using an alternative connection technique such as fibre optic cables.
   - Receiver bandwidth

     Note: A narrow receiver bandwidth suppresses the most noise interference but slows down the sweep. A broad receiver bandwidth results in fast measurements with a reduced noise immunity of the *FRAnalyzer*. The option **<adapt automatically>** (recommended) adapts the receiver bandwidth during the measurement for the best signal-to-noise ratio.
   - Total number of measurement points
   - Sweep mode
5. Under **Noise Suppression**, select the attenuation in the measurement channel:
   - **0 dB** to get the best signal-to-noise ratio with moderate risk of overload
   - **10 dB** to get good signal-to-noise ratio with low risk of overload
   - **20 dB** to get measurement results compatible with those obtained with the *FRAnalyzer* Version 1.0
   - **<adapt automatically>** (recommended) to adapt the attenuation during the measurement for the best signal-to-noise ratio without risk of overload
6. If you want to customize the distribution of the measurement points, proceed as follows.

Note: By customizing the distribution of the measurement points, you can increase the quality of your measurement with respect to the resolution and measurement time. Typically, 20 linearly distributed measurement points are sufficient within the range 20 Hz…200 Hz. At higher frequencies, a higher resolution is necessary due to the enhanced information content. Consequently, it is more suggestive to distribute the measurement points not evenly.

7. Under **Customize Frequency Ranges**, repeatedly click the **Add Frequency Range** button to generate as many frequency subranges as you want.
8. Select a frequency subrange.
9. In the **From Frequency** box, enter the lowest frequency of the subrange.
10. In the **To Frequency** box, enter the highest frequency of the subrange.

    Note: The start and stop frequencies chosen under **General** cannot be changed here. You can only set the distribution of the subranges.
11. In the **Number of Points** box, change, if necessary, the number of measurement points within the subrange. The maximum number of points per range is 400.
12. In the **Sweep Mode** box, click **linear** or **logarithmic** to select the respective sweep mode.
13. Repeat steps 8 to 12 to customize the measurement point distribution within the whole frequency range.
14. Click **OK** to save the sweep settings profile.

Note: Click **Remove Frequency Range** to delete the selected subrange, or click **Remove All** to remove all subranges.

To delete a user-defined sweep settings profile:

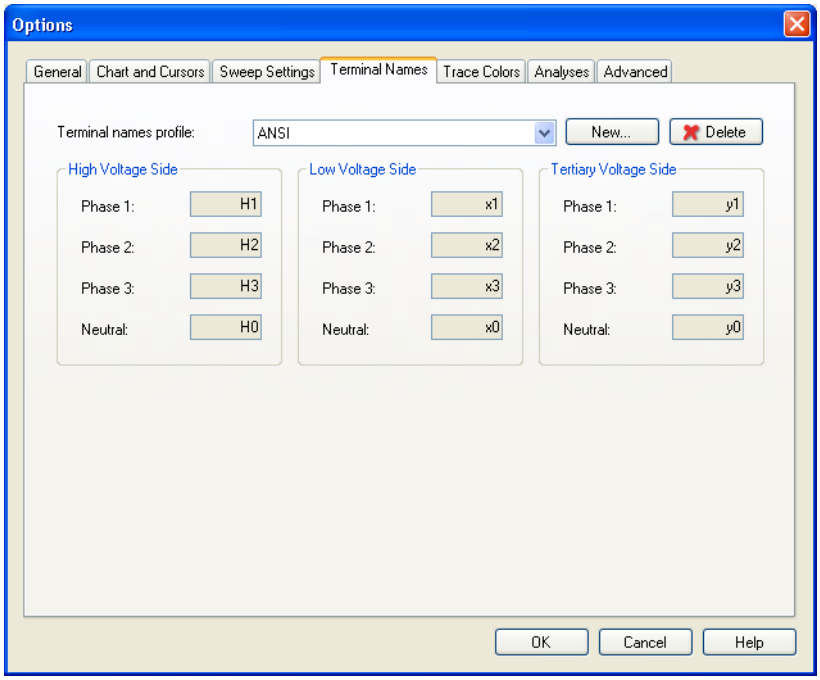
1. In the **Default sweep settings profile** list, select the profile you want to delete.
2. Click the **Delete** button.

To set the default sweep settings profile:

1. In the **Default sweep settings profile** list, click the profile you want to use as default.
2. Click **OK**.

On the **Terminal Names** tab, you can set the transformer's terminal naming conventions according to different standards and define your own terminal name profiles.

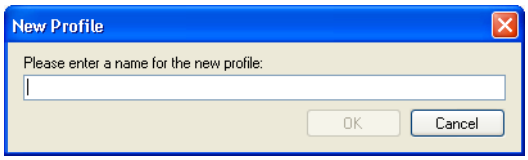
Figure 3-25:
Terminal names options



In the **Terminal name profile** list, select **ANSI**, **IEC** or **VDE** to set the transformer's terminal naming conventions according to the respective standard.

To define your own terminal name profile:

1. On the **Terminal Names** tab, click the **New** button.



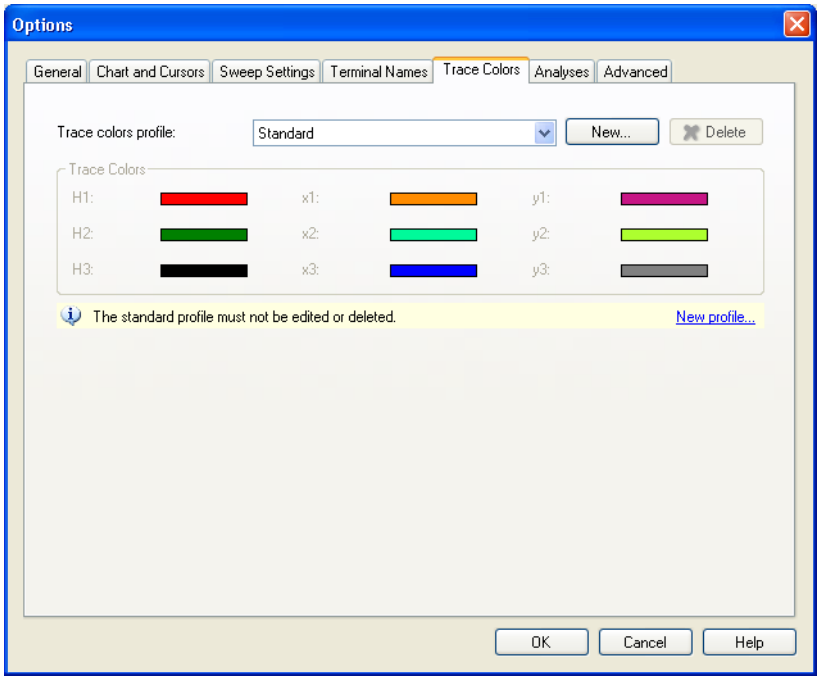
2. In the **New Profile** dialog box, type the profile name, and then click **OK**.
3. Under **High Voltage Side**, **Low Voltage Side** and **Tertiary Voltage Side**, enter your preferred naming conventions, and then click **OK**.

To delete a user-defined terminal name profile:

1. In the **Terminal names profile** list, select the profile you want to delete.
2. Click the **Delete** button.

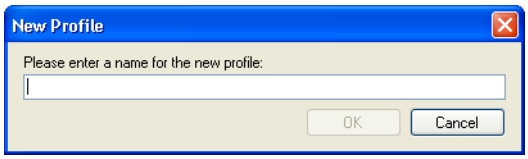
On the **Trace Colors** tab, you can set the default colors of the transformer's terminals and define your own trace color profiles.

Figure 3-26:
Trace colors options



To define your own trace color profile:

1. On the **Trace Colors** tab, click the **New** button.



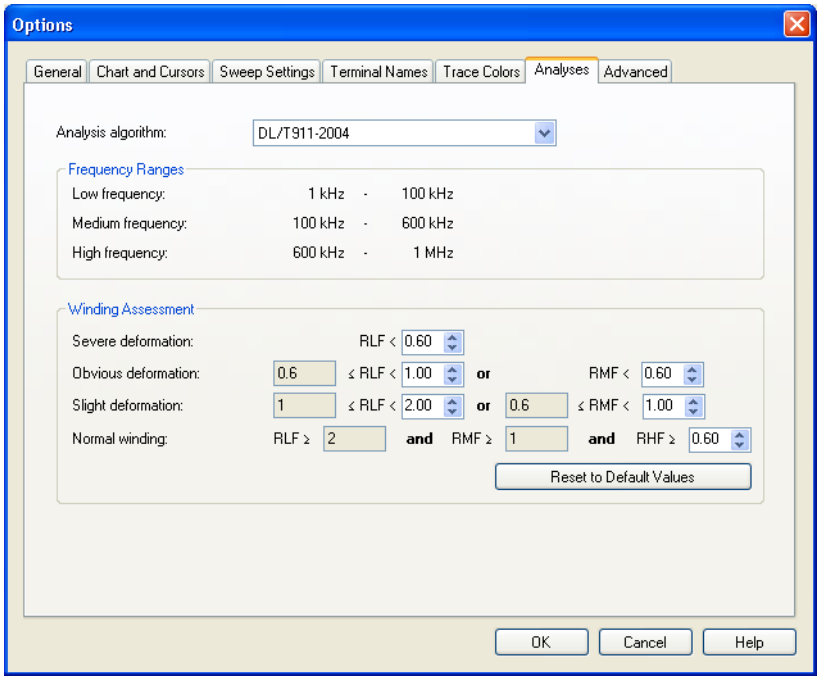
2. In the **New Profile** dialog box, type the profile name, and then click **OK**.
3. Under **Trace Colors**, click in the bars next to the trace names, and in the **Color** palette, set the default colors of the transformer's terminals.

To delete a user-defined trace color profile:

1. In the **Trace color profile** list, select the profile you want to delete.
2. Click the **Delete** button.

On the **Analyses** tab, you can set the default algorithm for the analysis of comparable test traces and the levels for the winding assessment factors. You can select the analysis algorithm according to the DL/T911-2004 and NCEPRI standards (see 4.5 "Analysis Algorithms" on page 88).

Figure 3-27:
Analyses options



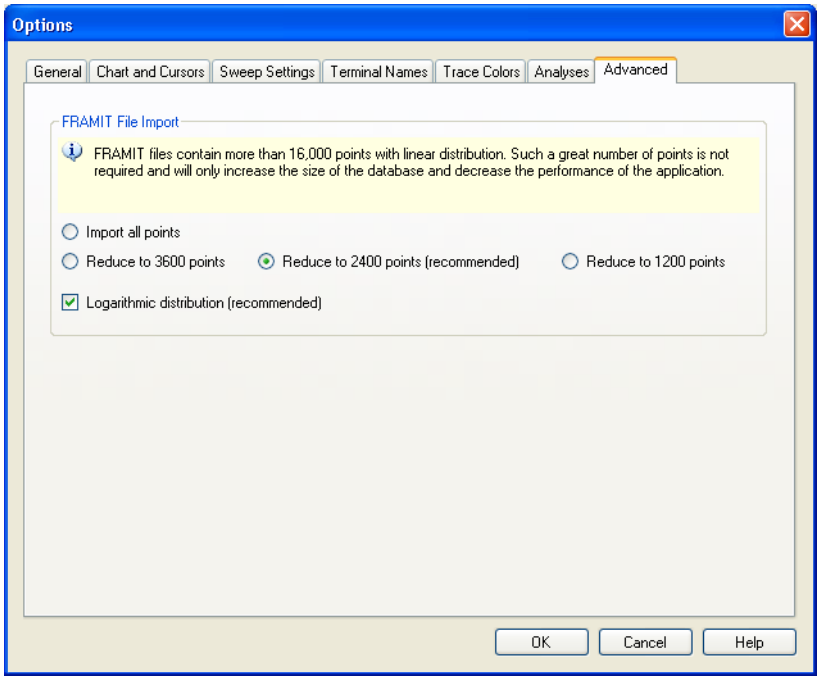
To select the default analysis algorithm according to the DL/T911-2004 or NCEPRI standards, select the respective entry in the **Analysis algorithm** list.

Under **Winding Assessment**, you can set the threshold levels for the winding assessment factors. To set the default threshold levels recommended by the relevant standards, click **Reset to Default Values**.

Note: The overall winding assessment relies on the analysis algorithm with the threshold levels for the winding assessment factors recommended by the DL/T911-2004 and NCEPRI standards. For other threshold levels, the overall winding assessment does not comply with the underlying standards.

On the **Advanced** tab, you can set the number of points and their distribution for data import from the *FRAMIT* test system to reduce the time required for processing the data.

Figure 3-28:
Advanced options



Under **FRAMIT File Import**:

- Click the number of points you want to import.
- Select or clear the **Logarithmic distribution** check box to set the logarithmic or the linear distribution of the measurement points.

3.8 Sweep Settings

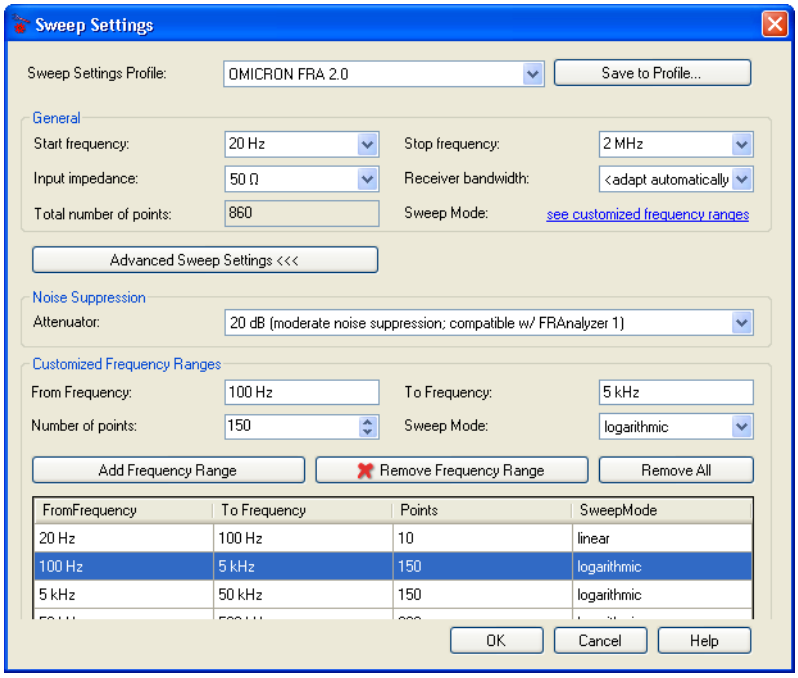
Any test with the *FRAnalyzer* is performed with specified sweep settings. The default sweep settings profile is set in the **Options** dialog box (see 3.7 "Setting Options" on page 66). You can set the frequency sweep parameters for any test individually according to your needs. We recommend to use the same sweep settings for the comparable tests.

Note: The sweep settings different from the settings of a default profile apply only to the selected test. You cannot change the sweep settings of a test after a trace has been measured.

To set the frequency sweep parameters of a test:

1. In the **Data Management** window (see 3.1 "Data Management Window" on page 33) or the **Test View** window (see 3.2 "Test View Window" on page 47), select the test whose sweep settings you want to set.
2. Click the **Sweep Settings** toolbar button or **Sweep Settings** on the **Test** menu to open the **Sweep Settings** dialog box.

Figure 3-29:
Sweep Settings dialog box



3. In the **Sweep Setting Profile** list, select the profile you want to use as the basis for setting the frequency sweep parameters, and then follow steps 4 to 13 of the procedure for configuring the your own sweep setting profiles on pages 69 to 70.
4. If you want to save the sweep settings in a profile, click the **Save to Profile** button, in the **Save Sweep Settings to Profile** dialog box, type the profile name, and then click **OK**.
5. In the **Sweep Settings** dialog box, click **OK** to assign the sweep settings to the selected test.

3.9 Importing and Exporting Data

3.9.1 Importing Data

With the *FRAnalyzer*, you can import and export measurement results and, depending on the data format, also the associated transformer and test data. The *FRAnalyzer* software facilitates importing the data from FRA test systems of other manufacturers such as Doble, PAX Diagnostics and Haefely Test AG by supporting the data import in the manufacturer specific formats. All file operations are done in the usual Windows manner.

The *FRAnalyzer* software supports the following data formats for data import.

Table 3-11: Supported data import formats

Format	File Extension	Description
FRAnalyzer	fra	*FRAnalyzer* native format[1]
FRAnalyzer Transformer File	tfra	*FRAnalyzer* native format[2]
FRAnalyzer CSV 2.0	csv	Comma-separated values format
FRAnalyzer CSV 1.0	csv	Comma-separated values format
CIGRE Exchange	xfra	Standard exchange format for trace data as defined by Cigré
FRAMIT 3.0	fra	*FRAMIT* specific format
Doble	sfra	Doble specific format
Doble CSV	csv	Doble specific format
TDT4	dat	China Electric Power Research Institute (CEPRI) specific format
TDT5	csv	CEPRI specific format
TDT6	csv	CEPRI specific format
Pax	pax	PAX Diagnostics specific format[3]
FRAX CSV	csv	PAX Diagnostics specific format
FRAX	txt	PAX Diagnostics specific format
Tettex	csv	Tettex specific format

1. Contains also the associated transformer and test data.
2. Collection of multiple .fra files in a ZIP archive
3. One file for the test data and a folder with one file for a test trace

To import a test:

1. Do one of the following:
   - In the **Data Management** window, right-click in the **Tests** area, and then click **Import**.
   - On the **Test** menu, click **Import**.
2. In the **Open File** dialog box, browse to the file containing the data you want to import.

By using the FRAnalyzer Transformer File format, you can import all tests for the associated transformer as follows:

1. Do one of the following:
   - In the **Data Management** window, right-click in the **Transformers** area, and then click **Import**.
   - On the **Transformer** menu, click **Import**.
2. In the **Open File** dialog box, browse to the file containing the data you want to import.

3.9.2 Exporting Data

The *FRAnalyzer* software supports the following data formats for data export.

Table 3-12: Supported data export formats

Format	File Extension	Description
FRAnalyzer	fra	*FRAnalyzer* native format[1]
FRAnalyzer Transformer File	tfra	*FRAnalyzer* native format[2]
FRAnalyzer CSV 2.0	csv	Comma-separated values format
CIGRE Exchange	xfra	Standard exchange format for trace data as defined by Cigré For details, see *Mechanical Condition Assessment of Transformer Windings Using Frequency Response Analysis (FRA)*, April 2008, Section 2.4.7.

1. Contains also the associated transformer and test data.
2. Collection of multiple .fra files in a ZIP archive

To export a test in the FRAnalyzer or FRAnalyzer CSV 2.0 format:

1. Do one of the following:
   - In the **Data Management** window, right-click in the **Tests** area, and then click **Export**.
   - On the **Test** menu, click **Export**.
2. In the **Save Test** dialog box, browse to the file you want to save the data to.

To export a test in the CIGRE Exchange format:

1. Do one of the following:
   - In the **Data Management** window, right-click in the **Tests** area, and then click **Export in CIGRE Format**.
   - On the **Test** menu, click **Export in CIGRE Format**.
2. In the **Browse for Folder** dialog box, browse to the folder you want to save the data to.

   Note: When saving a file, one file per trace is created and the file names are generated automatically in accordance with the Cigré standard.

By using the FRAnalyzer Transformer File format, you can export all tests for the associated transformer as follows:

1. Do one of the following:
   - In the **Data Management** window, right-click in the **Transformers** area, and then click **Export**.
   - On the **Transformer** menu, click **Export**.
2. In the **Save Transformer and Tests** dialog box, browse to the file you want to save the data to.

3.9.3 Maintaining the Database

The *FRAnalyzer* data is organized in a database on the hard disk of your computer. It is recommended to periodically store the data in a removable data storage device to protect it against loss or damage. To back up the data, click **Backup Database** on the **File** menu, and then save the data in an archive file.

Note: Restoring the database overwrites the data in the database.

To restore the database from the archive file, click **Restore Database Backup** on the **File** menu, and then browse to the file containing the data you want to restore.

Note: You can only restore the databases created with the same or an earlier version of the Microsoft SQL Server as installed on your system.

3.10 Reporting

You can print a report on a test. The test report includes the transformer and test data, the measurement results and assessments. To print a test report, click **Print** on the **File** menu. You can also export the report data in a Microsoft Excel™ worksheet to easily create fully customized reports. To export the report data, click **Export Report As Excel File** on the **File** menu.

Alternatively, you can copy a diagram to the clipboard and then process it by using another application, for example Microsoft Word. To copy the displayed diagram to the clipboard, right-click in the display pane of the **Test View** window, the **Comparison** window or the **Assessment** window, and then click **Copy**.

3.11 Calibrating the *FRAnalyzer*

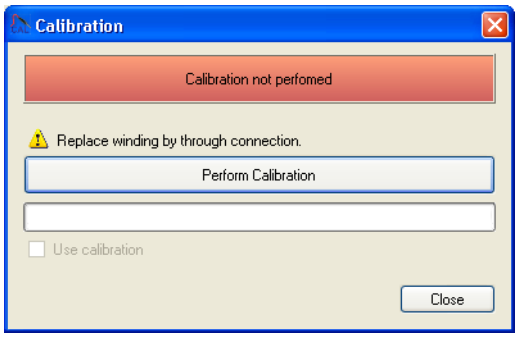
The *FRAnalyzer* is calibrated automatically on startup. It is recommended to calibrate the *FRAnalyzer* before performing a test or after changing the cables to eliminate the effect of the cables.

Note: The calibration applies only to the selected test. The calibration is not available for tests with customized sweep ranges.

To calibrate the *FRAnalyzer*:

1. In the **Data Management** window or in the **Test View** window, select the test for which you want to calibrate the *FRAnalyzer*.
2. Click **Calibration** on the **Tools** menu.

Figure 3-30:
Calibration dialog box



3. Connect the SOURCE connector to both the REFERENCE connector and the MEASUREMENT connector using the delivered BNC T adapter.

Figure 3-31:
BNC T adapter

4. In the **Calibration** dialog box, click the **Perform Calibration** button and wait until the calibration is finished. The calibration takes about 100 s.
   After the calibration has been finished, **Calibration performed** is displayed in a green box.
5. Click **Close**.

Note: The calibration status is displayed in the status bar (see 3.6 "Status Bar" on page 65).

4 Testing with the *FRAnalyzer*

With the *FRAnalyzer*, you can measure frequency responses of the transformer windings, compare the measurement results and assess the transformer windings by calculating the difference between the measurement results of two comparable test traces.

4.1 Test Traces

For testing with the *FRAnalyzer*, the test traces are of fundamental importance. The frequency response of the test trace strongly depends on the vector group of the transformer and the measurement type (for example, end-to-end, interwinding, and others). When adding a new test, the default test traces are created automatically according to the FRA testing recommendations. You can intentionally change them for your specific applications.

Typically, you do not need to change the default test traces. In well-founded cases, you can delete the default test traces and add new test traces. In particular, in typical *FRAnalyzer* applications proceed as follows:

- If you want to test a transformer for the first time, create a new test with the transformer under test associated with the test (see "Tests Area" on page 40). Then the default test traces are likely the traces you want to test.
- If you want to compare the current measurement results with the reference measurement results, create a new test by using the reference test as template (see "Tests Area" on page 40). Then the default traces created by the test template are exactly the traces you want to test.
- If you want to test a transformer in your own way, customize the traces you want to measure (see "Traces Area" on page 43).

You can change the test trace line colors by using the **Change Color** command (see 3.2.1 "Test View Window Edit Pane" on page 48).

4.2 Performing Measurements and Tests

Before performing measurements with the *FRAnalyzer*, you must create the transformer under test, a test and the test traces you want to measure. For detailed information on how to add a transformer, a test and test traces, see 3.1 "Data Management Window" on page 33.

To measure a test trace:

1. Add the transformer under test (see "Transformers Area" on page 38).
2. Add a test with test traces (see "Tests Area" on page 40 and 4.1 "Test Traces" on page 83).
3. Optionally, change the default test traces (see "Traces Area" on page 43).
4. In the **Traces** area of the **Data Management** window, select the test trace you want to measure.
5. Click the **Trace Details** tab, and then connect the *FRAnalyzer* to the transformer's terminals as shown by the **Red** and **Blue** boxes.
   For detail information on the connection technique, see 2.4 "Connecting the FRAnalyzer to a Power Transformer" on page 28.
6. Do one of the following:

- Click the **Start Measurement** toolbar button  .
- Right-click the selected trace, and then click **Start Measurement**.
- Click **Start Measurement** on the **Trace** menu.
- Under **Selected Trace**, click the **Start** button.

7. Click the **Test View** tab to display the measurement results (see 3.2 "Test View Window" on page 47).

After the measurement has been finished, the measurement results are saved in the *FRAnalyzer* database and the symbol  is displayed in the State column of the trace record.

To stop a measurement, do one of the following:

- Click the **Stop Measurement** toolbar button  .
- Right-click the test trace being measured, and then click **Stop Measurement**.
- Click **Stop Measurement** on the **Trace** menu.
- Under **Selected Trace**, click the **Stop** button.

After you stopped a measurement, the measurement results obtained until then will be cleared.

To perform a complete test, repeat steps 4 to 7 of the procedure described earlier in this section for all test traces. After the test has been completed, the symbol  is displayed in the State column of the test record.

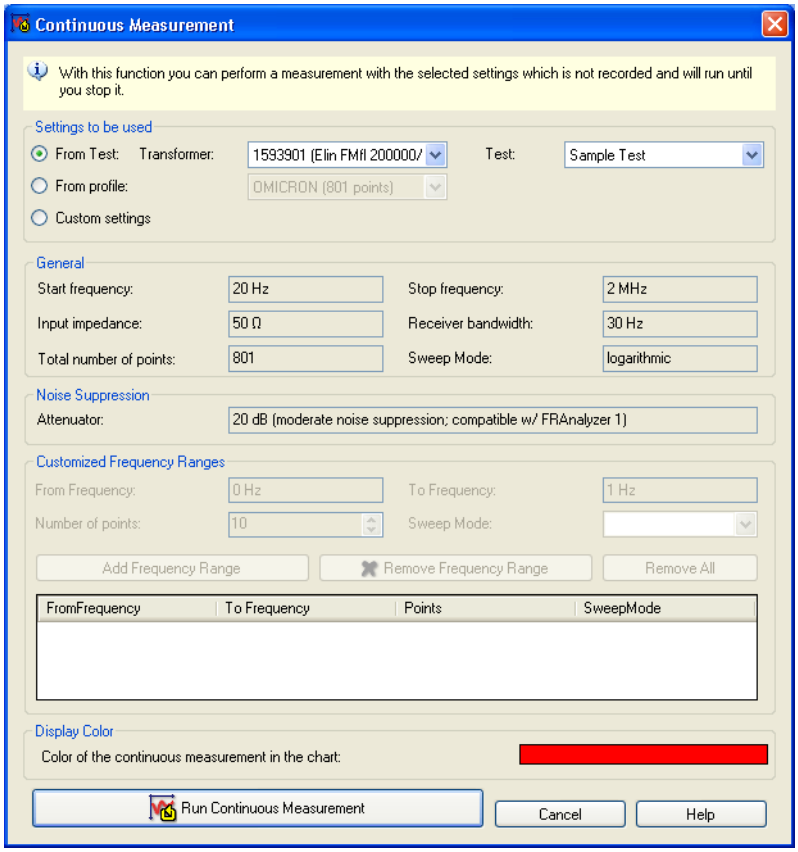
To clear the measurement results, do one of the following:

- Right-click the trace whose results you want to clear, and then click **Clear Results**.
- Click the trace whose results you want to clear, and then click **Clear Results** on the **Trace** menu.

The *FRAnalyzer* provides additionally a measurement mode for continuous measurements without saving the measurement results. In the continuous measurement mode, the frequency is repeatedly swept from the start frequency to the stop frequency and the measurement results are graphically displayed.

To start the continuous measurement mode:

1. Click the **Continuous Measurement** toolbar button or **Continuous Measurement** on the **Tools** menu to open the **Continuous measurement** dialog box.



2. Under **Settings to be used**, click:
   - **From test**, and then select the test whose settings you want to use.
   - **From profile**, and then select the profile whose settings you want to use.
   - **Custom settings**, and then customize the sweep settings as described in 3.8 "Sweep Settings" on page 75.
3. Under **Display Color**, optionally set the display color of the continuous measurement.
4. Click the **Run Continuous Measurement** button.

4.3 Comparing the Measurement Results

You can diagnose the defects in the transformer windings and magnetic core by comparing the measurement results for comparable test traces. Comparable test traces are:

- The same transformer windings measured at different times
- Windings on the same voltage side of one transformer
- Windings on the same voltage side of transformers of the same type and construction, so-called "sister units"

For detailed information on how to work with comparisons, see 3.3 "Comparison Window" on page 54.

To compare measurement results:

1. In the **Comparison** window, add a comparison (see 3.3.1 "Comparison Window Edit Pane" on page 55).
2. Add comparable test traces to the comparison (see 3.3.1 "Comparison Window Edit Pane" on page 55).
3. Compare the frequency responses of the compared test traces visually (see 3.3.2 "Comparison Window Display Pane" on page 58).

4.4 Assessing the Transformer Windings

With the *FRAnalyzer*, you can assess the transformer windings by calculating the winding assessment factors of the frequency responses of two comparable test traces. You can calculate the winding assessment factors by using different algorithms (see 4.5 "Analysis Algorithms" on page 88). For detailed information on how to work with assessments, see 3.4 "Assessment Window" on page 59.

To assess the transformer windings:

1. Click the **Assessment** tab to open the **Assessment** window.
2. Under **Winding Assessment**, select the algorithm (see 4.5 "Analysis Algorithms" on page 88) you want to use for the assessment.
3. Add and configure an assessment of comparable test traces (see 3.4.1 "Assessment Window Edit Pane" on page 60).
4. Under **Winding Assessment**, read the winding assessment factors for the respective frequency ranges and the overall winding assessment.

4.5 Analysis Algorithms

The assessment of the transformer windings under test is based on two different algorithms described later.

4.5.1 DL/T911-2004

DL/T911-2004 is a standard for the frequency response analysis widely used in the People's Republic of China. For detailed information, see the China Electric Power Publishing Co. website www.cepp.com.cn. The algorithm evaluates the similarity of the frequency responses of two transformer's test traces by calculating the factors R_{LF}, R_{MF} and R_{HF} (see Table 4-1: "Winding assessment factors according to the DL/T911-2004 standard").

The basic underlying formulas of the DL/T911-2004 algorithm include:

$$D_x = \frac{1}{N}\sum_{k=0}^{N-1}\left[X(k) - \frac{1}{N}\sum_{k=0}^{N-1}X(k)\right]^2 \qquad \text{(Eq. 4-1)}$$

$$D_y = \frac{1}{N}\sum_{k=0}^{N-1}\left[Y(k) - \frac{1}{N}\sum_{k=0}^{N-1}Y(k)\right]^2 \qquad \text{(Eq. 4-2)}$$

$$C_{xy} = D_x \times D_y \qquad \text{(Eq. 4-3)}$$

$$LR_{xy} = C_{xy}/(\sqrt{D_x D_y}) \qquad \text{(Eq. 4-4)}$$

$$R_{xy} = \begin{cases} 10 & \text{if } 1 - LR_{xy} < 10^{-10} \\ -\lg(1 - LR_{xy}) & \text{otherwise} \end{cases} \qquad \text{(Eq. 4-5)}$$

where $X(k)$, $Y(k)$ are comparable frequency response sequences of length N.

The algorithm evaluates the factor R_{xy} at fixed frequencies within the frequency range 1 kHz…1 MHz. Consequently, the algorithm works only for frequency responses including measurement results within 1 kHz…1 MHz. Measurement results out of this range are not considered. The factor R_{xy} evaluated in different frequency ranges yields the winding assessment factors as given in the following table.

Table 4-1: Winding assessment factors according to the DL/T911-2004 standard

Winding Assessment Factor	Frequency Range
R_{LF}	1 kHz…100 kHz
R_{MF}	100 kHz…600 kHz
R_{HF}	600 kHz…1 MHz

Using the winding assessment factors described in the preceding table, the transformer winding deformation conditions are defined as follows.

Note: The data in the following table applies to the power transformers with S > 1 MVA.

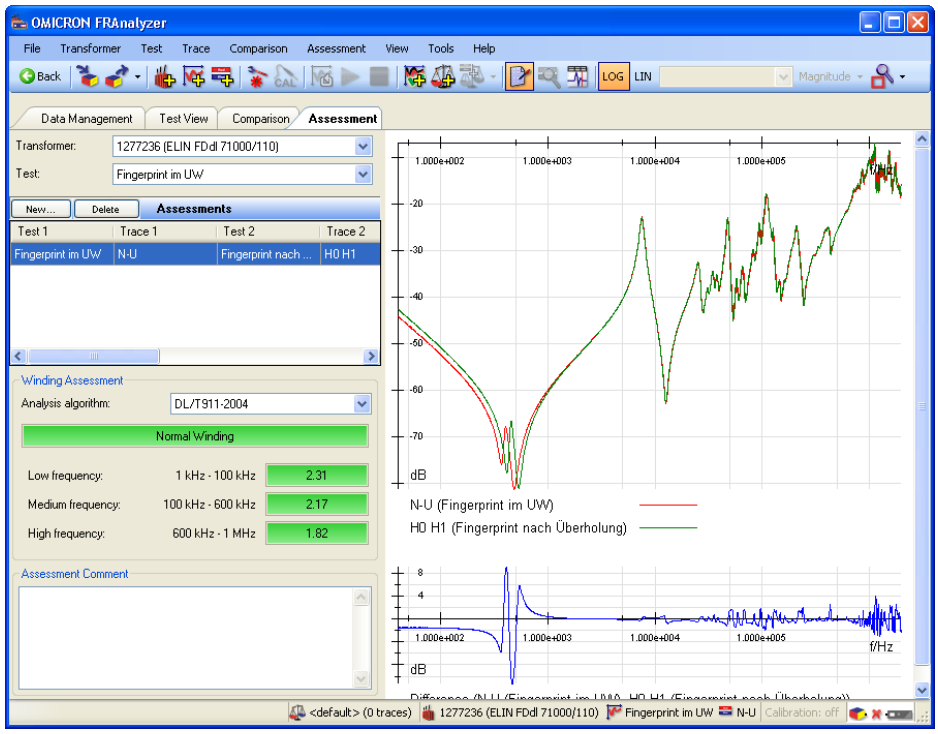
Table 4-2: Winding assessment according to the DL/T911-2004 standard

Winding Deformation Degree	Winding Assessment Factors
Normal winding	$R_{LF} \geq 2.0$ AND $R_{MF} \geq 1.0$ AND $R_{HF} \geq 0.6$
Slight deformation	$2.0 > R_{LF} \geq 1.0$ OR $0.6 \leq R_{MF} < 1.0$
Obvious deformation	$1.0 > R_{LF} \geq 0.6$ OR $R_{MF} < 0.6$
Severe deformation	$R_{LF} < 0.6$

Note: The algorithm according to the DL/T911-2004 standard analyzes only comparable test traces (the same test trace at different times or the same voltage side windings) if the measurement results cover the frequency ranges required for the calculation of the winding assessment factors (see Table 4-1: "Winding assessment factors according to the DL/T911-2004 standard" on page 89). In all other cases, the calculated winding assessment factors have no meaning or cannot be calculated and the *FRAnalyzer* displays **Assessment Not Possible**.

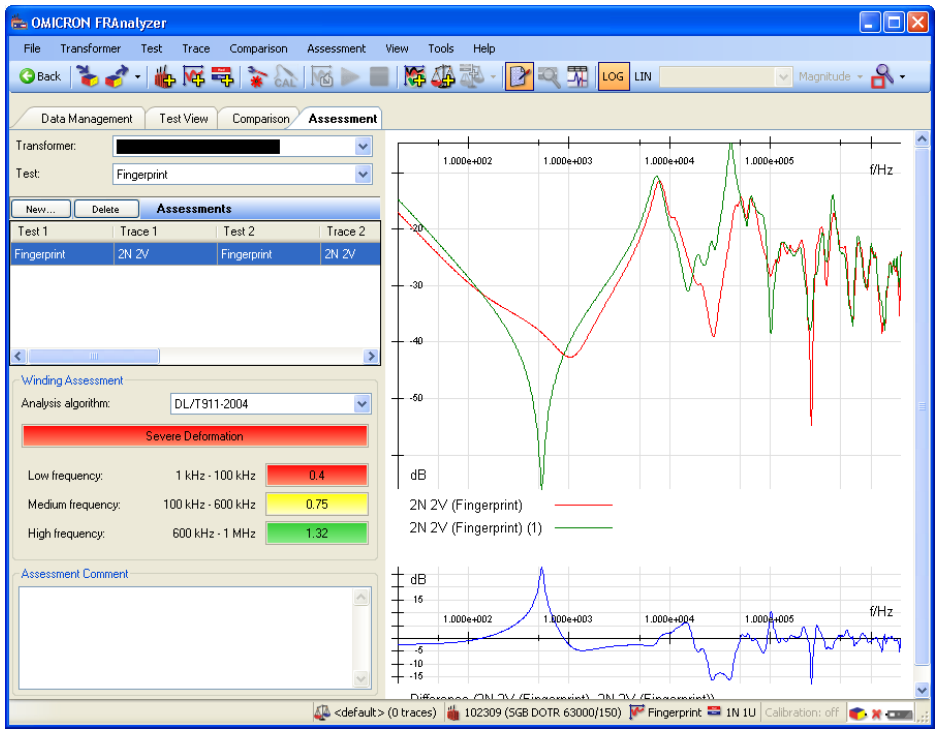
As an example, the Figure 4-1: "Winding assessment of an intact transformer" shows the winding assessment of an intact transformer.

Figure 4-1:
Winding assessment of an intact transformer



As an example, the Figure 4-2: "Winding assessment of an defective transformer" shows the winding assessment of an defective transformer.

Figure 4-2:
Winding assessment of an defective transformer



4.5.2 NCEPRI

NCEPRI is an alternative established method for the transformer winding deformation assessment. For detailed information, see the NCEPRI website www.ncepri.com. The algorithm evaluates the similarity of the frequency responses of two transformer's test traces by calculating their root mean-square deviation

$$E_{12} = \sqrt{\frac{\sum_{i=1}^{N} (F_{1i} - F_{2i})^2}{N}} \qquad \text{(Eq. 4-6)}$$

where F_{1i}, F_{2i} are comparable frequency response sequences of length N in dB.

The winding assessment factor E_{12} is evaluated in different frequency ranges for the high-voltage, low-voltage and tertiary windings as given in the following table.

Table 4-3: Frequency ranges according to the NCEPRI standard

Winding	Frequency Range
High-voltage	10 kHz…515 kHz
Low-voltage	10 kHz…600 kHz
Tertiary-voltage	10 kHz…700 kHz

Using the winding assessment factor E_{12}, the transformer winding deformation conditions are defined as follows.

Table 4-4: Winding assessment according to the NCEPRI standard

Winding Distortion Level	Winding Assessment Factor in dB
Normal condition	$E_{12} < 3.5$
Slight distortion	$3.5 < E_{12} < 7.0$
Severe distortion	$E_{12} > 7.0$

Note: The algorithm according to the NCEPRI standard analyzes only comparable test traces (the same test trace at different times or the same voltage side windings) if the measurement results cover the frequency ranges required for the calculation of the winding assessment factor (see Table 4-3: "Frequency ranges according to the NCEPRI standard"). In all other cases, the calculated winding assessment factor has no meaning or cannot be calculated and the *FRAnalyzer* displays **Assessment Not Possible**.

Note: The overall winding assessment relies on the analysis algorithm with the levels for the winding assessment factors recommended by the respective standards and consequently cannot be guaranteed by OMICRON electronics.

5 Application Example

5.1 Introduction

The following application example guides you step by step through an FRA test using the *FRAnalyzer*. As a typical example, a 110 kV/28 kV/10.75 kV-rated 60 MVA power transformer with the YNyn0d5 vector group is tested.

Note: Observe all local safety instructions to isolate the transformer.

Figure 5-1:
Power transformer under test

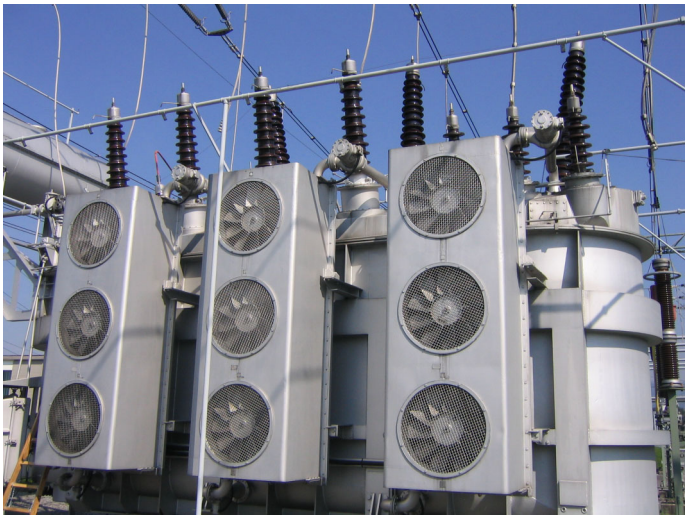
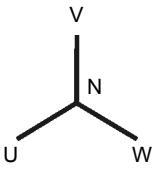
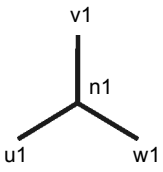
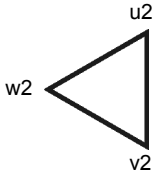


Table 5-1:
Winding organization of the tested transformer

Winding		
High-voltage side	Low-voltage side	Tertiary-voltage side
		

For detailed information on using the *FRAnalyzer* software, see 3 "The FRAnalyzer Software" on page 33 or the *FRAnalyzer* Help. By following the test procedure, you can practice operating the *FRAnalyzer*. To obtain the test data without testing a real transformer, import the *Sample Test_1.tfra* and *Sample Test_2.fra* files available in the *Sample Tests* folder on the *FRAnalyzer* CD-ROM.

5.2 Preparing the Test

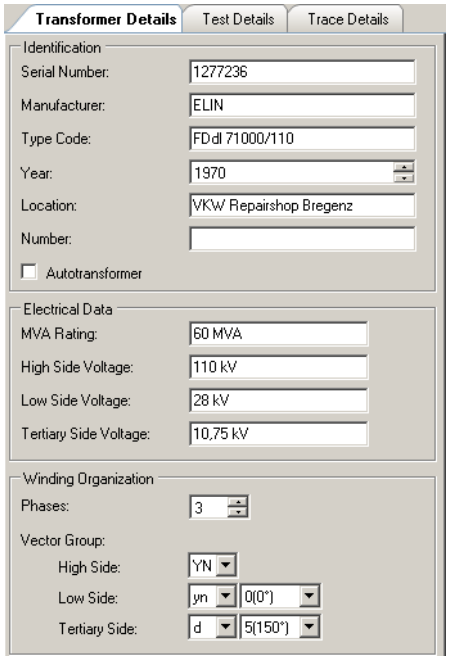
With the *FRAnalyzer*, you can prepare an FRA test by setting all relevant data before on-site testing. After then, a field test controlled by the *FRAnalyzer* software runs, requiring only selection of the predefined test traces and connection of the corresponding transformer**'s** terminals. After the test has been completed, you can assess the transformer windings.

Note: Before performing measurements, it is recommended to calibrate the *FRAnalyzer* (see 3.11 "Calibrating the FRAnalyzer" on page 80).

5.2.1 Adding a Transformer Record

After starting the *FRAnalyzer* software, add a transformer record in the **Data Management** window. On the **Transformer Details** tab, enter the transformer data as follows. Note that the number of phases and the vector group match the transformer winding organization (see Table 5-1: "Winding organization of the tested transformer" on page 93).

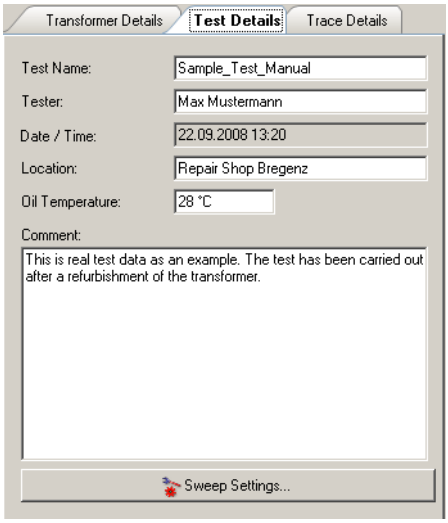
Figure 5-2:
Transformer data



5.2.2 Adding a Test Record

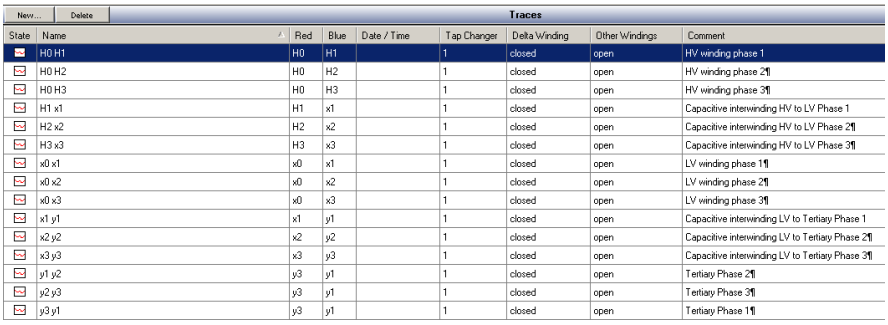
In compliance with the terminal naming conventions used at the tested transformer, set the **Terminal Names** option to the CIGRE standard. In the **Data Management** window, add a test record. Click the **Test** tab, and then type the test details as follows.

Figure 5-3:
Test details



In the **Traces** area, check the test traces. The test traces are created according to the recommendations for the transformer under test and you do not need to change them.

Figure 5-4:
Test traces



State	Name	Red	Blue	Date / Time	Tap Changer	Delta Winding	Other Windings	Comment
	H0 H1	H0	H1		1	closed	open	HV winding phase 1
	H0 H2	H0	H2		1	closed	open	HV winding phase 2¶
	H0 H3	H0	H3		1	closed	open	HV winding phase 3¶
	H1 x1	H1	x1		1	closed	open	Capacitive interwinding HV to LV Phase 1
	H2 x2	H2	x2		1	closed	open	Capacitive interwinding HV to LV Phase 2¶
	H3 x3	H3	x3		1	closed	open	Capacitive interwinding HV to LV Phase 3¶
	x0 x1	x0	x1		1	closed	open	LV winding phase 1¶
	x0 x2	x0	x2		1	closed	open	LV winding phase 2¶
	x0 x3	x0	x3		1	closed	open	LV winding phase 3¶
	x1 y1	x1	y1		1	closed	open	Capacitive interwinding LV to Tertiary Phase 1
	x2 y2	x2	y2		1	closed	open	Capacitive interwinding LV to Tertiary Phase 2¶
	x3 y3	x3	y3		1	closed	open	Capacitive interwinding LV to Tertiary Phase 3¶
	y1 y2	y3	y1		1	closed	open	Tertiary Phase 2¶
	y2 y3	y3	y1		1	closed	open	Tertiary Phase 3¶
	y3 y1	y3	y1		1	closed	open	Tertiary Phase 1¶

When testing a transformer, check and, if necessary, change the **Tap Changer**, **Delta Winding Open** and **Other Winding** settings on the transformer as specified by the test traces.

Note: It is recommended to use the logarithmic distribution of the measurement points. Typically, it is advantageous to set more measurements points in the upper part of the frequency range by adding frequency subranges (see 3.7 "Setting Options" on page 66).

5.3 Putting the *FRAnalyzer* into Operation

Connect the *FRAnalyzer* to the power transformer under test as follows (for the accessories used, see 1.2.4 "Delivery" on page 20):

1. Connect the yellow, red and blue coaxial cables to the SOURCE, REFERENCE and MEASUREMENT connectors of the *FRAnalyzer* respectively.

Figure 5-5: Connecting coaxial cables

2. Connect the grounding cable to the equipotential ground terminal on the *FRAnalyzer* rear panel, and clamp its other end to the transformer tank.

Figure 5-6: Grounding the *FRAnalyzer*

3. Connect the *FRAnalyzer* to the computer using a USB cable (see 2.3 "Connecting the FRAnalyzer to the Computer" on page 26).
4. Power the *FRAnalyzer* (see 2.2 "Powering the FRAnalyzer" on page 24).

For each trace test, connect the *FRAnalyzer* to the corresponding transformer's terminals as described in 5.4 "Connecting the FRAnalyzer to the Transformer's Terminals" later. To complete the test, repeat the procedure for all test traces.

5.4 Connecting the *FRAnalyzer* to the Transformer's Terminals

To perform a measurement, for example of the N U test trace, connect the *FRAnalyzer* to the transformer's terminal bushings N and U. For detailed information on the connecting technique, see 2.4 "Connecting the FRAnalyzer to a Power Transformer" on page 28.

To connect the *FRAnalyzer* to the transformer's terminal bushings N and U:

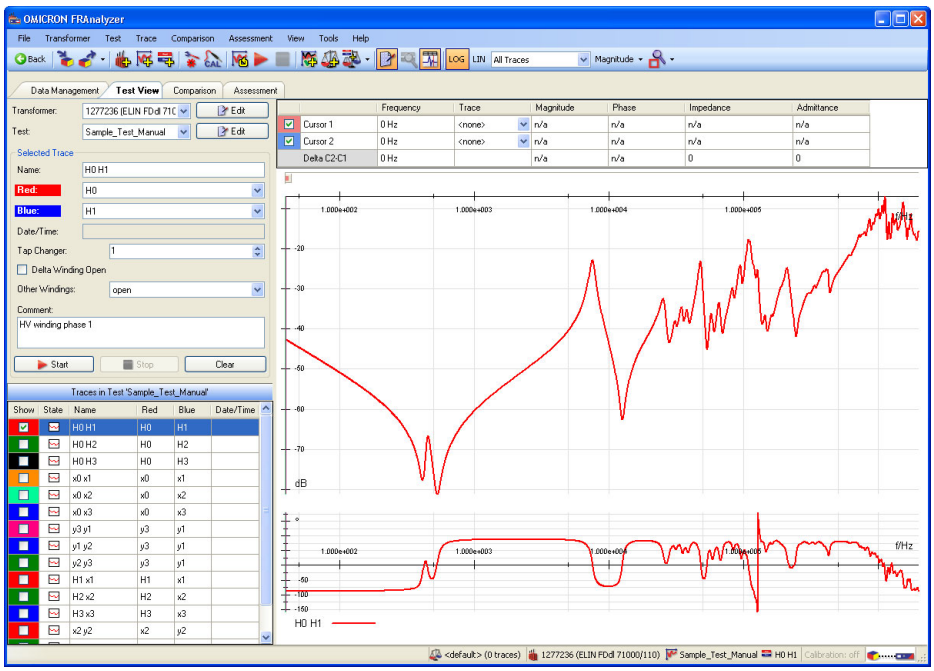
1. Connect the yellow and red coaxial cables to the transformer's terminal bushing N using a bushing clamp.
2. Ground the bushing clamp using two aluminium braids and the screw clamps.
3. Connect the blue coaxial cable to the transformer's terminal bushing U using a bushing clamp.
4. Ground the bushing clamp using two aluminium braids and the screw clamps.

5.5 Measuring the Test Traces

To measure a test trace:

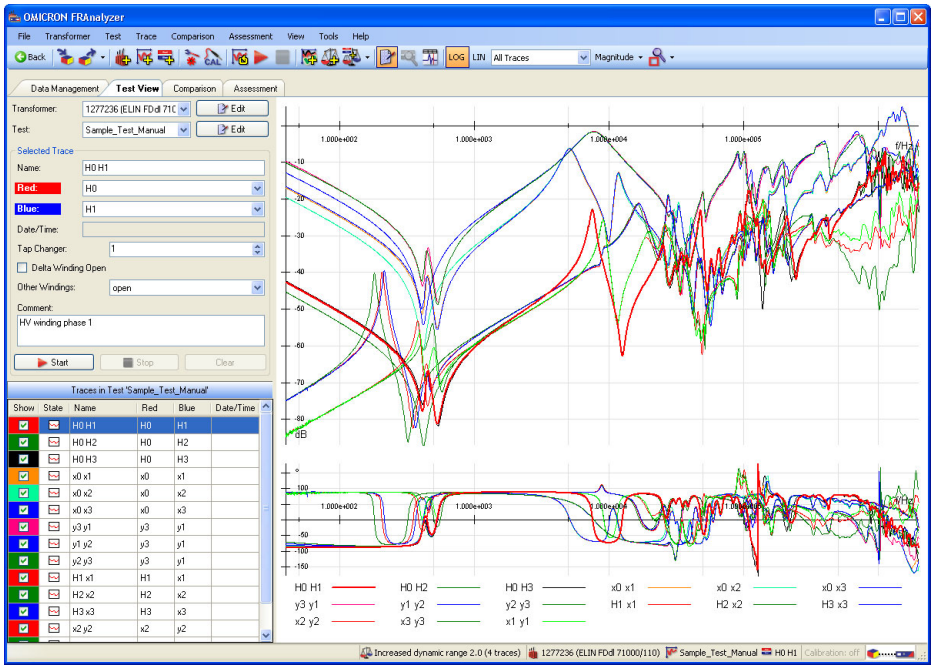
1. In the **Test View** window, select the trace you want to measure.
2. Click the **Start Measurement** toolbar button or the **Start** button to start the measurement.

Figure 5-7:
N U trace measurement



3. Repeat the measurement for all test traces.

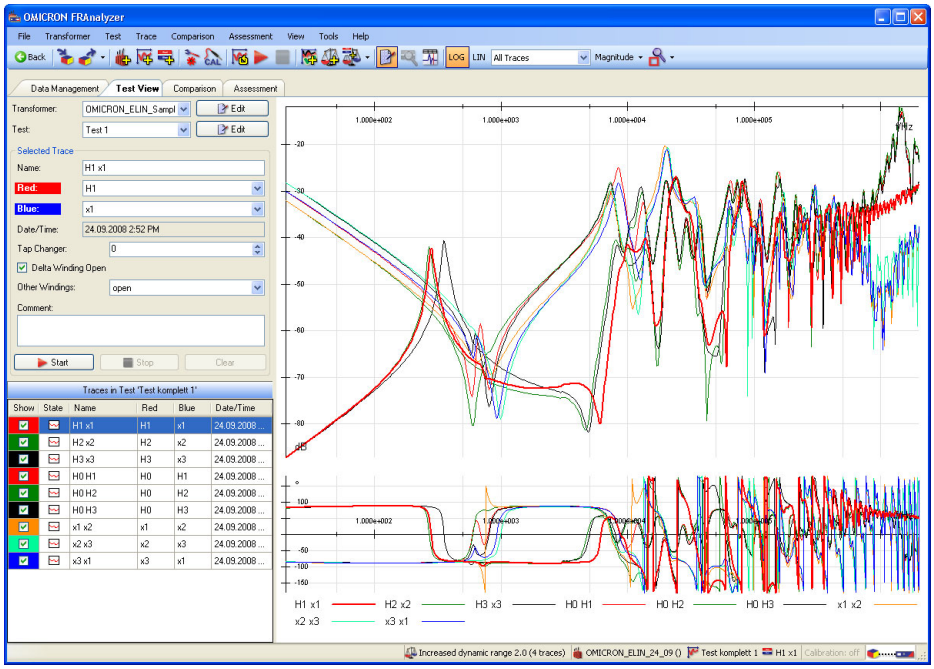
Figure 5-8:
Measurement results



5.6 Assessing the Transformer Windings

To assess the transformer windings, compare the measured frequency responses of the test traces with a previous reference test. For this purpose, import the reference test data available in the *1593901 - Sample Reference Test.fra* file in the *Sample Tests* folder on the *FRAnalyzer* CD-ROM.

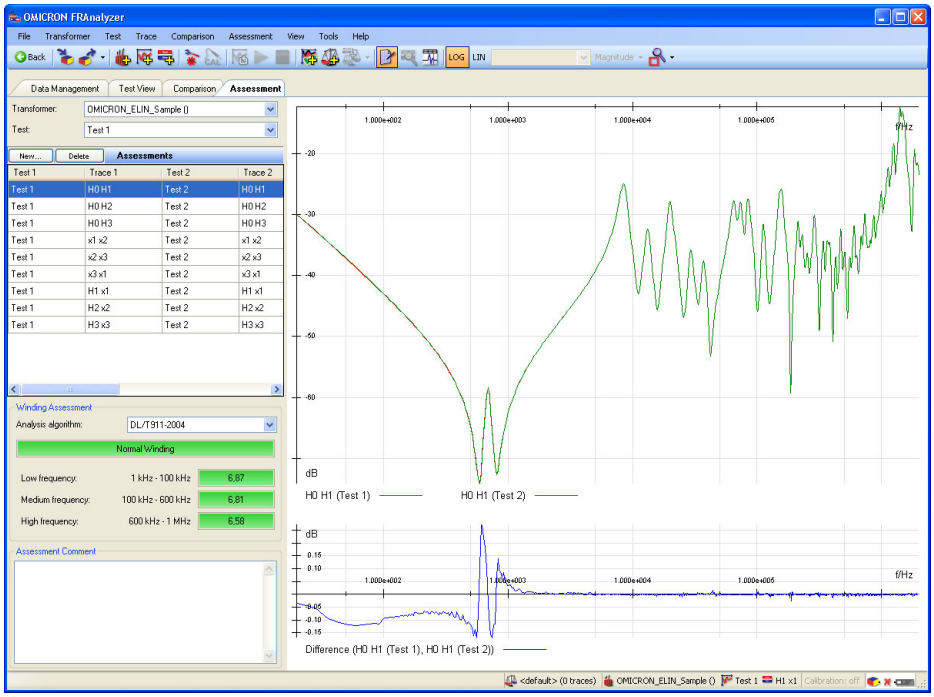
Figure 5-9:
Reference test



To assess the transformer winding under test:

1. Click the **Assessment** tab to open the **Assessment** window.
2. Under **Winding Assessment**, select the algorithm you want to use for the assessment.
3. Add and configure an assessment of two comparable traces, for example the N U traces of the *Sample Test* and the *Sample Reference Test*.
4. Under **Winding Assessment**, read the winding assessment factors for the respective frequency ranges and the overall winding assessment.

Figure 5-10: Transformer winding assessment



Note: The overall winding assessment relies on the analysis algorithm with the levels for the winding assessment factors recommended by the respective standards and consequently cannot be guaranteed by OMICRON electronics.

6 Technical Data

6.1 The *FRAnalyzer* Specifications

Table 6-1: The *FRAnalyzer* specifications

Characteristic	Rating
Frequency range	10 Hz…20 MHz
Source Output	
Output impedance	50 Ω
Connector	BNC
Wave form	Sinusoidal signal
Amplitude	1 Vrms at 50 Ω load
Reference (CH 1) and Measurement (CH 2) Inputs	
Input impedance	Low or high impedance selectable
Low impedance	Input impedance 50 Ω
High impedance	Input impedance 1 MΩ ±2% Input capacitance 40…55 pF
Connectors	BNC
Input sensitivity	2.83 Vp-p
Dynamic range	> 120 dB
Accuracy	< 0.1 dB (down to –50 dB) and ±1 dB (between –50 dB and –80 dB)

6.2 Computer Requirements

Table 6-2:
Computer requirements

Characteristic	Requirement
Minimum configuration	Intel-based processor 1 GHz, 1 GB RAM, CD-ROM drive
Interface	USB 1.1 or USB 2.0
Operating system	Microsoft Windows XP or Windows Vista

6.3 Power Requirements

Table 6-3:
Power requirements

Power Supply	Rating
Battery Pack	
Nominal voltage	12 V
Rated capacity	3.4 Ah
Operating time[1]	6 h
Charging time[1]	5 h
Nominal charging current	1 A
Fuse	2 A quick acting F
Transportation	No transportation constraints apply.
AC Power Supply	
Input voltage/frequency	100…240 V/50…60 Hz

1. Typical value

6.4 Environmental Requirements

Table 6-4: Environmental requirements

Characteristic	Condition	Rating
Temperature	Storage	–35…+60ºC/–31…+140ºF
	Operating	–10…+55ºC/+14…+131ºF
	For specifications	23ºC ± 5ºC/73ºF ± 9ºF with < 1ºC/1.8ºF deviation from the calibration temperature (error-corrected temperature range)
Relative humidity	Storage	20…95%, non-condensing
	Operating	20…95%, non-condensing

6.5 Mechanical Data

Table 6-5: The *FRAnalyzer* mechanical data

Characteristic	Rating
Dimensions (w × h × d)	26 × 5 × 26.5 cm/10.24 × 2 × 10.5 inch
Weight	< 2 kg/4.4 lb (without measuring cables)

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For addresses of OMICRON offices with customer service centers, regional sales offices or offices for training, consulting and commissioning please visit our Web site.

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