FRAX 150
Sweep Frequency Response Analyzer

- **Highest dynamic range and accuracy in the industry**
- **Built-in PC with powerful backlit screen for use in direct sunlight**
- **Highest possible repeatability by using reliable cable practice and high-performance instrumentation**
- **Fulfills all international standards for SFRA measurements**
- **Advanced analysis and decision support built into the software**
- **Imports data from other FRA test sets**

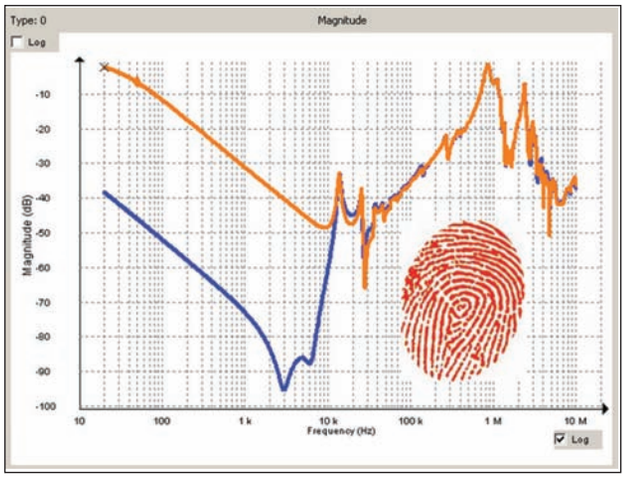
DESCRIPTION

Power transformers are some of the most vital components in today's transmission and distribution infrastructure. Transformer failures cost enormous amounts of money in unexpected outages and unscheduled maintenance. It is important to avoid these failures and make testing and diagnostics reliable and efficient.

The FRAX 150 Sweep Frequency Response Analyzer (SFRA) detects potential mechanical and electrical problems that other methods are unable to detect. Major utilities and service companies have used the FRA method for more than a decade. The measurement is easy to perform and will capture a unique "fingerprint" of the transformer. The measurement is compared to a reference "fingerprint" and gives a direct answer if the mechanical parts of the transformer are unchanged or not. Deviations indicate geometrical and/or electrical changes within the transformer.

FRAX 150 detects problems such as:

- Winding deformations and displacements
- Shorted turns and open windings
- Loosened clamping structures
- Broken clamping structures
- Core connection problems
- Partial winding collapse
- Faulty core grounds
- Core movements



Collecting fingerprint data using Frequency Response Analysis (FRA) is an easy way to detect electro-mechanical problems in power transformers and an investment that will save time and money.

APPLICATION

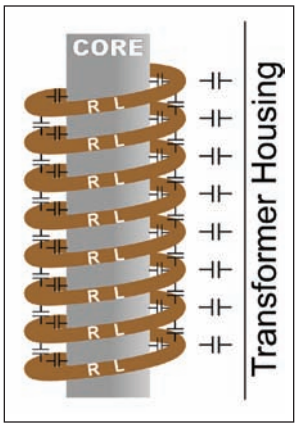
Power transformers are specified to withstand mechanical forces from both transportation and in-service events, such as faults and lightning. However, mechanical forces may exceed specified limits during severe incidents or when the insulation's mechanical strength has weakened due to aging. A relatively quick test where the fingerprint response is compared to a post event response allows for a reliable decision on whether the transformer safely can be put back into service or if further diagnostics is required.

Method Basics

A transformer consists of multiple capacitances, inductances and resistors, a very complex circuit that generates a unique fingerprint or signature when test signals are injected at discrete frequencies and responses are plotted as a curve.

Capacitance is affected by the distance between conductors. Movements in the winding will consequently affect capacitances and change the shape of the curve.

The SFRA method is based on comparisons between measured curves where variations are detected. One SFRA test consists of multiple sweeps and reveals if the transformer's mechanical or electrical integrity has been jeopardized.



Practical Application

In its standard application, a "finger print" reference curve for each winding is captured when the transformer is new or when it is in a known good condition. These curves can later be used as reference during maintenance tests or when there is reason to suspect a problem.

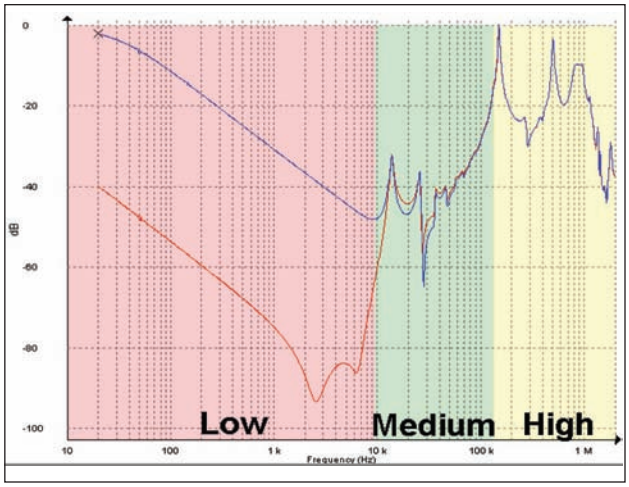
The most reliable method is the time based comparison where curves are compared over time on measurements from the same transformer. Another method utilizes type based comparisons between "sister transformers" with the same design. Lastly, a construction based comparison can, under certain conditions, be used when comparing measurements between windings in the same transformer.

These comparative tests can be performed 1) before and after transportation, 2) after severe through faults 3) before and after overhaul and 4) as diagnostic test if you suspect potential problems. One SFRA test can detect winding problems that requires multiple tests with different kinds of test equipment or problems that cannot be detected with other techniques at all. The SFRA test presents a quick and cost effective way to assess if damages have occurred or if the transformer can safely be energized again. If there is a problem, the test result provides valuable information that can be used as decision support when determining further action.

Having a reference measurement on a mission critical transformer when an incident has occurred is, therefore, a valuable investment as it will allow for an easier and more reliable analysis.

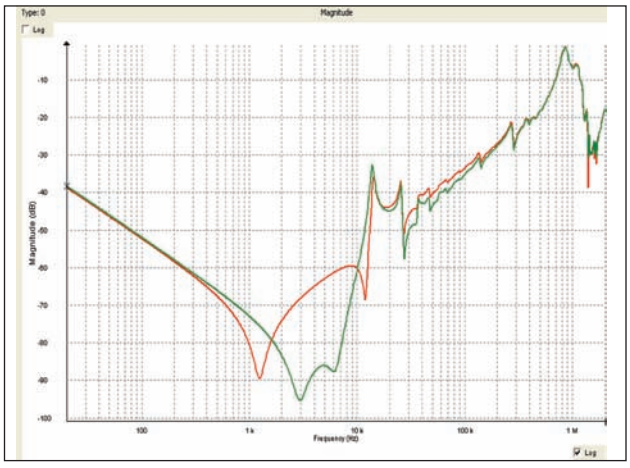
Analysis and Software

As a general guideline, shorted turns, magnetization and other problems related to the core alter the shape of the curve in the lowest frequencies. Medium frequencies represent axial or radial movements in the windings and high frequencies indicate problems involving the cables from the windings, to bushings and tap changers.



An example of low, medium and high frequencies

The FRAX Software provides numerous features to allow for efficient data analysis. Unlimited tests can be open at the same time and the user has full control on which sweeps to compare. The response can be viewed in traditional Magnitude vs. Frequency and/or Phase vs. Frequency view. The user can also choose to present the data in an Impedance or Admittance vs. Frequency view for powerful analysis on certain transformer types.

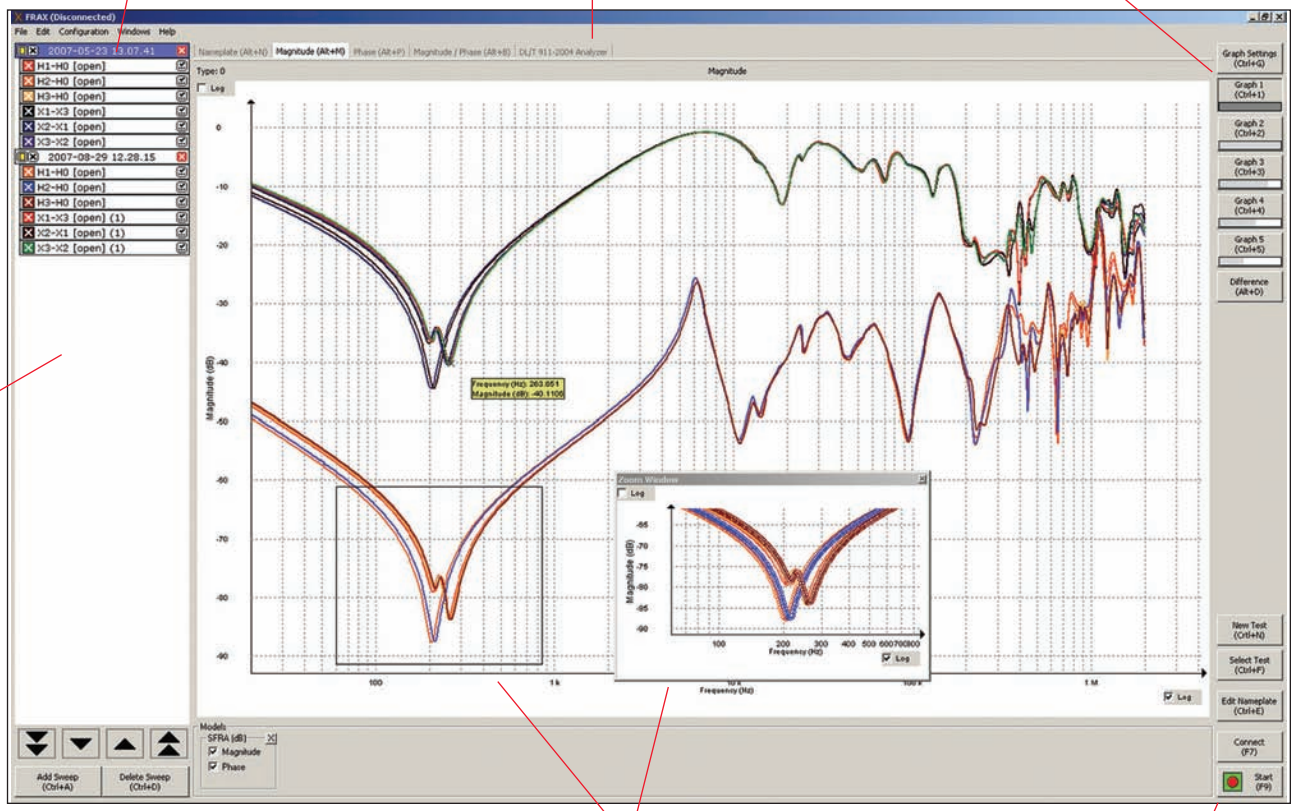


The figure above shows a single phase transformer after a service overhaul where, by mistake, the core ground never got connected (red), and after the core ground was properly connected (green). This potential problem clearly showed up at frequencies between 1 kHz and 10 kHz and a noticeable change is also visible in the 10 kHz - 200 kHz range.

Test Object Browser — Unlimited number of tests and sweeps. Full user control.

Quick Select Tabs — Quickly change presentation view for different perspectives and analysis tools.

Quick Graph Buttons — Programmable graph setting lets you change views quickly and easily.

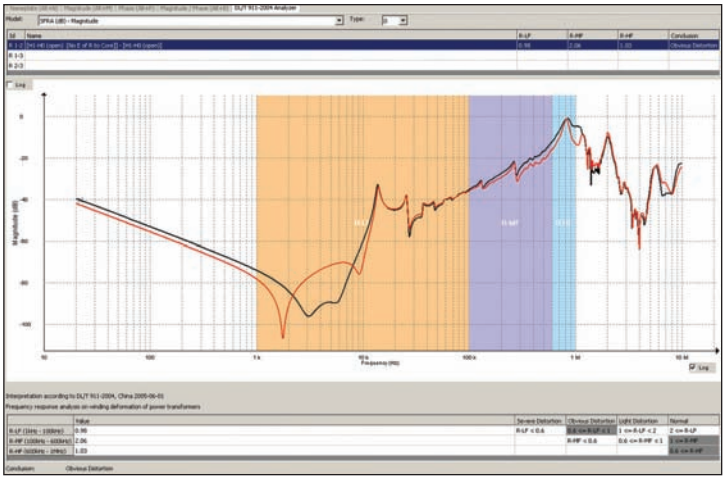


Sweep/Curve Settings — Every sweep can be individually turned on or off, change color, thickness and position.

Dynamic Zoom — Zoom in and move your focus to any part of the curve.

Operation Buttons — All essential functions at your fingertips; select appropriate function keys on screen with mouse.

Built-in-decision support is provided by using a built-in analysis tool based on the international standard DL/T 911-2004.



Automated analysis compares two curves using an algorithm that compare amplitude as well as frequency shift and lets you know if the difference is severe, obvious, or light.

Considerations When Performing SFRA Measurements

SFRA measurements are compared over time or between different test objects. This accentuates the need to perform the test with the highest repeatability and eliminates the influence from external parameters such as cables, connections and instrument performance. FRAX offers all the necessary tools to ensure that the measured curve represents the internal condition of the transformer.

Good Connections

Bad connections can compromise the test results which is why FRAX offers a rugged test clamp that ensures good connection to the bushings and solid connections to the instrument.

Contacts made with the C-clamp guarantee good connections

Shortest Braid Concept

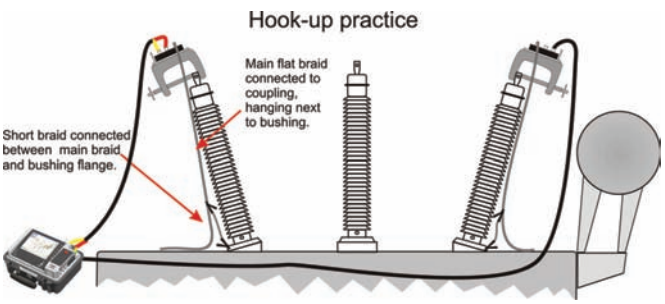
The connection from the cable shield to ground has to be the same for every measurement on a given transformer. Traditional ground connections techniques have issues when it comes to providing repeatable conditions. This causes unwanted variations in the measured response for the highest frequencies that makes analysis difficult.

The FRAX braid drops down from the connection clamp next to the insulating discs to the ground connection at the base of the bushing. This creates near identical conditions every time you connect to a bushing whether it is tall or short.

FRAX 150 with Built-in PC

FRAX 150 has a built-in PC with a high contrast, powerful backlit screen suitable for work in direct sunlight. The cursor is controlled via the built-in joystick or using an external USB mouse and the built-in keyboard makes data entry easy.

All data is stored on the built-in hard drive. The data can be moved to any other computer using a USB memory stick.



Import and Export

The FRAX software can import data files from other FRA instruments making it possible to compare data obtained using another FRA unit. FRAX can import and export data according to the international XFRA standard format as well as standard CSV and TXT formats.

Optimized Sweep Setting

The software offers the user an unmatched feature that allows for fast and efficient testing. Traditional SFRA systems use a logarithmic spacing of measurement points. This results in as many test points between 20Hz and 200Hz as between 200KHz and 2MHz and a relatively long measurement time.

The frequency response from the transformer contains a few resonances in the low frequency range but a lot of resonances at higher frequencies. FRAX allows the user to specify less measurement points at lower frequencies and high measurement point density at higher frequencies. The result is a much faster sweep with greater detail where it is needed.

Variable Voltage

The applied test voltage may affect the response at lower frequencies. Some FRA instruments do not use the 10 V peak-to-peak used by major manufacturers and this may complicate comparisons between tests. FRAX standard voltage is 10 V peak-to-peak but FRAX also allows the user to adjust the applied voltage to match the voltage used in a different test.

FTB 101

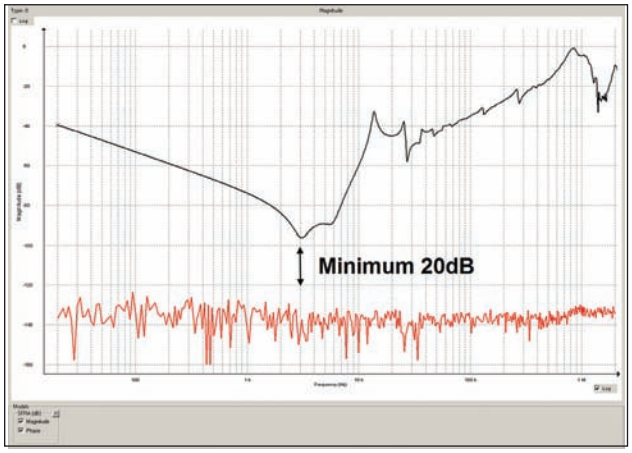
Several international FRA guides recommends to verify the integrity of cables and instrument before and after a test using a test circuit with a known FRA response supplied by the equipment manufacturer. FRAX comes with a field test box FTB101 as a standard accessory and allows the user to perform this important validation in the field at any time and secure measurement quality.

FTB 101 Field Test Box

FRAX 150 has a built-in computer with high contrast and powerful backlit screen suitable for use in direct sunlight.
Solid connections using the C-clamps and the shortest braid method to connect the shield to ground makes it possible to eliminate connection problems and cable loops that otherwise affect the measurement.

DYNAMIC RANGE

Making accurate measurements in a wide frequency range with high dynamics puts great demands on test equipment, test leads, and test set up. FRAX 150 is designed with these requirements in mind. It is rugged, able to filter induced interference and has the highest dynamic range and accuracy in the industry. FRAX 150 internal noise level is shown in red below with a normal transformer measurement in black. A wide dynamic range, i.e. low internal noise level, allows for accurate measurements in every transformer. A margin of about 20 dB from the lowest response to the internal noise level of the instrument must be maintained to obtain ±1 dB accuracy.



An example of FRAX 150's dynamic limit (red) and transformer measurement (black)

OPTIONAL ACCESSORIES

The FRAX Demo box FDB 101 is a transformer kit that can be used for in-house training and demonstrations. The small transformer is a single-phase unit with capability to simulate normal as well as fault conditions. Open as well as shorted measurements can be performed. The unit also contains two test impedances, one of them the same as used in the FTB101 field test box.

SPECIFICATIONS

General

FRA Method:	Sweep frequency (SFRA)
Frequency Range:	0.1 Hz - 25 MHz, user selectable
Number of Points:	Default 1046, User selectable up to 32,000
Measurement time:	Default 64 s, fast setting, 37 s (20 Hz - 2 MHz)
Points Spacing:	Log., linear or both
Dynamic Range/Noise Floor:	>130dB
Accuracy:	±0.5 dB down to -100 dB (10 Hz - 10 MHz)
IF Bandwidth/Integration Time:	User selectable (10% default)
Software:	FRAX for Windows
Calibration Interval:	Max 3 years
Standards/guides:	Fulfill requirements in Cigré Brochure 342, 2008 Mechanical condition assessment of transformer windings using FRA and Chinese standard DL/T 911-2004, FRA on winding deformation of power transformers, as well as other international standards and recommendations

Input Power

90 - 264 V ac, 47 - 63 Hz

Analog Output

Channels:	1
Compliance Voltage:	Output voltage 0.2 - 24 V p-p (open circuit)
Measurement Voltage at 50 Ω:	10 V (adjustable 0.1-12 V)
Output Impedance:	50 Ω
Protection:	Short-circuit protected

Analog Input

Channels:	2
Sampling:	Simultaneously
Input Impedance:	50 Ω
Sampling Rate:	100 MS/s

Operating System

Windows® based

Memory

1000 records in internal memory. External storage on USB stick

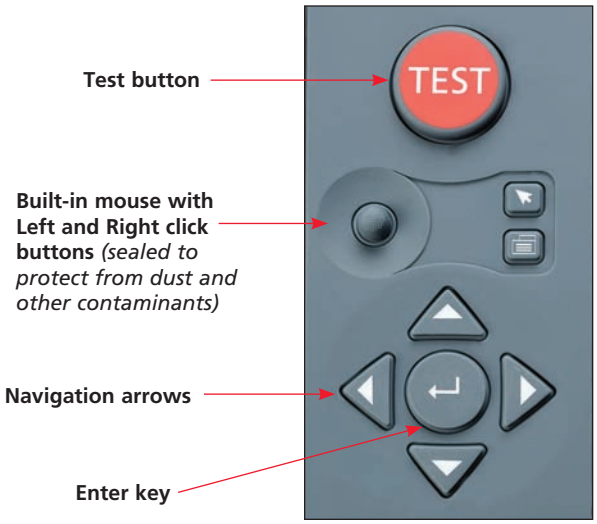
Physical

Dimensions:	305 mm x 194 mm x 360 mm (12 in. x 7.6 in. x 14.2 in.)
Weight:	6 kg (13 lb)

Environmental

Operating Ambient Temp:	0° C to +50° C / +32° F to +122° F
Operating Relative Humidity:	< 90% non-condensing
Storage Ambient Temp:	-20° C to 70° C / -4° F to +158° F
Storage Relative Humidity:	< 90% non-condensing
CE Standards:	IEC61010 (LVD) EN61326 (EMC)

CLOSE-UP OF FRAX 150 CONTROL PANEL



INCLUDED ACCESSORIES

Included accessories shown above: Mains cable, ground cable, (2) ground braid sets, (2) earth/ground braid leads (insulated), (2) C-clamps, generator cable, measure cable, field test box, nylon accessory pouch, (2) earth/ground braids with clamp, and canvas carrying bag for test leads

ORDERING INFORMATION

Item (Qty)	Cat. No.
FRAX 150 with 18 m (60 ft) Leads	AC-39090
FRAX 150 with 9 m (30 ft) Leads	AC-39092
Included Accessories	
AC Power Cord (IEC60320-C13 to US standard)	17032
AC Power Cord (IEC60320-C13 to Schuko CEE 7/7)	17032-13
Canvas Carrying Bag (for leadset)	30915-211
Ground Cable 5 m (16 ft)	1001-428
FRAX software for PC	1001-427
2 x 3 m (9 ft) Earth/Ground Braid Lead	GC-30033
2 x 3 m (9 ft) Earth/Ground Braid Lead (insulated)	GC-30036
2 x C-clamp (Bushing Clamps)	GC-80010
2 x G-clamp (Ground Braid Clamps)	GC-80020
FRAX Generator Cable, 2xBNC, 9 m (30 ft) *for use with AC-39092 only*	GC-30040

Item (Qty)	Cat. No.
FRAX Measure Cable, 1xBNC, 9 m (30 ft) *for use with AC-39092 only*	GC-30050
FRAX Generator Cable, 2xBNC, 18 m (60 ft) *for use with AC-39090 only*	GC-30042
FRAX Measure Cable, 1xBNC, 18 m (60 ft) *for use with AC-39090 only*	GC-30052
Field Test Box, FTB-101	AC-90060
2 x 305 mm (1 ft) Earth/Ground Braid with Clamp	GC-30035
Nylon Accessory Bag	GD-31040
User's Manual	AVTMFRAX150
Optional Accessories	
Calibration Set	AC-90020
FRAX Demo Box FDB 101	AC-90050

UK
Archcliffe Road, Dover
CT17 9EN England
T +44 (0) 1 304 502101
F +44 (0) 1 304 207342
UKsales@megger.com

UNITED STATES
4271 Bronze Way
Dallas, TX 75237-1019 USA
T 1 800 723 2861 (USA only)
T +1 214 333 3201
F +1 214 331 7399
USsales@megger.com

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