FRAX 101
Sweep Frequency Response Analyzer

- **Smallest and most rugged FRA instrument in the industry**
- **Highest possible repeatability by using reliable cable practice and high-performance instrumentation**
- **Fulfills all international standards for SFRA measurements**
- **Highest dynamic range and accuracy in the industry**
- **Wireless communication and battery operated**
- **Advanced analysis and decision support built into the software**
- **Imports data from other FRA test sets**

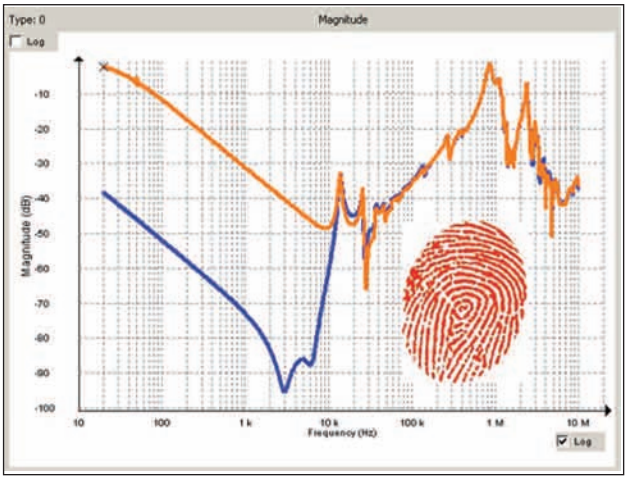
DESCRIPTION

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 101 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 101 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
- Hoop buckling



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.

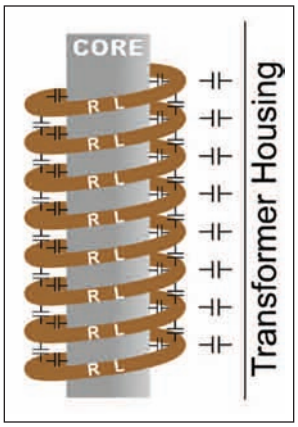
APPLICATION

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.

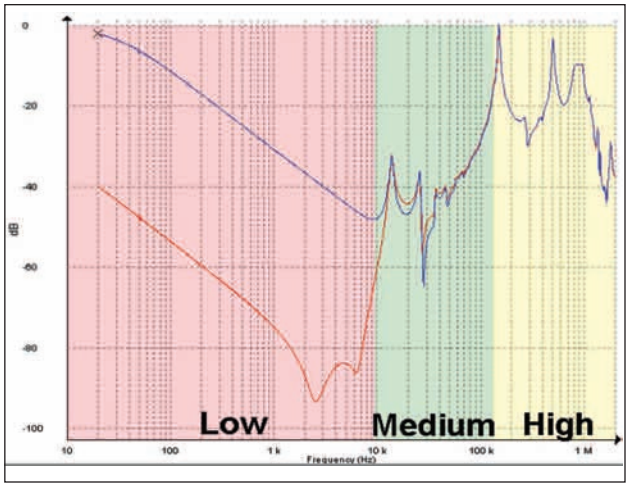
The most reliable method is the time based comparison where curves are compared over time on measurements from the same transformer. Another method utilizes type based comparisons between "sister transformers" with the same design. Lastly, a construction based comparison can, under certain conditions,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

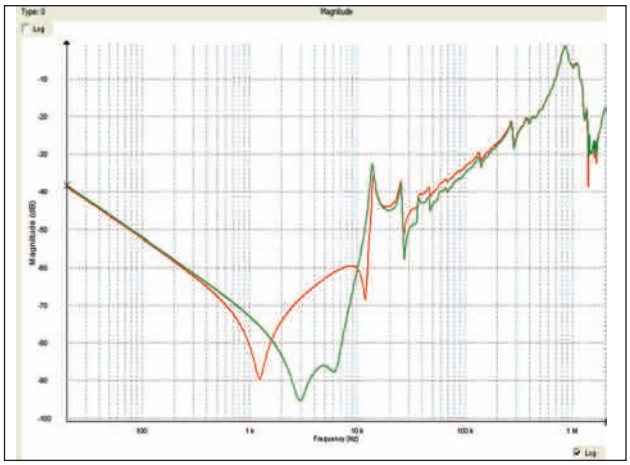
Analysis and Software

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.

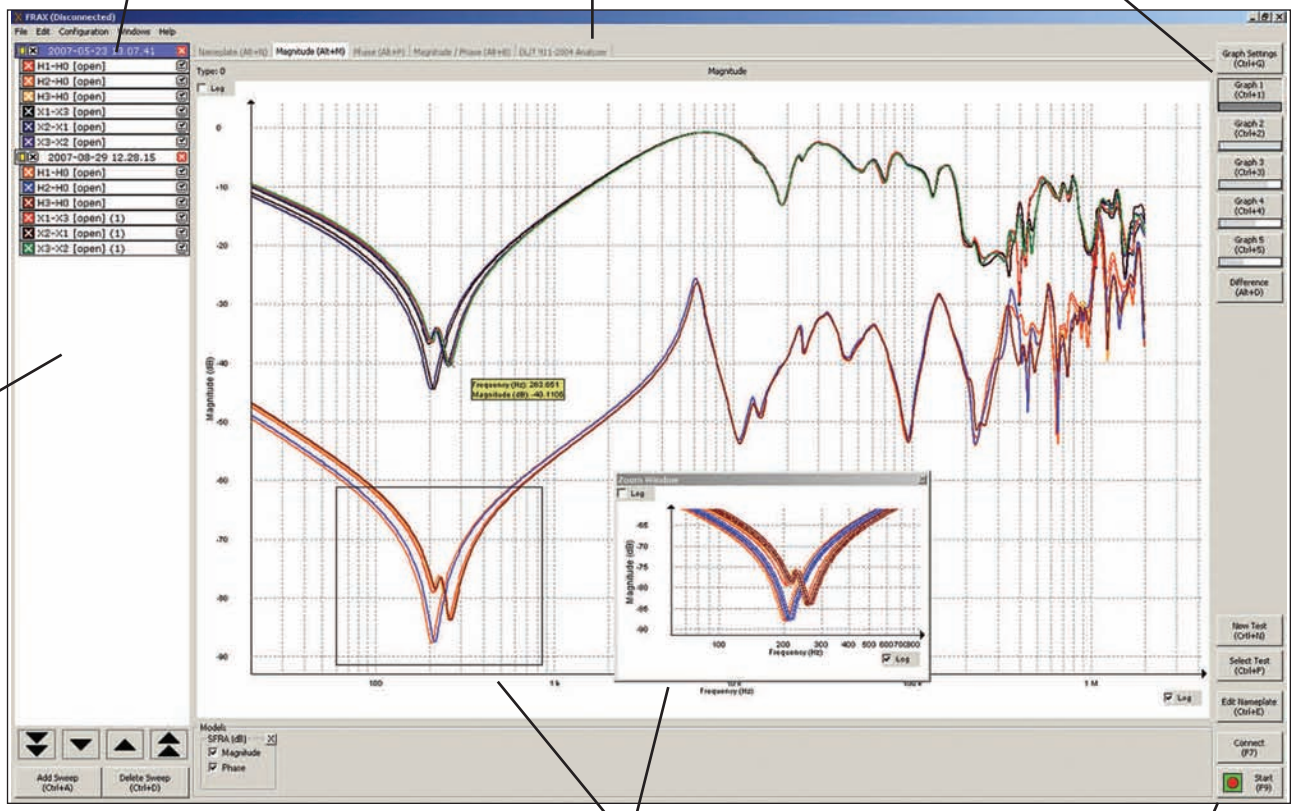


The figure above shows a single phase transformer after a service overhaul where, by mistake, the core ground never got connected (red), and after the core ground was properly connected (green). This potential problem clearly showed up at frequencies between 1 kHz and 10 kHz and a noticeable change is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

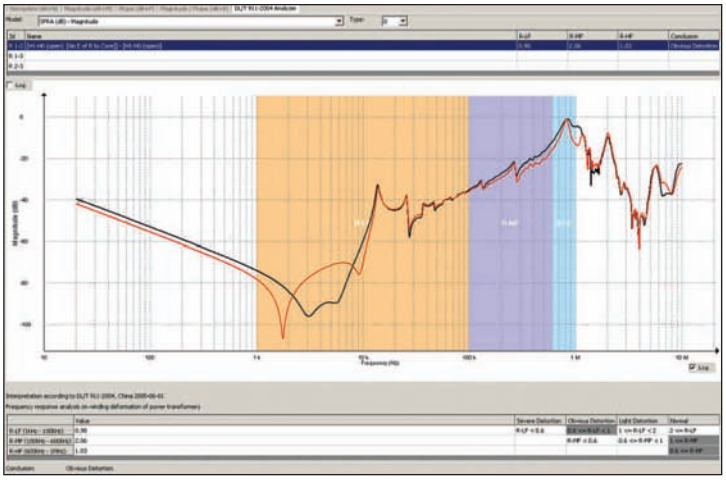


Sweep/Curve Settings — Every sweep can be individually turned on or off, change color, thickness and position.

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

Operation Buttons — All essential functions at your fingertips; select with mouse, function keys or touch screen.

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

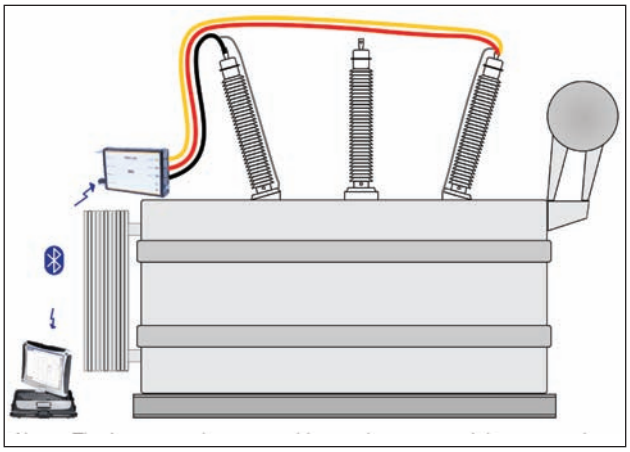
Bad connections can compromise the test results which is why FRAX offers a rugged test clamp that ensures good connection to the bushings and solid connections to the instrument.

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.



The laptop can be operated by touch screen and the communication is wireless via Bluetooth. Measurement ground braids connect close to the connection clamps and run next to the bushing to the flange connection to avoid cable loops that otherwise affect the measurement.

The Power of Wireless

FRAX 101 uses class 1 Bluetooth® wireless communication. Class 1 Bluetooth® has up to 100 m range and is designed for industrial applications. An optional internal battery pack is available for full wireless flexibility. Shorter and more light-weight cables can be used when the user is liberated from cable communication and power supply cables.

A standard USB interface (galvanically isolated) is included for users who prefer a direct connection to their PC.

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.

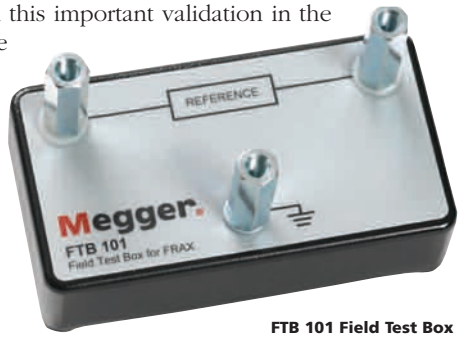
The frequency response from the transformer contains a few resonances in the low frequency range but a lot of resonances at higher frequencies. FRAX allows the user to specify less measurement points at lower frequencies and high measurement point density at higher frequencies. The result is a much faster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

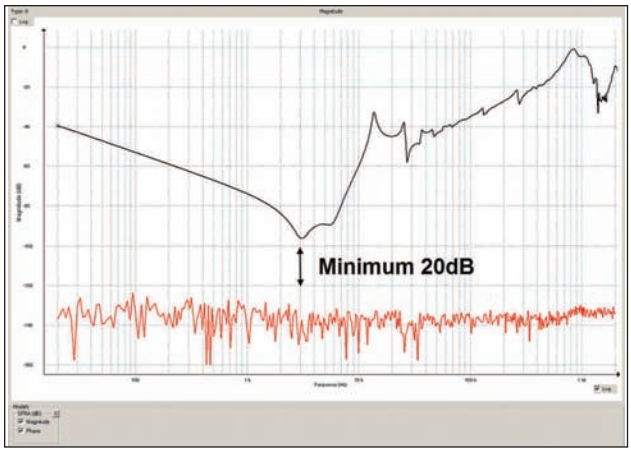
Several international FRA guides recommends to verify the integrity of cables and instrument before and after a test using a test circuit with a known FRA response supplied by the equipment manufacturer. FRAX comes with a field test box FTB101 as a standard accessory and allows the user to perform this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



FTB 101 Field Test Box

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 101 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 101 dynamic range or noise floor is shown in red below with a normal transformer measurement in black. A wide dynamic range, low noise floor, allows for accurate measurements in every transformer. A margin of about 20 dB from the lowest response to the instruments noise floor must be maintained to obtain ±1 dB accuracy.



An example of FRAX 101's dynamic limit (red) and transformer measurement (black)

FEATURES AND BENEFITS

- Smallest and most rugged FRA instrument in the industry.
- Guaranteed repeatability by using superior cabling technology, thus avoiding the introduction of error due to cable connection and positioning (which is common in other FRA manufacturers' equipment).
- Fulfills all international standards for Sweep Frequency Response Analysis (SFRA) measurements.
- Highest dynamic range and accuracy in the industry allowing even the most subtle electro-mechanical changes within the transformer to be detected.
- Wireless communication allows easy operation without the inconvenience of cable hook up to a PC.
- Battery input capability allows for easy operation without the need for mains voltage supply.
- Advanced analysis and support software tools allows for sound decision making with regard to further diagnostics analysis and/or transformer disposition.

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:	±0.3 dB down to -105 dB (10 Hz - 10 MHz)
IF Bandwidth/Integration Time:	User selectable (10% default)
Software:	FRAX for Windows 2000/ XP/Vista
PC Communication:	Bluetooth and USB (galvanically isolated)
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

Analog Output

Channels:	1
Compliance Voltage:	0.2 - 20 V peak-to-peak
Measurement Voltage at 50 Ω:	0.1 - 10 V peak-to-peak
Output Impedance:	50 Ω
Protection:	Short-circuit protected

Analog Input

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

Physical

Instrument Weight:	1.4 kg/3.1 lbs
Case and Accessories Weight:	15 kg/33 lbs
Dimensions:	250 x 169 x 52 mm 9.84 x 6.65 x 2.05 in
Dimensions with Case:	520 x 460 x 220 mm 20.5 x 18.1 x 8.7 in.
Input Voltage:	11 - 16 V dc or 90 - 135 V ac and 170 - 264V ac, 47-63 Hz

Environmental

Operating Ambient Temp:	-20°C to +50°C / -4°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)

PC Requirements

(PC not included)

Operating System:	Windows 2000/ XP / Vista
Processor:	Pentium 500 MHz
Memory:	256 Mb RAM or more
Hard Drive:	Minimum 30 Mb free
Interface:	Wireless or USB (client)

OPTIONAL ACCESSORIES

- The built-in battery pack offers flexibility when performing tests on or off the transformer.
- The Active Impedance Probe AIP 101 should be used when measuring grounded connections such as to the transformer tank or a bushing connected to the transformer tank. AIP 101 ensures safe, accurate and easy measurements to ground.
- The Active Voltage Probe AVP 101 is designed for measurements when higher input impedance is needed. AVP 101 can be used for measurements where up to 1 MΩ input impedance is required.

FRAX cable set consists of double shielded high quality cables, braid for easy and reliable ground connection, and clamp for solid connections to the test object.

ORDERING INFORMATION

Item (Qty)	Cat. No.
FRAX 101 complete with: ac/dc adapter, mains cable, ground cable 5 m (16 ft), transport case, USB cable, Bluetooth adapter, Windows software, 4 x 3 m (10 ft) ground braid set, 2 x C-clamp, field test box, generator cable 18 m (59 ft), measure cable 18 m (59 ft), manual	AC-19090
FRAX 101, incl. battery, complete with: ac/dc adapter, mains cable, ground cable 5 m (16 ft), transport case, USB cable, Bluetooth adapter, Windows software, 4 x 3 m (10 ft) ground braid set, 2 x C-clamp, field test box, generator cable 18 m (59 ft), measure cable 18 m (59 ft), battery pack, manual	AC-19091

Item (Qty)	Cat. No.
Optional Accessories	
Battery option, 4.8 Ah	AC-90010
Calibration set	AC-90020
Active impedance probe AIP 101	AC-90030
Active voltage probe AVP 101	AC-90040
FRAX Demo box FDB 101	AC-90050
Field Demo Box FTB 101	AC-90060
Ground braid set, 4 x 3 m including clamps	GC-30031
FRAX Generator cable, 2xBNC, 9 m (30 ft)	GC-30040
FRAX Generator cable, 2xBNC, 18 m (59 ft)	GC-30042
FRAX Measure cable, 1xBNC, 9 m (30 ft)	GC-30050
FRAX Measure cable, 2xBNC, 18 m (59 ft)	GC-30052
FRAX C-clamp	GC-80010
FRAX for Windows	SA-AC101

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

Registered to ISO 9001:2000 Cert. no. 10006.01
FRAX101_DS_en_V01