FRAX Series
Sweep Frequency Response Analyzers

- **Highest dynamic range and accuracy in the industry**
- **Smallest and most rugged FRA instrument in the industry**
- **Fulfills all international standards for SFRA measurements**
- **Advanced analysis and decision support built into the software**
- **Imports data from other FRA test sets**

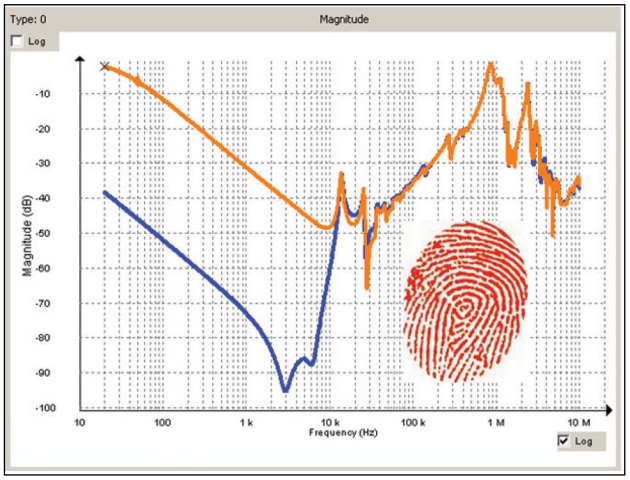
Description

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 series of sweep frequency response analyzers (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 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



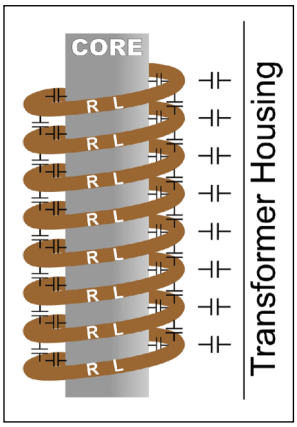
Collecting fingerprint data using Frequency Response Analysis (FRA) is an easy way to detect electro-mechanical problems in power transformers and an investment that will save time and money.

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.

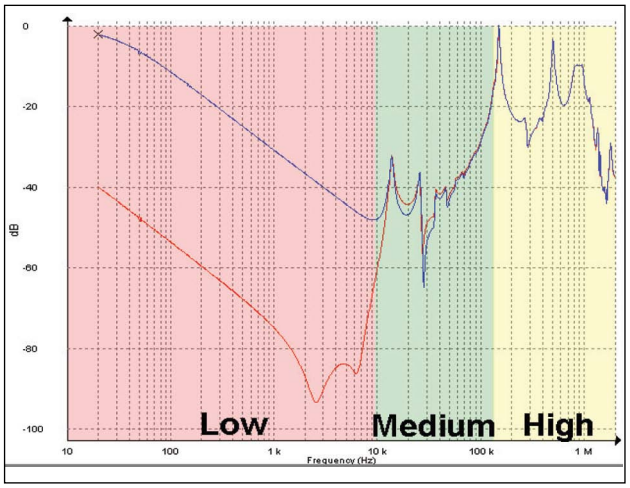
The most reliable method is the time-based comparison where curves are compared over time on measurements from the same transformer. Another method utilizes type-based comparisons between sister transformers with the same design. Lastly, a construction-based comparison can, under certain conditions,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

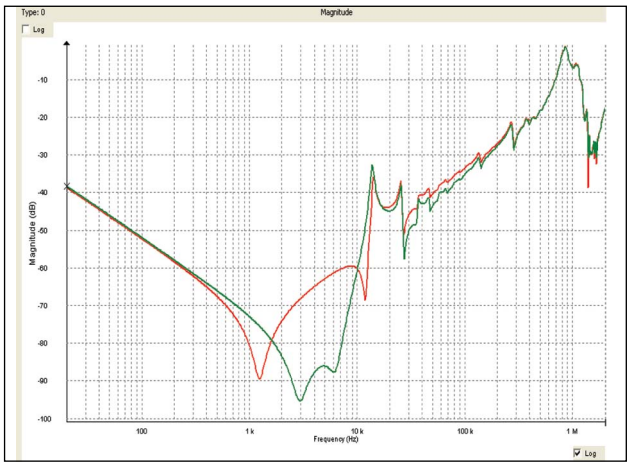
Analysis and software

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 frequency response.

The FRAX software provides numerous features for efficient data analysis. Unlimited tests can be open at the same time and the user has full control of 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.



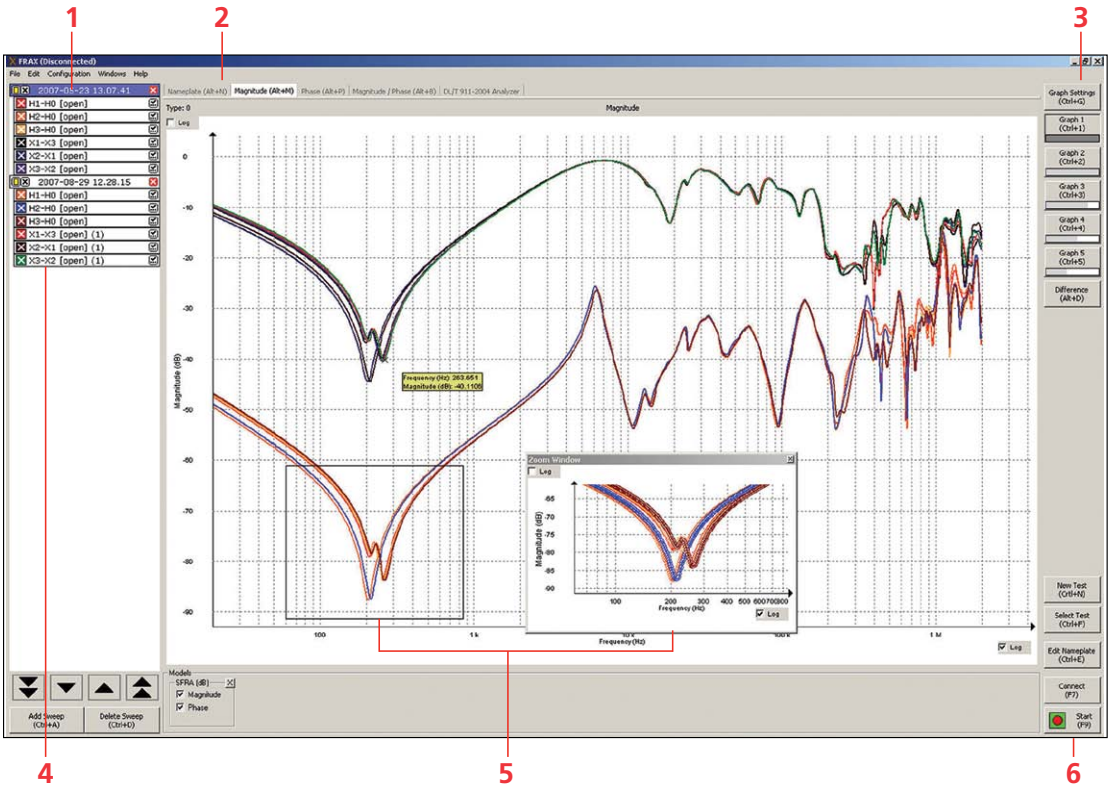
The figure above shows a single-phase transformer after a service overhaul where, by mistake, the core ground never got connected (red), and after the core ground was properly connected (green). This potential problem clearly showed up at frequencies between 1 kHz and 10 kHz and a noticeable change is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

Benefits

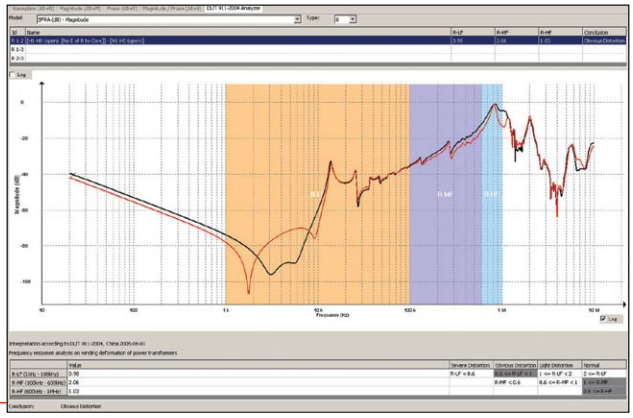
- Smallest and most rugged FRA instrument in the industry).
- Guaranteed repeatability by using superior cabling technology, thus avoiding the introduction of error due to cable connection and positioning (which is common in other FRA manufacturers' equipment).
- Fulfills all international standards for Sweep Frequency Response Analysis (SFRA) measurements (IEC 60076-18, Method 1).
- Highest dynamic range and accuracy in the industry allowing even the most subtle electro-mechanical changes within the transformer to be detected.
- Advanced analysis and support software tools allows for sound decision making with regard to further diagnostics analysis and/or transformer disposition.
- Built-in PC with powerful backlit screen for use in direct sunlight (FRAX 150).

Features

1. Test object browser – Unlimited number of tests and sweeps. Full user control.
2. Quick select tabs – Quickly change presentation view for different perspectives and analysis tools.
3. Quick graph buttons – Programmable graph setting lets you change views quickly and easily.
4. Sweep/curve settings – Every sweep can be individually turned on or off, change color, thickness and position.
5. Dynamic zoom – Zoom in and move your focus to any part of the curve.
6. Operation buttons – All essential functions at your fingertips; select with mouse, function keys or touch screen.
7. 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.



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



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

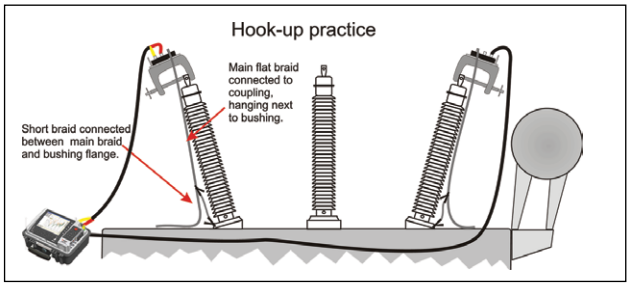
Bad connections can compromise the test results, which is why FRAX offers a rugged test clamp that ensures good connection to the bushings and solid connections to the instrument.

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) and is the recommended way of connecting in CIGRE TB342 and IEC 60076-18.



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.

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 20 Hz and 200 Hz as between 200 kHz and 2 MHz and a relatively long measurement time.

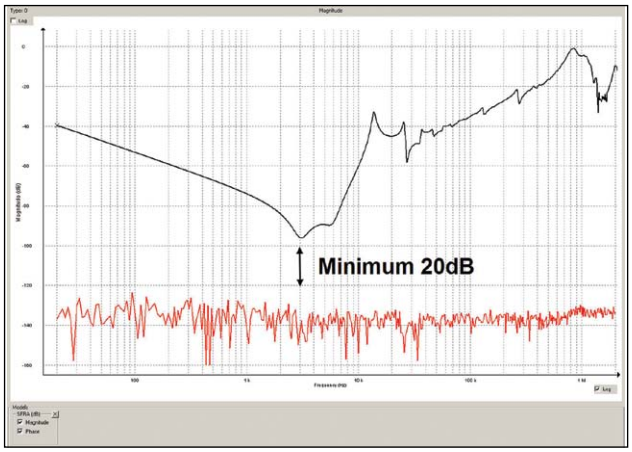
The frequency response from the transformer contains a few resonances in the low frequency range but a lot of resonances at higher frequencies. FRAX allows the user to specify less measurement points at lower frequencies and high measurement point density at higher frequencies. The result is a much faster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

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 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 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 a transformer measurement in comparison with the internal noise level in FRAX.

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

Close-up of FRAX 150 control panel

Specifications FRAX 99/101/150

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

Environmental

Application field	The instrument is intended for use in medium and high-voltage substations and industrial environments.

Ambient temperature

Operating	
FRAX 150	-5°C to +50°C (23°F to +122°F)
FRAX 99/101	-20°C to +55°C (-4°F to +131°F)
Storage	-20°C to 70°C (-4°F to +158°F)

Humidity < 95% RH, non-condensing

CE-marking

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

General

Mains voltage	90 – 264 V AC, 47 – 63 Hz

Dimensions

Instrument	
FRAX 150	305 x 194 x 360 mm (12" x 7.6" x 14.2")
FRAX 99/101	250 x 169 x 52 mm (9.84" x 6.65" x 2.05")
Transport case	
FRAX 150	–
FRAX 99/101	520 x 460 x 220 mm (20.5" x 18.1" x 8.7")

Weight

Instrument	
FRAX 150	6 kg (13 lbs)
FRAX 99/101	1.4 kg (3.1 lbs) 1.8 kg (4 lbs) with battery
Case and accessories	
FRAX 150	16 kg (35 lbs)
FRAX 101	15 kg (33 lbs)
FRAX 99	12 kg (26 lbs)

Measurement section

Test method	Sweep frequency (SFRA)
Frequency range	0.1 Hz – 25 MHz, user selectable
Frequency resolution	< 0.01%
Frequency inaccuracy	< 0.01%
Level resolution	< 0.001 dB
Number of points	Default 1046, Up to 32 000 points, user selectable
Measurement time:	Default 64 s, fast setting, 37 s (20 Hz – 2 MHz)
Points spacing	Log., linear or both
Sweep settings	Individual settings for customer defined frequency bands. Linear and logarithmic scale or combination of both
Dynamic range/internal noise	+20 to -115 dB (FRAX99) +20 to -130 dB (FRAX101 and 150)
Inaccuracy	± 0.3 dB from +10 dB down to -40 dB ± 0.5 dB down to -100 dB (FRAX 101/150) ± 1 dB down to -100 dB (FRAX 99)
IF bandwidth	User selectable, default <10%
PC Communication	
FRAX 150	Internal USB (galvanically isolated)
FRAX 101	Bluetooth and USB (galvanically isolated)
FRAX 99	USB (galvanically isolated)
Software	FRAX for Windows 2000/ XP/Vista/7
Standards / guides	Fulfill requirements in Cigré Brochure 342, 2008. Mechanical condition assessment of transformer windings using FRA DL/T 911-2004, FRA on winding deformation of power transformers, IEC 60076-18 and IEEE PC57.149 as well as other standards and recommendations

Analog Output

Channels	1
Compliance voltage	0.20 – 24 V p-p (FRAX 101/150) 20 V p-p (FRAX 99)
Measurement voltage at 50 Ω	0.1 – 12 V p-p (FRAX 101/150) 10 V p-p (FRAX 99)
Output impedance	50 Ω
Protection	Short-circuit protected
Frequency range	0.1 Hz – 25 MHz
Sweep direction	Low to high or high to low

Analog Input

Channels	2
Sampling	Simultaneously
Frequency range	0.1 Hz – 25 MHz
Input impedance	50 Ω
Sampling rate	100 MS/s

PC (FRAX 150)

Operating system	Windows® XP (embedded)
Memory	1000 records in internal memory External storage on USB stick

PC Requirements (FRAX 99/101) Note: PC not included

Operating system	Windows XP / Vista / 7
Processor	Pentium 500 MHz or higher
Memory	256 Mb RAM or more
Hard drive	Minimum 30 Mb free
Interface	Wireless / USB (FRAX 99/101) USB and Ethernet (FRAX 99)

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.

FTB101

Several international FRA guides recommend verification integrity of cable 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.

Optional accessories

FDB101

The FRAX demo box FDB101 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.

Ordering information

Item	Art. No.
FRAX-101	
With accessories, 18 m (60 ft) cable set	AC-19090
With accessories incl. battery, 18 m cable set	AC-19091
With accessories, 9 m (30 ft) cable set	AC-19092
With accessories incl. battery, 9 m cable set	AC-19093
FRAX-99	
With accessories, 9 m cable set	AC-29090
With accessories, 18 m cable set	AC-29092
With accessories, incl. battery, 9 m cable set	AC-29095
With accessories, incl. battery, 18 m cable set	AC-29096
FRAX-150	
With accessories, 18 m cable set	AC-39090
With accessories, 9 m cable set	AC-39092

Included accessories for all models

Generator cable
Measure cable
4 x 3 m (10 ft) ground braid set
2 x 0.3 m (1 ft) braid with clamp
2 x C-clamp (bushing connector clamp)
2 x G-clamp (ground clamp)
Field Test Box FTB101
Ground cable 5 m (15 ft)
Mains cable
FRAX software for Windows
User manual

Additional included accessories for FRAX 99

AC/DC adapter
Light transport case
Canvas carrying bag (for accessories)
USB cable

Additional included accessories for FRAX 101

AC/DC adapter
Transport case
Bluetooth adapter
USB cable

Additional included accessories for FRAX 150

Canvas carrying bag (for accessories)

Optional Accessories

Calibration set	AC-90020
FRAX demo box FDB 101	AC-90050
FRAX generator and ref cable, 9 m (30 ft)	GC-30040
FRAX generator and ref cable, 18 m (60 ft)	GC-30042
FRAX measure cable, 9 m (30 ft)	GC-30050
FRAX measure cable, 18 m (60 ft)	GC-30052
C-clamps	GC-80010
E-clamp (single hand grip clamp)	GC-80030

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