# FRAX Series
## Sweep Frequency Response Analyzers


- **Highest dynamic range and accuracy in the industry**
- **Fulfills international standards for SFRA measurements**
- **Advanced analysis and decision support built into the software. FRAX 150 with built in PC and touchscreen**
- **Imports data from other FRA test sets**
- **Wireless communication (FRAX 101)**
- **Battery operated (optional FRAX 99 and FRAX 101)**
- **Continuity control of ground connections (FRAX 101 and 150)**

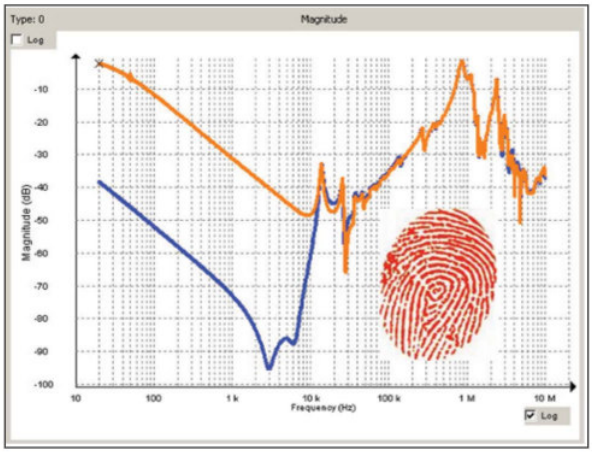
## DESCRIPTION

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 mechanical and electrical changes of the core and winding assembly of power transformers. Major utilities and service companies have used the FRA method for more than a decade and the method is covered in international standards. The measurement is easy to perform and will capture a unique fingerprint of the transformer. The measurement result 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
- Broken clamping structures
- Core connection problems
- Partial winding collapse
- Faulty core grounds
- Core movements



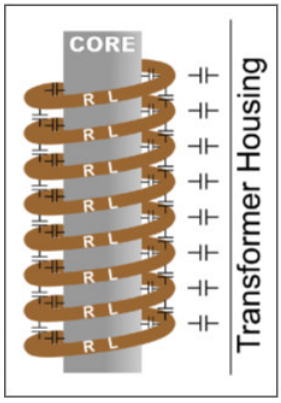

Collecting fingerprint data using Frequency Response Analysis (FRA) is an easy way to detect electro-mechanical problems in power transformers and an investment that will save time and money.

## 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 fingerprint/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.

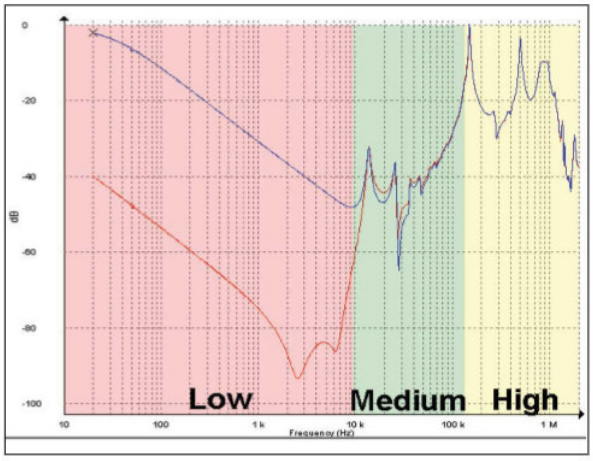
The most reliable method is the time-based comparison where curves are compared over time on measurements from the same transformer. Another method utilizes type-based comparisons between sister transformers with the same design. Lastly, a construction-based comparison can, under certain conditions,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

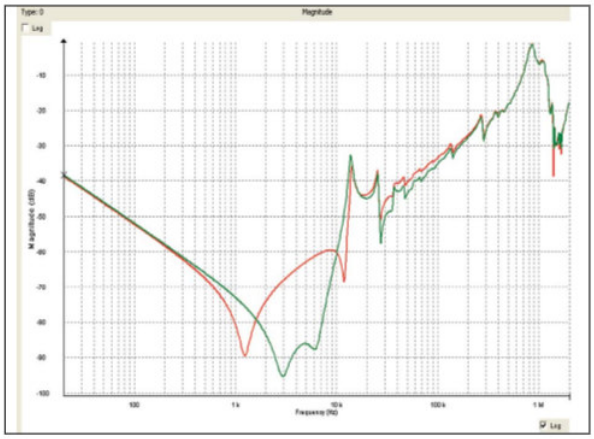
## ANALYSIS AND SOFTWARE

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.



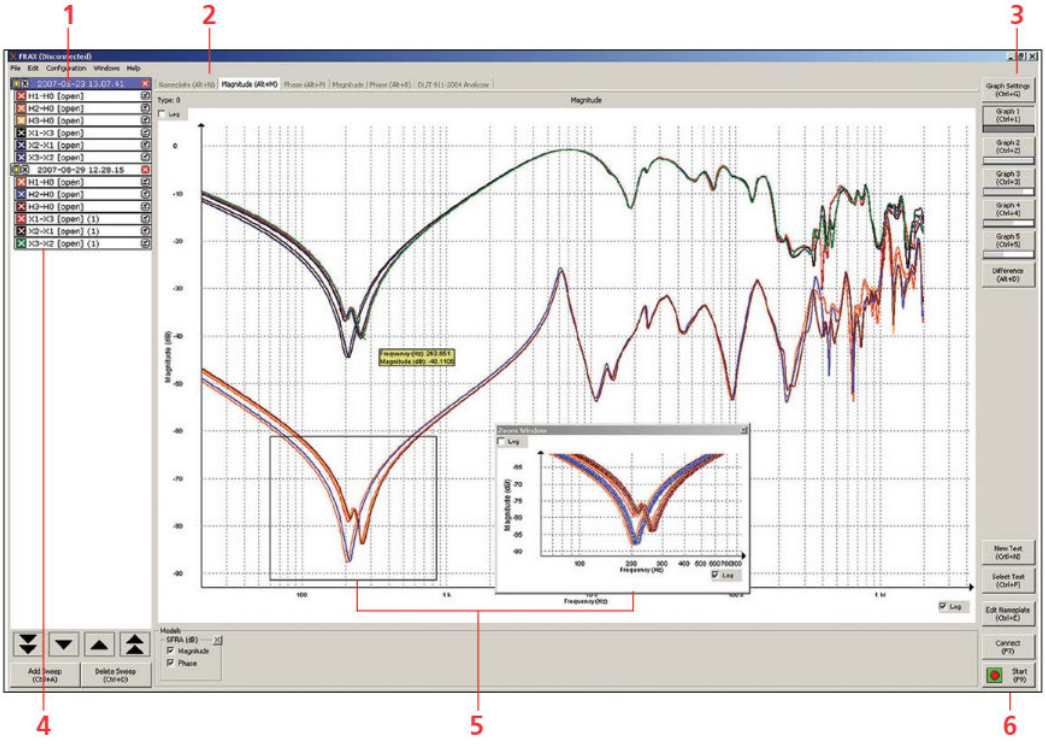

The figure above shows a single-phase transformer after a service overhaul where, by mistake, the core ground never got connected (red), and after the core ground was properly connected (green). This potential problem clearly showed up at frequencies between 1 kHz and 10 kHz and a noticeable change is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

## BENEFITS

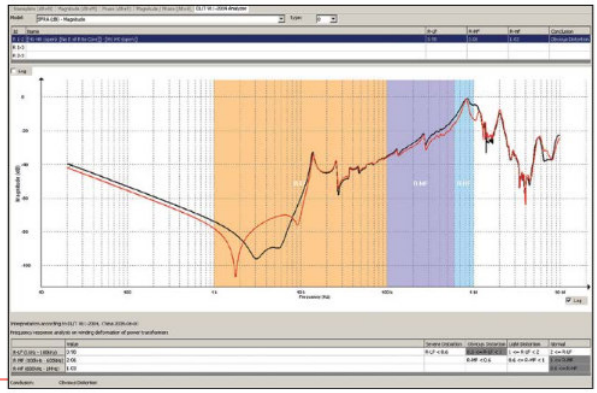
- Smallest and most rugged FRA instrument in the industry.
- Guaranteed repeatability by using superior cabling technology and standardized signal cable grounding technique (IEC 60076-18, Method 1).
- Fulfills international standards for Sweep Frequency Response Analysis (SFRA) measurements (IEC 60076-18, IEEE C57.149 etc).
- 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 touchscreen (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 correlation analysis supporting 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.

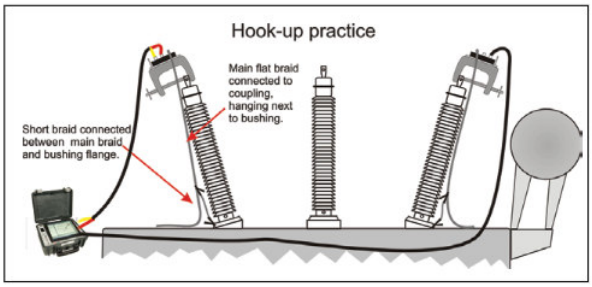
### Good connections

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.

The connection from the cable shield to ground has to be the same for every measurement on a given transformer. Traditional ground connection techniques have issues when it comes to providing repeatable conditions. This causes unwanted variations in the measured response for the highest frequencies and 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 (regardless if 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 using IEC 60076-18, Method 1, to connect the shield to ground, makes it possible to eliminate connection problems and cable loops that otherwise affect the measurement.

### Ground loop control (FRAX 101 and 150)

The built-in 'Ground Loop Detector' in FRAX checks the test setup and assures that all connections including the grounding braids are properly connected.

### 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.

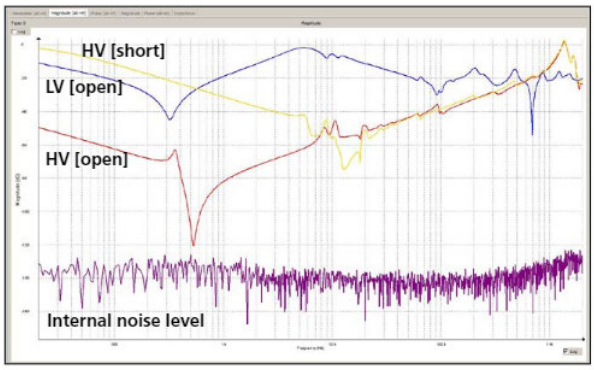
The frequency response from the transformer contains a few resonances in the low frequency range, but a lot of resonances at higher frequencies. FRAX allows the user to specify less measurement points at lower frequencies and high measurement point density at higher frequencies. The result is a much 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 is illustrated below where the red trace is the internal noise in the unit and black trace is a typical transformer measurement. A wide dynamic range (low internal noise) allows for accurate measurements in every transformer.




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 12" touchscreen

| SPECIFICATIONS | FRAX 99 | FRAX 101 | FRAX 150 |
|---|---|---|---|
| Specifications are valid at nominal input voltage and an ambient temperature of +25°C ±5°, (77°F). Specifications are subject to change without notice. | | | |
| **Environment** | | | |
| *Application field* | The instrument is intended for use in medium and high-voltage substations and industrial environments. | | |
| *Ambient temperature* | | | |
| *Operating* | -20°C to +55°C (-4°F to +131°F) | -20°C to +55°C (-4°F to +131°F) | -5°C to +50°C (23°F to +122°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** | | | |
| *DC power supply* | 11– 16 V DC | | |
| *AC power supply* | 90 – 264 V AC, 47 – 63 Hz | | |
| *Internal battery* | 24 Wh/2.2 Ah | 49 Wh/4.4 Ah (optional) | No |
| *Dimensions* | | | |
| *Instrument* | 250 x 169 x 52 mm (9.84" x 6.65" x 2.05") | | 410 x 340 x 205 mm (16.1" x 13.4" x 8") |
| *Transport case* | 520 x 460 x 220 mm (20.5" x 18.1" x 8.7") | | No |
| *Weight* | | | |
| *Instrument* | 1.4 kg (3.1 lbs) 1.8 kg (4 lbs) with battery | | 8.5 kg (18.7 lbs) |
| *Case and accessories* | 12 kg (26 lbs) | 15 kg (33 lbs) | Accessories 10kg (22 lbs) |
| **Measurement section** | | | |
| *Test method* | Sweep frequency (SFRA) | | |
| *Frequency range* | 0.1 Hz – 25 MHz, user selectable | | |
| *Frequency resolution* | 0.01% | | |
| *Frequency accuracy* | 0.01% (measurement error) | | |
| *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 | | |
| *Internal noise level (average 20 Hz to 2 MHz)* | < -120 dB | < -140 dB | < -140 dB |
| *Dynamic range1)* | >130 dB | >150 dB | >150 dB |
| *Inaccuracy* | ±0.1 dB from +10 dB down to -40 dB ±1 dB down to -100 dB | ±0.1 dB from +10 dB down to -40 dB ±0.5 dB down to -100 dB | |
| *IF bandwidth* | User selectable, default <10% | | |
| *USB* | Yes | Yes | 4 type A, 1 type B |
| *Bluetooth* | No | Yes | No |
| *FRAX Software for Windows 2000/XP/Vista/7/8/10* | Yes | Yes | Yes |
| *Standards / guides* | Fulfills requirements in IEC 60076-18, IEEE C57.149-2012, CIGRE Technical Brochure 342, DL/T 911-2004, as well as other international standards and recommendations | | |
| *Ground loop detection* | No | Yes | Yes |
| **Analog Output** | | | |
| *Channels* | 1 | 1 | 1 |
| *Compliance voltage* | 20 V p-p | 0.20 – 24 V p-p | 0.20 – 24 V p-p |
| *Measurement voltage at 50 Ω* | | 0.1 – 12 V p-p | 0.1 – 12 V p-p |

| | | | |
|---|---|---|---|
| *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* | Simultaneous | | |
| *Frequency range* | 0.1 Hz – 25 MHz | | |
| *Input impedance* | 50 Ω | | |
| *Sampling rate* | 100 MS/s | | |
| **Built in PC** | No | No | Yes |
| *Operating system* | – | – | Windows XP embedded |
| *Touchscreen* | – | – | 12" |
| *Memory* | – | – | 1000 records in internal memory<br>External storage on USB stick |

*1) Dynamic range is defined from +10 dB to internal noise in the unit*

## 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, 9 m (30 ft) cable set | AC-19092 |
| With accessories incl. battery, 18 m cable set | AC-19091 |
| With accessories incl. battery, 9 m cable set | AC-19093 |
| **FRAX-99** | |
| With accessories, 18 m cable set | AC-29092 |
| With accessories, 9 m cable set | AC-29090 |
| With accessories, incl. battery, 18 m cable set | AC-29096 |
| With accessories, incl. battery, 9 m cable set | AC-29095 |
| **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)

| Item | Art. No. |
|---|---|
| **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-clamp | GC-80010 |
| E-clamp (single hand grip clamp) | GC-80030 |

SALES OFFICE
**Megger Sweden AB**
**Rinkebyvägen 19**
**SE-182 36 DANDERYD**
**SWEDEN**
**+46 8 510 195 00**
**seinfo@megger.com**

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