

APPLICATION NOTE 24

IEC60076-18 - SFRA of Power Transformers, Typical Test Sequences

This application note will discuss typical transformer configurations and measurement sequences as specified in the IEC60076-18 international standard. This guide is based on the operation of the N4L SFRA45 Sweep Frequency Response Analyzer and will provide a baseline for measurements which can be applied in most situations. Additional measurements may be carried out either to provide extra information or to match previous measurement configurations or test sequences.

- **Zero dB check:** Before any measurements are taken, the engineer is advised to perform a “Zero dB check” of the instrument and connection leads/clamps. The connection leads should be connected as per fig.1 below;



Fig.1

Using the default settings of the SFRA45, the instrument sweep is already set to a 10Hz to 20MHz sweep in 2000 steps. This can be altered in the “SWEEP” menu, in most cases 10Hz to 2MHz will be an acceptable frequency range for the test. When using the N4L clamp set you should enter the CH1 menu and select “N4L Clamps - YES”. All that is now required is to turn on the generator and select “START” to begin the sweep. It should be observed that the bode plot will provide an equal to or better response than +/-0.5dB @ 2MHz and better than +/-3dB at 20MHz. IEC60076 states that the maximum attenuation during a Zero dB check should be <0.6dB at 2MHz. Typical values of 0.06dB are expected with the SFRA45 and the N4L lead set, an indication of the SFRA45’s performance.

- **Standard Measurements:** The standard measurement approach will be from “end-to-end” of each phase of each winding, each phase should be separated as far as possible with all other terminals left floating.



Note: Additional measurements, such as capacitive inter winding, inductive inter winding and end-to-end short circuit tests can also be carried out.

- **Tap Position:** For transformers with an on load tap changer, two tests must be performed.
 - (a) With highest number of turns in circuit
 - (b) With the OLTC out of circuit.

Note: Other windings with a fixed amount of turns will be tested in a tap position of maximum number of turns in the test circuit.

- **Auto-Transformers:** The standard measurements for auto-transformers with a line-end tap changer are as follows:
 - (a) On the series winding with the minimum amount of turns of the tap winding in circuit
 - (b) On the common winding with the maximum number of turns of the tap winding in circuit.
 - (c) On the common winding with the minimum number of turns of the tap winding in circuit.

Note: This measurement approach is intended to provide measurements both with and without the tap winding in circuit; this aids the diagnosis of a fault.

For neutral or changeover positions, the direction of the “change” of the tap-changer itself will be in the “Voltage-Lowering” direction, the direction of movement should always be recorded.

With a de-energised tap changer, the standard measurement will be on the “as-found” DETC tap position. In the factory, the standard measurements will be on the tap with the highest number of turns in circuit and in the service position, if known.

If the service position is not known, then the measurements will be on each DETC position unless data is available from a previously recorded identical transformer.

- **Star and auto connected windings with a neutral terminal**

As a rule, the signal (Generator) should be applied to the neutral terminal, or for series windings the lower voltage terminal.

Note: If in previous tests the measurements were performed with the generator connected to the line terminals, this test should also be carried out.

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A star connected winding with no neutral

Star connected windings with no neutral brought out can be treated as a delta winding.

Standard measurements for Star Connected winding with Taps

Test No.	Signal and Reference (CH1)	Response (CH2)	Tap Position
1	Neutral	Line Terminal Phase 1	Max Turns
2	Neutral	Line Terminal Phase 2	Max Turns
3	Neutral	Line Terminal Phase 3	Max Turns
4	Neutral	Line Terminal Phase 1	Tap winding out of circuit
5	Neutral	Line Terminal Phase 2	Tap winding out of circuit
6	Neutral	Line Terminal Phase 3	Tap winding out of circuit

Table 1

• **Delta windings and other windings without an accessible neutral**

If delta windings can be split, the measurements should be carried out as such. As a rule, measurements should be made on each phase, injecting the reference (Generator) signal to the terminal with the lowest number or letter nearest the start of the alphabet.

For example,

A to B,

V to W or

1 to 2

Note: For delta tertiary or stabilising windings, the delta shall be closed.

If the delta tertiary is earthed at one corner during service, this should be removed if possible without the removal of liquid or gas.

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**Delta connected winding without tap**

Test	Signal and Reference (CH1)	Response (CH2)
1	A, U, R or 1	B, V, S or 2
2	B, V, S or 2	C, W, T or 3
3	C, W, T or 3	A, U, R or 1

Table 2

- Zig Zag connected windings**

Zig Zag connected windings can be treated as a star winding with a neutral connection.

- Two winding three phase transformers**

One measurement of each phase on every winding, this would be a total of six measurements for a transformer without taps and nine with an OLTC.

- Three phase auto-transformers**

Standard measurements consist of one on each phase of the series winding and the common winding, with additional measurements for common windings with an OLTC. A total of 6 measurements for transformers without tap changers and 9 for transformers with a tap changer. If a tertiary winding is brought out three additional tests on this winding are required.

- Phase shifting transformers**

Standard measurements are from the input to the output terminal on each phase and from the neutral of the shunt winding to the output on each phase. This should be performed on the neutral tap and the extreme tap, being a total of 18 measurements.

If the transformer is a “two-core” type with external interconnections that can be removed on site then the transformer can be treated as two separate entities.

- Reactors**

Standard measurements are from the input to the output terminal on each phase, a total of three measurements. Shunt reactors can be treated as a star wound transformer, with three measurements without taps and six measurements with taps.

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- **Are any additional tests required?**

Any additional measurements should be specified by stating the signal/reference, response, earth arrangements and if the terminals are floating or connected together. The current tap position and the previous tap position for each additional measurement should be recorded. A typical format for the recording of such results is illustrated in table 3 below;

Measurement	Tap	Previous Tap	Source and reference (Vin)	Response (Vout)	Terminals Earthed	Terminals connected together	Comments
1							
2							
3							
.....							

Table 3

- **Saving data**

IEC60076-18 states that the instrument must record and save data in a defined XML format as per table 4, for clarity we have defined each item. Once a sweep is complete the engineer can save the sweep data by entering the “PROG” menu and selecting the desired memory location to save the data (memory stick/internal) and then entering the name of the sweep to be saved. Items in **red** are auto completed by the instrument.

The SFRA45 Sweep Frequency Response analyzer was developed in collaboration with one of the world largest power transformer manufacturers and complies fully to IEC60076-18.



Test data definitions

Identifier	Typically the customer serial number or the location number of the transformer/reactor
Date	Date the test was carried out
Time	Time the test was completed
Manufacturer	Manufacturer of the transformer
Serial No	Serial number of the transformer
Measuring equipment	SFRA45 Serial number and model number
Peak Voltage	Vpk setting in the output menu
Reference terminal	The identifier of the transformer/reactor terminal to which the Generator/CH1 connection was made
Response terminal	The identifier of the transformer/reactor terminal to which the CH2 connection was made
Connected terminals	The identifiers of the transformers/reactors terminals that were connected together during the test in the format ID1-ID2-ID3 , ID4-ID5-ID6 (e.g. A-B-C , D-E-F would denote terminals A,B and C were connected together and terminals D, E and F were separately connected together)
Earthed terminals	The identifier for each terminal connected to the transformer/reactor tank during the test
OLTC	Tap position indicated on the transformer/reactor during the test
Previous OLTC position	The tap position from which the tap changer was moved in order to be at its current position
DETC position	Position of the DETC
Temperature	Transformer/reactor temperature
Fluid filled	Yes/No
Comments	Provides additional comments box. Example “service” if the bus bars are removed but bushings installed.
Unshielded length	Length of earth braid used

Table 4

In the next application note on the subject of SFRA, we will discuss how to interpret the results obtained with the SFRA45 test system.

For more information on the SFRA45 Sweep Frequency Response Analyzer please visit our website www.newtons4th.com