

Power Transformer – SFRA Connections Guide

Transformer Frequency Response Analysis (FRA) Test

Introduction

This specification provides guidelines for an FRA test on transformers.

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1 Scope and Application

Frequency Response Analysis (FRA) testing is a diagnostic test that provides:

- an indication of the health of the transformer
- a baseline set of reference results for comparison in the future

These specifications cover the requirements for Frequency Response Testing at the factory and for field commissioning tests. The factory and commissioning test data may be used as baseline data for comparison to future field tests.

All tests shall be performed by qualified test personnel who are familiar with the test equipment and capable of basic interpretation of the test results. The test personnel must be able to recognize valid and invalid results, or have access to support.

2 Test Procedures

The tests shall be performed with the transformer assembled and oil filled.

The transformer should be disconnected from any power systems or supplies except for auxiliary supplies to tap changers, pumps, fans etc.

Core ground bushings shall be connected to ground; they do not normally form a part of the test process.

All windings shall be tested as shown in the tables in section 7.

Tests on windings with tap changers shall be performed in 2 tap positions; (1) with the DETC and LTC (if equipped) in the neutral position and (2) in the tap combination that places all sections of the windings in the circuit.

The tap positions shall be noted on the test report for each test.

When tests are performed at neutral tap position, the previous tap position must be recorded as this will affect the test result.

Bushings not under test, including neutrals, shall be ungrounded and disconnected.

Test cable coaxial shields must be grounded at both ends (at the base of the test bushing flanges and at the BNC connection to the Test set).

The test set ground should be directly connected to the specimen ground.

3 Test Connections

3.1 Test Connection Protocol

In general, the smallest possible sections of a transformer winding should each be tested separately.

Check the nameplate for actual connection details.

Where a delta winding is completed externally, it should be left as three separate windings if possible, as is often found on a generator step up unit. If only one corner of the delta is brought out, it should be completed during tests on other windings; this ensures a degree of symmetry for those tests on other windings.

The test connections described here do not include repeat tests for different tap positions. These are required where a tap changer is present.

3.2 Open and Short Circuit Tests

Open circuit tests are performed on a winding with all other connections floating and disconnected; the only exception to this is where a delta winding has one corner completed external to the tank, providing symmetry between test set ups.

Short circuit tests are performed on a HV winding by shorting together the LV connections, without grounding. The neutral is not included in the shorting process.

3.3 Single Phase – Double Wound

	<i>Open Circuit Tests</i>		<i>Short Circuit Test</i>
	<i>Other bushings float</i>		<i>X1-X2 shorted together and floating</i>
	<i>HV Winding</i>	<i>LV Winding</i>	
	Test 1	Test 2	Test 3
<i>Single Phase</i>	H1-H2	X1-X2	H1-H2

Table 1 - Single Phase Double Wound

3.4 Single Phase – Autotransformer

	<i>Open Circuit Tests</i>		<i>Short Circuit Test</i>
	<i>Other bushings float</i>		<i>X1-N shorted together and floating</i>
	<i>HV Winding</i>	<i>LV Winding</i>	
	Test 1	Test 2	Test 3
<i>Single Phase</i>	H1-X1	X1-N	H1-X1

Table 2 - Single Phase Autotransformers

3.5 Two Winding Transformers

	<i>Open Circuit Tests</i>						<i>Short Circuit Tests</i>		
	<i>All other bushings float</i>						<i>x1-x2-x3 shorted together; x0 floating</i>		
	<i>HV Windings</i>			<i>LV Windings</i>					
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
<i>Delta-Wye</i>	H1-H3	H2-H1	H3-H2	X1-X0	X2-X0	X3-X0	H1-H3	H2-H1	H3-H2
<i>Wye Delta</i>	H1-H0	H2-H0	H3-H0	X1-X3	X2-X1	X3-X2	H1-H0	H2-H0	H3-H0
<i>Delta-Delta</i>	H1-H3	H2-H1	H3-H2	X1-X3	X2-X1	X3-X2	H1-H3	H2-H1	H3-H2
<i>Wye-Wye</i>	H1-H0	H2-H0	H3-H0	X1-X0	X2-X0	X3-X0	H1-H0	H2-H0	H3-H0

Table 3 - Two Winding Transformers

3.6 Three Phase Autotransformer

A three phase autotransformer may have a single common neutral (H0X0) or three separable neutrals (N1, N2, N3). A tertiary winding may be present; it is tested the same way in either version of neutral bushing arrangement.

	<i>Open Circuit Tests</i>						<i>Short Circuit Tests</i>		
	<i>All other bushings float</i>						<i>X1-X2-X3 shorted together; H0X0 floating</i>		
	<i>HV Windings</i>			<i>LV Windings</i>					
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
<i>Wye-Wye</i>	H1-X1	H2-X2	H3-X3	X1-H0X0	X2-H0X0	X3-H0X0	H1-X1	H2-X2	H3-X3

Table 4 – Three phase autotransformer - common neutral – main windings

	<i>Open Circuit Tests</i>						<i>Short Circuit Tests</i>		
	<i>All other bushings float</i>						<i>X1-N1 shorted together X2-N2 shorted together X3-N3 shorted together</i>		
	<i>HV Windings</i>			<i>LV Windings</i>					
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9

Wye-Wye	H1-X1	H2-X2	H3-X3	X1-N1	X2-N2	X3-N3	H1-X1	H2-X2	H3-X3
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Table 5 - Three phase Autotransformer - neutrals separable - main windings

If the tertiary winding is brought out as three separate bushings, the corners of the tertiary delta, then three separate tests may be performed.

If only one corner of the delta is brought out, as is done for external completion of the delta winding, then only one test may be performed.

	Open Circuit Tests			Short Circuit Tests		
	<i>All other bushings float</i>			<i>Y1-Y2-Y3 shorted together and floating</i>		
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
Single Corner	Ya-Yb			<i>Not applicable</i>		
Full Delta	Y1-Y3	Y2-Y1	Y3-Y2	H1-X1	H2-X2	H3-X3

Table 6 – Three phase Autotransformer - Tertiary Winding

3.7 Three winding transformer Ydd

Wye Delta Delta	Open Circuit Tests – all other bushings floating								
	HV Windings			LV Windings			LV Windings		
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
	H1-H0	H2-H0	H3-H0	X3-X1	X2-X1	X3-X2	Y3-Y1	Y2-Y1	Y3-Y2
	Short Circuit Tests								
	<i>x1-x2-x3 all shorted together and floating; other bushings float</i>			<i>y1-y2-y3 all shorted together and floating; other bushings float</i>					
	Test 10	Test 11	Test 12	Test 13	Test 14	Test 15			
	H1-H3	H2-H1	H3-H2	H1-H3	H2-H1	H3-H2			

Table 7 - Three Winding Transformer – Wye-Delta-Delta

3.8 Three winding transformer dYY

Delta Delta Wye	Open Circuit Tests – all other bushings floating								
	HV Windings			LV Windings			LV Windings		
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
	H1-H3	H2-H1	H3-H2	X1-X0	X2-X0	X3-X0	Y1-Y0	Y2-Y0	Y3-Y0
	Short Circuit Tests								
	<i>x1-x2-x3 all shorted together and floating; all other bushings floating</i>			<i>y1-y2-y3 all shorted together and floating; all other bushings floating</i>					

	Test 10	Test 11	Test 12	Test 13	Test 14	Test 15			
	H1-H3	H2-H1	H3-H2	H1-H3	H2-H1	H3-H2			

Table 8 - Three Winding Transformers- Delta-Delta-Wye

3.9 Other designs

Where transformer winding test configurations are required which are not covered in the above tables, please refer to the Doble M5100 User Guide, or other available guides, for test technique.