



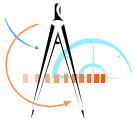
RESIDUAL LIFE ANALYSIS FOR TRANSFORMER

BY

Laxmi Associates

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Transformer Remaining Life Assessment Report

Project : RLA of Transformer	Client : Reliance Industries Ltd
Rating : 125 MVA, 231/11 kV	Sr. No. : 13142 - 01
Location : C2 - CPP Plant	Date : 24 & 26-12-2021

Report Title : Residual Life Assessment for Transformer
Client : Reliance Industries Ltd., Jamnagar
Location : C2 – CPP Plant, Jamnagar
Report Submitted to : Electrical Maintenance Dept.
Report version : Final

Reliance – Jamnagar

Field Test Conducted by

Remaining Life Assessed by

Er. Bhargav & Er. Diwakar
Testing & Commissioning Engg.

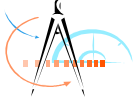
Dr. Aradhana Ray,
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Engineering Consultant

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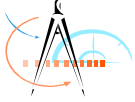
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Summary:

This residual life analysis of Transformer is divided into four following stages

1. Engineering Analysis
2. Field/Lab tests
3. External inspections
4. Life and risk of failure assessment

Stage	Activity Description	Purpose
1	Engineering Analysis	Reviewing historical condition
	Winding Insulation loss of life calculation	Estimate the loss of life of the paper insulation based on operating conditions
2 a	Field Electrical Test	Reconfirm / verify the electrical characteristics
	Overall winding Insulation tests (IR & Tan delta)	Measure deterioration of overall insulation (winding to ground and inter winding)
	Bushing Tests	Measure condition of bushing insulation
	No Excitation current tests	Measure condition of inter turn insulation, core and LTC system
	Turns Ratio test	Identify the defect in inter winding insulation and LTC
	Winding Resistance test	Evaluate the continuity condition of the winding conductor
	Short circuit impedance & Leakage reactance test	Evaluate the winding deformation
	Sweep Frequency Response Analysis	Evaluate the winding deformation , mechanical and electrical condition of winding and core
2 b	Lab Tests	Reconfirm / verify the physical and chemical characteristics
	Dissolved Gas Analysis	Evaluate possible fault conditions
	Full Oil quality screen test	Physical and chemical condition of oil
	Evaluation of Cellulosic material by Furan test	Estimate the paper aging
3	Visual Inspection	Verify the condition of visible components and construction
	External inspection	Identify broken or deteriorated exterior components
4	Life and Risk of Failure assessment	Evaluate the overall condition in key areas based on data from stages 1, 2 and 3



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This report mentioned about the complete condition assessment of transformer as mentioned below.

Findings:

✓ Visual Inspection	- Found normal
✓ Magnetizing Current Test	- Found normal
✓ Magnetic Balance test	- Found normal
✓ Winding Resistance test	- Found normal
✓ Turns Ratio test	- Found normal
✓ Sweep Frequency Response Analysis	- Found normal
✓ Short circuit impedance test	- Found normal
✓ Dielectric aging assessment (Frequency Domain Spectroscopy)	- Found normal
✓ IR & PI Test	- Found normal
✓ Tan delta and Capacitance test winding & bushing	- Found normal
✓ Moisture assessment	- Dry
✓ DGA Analysis	- Found normal
✓ Furan Analysis	- Found normal
✓ Oil Routine test	- Found normal

Condition assessment :

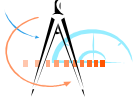
Mechanical condition of Core and winding assembly: Normal aging profile

Dielectric condition of Overall insulation: Normal aging profile

Thermal condition of oil and winding assembly: Normal aging profile

The overall assessment of transformer health is as summarized below:

- The Tan delta values in GST & UST mode for HV and LV windings are Normal for this type of rating and age of Transformer.
- Average moisture content absorbed by cellulose insulation indicate Dry insulation, for this type of age, rating and application of Transformer. Note that moisture reduces the breakdown strength of paper and has direct impact on life of transformer.



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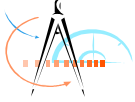
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- The variation in measured voltage ratio is found to be within 0.5% , when compared to designed rated value indicated on nameplate and hence the results are found OK as per IEEE Standard 62: 1995 and is thus acceptable.
- Capacitance and SFRA test indicate no abnormality in mechanical condition of Core & winding assembly inside the transformer.
- Magnetizing current data is also indicating that electrical condition of Transformer is okay.
- Winding resistance measurements indicate normal data when compared on three phase basis. The unbalance in winding resistances for HV & LV winding is not exceeding the permissible limit of 5 % as specified by IEEE Standard 62: 1995 and is thus acceptable.
- The short circuit Impedance is comparable among three phases & the results are found acceptable as per IEEE Standard 62: 1995.
- The tan delta values as measured in UST mode are mainly concerned with the Insulation of the HV Core insulation of Bushing (C1). The tan delta values of C1 for HV Bushings are normal (less than 0.7 %) and it indicates normal aging of insulation.
- Variation of Tan delta with change in frequency indicates normal aging profile of HV Bushing.
- All the oil routine test results are within the limits as prescribed in the IEEE Std C57.106-2002, and it indicates normal aging of oil.
- The total combustible gas limits are within the permissible range as specified under "Condition 1" of Total Dissolved Key Gas Concentration analysis specified by IEEE C57-104-2008.
- The Furan content is Low.

Recommendation:

Based on above observed results and information available, following points shall be noted:

- Oil quality is good .
- All Electrical tests indicate that transformer is working satisfactorily.



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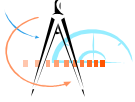
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- Oil Sample for DGA test should be taken on Yearly basis, to monitor if any further rise in gas content is there.
- Moisture content of Insulation should be monitored after three years to see any further gradual rise of moisture content is there in Insulation.

Overall performance of this **transformer is satisfactory for normal operation in the system.**

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1.0 Introduction:

The **RIL-Jamnagar** planned to do life assessment of Power transformer. The background for this plan is, the transformer in plant has been in service since **4 Years and Life assessment of Power Transformer was necessary.**

To carry out this task, planned shutdown schedules were made for Transformer. Our testing team carried out all field testing offline. Based on field test reports, historical information, temperature and loading profile the remaining life of this transformer is evaluated.

This document describes the detailed assessment and various tests done in the **125 MVA Power Transformers.**

2.0 Scope of work:

To carry out remaining life assessment in Transformers by conducting a detail study about the present condition. These analyses have to be made by conducting an evaluation based on the various tests carried out and historical information like temperature and loading profile.

3.0 Reference:

The residual life analysis on power transformer evaluated in reference with the following standards and publications.

IEEE.62.1995. IEEE Guide for diagnostic field testing of electric power apparatus Part-1: Oil filled Power transformers, Regulators and Reactors.

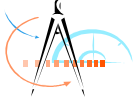
IEEE Std C57.12.90-1999. IEEE Standard test code for liquid immersed distribution power and regulating transformer

IEEE Std C57-104-1991. IEEE Guide for the detection and determination of generated gas in oil-immersed transformers and their relation to the serviceability of the equipment.

IEEE Std C57-106-2002. IEEE Guide for acceptance and maintenance of insulating oil in equipment

IEEE Std C57.91-1995. IEEE Guide for loading mineral oil immersed transformers

IEC 60450-1974 Measurement of the average viscometric degree of polymerization of new and aged cellulosic electrically insulating materials



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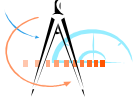
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4.0 Instruments used:

Sl. No.	Instrument	Make	Instrument Sr. No.	Date of Calibration	Calibration due on
1	Tan delta	ISA	19/0285401	02-09-2021	01-09-2022
2	Turns Ratio	Eltel	20171615	02-10-2021	01-10-2022
3	Winding Resistance	Scope	2304.08E434	09-10-2021	08-10-2022
4	IR Tester	Megger	10217562	28-04-2021	27-04-2022
5	SFRA Kit	Omicron	DF298T	02-02-2021	01-02-2022
6	Domino	Doble	K5040007	02-02-2021	02-02-2022
7	DIRANA – IDAX	Megger	1800711	20-03-2021	19-03-2022
8	Oil testing at GEL	-	-	-	-

5.0 Name Plate Details:

Company	RIL	Serial Number	13142 – 01
Location	Jamnagar	Special ID (Tag No.)	ET – BBC952 – 001A
Manufacturer	ABB	Vector Group	YNd11
Yr. Manufactured	2017	Phases	3
kV	231/11	MVA	125



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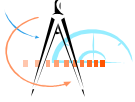
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6.0. Test Data:

6.1. Off-line test data

6.1.1. Visual Inspection

Sl. No	Description	Observation
1	Check the equipment is cleaned and insulators are free from dust/dirt etc	OK
2	Check any Oil Leakage	Normal
3	Check that Earthing has been properly done and connected to the Earthing grid for the following.	OK
	a. Main Tank	OK
	b. Marshalling box	OK
4	Check the HV/LV Neutral is grounding properly, connected to two earth pits.	OK
5	Check Silica gel in the Main breather is active	OK
6	Oil is filled in the oil cup of breather up to the level marked	OK
7	Check there is no oil leakage in Radiator side	NO
8	Check any Leakage found in Main Tank	Yes
9	Check any Signs of Overheating	Normal
10	Check the Oil Level in conservator	OK
11	Check the Gaskets or Seals, Leaks etc.	OK
12	Check the marshalling box wiring and condition	OK



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6.1.2 Capacitance and Tan delta test

Tangent Delta and Capacitance Measurement of Transformer Winding:

In a two-winding transformer there are main three insulation zones: HV-TANK (CH) , HV-LV (CHL) , and LV-CORE (CL).

CH (HV to earth) :

The typical components of the space HV-TANK are the oil, oil-pressboard space, coil support insulation (situated between the bottom or top turn and the ground), high-voltage bushings and shunting insulation of leads, LTC, etc.

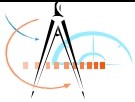
The main part of this insulation space is the oil. This insulation zone presents a good opportunity to identify the condition of the oil. The relatively small capacitance of the coil support insulation, bushings and shunting insulation components allows us to detect only severe defects in these components. Thus, the main goal of the measurements in the zone HV-TANK is to determine the condition of the oil and to detect severe defects in the other components.

CHL (HV to LV):

The inter winding space includes component: oil-pressboard space . The composition of the space allows us to detect and identify the condition of the pressboard barriers as well as of the oil. This is the only space where one can practically estimate water content in the pressboard.

CL (LV to earth):

The typical components of the LV-CORE space are: oil-pressboard space, coil support insulation, shunting insulation of the leads, LTC, LV bushings, etc. This space is the least useful in evaluating the condition of the solid insulation. The main goal of the measurements in the space LV-CORE is the detection of severe surface contamination or significant local moisture concentration in the insulation components, etc.



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Test Data Analysis:

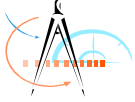
I. Tangent Delta and Capacitance Measurement of Transformer Winding:

OTI: 30°C

Winding Combination	Voltage (KV)	Test Mode	Capacitance (nF)	Tan Delta (%)
HV/LV	2	UST	6.5073	0.168
	5		6.5095	0.172
	10		6.5451	0.171
HV/ground with LV Guard	2	GST-g	6.4325	0.424
	5		6.4350	0.432
	10		6.4709	0.448
HV/LV+Ground	2	GST	12.9347	0.295
	5		13.0130	0.299
	10		13.0849	0.303
LV/HV	2	UST	6.5069	0.166
	5		6.5091	0.167
	10		6.5447	0.166
LV/ground with HV Guard	2	GST-g	24.4291	0.371
	5		24.7097	0.379
	10		24.7122	0.381
LV/HV Ground	2	GST	31.0961	0.328
	5		31.2866	0.337
	10		31.2908	0.329

REMARKS:

- ✓ The tan delta values measured in UST mode are mainly concerned with the Insulation of the HV winding and LV winding. These values are normal for MV voltage rating Transformer.
- ✓ The tan delta values in GST mode takes all currents that flow to ground into consideration and the dielectric losses are high compared to UST mode. These values are Normal for MV voltage rating Transformer.



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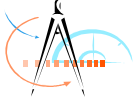
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Tangent Delta and Capacitance Measurement of Transformer Bushings:

Bushings Details	Mode	Test Voltage (kV)	Capacitance (pF)	Tanδ (%)
Sr. No: 27163183 Make: ABB KV: 245 Identification: 1U	UST	2	327.77	0.614
		5	328.06	0.610
		10	328.13	0.605
	GST-g	1	547.53	1.103
Sr. No: 27163147 Make: ABB KV: 245 Identification: 1V	UST	2	328.01	0.533
		5	328.30	0.532
		10	328.36	0.528
	GST-g	1	547.23	0.683
Sr. No: 27163149 Make: ABB KV: 245 Identification: 1W	UST	2	339.07	0.504
		5	339.30	0.501
		10	339.43	0.498
	GST-g	1	445.86	0.636
Sr. No: 67163075 Make: ABB KV: 72.5 Identification: 1N	UST	2	268.50	0.539
		5	268.60	0.539
		10	268.70	0.536
	GST-g	1	2888.6	0.523

At 3.6 KV

Frequency	Capacitance of HV Bushing (pF)				Tan δ of HV Bushing (%)			
	1U	1V	1W	1N	1U	1V	1W	1N
17 Hz	329.09	329.24	340.15	269.93	0.646	0.506	0.474	0.499
25 Hz	328.62	328.83	340.76	269.11	0.638	0.531	0.484	0.518
34 Hz	328.24	328.49	339.44	268.85	0.620	0.534	0.485	0.531
43 Hz	327.96	328.24	339.19	268.63	0.614	0.533	0.495	0.535
51 Hz	327.75	328.07	339.02	268.48	0.615	0.549	0.502	0.544
68 Hz	327.38	327.74	338.71	268.21	0.606	0.542	0.507	0.556
85 Hz	327.07	327.44	338.42	267.96	0.605	0.551	0.520	0.562
102 Hz	326.80	327.19	338.16	267.76	0.602	0.555	0.528	0.573
119 Hz	326.58	326.98	337.96	267.58	0.605	0.560	0.532	0.573
136 Hz	326.38	326.80	337.77	267.43	0.604	0.560	0.538	0.562
187 Hz	326.47	326.92	337.90	267.51	0.602	0.576	0.553	0.594
255 Hz	326.25	326.70	337.69	267.33	0.601	0.581	0.560	0.602
323 Hz	325.82	326.28	337.26	266.98	0.598	0.589	0.575	0.609
391 Hz	325.47	325.93	336.91	266.80	0.593	0.591	0.579	0.615



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REMARKS:

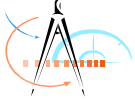
- The tan delta values as measured in UST mode are mainly concerned with the Insulation of the HV Core insulation of Bushing (C1). The tan delta values of C1 for HV Bushings are normal (less than 0.7 %) and it indicates normal aging of insulation.
- Variation of Tan delta with change in frequency indicates normal aging profile of HV Bushing.

6.1.3 Turns Ratio test: HV/LV

Tap No.	MEASURED RATIO			CALCULATED RATIO	%DEVIATION		
	1U - 1N/ 2U - 2W	1V - 1N/ 2V - 2U	1W - 1N/ 2W - 2V		U	V	W
5	11.515	11.536	11.5158	11.518	-0.026	0.156	-0.019

REMARKS:

- The variation in measured voltage ratio is found to be within 0.5% , when compared to designed rated value indicated on nameplate and hence the results are found OK as per IEEE Standard 62: 1995 and is thus acceptable.



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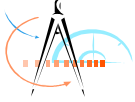
6.1.4 No Load excitation current test:

Applied 1 Phase on HV Side and Current measured in HV. (LV Side kept Open)

TAP POS.	Voltage Applied HV Side (Volts)			Measured Current (mA)		
	1U - 1N	1V - 1N	1W - 1N	1U	1V	1W
5	230	230	230	3.13	2.59	3.01
	440	440	440	4.34	3.46	4.21
	1000	1000	1000	6.49	5.18	6.37
	2000	2000	2000	9.59	7.47	9.47
	5000	5000	5000	17.10	13.15	17.00
	10000	10000	10000	27.81	20.70	27.74

Applied 1 Phase on LV Side and Current measured in LV. (HV Side kept Open)

TAP POS.	Voltage Applied LV Side (Volts)			Measured Current (mA)		
	2U-2W	2V-2U	2W-2V	2U	2V	2W
-	243.0	243.2	243.3	139.1	103.6	139.0



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6.1.5 Winding Resistance test:

Note: OTI Temp: 30°C

HV Side Winding Resistance:

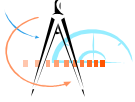
Tap No.	1U - 1N (mΩ)	1U - 1N (mΩ)	1V - 1N (mΩ)	1V - 1N (mΩ)	1W - 1N (mΩ)	1W - 1N (mΩ)
	R@30°C	R@75°C	R@30°C	R@75°C	R@30°C	R@75°C
5	276.1	323.0	275.3	322.0	275.4	322.2

LV Side Winding Resistance:

Tap No.	2U - 2V Res (mΩ)	2U - 2V Res (mΩ)	2V - 2W Res (mΩ)	2V - 2W Res (mΩ)	2W - 2U Res (mΩ)	2W - 2U Res (mΩ)
	R@30°C	R@75°C	R@30°C	R@75°C	R@30°C	R@75°C
-	1.146	1.341	1.143	1.337	1.146	1.341

Formula for Calculating Resistance@ 75 C = $((235+75)/(235+\text{Measured Temp})) \times \text{Resistance @ Measured Temp.}$

REMARKS: The unbalance in winding resistances for HV & LV winding is within the permissible limit of 5 % as specified by IEEE Standard 62: 1995 and is thus acceptable



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6.1.6 Insulation Resistance test:

When we carry out the Insulation resistance test the reading of IR is time dependent as the total current flowing in the circuit varies and is equal to the sum of the three components mentioned below.

1. Capacitive Charging current: is the initial surge of current that occurs when we apply DC voltage to a conductor insulation. Capacitive current starts high and then drops very fast and lasts only for a few seconds as the dc voltage is applied.

2. Polarization Absorption current: Starts high and then drops. Absorption current is caused by the polarization of molecules within dielectric material. In low-capacitance equipment, the current is high for the first few seconds and decreases slowly to nearly zero. Normally in one minute reading of IR the absorption current will be dominant for all insulation Bad or good. In case of wet and contaminated insulation, there will be no decrease in the absorption current for a long time and in 10 minute reading also these component are dominant and PI value will be lower.

3. Conductive Leakage current: also called "conduction current," is the steady flow of current through and on the insulation. No insulation is perfect; even new insulation will have some leakage current, albeit small. This leakage current will increase as the insulation ages. It also will worsen when the insulation is wet or contaminated.

The total current flowing in the circuit is equal to the sum of the components, when a DC voltage is applied. It starts at a relatively high value and then drops, settling at a value just slightly above the leakage current. In bad or deteriorated insulation, the total current will drop slowly, or may even increase.

Note: I) **PI - Polarization Index** =
$$\frac{\text{IR Value at 600 seconds}}{\text{IR Value at 60 seconds}}$$

IR – It indicates status of insulation, however it fails to detect contamination and voids. Its absolute value is less important than continuous steep fall.

PI – It indicates dryness of insulation. Minimum value of Oil –Paper insulation should be 1.5.

OTI=30°C

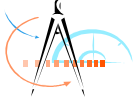
Applied 5 kV

Test Connection	15 Sec.GΩ	1 Min. GΩ	10 Min.GΩ	PI (600s/60s)
HV/E	7.8	8.6	16.98	1.97
LV/E	13.8	17.8	28.7	1.61
HV/LV	15.1	17.8	30.9	1.73

- Formula for Calculating PI (Polarization Index) = IR@ 600 Sec / IR@60 Sec

REMARKS:

1. The IR & PI values are within acceptable limits and it indicates that the moisture content of oil-paper insulation is low.
2. There is no significant aging byproducts exists and aging profile is normal.



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6.1.7 Magnetic Balance test:

HV SIDE:

Tap No. 5

1U - 1N (Volt)	1V - 1N (Volt)	1W - 1N (Volt)
242.9	224.1	18.85
128.2	243.0	118.1
18.56	223.9	243.1

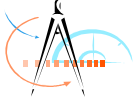
LV SIDE:

2U - 2V (Volt)	2V - 2W (Volt)	2W - 2U (Volt)
243.0	196.3	47.34
120.1	243.2	122.9
47.88	195.8	243.3

6.1.8 Short Circuit Current Test:

Applied 3 Phase on HV Side & Measured current on HV & LV Side, while LV Kept shorted.

TAP POS.	Voltage Applied HV Side (Volts)			Measured Current (A)		
	1U-1V	1V-1W	1U-1W	1U	1V	1W
5	421.7	421.6	421.0	4.76	4.76	4.76



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6.1.9 Frequency Domain Spectroscopy (FDS) Analysis test:

Moisture Analysis of Transformer Insulation:

The dryness of the oil-paper insulation systems in power transformers is a key factor in both their short and long term reliability since moisture has deleterious effects on dielectric integrity and insulation ageing rates.

The dielectric frequency response analysis method, which is based on wide range measurements in time and frequency domains, is a useful tool to evaluate the moisture condition of the electrical insulation systems.

In the Dielectric method using the Frequency Domain Spectroscopy (FDS), the dissipation factor of the insulation system under test is measured by frequency sweep. The onsite measurement is considerably accelerated by a combination of time and frequency domain measurements. The frequency range from 1 kHz down to 0.1 Hz is measured in frequency domain, whereas the range from 0.1 Hz down to 0.1 mHz is measured in time domain.

A dielectric response measurement is a three terminal measurement that includes the output voltage, the sensed current and a guard as shown in Figure 2. The moisture analysis is obtained for the solid insulation between HV and LV winding separately as indicated in Table below.

Insulation	Moisture Content of inter winding insulation	Remark
HV / LV	0.5 %	Dry

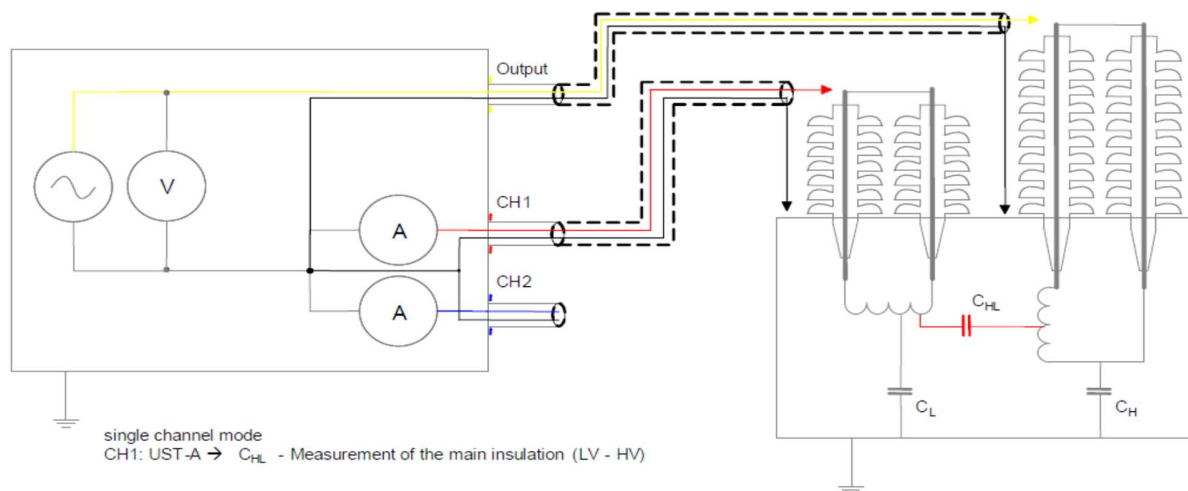
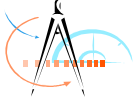


Figure 2: Schematic for UST connection of dielectric response measuring system to a transformer for CHL configuration



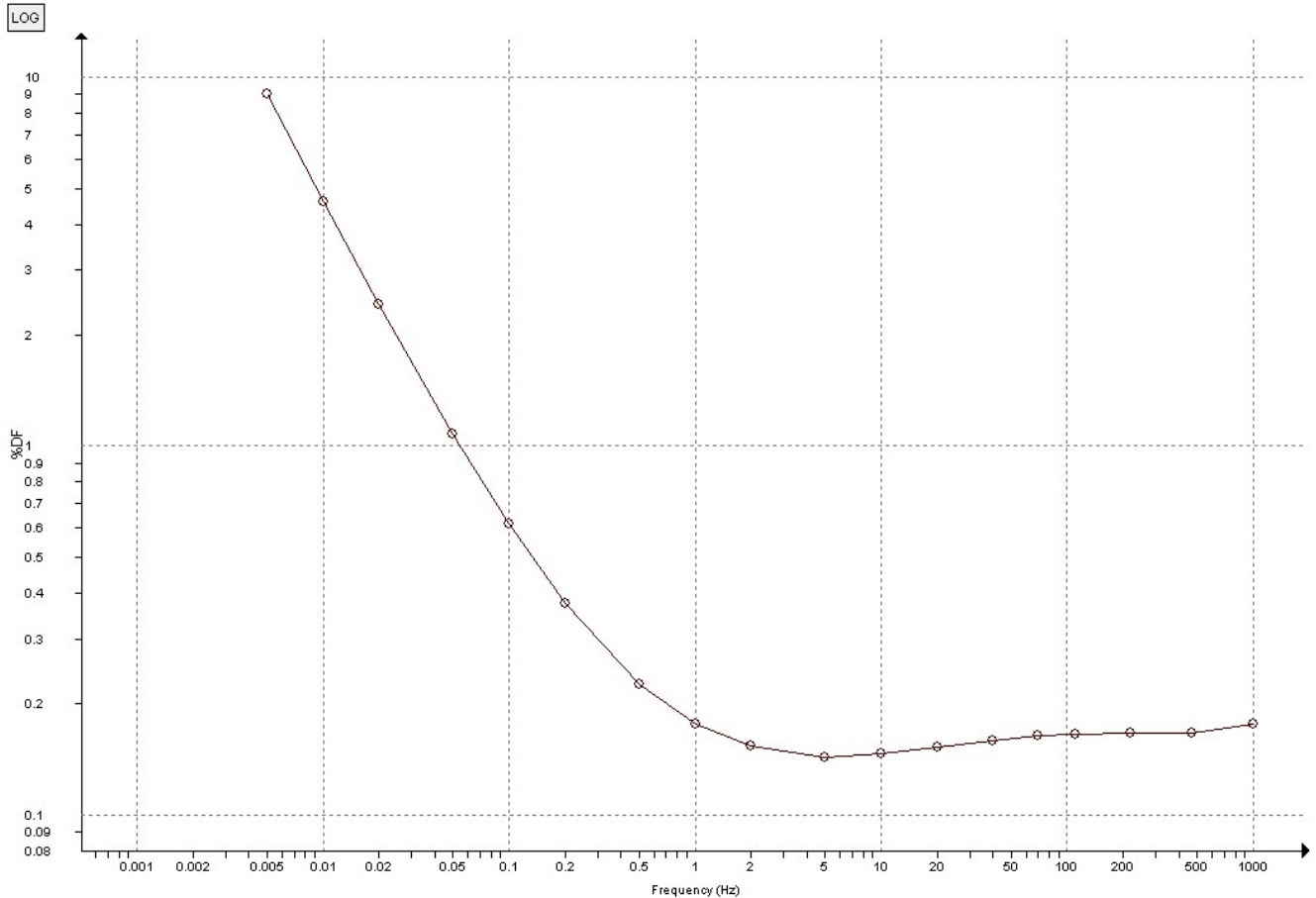
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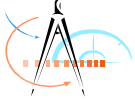
Moisture Assessment curve for CHL insulation measured by FDS+PDC combined method

Plot:



Remarks:

Moisture measurement by FDS+PDC method (DIRANA Test) indicates a Dry insulation (as per International Standards for in-service Auto Transformers). Note that moisture reduces the breakdown strength of paper and has direct impact on life of transformer.



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6.1.10 Sweep Frequency Response Analysis test:

Brief Description of SFRA:

The SFRA test involves measuring the frequency responses of each individual winding. The frequency response is measured by injecting a sine wave signal with respect to earth at one end of winding to be tested and measuring the signal amplitudes there and at other end of the winding as shown in Figure I. The attenuation (in dB) of the transmitted signal relative to reference signal at the input terminal is measured over a frequency range from 10 Hz to 2 MHz.

Measurement of Open circuit SFRA plot of winding:

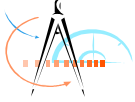
Sr. No.	Test winding	SFRA connections
1	HV winding Open circuit SFRA plot HV terminals- HV HV terminal- N	Signal injected in "HV" bushing terminal with respect to earth and measured at "N" bushing terminal with respect to earth.
2	LV winding Open circuit SFRA plot LV terminal- LV Neutral terminal- LV	Signal injected in "LV" bushing Terminal with respect to earth and measured at "LV" bushing terminal with respect to earth.

- All other bushings were floating and not connected to ground during the individual measurement. Measurements were carried out for tap no. 5.

Measurement of Short circuit SFRA plot of winding:

Sr. No.	Test winding	SFRA connections
1	HV winding Short circuit SFRA plot	Signal injected in "HV" and "N" bushing terminal with respect to earth and measured at phase bushing terminal with respect to earth. Terminal of LV winding was shorted for the test.

- All other bushings were floating and not connected to ground during the individual measurement.
- Measurement was carried out at tap no 5.



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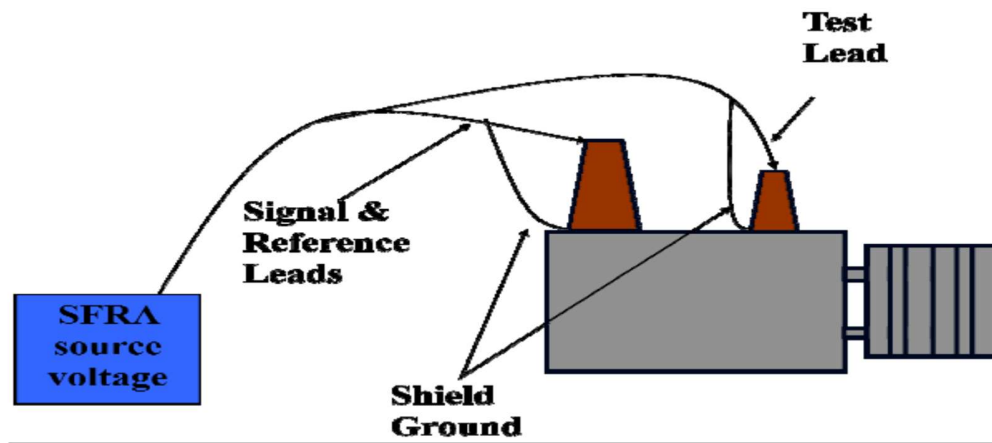


Figure I: Circuit description of SFRA

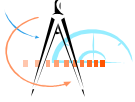
PURPOSE:

- Assess Mechanical Condition of Transformers (Mechanical distortions)
- Detect Core and Winding Movement due to large electromagnetic forces from fault currents
- Winding Shrinkage causing release of clamping pressure
- Transformer Relocations or Shipping damages

SFRA test is not required under normal operating conditions, but is recommended to be repeated over different time periods, if the transformer is subject to sudden load fluctuations or surges from external system or any short circuit faults.

REMARKS:

- **The SFRA plots are enclosed in Annexure-1 of this report.**
- These plots are taken as initial signatures and may be compared with any SFRA measurements taken in future.
- For HV winding the SFRA Open and Short circuit plots are identical when compared on three phase basis, which indicates that there is no significant winding movement in this transformer as shown in Annexure 1.
- For LV winding also, the SFRA Open circuit plots are identical when compared on three phase basis, which indicates that there is no significant winding movement in the transformer as shown in Annexure 1.



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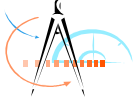
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6.2.1 On Line Test data:

6.2.1 Oil Analysis:

SI No	Test Description	Test Method	Unit	Result	Requirement as per
					Specification
1	Breakdown Voltage	IEC 60422	KV	84	30 KV Min
2	Flash point	IEC 60296	-	146	135°C Min
3	Water Content	IEC 60422	Ppm	5	25 Max.
4	Inter Facial Tension	IEC 60422	mN/m at 27°C	40	22 Min.
5	Total Acid Number	IEC 60422	mgKOH/g	0.005	0.3 Max.
6	Sludge	IEC 60422	%Wt	ND	<0.02%
7	Specific Resistivity at 90°C	IEC 60666	GOhm.cm	230	0.2 Min.
8	Dissipation Factor @90°C	IEC 60422	-	0.0015	0.5 Max.
9	Furan Analysis	IEC-61198: BS148			
	5-hydroxy-methyl-2-furfuraldehyde		Ppm	NIL	
	2-furfural		Ppm	0.012	
	2-Acetyl furan		Ppm	NIL	
	5-methyl-2-furaldehyde		Ppm	NIL	
	2-furfuryl alcohol		Ppm	NIL	
	Total Furan		Ppm	0.012	5 ppm Max
10	Dissolved Gas Analysis	IEEE-C57.104-2008			
	Hydrogen H2		Ppm	BDL	100
	Methane CH4		Ppm	<1	120
	Ethane C2H6		Ppm	BDL	65
	Ethylene C2H4		Ppm	BDL	50
	Acetylene C2H2		Ppm	BDL	1
	Carbon Monoxide CO		Ppm	235	350
	Carbon Di Oxide CO2		Ppm	2122	2500
	Oxygen O2		Ppm	4288	-
	Nitrogen N2		Ppm	26224	-



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REMARKS: OIL ROUTINE TEST DATA

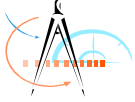
- All the results are within the limits as prescribed in the IEEE Std C57.106-2002.

REMARKS: DGA DATA

- The total combustible gas limits are within the permissible range as specified under "Condition 1" of Total Dissolved Key Gas Concentration analysis specified by IEEE C57-104-2008.

REMARKS: FURAN TEST DATA

- Furan content is Low.



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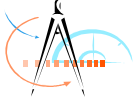
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7.0 Historical Information:

The below Historical Information are all Gathered from Client.

Sr. No	Historical Information	Information gathered
1	All previous Oil routine tests, DGA, Furan data	Not Available
2	List of maintenance history like bushing, OLTC & LA failure, repair, relocation.	No
3	Loading profile of transformer	<60 %
4	Oil processing, degassing, replacement history	No
5	Any major fault in the system, transformer has withstood	No
6	Copy of nameplate detail	Yes
7	All previous condition assessment data like Capacitance, PF, Leakage reactance, Resistance, Ratio, SFRA, No load excitation current test	Not Available
8	Test data of sister units in the system if available	Yes
9	Any major internal failure and factory repair	No
10	Average Ambient	33 C
11	Outdoor Application	YES
12	Pollution level	Industrial
13	Bushings	OK
14	Tap Changer	Offload
15	Surge Arresters	NA
16	Main Tank	
	➤ Bulged	NO
	➤ Cracked	NO
	➤ Leaks	NO
	➤ Signs of Overheating	NO
	➤ Oil Level in conservator	OK
	➤ Gas pressure on sealed Transformer	NO
	➤ Control Cabinet Problem	NO



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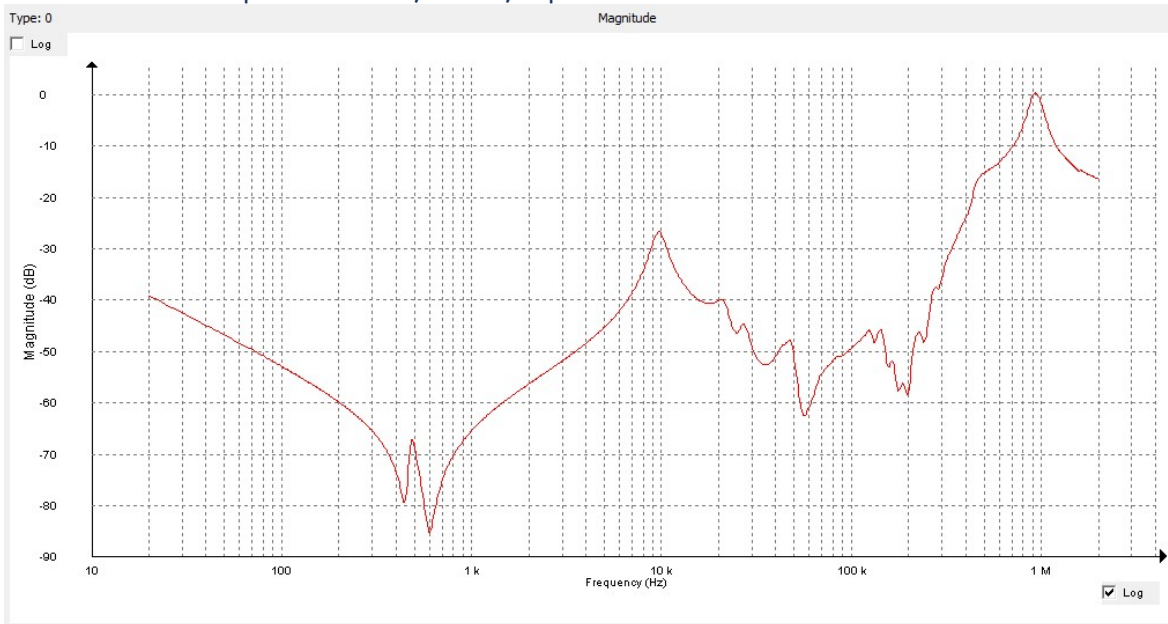
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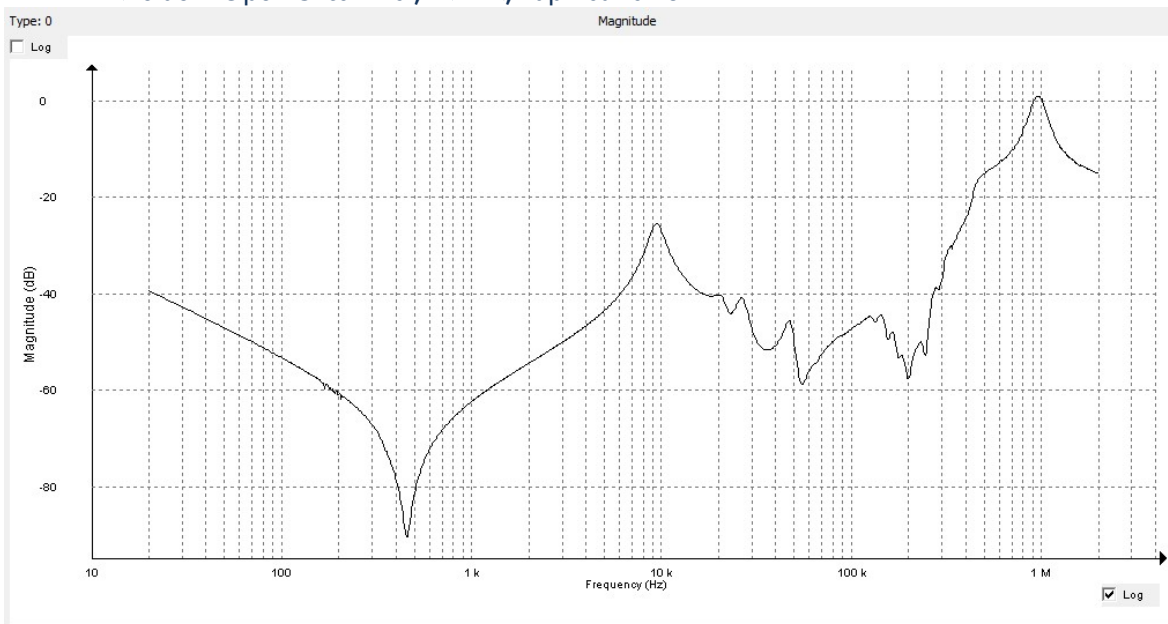
Annexure-I

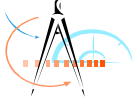
Sweep Frequency Response Analysis

1. HV Side – Open Circuit Plot, 1U-1N, Tap Position-5



2. HV Side – Open Circuit Plot, 1V-1N, Tap Position-5



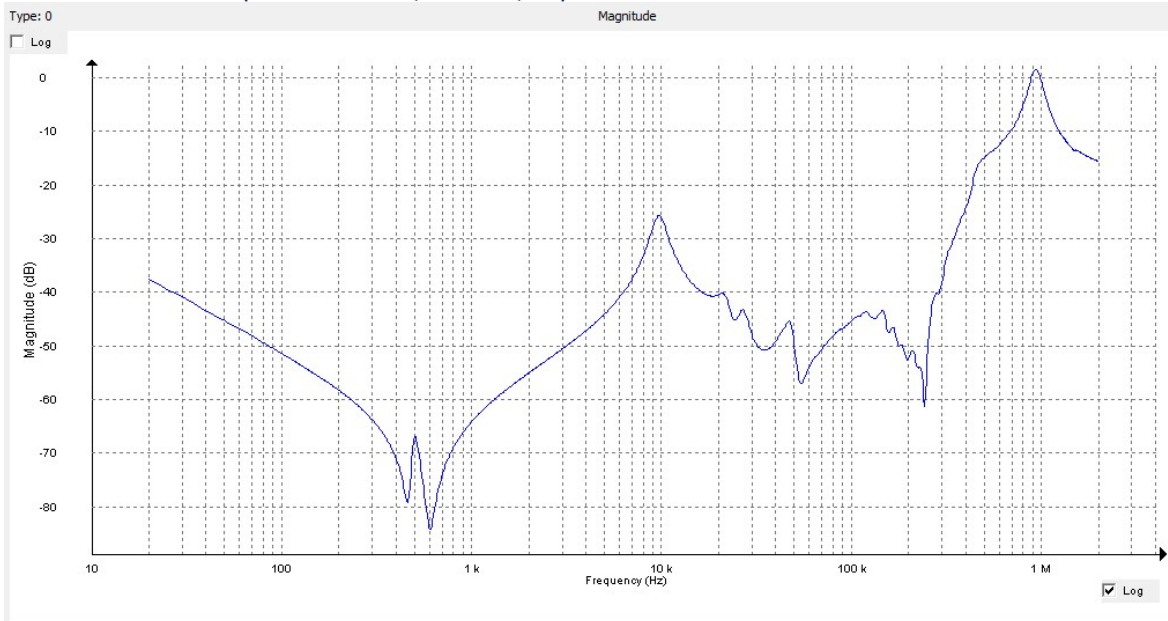


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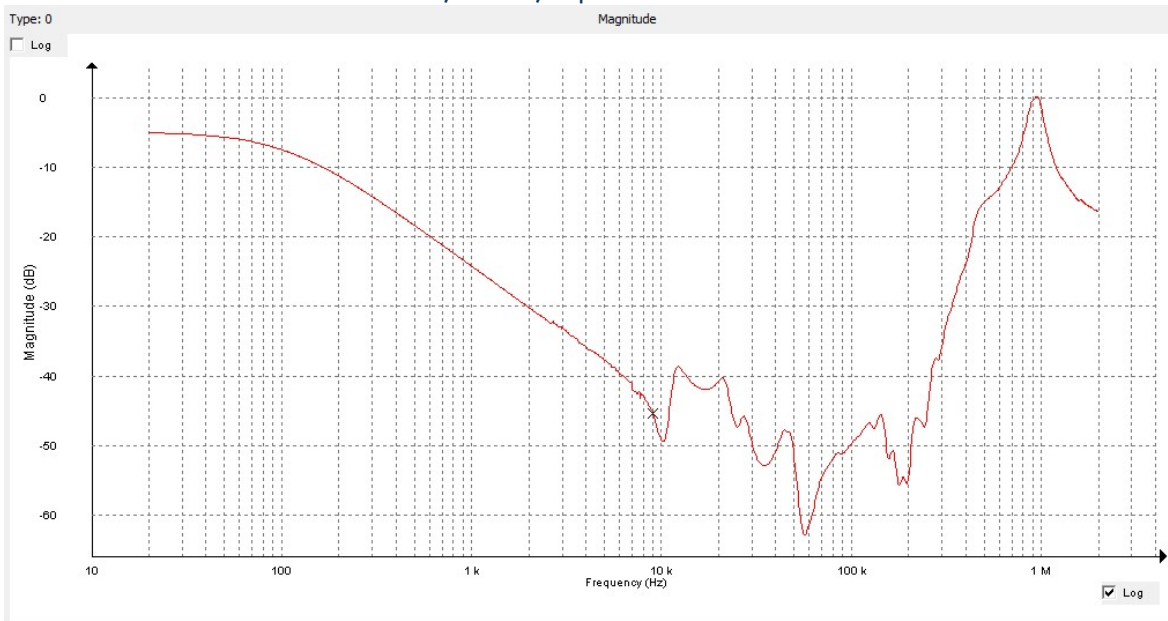
Transformer Remaining Life Assessment Report

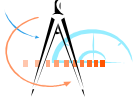
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3. HV Side – Open Circuit Plot, 1W-1N, Tap Position-5



4. HV Side – LV Short Circuit Plot, 1U-1N, Tap Position-5



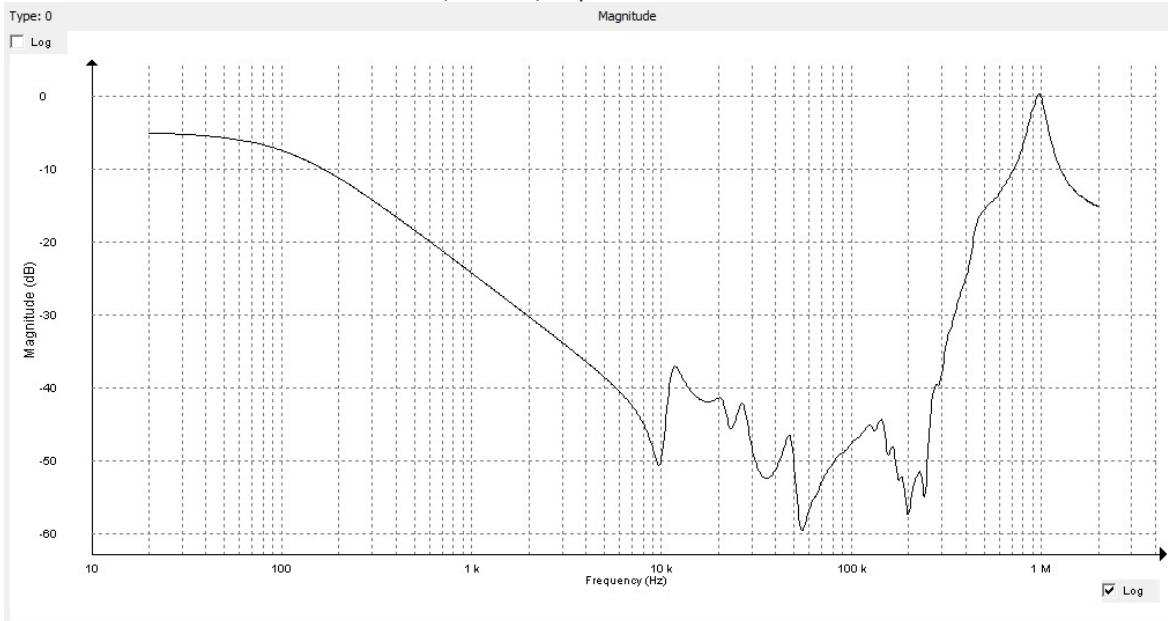


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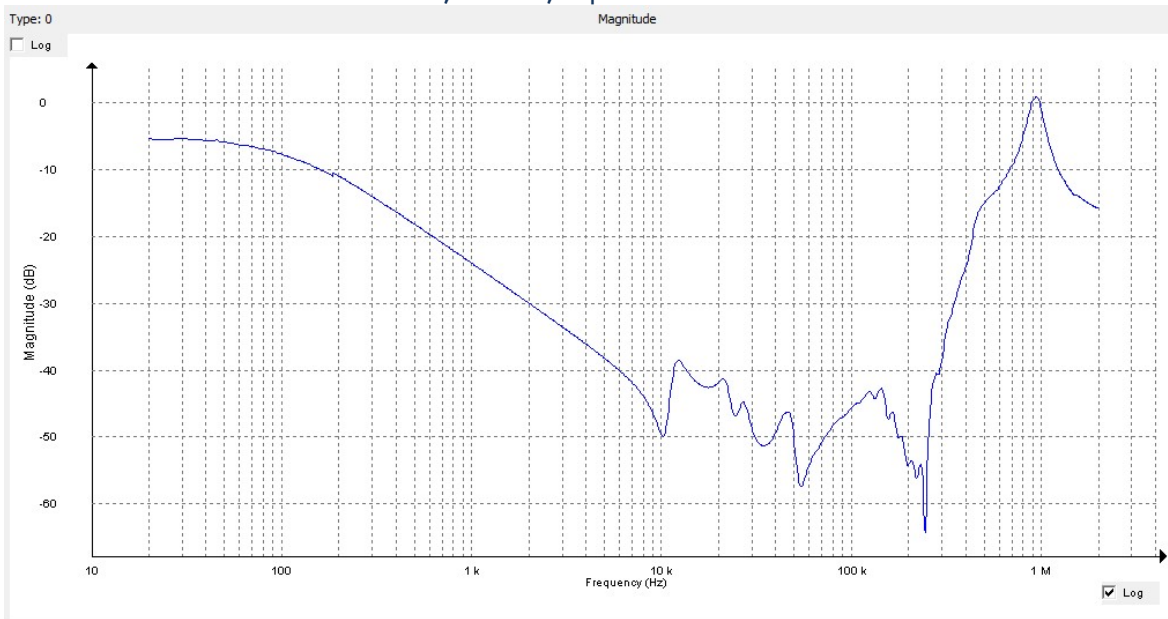
Transformer Remaining Life Assessment Report

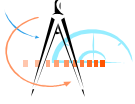
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5. HV Side – LV Short Circuit Plot, 1V-1N, Tap Position-5



6. HV Side – LV Short Circuit Plot, 1W-1N, Tap Position-5



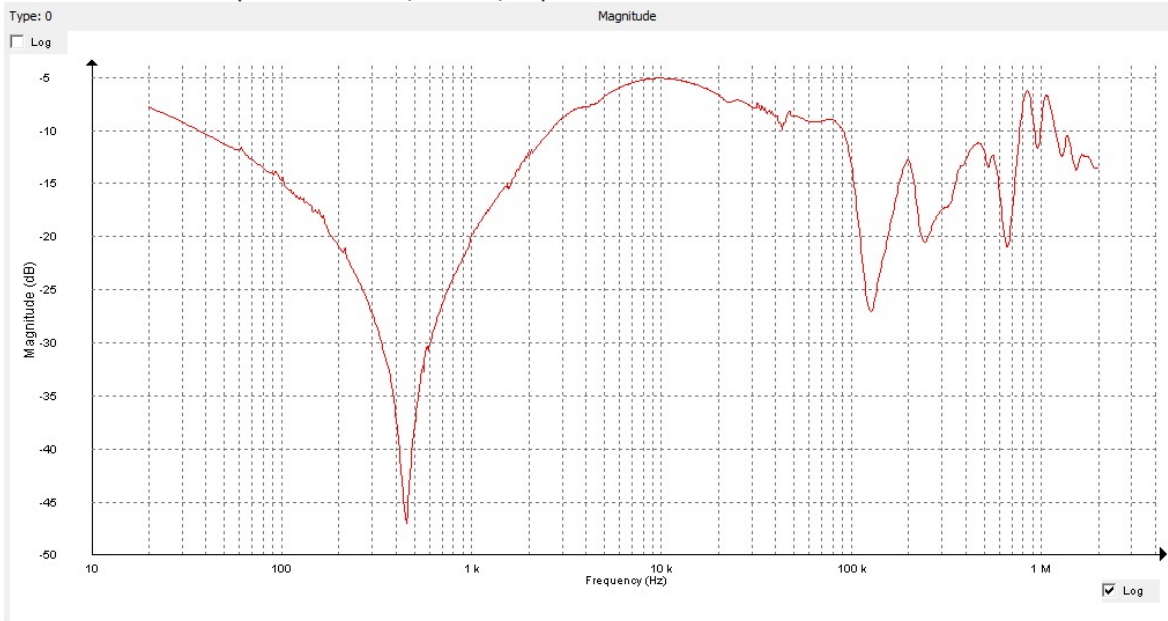


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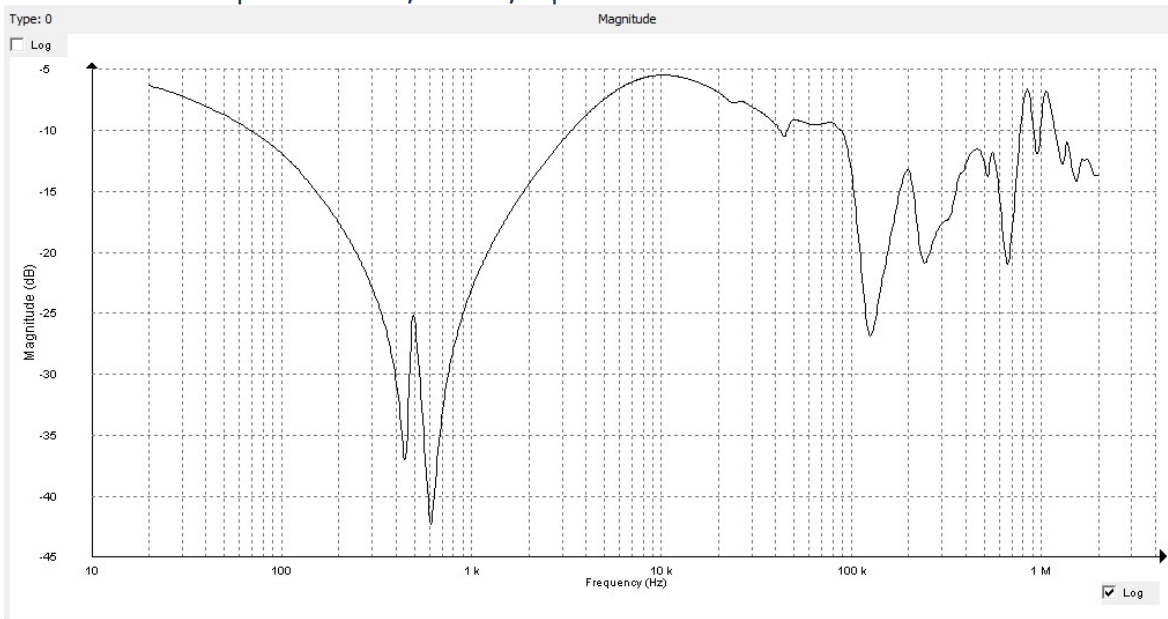
Transformer Remaining Life Assessment Report

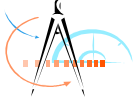
Project : RLA of Transformer	Client : Reliance Industries Ltd
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7. LV Side – Open Circuit Plot, 2U-2V, Tap Position-5



8. LV Side – Open Circuit Plot, 2V-2W, Tap Position-5



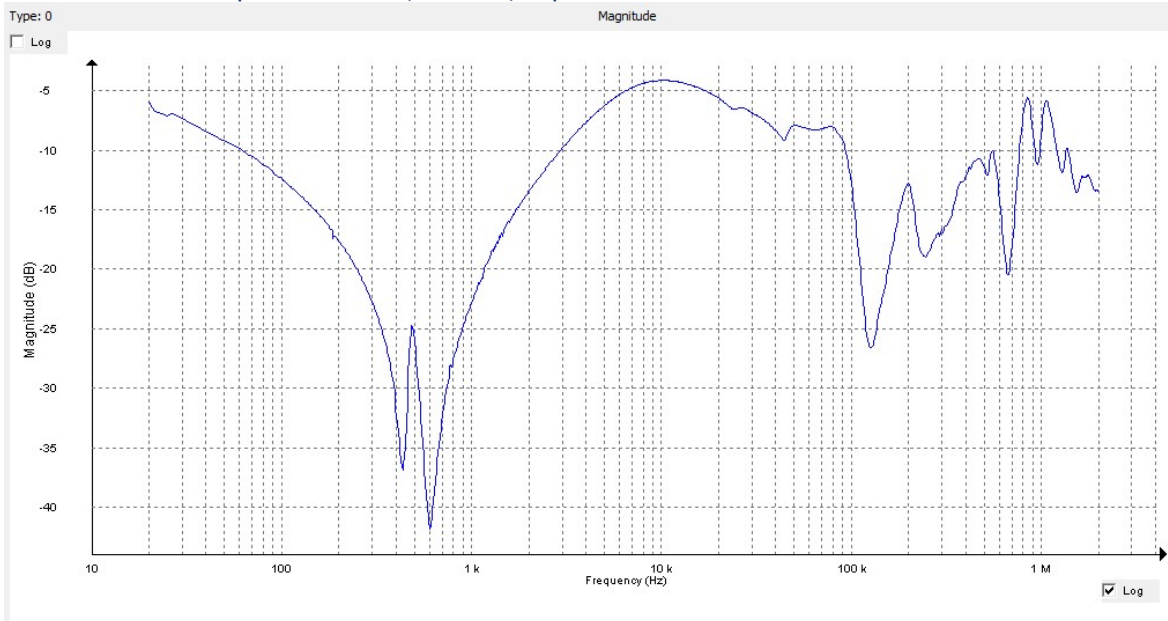


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9. LV Side – Open Circuit Plot, 2W-2U, Tap Position-5



Please contact us in case of any further query regarding this report.

Thanks!

Dr. Aradhana Ray

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