TOSHIBA	**Toshiba Transmission and Distribution Systems(India) Private Limited,** **EHV Test Lab, Unit – 09, Rudraram (Vi), Patancheru (Ml), Medak (Dist.), Telangana, 502329, India. Ph: 040 – 30717252**	Certificate No: T – 3002

Test Report No: TTDI/U9/90212A01/TR/07/17/03 **Dated:05.07.2017**

TEST REPORT

Name & Address of the Customer	M/s Wilson Power Solutions Ltd, Westland Works, Westland Square, Beeston,Leeds, LS115SS, U.K.
Name & Address of the Manufacturer	M/s Toshiba Transmission & Distribution Systems (India) Pvt. Ltd, Power Transformer Division, Unit – 09, Rudraram(Vi),Patancheru(Ml), Medak(Dist), A.P. 502329, India.
Particulars of the sample tested	20 MVA,132 / 11 kV, YNd1, 3- Phase Oil Filled, Copper Wound, Power Transformer.
Purchase Order No.	P 15473 dated 02.08.2016
Condition of the Transformer On Receipt	New
Quantity	One No
Date(s) of the Test	03.07.2017 to 04.07.2017
Transformer Serial No.	90212A01
Reference Standard	IEC 60076 (Part – 1: 2011& Part – 3:2013)
No. Of Pages	40 Pages
Test Results	All the Routine Tests Results are found to be met with the customer specified requirement and reference standard.
TESTED BY	**VERIFIED & APPROVED BY**
P.Eswaramoorthy **Assistant Manager,** **Toshiba – TTDI,** **Rudraram.**	**K.Srikanth Reddy** **Asst. Manager,** **Toshiba – TTDI,** **Rudraram.**

Summary of Test Results

Parameters	MVA	Measured Values	Guaranteed Values	Tolerance
No Load Loss at Normal tap 100 % of Rated Voltage	20	11.46 kW	12.0 kW	---
HV-LV,Load Losses at 75Deg. C, at Normal Tap (09)	20	104.32 kW	120.0 kW	---
HV-LV SC % Impedance at 75Deg. C, at Normal Tap (09)	20	12.06 %	12.0%	±7.5%

TESTED BY	VERIFIED & APPROVED BY
P.Eswaramoorthy Assistant Manager, Toshiba – TTDI, Rudraram.	K.Srikanth Reddy Asst. Manager, Toshiba – TTDI, Rudraram.

List of Tests conducted

TESTED BY	VERIFIED & APPROVED BY
P.Eswaramoorthy Assistant Manager, Toshiba – TTDI, Rudraram.	K.Srikanth Reddy Asst. Manager, Toshiba – TTDI, Rudraram.

Note:

1. This test(s) results relates only to the item(s) tested.
2. Publication or reproduction of this report in any form is not permitted without the written consent of Quality Manager, Toshiba Transmission & Distribution Systems (India) Pvt. Ltd, and Rudraram.
3. The results reported in this report are valid at the time of and under the stipulated conditions of measurements.
4. The tests marked with "*"mark are not accredited by NABL.

1. Voltage Ratio Test at All Taps

Tapings on HV Winding: +10 % to –10 % in steps of 1.25 %

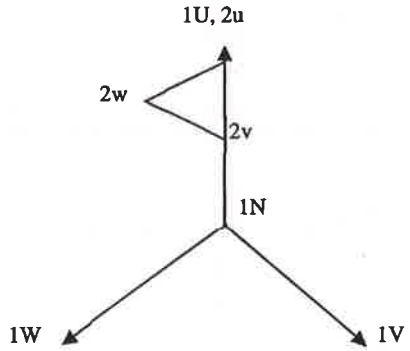
Tap No	Nominal Ratio	Actual Ratio					
		U – phase		V – Phase		W – Phase	
		Measured Ratio	% deviation	Measured Ratio	% deviation	Measured Ratio	% deviation
1 (Max)	7.6210	7.6275	0.09	7.6270	0.08	7.6275	0.09
2	7.5344	7.5405	0.08	7.5400	0.07	7.5405	0.08
3	7.4478	7.4535	0.08	7.4530	0.07	7.4540	0.08
4	7.3612	7.3660	0.06	7.3660	0.06	7.3665	0.07
5	7.2746	7.2795	0.07	7.2790	0.06	7.2800	0.07
6	7.1880	7.1920	0.06	7.1920	0.06	7.1925	0.07
7	7.1014	7.1055	0.06	7.1055	0.06	7.1055	0.05
8	7.0148	7.0185	0.05	7.0185	0.05	7.0190	0.06
9 (Nor)	6.9282	6.9315	0.05	6.9315	0.05	6.9315	0.05
10	6.8416	6.8445	0.05	6.8440	0.04	6.8450	0.05
11	6.7550	6.7575	0.04	6.7570	0.03	6.7575	0.04
12	6.6684	6.6705	0.03	6.6705	0.03	6.6705	0.03
13	6.5818	6.5835	0.03	6.5835	0.02	6.5840	0.03
14	6.4952	6.4965	0.02	6.4960	0.01	6.4970	0.02
15	6.4086	6.4095	0.01	6.4095	0.01	6.4095	0.02
16	6.3220	6.3230	0.01	6.3225	0.01	6.3230	0.01
17(Min)	6.2354	6.2355	0.00	6.2355	0.00	6.2355	0.00

2. Verification of vector group

Terminals Shorted: 1U & 2u

3 – Phase Voltage Supply applied on: HV Side

Sl. No	Terminals	Voltage
1	1U-1V	409
2	1V-1W	411
3	1U-1W	411
4	1W-2u	411
5	1V-2u	408
6	1W-2w	380
7	1V-2w	411
8	1U-2v	34
9	1N-2v	201
10	1U-1N	236



Conditions to be satisfied:

Vector group	Conditions	Result
YNd1	1W-2u = 1V-2u 1W-2w < 1V-2w and 1U-2v + 1N-2v = 1U-1N	All conditions are satisfied , Vector group is verified

3. Magnetic Balance Test (Test Conducted at Tap No: 09)

Voltage Applied on HV side in Volts

Voltage Applied on HV in Volts	Voltage Measured on HV in Volts		
	1U-1N	1V-1N	1W-1N
1U-1N	**236**	223	12
1V-1N	126	**236**	110
1W-1N	15	222	**237**

4. Measurement of Magnetizing Current with Low Voltage Supply

4 A.1) Measured on HV Side (Test Conducted at Tap No: 09)

3 Phase Supply (410V) applied on HV side, LV in Open Condition

Voltage measured on	1U-1V	1V-1W	1W-1U
Voltage measured	408	411	410
Current Measured on	1U	1V	1W
Measured Current (mA)	0.805	0.493	0.909

4 A.2) Measured on LV Side

3 Phase Supply (410 V) applied on LV side, HV in Open Condition

Voltage measured on	2u-2v	2v-2w	2w-2u
Voltage measured	408	411	411
Current Measured on	2u	2v	2w
Measured Current (mA)	70.0	30.17	60.0

5. Measurement of Insulation Resistance & PI

Top oil Temperature: 48.0°C Bottom Oil Temperature: 43.0°C Average oil Temperature: 45.5°C

TIME	HV- LV	HV- EARTH	LV – EARTH
At 15 sec	2.74 G Ohms	2.58 G Ohms	2.36 G Ohms
At 60 sec	5.18 G Ohms	3.36 G Ohms	3.86 G Ohms
At 600 sec	18.5 G Ohms	5.09 G Ohms	7.17 G Ohms
A.I	1.891	1.302	1.636
P.I	3.571	1.515	1.858

$$\text{\# Absorption Index} = \frac{\text{Insulation Resistance at 60 Sec}}{\text{Insulation Resistance at 15 Sec}}$$

$$\text{\# Polarization Index} = \frac{\text{Insulation Resistance at 600 Sec}}{\text{Insulation Resistance at 60 Sec}}$$

6. Measurement of Winding Resistance

$$\text{Avg. Resistance at 75 °C} = \text{Avg. Resistance at } T_{avg} \times \frac{(235 + 75)}{(235 + T_{avg.})}$$

Top oil Temperature: 39.0°C Bottom Oil Temperature: 34.0°C Average oil Temperature: 36.5°C

6.A) LV Winding Resistances

2u – 2v (Ohms)	2v – 2w (Ohms)	2w – 2u (Ohms)	Average Resistance / ph in Ohms	Average Resistance / ph in Ohms at 75 Deg. C
0.019704	0.019698	0.019783	0.029593	0.033789

6. B) HV Winding Resistances:

Tap No	1U-1N (Ohms)	1V-1N (Ohms)	1W-1N (Ohms)	Average Resistance / Phase (Ohms)	Average Resistance / Ph at 75°C (Ohms)
1 (Max)	2.2464	2.24720	2.25060	2.24807	2.56685
2	2.2170	2.21780	2.22060	2.21847	2.53306
3	2.1872	2.18800	2.19100	2.18873	2.49911
4	2.1578	2.15840	2.16120	2.15913	2.46531
5	2.1280	2.12860	2.13160	2.12940	2.43136
6	2.0988	2.09880	2.10180	2.09980	2.39756
7	2.0712	2.06920	2.07220	2.07087	2.36453
8	2.0390	2.03940	2.04260	2.04033	2.32966
9 (Nor)	2.0074	2.00740	2.01020	2.00833	2.29312
10	2.0388	2.03920	2.04240	2.04013	2.32943
11	2.0686	2.06920	2.07240	2.07007	2.36361
12	2.0984	2.09880	2.10220	2.09980	2.39756
13	2.1282	2.12860	2.13180	2.12953	2.43151
14	2.1578	2.15800	2.16160	2.15913	2.46531
15	2.1900	2.18760	2.19100	2.17880	2.48776
16	2.2170	2.21720	2.22060	2.20927	2.52255
17 (Min)	2.2468	2.24720	2.25060	2.23827	2.55566

7. Measurement of Capacitance and Tan Delta of Windings & Bushings

7. A) Measurement of Capacitance and Tan Delta of Windings

Top oil Temperature: 48.0°C Bottom Oil Temperature: 43.0°C Average oil Temperature: 45.5°C

Measured between	Applied Voltage (kV)	Capacitance (nF)	Tan Delta
HV – LV	5	4.0801	0.00221
	10	4.0794	0.00211
HV –Ground	5	2.7733	0.00296
	10	2.7729	0.00301
LV – Ground	5	6.8486	0.00494
	10	6.8476	0.00496

7. B) Measurements of Capacitance and Tan Delta of Bushings

Ambient Temperature: 32.0°C

Bushing Sl.No.	Rated Voltage (kV)	Applied Voltage (kV)	Capacitance (pF)	Tan Delta
37997010559	145	10	298.17	0.00237
37997010560	145	10	307.98	0.00237
37997010524	145	10	299.37	0.00238

8. Measurement of No Load Loss and No Load Current at Rated Frequency-50Hz

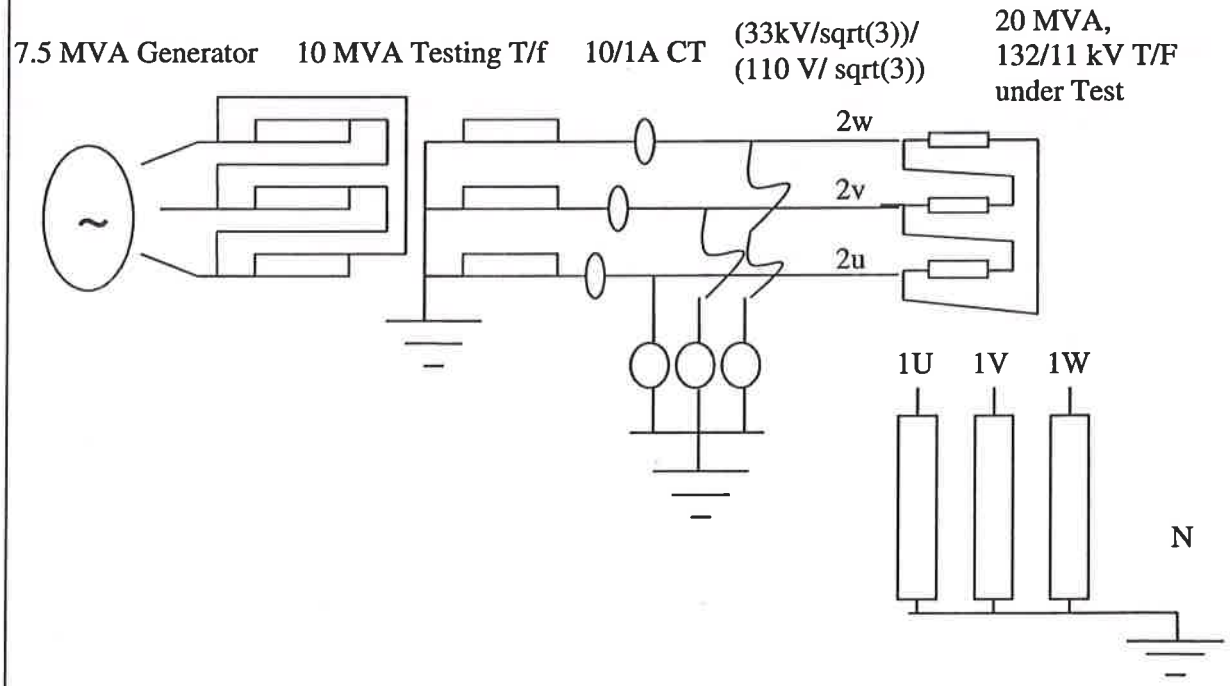
8. A) Test Condition:

Transformer Energized from	:	LV side
Base kV @ 100% No Load Current	:	11 kV
Base MVA for % No Load Current	:	20 MVA
Test Frequency	:	50 Hz
Tap Position	:	09 (Normal tap)
Guaranteed No Load Loss at Nominal Voltage	:	12 kW

Corrected No-Load Loss (P_o) = Measured No-Load Loss (P_m) * (1+D)

$D= (U^1-U)/U^1$

8. B)Test Circuit Diagram:



8. C) Test Results (Before HV Tests)

% Rated Voltage	Applied Voltage (mean) U^1 (kV)	Applied Voltage (rms) U (kV)	No Load Current (Amps)	No Load Current in terms of % Full Load Current(%)	Measured No Load Loss (Pm) (kW)	Corrected No Load loss (Pc) (kW)
90%	9.927	9.957	0.5335	0.0508	8.45	8.42
100%	11.011	11.015	1.0568	0.1007	11.46	11.46
110%	12.101	12.079	6.0410	0.5755	19.15	19.18

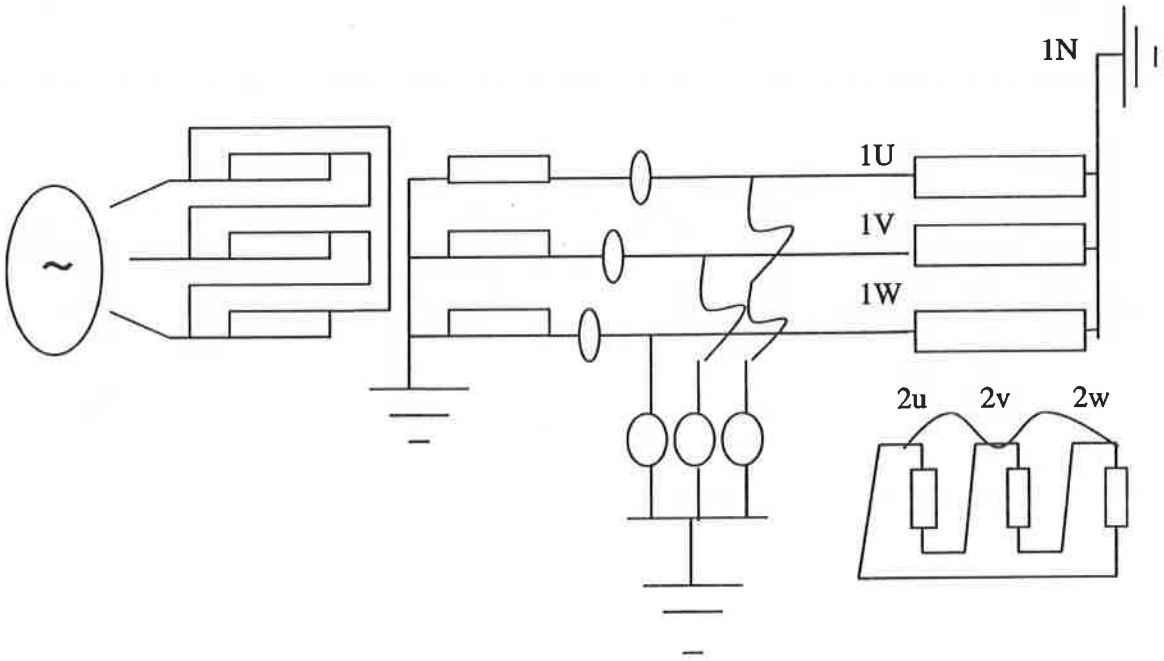
8. D) Test Results (After HV Tests)

% Rated Voltage	Applied Voltage (mean) U^1 (kV)	Applied Voltage (rms) U (kV)	No Load Current (Amps)	No Load Current in terms of % Full Load Current(%)	Measured No Load Loss (Pm) (kW)	Corrected No Load loss (Pc) (kW)
90%	9.961	9.975	0.5365	0.0511	8.55	8.54
100%	11.018	11.031	1.0602	0.1010	11.62	11.61
110%	12.104	12.129	6.0562	0.5769	19.32	19.28

9. Measurement of Impedance Voltage and Load Loss

9. A) Test Circuit Diagram:

Generator Testing T/f 250/1A CT (33kV/√3)/(110V/√3) PT 20 MVA T/f under test



9. B) Test Results

Test Voltage Supply from	:	HV side
Reference Base	:	20 MVA
Guaranteed Load Loss at Normal Tap (05)	:	108 kW
Guaranteed Impedance at Normal Tap (05)	:	12.0 % ± 7.5 % Tolerance
Top oil Temperature	:	39.0 °C
Bottom oil Temperature	:	34.0 °C
Average oil Temperature	:	36.5 °C

Tap Position	Highest Tap (Tap 01)	Principal Tap (Tap 05)	Lowest Tap (Tap 17)
Impedance Voltage Measured	17.031 kV	15.843 kV	14.027 kV
Current passed	74.43 Amps	87.20 Amps	97.15 Amps
Measured Load Loss	82.1 kW	94.6 kW	112.7 kW
Frequency	49.938 Hz	49.945 Hz	50.028 Hz
Rated Current	79.52 Amps	87.48 Amps	97.20 Amps
Impedance Voltage at rated current & frequency	18.218 kV	15.911 kV	14.026 kV
Load Loss at rated current & frequency	93.713 kW	95.208 kW	112.816 kW
Load loss at 75 Deg. C	**102.09 kW**	**104.32 kW**	**124.43 kW**
Guaranteed Load Loss (kW)	**---**	**108 kW**	**---**
% Impedance at 75 Deg. C	**12.55 %**	**12.06 %**	**11.81 %**
Guaranteed % Impedance at 75 Deg. C	**---**	**12 % ± 7.5 %**	**---**

CALCULATION OF LOAD LOSS AND IMPEDANCE AT 75 Deg C FOR 90212A01		
Tap changer side and tap switch position	HV & Max (01) tap	**FORMULAE USED**
HV	star	
LV	delta	
HV U phase resistance in Ohms	2.24640	
HV V phase resistance in Ohms	2.24720	
HV W phase resistance in Ohms	2.25060	
Average HV resistance / phase	2.24807	(Resistance of U phase+V phase+W phase)/3
LV u phase resistance in Ohms	0.019704	
LV v phase resistance in Ohms	0.019698	
LV w phase resistance in Ohms	0.019783	
Average LV resistance / phase	0.029593	(Resistance of u phase+ v phase+ w phase)/2
Temperature at time of measuring resistance in centigrade (T1)	36.5	
Rated HV phase current at tap on which test is conducted in Amps (I HV)	79.52	
Rated LV phase current (I LV)	606.06	
HV I2R losses at resistance measuring temperature in watts	42646.48	3*(HV phase curent)2*Average HV resistance
LV I2R losses at resistance measuring temperature in watts	32608.75	3*(LV phase curent)2*Average LV resistance
Total I2R losses at measured temperature in watts	75255.23	Total I2R losses = HV I2R losses + LV I2R losses
Temperature at time of conducting load loss test in centigrade (T2)	36.50	
Total I2R losses at load loss test temperature in watts(W at load loss temp)	75255.23	Total I2R losses*(235+T2)/(235+T1)
Total I2R losses at 75 Deg C in watts (W at 75 Deg C)	85926.78	W at load loss temp*(235+75)/(235+T2)
Current measured while conducting load loss test in Amps (I measured)	74.43	
Frequency measured while conducting load loss test in Hz (F measured)	49.938	
Loss measured while conducting load loss test in kilo Watts(W measured)	82.10	
Voltage measured while conducting load loss test in volts (V measured)	17031.256	
Corrected load loss in kilowatts	93.71300	(I HV / I measured)2*W measured
Total load loss in Watts (TLL)	93713.0	
Stray losses at load loss test temperature in watts(S at load loss temp)	18457.77	TLL - W at load loss temp
Stray losses at 75 Deg C in watts(S at 75 Deg C)	16165.44	S at load loss temp*(235+T2)/(235+75)
Load loss at 75 Deg C in watts(TLL at 75 Deg C)	102092.22	W at 75 Deg C + S at 75 Deg C
Load loss at 75 Deg C in kilo watts	**102.09**	
Impedance calculation		
Rated Voltage at above mentioned tap in volts(V Rated)	145200	
Rated VA	20000000	
% Resistance at at load loss temperature(%R at load loss temp)	0.47	(TLL / Rated VA)*100
Corrected voltage (V corrected)	18218.55	V measured*(I HV / I measured)*(50 / F measured)
% Impedance at load loss temperature(%Z load loss temp)	12.55	(V corrected / V Rated)*100
% Reactance (%X)	12.54	Sqrt{(%Z load loss temp)2 - (%R load loss temp)2}
% Resistance at 75 Deg C temperature(%R at 75 Deg C)	0.51	(TLL at 75 Deg C / Rated VA)*100
%Impedance at 75 Deg C temperature	**12.55**	Sqrt{(%X)2 + (%R at 75 Deg C)2}

CALCULATION OF LOAD LOSS AND IMPEDANCE AT 75 Deg C FOR 90212A01		
Tap changer side and tap switch position	HV & Normal (09) tap	**FORMULAE USED**
HV	star	
LV	delta	
HV U phase resistance in Ohms	2.00740	
HV V phase resistance in Ohms	2.00740	
HV W phase resistance in Ohms	2.01020	
Average HV resistance / phase	2.00833	(Resistance of U phase+V phase+W phase)/3
LV u phase resistance in Ohms	0.0197040	
LV v phase resistance in Ohms	0.0196980	
LV w phase resistance in Ohms	0.0197830	
Average LV resistance / phase	0.029593	(Resistance of u phase+ v phase+ w phase)/2
Temperature at time of measuring resistance in centigrade (T1)	36.5	
Rated HV phase current at tap on which test is conducted in Amps (I HV)	87.48	
Rated LV phase current (I LV)	606.06	
HV I2R losses at resistance measuring temperature in watts	46107.82	3*(HV phase curent)2*Average HV resistance
LV I2R losses at resistance measuring temperature in watts	32608.75	3*(LV phase curent)2*Average LV resistance
Total I2R losses at measured temperature in watts	78716.57	Total I2R losses = HV I2R losses + LV I2R losses
Temperature at time of conducting load loss test in centigrade (T2)	36.50	
Total I2R losses at load loss test temperature in watts(W at load loss temp)	78716.57	Total I2R losses*(235+T2)/(235+T1)
Total I2R losses at 75 Deg C in watts (W at 75 Deg C)	89878.96	W at load loss temp*(235+75)/(235+T2)
Current measured while conducting load loss test in Amps (I measured)	87.20	
Frequency measured while conducting load loss test in Hz (F measured)	49.945	
Loss measured while conducting load loss test in kilo Watts(W measured)	94.6	
Voltage measured while conducting load loss test in volts (V measured)	15843.06874	
Corrected load loss in kilowatts	95.20850	(I HV / I measured)2*W measured
Total load loss in Watts (TLL)	95208.5	
Stray losses at load loss test temperature in watts(S at load loss temp)	16491.93	TLL - W at load loss temp
Stray losses at 75 Deg C in watts(S at 75 Deg C)	14443.74	S at load loss temp*(235+T2)/(235+75)
Load loss at 75 Deg C in watts(TLL at 75 Deg C)	104322.69	W at 75 Deg C + S at 75 Deg C
Load loss at 75 Deg C in kilo watts	**104.32**	
Impedance calculation		
Rated Voltage at above mentioned tap in volts(V Rated)	132000	
Rated VA	20000000	
% Resistance at at load loss temperature(%R at load loss temp)	0.48	(TLL / Rated VA)*100
Corrected voltage (V corrected)	15911.44	V measured*(I HV / I measured)*(50 / F measured)
% Impedance at load loss temperature(%Z load loss temp)	12.05	(V corrected / V Rated)*100
% Reactance (%X)	12.04	Sqrt{(%Z load loss temp)2 - (%R load loss temp)2}
% Resistance at 75 Deg C temperature(%R at 75 Deg C)	0.52	(TLL at 75 Deg C / Rated VA)*100
%Impedance at 75 Deg C temperature	**12.06**	Sqrt{(%X)2 + (%R at 75 Deg C)2}

CALCULATION OF LOAD LOSS AND IMPEDANCE AT 75 Deg C FOR 90212A01		
Tap changer side and tap switch position	HV & Min (17) tap	**FORMULAE USED**
HV	star	
LV	delta	
HV U phase resistance in Ohms	2.24680	
HV V phase resistance in Ohms	2.24720	
HV W phase resistance in Ohms	2.25060	
Average HV resistance / phase	2.24820	(Resistance of U phase+V phase+W phase)/3
LV u phase resistance in Ohms	0.0197040	
LV v phase resistance in Ohms	0.0196980	
LV w phase resistance in Ohms	0.0197830	
Average LV resistance / phase	0.0295925	(Resistance of u phase+ v phase+ w phase)/2
Temperature at time of measuring resistance in centigrade (T1)	36.5	
Rated HV phase current at tap on which test is conducted in Amps (I HV)	97.2	
Rated LV phase current (I LV)	606.06	
HV I2R losses at resistance measuring temperature in watts	63721.90	3*(HV phase curent)2*Average HV resistance
LV I2R losses at resistance measuring temperature in watts	32608.75	3*(LV phase curent)2*Average LV resistance
Total I2R losses at measured temperature in watts	96330.65	Total I2R losses = HV I2R losses + LV I2R losses
Temperature at time of conducting load loss test in centigrade (T2)	36.50	
Total I2R losses at load loss test temperature in watts(W at load loss temp)	96330.65	Total I2R losses*(235+T2)/(235+T1)
Total I2R losses at 75 Deg C in watts (W at 75 Deg C)	109990.80	W at load loss temp*(235+75)/(235+T2)
Current measured while conducting load loss test in Amps (I measured)	97.15	
Frequency measured while conducting load loss test in Hz (F measured)	50.028	
Loss measured while conducting load loss test in kilo Watts(W measured)	112.7	
Voltage measured while conducting load loss test in volts (V measured)	14027.01347	
Corrected load loss in kilowatts	112.81604	(I HV / I measured)2*W measured
Total load loss in Watts (TLL)	112816.0	
Stray losses at load loss test temperature in watts(S at load loss temp)	16485.38	TLL - W at load loss temp
Stray losses at 75 Deg C in watts(S at 75 Deg C)	14438.01	S at load loss temp*(235+T2)/(235+75)
Load loss at 75 Deg C in watts(TLL at 75 Deg C)	124428.81	W at 75 Deg C + S at 75 Deg C
Load loss at 75 Deg C in kilo watts	**124.43**	
Impedance calculation		
Rated Voltage at above mentioned tap in volts(V Rated)	118800	
Rated VA	50000000	
% Resistance at at load loss temperature(%R at load loss temp)	0.23	(TLL / Rated VA)*100
Corrected voltage (V corrected)	14026.38	V measured*(I HV / I measured)*(50 / F measured)
% Impedance at load loss temperature(%Z load loss temp)	11.81	(V corrected / V Rated)*100
% Reactance (%X)	11.80	Sqrt{(%Z load loss temp)2 - (%R load loss temp)2}
% Resistance at 75 Deg C temperature(%R at 75 Deg C)	0.25	(TLL at 75 Deg C / Rated VA)*100
%Impedance at 75 Deg C temperature	**11.81**	Sqrt{(%X)2 + (%R at 75 Deg C)2}

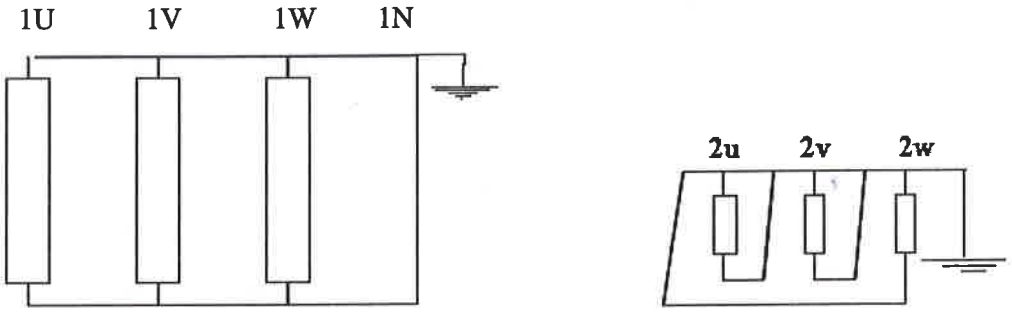
CALCULATION OF LOAD LOSS AND IMPEDANCE AT 75 Deg C FOR 90212A01	
TAP POSITION	09 (NORMAL)
% EFFICIENCY	
% EFFICIENCY=((X S COSØ) / (X S COSØ+ X2Pc+Pi))*100	
X = %LOAD	
S = KVA RATING	20000
Pc = LOAD LOSS IN KW	104.32
Pi = NO LOAD LOSS IN KW	11.61
R = % RESISTANCE AT 75Deg C	0.52
XR= % REACTANCE	12.04
COSØ = POWER FACTOR	
% EFFICIENCY AT UNITY POWER FACTOR	
FOR 125% OF FULL LOAD	99.31
FOR 100% OF FULL LOAD	99.42
FOR 75 % OF FULL LOAD	99.53
FOR 50 % OF FULL LOAD	99.62
FOR 25 % OF FULL LOAD	99.64
% EFFICIENCY AT 0.8 POWER FACTOR	
FOR 125% OF FULL LOAD	99.13
FOR 100% OF FULL LOAD	99.28
FOR 75% OF FULL LOAD	99.42
FOR 50% OF FULL LOAD	99.53
FOR 25% OF FULL LOAD	99.55
% REGULATION	
% REGULATION =(RCOSø+XRSINø)+{(XRCOSø-%RSINø)2/200}	
% REGULATION AT FULL LOAD AND UNITY POWER FACTOR	1.2470
% REGULATION AT FULL LOAD AND 0.8 POWER FACTOR	8.0787
% REGULATION AT FULL LOAD AND 0.9 POWER FACTOR	6.1623

P.&T

10. Applied Voltage Test

Test Circuit Diagram:

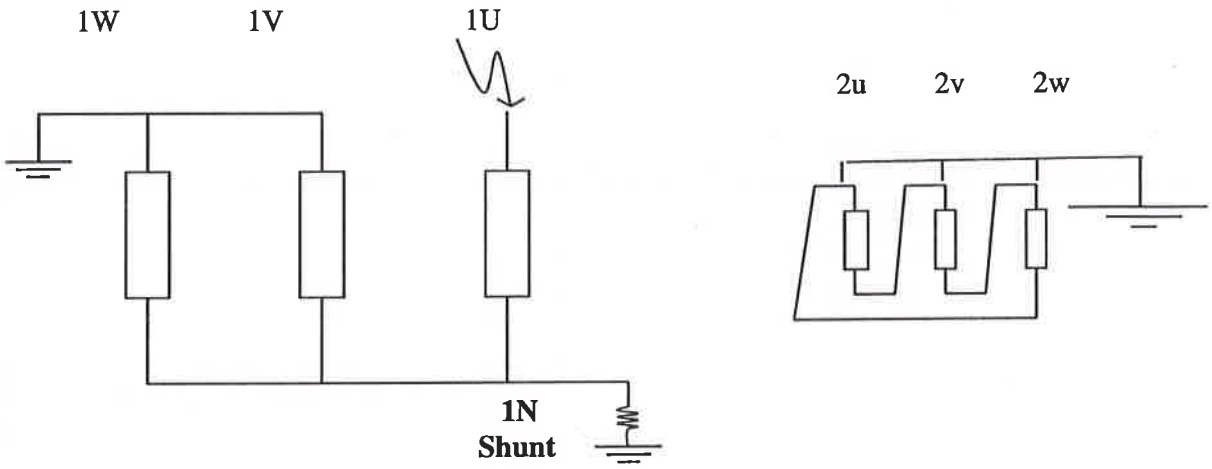
Test Circuit for "HV", LV tested similarly



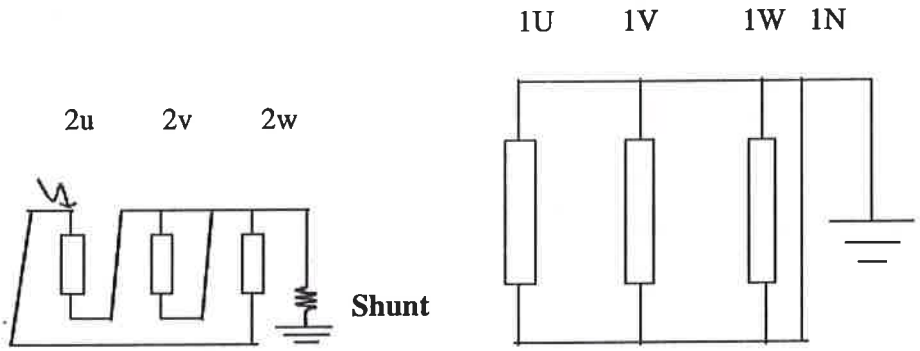
Voltage applied between	Applied Voltage	Time	Result
HV to LV & Earth	38 kV	60 Seconds.	Withstood
LV to HV & Earth	75 kV	60 Seconds	Withstood

11. Lightning Impulse Voltage Withstand Test

11. A) Test Circuit Diagram for HV – U Phase Lightning Impulse



11. B) Test Circuit Diagram for LV – U Phase Lightning Impulse



 # Similarly other phases tested.

Test circuit diagram shown above is for testing "1U"phase, other phases tested similarly.

Tolerances: T_1 = 0.84 µS to 1.56 µS ; T_2 =40µS to 60 µS

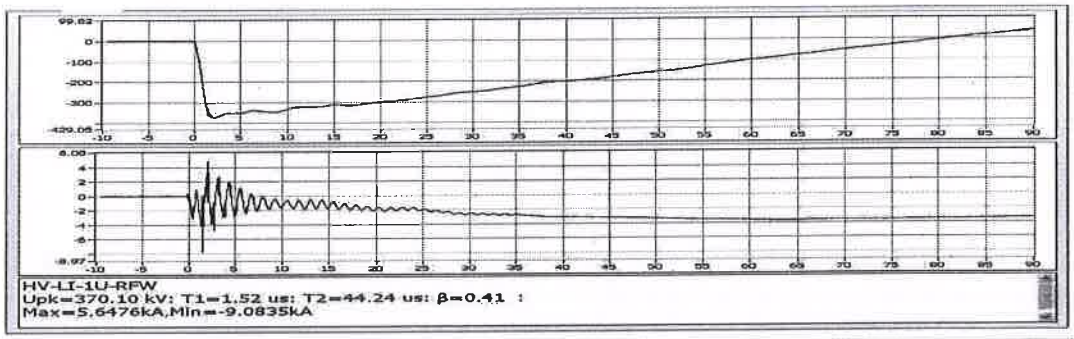
Tested By	Witnessed By

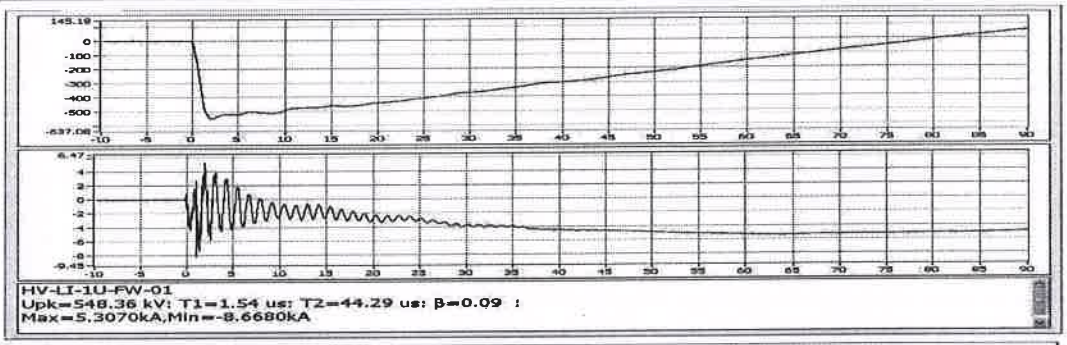
11.C) Test results for HV winding Lightning Impulse:

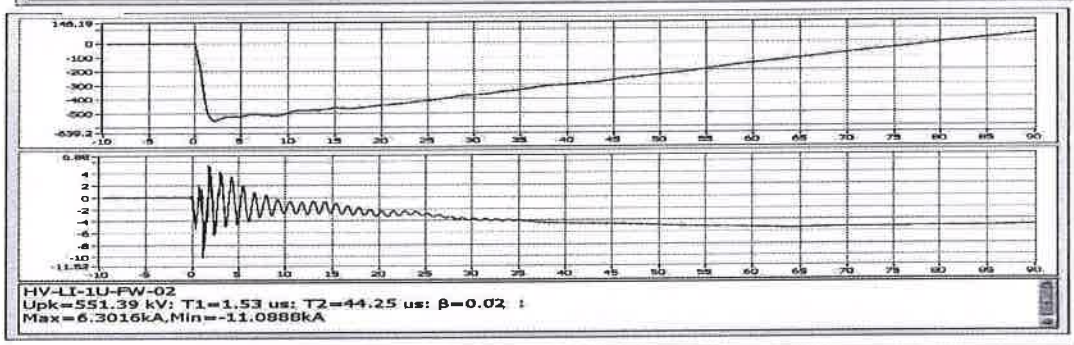
HV Connected To Phase	Earth Connected to	Negative Polarity			
		Wave Type	Test Voltage (kV_p)	Wave Shape	
				Front time T_1 (µs)	Tail Time T_2 (µs)
1U Phase (Tap -01)	HV Neutral Through Shunt & Phases 1V and 1W and all LV terminals and tank	50-70% RFW	370.10	1.52	44.24
		100 % FW	548.36	1.54	44.29
		100% FW	551.39	1.53	44.25
		100% FW	550.98	1.54	44.28
1V Phase (Tap -09)	HV Neutral Through Shunt & Phases 1U and 1W and all LV terminals and tank	50-70% RFW	368.80	1.55	44.27
		100 % FW	553.21	1.54	44.25
		100% FW	554.07	1.54	44.22
		100% FW	553.98	1.55	44.29
1W Phase (Tap -17)	HV Neutral Through Shunt & Phases 1U and 1V and all LV terminals and tank	50-70% RFW	368.03	1.54	44.39
		100 % FW	554.23	1.55	44.44
		100% FW	554.13	1.55	44.35
		100% FW	553.54	1.56	44.38

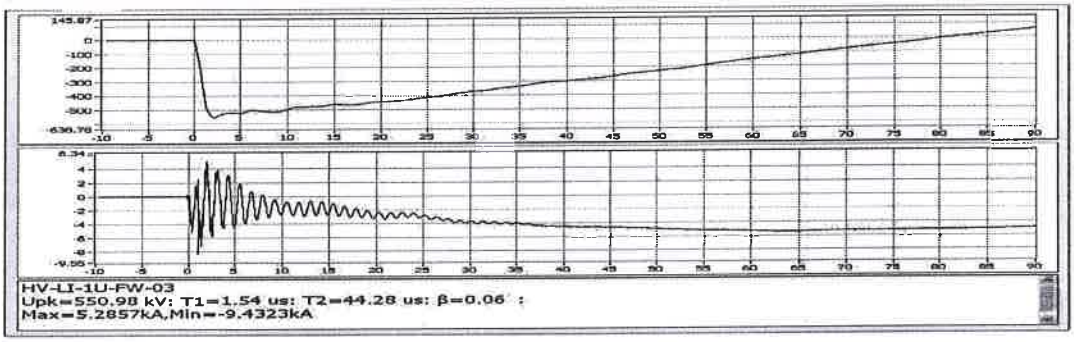
11 .D) Test results for LV winding Lightning Impulse:

LV Connected To Phase	Earth Connected to	Negative Polarity			
		Wave Type	Test Voltage (kV_p)	Wave Shape	
				Front time T_1 (µs)	Tail Time T_2 (µs)
2u Phase	2v and 2w Phases Through Shunt, all HV terminals and Tank	50-70% RFW	111.0	1.299	46.20
		100 % FW	169.0	1.296	46.97
		100% FW	169.0	1.291	46.37
		100% FW	170.0	1.292	46.98
2v Phase	2u and 2w Phases Through Shunt, all HV terminals and Tank	50-70% RFW	120.0	1.286	46.80
		100 % FW	170.0	1.303	46.18
		100% FW	170.0	1.298	46.75
		100% FW	170.0	1.292	46.76
2w Phase	2u and 2v Phases Through Shunt, all HV terminals and Tank	50-70% RFW	119.0	1.317	46.22
		100 % FW	171.0	1.300	46.85
		100% FW	171.0	1.288	46.78
		100% FW	171.0	1.287	46.84

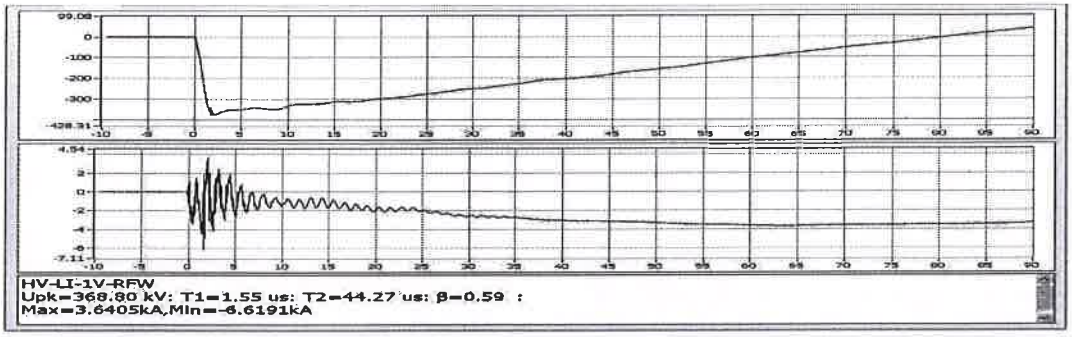


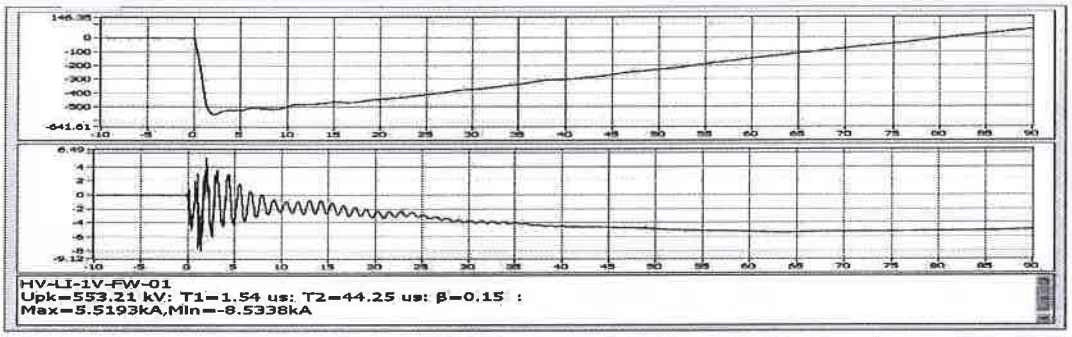


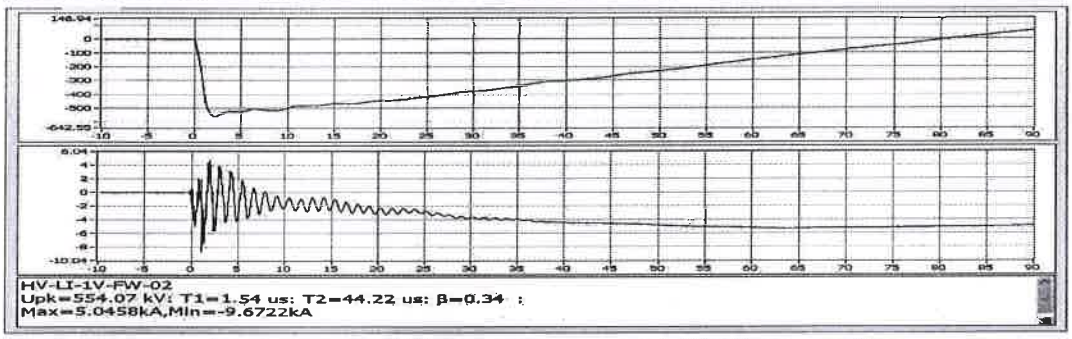


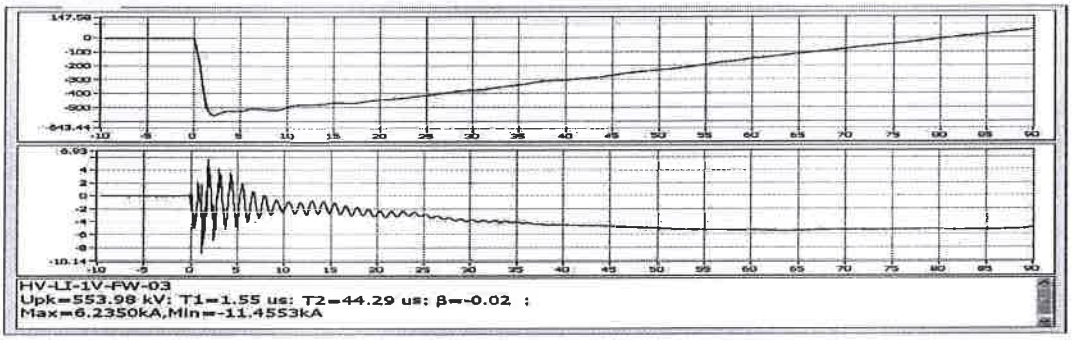


Tested By P.S.T	Witnessed By

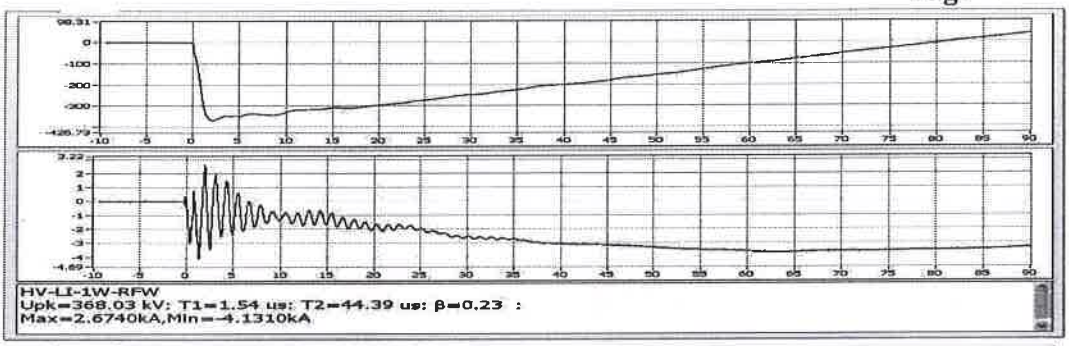


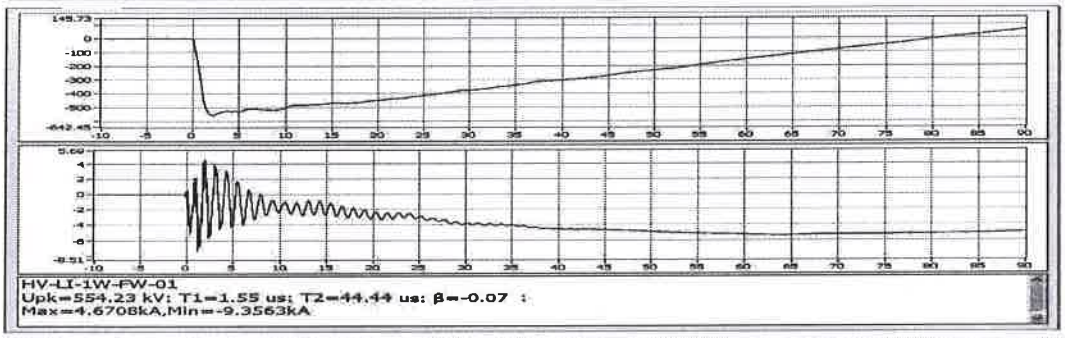


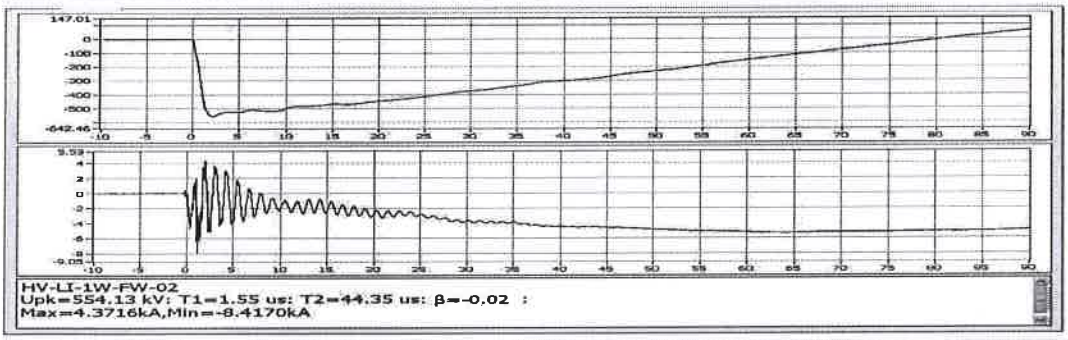


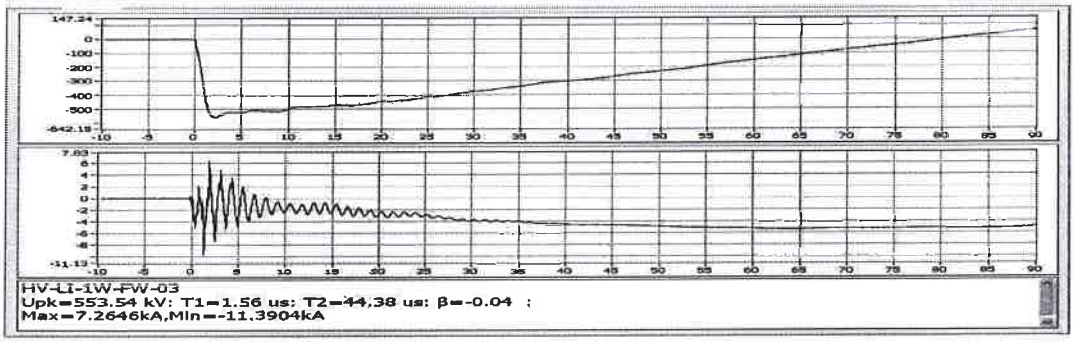


Tested By	Witnessed By

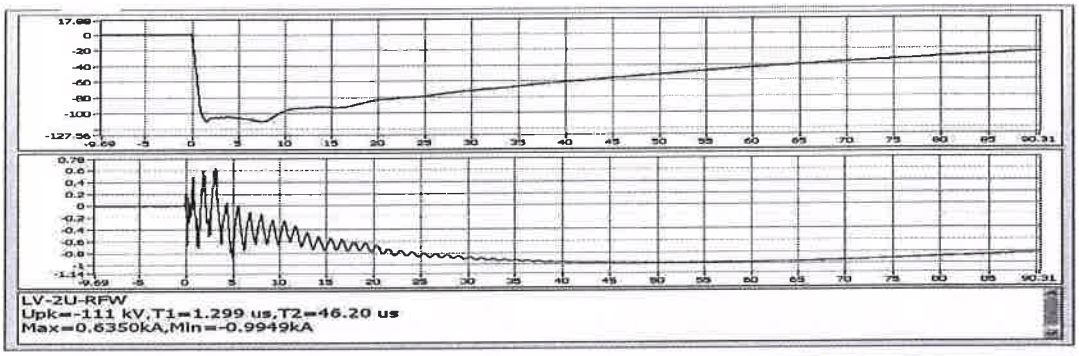


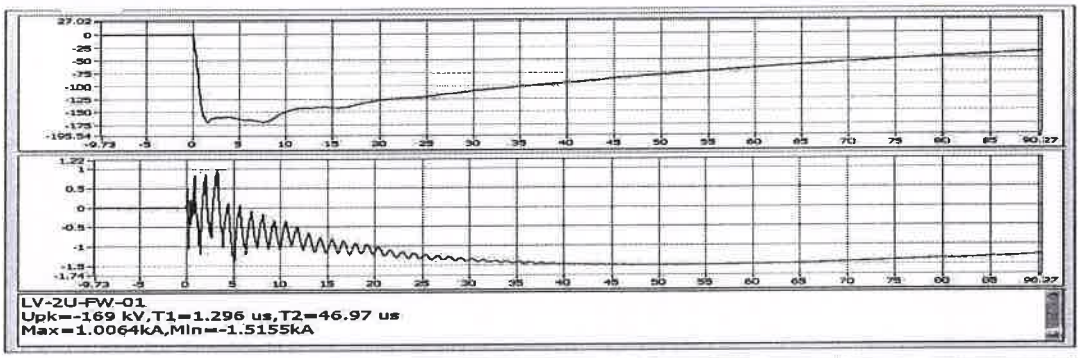


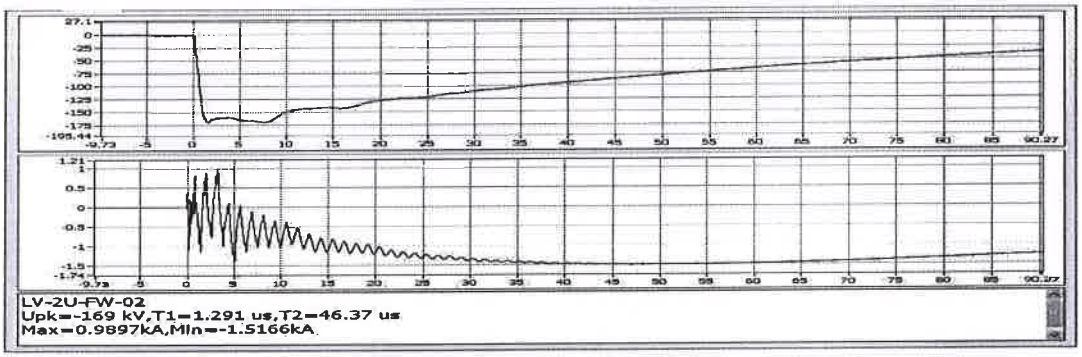


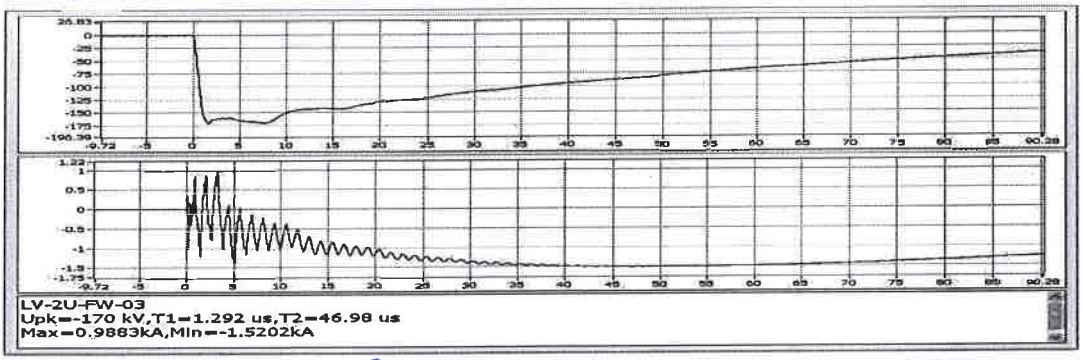


Tested By	Witnessed By

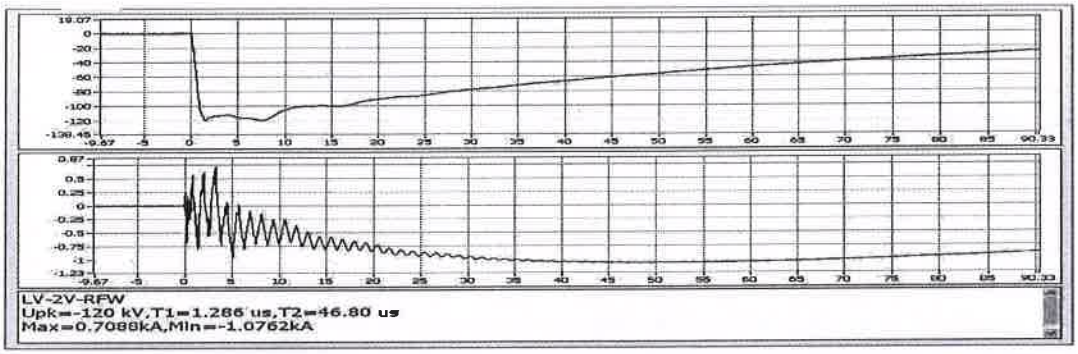


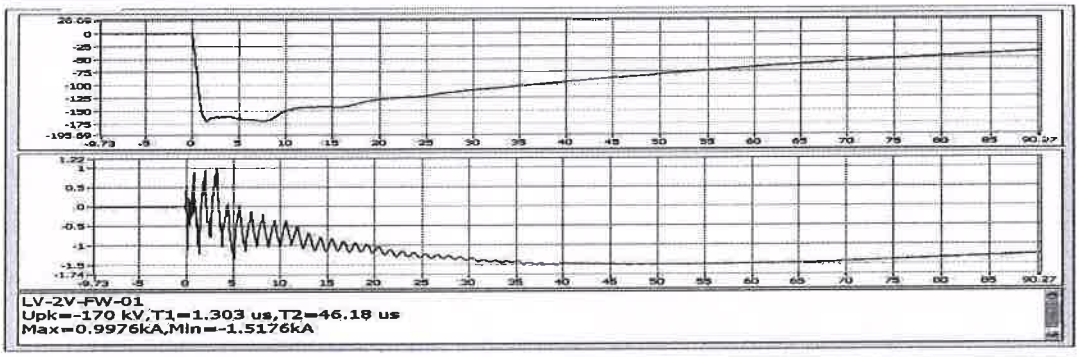


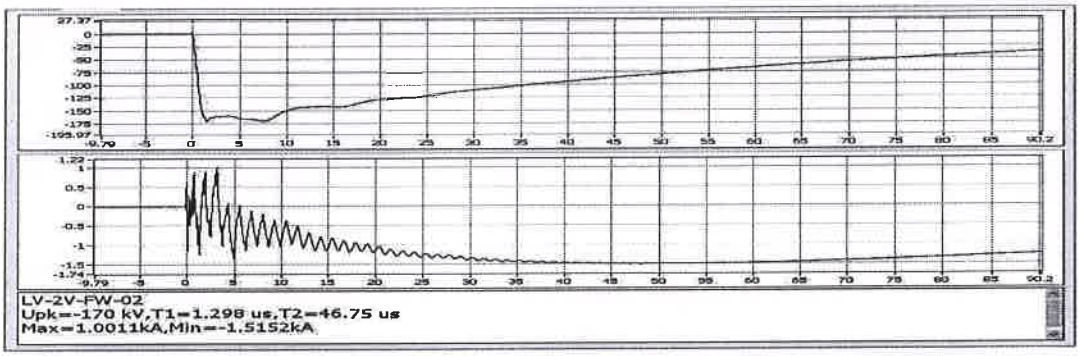


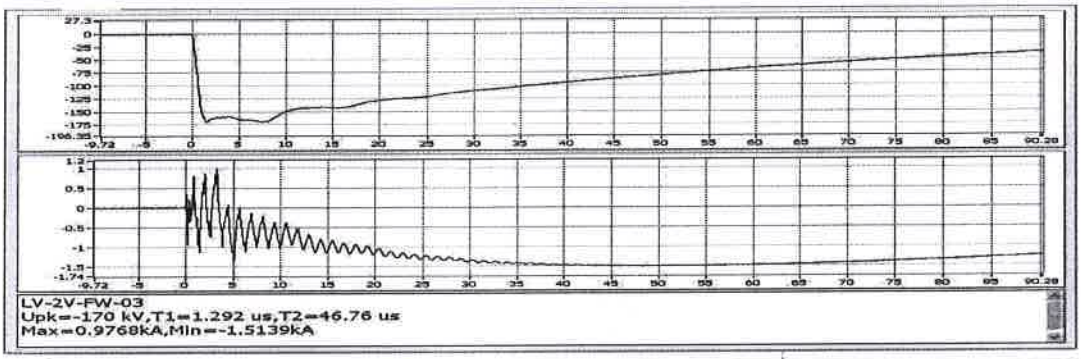


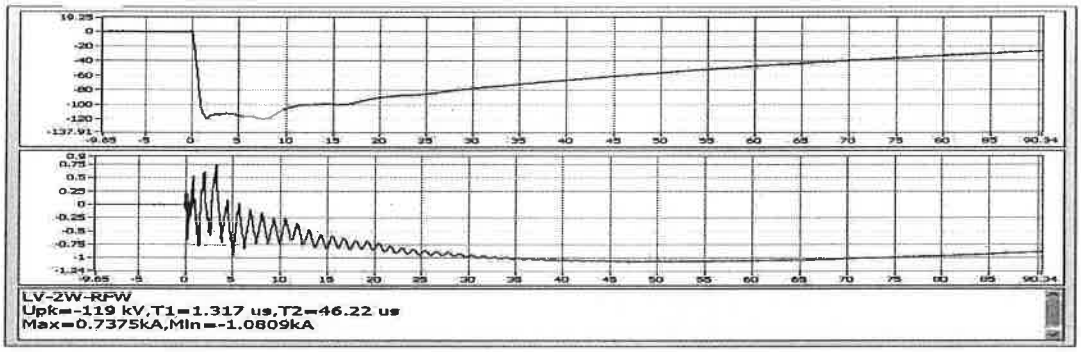
Tested By P.Sai **Witnessed By**

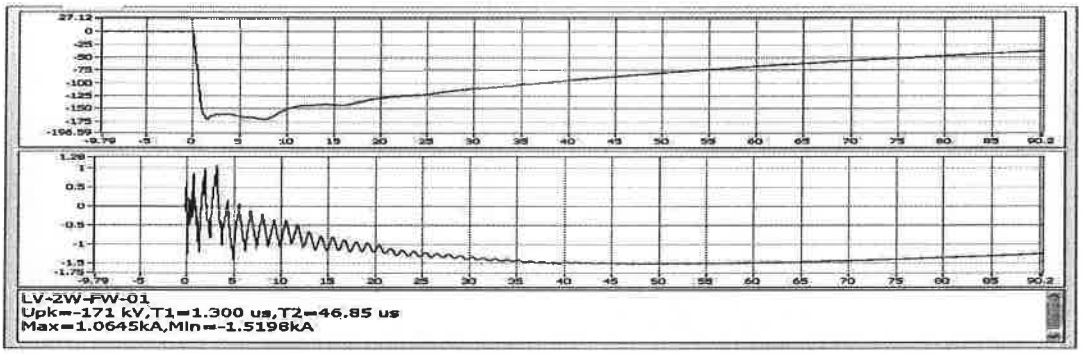

LV-2V-RFW
Upk=-120 kV,T1=1.286 us,T2=46.80 us
Max=0.7088kA,Min=-1.0762kA

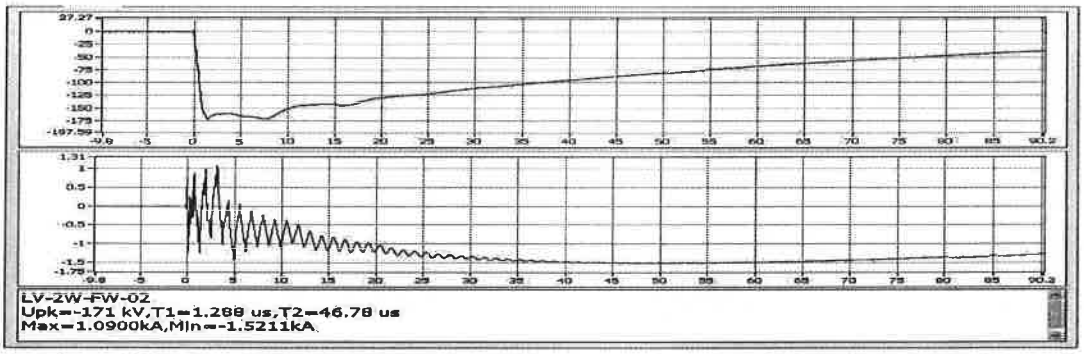

LV-2V-FW-01
Upk=-170 kV,T1=1.303 us,T2=46.18 us
Max=0.9976kA,Min=-1.5176kA

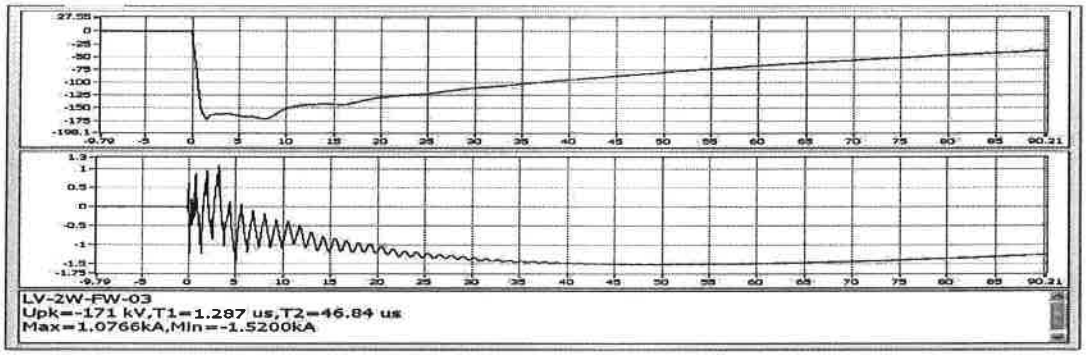

LV-2V-FW-02
Upk=-170 kV,T1=1.298 us,T2=46.75 us
Max=1.0011kA,Min=-1.5152kA


LV-2V-FW-03
Upk=-170 kV,T1=1.292 us,T2=46.76 us
Max=0.9768kA,Min=-1.5139kA


LV-2W-RPW
Upk=-119 kV,T1=1.317 us,T2=46.22 us
Max=0.7375kA,Min=-1.0809kA

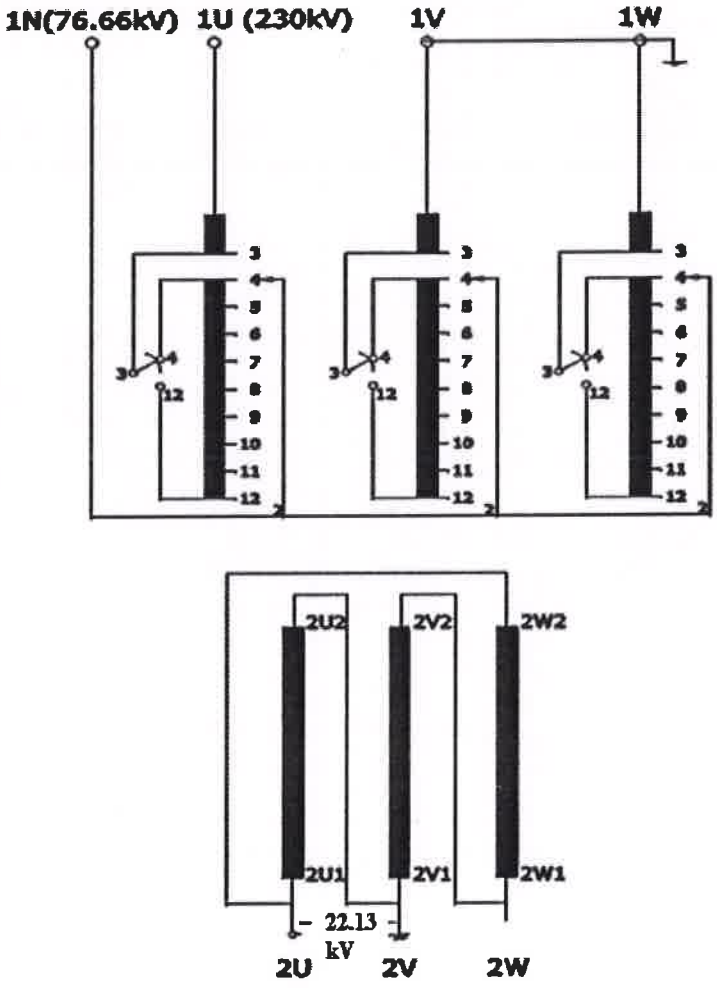

LV-2W-FW-01
Upk=-171 kV,T1=1.300 us,T2=46.85 us
Max=1.0645kA,Min=-1.5198kA


LV-2W-FW-02
Upk=-171 kV,T1=1.288 us,T2=46.78 us
Max=1.0900kA,Min=-1.5211kA


LV-2W-FW-03
Upk=-171 kV,T1=1.287 us,T2=46.84 us
Max=1.0766kA,Min=-1.5200kA

12. Line Terminal AC Withstand Voltage Test (LTAC)

12 A) Test Circuit Diagram



Note:
1. Test conducted at tap position 9.
2. Applied 2.012 times voltage to LV for 35 seconds at 175 Hz and Induced on HV Side
3. Test circuit shown above is for testing 'U' phase. Other Phases tested similarly

Tested By	Witnessed By

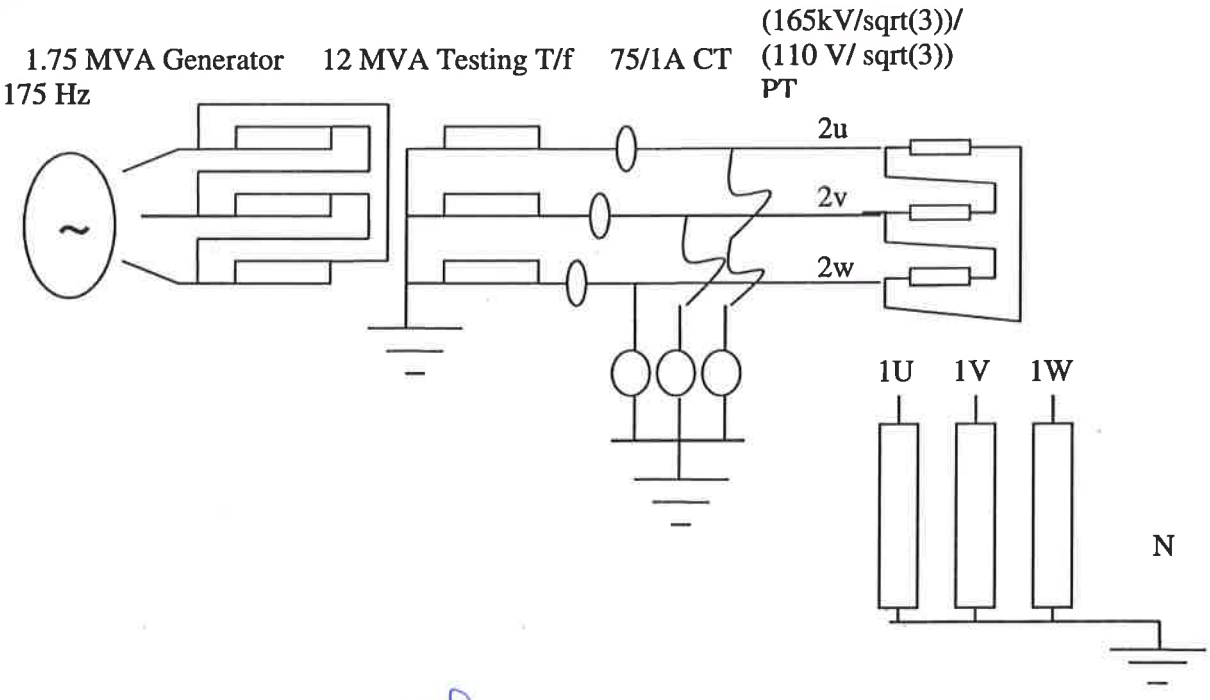
12.B) Test Results

Phase	U Phase	V Phase	W Phase
Applied Voltage	22.13 kV	22.13 kV	22.13 kV
Induced Voltage	230 kV	230 kV	230 kV
Test Frequency	175 Hz	175 Hz	175 Hz
Test Duration*	35 Sec	35 Sec	35 Sec
Result	Withstood	Withstood	Withstood

Note:
Test Duration = 120 *(Rated Frequency/Test Frequency)

13. Induced voltage with partial discharge measurement (IVW & IVPD):

13. A Test Circuit Diagram:

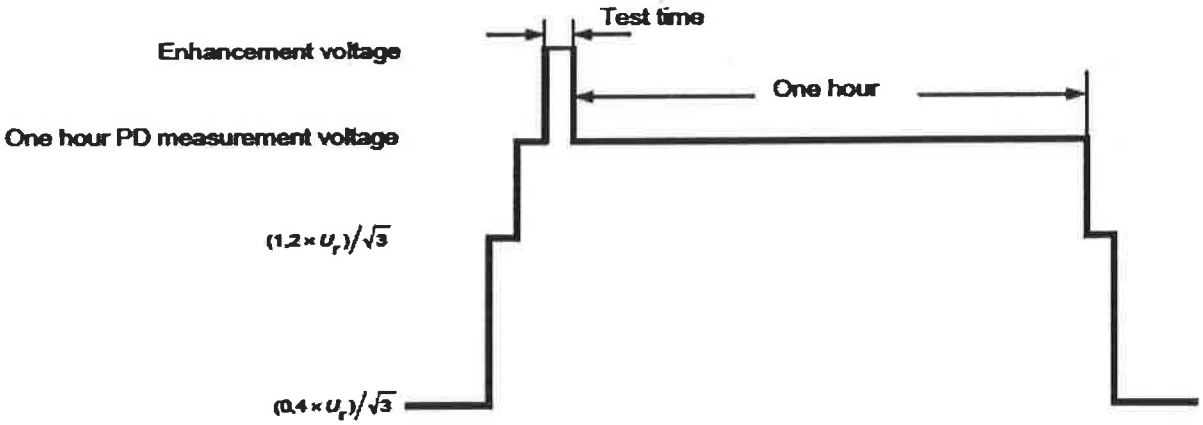


13. B Test Condition and Sequence:

Voltage Applied on: LV
Highest System Voltage U_m: 145kV

Voltage Induced On: HV
Highest Rated Voltage U_r: 132 kV

IVW and IVPD tests are combined.



Sequence No.	Required Test Voltage	Induced Voltage (kV)	Applied Voltage (kV)	Duration
A.	0.4 U_r / √3(Phase to earth)	30.48	4.399	For Background PD measurement
B.	1.2 * U_r / √3 (Phase to earth)	91.45	13.200	1 Minute
C.	1.58 * U_r / √3 (Phase to earth)	120.41	17.380	5 Minutes
D.	2* U_r/ √3 (Phase to earth)	152.42	22.000	35 Seconds
E.	1.58 * U_r / √3 (Phase to earth)	120.41	17.380	60 Min
F.	1.2 * U_r / √3 (Phase to earth)	91.45	13.200	1 Minute
G.	0.4 U_r / √3	30.48	4.399	For Background PD measurement

Tested By P. Sri

Witnessed By

13.C Test Results:

Time (Min)	HV Side PD (pC)		
	U – Phase	V – Phase	W - Phase
PD at "A" Level (Back Ground PD)	40.1	33.8	35.3
PD at "B" Level	70.9	40.0	39.3
PD at "C" Level	88.1	50.5	48.1
PD at "E" Level			
0	88.1	54.2	54.6
5	89.0	52.1	53.7
10	91.0	52.3	56.5
15	90.9	56.0	59.7
20	89.0	55.0	58.5
25	88.0	56.0	57.5
30	89.0	57.0	56.0
35	88.0	57.8	58.9
40	88.1	53.5	56.5
45	88.5	55.2	57.7
50	88.2	55.6	58.0
55	88.0	58.8	56.9
60	88.0	55.1	57.8
PD At "F" Level	73.0	40.4	38.4
PD At "G" Level (Back Ground PD)	39.0	35.1	36.1

Conclusion: 1. PD is less than 250 pC
2. There is no collapse of voltage

Tested By P. Sai **Witnessed By**

14. Test For Onload Tap Changer

S. No.	Operations	Remark
1.	Eight complete operating cycles with the transformer not energized. (A cycle of operation goes from one end of the tapping range to the other, and back again)	Checked and found satisfactory
2.	One complete operating cycle with the transformer not energized, with 85% of the rated auxiliary supply voltage	Checked and found satisfactory
3.	One complete operating cycle with the transformer energized at rated voltage and frequency at no load	Checked and found satisfactory
4.	Ten Cycles of tap change operations with ±2 steps on either side of the principal tapping with the rated current of the transformer with LV winding short-circuited	Checked and found satisfactory

15. Magnetic Circuit Isolation Test

Applied Voltage: 2.5 kV (D.C. Voltage)

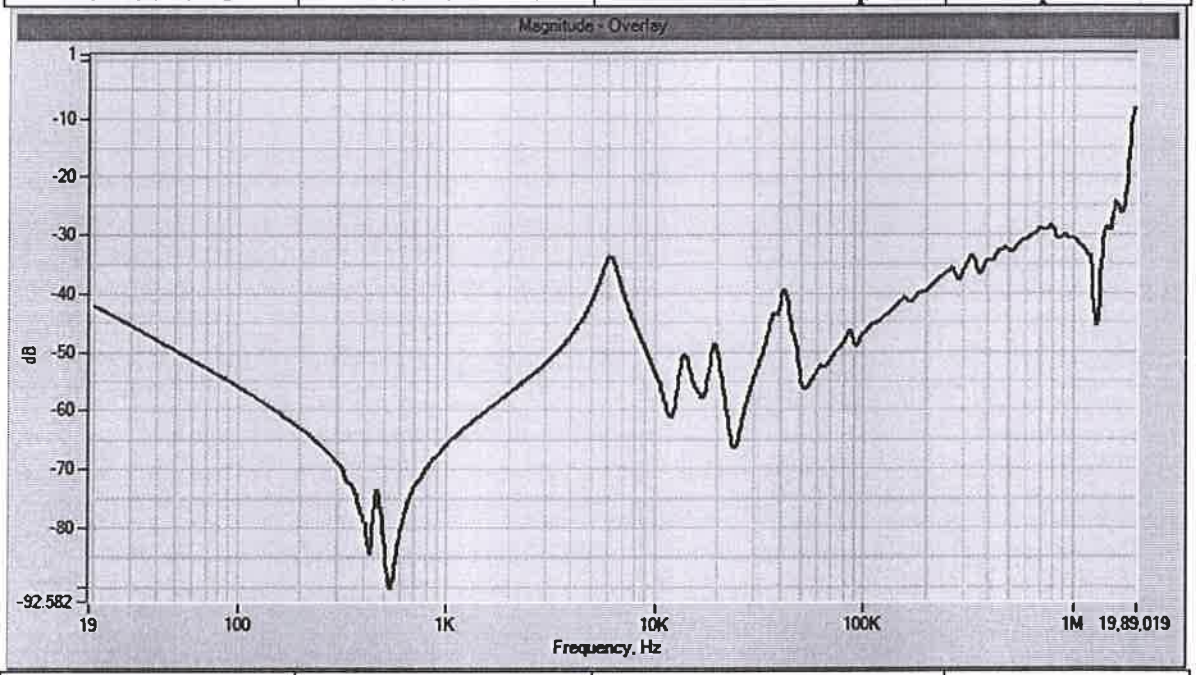
Time	Core – Core Clamp	Core – Earth	Core Clamp – Earth
60 Sec	3.12 G Ohms	3.32 G Ohms	3.97 G Ohms

Applied Voltage: 2.0 kV (A.C. Voltage)

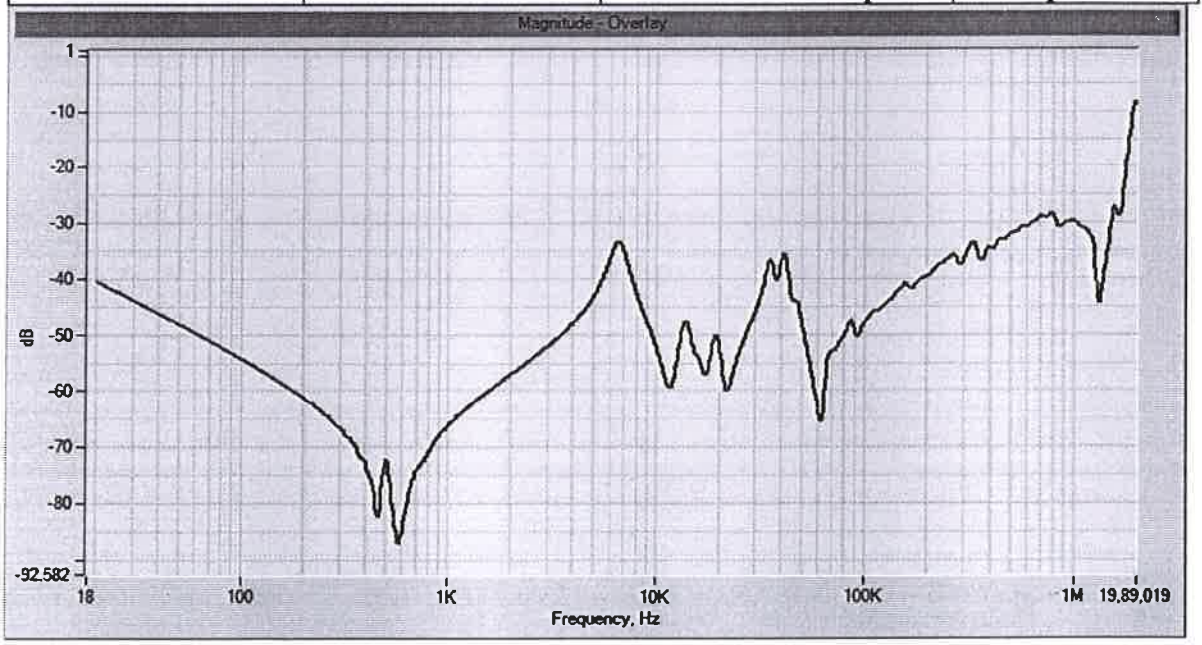
Time	Core – Core Clamp	Core – Earth	Core Clamp – Earth
60 Sec	Withstood	Withstood	Withstood

16. SFRA Test

Red lead : 1U	Black lead: 1N	Condition: LV open	Tap No: 1



Red lead : 1U	Black lead: 1N	Condition: LV open	Tap No: 9



Tested By	Witnessed By

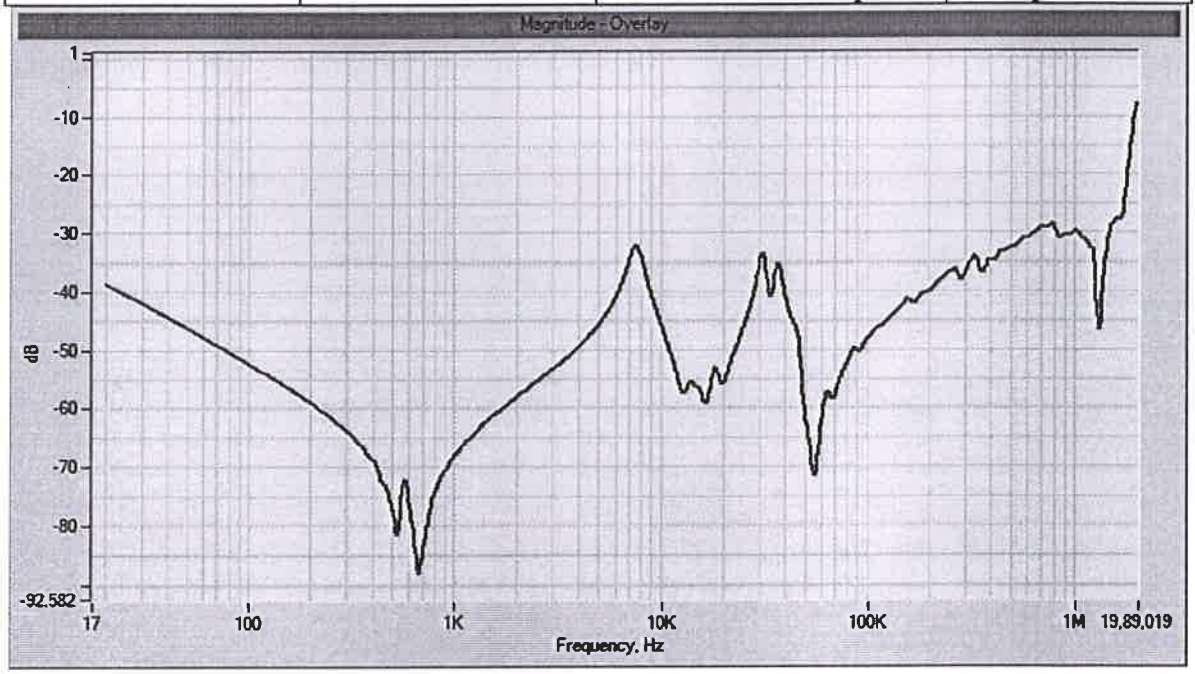
TOSHIBA

Toshiba Transmission and Distribution Systems(India) Private Limited,
EHV Test Lab, Unit – 09, Rudraram (Vi), Patancheru (ML), Medak (Dist.), Telangana, 502329, India. Ph: 040 – 30717252

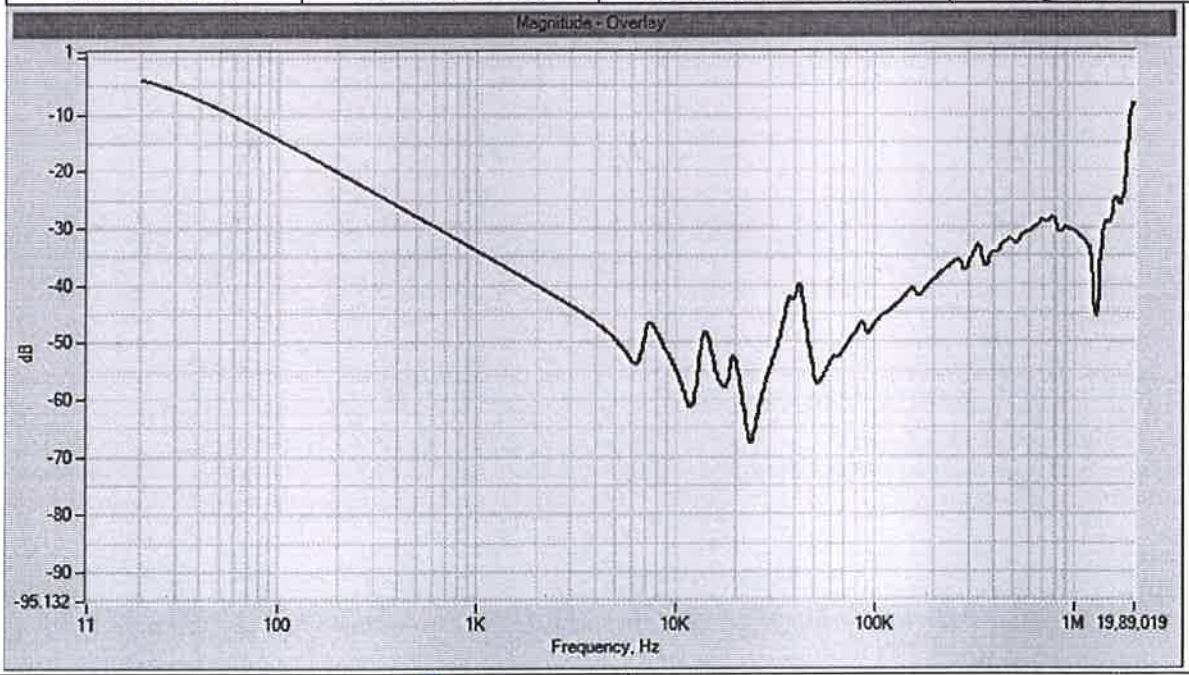
NABL Certificate No: T – 3002

Test Report No: TTDI/U9/90212A01/TR/07/17/03 **Dated: 05.07.2017**

Red lead : 1U	Black lead: 1N	Condition: LV open	Tap No: 17



Red lead : 1U	Black lead: 1N	Condition: LV Short	Tap No: 1



Tested By P. Sen	Witnessed By

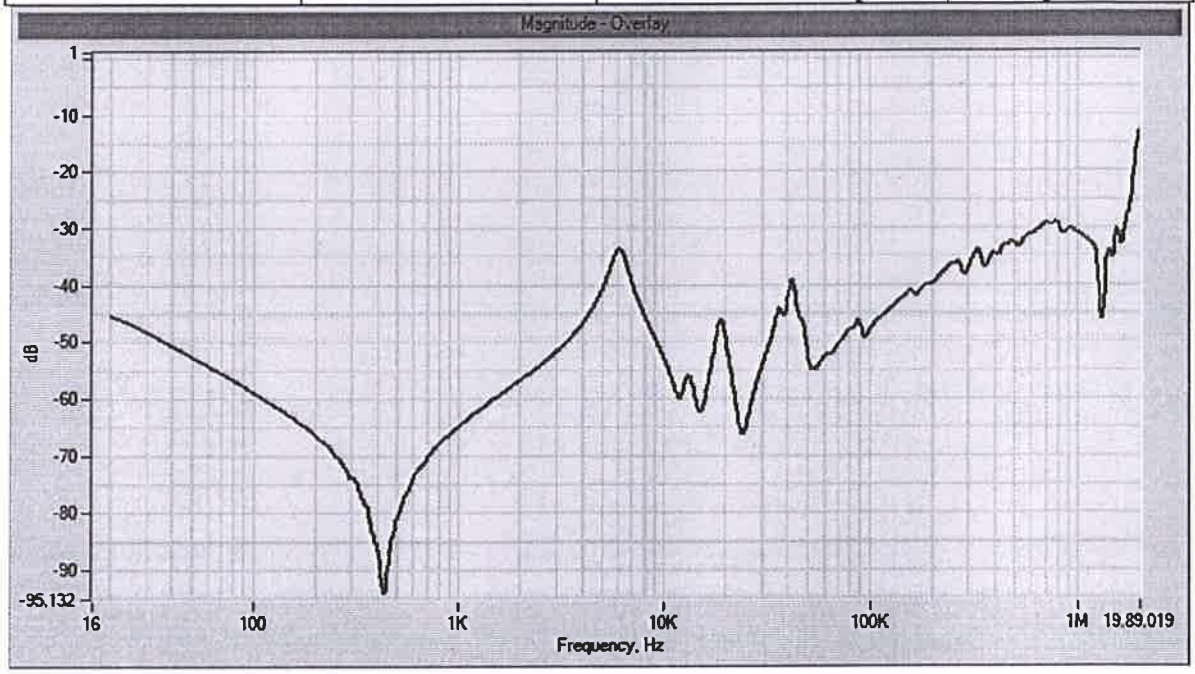
TOSHIBA

Toshiba Transmission and Distribution Systems(India) Private Limited,
EHV Test Lab, Unit – 09, Rudraram (Vi),
Patancheru (ML), Medak (Dist.), Telangana,
502329, India. Ph: 040 – 30717252

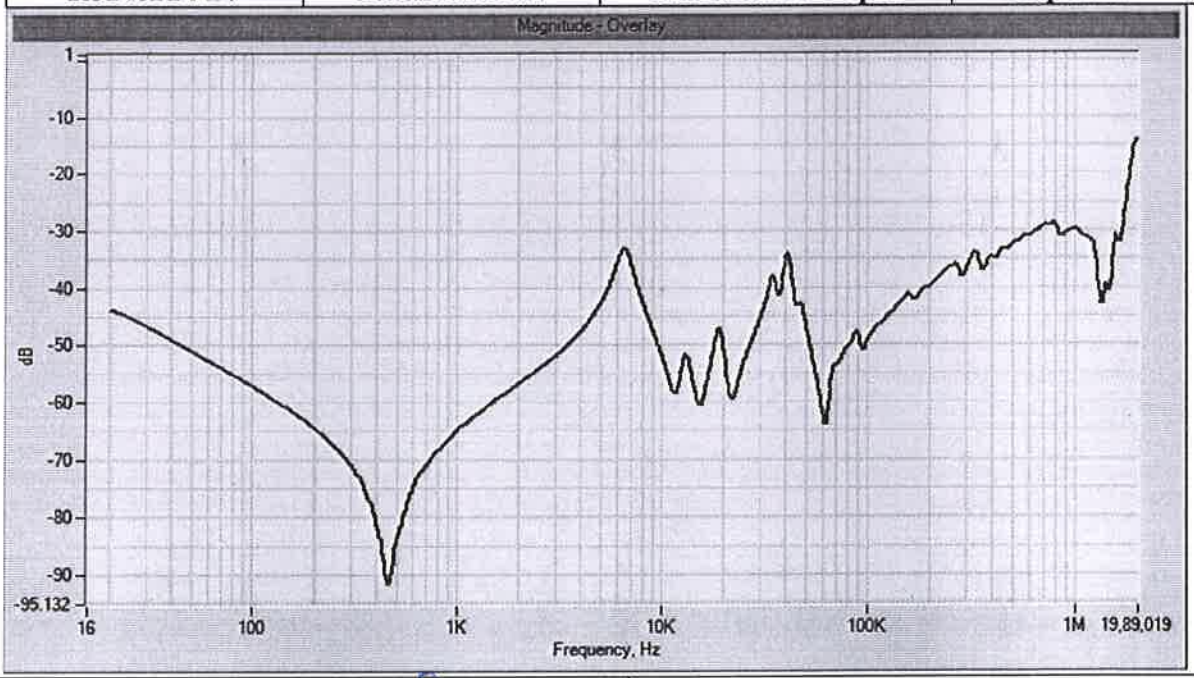
NABL Certificate No: T – 3002

Test Report No: TTDI/U9/90212A01/TR/07/17/03 **Dated: 05.07.2017**

Red lead : 1V	Black lead: 1N	Condition: LV open	Tap No: 1

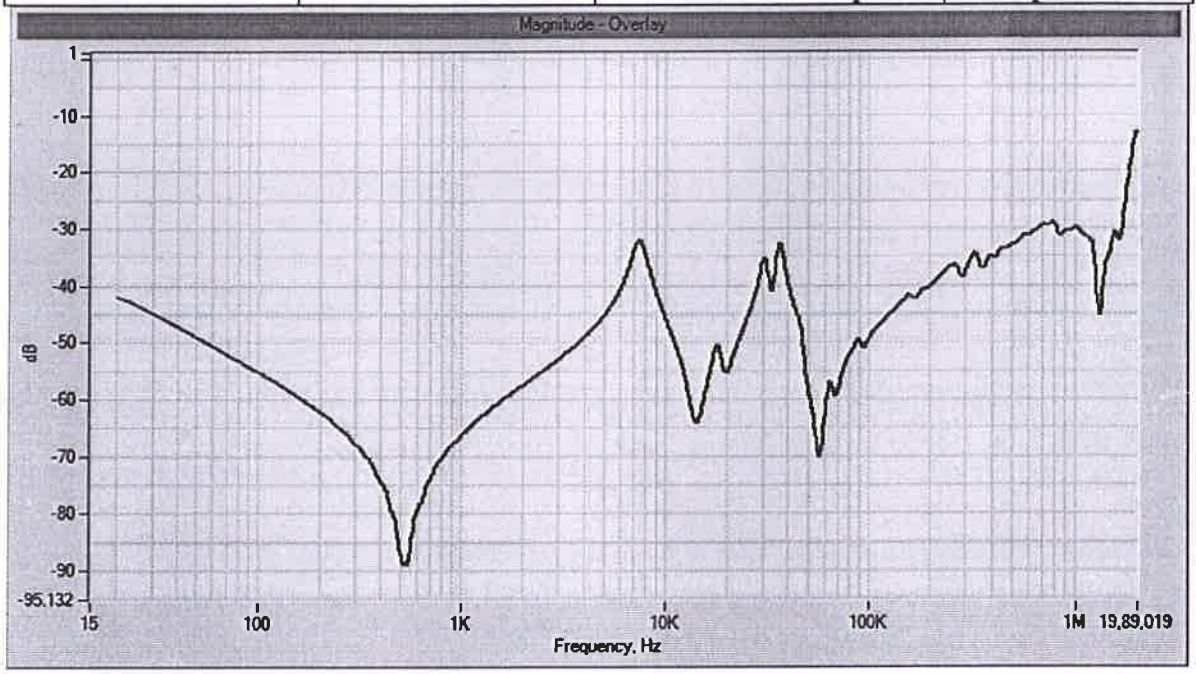


Red lead : 1V	Black lead: 1N	Condition: LV open	Tap No: 9

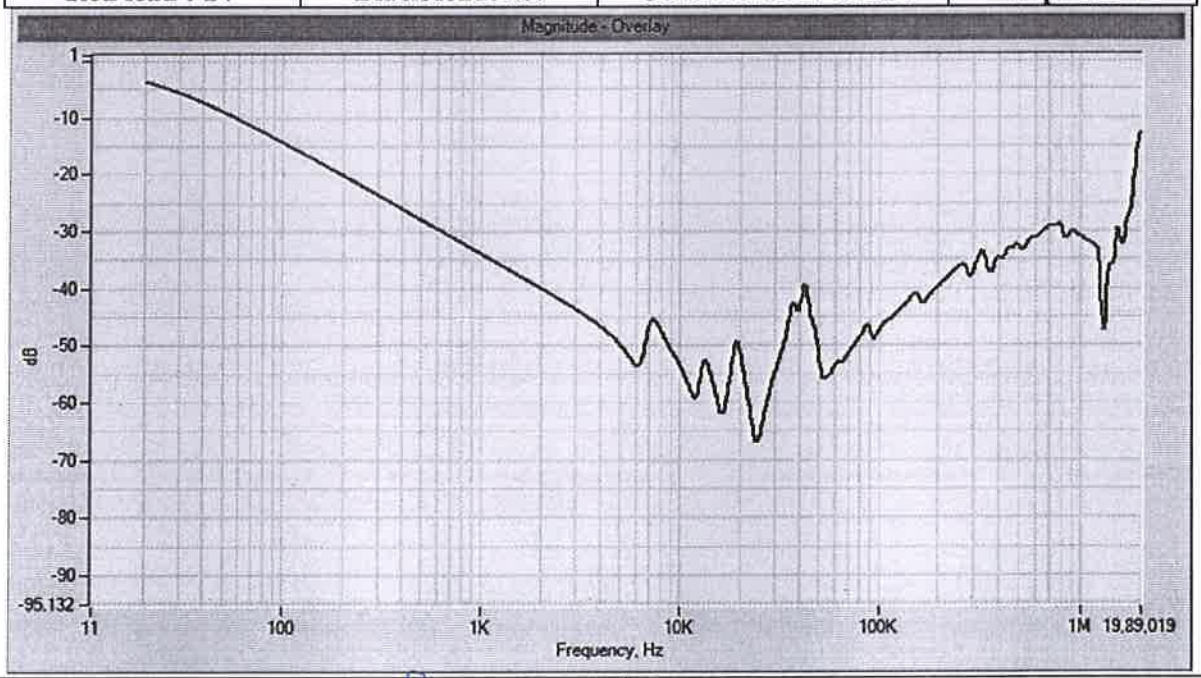


Tested By P. Roy **Witnessed By**

Red lead : 1V	Black lead: 1N	Condition: LV open	Tap No: 17

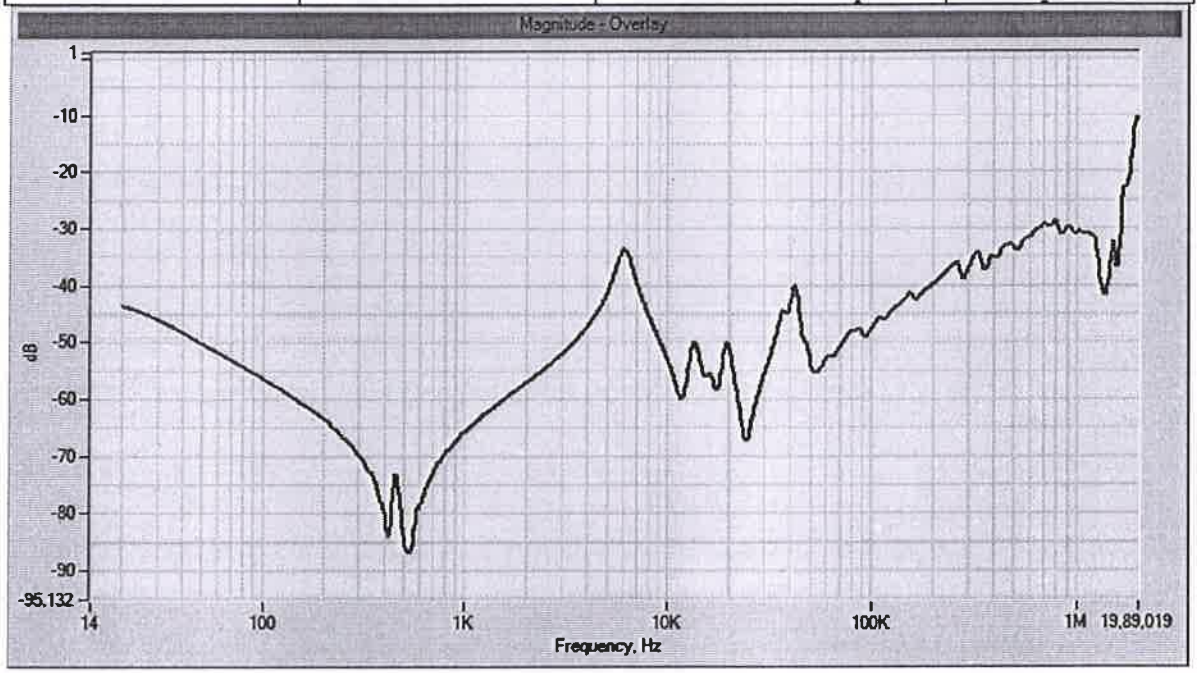


Red lead : 1V	Black lead: 1N	Condition: LV Short	Tap No: 1

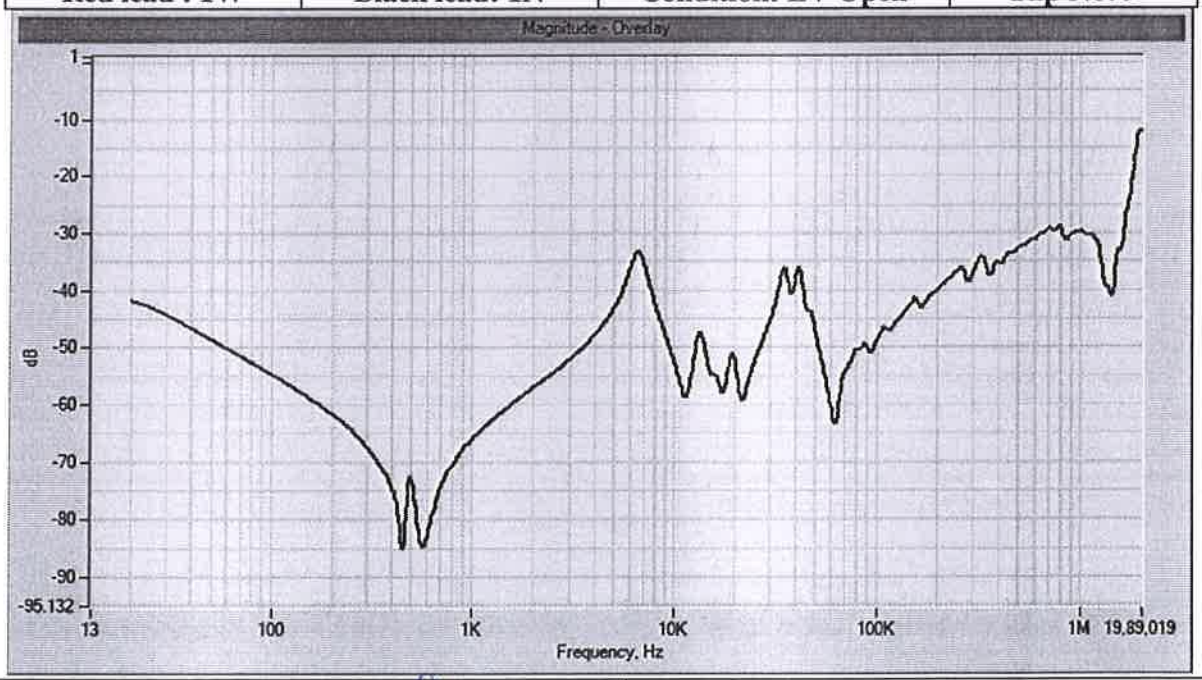


Tested By	Witnessed By

Red lead : 1W	Black lead: 1N	Condition: LV open	Tap No: 1



Red lead : 1W	Black lead: 1N	Condition: LV Open	Tap No: 9



Tested By P.Sai	Witnessed By

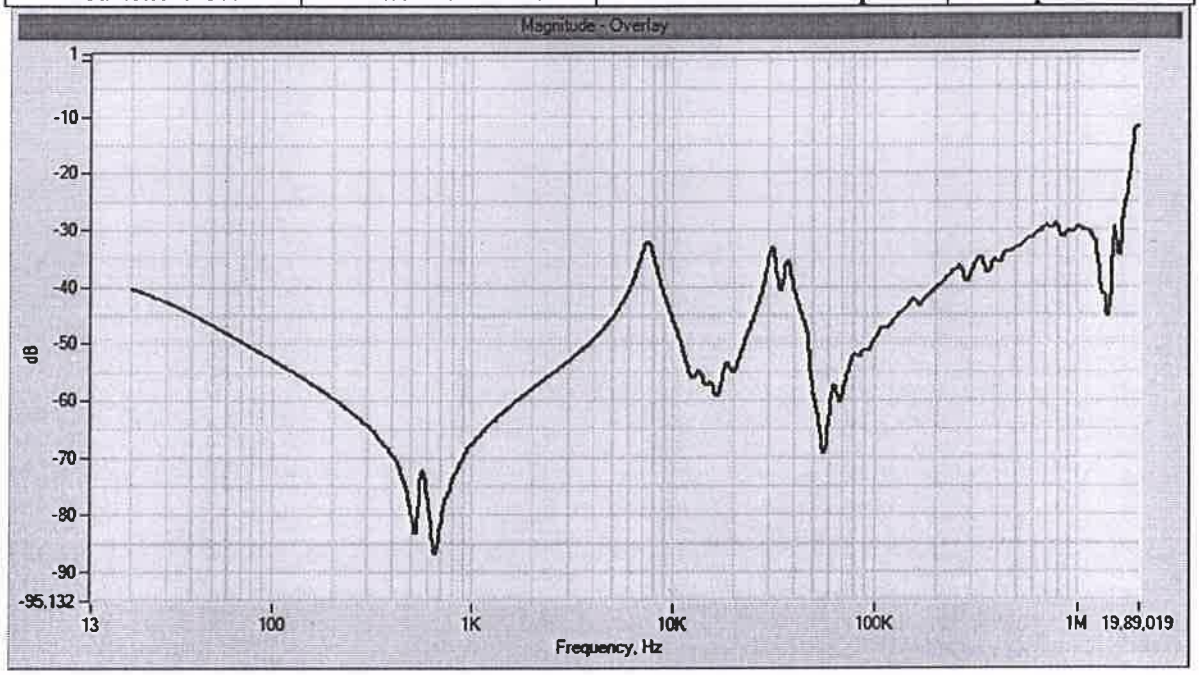
TOSHIBA

Toshiba Transmission and Distribution Systems(India) Private Limited,
EHV Test Lab, Unit – 09, Rudraram (Vi), Patancheru (ML), Medak (Dist.), Telangana, 502329, India. Ph: 040 – 30717252

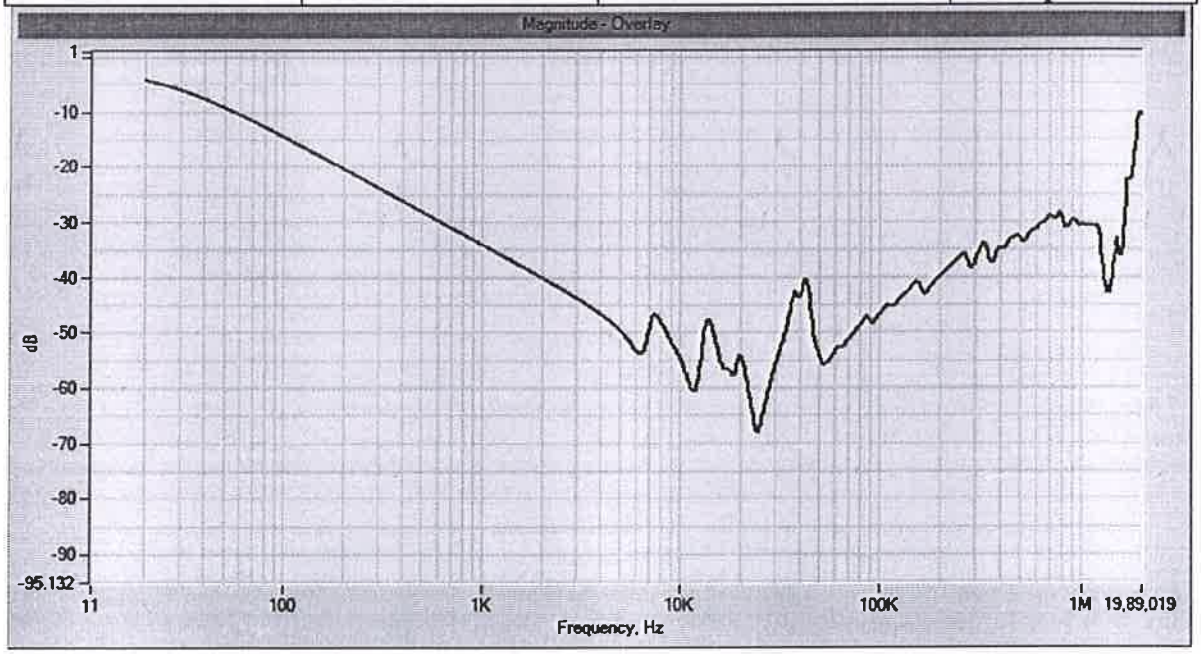
NABL Certificate No: T – 3002

Test Report No: TTDI/U9/90212A01/TR/07/17/03 **Dated: 05.07.2017**

Red lead : 1W	Black lead: 1N	Condition: LV Open	Tap No: 17



Red lead : 1W	Black lead: 1N	Condition: LV Short	Tap No: 1



Tested By	Witnessed By

TOSHIBA

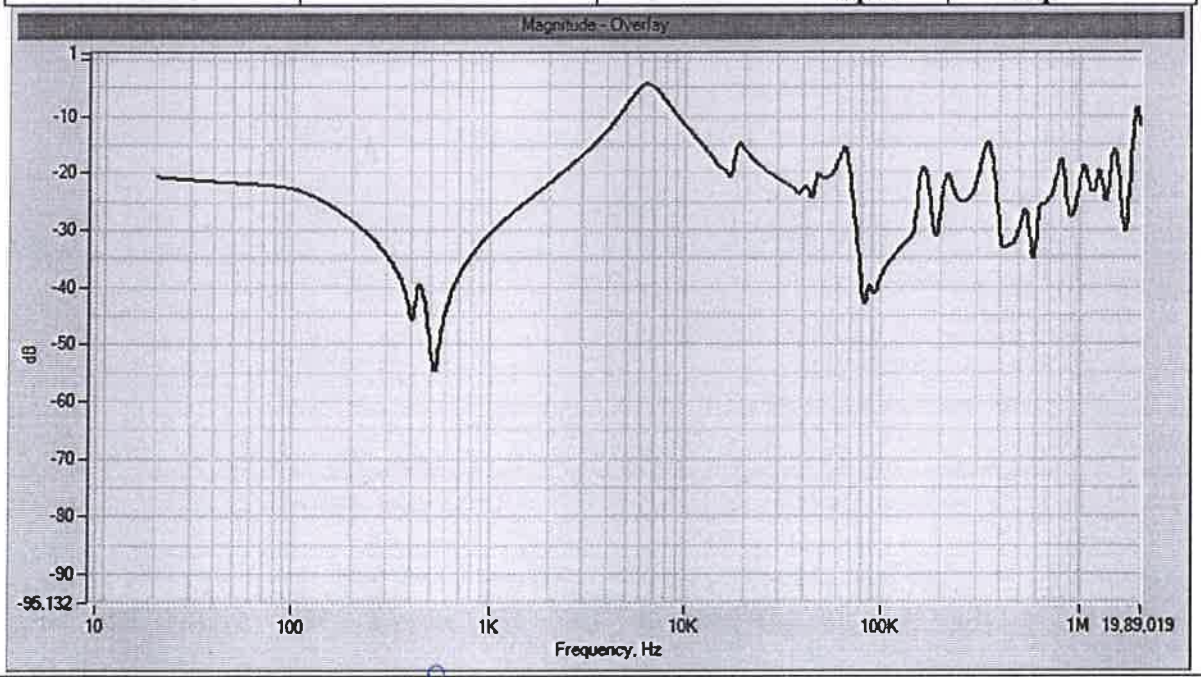
Toshiba Transmission and Distribution Systems(India) Private Limited,
EHV Test Lab, Unit – 09, Rudraram (Vi), Patancheru (ML), Medak (Dist.), Telangana, 502329, India. Ph: 040 – 30717252

NABL Certificate No: T – 3002

Test Report No: TTDI/U9/90212A01/TR/07/17/03 **Dated: 05.07.2017**

Red lead : 2u	Black lead: 2w	Condition: HV open	Tap No: 1

Red lead : 2v	Black lead: 2u	Condition: HV open	Tap No: 1



Tested By	Witnessed By

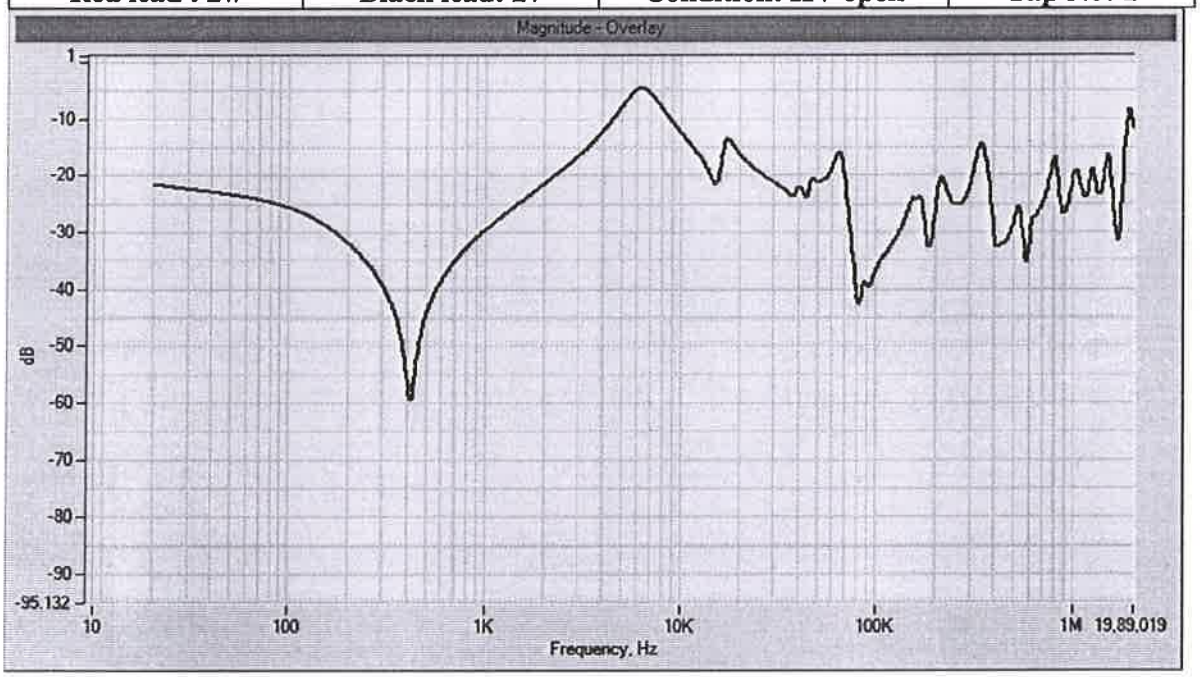
TOSHIBA

Toshiba Transmission and Distribution Systems(India) Private Limited,
EHV Test Lab, Unit – 09, Rudraram (Vi), Patancheru (ML), Medak (Dist.), Telangana, 502329, India. Ph: 040 – 30717252

NABL Certificate No: T – 3002

Test Report No: TTDI/U9/90212A01/TR/07/17/03 **Dated: 05.07.2017**

Red lead : 2w	Black lead: 2v	Condition: HV open	Tap No: 1



Tested By	Witnessed By