Experience of Dead Tank Current Transformer (CT) Tan Delta Analysis Using Narrow Band Delectric Frequency Response (NBDFR)

- By Team MRT, NLCIL TPS2EXPN

NBDFR(1Hz to 500Hz) which is a subset of DFR (1 mHz to 1 kHz) has been widely used for assessing the insulation of capacitance graded condenser type bushings, along with line frequency (50 Hz)tan delta. CEA document *"STANDARD SPECIFICATIONS AND TECHNICAL PARAMETERS FOR TRANSFORMERS AND REACTORS (66 kV & ABOVE VOLTAGE CLASS)* " 2021 recommends variable frequency tan delta for condenser type bushings.

Current transformer insulation system (capacitance graded insulation) is similar to that of condenser type bushings, especially in dead tank type CTs. NBDFR can be used for assessing the insulation of CTs along with traditional line frequency (50HZ) tan delta measurements, especially when we are looking for early indications of insulation deterioration. Papers & articles related to this are given in reference.

In NLCIL TPS2EXPN 400kV switchyard NBDFR measurements were recently carried out along with line frequency tan delta after proper surface cleaning. Line Freq measurements were carried out at 2, 5 & 10kV. NBDFR was carried out at 250V & 2kV for voltage tip-up and to check for any electromagnetic interference.

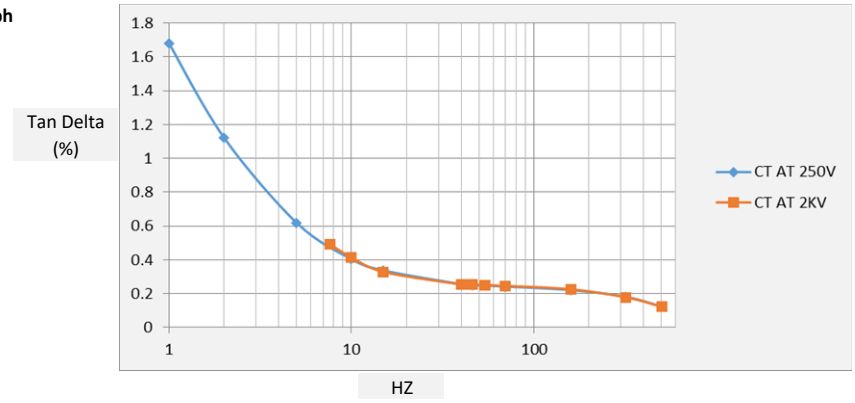
Total 19 no.s CTs of 19years old were tested. 12 CTs were in service and rest were spare. Out of 19 CTs, 6 No.s had high variable frequency tan delta results. Large varation in tan delta was seen from 54Hz to 10Hz to 1Hz. 1Hz value was also above 1%. Summary of measurements & a typical graph is given below. Detail values & graphs are given in subsequent pages.

Measurements Summary

400kV CT BAY NAME	Sr No.	Make	Mfg Year	Type	50HZ Tan Delta @ 10kV						Variable Freq TanD(%)@ 250V			Variable Freq TanD(%) @ 2kV	
					Factory Value		Previous Value		Current Value-2026						
					Cap (pf)	TanD (%)	Cap (pf)	TanD (%)	Cap (pf)	TanD (%)	1 HZ	7.5 HZ	54 HZ	7.5 HZ	54 HZ
PUGALUR-RPH	6173763	BHEL	2007	Dead Tank	783.8	0.31	780.92	0.28	783.33	0.253	**1.68**	0.404	0.248	0.414	0.25
TIE LINE - BPH	6173762	BHEL	2007	Dead Tank	811.2	0.35	808.7	0.265	808.73	0.251	**1.037**	0.409	0.241	0.418	0.243
GT-1 R Ph - Spare	6173745	BHEL	2007	Dead Tank	780.7	0.3	773.6	0.236	774.68	0.32	**3.65**	0.91	0.296	0.915	0.295
GT-1 Y Ph-Spare	6173746	BHEL	2007	Dead Tank	767.4	0.27	762.29	0.206	762.11	0.241	**2.6**	0.597	0.232	0.596	0.227
SPARE CT	6179783	BHEL	2007	Dead Tank	--	--	812.32	0.295	811.73	0.346	**1.983**	0.462	0.345	0.424	0.349

Note: 1) For above CTs C2 capacitance & tan delta measurements and Tap point IR at 500V were normal.
2) Maximum allowable frequency range in test kit at 250V is 1 to 505 Hz and at 2kV is 7.5 to 505Hz

Pugalur Rph CT Graph



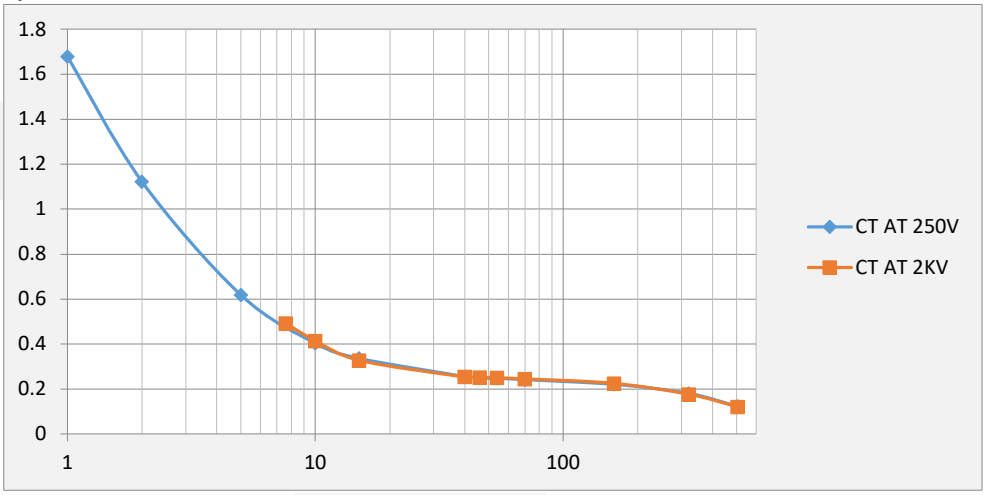
Repeat measurement carried out on a different day also showed similar results. As a precautionary measure Pugalur Rph & Tie Line Bph CTs were replaced.

References

1. IEEE-November 2021 Conference- Novel_approach_for_insulation_condition_assessment_of_high_voltage_substation_equipment_at_1_Hz
2. Megger Article Dated: 7 July 2023 -Assessing high voltage substation equipment at 1 Hz.
3. 2019 CIGRE Canada Conference- HV and EHV Current Transformer dielectric condition assessment and rootcause analysis.
4. INMR Article Dated:19 Oct 2025- Using DFR to Assess insulation in Bushing & Instrument Transformers

NLCIL TPSIIEXP	CURRENT TRANSFORMER TEST REPORT	STN : TPS2EXP
	EQPT : 400kV PUGALUR LINE CT RPH Repeat	Date : 08-04-2026

Variable Frequency Tan Delta: **PUG R Ph** (Sr No.6173763) Temp: 38°C



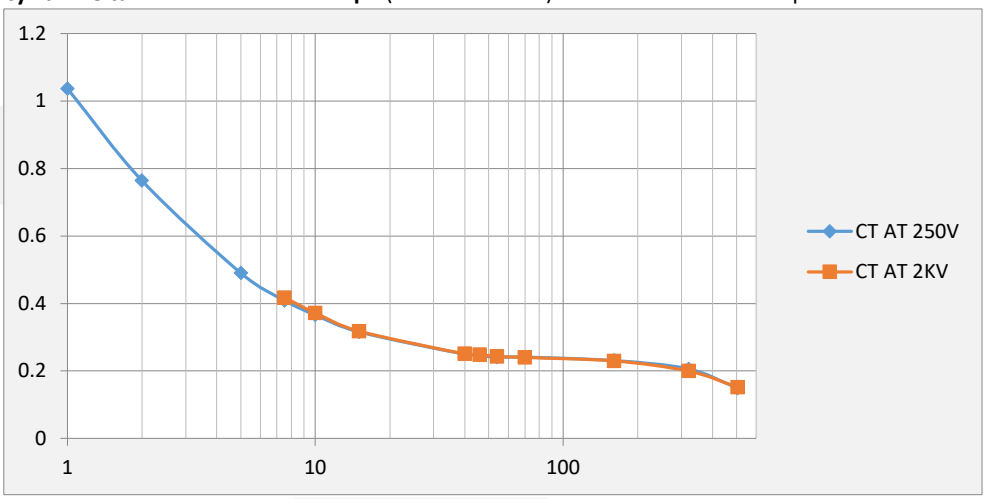
Applied Voltage	250V					2KV				
Test Mode	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD
UST-R	505	0.25	0.616	780.11	0.123	505	2.000	4.957	780.140	0.121
UST-R	320	0.25	0.39	781.08	0.181	320	2.000	3.141	781.010	0.177
UST-R	160	0.26	0.202	782.01	0.221	160	1.980	1.559	782.010	0.225
UST-R	70	0.24	0.083	783.07	0.242	70	2.020	0.696	783.080	0.245
UST-R	54	0.26	0.069	783.36	0.248	54	2.000	0.532	783.430	0.250
UST-R	46	0.24	0.055	783.55	0.249	46	2.000	0.453	783.590	0.252
UST-R	40	0.26	0.051	783.67	0.256	40	2.010	0.395	783.720	0.254
UST-R	15	0.28	0.021	784.53	0.337	15	2.050	0.151	784.540	0.328
UST-R	10	0.28	0.014	784.83	0.404	10	2.050	0.101	784.880	0.414
UST-R	5	0.28	0.007	785.92	0.619	7.6	2.040	0.077	785.240	0.493
UST-R	2	0.27	0.003	789.03	1.122					
UST-R	1	0.26	0.001	792.33	1.679					
UST-R										

Remarks:
Variable Freq. tan delta is on the higher side. Large varation seen from 54Hz to 10Hz to 1Hz. 1Hz tan delta is also above >1%

Tested By	Checked By	Approved By
GURU PRAKASH, EE, EM, MRT, TPS2E	Sunil Banoth, ACM, EM, TPS2E	R Pazhanivelan, DGM, EM, TPS2E

NLCIL TPSIIEXP	CURRENT TRANSFORMER TEST REPORT	STN : TPS2EXP
	EQPT : 400kV TIE LINE CT	Date : 16-04-2026

3) **Variable Frequency Tan Delta:** **Tie B ph** (Sr No. 6173762) Temp: 37°C



Applied Voltage	250V					2KV				
Test Mode	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD
UST-R	505	0.25	0.636	805.27	0.149	505	2	5.108	805.27	0.152
UST-R	320	0.25	0.404	806.33	0.206	320	2	3.242	806.24	0.2
UST-R	160	0.24	0.196	807.37	0.231	160	2	1.622	807.32	0.23
UST-R	70	0.24	0.084	808.44	0.241	70	2	0.71	808.39	0.24
UST-R	54	0.25	0.068	808.79	0.241	54	2	0.549	808.71	0.243
UST-R	46	0.25	0.059	808.9	0.246	46	1.99	0.466	808.89	0.249
UST-R	40	0.26	0.054	809.04	0.25	40	2.01	0.408	809	0.251
UST-R	15	0.28	0.021	810.06	0.316	15	2.05	0.156	810.05	0.318
UST-R	10	0.28	0.014	810.6	0.366	10	2.05	0.104	810.57	0.372
UST-R	7.5	0.28	0.011	811.06	0.409	7.5	2.040	0.078	811.040	0.418
UST-R	5	0.28	0.007	811.74	0.491					
UST-R	2	0.27	0.003	814.17	0.764					
UST-R	1	0.260	0.001	816.880	1.037					

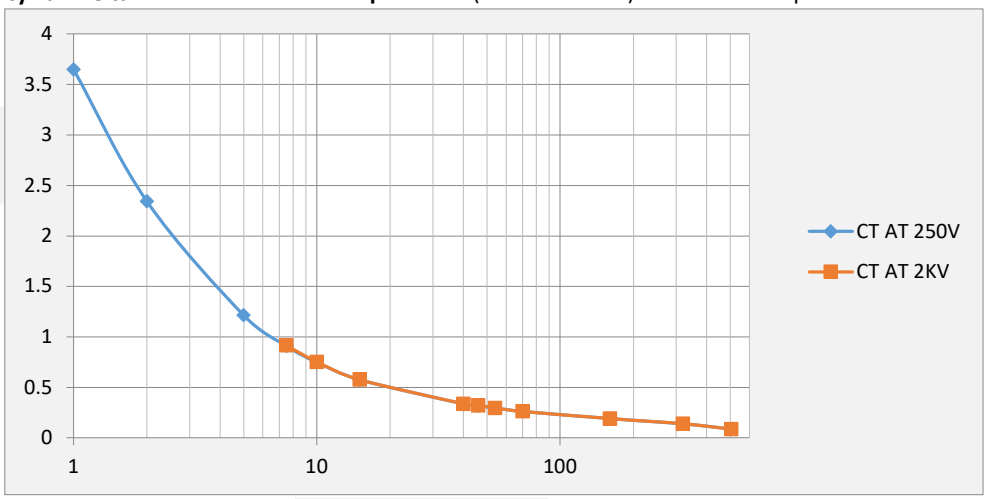
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NLCIL TPSIIEXP	CURRENT TRANSFORMER TEST REPORT	STN : TPS2EXP
	EQPT : 400kV GT1 RPH SPARE	Date : 10-04-2026

3) **Variable Frequency Tan Delta:** **GT1 R ph SPARE** (Sr No.6173745) Temp: 34°C



Applied Voltage	250V					2KV				
Test Mode	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD
UST-R	505	0.25	0.613	772.45	0.088	505	2	4.897	772.48	0.086
UST-R	320	0.25	0.388	773.33	0.138	320	2	3.102	773.21	0.14
UST-R	160	0.25	0.194	773.98	0.191	160	1.99	1.549	773.97	0.19
UST-R	70	0.25	0.085	774.72	0.262	70	2	0.683	774.7	0.262
UST-R	54	0.25	0.066	774.98	0.296	54	2	0.525	774.99	0.295
UST-R	46	0.25	0.056	775.13	0.316	46	2	0.447	775.14	0.321
UST-R	40	0.25	0.049	775.29	0.336	40	2	0.39	775.29	0.338
UST-R	15	0.28	0.02	776.49	0.576	15	2.05	0.15	776.55	0.576
UST-R	10	0.28	0.014	777.19	0.748	10	2.04	0.1	777.2	0.752
UST-R	7.5	0.28	0.01	777.81	0.91	7.5	2.04	0.075	777.82	0.915
UST-R	5	0.28	0.007	779	1.214					
UST-R	2	0.27	0.003	783.89	2.342					
UST-R	1	0.260	0.001	791.610	3.650					

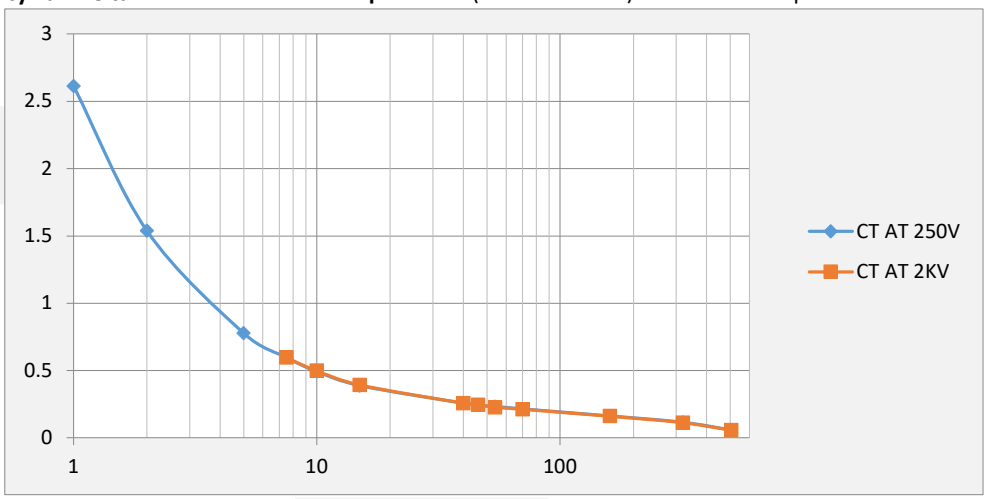
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NLCIL TPSIIEXP	CURRENT TRANSFORMER TEST REPORT	STN : TPS2EXP
	EQPT : 400kV GT1 YPH SPARE	Date : 10-04-2026

3) **Variable Frequency Tan Delta:** **GT1 Y ph SPARE** (Sr No.6173746) Temp: 40°C



Applied Voltage	250V					2KV				
Test Mode	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD
UST-R	505	0.25	0.605	759.72	0.058	505	2	4.82	759.76	0.057
UST-R	320	0.25	0.379	760.5	0.116	320	2	3.056	760.42	0.112
UST-R	160	0.25	0.191	761.15	0.162	160	1.98	1.513	761.12	0.161
UST-R	70	0.25	0.084	761.87	0.215	70	2	0.671	761.85	0.212
UST-R	54	0.25	0.065	762.11	0.232	54	1.99	0.514	762.1	0.227
UST-R	46	0.25	0.055	762.25	0.244	46	2	0.441	762.27	0.245
UST-R	40	0.25	0.048	762.38	0.258	40	2	0.383	762.38	0.257
UST-R	15	0.28	0.02	763.3	0.388	15	2.05	0.147	763.31	0.392
UST-R	10	0.28	0.013	763.74	0.492	10	2.05	0.098	763.75	0.498
UST-R	7.5	0.28	0.01	764.16	0.597	7.5	2.05	0.074	764.11	0.596
UST-R	5	0.28	0.007	764.75	0.779					
UST-R	2	0.27	0.003	767.14	1.539					
UST-R	1	0.260	0.001	770.790	2.613					

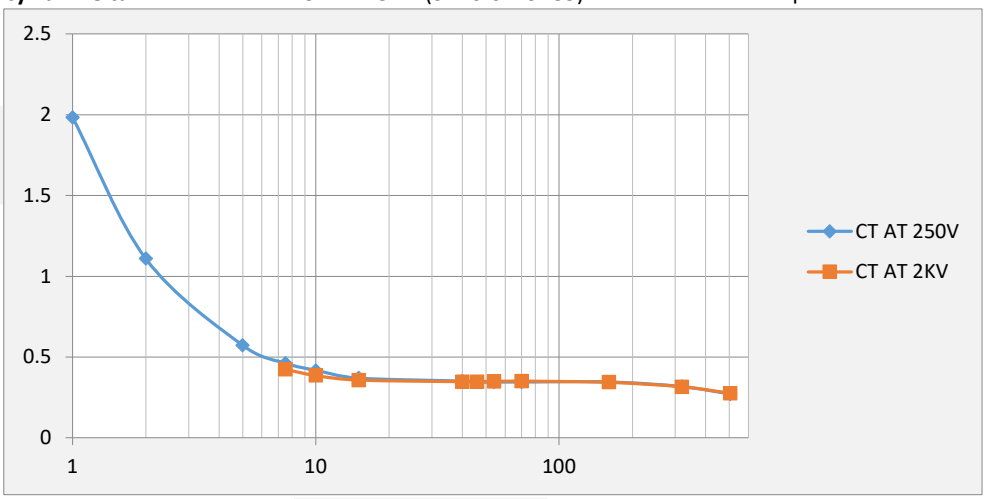
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NLCIL TPSIIEXP	CURRENT TRANSFORMER TEST REPORT	STN : TPS2EXP
	EQPT : 400kV SPARE CT	Date : 10-04-2026

Variable Frequency Tan Delta: **SPARE CT** (Sr no.6179783) Temp: 36°C



Applied Voltage	250V					2KV				
Test Mode	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD	f (Hz)	U (kV)	I (mA)	C (pF)	%TanD
UST-R	505	0.25	0.634	806.96	0.272	505	2	5.121	806.98	0.276
UST-R	320	0.25	0.407	808.31	0.317	320	1.99	3.231	808.23	0.316
UST-R	160	0.25	0.201	809.74	0.346	160	2	1.625	809.73	0.344
UST-R	70	0.25	0.089	811.3	0.345	70	2	0.712	811.34	0.351
UST-R	54	0.25	0.069	811.75	0.345	54	1.99	0.548	811.86	0.349
UST-R	46	0.25	0.058	812.04	0.345	46	2	0.469	812.13	0.348
UST-R	40	0.25	0.051	812.31	0.351	40	2	0.408	812.38	0.348
UST-R	15	0.28	0.021	813.59	0.37	15	2.05	0.157	813.86	0.358
UST-R	10	0.28	0.014	814.02	0.418	10	2.05	0.105	814.32	0.385
UST-R	7.5	0.28	0.011	814.36	0.462	7.5	2.04	0.078	814.54	0.424
UST-R	5	0.28	0.007	814.81	0.573					
UST-R	2	0.27	0.003	815.82	1.109					
UST-R	1	0.26	0.001	818.55	1.983					

Remarks:

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