Study Committee A3

Transmission and Distribution Equipment

Paper 10950_2022

Transmitted Overvoltage Requirements for Instrument Transformers

Tin PERKOVIĆ*
Končar – Instrument Transformers, Inc.

Igor ŽIGER
Končar – Instrument Transformers, Inc.

Miroslav BONIĆ
Končar – Electrical Engineerig Institute

Danijel BREZAK
Končar – Electrical Engineerig Institute

Motivation and objective

- Validation and comparison of requirements and test methods present in different international standards
- Analysis of influential parameters on Transmitted Overvoltage Test (TOV test) results
- Special considerations for Station Service Voltage Transformers (SSVTs) whose TOV performence is not adequately covered by international standards

Comparison of tests and standard requirements

There are two main approaches to TOV testing:

- Actual TOV test (LV or HV method). The test result provides actual value of transmitted overvoltage
- Grounding shield test. Test verifies only the existance of a grounded shield, not the actual value of transmitted overvoltage

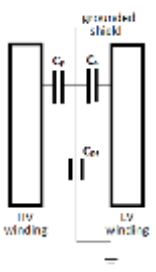
	IEC 61869-1:2007 IEC / IEEE 63253-5713-8	IEC 61869-1 38/652/CD	IEEE C57.13
Type of test	Low voltage (LV) TOV test	High voltage (HV) TOV test	Ground shield check
Parameter/ formula	$U_{tov} = 1{,}6 \times \frac{\sqrt{2}}{\sqrt{3}} \times U_m \times \frac{U_2}{U_1}$		$\frac{1}{C_{ps}} = \frac{1}{C_p} + \frac{1}{C_s}$
Voltage level of primary impulse	LV Impulse (typically between 100 and 500 V)	HV Impulse $50 - 1{,}6 \times \frac{\sqrt{2}}{\sqrt{3}} \times U_m$ kV	-
T_1 / T_2	0,5 µs ± 20% / > 50 µs	0,84 – 1,3 µs / > 50 µs	-
Requirement	$U_{tov} \leq 1{,}6\ kV$		$tolerance \pm 10\%$

Typical tests setups

LV Method

HV Method

Ground shield test schematic



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Units and parameters considered

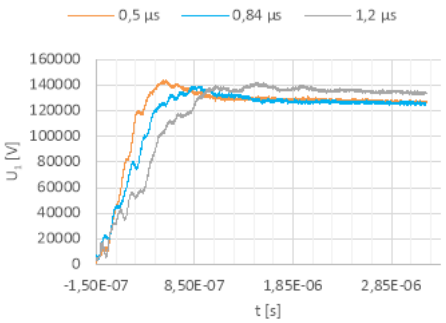
Units considered: 123 kV CT Type AGU, 123 kV VT Type VPU, 145 kV SSVT Type VPT-145 50 kVA

Parameters considered:

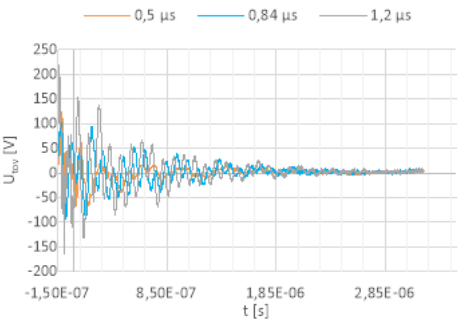
- HV test results as a function of a rise time
- Comparison of LV and HV test results
- Influence of the oscillations in primary waveform
- Influnce of grounded shield

Influnce of a rise time

Primary Waveforms - CT Type AGU

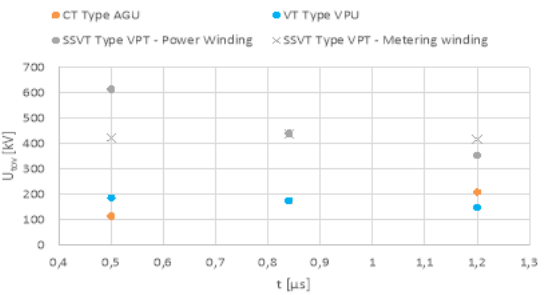


Secondary Waveforms - CT Type AGU



OBSERVATIONS:

- Rise time has an effect on the TOV value
- The rise time which garners „the best" perfromance for each transformer can be selected
- For that reason a single rise time, the one that gives the worst TOV performance for each transformer type is advisable



Comparsion of HV and LV test methods

Example - CT Type AGU-123

Test Method	U_{tov} [V]				
	Core No. 1	Core No. 2	Core No. 3	Core No. 4	Core No. 5
LV Method	38,8	61,6	62,2	65,7	129,2
HV Method	137,0	114,5	139,2	132,5	140,8

Example - SSVT Type VPT-145 50 kVA

Test Method	U_{tov} [V]			
	Power winding parallel connection	Power winding serial connection	Metering winding No.1	Metering winding No.2
LV Method	2336,7	1645,7	1257,8	1141,9
HV Method	666,4	613,9	422,9	442,0

OBSERVATIONS:

- LV method can underestimate and overestimate the level of TOV
- The recommendaion is that the HV method is used as relevant

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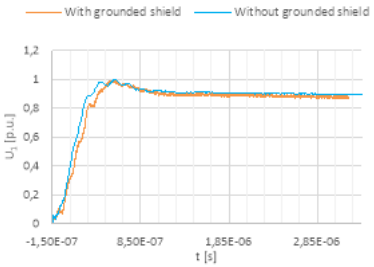
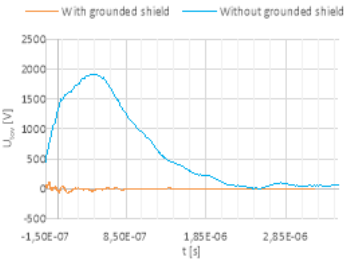
Influnce of grounded shield

Primary Waveform - CT Type AGU



Secondary Waveform - CT Type AGU



OBSERVATIONS:

- Grounded shield drastically reduces the effect of TOV
- Grounding shield test is a highly recommended routine test

Special considerations for Station Service Voltage Transformers

Primary wave parameters			[illegible]			
Test method	Rise time	[illegible] [kV]	Power winding parallel connection	Power winding serial connection	Metering winding No.1	Metering winding No.2
LV test results	0,5	0,2	2336,7	1145,7	1267,8	1141,9
	0,84	0,2	1143,7	952,0	1088,7	1041,3
	1,2	0,2	490,4	361,0	197,5	179,6
HV test results	0,5	50	666,4	613,9	422,9	442,0
	0,84	50	495,2	440,8	437,9	381,0
	1,2	50	425,9	354,2	416,8	387,5

OBSERVATIONS:

- SSVTs can have different winding types: Those intended for power delivery and those for metering applications
- Transformation ratio of power windings is typically 2-20 times lower than that of the metering windings which affects capacitance beetwen windings and typically results in a higher TOV
- SSVTs can have secondary voltage of power windings up to 1000 V. For that application the TOV requirements should follow guidelines of IEC 60364-4-44:2009 for category II.
- TOV performance of metering windings should conform to the requirements for instrument trnansformers

Conclusion

- LV method for transmitted overvoltage testing is fairly inconsistent – application of HV method is recommended
- Manipulation with rise time can significantly affect results – usage of a constant rise time for a specific tipe of a transformer is recommended
- Grounded shield drastically reduces transmitted overvoltages – recommendation is to introduce grounded shield check as a routine test in all international standards
- For SSVTs power and metering windings should be assessed differently due to the difference in rated voltages (and consequently winding capacitances) associated with them