

LIGHTNING OVERVOLTAGES PROPAGATION ACROSS VOLTAGE MEASUREMENT TRANSFORMERS

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Summary: This publication presents measurement results of lightning overvoltage propagation across HV voltage transformer (VT). High reliability of protection relays requires knowledge about surge propagation in neuralgic points for unusual conditions such as lightning. This problem appears simultaneously with growing number of electronic equipped HV/MV substations.

Keywords: voltage transformer, lightning, overvoltage, measurements.

1. Introduction

Protection relays lead in HV/MV substations and electric power distribution system. They are complex electronic devices. Protection relays are designed to cooperate with voltage and current measurement transformers. These devices are essential for proper HV/MV substation work. They incorrect work can provide black-out and large financial damage. Inducted overvoltages caused by lightning strike frequently appear in HV overhead transmission lines.

This publication presents measurement results of lightning overvoltage propagation across HV 60kV voltage transformer. High reliability of protection relays requires knowledge about surge propagation in neuralgic points of a HV/MV substation during lightning strike.

2. Analyzed voltage transformer

All presented below results base on measurements, which were made in high voltage testing laboratory. One type of HV voltage transformers were examined for different voltage levels, terminals configuration and units. All presented measurement results as an example are for the same one unit. During measurement output terminals were in open-circuit position. VT was grounded. Detail information about analyzed voltage transformer:

- type U60-1M09
- manufacturer ZWAWN Warsaw, Poland

- rated voltage $U_{1n}=60 / 130 / 325$ kV
test voltage 50Hz
surge test voltage 1,2/50 μ s
- rated voltage $U_{2n}=100: \sqrt{3} / 100:3$ V
- rated power $S_{2n}=120/30$ V·A [1]



Fig. 1. Photo of the CT test set-up

The lightning overvoltages were produced by the high-voltage surge generator (SG) – type UCS 500M6B. The SG covers transient and power fail requirement according to international standards with voltage capability of up to 1,2/50 μ s 6,6kV.

During measurements also were used:

- digital oscilloscope Tektronix TDS3032B 300MHz, 2,5GS/s,
- high voltage probe with 100x attenuation. Tektronix P6009 4kV, 180MHz, input capacitance 2.5pF, input resistance 10M Ω , cable length 9ft,
- high voltage coaxial cable $Z_0=50\Omega$.

SG was connected to the A-B voltage transformer terminals (M1-N1 in old notation) [2,3]. Different combinations were examined for different circuit

configurations: winding-winding, with add transformer TP-60, with add load (voltmeter), with MOV. One of examined combinations presents figure 2.

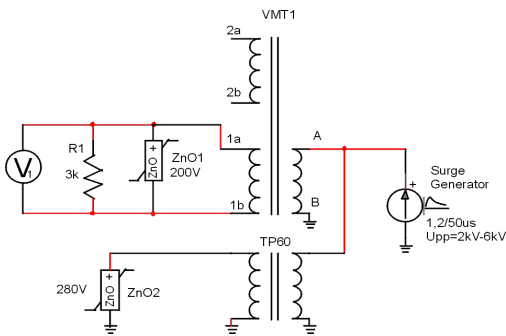


Fig. 2. Circuit diagram of the VT test set-up.

3. Measurements results

Measured voltage waveforms shapes are almost identical for all cases – max. peak value 800V for 6kV surge. Voltage waveforms measured for different lightning surge level seems to grow linear with increasing surge level (fig. 3).

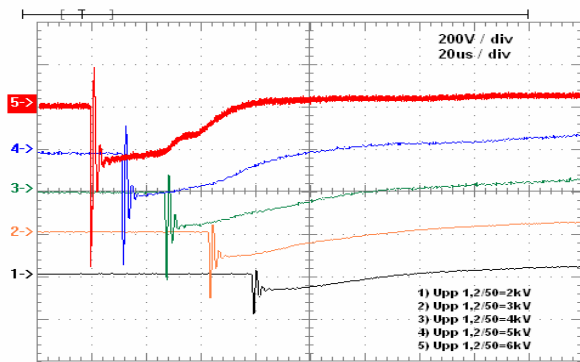


Fig. 3. Voltage waveforms measured between different secondary windings (1a-1b) for different surge peak voltage. Test circuit consists of: VT and SG.

There doesn't exist any influence between recorded peak voltage and load on the primary side of VT (fig.4).

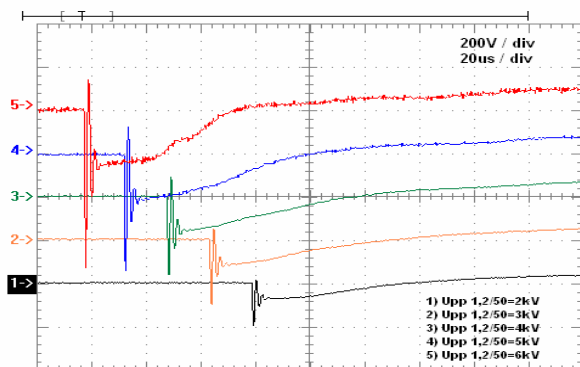


Fig. 4. Voltage waveforms measured between different secondary windings (1a-1b) for different surge peak voltage. Test circuit consists of: VT, SG and parallel TP-60.

Voltage waveforms measured for circuit with load on the secondary side are lower (fig. 5). All recorded voltage levels are about ten times lower then surge is. It

can be dangerous for devices cooperating with VT. Using metal oxide arresters (MOA) as the surge protection devices (SPD) can reduce peak voltages (fig.6).

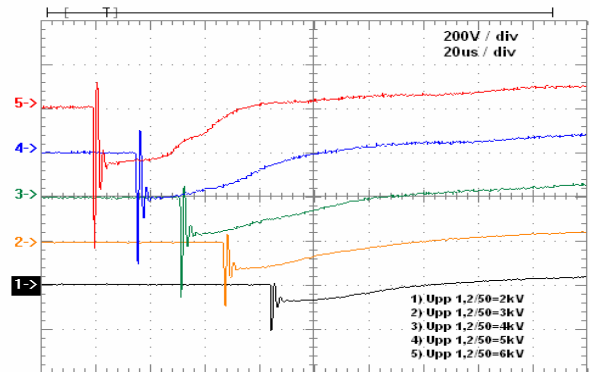


Fig. 5. Voltage waveforms measured between different secondary windings (1a-1b) for different surge peak voltage. Test circuit consists of: VT, SG, parallel TP-60 and voltmeter (as the load 3kΩ).

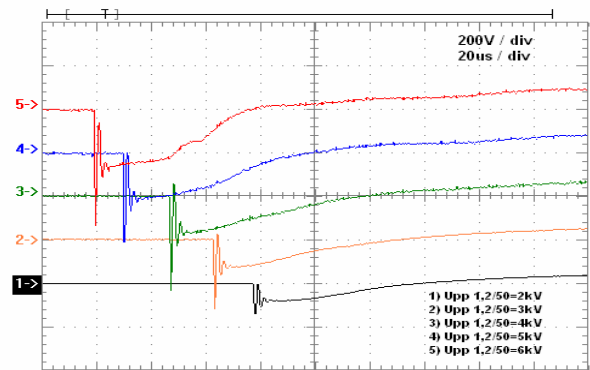


Fig. 6. Voltage waveforms measured between different secondary windings (1a-1b) for different surge peak voltage. Test circuit consists of: VT, SG, parallel TP-60 and voltmeter (as the load 3kΩ) and MOAs as SPD.

4. Conclusions

During creation a failure-free work conditions for protection relays directly connected with VT it's necessary to:

- install the SPDs with proper protection level,
- analyze lightning overvoltages levels in places of their installations.

5. References

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