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LIGHTNING OVERVOLTAGES PROPAGATION ACROSS HV CURRENT TRANSFORMER

Jaroslaw M. WIATER
jaroslawwiater@vela.pb.bialystok.pl
Białystok Technical University, Poland

Abstract: This publication presents measurement results of lightning overvoltage propagation across HV 110kV current transformer (CT). High reliability of protection relays requires knowledge about surge propagation in neuralgic points for unusual conditions such a lightning. This problem appears simultaneously with growing number of electronic equipped HV/MV substations.

Keywords: current transformer, lightning, overvoltage, measurements.

1. INTRODUCTION

Protection relays are complex electronic devices. They lead in HV/MV substations and electric power distribution system. Protection relays are designed to cooperate with current measurement transformers. Current transformers are designed to provide a current in its primary secondary proportional to the current flowing in its primary. These two 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 110kV current transformer. Current transformers don't influence on the transient behavior of the electric power network. There are some except in unusual circumstances of ferroresonance or lightning [1]. High reliability of protection relays requires knowledge about surge propagation in neuralgic points of a HV/MV substation during lightning strike.

2. ANALYZED CURRENT TRANSFORMERS

All presented below results base on measurements, which were made in Polish Transformer Service. These current transformers were survey there and measurements possibility appears then. One type of HV current transformer was examined for different voltage levels and terminals configuration. During measurement output terminals were in short-circuit position. CT wasn't grounded. Neutral terminal was connected to CT tub.

Detail information about analyzed current transformer:

- type J/110-4a
- manufacturer ZWAR Poland
- rated voltage U_n=123/230/550kV
  test voltage 50Hz
  surge test voltage 1,2/50μs
- rated current I_n=150/300/600A
- thermo-current I_{th}=18/30/30kA
- dynamic current I_{dyn}=45/75/75kA
- rated power S_{2n}=60/60/90/90 V·A

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

The lightning overvoltages were produced by the high-voltage impulse generator – UCS 500M6B. The UCS 500M6B is generator to cover transient and power fail requirement according to international standards with voltage capability of up to 6.6kV. Apart from the IEC 61000-4-5 standard for surge testing it also complies to ANSI/IEEE C62.41 for surge and ringwave testing. Some generator parameters are listed below [2]:

- voltage (open circuit) 250-6600V,
- pulse front time 1,2μs +/- 30%,
- pulse time to half value 50μs +/- 20%,
- current (short circuit) 125-3300A,
- direct output Via HV-coaxial connector, Zi=2Ω,

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 10MΩ, cable length 9ft,
- high voltage coaxial cable Z_o =50Ω.

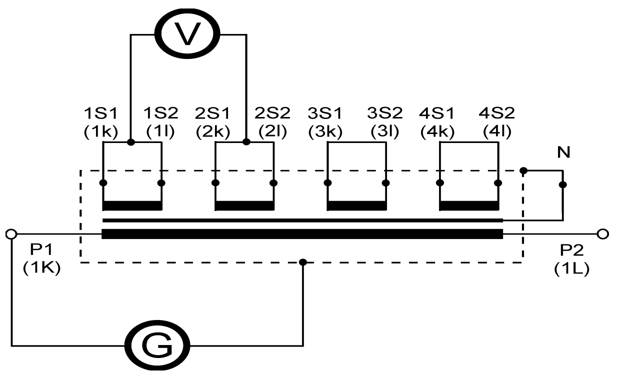

Fig. 2. Circuit diagram of the CT test set-up.

Surge generator was connected to the CT 1K-1L (P1-P2 in new notation) terminals and grounded to CT tub [2,3]. Different combinations were examined for different terminals configurations: winding-winding, winding-CT tub. One of examined combinations presents figure 2 (winding-winding).

3. MEASURMENT RESULTS

Measured voltage waveforms are almost identical for this case (fig. 3) – max. peak value 300V for 6kV surge. It's twenty times lower then surge is. Voltage waveforms measured between different secondary windings are much higher then last one (fig. 4). They are only two times lower then surge is. It can be dangerous for devices cooperating with CT. Voltage waveforms measured for different lightning surge level seems to grow linear with surge level (fig 5).

4. CONCLUSIONS

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

- install the surge protective devices (SPDs) with proper protection level,
- analyze lightning overvoltages levels in places of theirs installations.

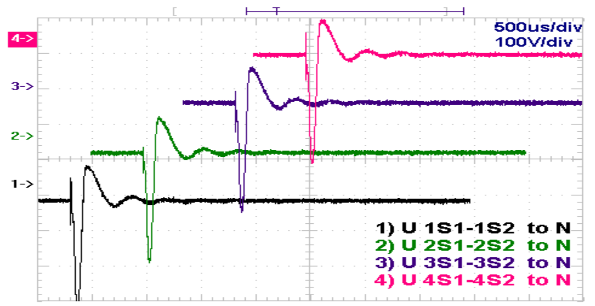

Fig. 3. Voltage waveforms measured between different secondary windings and CT neutral terminal.

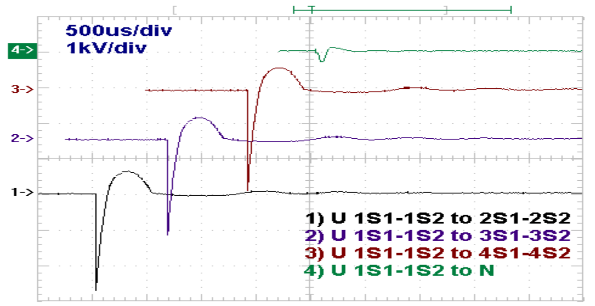

Fig. 4. Voltage waveforms measured between different secondary windings.

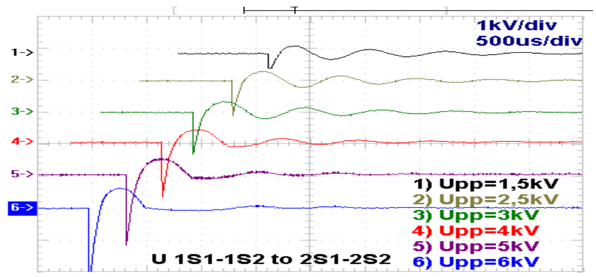

Fig. 5. Voltage waveforms measured between 1S1-1S2 and 2S1-2S2 for different lightning surge level.

5. REFERENCES

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