Measurement problems during lighting hazard simulation on the HV substation

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Abstract - **This paper presents a practical aspect of lightning ground potential rise (GPR) measurements. They were made during normal operation of the real high voltage substation and according a special procedure developed for this occasion. This procedure does not influence the protection relays and ensures a proper work of the HV substation even for 6kV surges.**

I. Introduction

High voltage substations are very often placed on the open area. They consist of many high metallic components such as overhead transmission pylons, busbar bridges etc. They are exposed to direct lightning strike. During direct strike, grounding system will transfer lighting current to earth. Parameters of this system are changing dynamically during the lightning current flow. This effect causes a ground potential rise with respect to remote earth or other substation grounding systems and is dangerous for electrical and electronic devices and systems.

This paper presents a practical aspect of lightning ground potential rise measurements. All measurements were made during normal work of the real high voltage substation and according a special procedure developed for this occasion (fig.1). This procedure does not influence the protection relays and ensures a proper work of the substation even for 6kV surges.

II. Measurement Problems

During measurements current and voltage surges were produced by the high voltage impulse generator – UCS 500M6B. All measurement equipment was supplied from gasoline generator. Special attention was pay to the problems, which occurred during measurements on the real and working substation (fig.2). Additional equipment used for measurement purposes was listed below:

- digital oscilloscopes Tektronix TDS3032B 300MHz, 2,5GS/s,
- high voltage probes with 100x attenuation. Tektronix P6009 4kV, 180MHz, input capacitance 2.5pF, input resistance 10MΩ, cable length 9ft,
- high voltage coaxial cable Zo =50Ω,
- gasoline generators,
- UPS (uninterruptible power supply) with inverter etc.

First problem which appeared during measurements was related to interconnections between grounding system and the power supply of measuring devices by the neutral wire. It was observed that after about 2μs time surge produced by generator overlapped the recorded waveform. This can cause a large measurement error. Current traveling wave went from surge generator to grounding system and then by the neutral wire to the digital oscilloscopes. Only one solution is possible for this kind of galvanic interference. It is necessary to secure power delivery from additional supply for each digital oscilloscope. This source must be ungrounded and stabilized.

Second problem link with power supply stability. Proper voltage stabilization was necessary for digital oscilloscope. The typical gasoline generator could not be used. Its voltage fluctuation was to high for very sensitive recording device. It was real necessary to use UPS with inverter. The used UPS was constantly charged from gasoline generator and disconnected from it for measurement moment. The UCS 500M6B surge generator also required a separating transformer despite gasoline generator.

Next very important matter is to secure separation between steering circuits after power supply separation. Each digital oscilloscope should have different circuit for synchronization with surge generator. Ground of selected oscilloscope triggering input should not be connected to ground of surge generator and measured circuits too. The simplest way to resolve this problem is to build small current measurement transformers (CT) and install them on the high voltage surge generator output. Each CT for each digital oscilloscope. In our measurements ceramic high powered resistor was used (with hole inside to put current transferring wire into it). Additional triggering signal is necessary for HV substation with large grounding systems. Recorded voltages are very small and proper synchronization by advanced triggering in digital oscilloscope is not enough to observe any waveform.

During measurements very often appears next problem. Differences between real objects and its plans. Especially in placement of grounding system in earth. This fact is crucial when GPR is considered.

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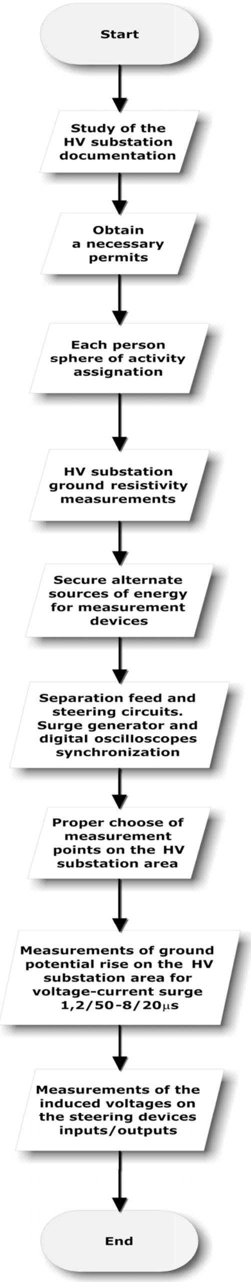

Figure 1. Measurements algorithm

Figure 2. Measurements in progress

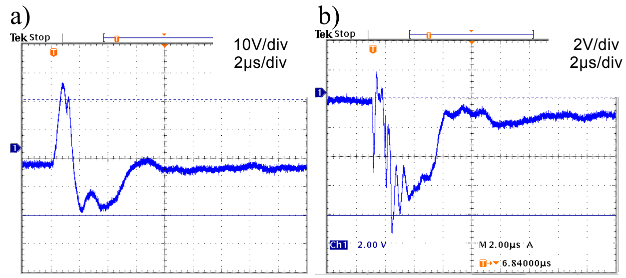

Figure 4. GPR on the: a) grounded metallic part of the 15kV busbar, b) grounded metallic part of the 110kV switching cell no.1

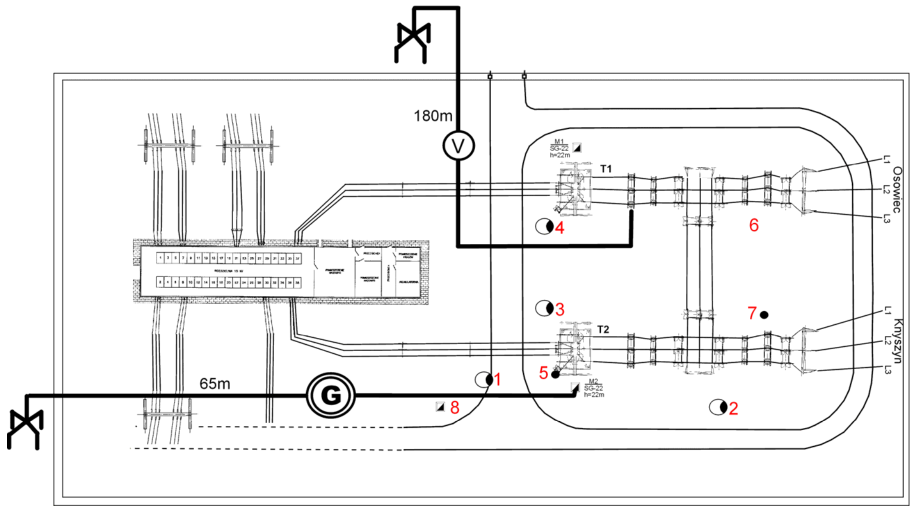

Figure 3. Connection diagram created for GPR measurements

III. Measurement Results

Figure 3 shows a functional block diagram of the equipment used for the ground potential rise measurements – a surge generator and digital oscilloscope. Current 0.1kA, 71/145µs was injected from a surge generator between the substation's lightning rod and a remote return electrode.

A digital oscilloscope measured potential difference between the two potential probes. This latter probe was placed at a series of locations, beginning close to the grid and ending near the return electrode, moving from point to point on the substation area. GPR of few selected points are presented on figure 4.

IV. Conclusions

Direct lightning strike to the earthed components of HV substation can cause severe interference problems in electronic equipment and systems. In the article few practical problems was presented. The specially created method was based on many attempts to measure GPR on working HV substation. Secure measurements with HV current surge generator was realized.

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