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Measurements of electric disturbances in low voltage installations inside rooms near the high voltage laboratory

Abstract. *The paper is aimed to measurements of electric disturbances in low voltage installations inside rooms near the high voltage laboratory during its work. The high voltage laboratory is a part of Faculty of Electrical Engineering Warsaw University of Technology building and is placed close to other rooms, like library, classrooms or another laboratories. During measurements has been carried out a study to establish connection between the observed interference and high voltage laboratory work.*

Streszczenie. *W niniejszym artykule przedstawione zostały pomiary zaburzeń elektrycznych w instalacji niskonapięciowej w pomieszczeniach biurowych znajdujących się w otoczeniu laboratorium wysokonapięciowego. Laboratorium to jest częścią Gmachu Elektrotechniki Wydziału Elektrycznego Politechniki Warszawskiej. W jego otoczeniu znajdują się pomieszczenia takie jak biblioteka, sale wykładowe oraz inne laboratoria. W trakcie pomiarów przeprowadzona została analiza związku pomiędzy laboratoryjnymi pracami wysokonapięciowymi a obserwowanymi zaburzeniami. (**Pomiary zaburzeń elektrycznych w instalacji niskonapięciowej w pomieszczeniach w pobliżu laboratorium wysokich napięć**).*

Keywords: electromagnetic compatibility, induced voltages, high voltages, electromagnetic disturbances.
Słowa kluczowe: kompatybilność elektromagnetyczna, napięcia indukowane, wysokie napięcia, zaburzenia elektromagnetyczne.

Introduction

With advances in technology, we can observe in the environment increasing number of electromagnetic disturbances, sometimes with new amplitude-frequency characteristics. These disorders come to various electronic equipment, causing sometimes their wrong operation and, in extreme cases, even destruction. About this, what will be the effect of the influence of disturbances on the device determine the parameters of disturbances and immunity level the device on the type of disturbances. This fact especially concerns sensitive telecommunication devices [1]. For this reason, the manufacturer shall carry out appropriate electromagnetic compatibility tests, which confirm the ability of the device to work in a given electromagnetic environment.

The specific situation occurs when the device in it natural environment starts to work incorrectly. Then the reasons may be one of two: improper design and construction of the device or disorder that should not appear in this environment. Such a situation takes place in the Building of Electrical Engineering Warsaw University of Technology, where in addition to numerous rooms such as office, laboratories and lectures there is also a high-voltage laboratory, popularly known as High Voltage Hall. Due to emerging from time to time suspicion that the research and experiments carried out in HV laboratory are the source of disturbances that cause interference with sensitive electronics, such as computers the tests were conducted to dispel these doubts.

Research program

The first step was to investigate the link between works conducted in the high-voltage laboratory and the improper operation of equipment. For this purpose, several measuring locations have been selected, four of which will be presented in this article. Each of the selected location was equipped with sensitive electronic devices powered by the overall low voltage network. These premises were located in different places of the building in relation to the source lab, at the same or upper level, in further or closer distance. Situational diagram is shown in Fig. 1.

Exact descriptions of this location:

- Laboratory of electromagnetic compatibility, overall power network (GE 109),
- High voltage laboratory space, power network for informatics infrastructure (GE 104),
- Institute's library (GE 209),
- Office room, power network for informatics infrastructure (GE 116).

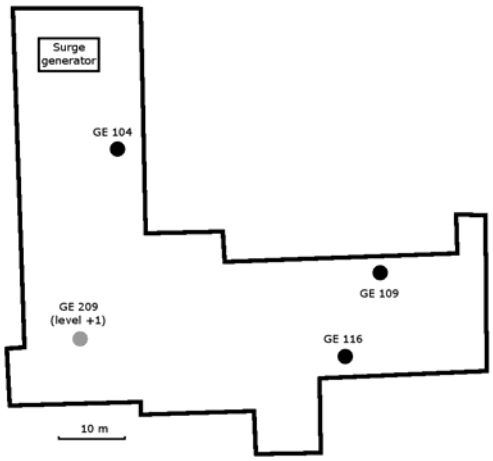

Fig. 1. Diagram of rooms locations where disturbances were examined.

Fig. 2. FLUKE VR101S Event Recorder

In each of these locations has been installed device for monitoring supply voltage condition and recording the situation where the supply voltage parameters have been exceeded and time of their occurrence. As the research monitoring and recording device FLUKE VR101S Event Recorder with Event View 2.16 software, shown in Fig. 2, was used.

Its configuration parameters defining the levels of disorders that cause its activation are as follows:

- Line to neutral thresholds:
  - swell voltage – 256 V
  - sag voltage – 210 V
  - transient deviation – 200 V
- Neutral to ground thresholds:
  - swell voltage – 10 V
  - transient deviation – 100 V
- Frequency thresholds:
  - minimum – 48,8 Hz
  - maximum – 51,2 Hz

As a result of observation, it was possible to read the total number of registered disorders and predict those which could be associated with the work in a high voltage laboratory. In the next step, field and oscilloscope tests were provided in these locations, which has been confirmed by the link of the source - effect. Tektronix TBS1052 oscilloscope and passive loop antena EMCO 6509 was used. Sampling frequency of this model of oscilloscope is 1 GS/s and bandwidth 50 MHz. Frequency range used antenna that 1 kHz to 30 MHz.

Results of monitoring and recording

The conducted monitoring revealed a diverse number of observed disorders, their nature and levels. Numbers of recorded events at individual locations are collected in table 1.

Table 1. Number of registered events. Used symbols: A – swells, B – transient events, C – sags, D – frequency events, E – lack of power events.

Location	Observation duration [days]	Number of events				
		A	B	C	D	E
GE 109	7	0	5	0	0	0
GE 104	9	0	12	0	0	0
GE 209	27	1	153	0	0	0
GE 116	7	1	3	0	0	0

Some additional recordings for location r. 209 might cause two thunderstorm days with some lightning discharges near this building. Unfortunately there were no lightning activity data from this period.

As we can observe the most frequent events were transient type. Its measured maximum value was about 400 V with duration about 10 μs. Exemplary record is presented in fig. 3.

In case of swell events its maximum value 45 V was registered in case of the room 116 and its duration was 1 cycle. Based on data from tab. 1 is possible to calculate average number of events per day:

- GE 109 – 0,71
- GE 104 – 1,33
- GE 209 – 5,70
- GE 116 – 0,57

This data gave information that devices in two of four rooms are quite often exposed on disturbances like transients. This two rooms are located in smaller distance to high voltage generator than the other two. In this way was prepared and executed second experiment with observation of direct connection between high voltage generation and events in power line as also electromagnetic field inside this rooms.

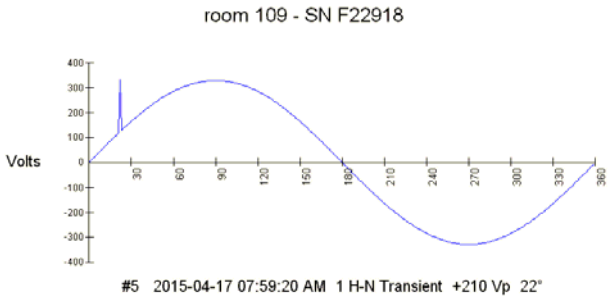

Fig. 3. Exemplary recording of transient event.

Additional measurements

This test relies on generating high voltage surge with maximum voltage level 1 MV and parallel observations of its effect on the power supply voltage and electromagnetic field in considered rooms.

Fig. 4. High voltage surge generator 2.4 MV, passive loop antena EMCO model 6509 and oscilloscope Tektronix TBS1052-EDU.

As a source of high voltage was used high voltage surge generator with maximum voltage level 2.4 MV, but for test it was reduced to 1 MV. Voltage measurement was performed with Tektronix TBS1052B-EDU oscilloscope equipped with attenuator. For electromagnetic field measurement was used EMCO 6509 passive loop antenna. All measurement equipment is presented on fig. 4. This antenna had four switchable measuring ranges: 0,001-0,06 MHz; 0,06-0,4 MHz; 0,4-1 MHz; 1-30 MHz.

Table 2. Collective summary obtained results.

Location	Frequency bandwidth, MHz				Voltage p-p V
	0,001 – 0,06 V	0,06 – 0,4 V	0,4 – 1 V	1 – 30 V	
GE104	73,80	56,80	84,00	260,00	704,00
GE116	0,27	0,39	0,39	2,28	
GE109	2,44	3,92	4,72	15,4	44,00
GE209	16,64	12,00	12,80	70,40	57,60

The measurements were carried out at four locations compliant with previously presented. In each of these was performed observation of changes in the supply voltage, and of the electric field in four bands of the antenna used for measuring. Measured were also reference levels (background) where there was no generated high voltage

disturbances. Collective summary of results is presented in Table 2.

As may be noted in the results shown in Table 1 maximum disturbance were recorded in the two closest locations. In the high voltage laboratory and in room GE 209. The room GE 209 is located on the second floor and from the generator, in addition to the distances of 25 meters, separate it the wall with thickness of 0.3 meter with the grounded metal cover on the laboratory side. Despite this, measured in real conditions disturbances can affect information technology equipment located there, and confirmation of this may be periodic notifications from the hardware user for its wrong action. Help in this situation was to equip the coming line – like power, computer and keyboard cables, with ferrite rings. In case of further rooms, eg. GE 109 and GE 116, measured disturbances was noticeable, but their levels were not significant enough to be able to unambiguously request that they may considerably have negative impact on electronic equipment.

In addition to differences in the levels of disturbances in the respective areas an interesting comparison is the difference in their levels relative to the measurement frequency band. It turns out that the greatest value field disturbances were measured in the range 1-30 MHz. In the other three bands this level was noticeably smaller.

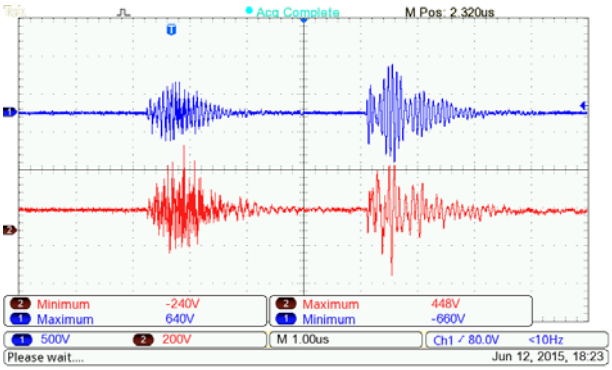

Fig. 5. Room GE 104 - measured electric field pulses in the band 1 - 30 MHz (CH1) and the power line surges (CH2).

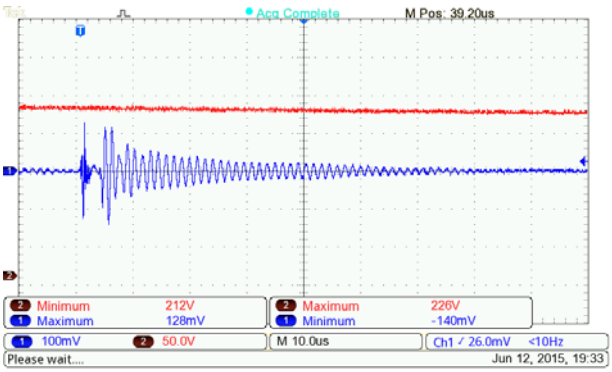

Fig. 6. Room GE 116 - measured electric field pulses in the band of 0.001 - 0.06 MHz (CH1).

The third interesting observation was the number of the observed disturbances, which appeared when a shot from a generator follow. Two overvoltage waves were observed, both in the case of electric field and in the supply line. The first of them characterized in duration from 1.4 to 4 μs and a second with a duration dependent on the currently selected antenna frequency band with the rule: the smaller band range the longer duration. In extreme cases, it was even 64 μs. Exemplary waveforms are shown in Fig. 5 - Fig. 7.

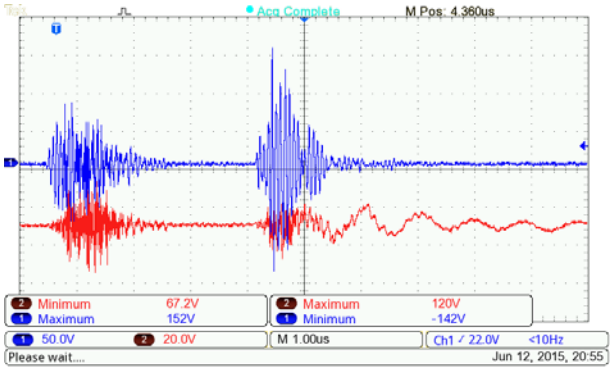

Fig. 7. Room GE209 - measured electric field pulses in the band 1 - 30 MHz (CH1) and the power line surges (CH2).

Conclusions

During the experiment, surveys were conducted in order to verify the probability of disrupting sensitive electronic devices during high voltage testing. For this purpose were selected four sites located at different distances from the source voltage surges generator as well as at different levels. The research was conducted in two stages: long-term monitoring power supply voltage and short-term measurements of electric field and power supply voltage changes when the surge follow. The results clearly demonstrated that in some of the selected location there is real probability to appear unwanted effects in the operation of electronic equipment, even with implemented shielding design. Only install additional resources in the form of ferrite rings has reduced the level of disturbances to a level compatible with the level of immunity existed there device (in this case it was computer [1]). Unquestionable influence on these results had the supply line routing method [3].

It was also observed different amplitude-time characteristics of the disturbances: a greater level of disturbances was observed for the higher bandwidth measurement (1-30 MHz). It follows to necessity of vulnerability analysis on the disorder of sensitive device with suitable frequency and disturbance level, and then selection of protective measures.

Also interesting is the fact that, installed on the walls of a high voltage laboratory grounded metal screen is moderately effective in this frequency band.

These conclusions confirm well known theory about creating protection zones for more sensitive devices, ie. using surge protective devices (SPD) [4].

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