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Experimental Study on The Overvoltage due to Lightning Surge

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Abstract: - Lightning surge damages of low voltage equipments in building are increasing due to increase in electrical and communication networks in the information-oriented society. And electrical circuits with semiconductor are very weak against lightning surge. To achieve effective method of surge protection on low voltage lines, there are needs for the relationship between propagation aspects of lightning surge and arrangement of indoor wire. This paper describes the experimental study on the relationship between them. This result may be raw data for establishment of surge protection system.

Key-Words: - Lightning, Surge, SPD, Travelling wave

1 Introduction

The information and communication appliances such as a personal computer and a facsimile have spread quickly in the information-oriented and computerized society. In addition, the miniaturization, low voltage work, and high-density setting technology of electronic components that form electrical appliances are progressing as well. These electrical appliances in a structure are attached to the grounding conductor, the communication line, the low voltage power supply line, the antenna wire, etc. Consequently, the invasion line of lightning surge has varied. As a result, the lightning damages in various forms, such as an operational interference or destruction of electrical appliances, are growing. In result, the manufacturer of consumer electronics has taken measure to the electrical appliances only. And the standard that low voltage electrical appliances should be protected from lightning. But these are not prepared in Japan yet. In Western Europe, however, a SPD (Surge Protective Device) is necessary in the main distribution board of a structure, based on the IEC standard. It is required to understand overvoltage phenomena due to the lightning surge generated in a structure in order to formulate a measure based on the standard. Nevertheless, it is difficult to use an actual size structure because of the limited space. And examining the effect of various parameters and components for each case is time consuming. Therefore, it is appropriate to perform the study by simulating a simulation structure in a laboratory. Furthermore, the use of a computer program based on simulation model, EMTP, should also be a helpful tool to investigate transient overvoltage phenomena due to lightning surge in low voltage installation.

2 Experiments and Results

This experiment is for the surge electric wave aspect due to the arrangement of indoor wire. In this experiment, the circuit which is able to facsimile the linking condition of general low voltage facilities is composed as shown in Fig. 1.

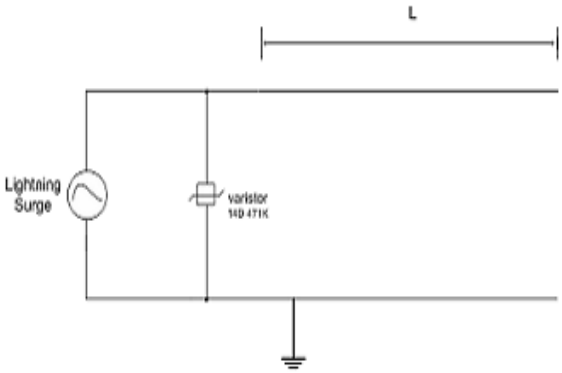

Fig. 1 The experimental circuit

The composition plan of Fig. 1 facsimiles the outlet which is located to the nearest spot from the surface. To find the electric wave aspect due to the

arrangement of indoor wire, the length is variably set by 1,3,5,10,15[m].

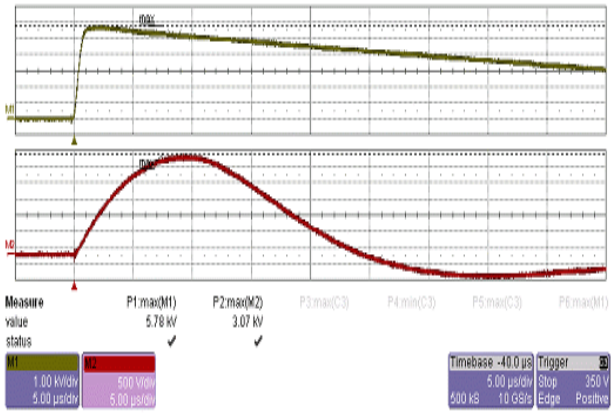

Fig. 2 Output waveforms of surge generator

The surge generators, which are used in this experiment, are IEC 61000-4 series, ANSI C62.41, UL 1449 etc. These are the simulation experimental instruments which are suitable for the international standard related to surge. And these instruments cause the 1.2/50[s] impulse voltage as shown in Fig. 2. By using these instruments, the surge is input to the installed wire in the simulation structure. And the amount of surge voltage in the end wire is measured with high voltage probe and oscilloscope. As changing the length of indoor wire, the output voltage of surge generator input to the wire inlet, and measured the maximum value of voltage in the end wire.

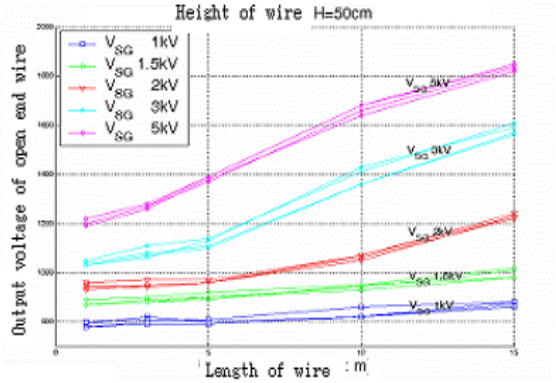

Fig. 3 Ending voltage's aspect according to the length of indoor wire(wire height 50[cm])

The corresponding result is shown in Fig. 3. The measuring voltage at the end of indoor wire increases as the length of indoor wire gets longer. And this aspect is found as a result of Fig. 3. From this experiment result, it is confirmed that the maximum value of ending voltage increases as the length of indoor wire and input voltage increase. Therefore, it is found that the aspect of decreasing the surge voltage restrain effect in the end by increasing of the wire length. The phenomena of travelling wave from the measuring wave could be observed as well.

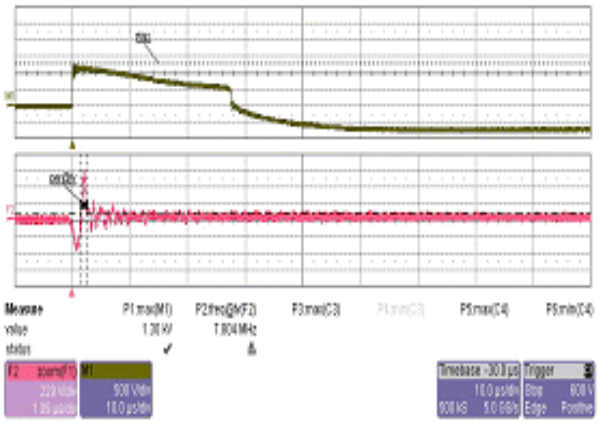

Fig. 4 Traveling wave when wire height 50[cm] and length 5[m]

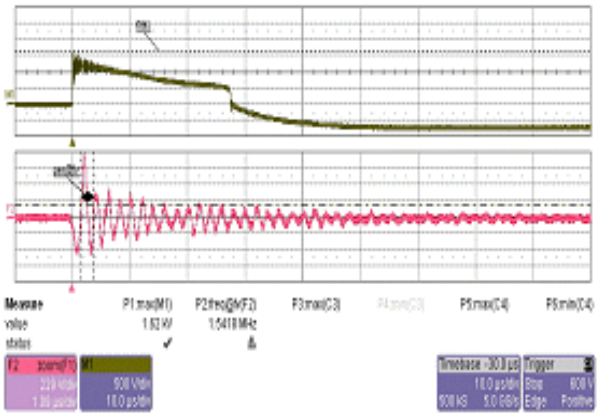

Fig. 5 Traveling wave when wire height 50[cm] and length 10[m]

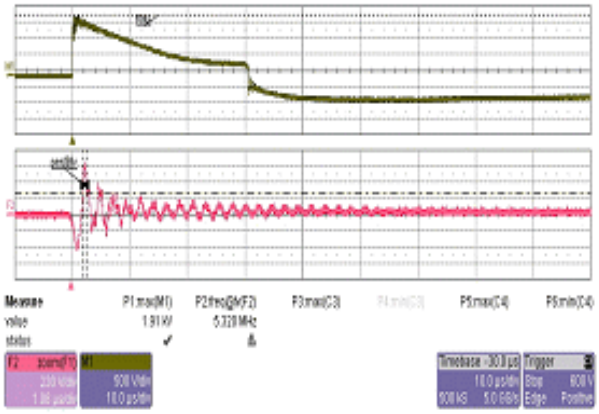

Fig. 6 Traveling wave when wire height 270[cm] and length 5[m]

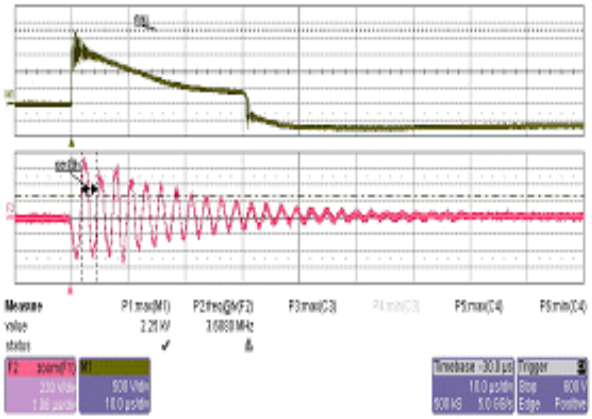

Fig. 7 Traveling wave when wire height 270[cm] and length 10[m]

The corresponding maximum and frequency of travelling wave, which is observed in the opened end wire by this travelling wave is shown in Table 1. From the result of Table 1, it is found that the frequency of travelling wave that measured in the opened end wire is reduced and the maximum is increased. It is according to the length of wire increases. This cause of phenomena is that the coming and going period of travelling wave extends by the wire length. Moreover, the line constant is increased as the height of wire installation increases. Consequently, the frequency of travelling wave which is measured in the opened end wire is decreased and the maximum value is increased.

Table 1. Maximum voltage and frequency of travelling wave at the ending wire

Length \ Height	50[cm]	270[cm]
5[m]	550V 6.42MHz	598V 3.7MHz
10[m]	710V 4012MHz	736V 3.24MHz

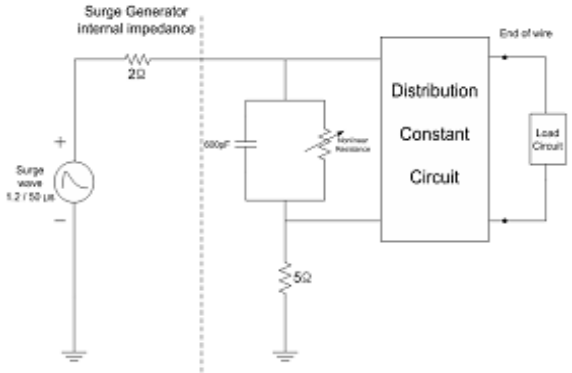

Fig. 8 . Simulation diagram to simulate traveling wave situation

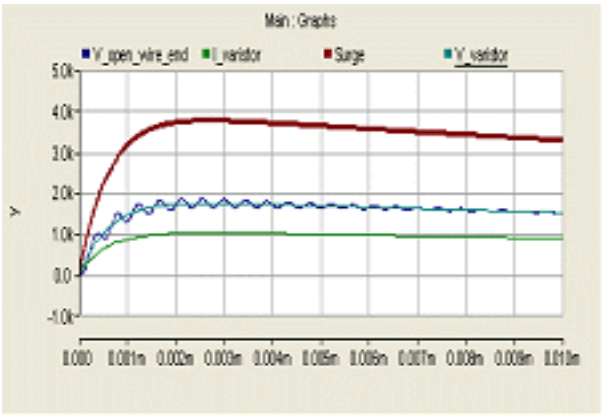

Fig. 9. Simulation result using by PSCAD-EMTDC program

3. Conclusions

In this study, the experiment is performed by changing the length of indoor wire to define the surge wave aspect due to the length of indoor wire. Consequently, the aspect of indoor wire ending voltage is gained because of the length of indoor wire. And the result is obtained as following below. It is confirmed from the experiment result that the lightning surge restrain effect decreases as the length of indoor wire extends. And the lightning surge verified that the travelling wave phenomenon occurs due to the impedance difference of both parts of wire. Moreover, the maximum value of both wire parts voltage by this travelling wave. And it is confirmed that the frequency of travelling wave that is measured in the end of opened wire, is decreased and the maximum value increased by the length of wire extends. Therefore, it is explained the overvoltage protect effect decreases by the SPD (Surge Protective Device) as it becomes more distant from the SPD. The lightning protection counterplan; installing the numbers of SPD or shortening the length of wire as possible etc.; should be provided for the effective lightning protection about communication instrument in indoor. In addition, it is considered that the lightning surge restrain method followed by the height of indoor wire should be established to achieve the facilities construction successfully for the effective lightning protection in indoor.

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