EXPERIMENTS WITH TELECOMMUNICATION LINES AT THE LIGHTNING EXPERIMENTAL SITE OF CACHOEIRA PAULISTA - BRAZIL

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SUMMARY

INTRODUCTION

Lightning discharges can reach a telecommunication system by a direct strikes mechanism, coupling through the earth or coupling through electromagnetic fields. In order to protect the telecommunications systems against the effects of lightning discharges, the Study Group 5 of the International Telecommunications Union (ITU-T) produced a Handbook and a set of Series K Recommendations, which contain texts with requirements, methods and procedures in order to protect the equipment, installations and the associated people from the effects of lightning discharges.

Two specific Recommendations deal with the protection of telecommunication lines using metallic symmetric conductors against lightning induced surges and direct lightning discharges [1] [2].

In order to develop new Recommendations and to upgrade the existing ones, some research activity is being carried out on several subjects, as for example:Shielding effect of metallic cable sheath over the lightning induced surges,

- Protective effect provided by the installation of Surges Protective Devices along a telecommunication line,
- Procedures for the protection of radio base stations of mobile telephony against lightning discharges.

Since 2001, Fundação CPqD and France Telecom R&D under a technical partnership, carried out such research activities on telecommunication systems at the International Center for Lightning Research (ICLR) located at INPE in Cachoeira Paulista - Brazil.

EXPERIMENTS WITH TELECOMMUNICATIONS LINES

Figure 1 shows schematically the experimental lines and the reference points. There are two aerial telecommunication cables of 3 km long installed in separated poles along the lines from Shelter 1 and Cabinet 2. The separation between the lines of poles is around 6 to 8 meters.

The cables are coded CTP-APL, being composed of 50 pairs of symmetric wires, with nominal diameter of 0.40 mm and nominal resistance of 136 Ω/km per conductor. The length of cable 1 (Line 1) is 2625 meters and cable 2 (Line 2) is 2588 meters. The 37 m difference between the cables (1.4%) is due to the irregularities of the terrain.

The philosophy of the experiment is to consider one line as a reference and to make the different changes on the other line.

The major points studied with the experimental lines can be classified into the following groups:

- **Shielding effect of metallic cable sheath**

The aim is to evaluate the shielding effect provided by the metallic sheath for several values of ground resistances for the sheath. During the research activities carried out at the Triggering Lightning Site, it has been possible to collect data regarding the shield effect of the metallic sheath of telecommunication cables against the induced surges due to natural and triggered lightning.

By measuring simultaneously the induced surges on both cables it's possible by comparison to evaluate the shielding effect provided by each configuration. Figure 2 and 3 give respectively the earthing configuration of sheath for cable 2 (Reference) and cable 1.

To illustrate the shielding effect the curves of figure 4 represent the common mode voltage induced respectively on cable 1 and cable 2. For this example of measurement, the shielding factor given by the ratio of the induced voltages VL1/VL2 is around 0,18.

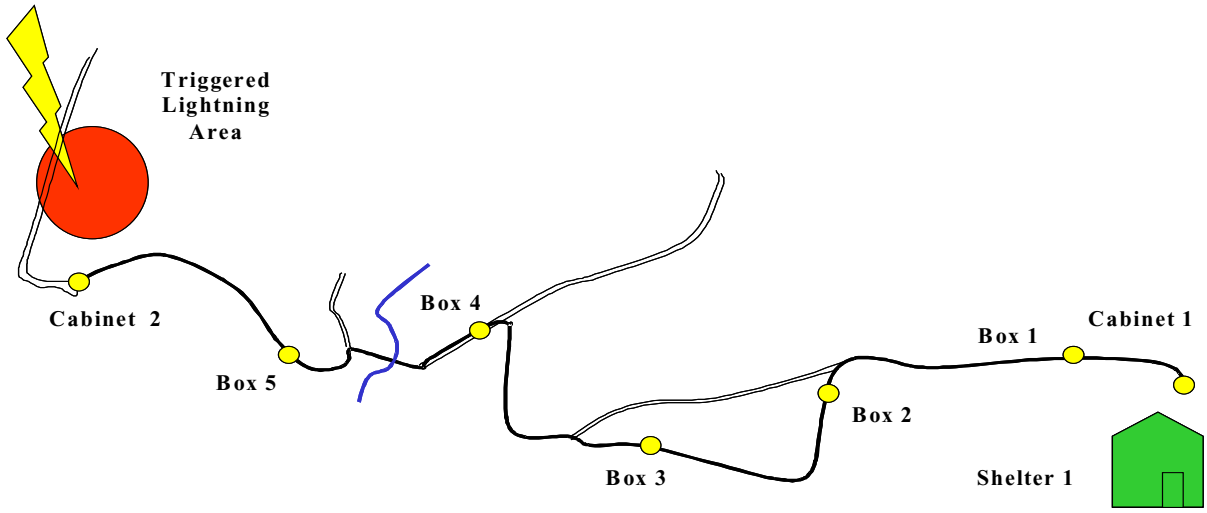

Figure 1 : Experimental telecommunications lines

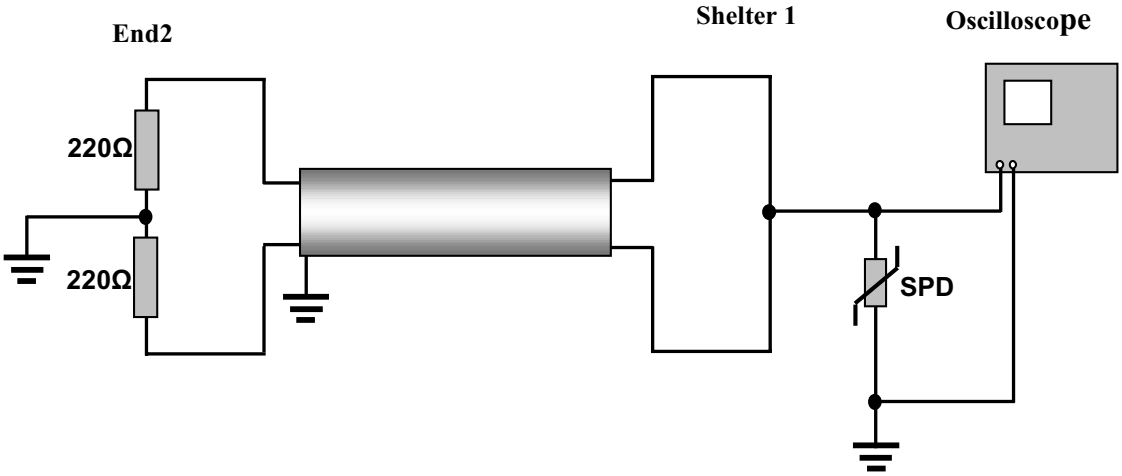

Figure 2 : Configuration of Cable 2 (reference)

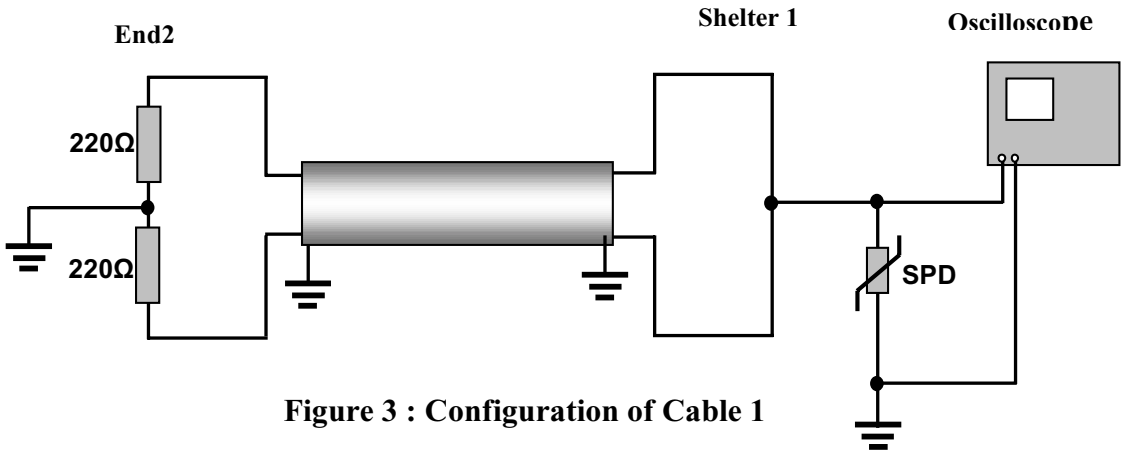

Figure 3 : Configuration of Cable 1

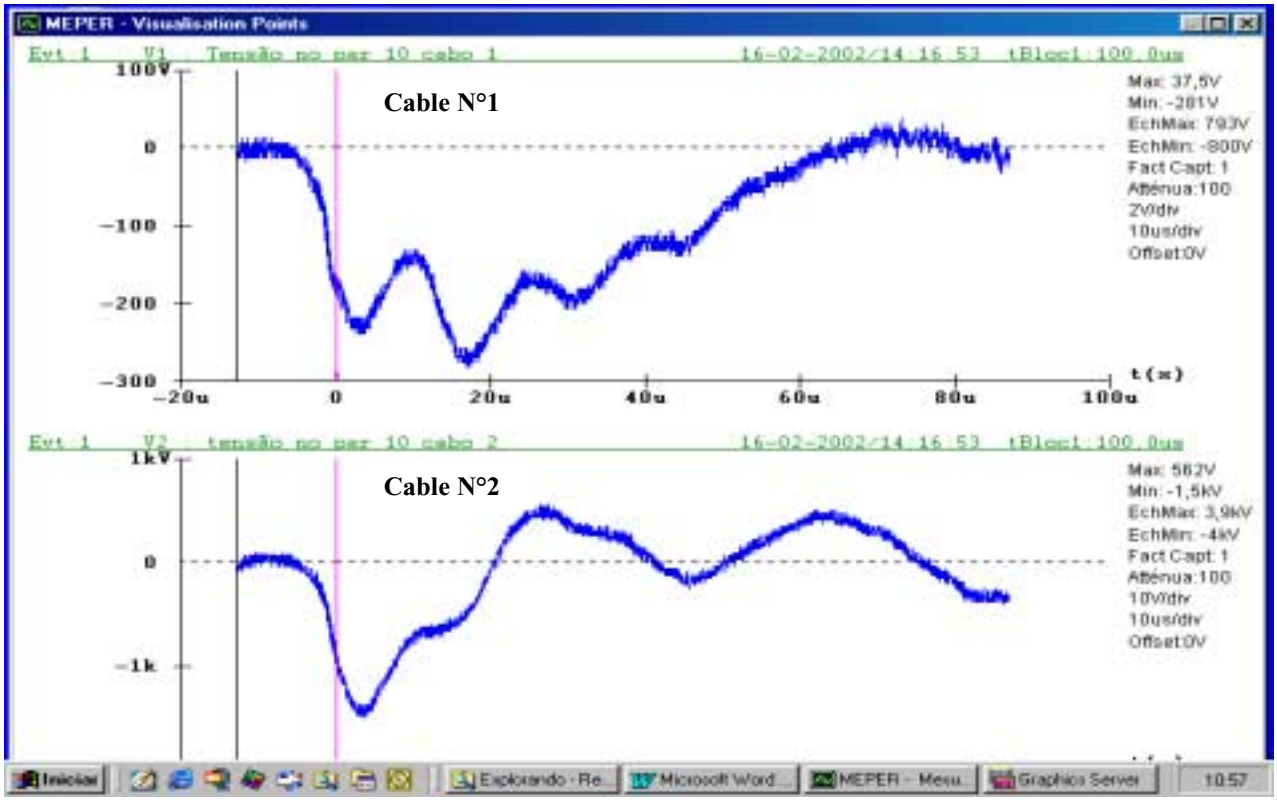

Figure 4: Shielding effect

By analysing 64 measurements of this type, the mean value obtained for the shielding factor is around 0,14.
Regarding all the results, it can be said that the shielding factor can be represented very closely by the refraction coefficient of the line, where the near end earth resistance is the dominant factor. In the great majority of the measurements, the peak values of the induced surges were detected during this "travelling wave" period, while the subsequent period, characterised by the natural oscillations of the line, resulted in lower peak values.

This data shows that the Annex A of the ITU-T Recommendation K.46 needs to be revised in order to better represent the real behaviour of the cable's metallic sheath.
The shielding factor related to earth of a shielded section when the shield is earthed at the end of the section can be evaluated by Equation (1):

$$K_{se} = 2\,R \;/\; (R + Z) \qquad (1)$$

Where:

R : earth resistance of the shield near end [Ω]
Z : surge impedance of the metallic sheath with respect to earth [Ω]

The surge impedance can be calculated by the equation (2):

$$Z = 60 \ln \{ [\, b + 648\, (\rho / f)^{1/2} \,] / r \} \qquad (2)$$

Where:

ρ : earth resistivity [Ω.m]
f : frequency representative of lightning induced surges [Hz]
r : radius of the metallic sheath [m]
b : height of the line (for aerial line) [m]
distance from conductor to earth (for buried line) [m]

Note: It's suggested to use f = 100 kHz.

- **Protective effect provided by the installation of Surges Protective Devices**

The aim of this experiment is to evaluate the effect of surge protective devices (SPD) installed at different points of line by measuring simultaneously the induced voltages on the cable 1 (with SPD) and Cable 2 (without SPD).
Several configurations have been studied in order to analyse the influence of the shield (with and without considering the shield of the cable), the total resistances of the shield grounding and supporting strand grounding.
The experiments are still under way but the results have not being analysed so far. The experiments will be probably finished by the end of April and some results will be presented during conference.

- **Direct strikes in the line**

The aim is to better understand the behaviour of the line when it is submitted to a direct strike. These experiments were postponed for the beginning of the next lightning season (October 2003).

CONCLUSION

The Experiments with Telecommunication Lines at the Lightning Experimental Site of Cachoeira Paulista - Brazil, have been described and the first results, regarding the shielding effect of metallic cable sheath, have been analysed. We have shown that this shielding factor can be represented very closely by the refraction coefficient of the line, where the near end earth resistance is the dominant factor.
The experiments are still under way and the next step is to evaluate also the protective effect provided by the installation of Surges Protective Devices along the lines. The first results on this issue will be presented during the conference

References

[1] International Telecommunication Union (ITU) - Rec.K.46, “The Protection of Telecommunication Lines Using Metallic Symmetric Conductors Against Lightning Induced Surges”, Geneva 2000.

[2] International Telecommunication Union (ITU) - Rec.K.47, “The Protection of Telecommunication Lines Using Metallic Conductors Against Direct Lightning Discharges”, Geneva 2000.