DATA CORRELATION OF A LIGHTNING DETECTION NETWORK TO THE TELECOM SUPERVISION SYSTEM OF A POWER COMPANY AND EVALUATION OF IMPROVEMENTS ON THE LPS OF A RADIO STATION

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1. INTRODUCTION

The FURNAS’ Telecommunication System via microwave is composed of SHF equipment installed in the Central Office in Rio de Janeiro and in the following installations: telecom repeaters, power substations and hydro-electric power plants, whose facilities are very susceptible to electromagnetic disturbances (Nobrega et al. 2000a, 2003). Moreover, the FURNAS’ microwave system is one of the most important telecom systems of the company and comprises more than a hundred sites located in the southeastern and midwestern regions of Brazil. This system is used for communication, control, supervision and protection of the FURNAS’ electric power system, composed of 10 Hydro-power plants, 43 power substations and around 19,000km of transmission lines.

The geographic location of some microwave sites and its high resistivity soil can make them very susceptible to lightning strikes. Mainly because of induced voltages and differences of potential along the earth grid. Moreover, high transient currents represent a threat to the operation of electric power systems, whose reliability depends on the availability of microwave radio stations. Thus, the strategic role of the FURNAS’ telecom system on the operation of the brazilian electric power system requires the implementation of reliable lightning protection procedures.

In this article, one of the most critical telecom sites of FURNAS, named as Macela station (23°8’24”S, 44°48’54”W) will be considered. It was built next to the frontier between Rio de Janeiro and São Paulo states and at an altitude of 1,800m above the sea level. Furthermore it was built in a region with a high incidence rate of lightning strikes and with high values of transient currents, whose soil presents a high resistivity of 30,000ohm.m (Serqueira et al. 1988). Thus, enhancements on the earthing system, which represents a fundamental item concerning lightning protection, are very difficult to be achieved.

Although the characteristics previously mentioned, improvements on the lightning protection system of the telecom system have been implemented since 1994 (Nobrega et al. 2000b).

The incidence of lightning strikes nearby a telecom station can be detected by the brazilian Lightning Location System (RINDAT), whose sensors are located around the country. In this article, the RINDAT database is correlated to the FURNAS’ Telecom Supervision System (SST) from 2001 to 2005. The SST monitors a group of approximately 80 microwave radio stations, whose equipment collects sensors’ data and send it to the Central Office in Rio de Janeiro. Previous data correlations were published in the technical literature by Nobrega et al. (2004) and Soares et al. (2005).

2. IMPROVEMENTS ON THE LPS OF THE RADIO STATION

2.1 Characteristics of the LPS

The lightning protection system (LPS) of the Macela station is composed of lightning rods installed on the top of a 19m telecom tower, whose down conductors are connected to the earth grid. Additionally, lightning cables are installed on the building roof and connected to the earth grid by down conductors. The earth grid is composed of radial cables and grounding rings installed around the building, as shown in Figure 1.

The telecom station under analysis is fed by a power transformer, 13.8kV/220-127V, 30kVA, installed in a pole located beside its building.
The previous surge protection system was composed of:

(a) Zinc oxide surge arrestors installed in the primary side of the Power Utility transformer (between the phase conductor and a point of the earth grid next to the pole);

(b) Zinc oxide varistors installed in the principal breaker box connected to the power transformer pole (they were connected between the phase conductor and the grounding cable of the chassis);

(c) Zinc oxide varistors installed in the existing Surge Protection Box, named as QPR1 (they were connected between the phase conductor and a grounding bar inside the box, which was isolated from the box’s chassis).

The previous configuration of grounding and surge protection is shown in Figure 2.

2.2 Implemented improvements

The improvements on the LPS of Macela station were made in the period 2001-02. The goal of these improvements was the reduction of damage to sensitive electronic equipment and the decrease of the number of EPS activations due to lightning. The new configuration of grounding and surge protection is shown in Figure 3.

The existing varistors were substituted by others with a higher peak current capacity (40kA). They were installed between the phase conductor and the neutral cable and inside the principal breaker box and the surge protection boxes. Additionally, a new surge protection box named as QPR2 was installed in the station.

The neutral cable was connected to the earth grid of the station inside an inspection box at the entrance of the building. Furthermore, other cables were connected to this grounding point: The grounding cable attached to an isolated bar inside
the surge protection box and an additional 2/0 AWG copper cable from the reference grounding bar inside the station.

According to the new surge protection configuration, the terminals of varistors connected to the neutral cable would be connected to different points of the earth grid. Then, a path of low inductance was necessary for the connection of these points. This was achieved by the installation of a metallic strip between the two selected points of the earth grid: one of them inside the inspection box and the other one next to the power transformer pole. The installed copper strip had the following dimensions: 8m x 100mm x 2mm. Additionally, it was buried 400mm deep in the soil and welded to the earth grid at the extremities.

The following difficulties at Macela station were overcome:

(a) Adverse characteristics of the region: a high incidence rate of lightning strikes with high values of transient currents, and a high resistivity soil;

(b) A share of the grounding system and the Power Utility transformer with other companies;

(c) Lack of data related to the project of the earth grid, which was built in the 1980 decade.

3. DATA CORRELATION

The database of the FURNAS Telecom Supervision System (SST) was correlated to lightning records stored in the brazilian Lightning Location System (RINDAT network) in the period 2001-05. The goal of this correlation is to confirm the achievements on the grounding and lightning protection system of the Macela station, implemented in the period 2001-02.

The FURNAS' Telecom Supervision System (SST) is an automatic system, which monitors the operation of equipment installed in microwave radio sites, like equipment failures and power interruptions. It is composed of two microcomputers and a group of 80 remote units installed in microwave radio stations. The Remote units collect data concerning power interruptions and equipment malfunction with the aid of local infrastructure sensors. Then, The acquired data is transmitted by a microwave link to the Central Office in Rio de Janeiro, where it is stored in two microcomputers. About 96 tele-signals and 8 tele-measurements are available. Additionally, these remote units can activate a number of 10 to 16 tele-

commands. These tele-signals and tele-measurements are periodically collected and the resultant records are stored in the SST database. Later, the records can be used for statistical analysis of power interruptions on the FURNAS' telecom system and damages to equipment. Moreover, the database can be easily analyzed using commercial software. At the present time, technical analyses are being developed for implementation of a new telecom supervision system, which will substitute the existing system.

The RINDAT network is the third largest Lightning Location System in the world. It resulted of a technical partnership which includes FURNAS and other power utility companies. Lightning sensors share data about thunderstorm location, estimated lightning characteristics and location of cloud to ground lightning strokes using geographic coordinates (RINDAT, 2006). They detect the electromagnetic field radiated from the return stroke and correlate them to the characteristics of a standard signal locally stored. After the discrimination of signals, the resultant data is transmitted to a Central unit by a dedicated telecommunication link. Then it is processed and distributed to display units. The location of RINDAT sensors are shown in Figure 4. Additionally, some sensors next to the telecom station are shown in Figure 5.

Lightning strokes were detected inside four circular regions, whose center coincides with the geographic coordinates of the telecom station. The following radii were chosen: 1, 2, 5 and 10km.

![Figure 4. Location of RINDAT sensors.](image-url)

Data correlation was made according to a data survey on the SST technical reports. Only those
reports possibly related to lightning strikes were selected, regarding the technical experience of the authors. Then, the number of days related to damage to equipment was correlated to RINDAT data and to the acquisitioned data of a sensor, which monitors the activation of the Emergency Power System (EPS).

Table 1 shows the resultant data correlation of the EPS activation sensor to the technical reports of the SST related to damage to equipment. On this table, it was considered the number of days which coincided with lightning strokes stored in the RINDAT database.

<table>
<thead>
<tr>
<th>Year</th>
<th>EPS Activation</th>
<th>Damage occurred(*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>01</td>
<td>01</td>
</tr>
<tr>
<td>2002</td>
<td>03</td>
<td>03</td>
</tr>
<tr>
<td>2003</td>
<td>01</td>
<td>01</td>
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<tr>
<td>2004</td>
<td>01 01</td>
<td>02</td>
</tr>
<tr>
<td>2005</td>
<td>01 01</td>
<td>02</td>
</tr>
</tbody>
</table>

(*) Number of days in which damage to equipment occurred possibly due to lightning.

4. DATA CORRELATION ANALYSIS

According to Table 1, the number of days in which the EPS activation occurred, possibly due to lightning, was reduced from 3 days in 2002 to 1 day in 2003. This result was achieved after the implementation of improvements on the lightning protection system of Macela station (EPS activations in 2002 occurred before the conclusion of them). In the period 2001-03 the number of days concerning EPS activations coincided with the number of days related to equipment damage probably due to lightning. Moreover, the acquisitioned data from the EPS activation sensor coincided with the RINDAT records regarding the number of days and the date of occurrence of EPS activations. This result is in accordance with the technical experience of the authors, because damage to equipment due to lightning is generally associated with EPS activation. Thus, the installation of a reliable EPS system in a critical telecom station has been a mandatory procedure.

According to technical reports of the SST, the EPS system was also activated four times in 2004, but not related to damage to equipment. In this case, the corresponding dates of lightning occurrences were correlated to records stored in the RINDAT database (the same circular regions of 10km around the station were considered). According to RINDAT records, lightning strokes were detected inside a piece of land between two circular regions with 2 and 10km of radius as shown in Figure 6. The incidence of lightning strokes near the power transmission lines of the Power Utility probably caused EPS activations due to power interruptions. Furthermore, resultant induced surge waves along the power lines did not cause damage to equipment connected to the alternate current power supply, due to the previously mentioned improvements on the lightning protection system.
sparks are developed inside the installation room during severe lightning strikes in the LPS system.

4. CONCLUSIONS

The improvements on the lightning protection system of Macela station increased the availability of FURNAS’ telecom system, which is strategic for the operation of the Brazilian electric power system.

The following results were achieved:

(a) Reduction of the number of days related to damage to telecom equipment due to lightning. Specially, on modules of equipment fed by an alternate current power line.

(b) Decrease of maintenance expenses and reduction of EPS activations, which diminished the amount of fuel consumed by the emergency power engine.

The installation of new sensitive equipment in telecom stations requires new studies on grounding and lightning protection systems. Then, a research on the lightning protection system of FURNAS telecom stations has been developed by the Lightning Research Center from 2003 to 2006, whose partial results were previously published in the technical literature (Visacro, S. et al. 2005).

5. REFERENCES


6. ACKNOWLEDGEMENTS

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