

LIGHTNING PROTECTION OF SPECIAL TOWERS IN AMAZONIA

G. A. D. Dias¹, F. V. Sonalio¹, L. C. F. da Silva¹, H. L. Blauth, A. Eybert-Berard, J. Pissolato F^o
 Pontificia Universidade Católica do Rio Grande do Sul, Av. Ipiranga 6681, Porto Alegre, RS, Brazil
 HINDELET, Novo Hamburgo, RS, Brasil
 Universidade Estadual de Campinas, Barão Geraldo, Campinas, SP, Brasil

Abstract: The LBA project needs to install towers in the middle of the Brazilian Amazon Rain Forest and also have to protect them against direct lightning strokes. So, we present in this paper, studies done to protect the towers against direct lightning strokes, the grounding system used to discharge the lightning current in these stations and also the studies of ElectroMagnetic Compatibility (EMC) to protect the electronic devices when induced and/or conducted voltage is generated in the control cables due to direct stroke in the shielding system of each tower.

INTRODUCTION

The LBA, Large Scale Biosphere-Atmosphere Experiment in Amazonia, is an international research initiative led by Brazil. LBA is designed to create the new knowledge needed to understand the climatological, ecological, biogeochemical, and hydrological functioning of Amazonia, the impact of land use change on these functions, and the interactions between Amazonia and the Earth system.

In LBA emphasis is given to observations and analysis which will enlarge the knowledge base for Amazonia in six general areas:

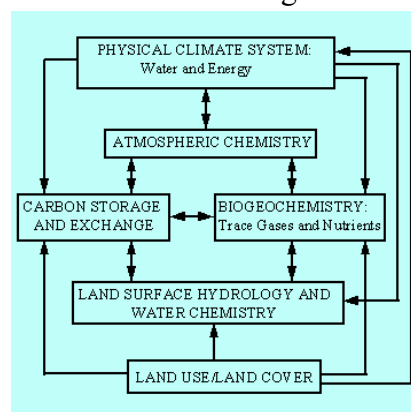


Figure 2 – LBA covered areas

the rain forest.

The equipment listed before are part of the structure of LBA. The towers started to be hit by lightning strokes and several sensor started to burn. Due the difficult access to the region where the towers are, protections against these effects must be set.

The LBA project is a fellowship of INPE – Instituto Nacional de Pesquisas Espaciais (National Institute of Space Research) and NASA–National Aeronautic and Space Administration.



Figure 1 – LBA Project map and logo

Physical Climate, Carbon Storage and Exchange, Biogeochemistry, Atmospheric Chemistry, Hydrology, and Land Use and Land Cover. The program is designed to address major issues raised by the Climate Convention. It will help provide the basis for sustainable land use in Amazonia, using data and analysis to define the present state of the system and its response to observed perturbations, complemented by modelling to provide insight into possible changes in the future.

The data for the analysis are being obtained from measurement equipments (sonic anemometer, anemoscope, pluviometer, solar panels, thermometers, etc.) installed in instrumented towers placed in the middle of

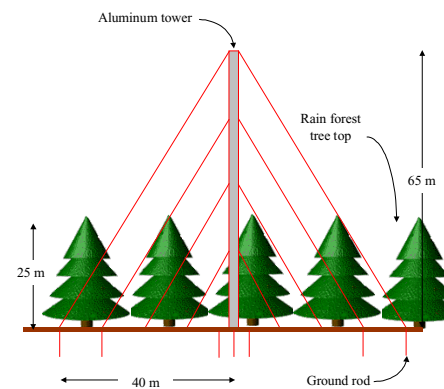


Figure 3 –The towers.

LIGHTNING STRIKES ON THE REGION

Nowadays on Brazil the data acquisition for the determination of the keraunic level is made by three different systems, the BLDN, Brazil Lightning Detection Network, placed on Rondonia, the exactly same state where are located the LBA tower; the SLT, Storm Location System, on the South-east region; the SIMEPAR, Parana Meteorological System, located on the South region of the country. The Figure 4, shows the location of the three systems and the GFD-Ground Flash Density map of Brazil.

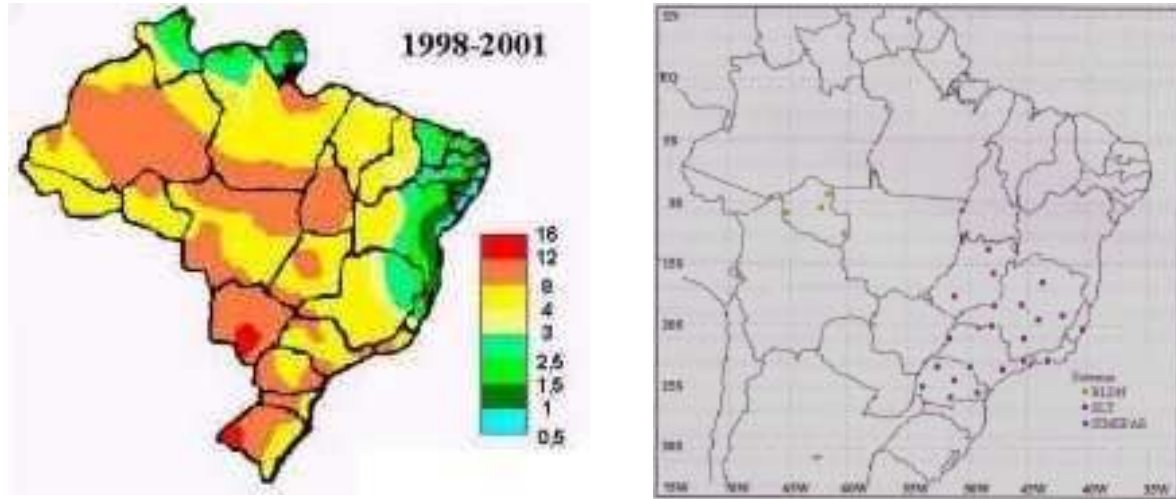


Figure 4 – GFD Map from Brazil and the location of the BLDN, SLT and SIMEPAR

With the isokeraunic map it was calculated the GFD-Ground Flash Density of the region resulting in a range of 4-12 stroke/km²/year.

SOIL MODEL

The soil model used to evaluate Rondonia grounding systems is presented below, and uses the sum of minimum phase shift parcels, W_j .

$$W = \sigma + I \varepsilon \omega \quad (1)$$

Where: σ : conductivity;
 ε : permittivity;
 ω : $2 \cdot \pi \cdot f$, f being the frequency

$$W = \sum_{j=0}^m W_j \quad (2)$$

Apart from slow phenomena and hysteresis type phenomena, soli behavior is, typically, of minimum phase shift type. For a great number of soils, on frequency range (0, 2MHz), in a first approach, it is:

$$\sigma = a + b \omega^\alpha \quad (3)$$

$$\omega \varepsilon = c \omega^\alpha \quad (4)$$

Where a , b , c and α are Constant parameters (frequency independent). For the Rondonia region the resulting soil parameters were:

$$A = 84.16 \mu\text{S/m}$$

$$B = [0.057849 + j0.12097] (\mu\text{S/m}) s^\alpha$$

$$\alpha = 0.71603$$

Which resulted in $\rho = 11882 \Omega \cdot \text{m}$, constant.

THE STRUCTURE

These towers are constructed with metallic structures, erected with modules in aluminium tubes, with a square section (2m x 2m) and about 65m high with meteorological system, sensors, placed distant from the tower (about 2 to 4.5 m), vertically and horizontally. The Figure 3 shows the representation of the towers.

LIGHTNING PROTECTION

As said before on the paper, every tower has several equipment installed and to have a tower damaged by strikes would cost several dollars and precious time. In fact, LBA had two of its towers hit by strikes and they spent US\$ 80,000.00 in one station and US\$140,000.00 on another.

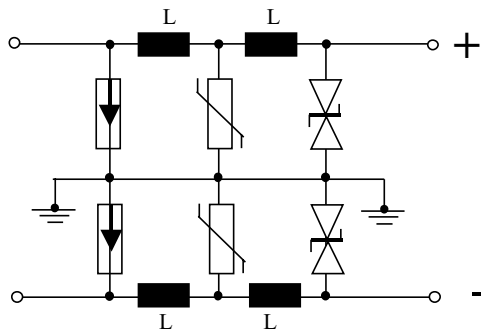


Figure 5 – Equipment Protector

Because of that, it was chosen to utilize IEC Protectors Class C and the following criteria:

- Three level systems were used to deal with low response times and large energies;
- All system was isolated from earth through surge suppressors.

For the protection of the equipment, the structure showed on the Figure 5, was utilized: two sparkgaps, two zinc oxide varistor and two Transzorb.

GROUNDING AND BONDING

The ground systems in each tower must agree with the following criteria:

- The ground impedance must be kept at a very low value (economically feasible) and in tower must be installed many ground conductors to deviate the lightning to the soil. The existence of these ways is important to decrease the voltages generated by one direct strike.
- The evaluation method must use the best computational tool available.

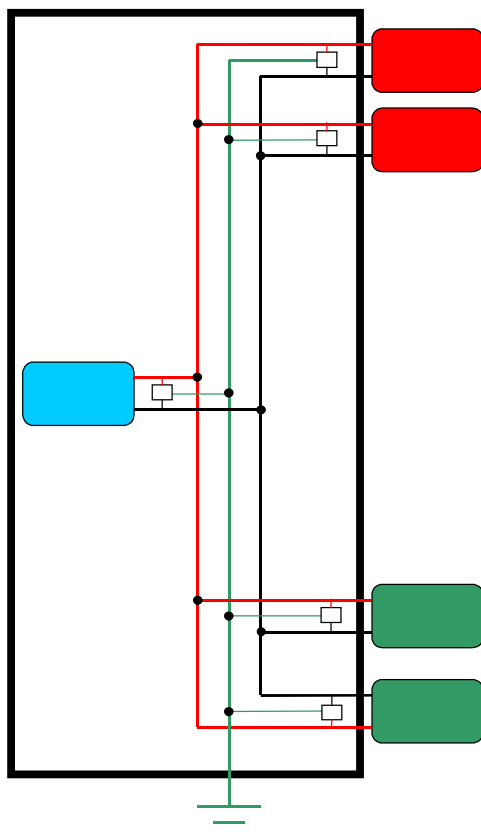


Figure 6 – Representative of the equipment protectors

The figure 4 shows the position and a schematic connection of the equipment protectors on the LBA towers. The big box with the thick line represents the tower metallic structure, the colored boxes represents the connected equipment, in green we have the equipments situated in the tower feet, in opposition we have the red boxes representing the equipments on the tower top and, finally, in blue we have the batteries and the voltage regulators that despite the other are located inside the tower. The small white boxes represent the protector of each equipment, detailed on figure 6.

The green line represents the ground conductor, the red line represents the positive conductor and the black one represents the negative conductor.

For the grounding, was implanted around the tower base, a grounding ring approximately square of 6m, with 8 copperweld grounding rods. This ring is

connected to the tower base in its 4 edges. The two guys more distant of each edge were, also, grounded with the same rods, Figure 3.

CONCLUSIONS

The protection of a LBA tower on Amazonia for lightning strikes as the grounding and bonding system are not easy tasks to do. Due to the protection of the rain forest tree roots, the grounding ring and the linear counterpoise could not be installed, because it could endanger the species of that region. All the installations have to be project considering that none tree or even a tree root can be moved or removed.

But its guaranteed that since the installation to nowadays, the performance of lightning protection system and grounding system presents satisfactory results.

ACKNOWLEDGEMENTS

We are grateful to Mr. Luís Fernando Heine and Mr Arnaud Lefort, respectively from HINDELET and INDELEC, for their financial support, and Dr. Osmar Pinto Jr and Dr. Antônio Ocimar Manzi, both from INPE-Instituto Nacional de Pesquisas Espaciais (Brazilian National Institute of Space Research), for their valuable information.

REFERENCES

Dias, G. A. D. & task force, "Protection against direct lightning strikes of buildings in the metropolitan train in the area of POA", *Proceedings of the V SIPDA - International Seminar on Lightning Protection*, pp 240-245, Santos, Brazil, 2001.

Dias, G. A. D., Haffner, S., Telló, M., "Blindagem de Instalações Elétricas Contra Descargas Atmosféricas Diretas Empregando Métodos Probabilísticos", *Proceedings of the III SIPDA-International Seminar on Lightning Protection*, São Paulo, SP – Brazil, 1994.

Golberi S.; Silveira, Jony L.; Raizer, Adroaldo; Dias, Guilherme A. D. and Telló, Marcos, "Análise de malhas de aterramento com o Método TLM (Transmission-line Modeling Method)", *Proceedings of the CBMag'2000 - Congresso Brasileiro de Eletromagnetismo*, Natal, RN – Brazil, 2000.

ANSI/IEEE C62.45-1987, IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.

The LBA concise experimental plan and homepage: <http://lba.cptec.inpe.br/lba/indexi.html>

C.M.Portela, M.C.Tavares,Pissolato F.J."Quasi modos Frequency Dependent Three-Phase Transmission Line Model - Analyzing the Earth Conductivity Influence to Electromagnetic Transient Phenomena. IEEE PES - Jan 23 - 27/2000 - Singapore.

IEC 61024-1 Ed. 1.0, Protection of structures against lightning - Part 1: General principles

IEC 61312-1 Ed. 1.0, Protection against lightning electromagnetic impulse - Part 1: General principles