Abstract: This paper presents some methods and results of field measurements of lightning effects in a typical base station of global system for mobile communication. A direct lightning stroke to the antenna tower has been modelled by surge generator connected to the tower. The paper concentrates on surge currents distributions in conducting parts of the tower structure and the equipotential bonding system of the container. In considerations, effects of different surge current shapes as well as grounding system have been also taken into account.

Keywords: lightning current distribution, lightning protection, global systems for mobile communication.

1. INTRODUCTION

It has been shown by field experiences that radio communication stations are one of the preferential points for direct lightning strikes. This is mainly connected with the specific features of their construction i.e. the presence of high communication towers and their topographical location – mostly at an open area or at hills. Moreover there might be often limited possibilities of applying the lightning protection elements on towers or specific conditions or requirements for grounding systems.

In most cases, serious lightning failures in radio communication stations are caused by direct lightning stroke either to the low voltage power line near the radio station or to the communication tower or mast. Because of high altitude of placing radio transmission antennas, lightning strokes to the structures supporting the antennas are relatively frequent.

In such a case the effects of lightning are twofold. The lightning current flowing thorough the conducting parts of the whole structure and associated grounding system creates high voltage differences between conductors. This cause a direct and very serious danger, particularly for equipment connected to the grounding system. Some parts of this current may flow directly through the cabling systems into the radio-transmission equipment. On the other hand, the same lightning current creates strong electromagnetic pulses, which can generate large over-voltages and overcurrents in wires of electric and electronic systems.

The problem of either numerical simulations as well as field modelling of lightning influence is quite difficult because it is impossible to take into consideration all the phenomena and to ensure the conditions that exist during real lightning. However numerical simulations and field modelling together are the most effective way for evaluation the possible effects of lightning. In field modelling, for example, it is practically impossible to eliminate the influence of the test circuit, but it can be estimated by numerical simulations.

This paper presents some methods and results of investigations of surge currents distributions in conducting elements of a typical base station for mobile communication systems. In the study a direct lightning stroke to the antenna tower has been assumed and modelled by a surge generator connected to the tower. The surge currents in various points at the station have been measured.

2. MEASUREMENT TEST SETUP

The investigations were performed for a typical base station (fig. 1) of global system for mobile communication consisted of a 50m high, 3-leg, steel tower and a 3.8m long, 2.5m wide, 3m high container. The station was fully equipped and working.

Fig. 1. General view of the investigated base station
For simulations of a direct lightning stroke to the tower it is necessary to inject the surge current at a higher parts of the tower. It is, however, quite a difficult technical task to connect the surge generator to the top (50m above ground) leading the generator’s conductor possibly far away from the tower. A reliable compromise is to connect the surge generator at relatively low altitude, up to 20m, as it is shown in figure 2a). However it is not a sufficient model of the lightning stroke. According to the lightning protection zone concept this altitude meets the boundary of protection zone already for the I protection level (the radius of the rolling ball according to IEC 61024-1 is 20m) and is under the boundary of protection zone for the remaining protection levels.

Another possibility is to lead the generator’s conductor along with the tower as it is shown in figure 2b). In this case, in turn, the influence of the test circuit is larger. The best way is to use a shielded cable, but for estimating its influence by numerical simulations it is even easier to simulate a non-shielded one.

In these investigations, for connecting the surge generator to the tower, the antenna grounding conductor (Cu – 50mm²) running along the middle supporting leg of the tower was used (see figure 2b). This grounding conductor was isolated and connected to the antenna and the tower structure at the top of the tower at about 45m above ground. For the test purposes this conductor was disconnected from the grounding system at the bottom of the tower and connected to one terminal of the surge generator directly or by 10 or 50Ω resistor. In this way a direct lightning strike to the antenna was simulated.

For possible equal distribution of the test current in the earth, four separate return conductors were used to connect the other terminal of the surge generator to four points around the station. Two scenarios of connecting the other terminal of the surge generator were considered:

(1) The other terminal of the surge generator was connected by four isolated conductors (Cu – 10mm²) to four points of the station fence at which the fence was connected to the grounding system (see figures 3 and 6).

(2) The other terminal of the surge generator was connected by four isolated conductors (Cu – 10mm²) to four 75cm steal rods driven into the ground in some distance behind the station fence (figure 4).

For the purposes of further numerical verifications, the resistance of the station grounding system and the soil resistivity were measured. The resistance of the station grounding system with respect to remote ground, measured at the frequency of 280kHz amounts to about 6.7Ω and the soil resistivity was about 1600Ωm.

Different waveforms of the test current surge with approximately double-exponential shape were used:

- 12/50μs/210A or 8/50μs/84A – for scenario (1);
- 1.2/50μs/16A – for scenario (2).
For currents measurements, Tektronix probes P6021 of a band of 8.5 kHz – 100 MHz were used and the data were registered by the 100 MHz oscilloscope HP 54600B connected to the computer. The measurement equipment is shown on figure 5.

Fig. 5. Surge current measurements in equipotential bonding system of the container

3. MEASURED RESULTS FOR SCENARIO (1)

Figure 6 presents an overall top view of the base station together with the test circuit layout for scenario (1). On the figure, the measured amplitudes of surge currents in the terminals of the surge generator as well as currents flowing to the grounding system from the tower’s legs at the base of the tower are marked. As it is seen from the figure the currents distribution is very unequal. Example time domain current measured at the tower’s leg no 2 is presented in figure 7.

Fig. 6. Test circuit layout and the measured current distributions for scenario (1)

Fig. 7. Measured time domain current in the tower’s leg no 2

Further, some currents in grounding conductors at the entry of the antenna cables to the container were also measured. The results are presented in figures 8 and 9. An equipotential bonding conductor and six antenna cable grounding conductors are connected to the ground-bar at the entry to the container. The equipotential grounding conductor links the middle leg of the tower with the ground-bar, which is connected directly to the grounding system at the entry to the container as it is shown in figure 8. This figure presents also the measured amplitudes of surge currents in one of the antenna cable grounding conductors, in the equipotential bonding conductor and in the grounding conductor of the ground-bar. The time domain current in the equipotential bonding conductor is shown in figure 9.

Fig. 8. Amplitudes of surge currents in one of the antenna cable grounding conductors and in equipotential bonding conductors at the entry to the container

Fig. 9. Time domain current in equipotential bonding conductor at the entry to the container (see fig. 8)
The general view on currents distribution in equipotential bonding system inside the container is presented in figure 10 (the amplitudes of surge currents) and an example time domain current in grounding conductor of the exchange equipment is shown in figure 11.

![Figure 10: Surge currents distribution in equipotential bonding system of the container](image)

![Figure 11: Time domain surge current in grounding conductor of the exchange equipment](image)

It is seen from figure 8 that the total current drained off to the grounding system from the antenna cables coating at the entry to the container amounts to about 5.2% of the total current injected into the top of the tower. About 3.3% of the total current flows into the container through the antenna cables coating.

Relatively high current (about 3.9%) flows to the main ground-bar inside the container from the copper equipotential bonding strap running along three walls of the container. In spite of the equipment connected to this strap as it is shown in figure 10, there was a cable rack running under the ceiling about 0.5m above the strap, which was as well connected to this strap at three points.

Relatively high current (4% of the total current) flows also to the main ground-bar from the power supply.

**4. CONCLUSIONS**

In this paper the methods of investigation of surge currents distributions in conducting elements of a typical base station of global systems for mobile communication have been presented. In considerations various ways of modelling a direct lightning strike to the tower have been taken into account. The direct lightning stroke to the antenna tower has been modelled by a surge generator connected to the tower.

For obtaining possibly equal distribution of the surge currents in the earth, four return conductors of the generator were used during the measurements. These conductors were connected according to two different scenarios for the purpose of evaluating the influence of the soil. In scenario (1) these conductors were connected to the station fence at points where the fence is connected to the grounding system and in scenario (2) the generator return conductors were connected to four steel rods driven into the ground in some distance behind the station fence.

Some field measurement results in the investigated base station for scenario (1) have been also presented.

The surge currents in various points at the station have been measured. Up to about 4% of the total surge current might flow to the main ground-bar from particular piece of equipment inside the container. The total current flowing to the ground from the main ground-bar of the container amounts to over 13% of the total surge current.

The measured results will further be the basis for verification of numerical simulations of lightning effects in order to evaluate the simulation methods and to extend these methods for the cases that cannot be modelled experimentally.

**REFERENCES**


