# Method of GSM Broadcasting Station Grounding System Analysis – Measurements and Calculations

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**Abstract**: This paper was undertaken in order to verify configuration of the existing GSM broadcasting station grounding system. Real measurements were made. Presented method was supported by computer simulation. This method is useful to approximate touch and step voltage during lightning strikes for personnel within the GSM broadcasting station area. Method base on up-to-date system data, appropriate measurement techniques and instrumentation, and state-of-the-art computer modeling methods.

**Keywords**: GSM, grounding system, measurements

## 1. Introduction

The safety is the primary function of grounding. Grounding systems are designed so that they do provide the necessary safety functions. Grounding also have other functions in some applications but the safety should not be compromised in any case. Grounding is quite often used to provide common ground reference potential for all equipments but the existing building grounding systems might not provide good enough ground potential for all equipments which might lead to ground potential difference and ground loop problems which are common problems in GSM base stations.

Most GSM engineers must regularly deal with design and operational problems whereby of the lightning currents following along undesirable paths result in various effects ranging from minor annoyances to spectacular failures. A significant number of these subjects are related to grounding and electromagnetic interference. A good understanding of these subjects and appropriate engineering software tools is critical to every GSM utility which is concerned with the safety and reliability of its system and its responsibility towards the public and its employees. The following paper underlines the importance and the adequacy of the grounding and electromagnetic interference to humans and devices safety.

## 2. GSM broadcasting station description

GSM broadcasting station structure depends on the terrain shape and GSM operator specifications. The infrastructure of typical GSM station basically consists of the following systems: container, hybrid power system, masts and antennas.

Analyzed typical 60m high GSM broadcasting station is connected to the grounding system which consists of two grounding rings connected to another grounding ring, which is the grounding of the container of the electronic devices and associated grounding of the fence.

The container is lined with a sound absorbing wall. A feeder rack connects the equipment in the container to external equipment and antennas. The container is equipped with heating or air conditioning equipment. A hybrid power supply system. The equipment is supplied by external power, directly from MV/LV transformer.

**Figure 1: GSM broadcasting station – real photo**

Masts and antennas for satellite communications are installed beside the container. Construction can be easily modified. The masts can be 15, 25, 50 or 60 meters, self-supporting or equipped with bardunes [1].

### 3. GSM broadcasting station grounding system measurements

Soil resistivity measurements was made by injecting current into the earth between two outer electrodes and measuring the resulting voltage between two potential probes placed along a straight line between the current injection electrodes.

When the electrodes are close together, the measured soil resistivity is indicative of local surface soil characteristics. When the electrodes are far apart, the measured soil resistivity is indicative of average deep soil characteristics throughout a much larger area.

Traverse of soil resistivity measurements, using Wenner method, shows figure 2.

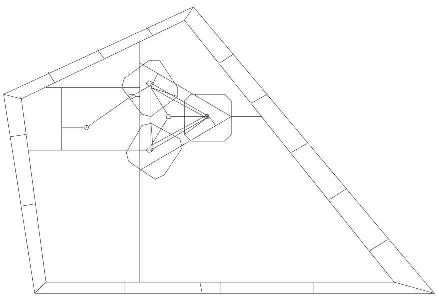

**Figure 2: Soil resistivity measurements traverse (Wenner method) - in background GSM grounding grid**

Figure 3 is a functional block diagram of the equipment used for the scalar potential measurements – a surge generator and a frequency-selective voltmeter (i.e., digital oscilloscope).

As shown in figure 3, a current is injected from a surge generator 8/20 0.1kA between the substation's grounding grid and a remote return electrode. A frequency-selective voltmeter measures the potential difference between the two potential probes. This latter is placed at a series of locations, beginning close to the grid and ending near the return electrode, moving along a linear traverse. Scalar potential measurements were made according to the ANSI/IEEE Std 80-2000 along traverse shown on figure 4 [5].

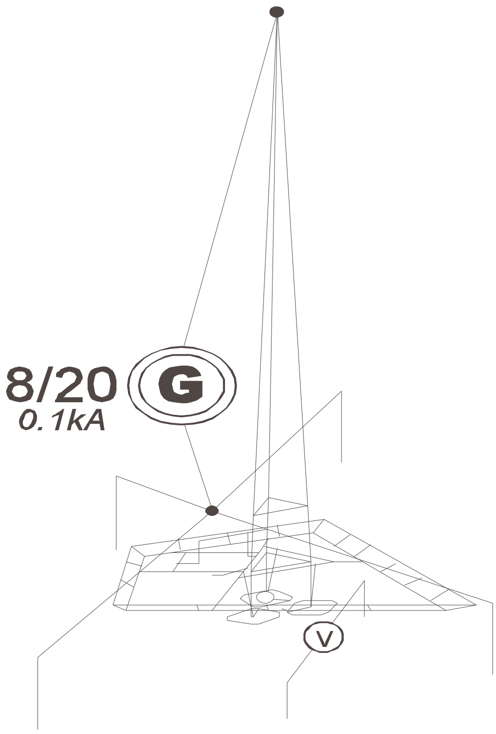


**Figure 3: Functional block diagram of the equipment used for the scalar potential measurements**

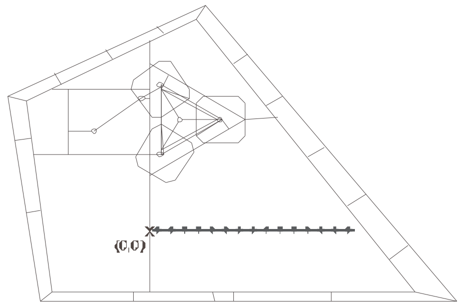


**Figure 4: Scalar potential measurements traverse – in background GSM grounding grid**

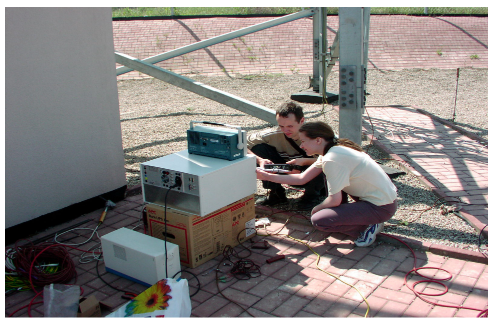

**Figure 5: Photos from measurements**

## 4. Measurements and simulation results

Presented method is used to verify buried grounding system configuration.

Method base on comparison of two scalar potential profiles – measured with computed. Only shift of the profiles shape is important for primarily purpose. Verification of buried grounding system can show real grounding gird location. Always shift exist between real one and the plans.

The plots on figure 7 compare the measured scalar potential with scalar potential computed from the above soil structures. As these plots show, the computed curves fit the measured data very well. The grounding grid in real station is shifted by 2,9m from originally projected location.

It's common knowledge that soil isn't homogeneous. Real measurements can approximate only resultant value of grounding resistivity. Soil consists of few layers. It's very expensive and time cost to measure real grounding resistivity. It's much easier to do it indirectly. Computer simulation base on the 3D model performed in SesCAD and the soil models. Different soil models were investigated to approximate peak value of the scalar potential profile. "RMS Error" column in table 1 provides a quantitative measure of the agreement between the measurements and the proposed soil models. The RMS error ranges from about 2% to 60%, which is excellent.

**Table 1.** Agreement between the measurements and the proposed soil models.

| Soil Type | Ground resistivity [Ω·m] | RMS Error [%] |
|---|---|---|
| Two layers | 910/182 | -60% |
| Two layers | 262/1056 | +15% |
| Two layers | 16/503 | +2% |
| Uniform | 807 | +37% |

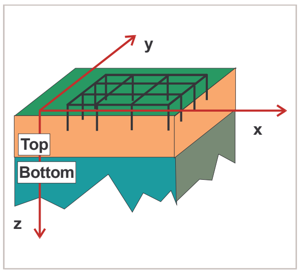


**Figure 5: Horizontal two layer soil type**

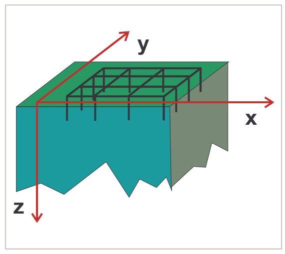


**Figure 6: Uniform soil type**

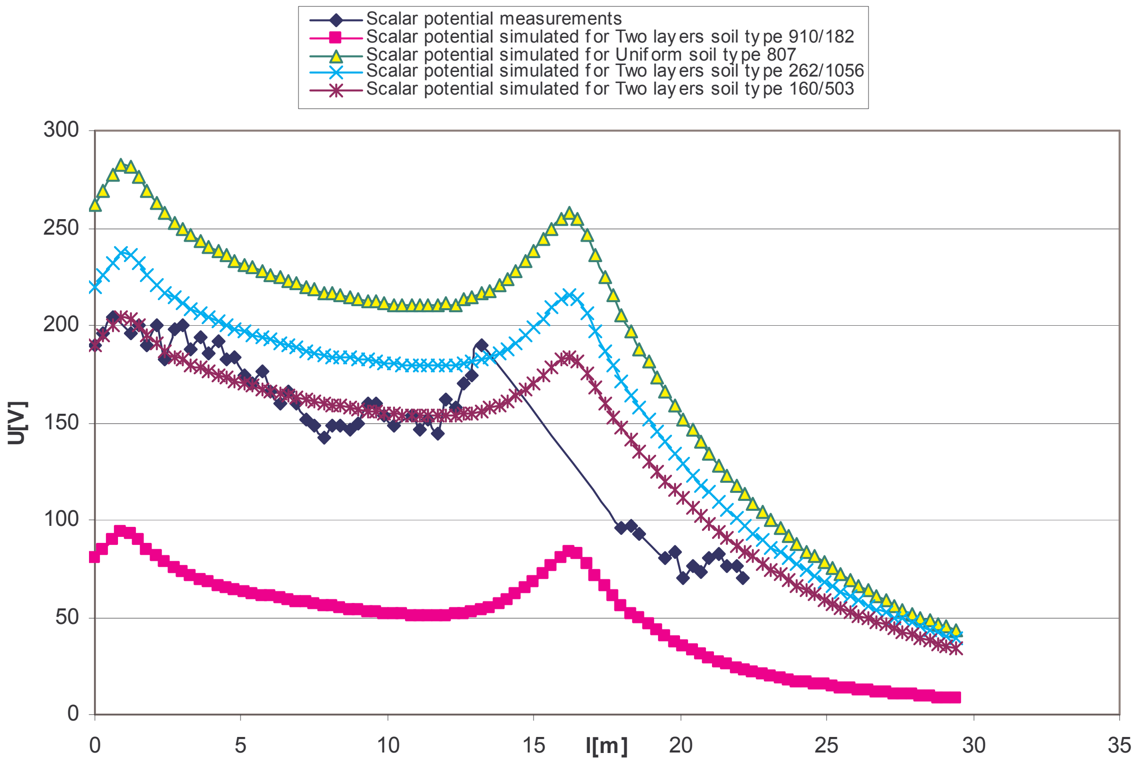


**Figure 7: Scalar potential compare between measurements and simulation**

Mathematical model was employed for the prediction of scalar potential. For each metallic conductor which station consists of, one unknown occurs in the equations used for current distribution computation during excitation – same as used for real measurements. Analyzed station consists of 182 conductors. This means 182 unknowns. Surge was spread out by Fast Fourier Transform into 32 frequencies. CDEGS Software was used for computer current distribution calculations and for scalar profile too [6].

## 4. Conclusions

Presented method can be also used to verify buried grounding system configuration without any earthwork and to approximate a real ground structure without any expensive devices.

By judiciously selecting a soil types from uniform to 2 layer soil type or more, taking care to lay out the measurement leads to minimize induction, and correcting the simulated results for soil resistivity values and soil type models using computer software such as HIFREQ [4] and FFTSES [3] the right values can be obtained. All values can be measured at the operating GSM broadcasting station.

## 5. Acknowledgment

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## 6. References

[1] *The TELE Greenland Modular Container System*, TELE Greenland Catalog 2003.

[2] *HIFREQ Theory*, Safe Engineering Services & Technologies Ltd., Montreal Canada.

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[5] IEEE Std 80-2002: IEEE Guide for Safety in AC Substation Grounding.

[6] *CDEGS Hifreq Software*, Safe Engineering Services & Technologies Ltd., Montreal Canada.