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Lightning protection

Lightning Earthing

Lightning is an electrical discharge which generates a very high magnitude current. Lightning protection systems are made to conduct this electrical charge to the ground, where it will dissipate. The lightning protection systems are equipped with earthing systems that are key parameters to achieve an effective protection of structures, equipment and people. Such an earthing system should then be characterized especially at high frequency for effectively achieve its goal. This is done both at the design stage after getting information about the soil electrical characteristic, then after achievement to validate, or to complete if needed, the existing earthing system. For facilities equipped with old earthing systems, where its constitution is often no more known, measurement provide access to relevant characteristics to validate or improve locally an earthing electrode, allowing to upgrade an installation with a much lower final cost compared with the implementation of a new earthing system. The design and validation of lightning earthing systems is based on the following actions:

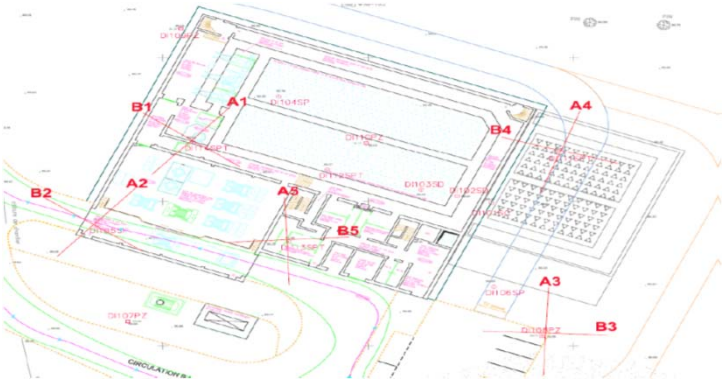
- **Soil characterization based on resistivity measurement for earthing design or as a basis for a Lightning Risk Assessment better dedicated to the site,**
- **Design of earthing system by analytical way or modeling / simulation,**
- **Validation or characterization of existing or specifically created earthing systems associated with analysis of results taking into account the lightning current dissipation target (High Frequency measurements),**
- **Checking the state of a site earthing network, in order to ensure that it is unique, continuous as well as in good condition. Generally for quite old sites that have undergone many changes over time, the design and implementation of earthing electrodes or earthing network is no more known nor documented. Only dedicated measuring methods allow to check the true state of the earthing network.**

1. Soil characterization – Resistivity measurement

The key parameter for the earthing design is the soil resistivity where earthing electrode will be implemented. Furthermore the value of the resistivity affects the level of risk on the buried conductive lines. For the Lightning Risk Assessment this value is also taken into account for these lines.

The soil resistivity is mainly depending on the geological nature of the soil but also what was locally done, as embankments, foundations or significant metallic parts, such as pipes. All these elements give an inhomogeneous soil resistivity. The only way to assess the appropriate resistivity remains a site campaign measurement.

It is therefore essential to perform measurement of soil resistivity in different places along different axis and for the depth where earthing system will be implemented (achievement of a "mapping" where a structure will be erected) to obtain a 3D cartography of soil resistivity in the useful area.



Example of implementation of measuring points for a site at construction stage.

Knowledge of soil resistivity allows to define better optimized earthing geometry and size, and therefore at a lower cost. This way have also the advantage of reaching a satisfactory value for the earthing resistance with less uncertainties.

From the various measurements and their deviation we determine one or more resistivity values (each assigned to a given area) that will allow to design with good accuracy the size and geometry of earthing conductors.

SEFTIM is qualified by INERIS Qualifoudre N°051166303010

And certified ISO 9001 by Bureau Veritas Certification

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2. Earthing design by analytical way or modelling / simulation

Ground resistivity knowledge is used to define, for a given geometry, the necessary size to achieve the targeted earthing resistance. However in the case of nearby grounding (with a strong coupling), or with arbitrary geometry network, it become impossible to use an analytical method.
Simulation tools allow access to a reliable results. It is nevertheless necessary to use precise geometric model of the earthing network to be developed. The modelling tools give also the ability to use several soil layers with different resistivity, that is very difficult by the analytical way.
The main advantage is, of course, to simulate easily many different shapes of earthing networks in order to optimize it before it is installed.

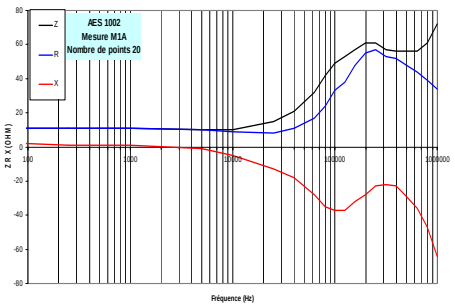
Earthing system model for an installation

3. High frequency earthing system characterization

During a lightning strike on a structure, the lightning current will be divided between the earthing system, the different services leading to the structure, including electric cables, and in the natural paths (reinforcement of foundations). The current distribution between these different paths is done according to the earth impedance of each of them. To minimize the currents injected into the services, it is important to ensure that the impedance of the earthing system is sufficiently low. It is especially very important for wind turbines that are very exposed to lightning and are connected to a single electric system.
Lightning current analysis shows that it is composed of a large frequency spectrum whose amplitude remains important up to 1MHz. It is therefore necessary to have a low impedance for the earthing system for frequencies up to around one megahertz.

For existing earthing system whose geometry is not known, only measurements allows to get the impedance up to high frequencies. This is particularly useful in the case of earthing systems that have an important size, or for loop shape earthing systems (Type B according to IEC 62305-3) requiring the lightning current to travel along a very long length to dissipate into the ground that causes a high value of the impedance at high frequency observed during the measurement. This measurement method is also very useful when it is not possible to disconnect the earthing system (buried or soldered connexions, explosive sites, high voltage towers …).

High frequency earth meter,
Measurement results: Impedance variation related to frequency



When the earthing sytem is not considered as "good", but when the values are still in the expected order of magnitude, it is possible, by calculation, using the impedance values actually measured, to redefine the current distribution between earthing system(s) and existing services (method defined in IEC 62305-1). This usually has the effect of slightly increasing the current that to be handle by the Type 1 Surge Protective Devices connected at the entrance of the lines, but it remains very advantageous in terms of cost.

4. Checking condition of an earthing system

To ensure an effective protection (particularly to prevent damages caused by electrical potential differences between the various metal parts), it is necessary to ensure that the earthing system of a site is unique and continuous. For this, it is necessary to verify that all metallic structures are connected by an equipotential bonding (low impedance) to the earthing system and that its is continuous.
SEFTIM has performed continuity measurements and earth measurements at Low and High Frequency to evaluate the existing earthing system to locally improve, at the most relevant locations, the equipotential and earthing system. The aim is to minimize the current injected in the lines and installations of the plant, without the systematic use of surge protective devices.