

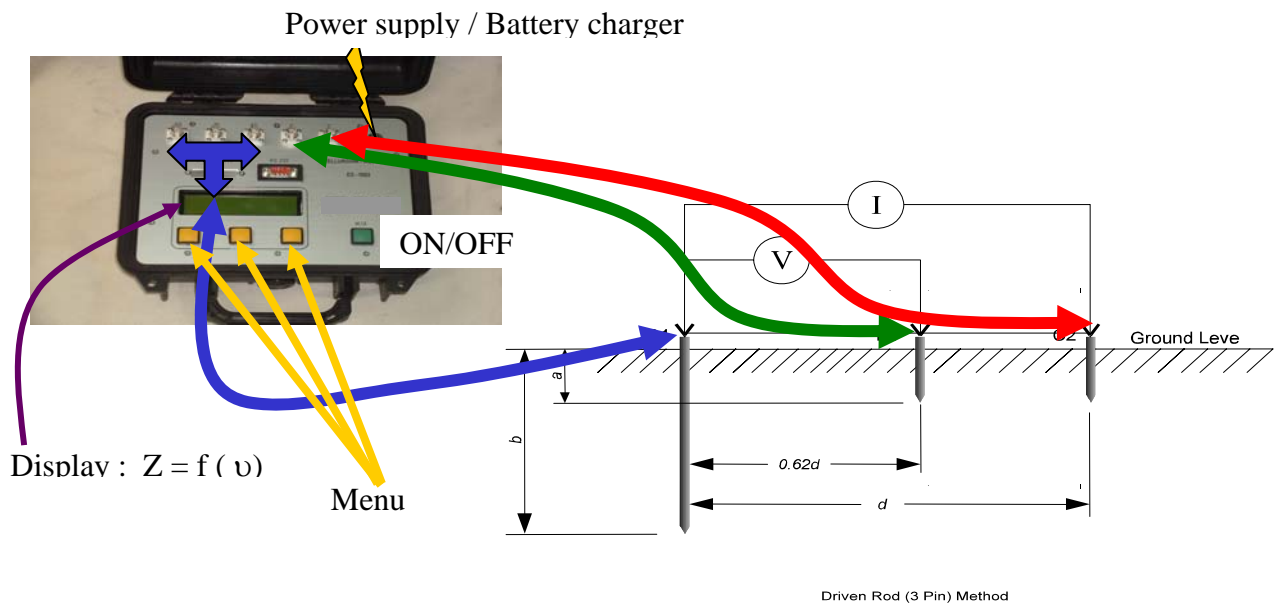
What benefit can be obtained from high frequency earth impedance meters based on variable frequency small injection ?



A typical High Frequency Earth Meter based on variable frequency injection: AES1002

There are at least 4 different applications for such high frequency earth meters

Let's remind first what the working principle for the device is. It injects current at 20 different frequencies from 79 Hz to 1 MHz according to a logarithmic scale to get a better accuracy where it is most needed i.e. at high frequencies. In practice, the earth impedance remains quite stable over a large frequency range and starts to change around 50 to 100 kHz. The measurement method is the usual 3 pins method.



HF measurement principles

We are using the term earth impedance but in practice what are we really measuring ? With a conventional earth meter we are measuring a « resistance » which for low frequencies is equivalent to the earth impedance. As a matter of fact :

$$Z = \sqrt{R^2 + X^2(f)}$$



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Where Z is the impedance, R the resistance, X the reactance depending on frequency f and which will be beneficial in high frequency if it is of capacitive nature but will be detrimental if it is of inductive nature.

The international and European standard IEC/EN 62305-3 is defining the earth impedance by the following terms :

conventional earth impedance

ratio of the peak values of the earth-termination voltage and the earth-termination current which, in general, do not occur simultaneously

The value is said « conventional » as when the current flows through the earthing system, due to the lightning high frequency behaviour and due to the generally inductive nature of earthing systems, the voltage U across the earthing system is not in phase with the current I. For simplicity sake the ratio U/I is then defined and it is what was called in the past (before the new standard has been published in January 2006) the earth resistance ! Hopefully, the new standard shows very clearly that what has to be considered the high frequency behaviour.

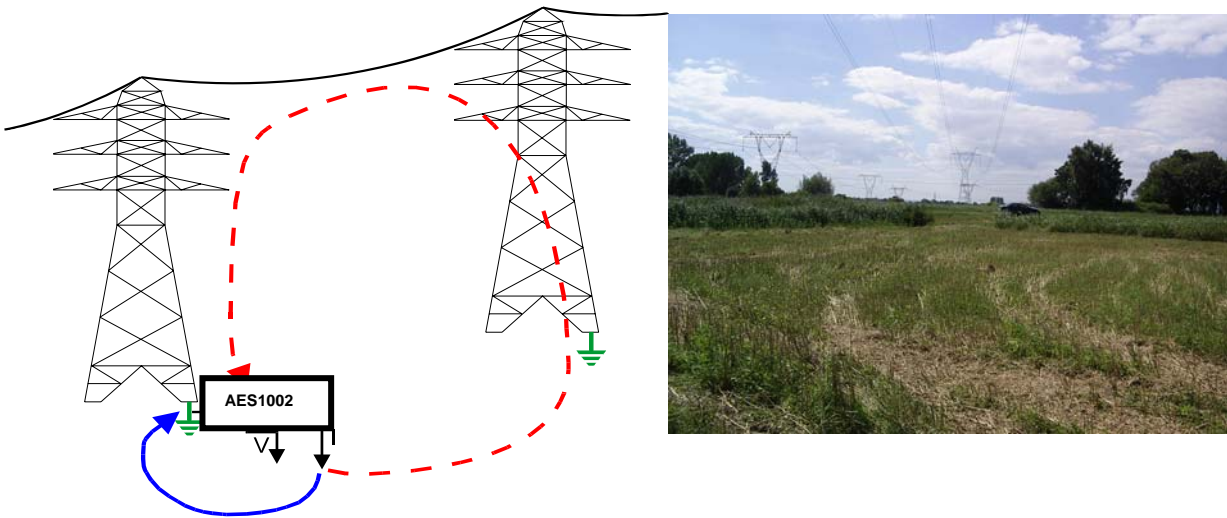
It is necessary to remember that the earth impedance is depending both on the soil (homogeneity, state, granulometry, humidity) and earth electrodes. It is a characteristic of the capacity to let flow the current in the soil from the earth electrode as well as its path towards the 0 potential reference (deep soil or remote soil, potential is said to be a reference potential as its value will not vary whatever is the current injected in the soil).

Let's come back to high frequency earth measurements. There are roughly two methods. One is injecting an impulse current in the soil and the voltage generated is measured which gives by division by the injected current the impedance value at a given frequency. The second method is injecting currents at variable frequencies. This is the one we have selected. This allows us to determine the spectral behaviour of the earthing system. So this method is much more powerful as in addition to obtain the earth impedance it gives also powerful analysis tools as we will show.

First application : measurement without earthing disconnection !

HV pylons earth measurement is difficult for utilities. As a matter of fact, in case of fault on the line a fault current will flow in the local pylon earthing and will create high potential rise creating a hazard for people in the vicinity. To avoid this situation it is necessary a) to have a low earthing resistance value and b) to maintain it in a good state all over the years. But this earthing may degrade with time (e.g. corrosion effect). At a period where copper, even buried or under voltage, is removed to be sold on the black market, the risk is even greater that the earthing system is not as operational as expected. It is then necessary to make the measurement of this earthing periodically. However, the HV pylons are often connected together by a shielding cable used as a lightning protection for the lines. This cable is connected to earth via the pylons. What happen when a measurement of the earthing system is made in the usual way (i.e. at low frequency)? There are basically two cases which lead in fact to the same conclusion. In the first case, there is not any disconnecting link allowing disconnecting the earthing from the pylon. What is measured is then not only the local earthing but also all the other ones connected in parallel by the shielding cable. In the second case, there is a disconnecting link but it is not allowed to open it while the line is energized. To disenergise the line only for making the earthing measurements is nonsense.

There is only one practical answer: use AES1002. The aim is not to validate the high frequency behaviour of this earthing. If the local earthing is not good and if the other earthing connected in parallel are, the low frequency (LF, bottom of the curve produce by AES1002) but the high frequency behaviour (HF, upper part of the curve) will not be good. In fact, the average 40 m of the pylon and the 100 m line length will lead to a high inductance in practice. What should be done should be to measure the local earthings at a reference time (either at construction stage for new pylons or at any time used as a reference for already existing pylons) using AES1002 and keeping the curve to be sued as a reference and in future it will be possible to easily determine if the earthing has degraded or if it is only a variation coming form the climatic conditions (change between sunny and rainy days for example).



Local earth measurement for HV pylons

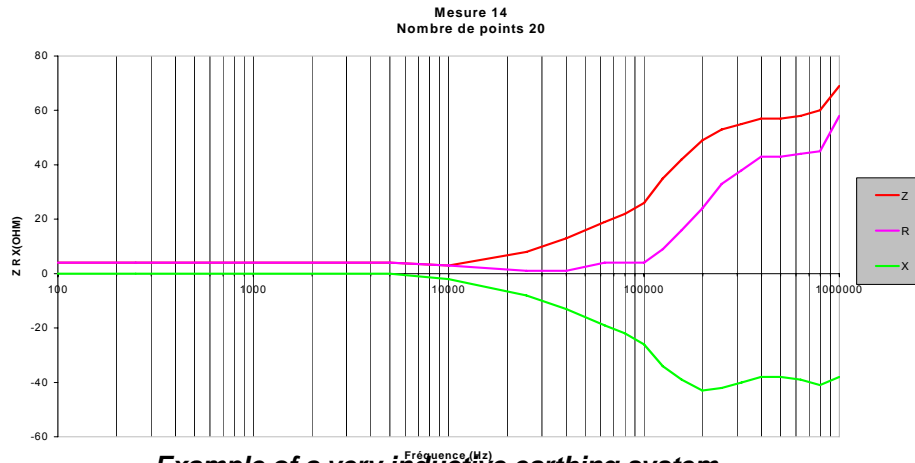
This is one of the clear advantages of the earthing measuring with AES1002 which gives the profile of the earthing over frequency and allow differentiating various cases easily.

This type of measurement can be adapted to all cases where the earthing cannot be disconnected easily. If the current injected in the earthing system by the AES1002 device cannot be tolerated, it is possible a compensating module (please contact us).

Second application : analysis of already built earthing systems

A frequent case encountered in field is the one of the earthing system which is not documented. One will remember that many years before the earthing was made at this location and has this design but of course nobody (except in rare cases) will go digging to check if the remembering is accurate or not. Another identical case is the one where the controlling technician is coming to the site under construction after the trench has been filled again and in that case he has no other choice than to use earthing measurement to evaluate quality of the earthing system (in that case he used up to now the usual 10 Ω limit to accept or not the earthing system).

AES1002



The AES1002 with its capability to give the profile of the earthing system allows measuring the earthing and to differentiate between a multi-radial system, a single rod or an extended buried tape or any other type of earthing. For example, we have been using this method on a petrochemical site where we have demonstrated that the mesh lightning protection system had not earthing loop but only earth rods located at the downconductors locations opposed to what was written in the specification and what the user was believing. Either the loop had never existed or the loop was degraded mechanically or by corrosion. Whatever was the reason for the absence of the loop the user got the information without using a single shovel!

The international and European standard IEC/EN 62305-3 is clearly meaning the same as in Annex E we can read:

High frequency measurement is possible at the installation stage as well as for the maintenance of the earthing system to check adequacy between the designed earthing system and the need.

Third application : cost saving !

What to do when the earthing resistance exceeds 10Ω ? In practice it is necessary to improve the earthing. If the unacceptable value is due to degradation with time, very costly work needs to be undertaken. This is particularly true if structure itself is used as the earthing system (silo, tank ...).



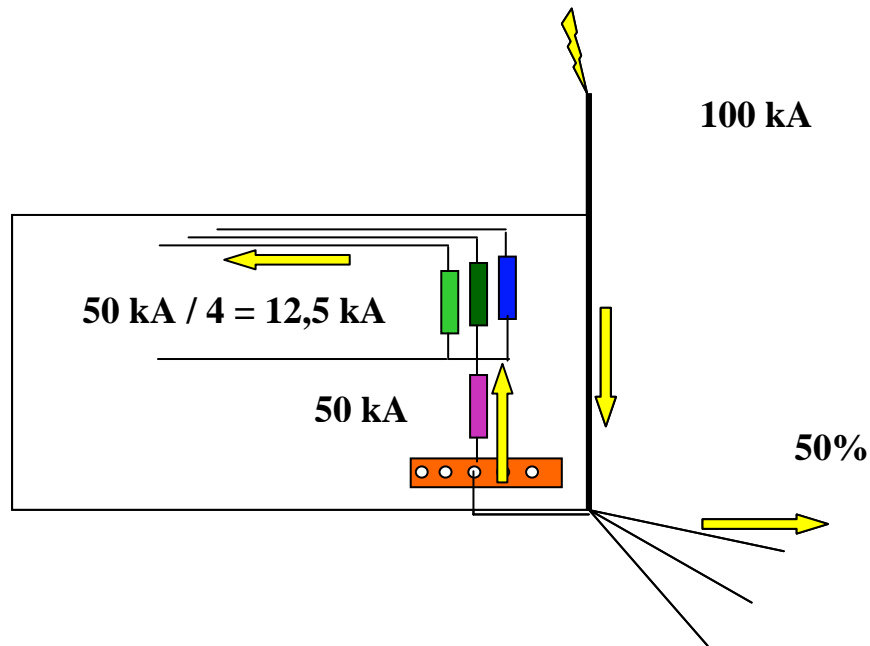
Metallic silo with concrete foundations and metal anchorage rods in the soil being used as a natural earthing system

By making the measurement with AES1002, one is able to validate the high frequency behaviour of the earthing system and so one can qualify the earthing system as being able to behave well under lightning conditions or not are able. Studies presented and discussed during international conference (ICLP, SIPDA) proposed HF criteria to be used to validate high frequency behaviour of earthing system dedicated to be as simple as the usual 10Ω value which is very well known. These criteria, based both on experience and on simulations giving the voltage generated at the earthing system in case of lightning strike, show that earthing systems that do not comply with the 10Ω LF criterion are however able to behave well in lightning conditions. A controller can then validate an earthing system even if the 10Ω criterion is not met and avoid costly and useless work.

Fourth application : validation of a « lightning » earth

Why do we need a lightning earthing?

Purpose is mainly to allow the lightning current coming from the lightning protection system or the surge protective devices to flow back to deep earth when minimizing voltage generated which can be dangerous both for human beings (step and touch voltage) and for equipments (overvoltages). As soon as there is a lightning protection system SPDs are needed at services entrance and the design of those SPDs is based on a simple assumption : 50% of the current flow in the soil and 50% in the electrical installation and thus through the SPDs. Average case for the SPD design (the famous 12,5 kA coming from IEC 60364 standard) is only valid if there is at least 50% of the original lightning current which flows to deep earth and this means that the earthing system is designed for the lightning stress.



Typical sharing of current between the lightning earthing system and the electrical installation as assumed by standards

If not it is necessary to make a calculation to design the SPDs taking into account the respective earthing impedances and connected circuit impedances. Good luck ! In practice the most simple solution is to build a high frequency earthing system and to validate it with the high frequency earth meter AES1002. But in the worse case, when it is not possible to build such a dedicated earthing system and when the calculation should then be performed, it is necessary to use the earth impedance given by the AES1002 HF earth meter for that calculation.



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Four good reasons to use the High Frequency Earth Meters!

Specific adaptation kits allow using the device for measuring extended earthing system (up to 100 m) by compensating (hard and soft) the measurement as well as for measuring the earthing without any injection of current in the building/electrical earthing when the earthing system cannot be disconnected (please contact us for these applications)

AES1002 was selected by us as it has been originally developed for France TELECOM and has been validated by many studies made on various earthing systems specifically built for that experiment. It is then applied by many users all over the world (French police, French Army, US Army, Ineris, Universities, Studies companies, measuring equipment companies, lightning protection industrials ...)

The high frequency measurement concept has been also validated by seminars and conference with attendance of well recognized international scientists and by many measurements all over the, which has led to the introduction of the concept in the most recent standard 62305-3.

Note : the surge injection type lightning earth meters are generally able to provide the fourth function