Influence of electromagnetic frequencies and their interference in the choice of the impedance of the grounding

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***Abstract*— The characteristic parameters of the electrode grounding of an electric high-voltage grid, such that the impedance of the earth, are a function of the frequency of the incident wave (in this case, it is the s4agit wave surge maneuver is that of lightning).**

In this article, we found it useful to study the behavior of the earth impedance subject to lightning surges or maneuver. At high frequencies, the behavior of earthing is different from the power frequency. This study was conducted by a specific Matlab simulation of high-voltage substation Souk Ahras for an objective study of the impact of the surge for testing earth resistance by existing international standards obeying the protection of property and persons.

Keywords*— Overvoltage, Ground impedance, RLC circuit, Electromagnetic interference, Simulation surges.

I. INTRODUCTION

An electric installation of quality must answer the user expectations in terms of electric safety of exploitation.At the time of one defect to the ground in a station or on a line of transport of energy, the fault current seeks to run out in the ground through the grounding electrodes what makes assemble the local potential of the ground compared to that of a remote ground.For that, since the advent of industry and the keen demand in electric power.The problems connected to the design of earthing hold the attention of the electric engineers and the originators of the stations and the lines of transport of energy in high voltage.

The importance of the design of earthing of the lines of transport of energy and the switchyards holds of the need for reducing the costs associated with the installation with the ground electrodes, to protect the material.To improve quality of the service and to limit harmful to the neighbouring apparatuses and potentially dangerous overpressures for the individuals.

The management of the electrical supply networks high voltage must take account of the electromagnetic disturbances of the tensions and the harmonic currents of the influence of the radiations of the lightning and the stray currents.
Usually for the distribution networks at industrial frequency account of it only resistance holds, but for the networks high voltage one must take account of the impedance.
In our article, we will propose a simple model of modeling per simulation MATLAB to evaluate the frequential characteristics of earthings, while approaching as much as possible physical realities.This model enabled us to study the effect of certain parameters (resistivity of the ground, characteristics geometrical and nature of the electrodes) on the transitory performances of earthings.

II. BASIC CONCEPTS ON THE SETTING OF THE GROUND

A. Definition and goal of a network

The design of a ground network owes account of the mode of the neutral.One application of the new C15-100 standard. A ground network consists of a whole of buried drivers, in contact direct with the ground and electrically connected between them.

B. Need for earthing

Earthings play an essential role in the protection of the individuals against the electric accidents and the insurance of the adequate operation of the electric installations.The need for earthing is felt in a very acute way with the increase of the importance of the feeding systems, the nominal voltages and the capacity of the short circuits.In the event of defect, the systems not connected to the ground produce overpressures more significant than those which are connected;what has a great advantage for the systems connected to the ground.To limit overpressures at the time of a defect a method consists has to put in series an adequate resistance in the earthed circuit like there is another method which leads to other type of earthing, either by reactance or direct.In practice, several elements of the power stations, the stations and the lines of

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transport of energy must be put at the ground.That ensures a way of return to the current in the event of defect, a lightning protection and overpressures as well as a protection of the individuals against the electric shocks.

C. Elements of an earthing

An electrode earth entirely hidden in the ground in a way to have a contact privileged with this one and a ground driver constitute an installation of earthing (malt).The driver connects the metal part or the neutral of the electric component to the earth electrode.In order to check the state of the earth electrodes the ground driver is provided with a ground terminal what makes it possible to separate the material from malt.

An earth electrode is usually made up of one or several vertical or horizontal electrodes such as metal stems.The form of the earth electrode is normally ordered by the physical site of the apparatuses and the metal structures to put at the ground;for example the earth electrode of a distribution or switchyard is generally constitutes of a ring main system of driver hidden in the ground and forms the lattice of the station.

D. Resistance and resistivity of the ground

Generally during the construction of an electric station one must take account of the topology and environment of the medium.The study of the constitution of the ground enables us to evaluate the resistivity of the ground.The resistivity of the ground is a variable quantity and which depends on several factors (the nature of the grounds, the rate of impurities, salinity, water the content, the temperature…). This is summarized in table 1 resulting from the draft study of the sonelgaz [1].

TABLE I
AVERAGE RESISTIVITIES OF THE VARIOUS TYPES OF GROUND

Nature of the ground	Resistivite in Ω.m
Marshy grounds	from 1 to 30
Silt and wet peat	from 5 to 150
Clay	form 40 to60
Siliceous sand	form 200 to 3000
Naked stony ground	form 1500 to 3000
Tender limestone	form 100 to 300
Compact or fissured limestone	form 500 to 5000
Compact or fissured limestone	form 50 to 300
Granites and likings	form 100 to 1000

The resistance of an earthing is directly proportional to the resistivity of the ground, if this one can be regarded as homogeneous.Another factor of which account will have to be held is the characteristic of the grounding electrode:matter, the form, depth in the ground, the number, the structure…
There are several models of the grounding electrodes, most significant are:
- The model of circuit RLC.
- The model of line of transmission (TL).
- The electromagnetic model (EMF).

III. MODELISATION OF THE INFLUENCE OF THE ELECTROMAGNETIC DISTURBANCE ON A LINE HT

Impedance of the electric stations and their safety from the insulation point of view and the continuity of service for the transmission of the great quantities of electric power. Us force to avoid the nonprogrammable cuts who will have a consequence on stability.

Knowing that for the area studies where the level keraunic is high, the discharges by the lightning constitute the principal cause of the cuts

A. Modeling of the electromagnetic disturbance on a circuit RLC

In this model, the electrode is regarded as a powerline opened with the one of the ends, with parameters distributed.The figure below illustrates this model.

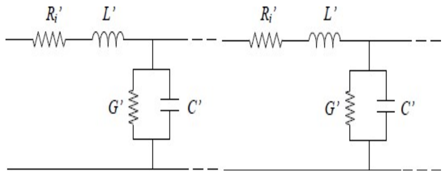

Figure 1. Model of the line of transmission.

Relations allowing to find the other characteristics distributed (linear inductance, conductance and capacity) from which derive from those given for the model of circuit RLC.

B. The model of circuit RLC

In this model, by neglecting its own resistance, the electrode is represented like a circuit RLC, as indicated in the following figure.

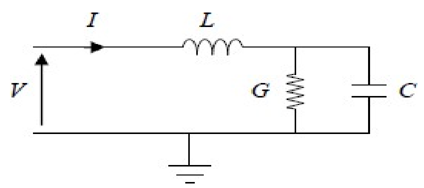

Figure 2. Model of circuit RLC.

This model is used with the quasi-static approximate assumption, which means that the effect of the delay in the

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wave propagation is neglected.As Olsen [7] shows it, this assumption is valid only for lengths of the electrode about

$$l = \frac{\lambda}{10} \quad (1)$$

λ : the wavelength in the ground.It depends on the electric parameters of the ground and is given by the following relation [9]:

$$\lambda = \frac{2\pi}{\omega\sqrt{\varepsilon\mu_0}}\left\{\frac{1}{2}\left[1+\sqrt{1+\left(\frac{\sigma}{\omega\varepsilon}\right)^2}\right]\right\}^{-1/2} \quad (2)$$

ω:The pulsation of the wave (related to the frequency by the relation $w=2.\pi\,.f$), ζ, μ and σ are respectively the dielectric permittivity, the magnetic permeability and the electric conductivity of the ground.
According to the studies by the various researchers [7-9] the wavelengths in the ground for the frequencies of 50 Hz, 100 Khz and 1 MHz are presented in the table below [2].

TABLE II
WAVELENGTHS IN THE GROUND

Frequency	Resistivite Ground (Ω.m)	WAVELENGTH $\varepsilon_r = 10$	WAVELENGTH $\varepsilon_r = 30$
50 Hz	100	4472	4472
	1000	14142	14142
	5000	31621	31621
100 kHz	100	100	99
	1000	308	291
	5000	616	484
1 MHz	100	31	29
	1000	77	53
	5000	93	55

In the area studies, the resistivities of the grounds are significant and often exceed the 1 kÙ m. With values of the frequency of the wave of the lightning not exceeding 1 MHz, the quasi-static assumption remains still valid in the majority of case, in so far as the lengths of the electrodes remain moderate. In this case, the impedance of earthing is given by the following relation, by neglecting the internal resistance of the electrode.

$$Z = j\omega L + \frac{1}{G + j\omega C} \quad (3)$$

For a cylindrical and vertical electrode, the following relations define parameters RLC of the circuit of the fig. 2.

$$R = \frac{1}{G} = \frac{\rho}{2\Pi\, l}\ln\frac{2l}{\gamma} \quad (4)$$

$$C = 2\pi\zeta\, l\left(\ln\frac{2l}{\gamma}\right)^{-1} \quad (5)$$

$$L = \frac{\mu_0}{2\pi} l.\ln\frac{2l}{\gamma} \quad (6)$$

Knowing that l is the length of the electrode and R is its ray. One chose an electrode vertical and cylindrical of ray equal to 1.25 cm, buried in a ground of homogeneous resistivity and relative permittivity, $\varepsilon_r = 10$ this is summarized in the form of a flow chart of the calculation (fig.3) where the variation of the impedance according to the frequency gives:

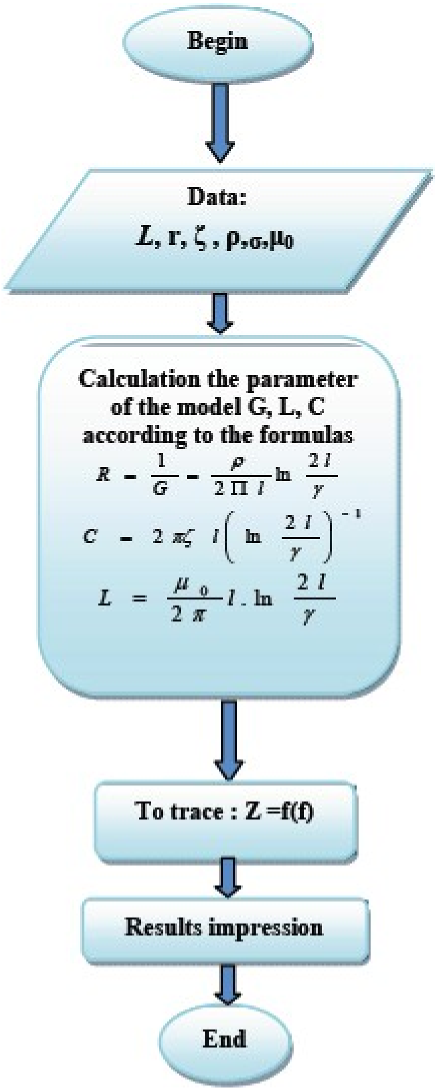

Figure 3. Flow chart of calculation.

The computation results are on the following figures:

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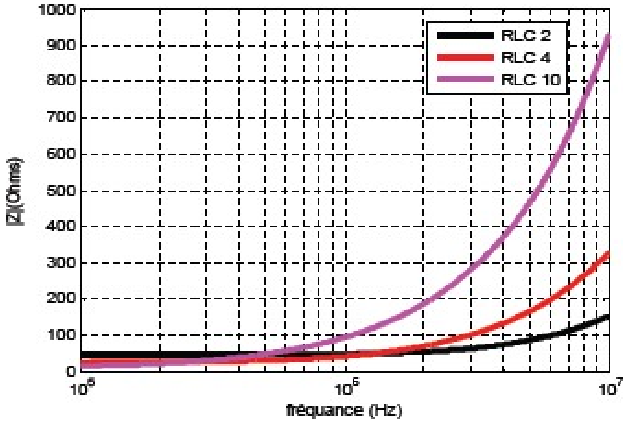
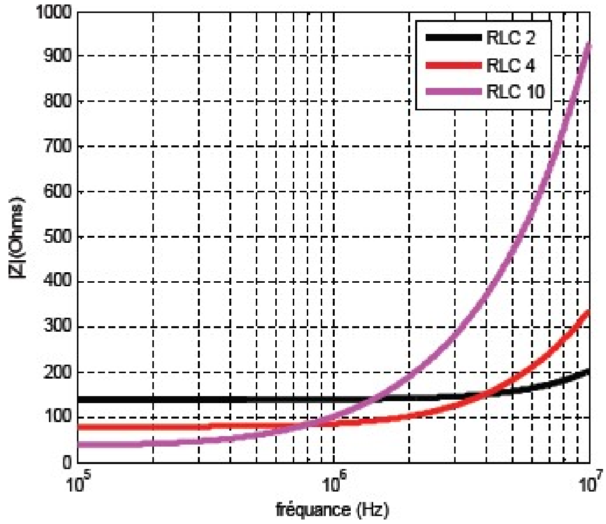
** FOR* P=*100 AND* L *= 2;4;10*



** FOR* P=*300 AND* L *= 2;4;10*



** FOR* P=*500 AND* L *= 2;4;10*

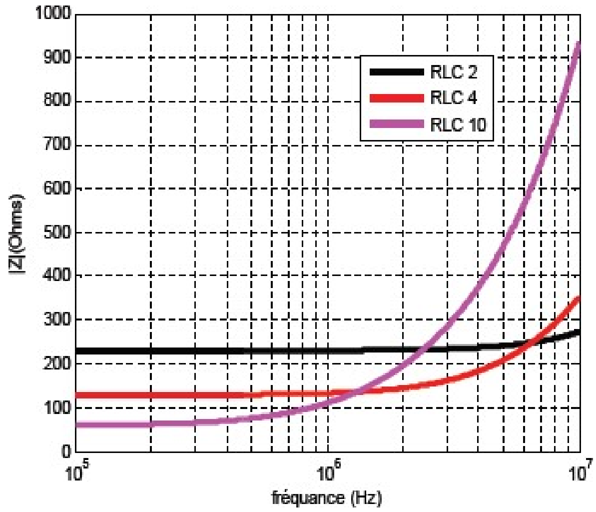


Figure 4. Impedance of ground according to the frequency, vertical electrode.

II. CONCLUSION

The concept of earthing implies several fields of research.The operation of the electric installations depends closely on the way in which certain devices are put at the ground and of the values of the parameters of earthings (resistance, inductance, capacity…).

The most significant parameter in the analysis of earthings in industrial frequency is the resistance which must be weakestpossible, to ensure the safety of the people and the

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material.The value of the resistance of earthing depends on the nature of the ground (resistivity) and the shape (geometry) of the ground electrodes.Several studies were undertaken in this field since several tens of years.This research highlighted methods of calculation which, to reduce complexity, are based on simplifying assumptions (homogeneous ground of resistivity, ground in two layers of different resistivities, sections of the drivers neglected…).

Being given that the resistance of earthing must be low and taking into account the great values of the resistivities in areas to study, the means to reduce this resistance to lower cost are proposed.In high frequencies, other parameters and phenomena are added and make the analysis much more complex especially the impedance made up.We proposed, in our article, a model of calculation (circuit RLC) of the characteristics of a vertical electrode per simulation MATLAB.The comparison with the results of the literature made it possible to validate the model.The advantage of our model is to take into account all the physics soil characteristics.This model, that we presented in this work for a vertical electrode, can be wide (with the help of adequate calculations) with the other shapes of more complex electrodes.

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