MEASUREMENT FREQUENCY INFLUENCE ON THE INTERFERENCE DISTURBANCES NEAR THE EXTRA HIGH VOLTAGE LINES

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SUMMARY

The principal objective of this paper is to present a determination calculation program of the exact profile of the level of radionoise of existing lines E.H.V and on project according to the frequency.
The method used for the determination of the disturbing field is an analytical method based on the theory of the modal propagation.
We present a calculation program based on MATLAB with examples of real lines.

Keyword: *Interference disturbances, frequency, extra high voltage, modal propagation.*

1. INTRODUCTION

The fundamental phenomenon of the radionoise disturbances is the impulse emission mode, during which the free charges ions and electrons are formed then violently pulled by the intense electric field in the vicinity immediate of the conductor carried to a extra high voltage.

The formation and the displacement of these charges in space close to the conductor cause a modification of the distribution of the electrostatic potentials, from which the emission results from an electromagnetic wave. [1,2,5]

The disturbances due to the conductors cannot be eliminated because on the one hand from their significant disturbing level and on the other hand of impossibility of carrying out tests on long distances from conductors.

2. CALCULATION OF THE RADIONOISE DISTURBANCES

2.1. Study of the propagation

The propagation of the disturbances along the line has an essential role in the formation of the disturbing field in a given point; it is thus important to study in detail the laws which govern this propagation while being based on the theory of the modes [1,2,6].

The various stages used in this method for calculation of the disturbing field are as follows:

- Determination of the exiting function.
- Calculation of the interference currents.
- Calculation of the disturbing field in the vicinity of E.H.V lines.

The laws of propagation of the voltages and the currents along the single-phase line are derived from the equations known as "the telegraphists".

When the line is multifilaire the equations can be used in matrix form and one can write: [1,6]

$$\left\{\frac{dV}{dy}\right\} = -[Z]\cdot\{I\}$$
$$\left\{\frac{dI}{dy}\right\} = -[Y]\cdot\{V\} \qquad (1)$$

By deriving the equations (1); one will have:

$$\left\{\frac{d^2V}{dy}\right\} = [Z]\cdot[Y]\cdot\{V\}$$
$$\left\{\frac{d^2I}{dy}\right\} = [Y]\cdot[Z]\cdot\{I\} \qquad (2)$$

As in general: $[Z].[Y]\neq[Y].[Z]$; it results from it that the tensions and the currents are propagated according to different laws, in addition, by developing the matrices, one notes that there is a coupling between the equations relating to each conduction, the resolution of such a system can be obtained via the notion of the modes.

2.2. General equations with losses of a multifilaire line

We introduce the modes directly on the level of the preceding differential equations; what will enable us to solve them in a way much easier thanks to separation of the variables used by the modal analysis; that is to say then [M] the matrix which diagonalise [Z].[Y], one can write:

$$[P_m] = [M]^{-1}[Z].[Y].[M]$$

and the same [N] the matrix which diagonalise [Y].[Z], one can write: $[Q_m] = [N]^{-1}[Y].[Z].[N]$

By indicating the modal sizes by the index 'm'; one can write:

$$\{V_m\} = [M]^{-1}\{V\}$$
$$\{I_m\} = [N]^{-1}\{I\} \qquad (3)$$

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Since the line is with losses, the product of the matrix [Z] and [Y] is not commutable, it results from it that the modes of the voltages and the currents are not the same ones, therefore:
[M]≠[N], which obliges us to make the calculation of the characteristics of propagation with losses which requires the determination of the complete terms of the matrices of the impedances [Z] and the admittances [Y].

Concerning the matrix of the admittances, one can generally admit without much error which the side losses are negligible, this matrix is reduced then to:

$$[Y] = J\omega C$$

The attenuation of propagation will be only due to the longitudinal losses, by Joule effect in the conductors and the ground and could be expressed according to a matrix of equivalent resistances [R] such as:

$$[Z] = [R] + J\omega[L] \tag{4}$$

One can calculate the matrix of inductances [L] which takes account of the penetration depth.

3. CALCULATION OF FIELDS ON THE GROUND

Let us consider initially to locate the problem the case of an infinite single conductor, seat of an effect crowns characterized by an exiting function Γ uniform, i.e. by the injection of a current I_0 per unit of length; the current of each elementary section of conductor is divided in two halves $I_0/2$; one moving towards the infinite one and the other towards the point of measurement; it is this half which interests us.

We admit that the propagation along the conductor of the current real $I_0/2$ obeys the same laws as the propagation of the sinusoidal current with the same frequency.

Instead of considering the current itself, one can consider the magnetic component H of the associated field: along a straight line parallel with the conductor, and passing by the point of measurement, this field varies like the current itself [1].

That is to say H_0 the field at the point of current injection i.e. corresponding instead of brush (y =Y) (figure 1)
and H: the field at the point of measurement y =0
In propagation with losses one will have:

$$H = H_0 e^{-(\alpha + j\beta)y} \tag{5}$$

where $(\alpha + j\ \beta)$ is the complex constant of propagation
Where: α is the attenuation coefficient in Neper/m.
β : is the constant wavelength.

The total field at the point of measurement is the superposition of the fields partial due to each elementary section of the conductor; one can show that it is calculated according to the relation:

$$H_t = \frac{H_0}{\sqrt{\alpha}} \tag{6}$$

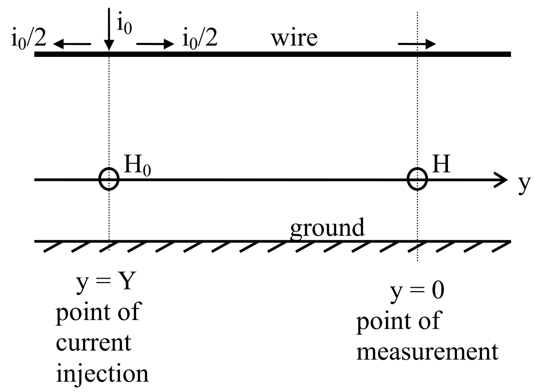

Fig. 1 Single-phase line.

Now we consider the case of a three-phase line and suppose that only the conductor (1) is the seat of corrona effect.

One can say that to the exiting function Γ_1 will correspond a system of currents injected into the three conductors.

To study the propagation, of these currents one breaks up them into modes and one separately examines the propagation of each of the three modes obtained.

The three modal currents m_i generated by Γ_1 are calculated by the following:

$$\begin{Bmatrix} m_1 \\ m_2 \\ m_3 \end{Bmatrix} = \frac{1}{2} \cdot \frac{1}{2 \cdot \pi . \varepsilon_0 \cdot} \cdot [N]^{-1} \cdot [C] \cdot \begin{Bmatrix} \Gamma_1 \\ 0 \\ 0 \end{Bmatrix} \tag{7}$$

Where $[N]^{-1}$ is the opposite matrix of the standardized modes.
[C] is the matrix of the capacities of the line.

With each modal current is associated a modal magnetic field which is propagated along the line passing by the point of measurement.

By preserving the same notations and the same reasoning as for a single-phase line; the field of each mode 'i', relating to the injection at the point will be there given to the point of measurement (y = 0) by:

$$H_i = H_0 \cdot e^{-(\alpha + j\beta)y} \tag{8}$$

The real elementary field due to the injection of the elementary currents in y = Y will be the sum of the three fields of mode:

$$H = \sum H_i \tag{9}$$

To obtain the total field, due to the effect of all along the conductor '1', one carries out, as in the case of a single-phase line, the quadratic summation of the modules of all the elementary fields by taking account of the attenuation of the modes; that is:

$$H_t^2 = \sum_i \frac{H_i^2}{\alpha_i} \tag{10}$$

4. PRACTISE FORMULAS FOR CALCULATION OF FIELDS

One prefers to measure the magnetic component of the guided fields; it can be according to the electric component. [1,2,9]

In the presence of several conductors "j" the total electric field by using the theory of the images will be the sum of the partial fields:

$$E(x) = \frac{1}{2\cdot\pi\cdot\varepsilon_0}\sum \frac{2.h_i q_j}{h_j^2 + \left(x-d_j\right)^2} \tag{11}$$

To the level of ground, the horizontal component of magnetic component of the field due to several conductors ‘’j’’ traversed by currents I_j will be given by:

$$H(x) = \frac{1}{2\pi}\sum_j I_j \cdot \left[\frac{h_j}{h_j^2+\left(x-d_j\right)^2} + \frac{h_j+2.p}{(h_j+2.p)^2+\left(x-d_j\right)^2}\right] \tag{12}$$

In propagation without losses, there is a relation of proportionality between component magnetic and component electric of the guided field and one can write:

$$E(x) = 60\sum_j I_j \cdot \left[\frac{h_j}{h_j^2+\left(x-d_j\right)^2} + \frac{h_j+2.p}{(h_j+2.p)^2+\left(x-d_j\right)^2}\right] \tag{13}$$

The Electric field E (X) will be given in µV/m

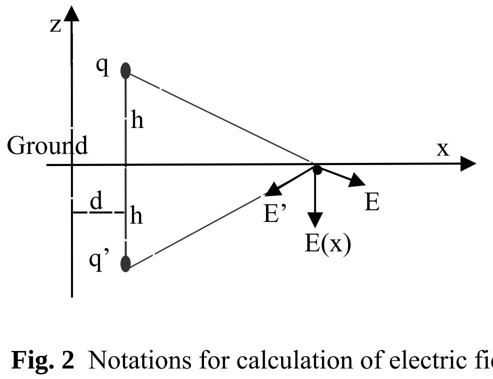

Fig. 2 Notations for calculation of electric field of a conductor above ground-level.

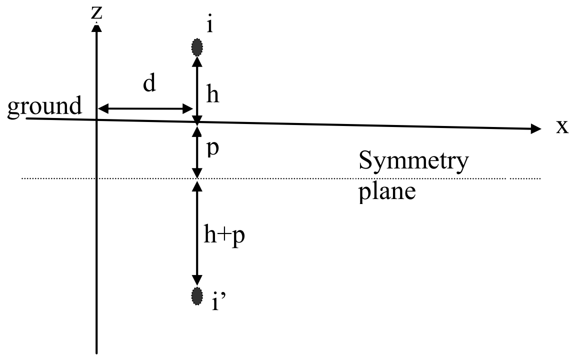

Fig. 3 Notations for calculation of the magnetic field above ground-level.

The magnetic field depends on the penetration depth of the currents return in the ground, therefore for the calculation of the impedances generalized instead of considering the images of the conductors compared to ground; we consider them compared to a fiction symmetry plane placed at a penetration depth "p" which depends on resistivity of the ground and frequency of measurement.

5. INFLUENCE FREQUENCY ON THE DETERMINATION OF RADIONOISE DISTURBANCES

The variation of the disturbing level, measured in a point given in the vicinity of a line according to the frequency of measurement results from the composition of 2 phenomenons: [2,11]

- First phenomenon:

The impulses of current generated in the conductors by the brushes present an own spectrum, which depends on their form. In the radiophonic frequency band where the positive brushes have a dominating effect, the spectrum has a pace appreciably independent of the amplitude of the brushes and diameter of the conductor. The spectrum of a complex signal resulting from the stationary random superposition of many impulses of form given is the same one as that of the elementary impulse.

- Second phenomenon:

The attenuation of propagation increases with the frequency, that involves a modification of the own spectrum of the impulses by accelerating the drawdown towards the increasing frequencies.

The measured spectra are generally rather irregular, because of the continual fluctuations of level of disturbing field during a measurement, and reflexions of propagation.

6. EXAMPLES

6.1. Horizontal line of 750 kV [5]

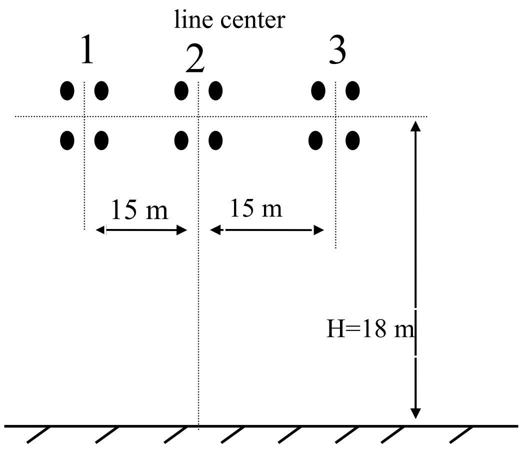

Fig. 4 Geometrical provisions of conductors

Voltage = 750 kV;

Ray of the beam = 0,212 m

Ray of conductor = 15,5 mm

Presentation of the results

After execution the program one respectively obtains to the curves (figure 5,6 and 7) representatives the modal fields of the first phase, the field of the first phase and the disturbing field of the line of 750 kV according to the frequency for a resistivity of ground = 100 Ω.m.

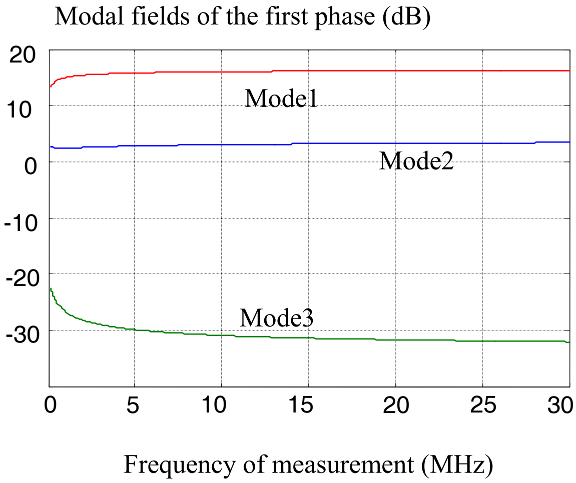

Fig. 5 Modal fields of the first phase according to frequency for 750 kV line

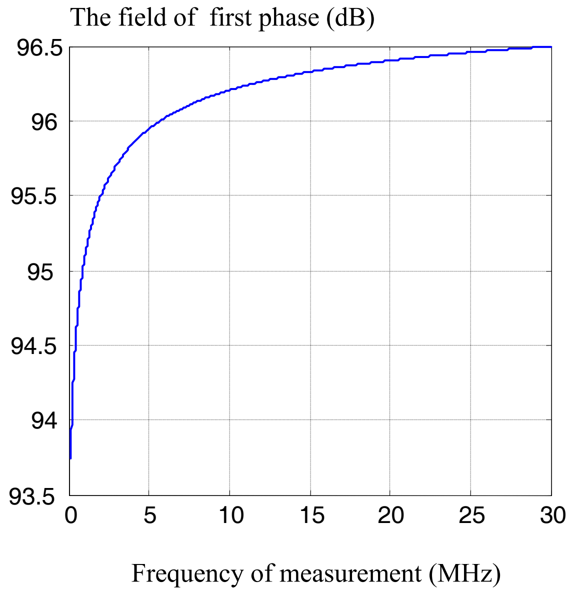

Fig. 6 The field of the first phase according to frequency for 750 kV line

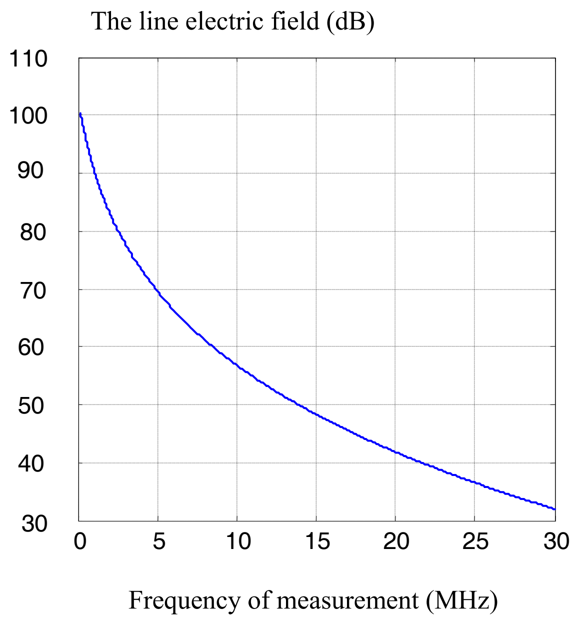

Fig. 7 The field of 750 kV line according to the frequency (dB)

6.2. Line of 522 kV with 2 terns [11]

Voltage = 522 kV;

Ray of the beam = 0,325 m

Ray of the conductor = 14,65 mm

Frequency of measurement = 0,5 MHz.

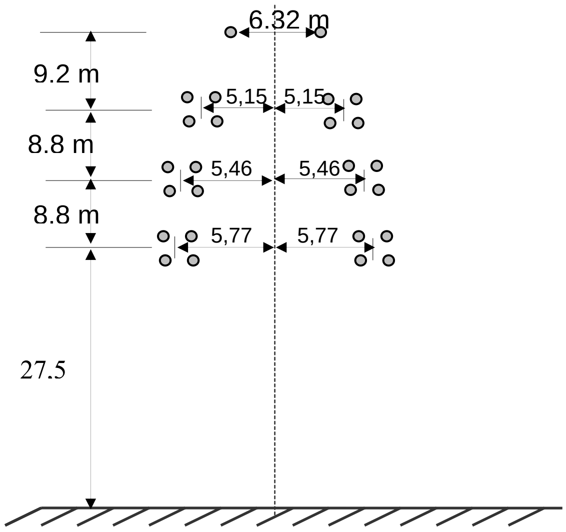

Fig. 8 Geometrical provisions of conductors

Presentation of the results

After execution of program on obtains the modal fields for each phase, we obtain finally the disturbing field of the line 522 kV with 2 terns according to the frequency for a resistivity of ground = 100 Ω.m (Figure 9)

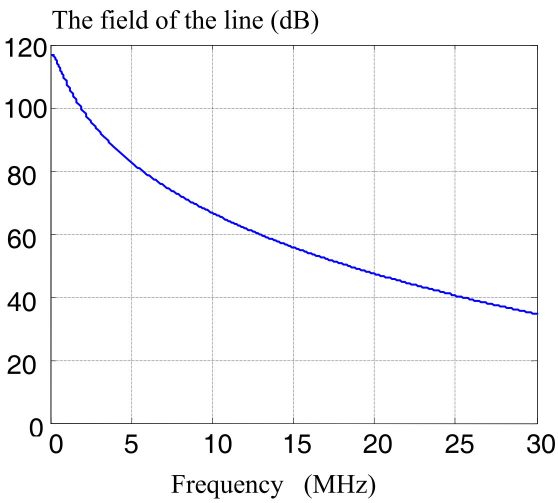

Fig. 9 Disturbing field of 522 kV line (2 terns) according to the frequency (dB)

7. INTERPRETATION OF THE RESULTS

According to the curves obtained one can say that the frequency of measurement influences directly the level of radionoise disturbances, there is a reduction according to the increase in the frequency because the self-impedances and mutual depend on this frequency.

The curve of variation of the level of radionoise disturbances the frequency band of 0,15 MHz to 30 MHz is swept and the values must be balanced to make sure that, whatever the frequency, the noise doesn't reach peaks exceeding the limits.

It is to be announced here that all calculations were made for:

1- a point located at a distance of 15 meters of the vertical plane containing the side phase and a 2 meters height.

2 - a climate of bad weather, because by using factors of correction one can deduce the level from radionoise disturbances for any climate.

8. CONCLUSION

Because of the electromagnetic coupling between the 3 phases of a three-phase line or between the 6 phases of a three-phase line with 2 terns, the determination of the self-impedances and mutual proves very complicated and with the method of the modes of propagation one could separate the disturbing levels for each phase.

The interest of this theory it is that it allows the study of the propagation by breaking up the system into mode which one treats separately (There is no interaction between these modes) and one reconstitutes the system after recombination of the modes after propagation to obtain the disturbing level of each phase in a separate way to finally obtain the disturbing level of the three-phase line.

Because this separation one can see the influence of the frequency of measurement directly on the radionoise disturbances and one can use this calculation program to study extra high voltage lines in project with much more precision.

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BIOGRAPHIES

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