Experimental study of electromagnetic environment in the vicinity of high voltage lines

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ABSTRACT

This work presents experimental characterization of electromagnetic environment in the vicinity of EL-HADJAR high voltage substation located in the eastern Algerian within a very high populated zone. The method applied in this study is progressive; it can initially study the behavior of electric and magnetic fields and different couplings between different neighboring lines that will be used later as a source of disturbance applied to the study of hearing implants electromagnetic compatibility. The results of measurements for the circuit of lines chose were significantly lower than the recommended standards ICNIR.

INTRODUCTION

Electric power substations, transmission and distribution lines, are some of the commonly known sources of electromagnetic pollution. Since many substations are surrounded by residential or commercial areas, people living near as well as those working within these substations may be exposed to very large EL magnetic fields [1]. Electrical Energy is transported from the power station to the substations through overhead electric lines and from there to the final users by the electromagnetic fields that are propagated throughout the lines, since the high-intensity electromagnetic fields can induce important voltages and currents in conducting elements located in their proximity. The 2007 Euro-barometer survey showed a strong concern and preoccupation of the European population to electromagnetic fields [2].

In absence of evidence that electromagnetic fields cause health problems, the precaution should be. However, the relationship between the electromagnetic fields exposure and occurrence of alleged diseases has not yet been proved. In this context various occupational health organizations have established limits of exposure to EM fields in the work and public places. Among these organizations are cited the ICNIRP and le standard IEEE guidelines which set a basic restriction on the density of electric current induced in the body by ELF fields [3, 4] mainly to avoid electrical shock hazards, minimize burn hazards, and reduce interference with medicals implants [5].

The evaluation of electric and magnetic quantities of charges emanating from power lines is important to establish the permissible exposure limits. At low frequency exposure to electromagnetic fields takes place in conditions of near field, and therefore the distribution of electric and magnetic fields near the source of the field is very complicated and in general it cannot be calculated analytically[6]. This justifies the choice of experimental method for the characterization of the electromagnetic environment near the high voltage power lines. Theoretically the electric fields were analyzed and validated in several works [7-9]. The mastery of techniques for measuring electromagnetic fields radiated by power lines and their compatibility, at our referral center (LGEG), is a precursor to involvement in experimental research on the impact of EMF on the biological environment in general and on health in particular. In this context we conducted this study in collaboration with multidisciplinary research teams: CHU of Annaba (the university hospital) and SONELGAZ (Algerian electricity company), whose purpose is to develop study protocols relating for electromagnetic fields compatibility in order to achieve a regional database on the experimental characterization of low frequency electromagnetic fields, which will be made available to the partners concerned. In this work the experimental measurement of electric and magnetic field have been made in the post of El-Hadjar which provides interconnection between the Far East region of Algeria and Tunisia, This position has a particular interest given its location in an urban area. It covers a range of voltage 220kv, 90kV, 60kV which will permit us to highlight the effects of inductive and capacitive coupling on the distribution of the magnetic and electric field generated in the vicinity of the line circuits operating in parallel.

MATERIEL AND METHOD

1. Model description

To characterize the electromagnetic environment of power lines, we conducted our investigation in coordination with the Algerian company of electricity (SONELGAZ) at EL-HADJAR electrical post located in eastern Algeria. Measurements have also been carried out under 220KV and 90KV lines located next to each other (Fig.1).

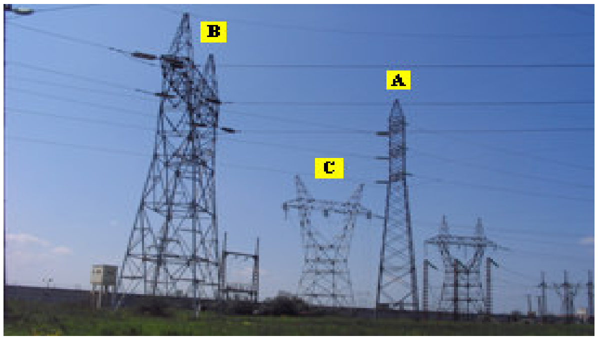

Figure 1 : Model studied

The lines B (90KV) and C (220KV) represents respectively SOUK-AHRAS city and EL-KALA city with a flat configuration, in the middle the line A (90KV) represents MEJAZ EL-SAFA city with a vertical configuration. The distance between phase lines, the clearance of conductors, cables Guard, the lengths of lines and the currents in conductors when measuring the electromagnetic field are mentioned in (Table 1).The Rapprochement between the geometric heights of the conductors of lines B (90KV) and C (220KV) is due to it being an old line of 220 kV that is now used at 90 kV.

Table 1: Geometrical model characteristics

Directions	Pylon A (90 kV) Mejaz El-Safa	Pylon B (90 kV) El-Kala	Pylon C (90 kV) Souk-Ahras
Height of the phase 1[m]	30.60	28.20	30.8
Height of the phase 2[m]	33.85	28.20	30.8
Height of the phase 3[m]	37.10	28.20	30.8
Height of the cable guard [m]	43.60	32.80	33.3
Phase Spacing [m]	3.25	07.00	7.7
Length [km]	45.70	66.75	86.4
Nub of conductors by phase	01.00	01.00	01.0
Value of current by phase [A]	0(unloaded line)	84.00	70.0

2. Experimental Investigation

Measurements of electric and magnetic fields have been conducted in the free space under the high voltage lines in order to achieve a characterization of the electromagnetic environment and to draw the profile of the electric field and magnetic field near the 220KV and 90 kV lines located a few meters from each other, taking into account the inductive and capacitive coupling between the different phases. For this, Measurements of the lateral profiles should begin from the center line in the area of interest and be made to a lateral distance of at least 30 m beyond the outside conductor[10].
In our case we started our measurements from the central pylon A moving in an east direction to the centre of pylon C, then in an west direction to the centre of pylon B using an referenced and calibrated electromagnetic field meter PMM8053A(Fig.2).

To avoid the perturbation of electrical field the device is equipped with an isotropic probe mounted on half a meter high non-conducting tripod. This instrument measures the electric and magnetic fields in three orthogonal directions in the frequency range 5Hz-40GHz, the indication of the field meter must remain constant. This is the only way to ensure that dangerous field strengths are not present. The acquisition of data was done in real time by the computer software package.

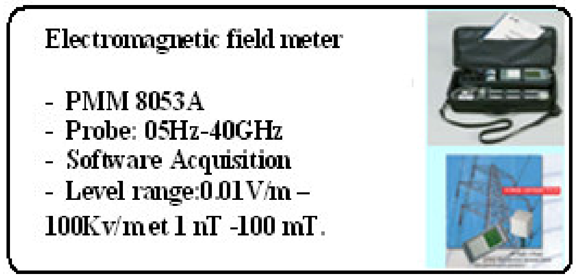

Figure 2 : Characteristics of the measuring equipment

EXPERIMENTAL RESULTS

Electrical field behavior

The figure 3 clarifies the field strength distribution at half meter height above the ground for the circuit of lines considered. This figure reveals that the maximum values of the generated electric field decrease, when increasing the ground clearance level which is highly dependent on the voltage of the line, while the location at which these maximum values occur is the center of the line C(22OKV).It is also revealed in this figure that as the spacing between tow lines adjacent to each other and running in parallel increases, the maximum field which occurs at the center of the structure decreases by a very significant amount. when we move from the right of the center line A (90kV) uncharged , with a vertical arrangement R-S-T of phases to the 7m point , the intensity of the electric field generated increases and reaches a maximum value of 401V/m. In the 14m point, R-S-T horizontal arrangement of the phases of the line B causes a cancellation of the quantities of electric field in the intermediate zone between the two lines A and B, the electric field intensity measured at this point is 166V / m.

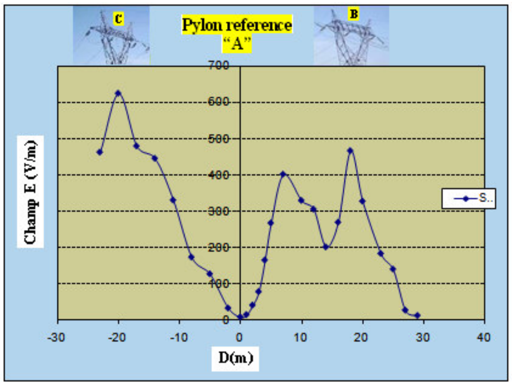

Figure 3: The profile of electric field

Magnetic field behavior

Figure 4 shows the transverse profile of the corresponding magnetic field depending on the distance to the axes of the pylons for the circuit lines A, B and C neighbors, both with the conductors in vertical and horizontal simple arrangement. The conductors of the line in the middle A are located at a height of 30, 6 m with a separation between phases of 3, 25 m and no current flowing through. At the moment of measuring the magnetic field, mean currents of 84 A and 70 A circulated respectively through the conductors of the lines B and C. As is observed in the figure maximum values of the magnetic field are obtained in the center of each line (the centers of the lines are located at 20 m for the line B on the right and -23 m for the line C on the left. The maximum value of the field is reached in the center of the line B and is below (2, 81µT, this values remain well below the maximum limit 100 µT set by European regulations). As can be seen, the value measured under the line C on the left (1.78 µ T) is much lower then the previous value, Evidently, this is due to the fact that a smaller current circulates through the latter and the height at which the conductors of the right line are placed is inferior to that of the conductors of the left line.

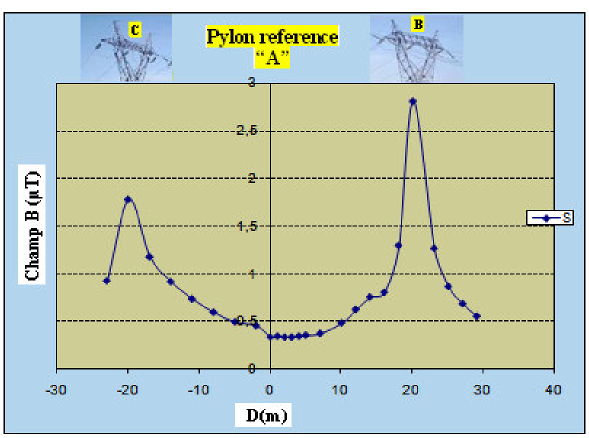

Figure 4: The profile of magnetic field

DISCUSSION

The profiles of electric and the magnetic field measurements are shown in Figures 3 and 4. It can be seen in these figures that the low frequency electromagnetic fields are located close to the line conductors; they have brought space relatively low and field strengths inversely proportional to the distance from the source.

Power lines located near to each other are coupled; the coupling appears in the profiles of the magnetic and electric field drawn .Lateral distribution of the electric and magnetic field strengths depends on the phase arrangement in power lines [11], the same phase arrangement R-S-T; R-S-T produces the lowest electric field strength and magnetic flux density in the intermediate zone between both lines than if another arrangement is used.

CONCLUSION

This experimental investigation has allowed us to make a collection of experimental data on the characterization of electromagnetic fields generated by power lines at low frequencies, to create a database that can be exploited in the transport of electrical energy in Algeria according to international standards. The profiles of electric and magnetic field surveys show the effects of inductive and capacitive coupling on the distribution of quantities of electric and magnetic charges generated by circuits of neighboring lines. The experimental results show that the maximum intensities of these fields have not exceeded the permissible limits set by ICNIRP which correspond to the exposure of the general public has limits of 100 µT for the magnetic field (B) and 5 kV / m for electric field (E) . These results will be used to study the interference of low frequency electromagnetic fields with medical implants (hearing aids), as part of a research project in collaboration with SONELGAZ (Algerian electricity society) and CHU (University Hospital) of Annaba.

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