

THE SURVEY OF THE ELECTROMAGNETIC ENVIRONMENT IN A RESIDENTIAL AREA TRAVERSED BY TRANSMISSION LINES

Valeriu David, Alexandru Salceanu, Mihai Cretu

Faculty of Electrical Engineering, Technical University of Iasi, Iasi, Romania

Abstract – This paper presents the instrumentation and the results of measurements of the magnetic and electric fields near an overhead high-voltage transmission line that passes through a residential area. For measurements have been used two sensors created and calibrated by the authors: a sensor for magnetic field measurement and a sensor for both magnetic and electric field measurements. The measurements have been made in several days with view to estimate the influence of the overhead high-voltage transmission line on the electromagnetic environment in a residential area (block of flats).

Keywords: electromagnetic environment, sensor for electric and magnetic field.

1. INTRODUCTION

The knowledge of electromagnetic environment is important both for area of electromagnetic compatibility [1] and for the area of “biologic compatibility” (biological effects produced by the electromagnetic fields), [2]. A main source of electric and magnetic field in low frequency range is the power lines. Because of this, there is a great interest in measurement of these fields [3-6].

The authors determined the electromagnetic environment in a special area, overhead high-voltage transmission line that passes near a residential zone. It was determinate the transversal and longitudinal variation of the field generated by transmission line and the fields within the block of flats.

For measurement have been utilised two sensors created and calibrated by authors: a sensor with response proportional to magnetic field, and a sensor which measures both magnetic and electric field in the same place in space. The first sensor permits the measurements of fields with high harmonic contents. The second sensor responds the necessity of the measuring E and H in the low frequency range (under 100 kHz) where the simultaneous measurement of E and H is difficult.

2. INSTRUMENTATION

The surveying of electromagnetic environment requires “in situ” measurement. The instrumentation used by the authors in measurement is constituted of two sensors and a Fluke 43 Power Quality Analyser.

2.1. The measurement of the B

The measurement of the B is made with an active magnetic field sensor, and the scope and harmonics modes of Fluke 43 Power Quality Analyser.

The active magnetic field sensor is made up of a field coil and a current amplifier. The immunity of the sensor to the electric field and a good common mode rejection is achieved by shielding and balancing the configuration, Fig 1. Thus, the coil has two symmetrical windings, suitable connected to a symmetric current amplifier. Because the load of the coil (the input of the current amplifier) is small, the active sensor has a response proportional to magnetic field. For frequency greater than critical frequency (about 30 Hz) the output voltage of active sensor is:

$$U = SB \quad (1)$$

where, the constant S is the sensor sensitivity and B is the magnetic flux density.

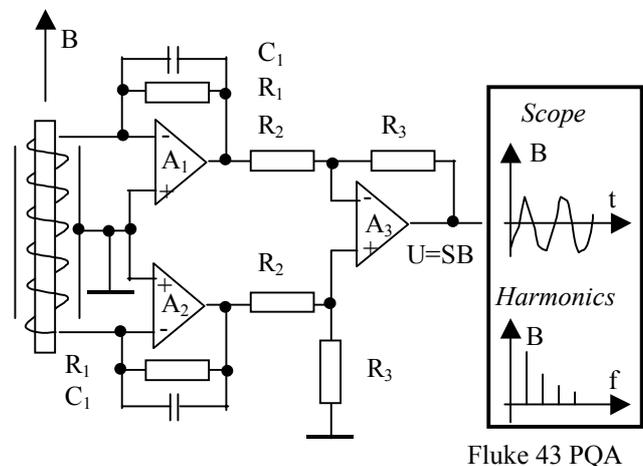


Fig. 1. Instrumentation for magnetic field measurement

The calibration of this active sensor of H is made through the standard field method. It is used a single round loop for generating the standard field [7], conforming Fig. 2., where AFG is an audio-frequency generator, R_s is a standard resistance and DVM is a digital voltmeter. The current, I , is determined by means of R_s and U . The magnetic field sensor (the coil) is placed in a centre of emitter loop.

The sensor factor is:

$$K = \frac{1}{S} = \frac{B}{U} = 0,53 \mu\text{T} \quad (2)$$

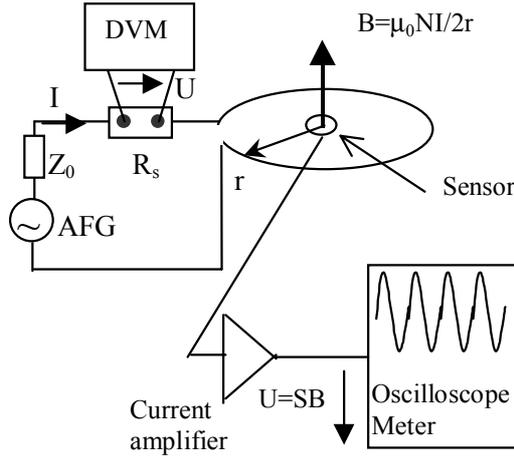


Fig. 2. The calibration of magnetic field meter

It was verified that the response of the sensor is linear for $B = 20 \text{ nT} \div 2 \text{ } \mu\text{T}$, and is independent of frequency in range of $50 \text{ Hz} \div 100 \text{ kHz}$.

2.2. The measurement of the magnetic and electric field

Fig. 3 presents a sensor for both H and E measurement [8].

The magnetic field is measured by the induction coil (inner shield winding) for which the voltage induced is:

$$U_C(t) = N\pi b^2 \frac{dB_x}{dt} = N\pi b^2 j\omega\mu_0 H_x \quad (3)$$

where: N is the number of the turns of the inner winding; b is the coil radius, and H_x is the magnetic field component perpendicular on the loop plane.

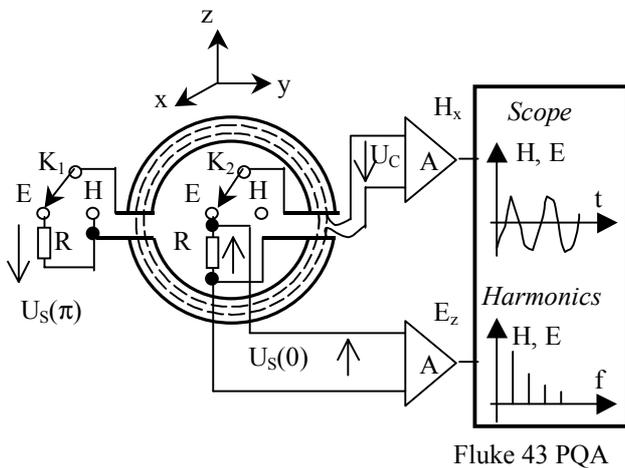


Fig. 3. The instrumentation for magnetic and electric field measurement

The electric field is measured using the shield of the coil, which in this case is a loop loaded with two resistance having the value R , in each of the diametrically opposed gaps (at angles $\phi_1=0$ and $\phi_2=\pi$).

The voltages in these diametrically opposed loads are:

$$U_S(0) = U_{S,H}(0) + U_{S,E}(0) = \frac{1}{2} \pi b^2 j\omega\mu_0 H_x + \pi b j\omega C R E_z \quad (4)$$

$$U_S(\pi) = U_{S,H}(\pi) - U_{S,E}(\pi) = \frac{1}{2} \pi b^2 j\omega\mu_0 H_x - \pi b j\omega C R E_z \quad (5)$$

Because H is measured with the inner winding, the shield is used only for E measurement. In this way it is possible to increase the resistance R from the gaps, in order to increase the sensitivity to the electric field, i.e. the voltage due to E ($U_{S,E}(0)$) should be much greater than one due to H ($U_{S,H}(0)$), resulting:

$$U_S(0) \cong U_{S,E}(0) = \pi b j\omega C R E_z \quad (6)$$

The calibration of this sensor is made also through the standard field method. Thus, for magnetic field is used same method described in 2.1. For electric field are used two parallel square electrodes, conforming Fig. 4.

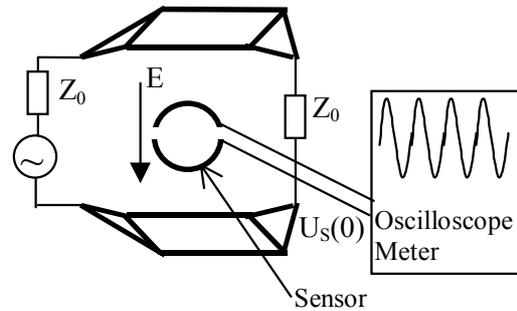


Fig. 4. The calibration of electric sensor

It was verified the sensor response linearity with the frequency and also the linearity with the electric field. Fig. 5 shows the theoretical and calibration curve for $f = 50 \div 1400 \text{ Hz}$ and $E = 289 \text{ V/m}$.

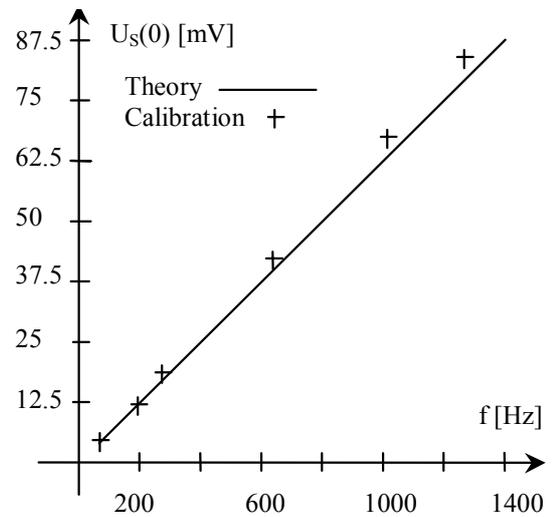


Fig. 5. The electric field response versus frequency

3. THE SURVEYED ZONE AND MEASUREMENT RESULTS

The measurement area is presented in Fig. 6. In immediate neighbourhood of the four circuits of 110 kV, there is, towards right, a forest and, towards left, a block of flats.

The currents in these four circuits are different and each line has a daily variation (home and industrial patterns). The currents in circuits for a workday and weekend at two different time of day are shown in Table I.

TABLE I. The current in circuits for two days

	Work day		Sunday	
	9 AM	8 PM	9 AM	8 PM
Circuit 1	25 A	10 A	15 A	20 A
Circuit 2	30 A	15 A	15 A	15 A
Circuit 3	20 A	10 A	10 A	10 A
Circuit 4	-	-	-	-

Measurements of magnetic and electric field transversal profiles were made at every 2 m distance and about 1 m above ground.

Fig.6.b shows two transversal semi-profiles of magnetic flux density B : one from the point O_1 to block of flats which is affected by power electrical connection of a block (distribution lines), and one from the point O_2 to the forest which is generated only of the transmission line. The points O_1 and O_2 are situated in centre of the cross section, but in different longitudinal places of the transmission line (lateral profile).

Concerning the longitudinal variation of the magnetic field, the ratio between B at the midspan (where the field is maximum) and B at the tower (where the field is minimum) was about 3.

It was made measurements of B (transversal profile in the midspan) in five days. The shape of the transversal profile changes in time because the variability of the current in circuits, but the maximum value of the magnetic field is always at about 6-8 m from the point O (the centre).

In Table II is given the maximum value of the magnetic field generated by high voltage transmission line (B_m) and the maximum value of magnetic field due distribution line (B_{md}) for measurements made in several days.

TABLE II. The maximum magnetic fields

	Day 1	Day 2	Day 3	Day 4	Day 5
B_m	355 nT	223 nT	281 nT	204 nT	192 nT
B_{dm}		208 nT	246 nT		

It was, also, measured the magnetic field in the hall of the block of flats which is situated near the overhead high-voltage transmission line. Thus, $B = 2 \mu\text{T}$ near a transformer situated in the hall, $B = 186 \text{ nT}$ at 1 meter from transformer and $B = 90 \text{ nT}$ in middle of the hall.

For E generated by the high-voltage transmission line the maximum value was about 2 kV/m.

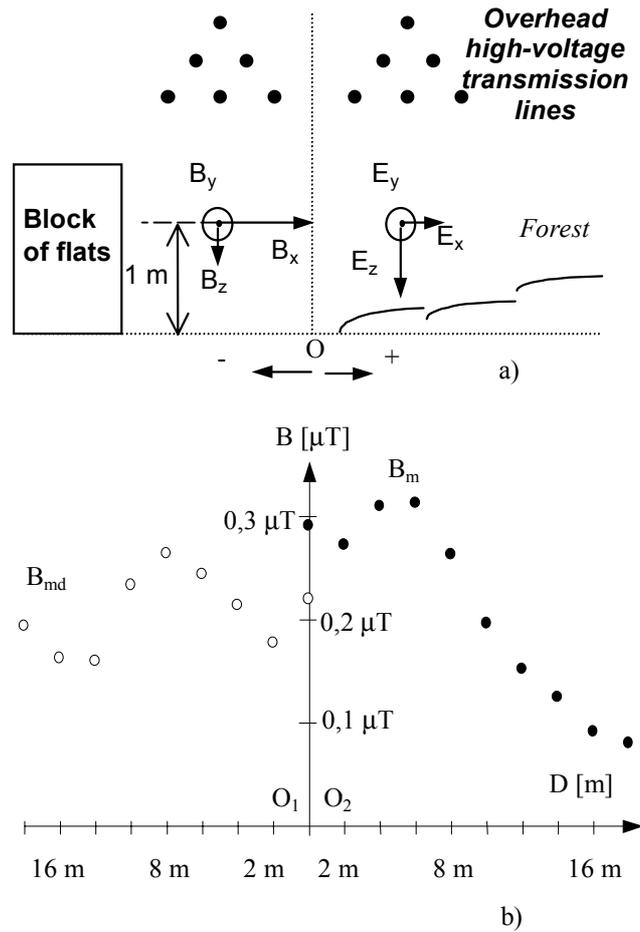


Fig. 6. a) Configuration of the surveyed zone; b) Transversal magnetic field semi-profiles.

4. CONCLUSIONS

Using two sensors made and calibrated by themselves, the authors measured the magnetic and electric field in a special area, overhead high-voltage transmission line that passes near a residential zone.

For characterising this area, the authors measured the electric and magnetic field around transmission line and the field within the block of flats.

The transversal profile of the high voltage transmission line is affected by the magnetic field generated by the distribution line. In this situation the maximum magnetic field generated by the distribution line is almost equally to field generated by transmission line.

For magnetic field generated by transmission line was determinate the longitudinal variation (maximum at midspan and minimum at towers) and the elliptic polarisation of the field vector.

The magnetic field within the block of flats has a high content of harmonics and it is not basically determinate by the transmission line.

In this area the electromagnetic environment is much small then that imposed by standards and recommendations [9]

ACKNOWLEDGMENTS

This paper was developed in the generous framework offered by Leonardo da Vinci Pilot Programme DeQuTest, having the code Ro/98/83550.

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Authors:

Associate professor Valeriu David, Faculty of Electrical Engineering, Technical University of Iasi, Blvd. Dimitrie Mangeron No 53, Iasi 6600, Romania, +40 32 278680, +40 32 237627, valdadid@ee.tuiasi.ro

Professor Alexandru Salceanu, Faculty of Electrical Engineering, Technical University of Iasi, Blvd. Dimitrie Mangeron No 53, Iasi 6600, Romania, +40 32 278680, +40 32 237627, asalcean@ee.tuiasi.ro

Professor Mihai Cretu, Rector of Technical University of Iasi, Blvd. Dimitrie Mangeron No 67, Iasi 6600, Romania, +40 32 278680, +40 32 237627, mcretu@ee.tuiasi.ro