Experimental Study of Emissions Produces by Inductive Transmission of Electical Energy

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Abstract- The discovery of the law of electromagnetic induction by M.Faraday and especially its uses in electrical engineering led to the evolution and progress of human civilization in the XXth and XXIst centuries.

Nikola Tesla had the brilliant idea of making the inductive transmission (wireless) of electrical energy over long distances but due to financial reasons he could not carry out his experiments.

Today, the idea issued more than 100 years ago by Tesla regarding inductive transmission (wireless) of electrical energy, is very topical at the same time with IT progress, presenting several advantages among which stand out: the lack of physical contact and thus of their wear, the possibility to be used in special environments (corrosive, acid, explosive), etc.

The inductive transmission of electrical energy of low power and for short range is used today to achieve induction (wireless) chargers for mobile phones, cameras, laptops, pacemakers, etc.

This paper presents experimental results obtained regarding the emissions of electric and magnetic field as well as interferences produced by a wireless charger, type Samsung, for a mobile phone.

The determinations were performed in the laboratory of Electromagnetic Compatibility within the National Institute for Research Development and Testing in Electrical Engineering of Craiova (ICMET).

Keywords—electromagnetic compatibility, electric field , inductive transmisson , charger for mobil phone; magnetic field

1.Introduction

The discovery of the law of electromagnetic induction by M.Faraday and especially its uses in electrical engineering led to the evolution and progress of human civilization in the XXth and XXIst centuries.

Nikola Tesla had the brilliant idea of making the inductive transmission (Wireless) of electrical energy over long distances but due to financial reasons he could not carry out his experiments.

Today, the idea issued more than 100 years ago by Tesla regarding inductive transmission (wireless) of electrical energy, is very topical at the same time with IT progress, presenting several advantages among which stand out: the lack of physical contact and thus of their wear, the possibility to be used in special environments (corrosive, acid, explosive), etc.

The inductive transmission of electrical energy of low power and for short range is used today to achieve induction (wireless) chargers for mobile phones, cameras, laptops, pacemakers, etc.

For any electronic product, of industrial, household or personal use, today the issue is raised to meet the terms of electromagnetic compatibility (electric and magnetic field emitted, interferences that may affect the human being or the operation of other electric or electronic devices around them).

This paper presents experimental results obtained regarding the emissions of electric and magnetic field as well as interferences produced by a wireless charger, type Samsung, for a mobile phone.

The determinations were performed in the laboratory of electromagnetic Compatibility within the National Institute for Research Development and Testing in Electrical Engineering of Craiova (ICMET).

2.Basic principles of inductive transmission

The inductive transmission of electrical energy that is the transfer of electric power by electromagnetic induction is a topical and important issue for scientific specialists and researchers in the field of electrical engineering, electronic and IT. The inductive transfer of electrical energy is based on the principles stated in two fundamental laws of electrical engineering namely the law of electromagnetic induction and the law of magnetic circuit.

In principle, the operation of a transmission system by induction of electrical energy is based on the variation of a magnetic field created due to the alternative current flowing through an electrical circuit, called the primary circuit and which induces a voltage in a second circuit, called secondary circuit, magnetically coupled with the primary one through air.[2]

3 Experimental determination of electric and magnetic field disturbances caused by wireless transmission of electrical energy

3.1. General aspects

Some of the current applications of the wireless transmission of electric energy have resulted in achievements in the IT field and namely chargers were manufactured on this principle for mobile phones, cameras, etc.

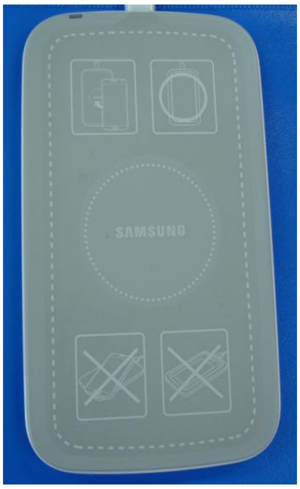

Fig.1 Wireless charger for a mobile phone

The study conducted was made on a wireless charger type Samsung, model EP-P 1001 EWE for a mobile phone (fig.1). The determinations made in the laboratory of electromagnetic compatibility of the National Institute for Research Development and Testing in Electrical Engineering of Craiova pursued the measurement of the electric and magnetic field in the space around the charger as well as disturbances of electric and magnetic field produced in different operational situations.

Measuring the value of the electric field (the intensity of the electric field) and of the magnetic one (magnetic induction) a device type Narda EFA-300 was used (fig.2).

Fig.2 Narda EFA-300

To determine the level of the disturbances produced the device EMI Test Receiver R&S ESCI was used, manufactured by ROHDE & SCHWARZ

, a loop antenna (circular) active for the measurements of magnetic field disturbances and a biconical one type UBAA 9114-251 type Schwarzbec, with the frequency range between 30-1000MHz and pyramidal horn type antenna with the frequency range between 1 GHz and 3 GHz .

Active loop antennas are provided with a preamplifier of high frequency powered by a battery, which aims to maintain constantly the antenna factor in a wider area but also to decrease it accordingly, which translates into the fact that the antenna becomes more sensitive at low frequencies.

In general, the loop antennas are screened, through the conductive tube, against the influence of the electric component of the field [4,5].

3.2. Experimental determinations

3.2.1 The determination of the electric and magnetic field

First, determinations of the values of the electric and magnetic field in the air were performed, the values obtained, for various operating situations of the charger, are shown in Table 1 (for the magnetic field) and Table 2 (for the electric field).

Table 1

The situation studied	B [nT]
1. Unpowered charger – in the air (at 2cm)	165
2. Charger powered at 220V/50Hz – in the air (at 2cm)	160
3. Charger powered at 220V/50Hz with charging phone– in the air (at 2cm)	172
4. Charger powered at 220V/50Hz with phone charged and in operation – in the air (at 2cm)	190

Table 2

Situation studied	E [V/m]
1. Unpowered charger – in the air (at 2cm)	60
2. Charger powered at 220V/50Hz – in the air (at 2cm)	193
3. Charger powered at 220V/50Hz with charging phone– in the air (at 2cm)	210
4. Charger powered at 220V/50Hz with phone charged and in operation – in the air (at 2cm)	294

The measurements were retaken in the anechoic chamber, the results obtained are shown in table 3 (for magnetic field) and in table 4 (for electric field).

Table 3

Situation studied	B [nT]
1. Reference level	180
2. Charger powered at 220V/50Hz – in the air (at 2cm)	180
3. Charger powered at 220V/50Hz with charging phone– in the air (at 2cm)	180

Table 4

Situation studied	E [V/m]
1. Reference level	62
2. Charger powered at 220V/50Hz – in the air (at 2cm)	198
3. Charger powered at 220V/50Hz with charging phone– in the air (at 2cm)	206

3.2.2. The determination of the electromagnetic field disturbances

The experimental measurements were performed taking into study two situations, namely:

- charger operating idly;
- charger operating with the phone charging.

The determinations of the magnetic field disturbances were performed using the device EMI Test Receiver R&S ESCI (fig.3), using an active loop antenna (circular antenna).

Fig.3 EMI Test Receiver R&S ESCI [7]

The results obtained are shown in fig.4 and fig.5 .

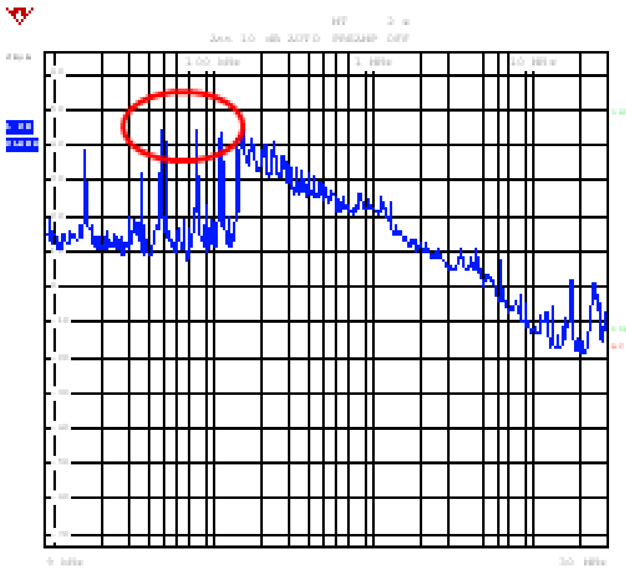

Fig.4 The results regarding the magnetic field disturbances with charger operating idly

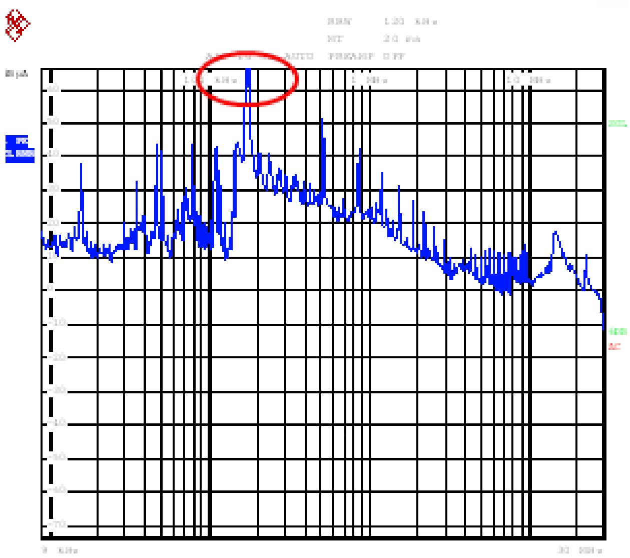

Fig.5 The results regarding the magnetic field disturbances with charger operating with phone charging

For the determinations of electric field disturbances was used for start the biconical antenna with frequency range between 30-1,000MHz, in vertical position, the results of the measurements being shown in fig.6 and fig.7.

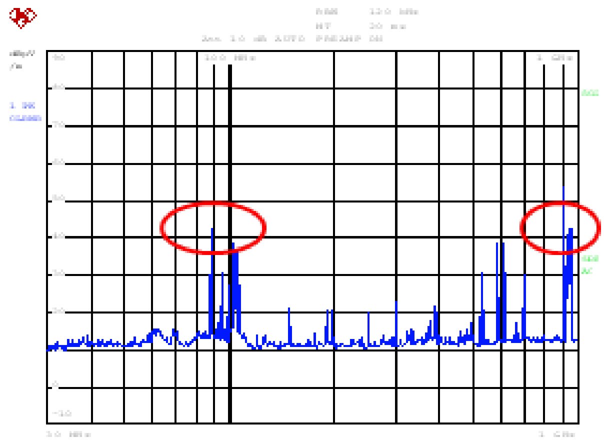

Fig.6 Determinations with vertical biconical antenna with charger operating idly

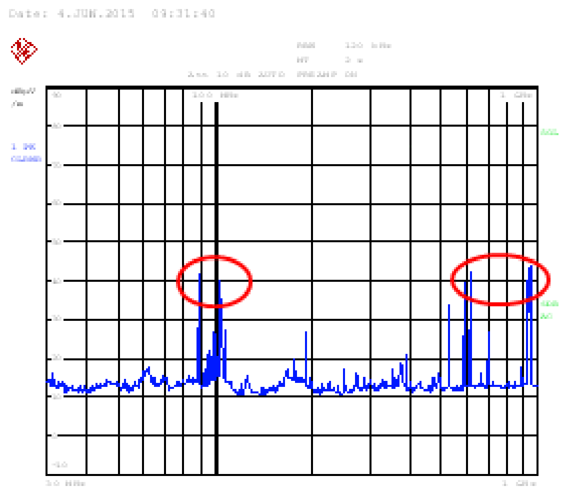

Fig.7 Determinations with vertical biconical antenna with charger operating with phone charging

Using the biconical antenna in a horizontal position the results shown in fig.8 and fig.9. were obtained .

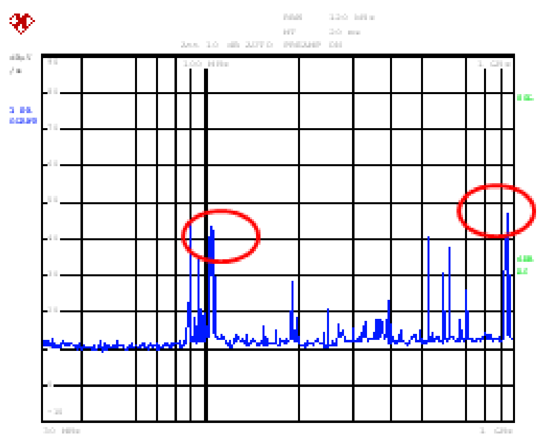

Fig.8 Determinations with horizontal biconical antenna with charger operating idly

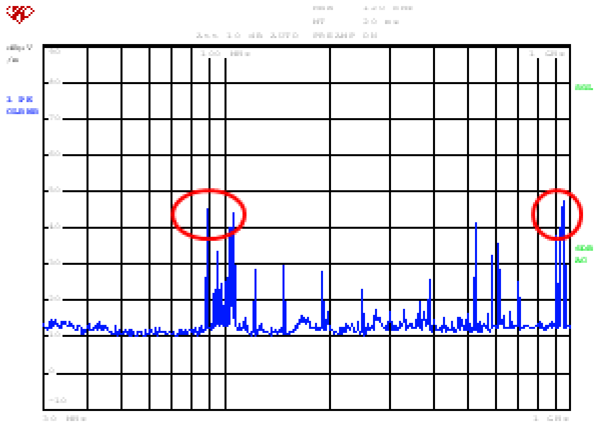

Fig.9 Determinations with horizontal biconical antenna with charger operating with phone charging

Further on are shown the results obtained with pyramidal horn antenna (with a frequency range between 1 GHz and 3 GHz) in fig.10 and fig.11.

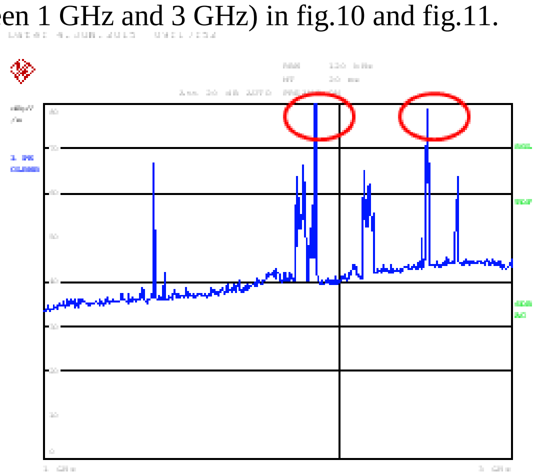

Fig.10 Determinations with horizontal horn antenna with charger operating idly

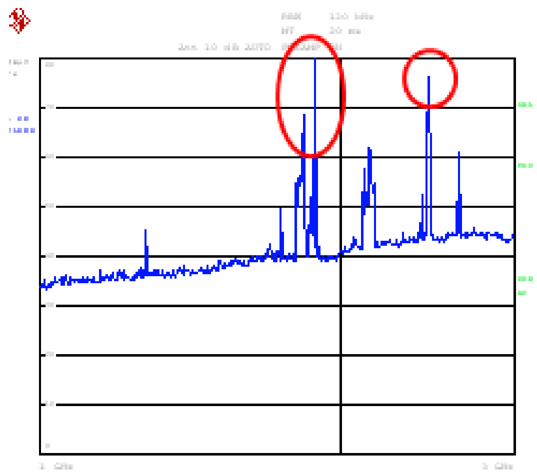

Fig.11 Determinations with horizontal horn antenna with charger operating with phone charging

3.3. The analysis of disturbances produced by wireless transmission of electrical energy

The values measured for the magnetic field (magnetic induction) in the cases studied, both in the air and in the anechoic chamber, and shown in Tables 1 and 3 show a low level of the magnetic field, values of the order nT.

The values of the electric field (the intensity of the electric field) around the charger, both in the air and in the anechoic chamber have similar values (table 2 and table 4).

Analyzing the experimentally determined values for disturbances of the magnetic field in the case of charger operating idly (fig.4) the maximum value of the disturbance is next to the frequencies of 40 and 80 kHz having the value of 45dBµA/m to which corresponds a value of the magnetic field of 0.23nT.

In the case of charger operating with the phone charging (fig.5) it is noticed that in the area of the frequencies included in the range 180-200 kHz two disturbances peaks are found, of 50 dBµA/m and of 70 dBµA/m to which the values of 0,4 nT respectively 4 nT correspond.

These values of the magnetic field are not dangerous for the human being who would be permanently or accidentally exposed, being lower than 10 µT .

With regard to the electrical and electronic equipment in offices and homes that have average length power cords, we consider that starting with a 30 MHz frequency, an important electromagnetic radiation is produced.

In specialized literature, two classes of limit values are established in this regard, namely A and B [5].

The wireless charger studied can be classified in Class B which includes devices that are intended to be used in homes.

Following the values obtained for the disturbances resulting from frequencies between 30 MHz and 1 GHz (which obviously includes the 30-100 MHz frequency range) measured with a biconical antenna (fig.6,7,8,9), we observed that these values (40dBµV/m) are in the according of the disturbance levels (48dBµV/m) stipulated in [5] for Class B devices.

In case of disturbances of the electric field, the maximum detected value is situated at the level of 80dBµV/m, around the frequency of 2 GHz, to this level of disturbance corresponding an electric field of 0.01 V/m, a value below the admitted limit for the respective frequency.

4.Conclusions

Besides the traditional uses of law of electromagnetic induction in electrical engineering, one usage, intuited more than 100 years ago by Nikola Tesla, is the wireless transmission of electrical energy.

Today, for small electric powers, wireless devices were manufactured for charging the batteries of portable devices like mobile phones, cameras, etc.

The measurements made in the specialty laboratory of ICMET Craiova were carried out with special equipments of industrial use namely the device type Narda EFA-300 and equipment EMI Test Receiver R&S ESCI manufactured by ROHDE & SCHWARZ .

The results obtained, both in the air and in the anechoic chamber, indicated the fact that the values of electrical and magnetic field, for various operating situations of the wireless charger (unpowered charger, charger powered at 220V/50Hz, charger powered at 220V/50Hz with phone charging, charger powered at 220V/50Hz with phone charging and operating, determinations in the air and the anechoic chamber) shown in Table 1, Table 2, Table 3 and Table 4, have similar values and their size is within admitted limits.

The disturbances of the electric and magnetic field detected and registered with specialty equipment indicated measured values permissible for the level of electrical and magnetic field [8]. Also, for peak values reported for the level of the electric and magnetic field non dangerous values for the magnetic field resulted (at a frequency of 80 kHz the magnetic field is 0.23nT) and for the electric field (at a frequency of 2GHz the electric field is of 0.01 V/m)

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