Concerning the Emitted Electromagnetic Radiation by the Electronic Devices

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Abstract— The rapid development of IT technologies has led to the achievement of new modern, performant equipment which should meet the actual requirements concerning the electromagnetic pollution**.** Inside the office buildings, houses, schools it is used more often the wireless access to the internet of the accounting technique (computer networks, laptops, tablets, etc.) by using routers. This article presents a synthesis of the experimental measurements carried out to determine the electromagnetic field emissions of electronic equipment (mobile phones, laptops, routers) specific to domestic and industrial applications. The experimental determinations were performed in the laboratory of Electromagnetic Compatibility within the National Institute for Research Development and Testing in Electrical Engineering of Craiova (ICMET). The experimental results had the purpose to verify if the electromagnetic field emissions values are within the range of the accepted limits regulated by the rules in force regarding the electromagnetic compatibility.

***Keywords*—** dipole antenna, electromagnetic compatibility, laptop, router, wireless devices.

I. INTRODUCTION

THE rapid development in terms of modern mobile telecommunication equipment and electronic computers led, besides the problems of new achieved technologies (hardware and software), to aspects regarding the achivement of the electromagnetic field EMF emission level. Lately, in the office buildings, houses, schools it is used more often the wireless access to the internet of the electronic devices (computers networks, laptops, tablets, etc.) by using routers. Concerning this matter, in the literature in the field are presented various aspects, some of them, still unconfirmed medical, regarding adverse reactions on on human health due to uncontrolled exposure and often long time to electromagnetic radiation. The main objectives of the research activity of the national and international institutions, working in the domain, is to establish guidelines and to find the way to limit the EMF exposure and in the same time to provide the protection methods to adverse effects over the human body.

This paper presents a synthesis of experimental determinations made in recent years to determine the electromagnetic field emissions of electronic equipment, studying and analyzing emissions for a wireless charger, type Samsung, for a mobile phone, a router type AC750 Dual Band, 750 Mbps, 2.4 GHz frequently used to connect to the internet in homes, offices, campuses etc**.,** and laptops.

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

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II. ELECTROMAGNETIC RADIATIONS SOURCES

The existence of sources of electromagnetic radiation is not something new to humanity. The terrestrial magnetic field is a permanent presence being created naturally due to the chemical and geological composition of Earth. Likewise, the cosmic radiation is permanently present in the atmosphere.

The current problems are due to the occurrence and development of the artificial sources of electromagnetic radiation, with which the man comes into daily in contact at office, at home, in transportation systems, etc. With the development of the production, transportation and use of electric energy on the large scale, starting with the end of the XIX century, mankind was and still is subjected to the action of some electromagnetic fields produced artificially by electrical and electronic equipment (electrical energy transportation lines, electrical transformers, electromagnets, radars, computers, household appliances, etc.). In this regard, it is important to analyze the non-ionizing electromagnetic fields which are radiations with frequency in the range 3 kHz ...300GHz; their energy does not determine the ionisation of the matter[1]. The biological effects of electromagnetic radiation depending on the wavelength and a lot of physical parameters [2]. The wireless telecommunications development

(mobile telephony), wireless transmission and interconnection between IT equipment and accessories, radar equipment which led to an exponential growth of apparatus which emit non-ionizing electromagnetic radiations.

The exposure to electromagnetic radiation is both occupational and environmental. The occupational exposure includes the sources used in home or service, to which we have direct daily access by using different types of electronic devices (cables, household appliances, IT, telecommunication, industrial devices, etc.). The ambient exposure includes external sources such as electrical panels and transformers, telecommunication antennas, high voltage lines, industrial installations, etc.). In many situations, one person can be exposed to the both kind of radiation sources [3].

Therefore it becomes very important to measure the level of the emitted radiations by the electronic devices which are parts of many applications and consequently to verify if the measured values are compliance with the regulated range by the law and standards in force.

III. Considerations regarding the effects of electromagnetic fields emissions over the human health

As it is was stated in the previous statements, studies and researches are permanently carried out in terms of effects on short, average and long-term of electromagnetic field radiation over the human body. The intensification of these researches was achieved due to the emergence and explosive development of mobile telephony and a telecommunications through the internet. Many researches have been carried out in order to see the excessive use of mobile telephony over the human health [4,5,6].

The thermal effect is a consequence of the live tissue exposure at the electromagnetic field, therefore in the head area, due to the use of the mobile phone, local warming up in terms of degree fractions are due to the excessive use which could lead to the increase of the human body temperature with 0.1^0C. [7,8]. As a result of industrial development, in the last years, of new artificial sources of electromagnetic radiations related to mobile telephony necessary equipment (antennas, stations, telephones, etc.), wireless links between IT equipment, etc, besides the known classical sources, the problem is raised more frequently and insistently over the effects of these radiations (short-term, average and long-term) over the human health.

Concerning the thermal effects of the electromagnetic radiation over the human body, it is possible that for the values of electromagnetic field intensities smaller than the ones which produce thermal effects, to appear non-thermal effects as well but not noticeable on average or long-terms, which, amongst others effects, it's possible to affect the activity of the human immunity system [2,7,9,10].

Likewise, it were reported, at different persons, a lot of other symptoms such as: headaches, dizziness, nausea, fatigue, anxiety, etc., due to the exposure to electromagnetic radiation, these failing to be proven till present time, being under research activity [2,6].

The effects of the electromagnetic field over the human health are directly proportional with the exposure time, the frequency and the magnitude of the electromagnetic field. In this paper, are presented the results of the experimental measurements carried out with the purpose to verify the level of the electromagnetic field emitted by the certain electronic devices. To measure and analyze the electromagnetic emissions were used a Samsung wireless charger for a mobile phone, one router, and laptops.

IV. Experimental setup

In this article is presented a part of the experimental determinations carried out to determine the electromagnetic field emissions of certain electronic equipment. The research work was carried out within a research contract whose beneficiary was ICMET Craiova.

It were studied and analyzed the electromagnetic emissions of a Samsung wireless charger for a mobile phone, a 2.4 GHz, AC 750 Dual Band router, 750 Mbps, and laptops.

The experimental determinations were performed with modern equipment in the laboratory of Electromagnetic Compatibility within the National Institute for Research Development and Testing in Electrical Engineering of Craiova, ICMET

A. Experimental determination for a wireless charger

The measurements were carried out on a wireless charger type Samsung, model EP-P 1001 EWE, for a mobile phone. Two situations of the experimental setup were considered, namely: a) wireless charger no load operating, b) wireless charger operating during the mobile phone charging. The experimental setup is shown in Figure 1.

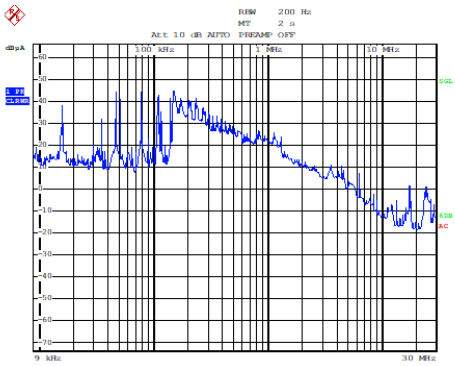
In Fig. 1a is presented the experimental assembly made for determining the magnetic induction value and that in Fig. 1b for determining the intensity of the electrical field emitted.

Concerning the the magnetic and electrical field numerical values resulting from the experimental determinations, these are synthesized in Table I.[11,12]

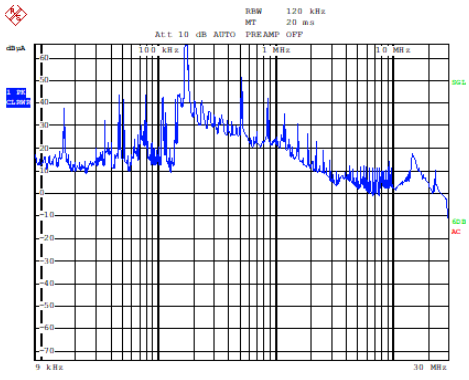
a) b)

Fig. 1.The experimental setup to measure the magnetic induction and electrical field intensity for wireless charger.

The measurements of the magnetic field disturbances were made by means the device EMI Test Receiver R&S ESCI, from Rohde&Schwarz, using an active loop antenna biconical type UBAA 9114-251 from Schwarzbec, within the frequency range 30…1000MHz and pyramidal horn type antenna within the frequency range 1 GHz…3 GHz . In the Figure 2 are shown two graphical reprezentations of the magnetic induction disturbances in those two situations mentioned above.



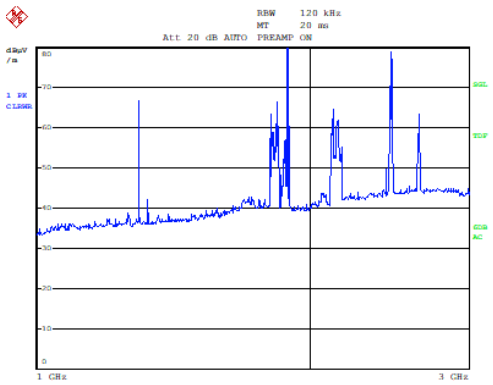
a)



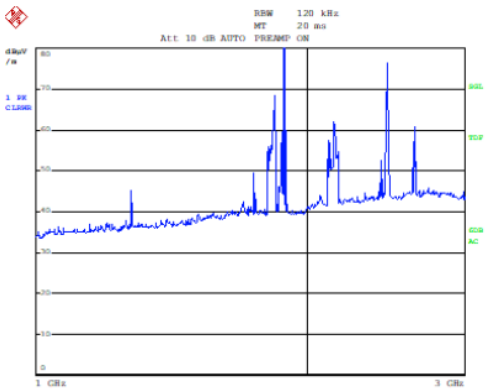
b)

Fig.2 Disturbancies of the magnetic induction vs frequency

a)with charger no load operating, b) with charger operating with phone charging



a)



b)

Fig.3 The electric field disturbances vs frequency

a)with unload charger, b) with charger operating with phone charging

Analyzing the experimental measured values of magnetic field disturbances in the case of charger no load operating (Fig.2a) the maximum value of 45dBµA/m of the disturbance is reached to the frequencies of 40 and 80 kHz, which corresponds to a value of the magnetic induction of 0,23nT. In case of charger operating with the phone charging (Fig.2.b) it is noticed that in the frequency range of 180-200 kHz, two disturbances peaks are observed, having values 50 dBµA/m and 70 dBµA/m, which correspond to the magnetic induction values of 0,4 nT respectively 4 nT.

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

In case of disturbances of the electric field, using a horizontally pyramidal horn antenna, the maximum value reaches the level of 80dBµV/m, around the frequency of 2 GHz; this level of disturbance corresponding to an electric field value of 0,01 V/m, as can be noticed from the Figure 3; this value is lower than the admitted limit for the respective frequency.

Concerning the magnetic and electrical field numerical values resulting from the experimental determinations, these are synthesized in Table I.

In case of disturbances of the electric field, the maximum detected value is 80dBμV/m, around the frequency of 2 GHz, to this level of disturbance corresponding an electric field of 0,01 V/m, a value which is lower than the admitted limit to the mentioned frequency.

B. Experimental determination for electronics devices

The experimental determinations have been carried out in the electromagnetic compatibility laboratory within ICMET-Craiova using the latest generation equipment

B.1Experimental determination for a laptop

For more accurate measurements, it is necessary to consider more practical cases, such as: variable number of work stations (connected users); type of sent information (data, video); the location of the access point and the distance to the work station; location of the wireless equipment; traffic direction (upload or download), etc. [13, 14].

The general conditions for performing the experimental determinations were: a) traffic direction: downloading; b) number of simultaneous users: one and/or two laptops type Dell Inspiron 15and type Lenovo IdeaPad 1000; c) different locations of the access point – wireless equipment: 40..100 cm; d) type of downloaded information: videos; e) ambient parameters: temperature $23,7^0$ C and humidity 47,6%.

A dipole precision antenna type PCD-8250, the frequency bandwidth 80 MHz...3 GHz, with conical radiation elements has been used. To record the experimental data, a spectrum analyser type Anritsu Spectrum Master MS 2711D and one laptop with dedicated software were components of the experimental setup from Figure 4.

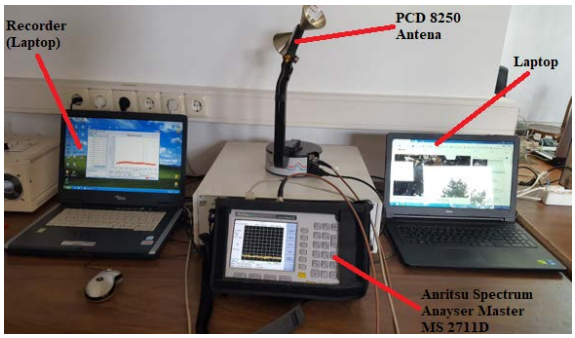


Fig.4 The experimental setup for laptops

In the laboratory, at a distance of approx. 2-3 m from the work stations (laptop), one router type AC750 Dual Band, 750 Mbps, 2.4 GHz was located. The results of the experimental determinations are synthesized and calculated for the electromagnetic field sizes, are presented in Table II. The values from the 0 raw. represent the results of the measurements performed in the laboratory with any other internal electromagnetic radiation sources (router, functioning laptops) with the goal to observe the level of existent electromagnetic radiations due to some external sources. The determinations noted with * represent the values of the electromagnetic field emissions measured for a laptop type Dell Inspiron 15 under the circumstance in which the router not working.

B.2 Experimental determinations for a router

In this work was studying the radiated emissions from router type AC750 Dual Band, 750 Mbps, 2.4 GHz frequently used for the connection to the internet in homes, offices, campuses and so on. In Fig.5 [15] the experimental setup is presented.

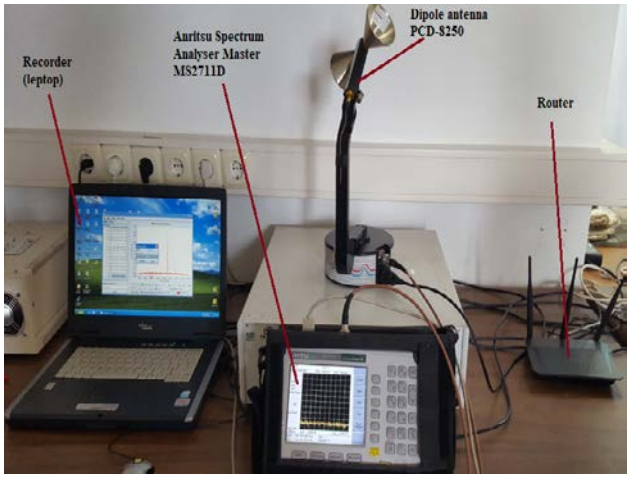


Fig.5 The experimental setup for a router

Analyzing the data presented in Table III, can be noticed that, accordingly to the international regulations [16, 17], that the measured values for the electromagnetic field emissions by the studied router are within the range of admitted limits. Therefore they are not dangerous for the human health. On the other hand, from the analysis of the values presented in table II, it results that the values of the electromagnetic field are increasing as the distance from the router increases, aspect which contradicts what was theoretically expected. This can be explained by the position of the measuring point relative to the wireless equipment and also the relative position of other sources of radiation inside the camera (eg laptop) to the router (at a distance of 60-80 cm between the antenna and the router, the laptop is in the router area) and other sources of external radiation to the laboratory. In the same time, both external sources radiations and the ones produced by studied equipment, suffer reflexion, diffraction in contact with the walls of the room. Therefore, diffuse dispersion phenomena appear and might have a significant impact over the electromagnetic field radiation distribution [18].

TABLE I

	B [nT]	E [V/m]
1. unloaded wireless charger	165	60
2. wireless charger loaded at 230V/50Hz	160	193
3. wireless charger loaded at 230V/50Hz with mobile phone	172	210
4. wireless charger loaded at 230V/50Hz with mobile phone in work	190	294

TABLE II

No.	Distance [cm]	No. of laptops	E [V/m]	H [A/m]	B [T]	dBμV/m	dBμA/m	f [GHz]
0			0.0286	$7.61\cdot10^{-5}$	$9.58\cdot10^{-11}$	89.13	37.63	
1	40	1	0.0120	$3.193\cdot10^{-5}$	$4.02\cdot10^{-11}$	81.58	30.08	2.448
2	60	1	0.0359	$9.552\cdot10^{-5}$	$12.03\cdot10^{-11}$	91.10	39.6	2.447
3	80	1	0.0196	$5.234\cdot10^{-5}$	$6.589\cdot10^{-11}$	85.88	34.38	2.446
4	60	2	0.0315	$8.381\cdot10^{-5}$	$10.55\cdot10^{-11}$	89.97	38.46	2.430
5 *	20	1	0.0205	$5.454\cdot10^{-5}$	$6.867\cdot10^{-11}$	86.24	34.74	2.443
6 *	60	1	0.0250	$6.652\cdot10^{-5}$	$8.374\cdot10^{-11}$	87.96	36.46	2.43

TABLE III

Nr.	Distance [cm]	Nr. of laptops	E [V/m]	H [A/m]	B [T]	dBμV/m	dBμA/m	f [GHz]
0			0.0286	$7.61\cdot10^{-5}$	$9.58\cdot10^{-11}$	89.13	37.63	2.441
1	40	1	0.0214	$5.69\cdot10^{-5}$	$7.168\cdot10^{-11}$	86.61	35.11	2.418
2		2	0.0562	$14.95\cdot10^{-5}$	$18.83\cdot10^{-11}$	94.99	43.49	2.147
3	60	1	0.02456	$6.535\cdot10^{-5}$	$8.227\cdot10^{-11}$	87.80	36.30	2.428
4		2	0.0765	$20.35\cdot10^{-5}$	$25.62\cdot10^{-11}$	97.67	46.17	2.412
5	100	1	0.0699	$18.6\cdot10^{-5}$	$23.4\cdot10^{-11}$	96.89	45.39	2.409
6		2	0.0562	$14.95\cdot10^{-5}$	$18.83\cdot10^{-11}$	94.99	43.49	2.415

TABLE IV [16]
REFERENCE LEVELS FOR OCCUPATIONAL EXPOSURE TO TIME-VARYING ELECTRICAL AND MAGNETIC FIELDS

Frequency range	E-field strength ($V\ m^{-1}$)	H-field strength ($A\ m^{-1}$)	B-field (μT)	Equivalent plane wave power density S_{eq} ($W\ m^{-2}$)
up to 1 Hz	—	1.63×10^5	2×10^5	—
1–8 Hz	20,000	$1.63 \times 10^5/f^2$	$2 \times 10^5/f^2$	—
8–25 Hz	20,000	$2 \times 10^4/f$	$2.5 \times 10^4/f$	—
0.025–0.82 kHz	$500/f$	$20/f$	$25/f$	—
0.82–65 kHz	610	24.4	30.7	—
0.065–1 MHz	610	$1.6/f$	$2.0/f$	—
1–10 MHz	$610/f$	$1.6/f$	$2.0/f$	—
10–400 MHz	61	0.16	0.2	10
400–2,000 MHz	$3f^{1/2}$	$0.008f^{1/2}$	$0.01f^{1/2}$	$f/40$
2–300 GHz	137	0.36	0.45	50

V. CONCLUSIONS

The experimental measurements which were done in the electromagnetic compatibility lab within ICMET-Craiova had as main objective to determine the values of the electromagnetic field emissions of a Laptop (Dell Inspiron 15 and Lenovo IdeaPad 100) in the presence of a wireless device (router - AC750 Dual Band, 750 Mbps, 2.4 GHz) and a Samsung wireless charger.

The analysis of the measurement results has indicated that the recorded values for the electromagnetic field

components for those two laptops in the presence of a router are within the range of limits regulated by international institutions. The experimental results of electromagnetic field radiation emitted by the router of general use in the achievement of some WPAN and WLAN type networks have indicated acceptable values for electrical and magnetic fields emitted and recorded within the acceptable margin by both the national and international regulations as not being harmful to the human being.

Based on the analysis of the measurements results allow us to make recommendations in order to promote a higher degree of electromagnetic biocompatibility between electromagnetic fields and the human organism.

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