22nd IMEKO TC4 International Symposium & 20th International Workshop on ADC Modelling and Testing
SUPPORTING WORLD DEVELOPMENT THROUGH ELECTRICAL&ELECTRONIC MEASUREMENTS
IASI, ROMANIA, September 14-15, 2017

Study on the Relationship between Magnetic Fields Generated by Home Appliances and Associated Drawn Currents

S. Ursache[1], E. Lunca[2], A. Salceanu[3], I. Pavel[4]

[1]*Technical University of Iasi, Faculty of Electrical Engineering, 23 Prof. Dimitrie Mangeron Street, Iasi, Romania, silviu_ursache@tuiasi.ro, +40 232 278683 / 1246*
[2]*Technical University of Iasi, Faculty of Electrical Engineering, 23 Prof. Dimitrie Mangeron Street, Iasi, Romania, elunca@tuiasi.ro,+40 232 278683 / 1246*
[3]*Technical University of Iasi, Faculty of Electrical Engineering, 23 Prof. Dimitrie Mangeron Street, Iasi, Romania, asalcean@tuiasi.ro,+40 232 278683 / 1157*
[3]*Technical University of Iasi, Faculty of Electrical Engineering, 23 Prof. Dimitrie Mangeron Street, Iasi, Romania, ionelpavel7@tuiasi.ro,+40 232 278683 / 1340*

***Abstract* – The exponential development of technology involves the usage of a larger and larger number of modern equipment, including household appliances. This fact is directly linked with the increase of the background level of low frequency magnetic fields. The main objective of this paper is to study the relationship between the low frequency magnetic field generated by the household appliances and the current consumption. The measurement system consists of the hand-held triple axis 480826 EMF Tester from Extech Instruments and 80i-400 clamp meter from Fluke. We have taken into account a number of 21 household appliances, the measuring point being always at 30 cm from source and 1 m above the ground or floor.**

Keywords – Home Appliances, Current Consumption, Magnetic Field Exposure

I. INTRODUCTION

In a century marked by technology development, consciously or not, we have come to depend on using the household appliances. Nowadays, due to the exigencies generated by the short time we have at our disposal to solve daily routine, they have become a necessity.

Once connected to the power supply network, these devices generate electric and magnetic fields. Consequently, the exposure has steadily increased with energy consumption.

A number of studies were published over the past decade related only on human exposure to low frequency electric and magnetic fields [1-2], without making a connection between the magnetic fields generated by appliances and the current consumption. In this paper we try to investigate this association for 21 common appliances, by establishing a test setup consisting of an adequate current sensors and magnetic flux density measuring equipment, taking into account several aspects such as: specifications of the measurement device, used method, current consumption and operating mode of the appliances.

The paper is organized as follows: Section II refers to a literature review with respect to home appliances consumption measurements and analysis, Section III presents the measurement methodology for study the relationship between the low frequency magnetic field generated by the household appliances and the current consumption; the measurement results and discussions are developed in Section iv.

II. LITERATURE REVIEW

The aim of this literature review is to emphasize main approaches regarding the low frequency magnetic field generated by the household appliances and current consumption.

Most recent studies dealt with the possible effects of the magnetic field exposure generated de household appliances [3-4]. Obviously, the human exposure should be considered for two groups, namely occupational (professionals) and general public is treated [5].

In [6] is presented a classification of household appliances operation cycles, beneficial to Smart Grid concept. Other studies refer to automatic methods of electrical appliances identification based on domestic

power consumption measurement [7-8].

Recent works are focused on monitoring the electric power consumption in households [9]. Regarding the characterization of the household appliances power consumption, the EU developed specific policy and legislation [10].

According with these studies here shortly presented we consider that is necessary to investigate the dependence between the low frequency magnetic field generated by household appliances and the current consumption.

III. INSTRUMENTATION AND MEASUREMENT METHDOLOGY

All magnetic fields measurements have been performed with a hand-held triple axis 480826 EMF Tester from Extech Instruments that operates in the frequency range from 30 Hz to 300 Hz, the RMS values of the magnetic flux density being calculated with the formula:

$$B = \sqrt{B_x^2 + B_y^2 + B_z^2} \quad (1)$$

where B_x, B_y and B_z are the RMS values of the magnetic flux density measured on the three orthogonal directions.

The intensity of the drawn current was measured with a 80i-400 clamp meter from Fluke, which have the output: 1 milli1ampere per ampere of input current. The measurements have been performed at 30 cm from the source and 1 meter above the ground or floor.

The experimental setup for studying the relationship between the magnetic field generated by the home appliances (EUT – Equipment Under Test) and current consumption is shown in Fig. 1.

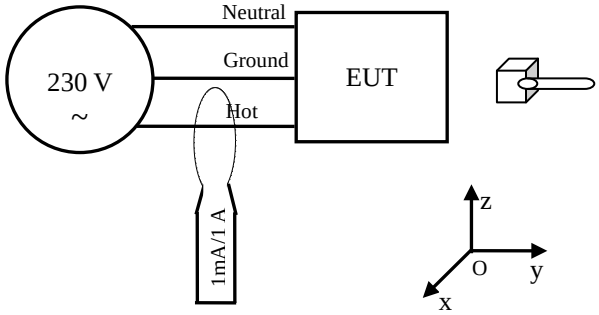

Fig. 1. The measurement setup

The measurement methodology presented above has been performed for two types of household appliances [11]:

- appliances for heating with high current consumption (**C1**): electric hob, electric heating, washing machine, iron, electric oven, electric tap;
- appliances with an electric motor (**C2**):microwave oven, hairdryer, refrigerator, meat machine, hand blender, hand mixer, electric vegetable cutter, vacuum cleaner, cooker hood, coffee grinder, fruit juicer.

IV. RESULTS AND DISCUSSIONS

A. Appliances for heating with high current consumption

We have performed measurements taking into account seven household appliances for which the dependence between the magnetic field and current consumption at 30 cm from the source have been evaluated.

Most household appliances with high current consumption operate based on the thermal effect of the electric current, as it can be observed in Table 1.The registered values of the drawn current range from the 6.25 A for electric heating to 22.3 A for electric hob. We also remarked that two similar home appliances, labeled in Table “iron 1” an “iron 2” have a different current consumption. The 2 A smallest values for the drawn current by appliances for heating was measured at the washing machine, also having an electric motor.

It is observed that the magnetic field generated by these household appliances range from 64.03 nT to 2800 nT. As we expected, in Fig. 2 it can be observe that is no direct proportionality between magnetic field and drawn current.

*Table 1. Typical values of magnetic flux density and drawn current at 30 cm for **C1***

	I[A]	B[nT]
Electric hob	22.3	87.74
Electric heating	6.25	64.03
Washing machine	2	241.03
Iron 1	6.3	2800
Iron 2	8.65	628.89
Electric tap	24.1	946.04
Electric oven	8.22	522.78

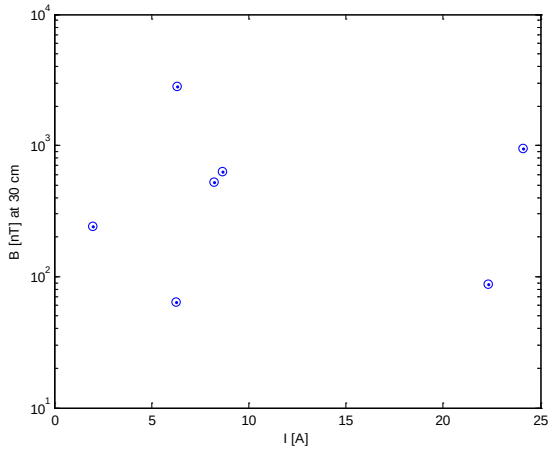

Fig. 2. The dependence between the magnetic field and drawn current for C1

B. Appliances with an electric motor

The household appliances that use an electric motor are doing mechanical work such as clothes washing, dust aspiration or air ventilation.

We have performed measurements on the magnetic field and drawn current, taking into account 13 household appliances, as it can be observed in Table 2.

*Table 2. Typical values of the magnetic flux density and drawn current at 30 cm for **C2***

	I[A]	B[nT]
microwave oven 1	5.75	5101.96
microwave oven 2	4.9	9053.86
microwave oven 3	2.9	10080
Refrigerator 1	0.4	75.49
Refrigerator 2	0.3	17.32
Meat machine	0.22	677.86
Hand blender	0.26	123.69
Hand mixer	0.45	9129.75
Electric vegetable cutter	6.15	785.42
Vacuum cleaner	0.45	756.96
Cooker hood	0.75	354.96
Coffee grinder	0.4	433.70
Fruit juicer.	0.13	78.74

Most of the recorded values of drawn current are smaller than 1 A, except three microwave ovens and electric vegetables cutter for which the current consumption ranges from the 2.9 to 6.15 A.

We notice that three microwave ovens have different values both for the current consumption and the associated magnetic flux density. E.g., for the first microwave oven the drawn current is 5.75 A, meaning two times more than current consumption of the second microwave oven.

Regarding the magnetic fields generated by the two microwave ovens, it can be observed that the ratio is also 2, but in favor of the first one. We also remarked that in case of a hand mixer, the drawn current has a very low value while the magnetic flux density is greater than 9 μT.

In case of three household appliances, two refrigerators and a fruit juicer, very low values for both the drawn current and magnetic flux density were recorded.

However, as we expected, it cannot be said that there is dependence between the current consumption and the magnetic field generated by the household appliances, as it shown in Fig. 3.

Considering all the results, we conclude that the household appliances from the first category have higher current consumption than those from the second category, but smaller magnetic field levels, as it shown in fig. 4.

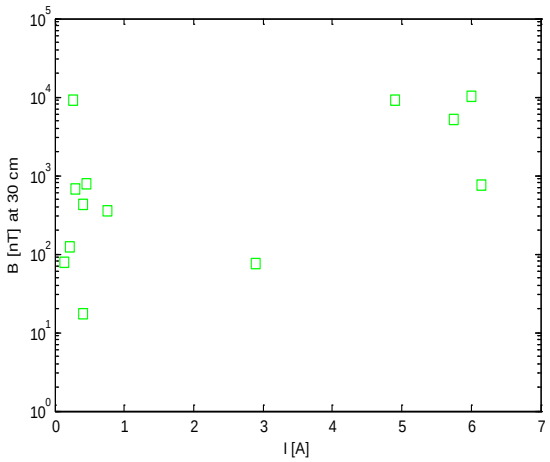

Fig. 3. The dependence between the magnetic field and drawn current for C2

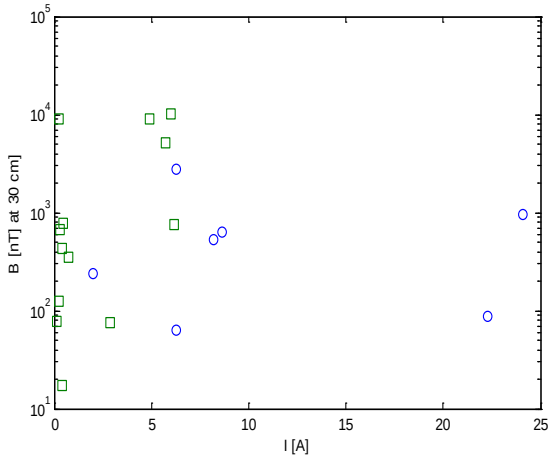

Fig. 4. The dependence between the magnetic field and drawn current both for C1 and C2

V. CONCLUSIONS

The market of the electronic products is steadily increasing and the number of the household appliances is getting bigger. There are frequently utilizations for various activities such as: heating, cleaning, therapy and hygiene or food preservation.

Even if some household appliances generate magnetic fields of tens of μT, a person spends a short time close to them and the human exposure to magnetic field is limited. Based on the measurements that we performed close to household appliances, we remarked there values of magnetic flux density around 10 μT, but magnetic field levels fall approximately with the inverse cube of distance, such that at one meter from the source the magnetic field has the same order of magnitude with the background magnetic field.

There are small devices such as hand mixers that generate high magnetic field level, even if the drawn

current is lower than 0.5 A.

On the other hand, we remarked that appliances based on the same operating principle generate different magnetic fields level and have a different current consumption. Therefore, in case of household appliances that operate based on the passing of the electrical current through a resistor, both the magnetic field level and the current consumption differ significantly from a device to another, without being a particular dependence between them.

Consequently, based on the measurements that we performed on the household appliances presented in this paper, we conclude that is no relationship between the magnetic field generated by these devices and the drawn current.

REFERENCES

[1] Lunca, E., Ursache S., Salceanu, A., *Study of the power-frequency magnetic fields in residences and schools*, AGIR, No. 3. 2012, pp. 689-694.

[2] Ali, E., Memari, A. R., *Effects of magnetic field of power lines and household appliances on human and animals and its mitigation*, 2010 IEEE Middle East Conference on Antennas and Propagation, DOI: 10.1109/MECAP.2010.5724167, 2010.

[3] Ursache, S., Salceanu, A. et al., *Indoor and outdoor measurements of the low frequency magnetic fields in an urban area*, 2016 International Conference and Exposition on Electrical and Power Engineering (EPE), 2016, pp. 1-4.

[4] Chen, M., Du, Y., *Magnetic field environments at power frequency inside modern buildings*, 2013 Asia-Pacific Symposium on Electromagnetic Compatibility (APEMC), 2013, **DOI:** 10.1109/APEMC.2013.7360626.

[5] Ali; E., Memari. A. R., *Effects of magnetic field of power lines and household appliances on human and animals and its mitigation*, IEEE Middle East Conference on Antennas and Propagation (MECAP), 2010, DOI: 10.1109/MECAP.2010.5724167.

[6] Wang, Z., Srinivasan, R., *Classification of Household Appliance Operation Cycles: A Case-Study Approach*, Energies 2015, 8, 10522-10536; doi:10.3390/en80910522.

[7] Lukaszewski, R.; Liszewski K.; Winiecki. W., *Methods of electrical appliances identification in systems monitoring electrical energy consumption*, 2013 IEEE 7th International Conference on Intelligent Data Acquisition and Advanced Computing Systems (IDAACS), **DOI:** 10.1109/IDAACS.2013.6662630.

[8] Serra, H.; Correia, J. et al., *Domestic power consumption measurement and automatic home appliance detection*, IEEE International Workshop on Intelligent Signal Processing, 2005, DOI: 10.1109/WISP.2005.1531645.

[9] Fitta, M., Biza, S., et al., *Exploring Techniques for Monitoring Electric Power Consumption in Household*s, UBICOMM 2010: The Fourth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies, 2010, pp. 471-477.

[10] Almeida, A., Fonseca, P. et al., *Characterization of the household electricity consumption in the EU, potential energy savings and specific policy recommendations*, Energy and Buildings, 43(8), 2011, pp.1884-1894.

[11] www.emf-portal.org