AN APPROACH TO ESTABLISHING MODELS FOR THE EMF EMISSION OF THE LAPTOPS BY ANN

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Abstract

The paper describes the measurement of the electromagnetic field around laptops. According to obtained results, we propose an approach to model magnetic field emission of the laptop. As an input element, we use vector of three known laptop characteristics. The output represents the magnetic field emission of the laptop. At the end, the proposed model obtained by ANN is validated on the real measured magnetic field values. The linearity between measured and predicted values proves the correctness of the proposed approach.

1. INTRODUCTION

Today, in most houses and work places in the modern world you can find at least one personal computer (PC). All computers emit low frequency magnetic radiation from all electric parts they are built-in. A laptop is a compact portable PC, usually battery-powered, which is small enough to carry it as well as to use it on the user's lap. This means that they are often used at close contact with the body, i.e. to the skin, bones, blood, genitals, and, in pregnant women, close to the fetus. All aforementioned circumstances are very dangerous to the users health [1]. The laptop emits extremely low frequency (ELF) magnetic field from the processors, cooler, electrical chips on motherboard and hard disc all the time it is working. If you put your laptop on a table you will reduce your exposure from ELF magnetic field at the bottom part of laptop to very low levels. Due to dangerous use of laptop in certain circumstances, it is an obstacle to predict magnetic field emission around laptop. The problem of modeling the laptop magnetic field emission to a very best of the authors knowledge hasn't been considered yet. Hence, some studies about this topic can be of great interest to professionals and scientists. In this paper, we try to establish a simple, but yet functional model giving the level of magnetic field emission in according to some laptop characteristics. This approach is based on three inputs vector representing laptop characteristics and one output representing magnetic field emission of the laptop in the office environment, i.e. at the top positions of the keyboard. These measuring positions are very important, because the laptop users are in close contact with the keyboard and touchpad all the time.

The paper is made in the following manner. Section 2 describes the magnetic field basics. Section 3 gives the measuring device characteristics and proposes the measuring positions at the laptop body. Section 4 presents the magnetic field measuring results. Section 5 proposes the ANN model according to the magnetic field measuring results. Section 6 makes conclusions.

2. MAGNETIC FIELD

The magnetic field is induced as a consequence of the current that flows through the electronic components of the laptop. The laptop users are exposed to a uniform magnetic field (in the neighborhood of the magnetic field emitter), which means that the time dependence of the field is the same in all points of the exposed subjects (laptop users) [2]. The magnetic induction **B** as a vector is characterized with its direction and magnitude. The direction of **B** can be decomposed into the three-unit directional vectors, which are parallel to each one giving its direction along the *x*, *y*, and *z* axis. The magnitude of **B** can be decomposed into the scalar components B_x, B_y and B_z, which are measured in the direction of the x, y, and z axis. Hence, **B** can be represented as follows:

$$B = B_x \cdot \hat{x} + B_y \cdot \hat{y} + B_z \cdot \hat{z} . \quad (1)$$

where $\hat{r}$ is a unit vector in the direction of r decomposed into the unit directional vectors along the x, y, and z axis.

The devices usually measure the root mean square value of the magnetic field induction |**B**|, which is calculated using its scalar components B_x, B_y and B_z:

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

3. MEASUREMENT

The measurements were performed in the office where the influence of the magnetic field is negligible, i.e. it is lower than 0.01 μT. EMF measurement was performed by Lutron EMF 828 device. It measures the magnetic induction from 0.01 μT to 2 mT, which frequency range is between 30 and 300 Hz. The EMF 828 has three measurement extents: 20 μT, 200 μT and 2000 μT. The precision of the measurement heavily depends on the measurement extent. Consequently, it is of the order 0.01 μT for the measurement extent of 20 μT, 0.1 μT for 200 μT and 1 μT for 2000 μT, respectively. Lutron EMF 828 measures all three components of the magnetic induction B, i.e. B_x, B_y and B_z. Accordingly, it measures root mean square (RMS) in the ELF magnetic field frequency given in eq. (2).

The measurement of magnetic field is usually performed by an EMF measuring device in the positions where the influence of the external magnetic field is negligible. It means that the level of the magnetic field has to be lower or equal to 0.01 μT [2]. In this study, we explore the magnetic field emitted by the laptop in the office environment. Up to now, the magnetic field measurement positions have been proposed in literature. The TCO standard proposed the positions where the laptop users are not in close contact with the laptop body. Hence, it is irrelevant to the laptop users [3]. Furthermore, ref. [4] proposes one measurement position in the middle of the keyboard and others 10 cm and 20 cm below the laptop and 10 cm up of the keyboard center and at the screen position. This approach is superfluous too. Except the position in the middle of the keyboard, all other positions are completely unsuitable. It is valid because the screen has negligible magnetic field emission. Furthermore, 10 and 20 cm away from the center point of emission is too far away to register significant amount of magnetic field emission, especially when the laptop is used at the desk. Due to the laptop construction, different level of the magnetic field is present in different parts of the keyboard/ touchpad area. Hence, this area should be divided into different measuring areas. In this study we use the approach which is proposed in [5]. It takes into account nine positions at the top of the laptop body, i.e. at the top of the keyboard. Figure 1 shows typical measuring position at the top of the laptop (office codition when laptop is operating on the office table).

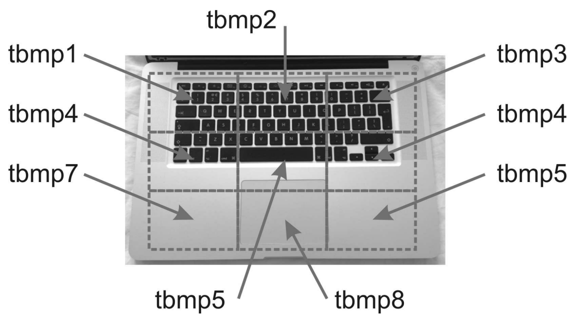

Figure 1. Nine measuring positions at the top of the keyboard

From Figure 1, the measuring points are marked as tbmp1-tbmp9. The measuring method is evaluated on 10 laptops of different typology and screen size: 17", 15.6", 14", 13.3" and 11.6". Measures have been collected when laptops were supplied by alternating current (AC) in the office environment.

4. RESULTS

The measurement results of the magnetic field B obtained at the top body measurement points in normal operating condition of the laptop are given in Table 1.

The minimum values of the measured magnetic field B obtained at the measuring points tbmp1-tbmp9 are between 0.0000 and 0.0548 μT. Furthermore, the maximum values of the magnetic field B are between 0.5819 and 2.2011 μT. At the end, the average values of the magnetic field B are from 0.1219 to 0.5468 μT.

5. ANN MODELING

Using into the consideration the level of the ELF magnetic field emission from the laptops, it is possible to design an artificial neural network (ANN) in order to predict the intensity of the magnetic field at the measured (top body) positions of the laptop. The neural network is mapping between a data set of numeric inputs and outputs, i.e. targets. We explore the results obtained by measuring magnetic field emission around 10 different portable computers in normal office operation condition. The measurement positions are at the top part of the laptop. Each area above the laptop was divided into nine regions such as: (i) upper left, (ii) upper central, (iii) upper right, (iv) medial left, (v) medial central, (vi) medial right, (vii) lower left, (viii) lower central and (ix) lower right. Collected data was pre-processed beforehand, and the total amount of 90 measured values was used in the ANN training phase. There are many physical parameters that can affect the intensity of the magnetic field. The most important of them are: (i) Passmark, which represents the one of the known processor calculation power estimation values, (ii) CPU total dissipation (CPU TD), i.e. processor dissipation in W, and (iii) laptop maximum power consumption (Laptop MPC), i.e. the total power consumption of the laptop in W.

Table 1. The measured magnetic field B at the top part of laptops in normal operating condition

Laptop	1	2	3	4	5	6	7	8	9	10
Minimum	0.0100	0.0141	0.0000	0.0173	0.0000	0.0548	0.0224	0.0173	0.0374	0.0316
Maximum	0.5819	1.7686	0.6138	2.2011	1.3743	1.8958	1.5069	4.2164	1.6739	1.4279
Average	0.1219	0.4805	0.1714	0.3709	0.4243	0.5468	0.2685	0.5475	0.3615	0.5323

Table 2. The laptop characteristics used for magnetic field prediction by ANN

Laptop	1	2	3	4	5	6	7	8	9	10
CPU Passmark	2327	2327	1687	2113	1911	7493	961	795	1477	2646
CPU TD (W)	17	17	25	35	35	45	17	31	25	35
Laptop MPC (W)	45	45	65	90	90	120	33	60	75	80

Table 3. The correlation coefficient R of the various neural network architectures

Number of hidden layer neurons	5 neurons	9 neurons	10 neurons
Correlation coefficient – R	0,946	0,874	0,915

Table 2 shows aforementioned laptop characterristics used to predict a magnetic field by ANN.

Accordingly, each input is given as a 3-element vector. The values of this vector are normalized to be used as input parameters. This process ensures that each input parameter will be in the range [0, 1].

Training and testing data sets were used for training and testing of the various ANN architectures. The number of nodes X in the hidden layer was varied from 5 to 10 neurons. The percentage of data used for training, testing and validating was varied.

The accuracy of the ANN model is performed by means of statistical parameters such as correlation coefficient. The correlation coefficient *R* is a statistical measure of the strength of correlation between the predicted and measured values. The correlation coefficients of the various ANN architectures are given in Table 3.

All of the used ANN architectures have relatively good fitting capabilities. Essentially, increasing the number of neurons in the hidden layer of the ANN didn't achieve the expected increasing in the value of the correlation coefficient *R*. Consequently, all architectures have relatively uniform values of the correlation coefficients *R*. Hence, there is no need for using robust neural network, which is memory and computer time consuming. Accordingly, ANN with 5 neurons in hidden level has satisfactory accuracy with the correlation coefficient equal to 0.946. The predicted values, along with the measured values of the ANN with 5 neurons in the hidden layer are shown in Figure 2.

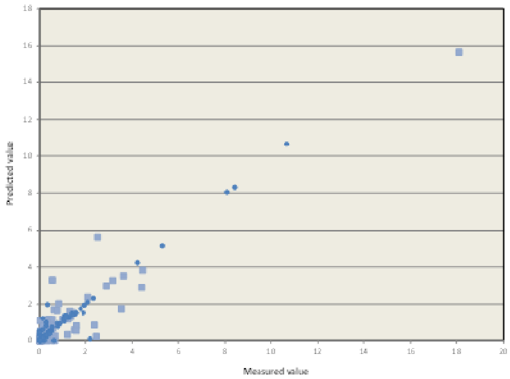

Figure 2. Measured vs. ANN predicted magnetic field values

The linearity of the given graph shows that the proposed ANN model predicts magnetic field values very good. Furthermore, it proves that our premise about important laptop characteristics that influence the output representing magnetic field is valid. This approach can be used for other measurements of the magnetic field emission around laptop.

6. CONCLUSION

The paper addressed the problem related to the ELF magnetic field emission produced by laptops. The measurement of the magnetic field was carried out by Lutron EMF 828. The obtained results showed that the laptop characteristics like power consumption and dissipation as well as laptop processor calculation capabilities have a tremensdous impact on the level of the magnetic field emission. It was proved by modelling laptop magnetic field emission with ANN.

Further research direction will be toward establishing the unique ANN based model for prediction of magnetic field emission around all parts of the laptop.

7. ACKNOWLEDGMENTS

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References

[1] International Agency for Research on Cancer (IARC) (2002). Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 80, Non-Ionizing Radiation, Part 1: Static and Extremely Low-Frequency (ELF) Electric and Magnetic Fields. Lyon, France: IARC Press.

[2] Bellieni, C. V., Pinto, I., Bogi, A., Zoppetti, N., Andreuccetti, D., Buonocore, G. (2012). Exposure to electromagnetic fields from laptop use of "laptop" computers. Archives of the Environmental and Occupational Health, 67 (1), 31-36.

[3] W. Hayt, J. Buck (2012). Engineering Electromagnetics. 8th ed. Ed. McGraw-Hill. New York, USA. pp. 1-25.

[4] [3] TCO'05 standard (2012). http://tcodevelopment.com/files/2013/04/TCO-Certified-Notebooks-4.0.pdf

[5] Maluckov, B. S., Tasić, V., Mladenović, S., Maluckov, Č. A. (2014). The magnetic fild from laptop computers. In Proceedings of XXII International conference Ecological Truth, ECO-IST'14, Bor, pp. 531-535.

[6] Brodic, D., Amelio, A. (2015). Classification of the Extremely Low Frequency Magnetic Field Radiation Measurement from the Laptop Computers. Measurement Science Review, 15 (4), 202-209.