

Magnetic Flux Density Distribution in Human Model Placed in ELF Magnetic Field

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1. Introduction

A complete human population is exposed to magnetic and electric field influence of natural Earth field and HF and RF fields from artificial sources. There is difference in exposure dose which varieties during the day and season. Electric and magnetic fields at the ELF range act independently of one another and are measured independently [1]. ELF fields are produced by a wide variety of products in home and in workplace as well, such as copiers, power lines, transformers, household appliances, electric trains and computers. Over the years, scientists have attempted to prove the ELF interaction theories on living beings [2]. Strong magnetic fields may cause the DNA damage, which initiate the cancer. On the other side the electro-equipment manufactures persistently deny this effects existence, although this statistics shows opposite results. Therefore it is understandable why the National and International agencies have difficulties to form standards for maximal human ELF field exposure. Anyway further researching is necessary on this subject [3, 4].

In this paper the human body is modelled using the Finite element method. This model is placed in working and living surroundings wherein the power lines for electric devices supplying exist. The aim of this paper is to determine the magnetic flux density distribution in human body model. Also, an average energy density in some human organs will be determined as a parameter, which can be usually found in the literature.

2. Human Body Model in ELF Magnetic Field

The human body is modelled using femm software [5], Fig. 1. For calculation this software use Finite element method. The human body is considered as an inhomogeneous structure in the sense of electrical conductivity. This model includes the electrical conductivities of brain, lung and liver, digestive organs and the other tissues [6].

Since the external ELF magnetic field is of 50 Hz frequency, the human model is considered as axial symmetrical which doesn't spoil the results accuracy. The proposed human model is placed in working and living surroundings. A human model height is 1.75m. The room is axial symmetrical with radius of 4m and height of 2.5m. The whole room is made from concrete and the walls are from lime mortar. The human model shoes have a rubber sole. In literature, the different values for electrical conductivity of concrete can be found. Opposite to the electrical properties, the mechanical properties of concrete are well known. It is supposed that the concrete "grows ripe" for one month [7].

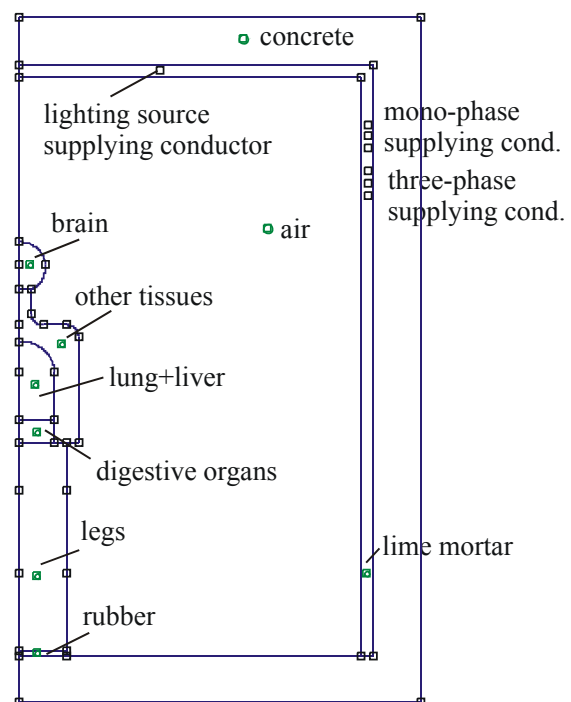


Figure 1: Human body modelling using femm

Unfortunately, the electrical properties of concrete don't follow the mechanical properties. The electrical conductivity of concrete decreases with the ages from 10^{-2} S/m for a wet concrete to 10^{-9} S/m for a dry concrete. In this paper for the electrical conductivity of concrete is used 10^{-3} S/m. In working and living surroundings the power lines for electric devices supplying exist. The conductors are modelled as closed circular current loops, which approximately correspond to electric installation system. Also the mono-phase and three-phase electrical devices supplying (max 6 kW electrical furnaces) and the lighting source supplying are taken into consideration. It is considered the lighting source of 800 W, the mono-phase devices of 2 kW and three-phase devices of 3 kW, 4.5 kW and 6 kW. The current values through the corresponding supplying conductors for each power are calculated and after that, they have been used in simulation.

3. Numerical Results

Because of easier presentation of the obtained results, the characteristic points on the human model are denoted in Fig. 2. In this paper the magnetic flux density distribution through the following directions will be shown:

- a) B - G, through the brain;
- b) C - H, through the lung and liver;

Using program package femm a mesh of 412592 nodes is created. Different combinations of supplying conductors are taken into consideration. In that way different conditions in the room depending of season and of daytime are simulated. The "worst" case is a winter night when the lighting source is on, the mono-phase electric devices (e. g. TV, radio etc.) are "on" and the three-phase electrical devices (e.g. electrical furnaces) are "on", too. In a summer day the lighting source is "off", the mono-phase electric devices are "on" and the three-phase electrical devices are "off". This is the "best" case. In Figs. 3 – 4 the magnetic flux density distributions through the brain, lung and liver for these two cases are shown. Considering the mono-phase electrical device-supplying conductors, two phases (phase 1 and phase 2) are active.

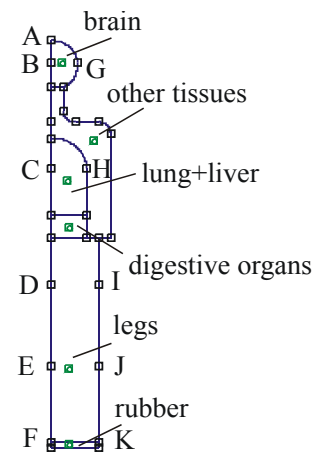


Figure 2: Human body model

Also, it is considered a three-phase device having 4.5kW. In Fig. 3 a the magnetic flux density level penetrated through the head is shown. The fluctuations in Fig. 3 b are result of mesh discretization. In this simulation the mesh size inside the human organs is 1mm. The obtained levels are above $1\mu\text{T}$. The obtained values in point C and point H, Fig. 3 b, haven't a large difference (4th decimal digit is different). Using a dot line, an average value of this distribution is presented. In Fig. 4 b using a dot line an average value of magnetic flux density distribution through the lung and liver is shown.

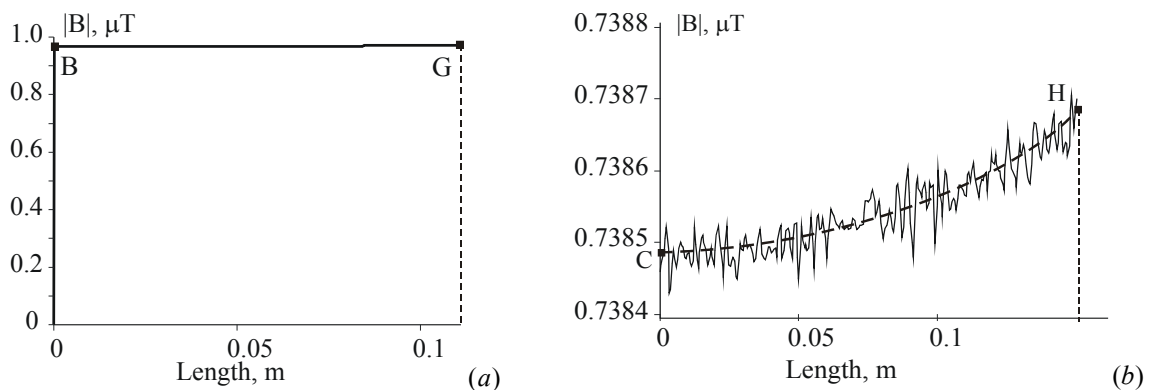


Figure 3: Magnetic flux density distribution – "summer day" case

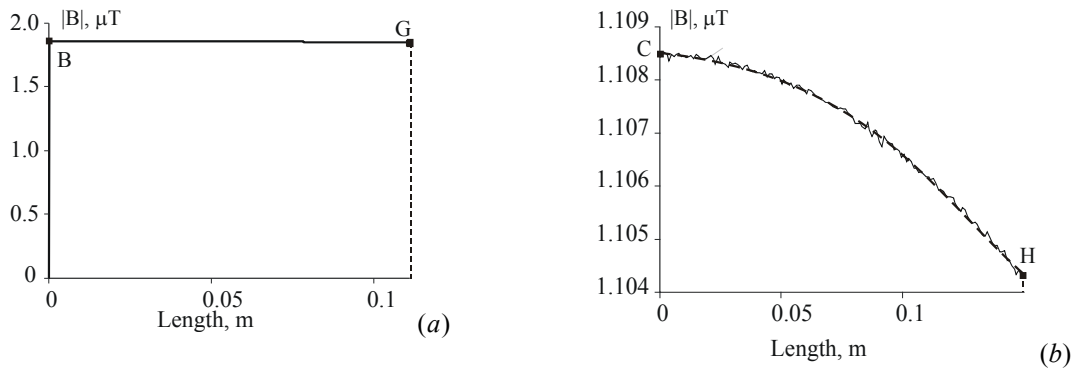


Figure 4: Magnetic flux density distribution – “winter night” case

In Fig. 5, the magnetic flux density distribution in the room for both observed cases is shown. From Fig. 5 *b* the mutual influence of lighting source and the electric devices on the magnetic flux density is evident. The magnetic flux density has bigger value for large distances from the wall. That results are shown in Fig. 6. The distance from the wall is denoted with l . Those directions are marked in Fig. 5 *b*. The obtained levels are above $1\mu\text{T}$ for second case.

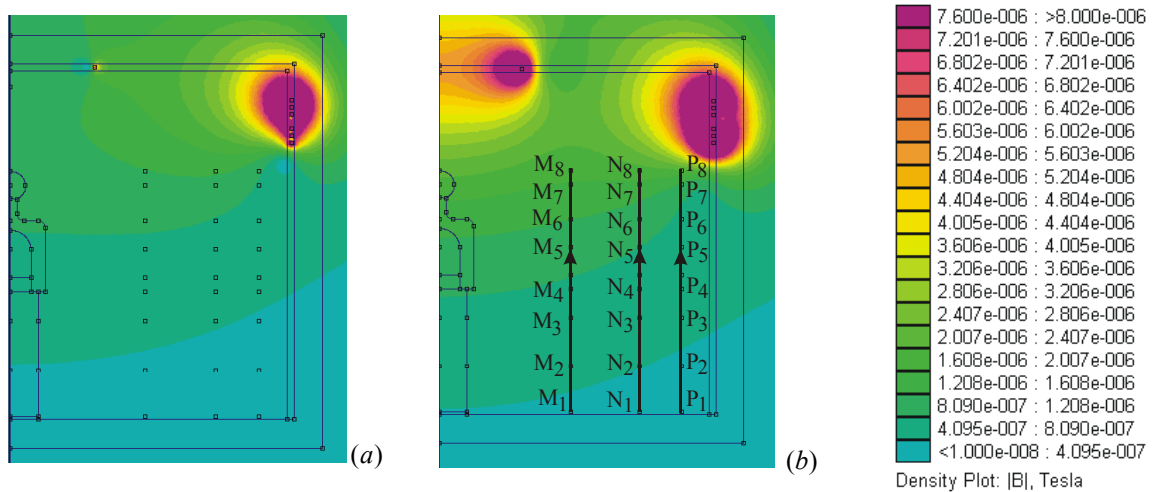


Figure 5: Magnetic flux density distribution – “summer day” (a) and “winter night” (b) case

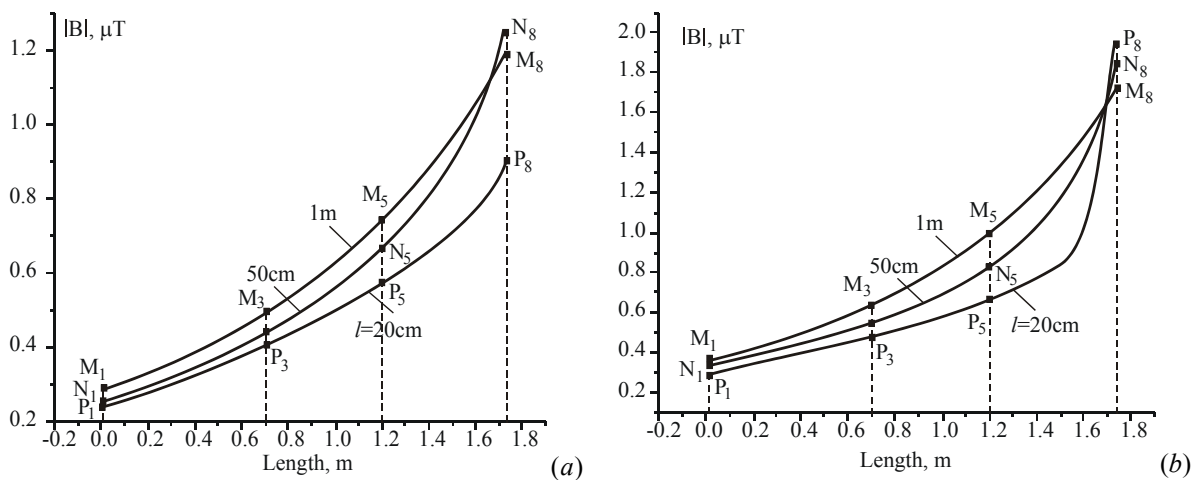


Figure: 6 Magnetic flux density distribution for different distances from the wall for “summer day” (a) and “winter night” (b) case

In Table 1, the average energy densities inside the brain, digestive organs, lung and liver for different three-phase electrical devices supplying are shown. It is considered the “worst” and the “best” cases, when the lighting source is “on” or “off”, the mono-phase electrical devices of 2 kW exist (phases 2 and 3 are active) and the three-phase electrical devices having the values of 3 kW, 4.5 kW and 6 kW. Increasing the power of electric devices, bigger average energy density is localized in human organs. The average energy density for the case when the mono-phase electrical devices of 2 kW exist, with the active phases 2 and 3, and the three-phase electrical devices are “off”, is shown in Table 2. The results are shown when the lighting source is: “on” (a “summer night” case) and “off” (a “summer day” case).

Table 1: Average energy density (J/cm^3)

Organs	“winter day” case			“summer day” case		
	Three-phase electric devices of 3 kW	4.5 kW	6 kW	Three-phase electric devices of 3 kW	4.5 kW	6 kW
Brain	1.0420	1.1020	1.1640	0.6391	0.6940	0.7513
Lung and liver	0.5365	0.5894	0.6453	0.4495	0.5009	0.5554
Digestive organs	0.4122	0.4575	0.5057	0.3620	0.4064	0.4537

Table 2: Average energy density (J/cm^3)

Organs	Lighting source	
	“On”	“Off”
Brain	0.38920	0.12420
Lung and liver	0.12030	0.07384
Digestive organs	0.08152	0.05660

4. Conclusions

In this paper the human body placed in working and living surroundings is modelled using the femm software. This software uses Finite element method. Medical studies have proved the influence of magnetic flux density (around 1nT) to adrenal gland. Also, the rat experiments have shown that in rat population, which have been exposed to ELF magnetic field influence, the female number was greater than male number in next generation and space disorientation and aggressive behaviour has been increased. Because of that it is very important to determine a safety standards in this area.

References

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