Propagation of Magnetic Fields from Electrical Domestic Appliances

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Abstract. The article presents a research into propagation of magnetic fields from electrical domestic devices. A safe distance at which magnetic induction does not exceed the background level is determined for each type of devices. It is proved that there are two stages of increasing magnetic induction as the distance from the source increases. At the first stage magnetic induction rises and electromagnetic field is formed. At the second stage exponential decrease of magnetic field induction takes place. Mathematical regularities of propagation of magnetic field from electrical domestic devices are experimentally educed.

1. Introduction

It is generally known that all electricalal household appliances generate electromagnetic fields. Nowadays the influence of electromagnetic rays on humans is an open subject for research [1-5]. It would not be true to claim that electromagnetic radiation has only a bad effect on humans because people live their lives in electricalal and magnetic fields formed by natural sources (for example the Earth and the Sun) [1,2,6].

Natural electromagnetic radiation is an essential condition for existence of humans and other biological species. It accelerates life processes, cell regeneration, metabolism and so on. Nowadays electromagnetic radiation is widely used in medicine for treating different diseases [3].

However it is equally thoughtless to believe that electromagnetic radiation is absolutely safe and can't be escaped. Though the latest statement can be recognized true natural electromagnetic influences cannot be given the same status as the impact of a range of modern electricalal appliances. Firstly, electromagnetic radiation has a great wavelength range. Secondly, it can have different energies. And thirdly, there is a great number of various types of electromagnetic rays [4,5]. Each type can possess some special impact and peculiar electromagnetic fields. In this view the problem of understanding the influence of different electromagnetic fields on people is urgent and requires extensive theoretical research and practical experiment in this area.

Table 1. The basic types of electromagnetic radiation.

Length	**Radiation**	**Frequency**
More than 100km	Low-frequency oscillations	0-3 kHz
100 km – 1mm 1 m – 1 mm	Radiowaves including microwaves	3kHz -3 THz 300Mhz – 300GHz
2 mm - 760 nm	Infrared radiation	150GHz - 400 THz
760 - 380 nm	Visible radiation (optical spectrum)	400 - 800 THz
380 - 3 nm	Ultraviolet radiation	800 - 100 PHz
10 nm - 1 pm	X-rays	30 PHz - 300 EHz
More than 10 pm	Gamma-rays	More than 30 EHz

According to world researches the following effects of electromagnetic fields on humans have been revealed:

- Changing DNA [6]
- Increasing the number of children suffering from asthma by 15% [7]
- Reducing melatonin (antioxidant and antitumoral inhibitor) and some other hormones [8].
- Increasing cancer risk by 40% [9].
- Histolytic changes causing worsening of reproductive function [10]
- Reducing sensibility of hair cells leading to hearing impairment
- Sleep problems
- Changes in protein structure

Two basic impacts revealed by modern science lead to such consequences of exposition to electromagnetic radiation:

- Heat impact
- Non-heat impact (reorientation of charged particles).

When studying the influence of electromagnetic fields on humans special attention should be paid to superhigh frequency waves (SHF). SHF (microwave) radiation is applied in microwave ovens, radio navigation, satellite television, cell phones. The Sun is a natural source of microwaves. Thus devices emitting superhigh frequency waves are widely used nowadays. There are data which prove especially strong effect of SHF on body organs with low heat circulation (brain tissues and eyes) [11-16].

The aim of the research is to estimate the impact of electromagnetic radiation of electricalal domestic appliances on humans.

To achieve this purpose the following tasks have been performed:

- Measuring magnetic induction at different distances from electricalal domestic appliances
- Determining the distance at which magnetic induction is on the background leel which is relatively safe for people
- Determining physical laws of magnetic field generation for different electricalal domestic appliances
- Determining mathematical dependences of magnetic induction and the distance from a radiation source.

2. Results and Discussion

Measurements were carried out by means of magnetic induction sensor LabQuest Vernier with relative error about 3%. Measurement range was 6.3 mT which is enough to study the generation of magnetic fields by different electricalal domestic appliances and determine their safety levels. The measurement pitch was about 0.1m which enabled finding the necessary graphic dependences.

The measurements of magnetic field induction were summarized in a table. The measurement unit is *mT*.

Table 1. Measurements of magnetic field induction, *mT*.

Electricala l domestic appliances	Capa-city	Distance										
		0,01m	0,1m	0,2m	0,3m	0,4m	0,5m	0,6m	00,7m	00,8m	0,9m	1,0m
Mobile phone in waiting mode	2100 W	0,0569	0,0561	0,0566	0,0571	0,0522	0,0521	0,0545	0,0459	0,0423	0,0358	0,0329
Mobile phone in conversati on mode		0,0659	0,0627	0,0626	0,0574	0,0633	0,0644	0,0628	0,0644	0,0633	0,0612	0,06
Monitor	34W	0,0497	0,0484	0,0052	0,0027	0,0067	0,0053	0,0055	0,0043	0,0057	0,0022	0,0021
System unit		0,0425	0,0508	0,0574	0,0633	0,0644	0,0628	0,0576	0,0423	0,0374	0,0081	0,0075
Electrical pot	2200 W	0,0623	0,0244	0,0236	0,0226	0,0220	0,0211	0,0178	0,0089	0,0021	0,0057	0,0032
Outlet		0,1307	0,1670	0,0529	0,0274	0,0623	0,0216	0,0197	0,0097	0,0052	0,0028	0,0026
Desk lamp	100W	0,0269	0,0211	0,0189	0,0135	0,0121	0,0134	0,0075	0,0053	0,0075	0,0043	0,0038
Microwav e oven	2300 W	0,0727	0,0646	0,0657	0,0453	0,0478	0,0433	0,0421	0,0450	0,0417	0,0210	0,0109
Electrical cooker	1500 W	0,2081	0,210	0,1307	0,0890	0,0463	0,0129	0,0044	0,0053	0,0089	0,0031	0,0029
Refrigerat or	1000 W	0,0609	0,0452	0,0339	0,0258	0,0148	0,0078	0,0073	0,0032	0,0057	0,0021	0,0075
Washing machine	2100 W	0,0612	0,0556	0,0331	0,0238	0,0149	0,0063	0,0085	0,0014	0,0083	0,0048	0,0038
Electrical iron	1800 W	0,0261	0,0278	0,0131	0,0039	0,0079	0,0053	0,0047	0,0073	0,0026	0,0028	0,0025

We have studied the basic types of electrical domestic appliances such as an electrical iron, a washing machine, a computer, a microwave oven, an electrical cooker, a refrigerator and others. All the devices were placed into the same room at the same time. For each measurement only one device was switched on, so the influence of the natural electromagnetic radiation was the same in all measurements and the relative error caused by a natural background and experiment conditions was minimized. As far as the aim of the research was to find physical regularities of changing magnetic induction as the distance from an induction source increases and to determine an average safe distance

we have not compared different brands of domestic appliance and only one sample of each device has been tested.

An analysis of the experimental data revealed the following regularities:

1. Induction exceeding limit value has not been registered. (Limit value for population equals 0.8mT for 8 hours working day according to state standard specifications).
2. It has been found out that electromagnetic field decreases as the distance from the source increase. For the most devices a safe distance i.e. the distance at which electromagnetic field reaches the natural background value is about 50cm in average. For low capacity devices (less than 100W) it is 20cm. Fig. 1 and 2 show graphic dependences of electromagnetic induction and the distance from the source.
3. For superhigh frequency (microwave) devices such as mobile phone and microwave oven there are oscillations of magnetic field induction but at the distance of 1m this decrease is insignificant. Fig. 3 and 4 show graphic dependences of electromagnetic induction form SHF devices and the distance from the source.

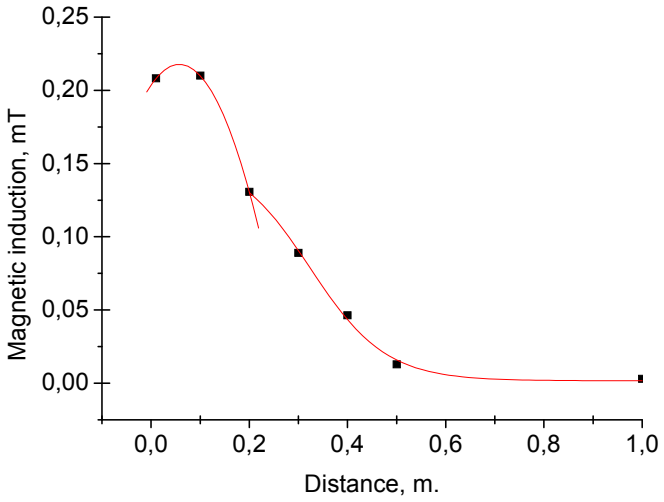

Figure 1. Dependence of electromagnetic induction and the distance from an electrical oven

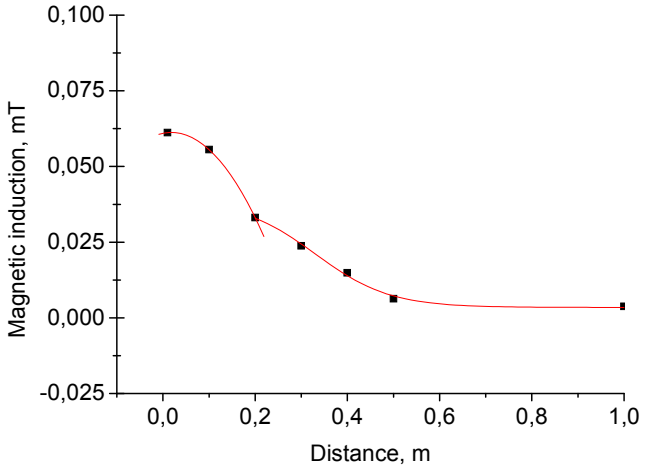

Figure 2. Dependence of electromagnetic induction and the distance from a washing machine.

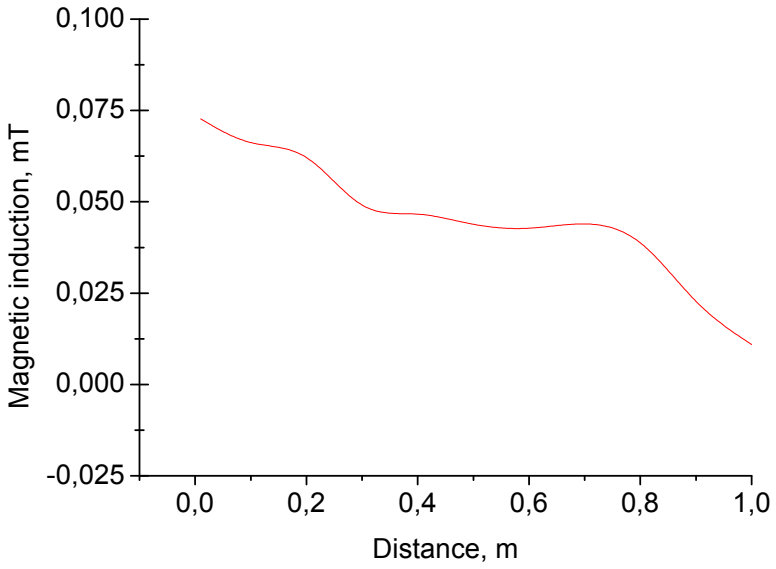

Figure 3. Dependence of electromagnetic induction and the distance from a microwave oven

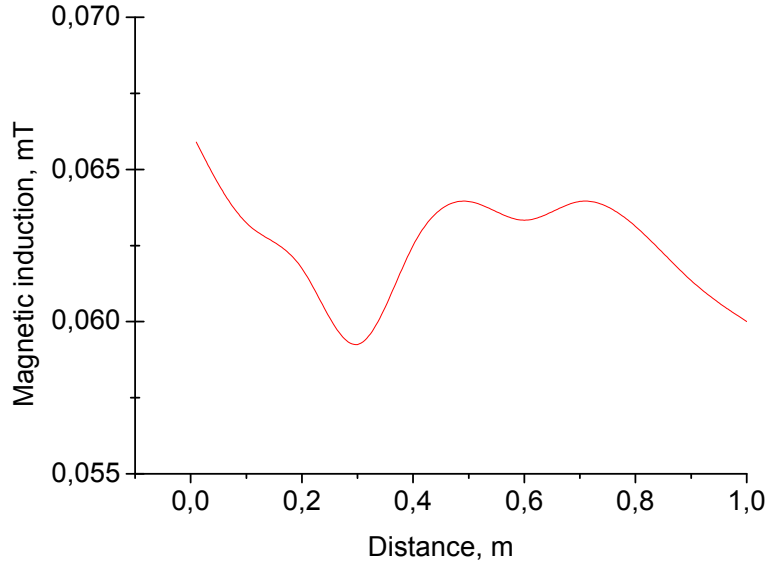

Figure 4. Dependence of electromagnetic induction and the distance from a mobile phone

Let us consider the special features which have been found out and peculiarities of radiation of magnetic fields by these devices. First of all in Fig.1 and 2 alongside with an evident decrease of magnetic induction as the distance increases we notice an initial increase of induction (at the distance of 20cm) which cannot be caused by a measurement error. This increase can be explained by the induction zone in which electrical and magnetic fields act separately, electromagnetic field being generated at the same time. The induction zone is generated by all electrical domestic appliances which are not based on superhigh frequency waves. So, we can conclude that there are two stages of

propagation of electromagnetic induction from electrical domestic appliances: at the first stage there is an induction zone, at the second stage there is an electromagnetic field propagation zone.

Devices based on superhigh frequency waves have a small induction zone and a large propagation zone (Fig.3 and 4).

Mathematical dependences of magnetic field induction and the distance from a device which is not based on SHF were determined by the methods of interpolation and approximation.

At the first stage we have determined polynominal dependence which is described by the formula:

$$B=A_1 r^{-2} + A_2 r + A_3 \quad (1)$$

where:

A_1, A_2, A_3- coefficients for the device, rel.units,

r – the distance, *m,*

B – magnetic induction, *T*.

At the second stage we have determined a hyperbolic dependence described by the formula:

$$B=X_1 r^{-1} + X_2 \quad (2)$$

where:

X_1, X_2 - coefficients for the device, rel.units.,

r – the distance, *m*,

B – magnetic induction, *T*.

Conclusions

The following conclusions can be made on the ground of the research:

1. Differences in generation and propagation of electromagnetic waves from different electrical devices have been found.
2. Devices based on SHF proved to have two stages of changing magnetic induction as the distance from the source increases.

   At the first stage, a slight increase of magnetic induction at an increasing distance takes place and polynominal analytical dependence can be observed.

   At the second stage, a hyperbolic dependence of induction decrease at an increasing distance takes place. And this research helps to solve the global issues of environmental safety [17-20].
3. A safe distance at which magnetic induction does not exceed the background level has been determined for each type of devices. It makes up ≈0.5m in average.

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