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100 mA – is it safe?

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ABSTARCT

The papers is devoted to theoretically and experimentally studies of currents flowing through body of a radiotelephone operator. Contrary to electromagnetic field energy absorption which is limited to the penetration depth a current induced in a point of a body is measurable in any other point of the body. Experimental studies show that in the case discussed a current induced in a hand or in a head of the operator is measurable in his foot or even in a body of other person (-s), if keeping their hands create a chain. Using traditional methods (suggested by the protection standards) these currents are unmeasurable.

Keywords— induced current, 100 mA, current in human's hand, current in human's head, health's safety, safety standard

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INTRODUCTION

The frequency range is significant when determining how to analyze the impact of the electromagnetic field (EMF)on the human body. The measurements of current inducted by EMF in the human body are performed at the lowest frequencies and most importantly, in the presence of high voltage power lines and medium- and long wave transmission stations (Directive 2004/40/EC of European Parliament and of Council. 2004).In comparison, the basic measurement of energy absorption for higher frequency ranges is SAR(Specific Absorption Rate). It determines the amount of power absorbed per unit of mass(CENELEC. 2003; IEEE. 2005). Many papers are devoted to SAR. However phenomenon of induced current in human body are relatively rarely analyzed
The purpose of this work is to focus on this phenomenon and show that it cannot be ignored, the limit set by the European Commission of 100mA is not too large, if anything it is set too low.

MATERIALS AND METHODS

Induced current is the current flowing in the human body exposed to EMF. It is induced due to the capacitive coupling of the body with the objects of primary or secondary sources of EMF. In the telecommunication devices, which obviously is an area of author's interest, the induced currents appear for example in radiophones(P Bienkowski; T Długosz; H Trzaska; 32nd Annual Meeting of the Bioelectromagnetics Society. 2009, CD Proceedings).

A typical cell phone is a source of many types of interactions. In order to view this complex phenomenon, the author would like to mention the main points in this order:

1. EMF caused by the cell terminal, which is emitted as an impulse at a certain frequency and duration. The effects of this field are the subject of many studies and the author mentions them only to systemize its effects.
2. The existence of nonlinearities on the human cells is assumed, thus also the possibility of detecting the envelope of the signal and the creation of currents in the organism with frequency equal to the changes in the amplitude modulation. Several attempts to confirm the existence of this effect on macroscopic scale have failed.
3. The amplifier of the terminal is powered from a power source – a battery. According to the Biot-Savart law, every electrical wire is surrounded by EMF. In most cases, the amplifier is placed at the top of the terminal, whereas the current source is at its bottom. That means that the wires powering the circuit are approximately the size of the terminal. Magnetic field generates low frequency currents in the operators body. Unlike the EMF created by the antenna, those currents spread over the entire body. This effect was discovered and initially analyzed by Bienkowski(P Bienkowski; Electrical Review. 2004, 12,1231).
4. There is no „monopole" antenna (Fig. 1a). In order for antenna to emit waves, it must be powered with reference to the ground (Fig. 1b). When radiophone user is talking on the phone, his body functions partially as a ground (Fig 1c).
5. Radiation caused by particular parts of radiophone or cell phone. The processor may be especially interesting and important because it is radiating in wide frequency band.

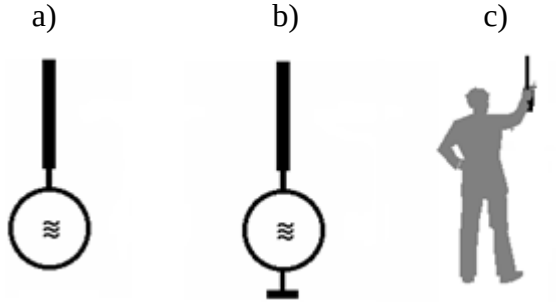


Fig. 1. Antenna of radiotelephone:
a) a monopole, b) a grounded antenna c) an antenna held by human

Although author deals with all of the above issues, only problem of induced currents is presented in this publication. Series of computer simulations were performed in order to provide comprehensive coverage of the subject as well as various sources of radiation of the radiophone or the cellphone were taking into account considering its influence on user's body.

The counterweight current is initially measure that operator's hand and mouth(HTrzaska; Electromagnetic Field Measurements in the Near Field, Scitech Pub Inc., USA, 2001). The study used hand model (Fig.2)in the form of a glass container with dimensions 6x11 cm and the length of120 cm. The model is equipped with a metal bottom attached thru the thermocouple to the tested terminal. The length of the "hand" is adjusted by changing the height of liquid column. It was shown that if the power supplied to the antenna's terminal oscillates around 5W, then the counterweight current is expected to be about 0.3A at frequencies up to about 300MHz

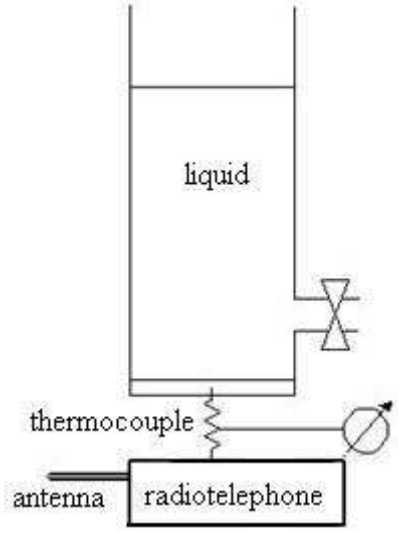


Fig. 2.Model ofthe radio operator's hand

RESULT AND DISSCUSION

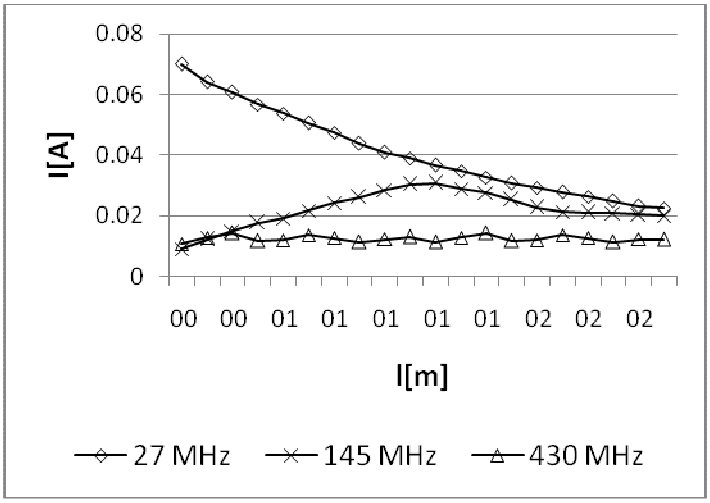
Table 1presents the results of measurements of hand's current (I_r) for several types of radio telephones with a capacity of5W,equipped with various types of antennas**(**HTrzaska; Electromagnetic Field Measurements in the Near Field, Scitech Pub Inc., USA, 2001**)**.In addition, we're showing the increase of the electric field intensity(ΔE) measure that 10 m distance from the radio telephone mountedon the insulated supporting relation to the radio phone held in the user's hand. The presented data shows the important role of a counter weight in the form of radio phone operator.

Table1.The measured values of the current in operator's hand antennas (P Bienkowski;H Trzaska."Electromagnetic Measurements in the Near Field, Scitech Pub Inc., USA, 2011)

Frequency [MHz]	E Δ	I_r [mA]	Length of antenna [m]
27	15x	170	1,5
27	10x	150	0,25
144	3x	90	5/8
144	2x	80	0,15
432	1,5x	50	0,12

The author has extended this research with numerical analysis using Method of Moments which is the basis for software named FEKO. Computer simulations were performed at devices nominal power 5W and at following frequencies:27 MHz, 145 MHz and 430MHz. They were performed with several types of antennas and in different positions of the tested device with respect to the model. Selected results of the current changes in the hand as a function of length of the hand for different frequency and length of antenna are shown in Fig. 3.

a)



b)

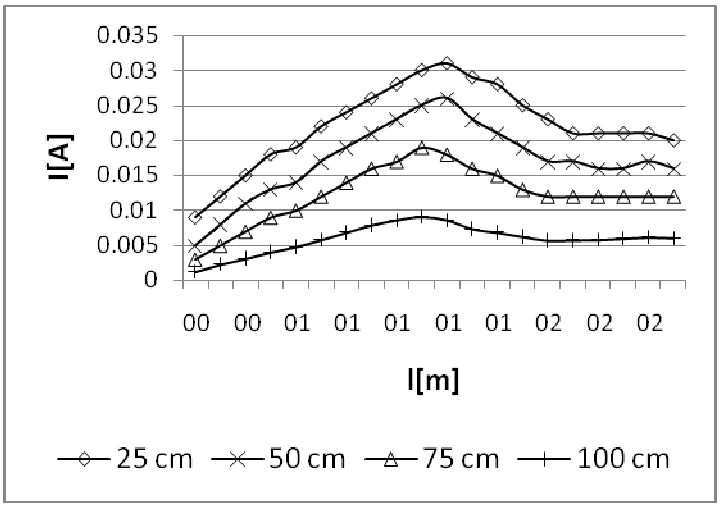


Fig.3.The results of current distribution in the hand of the radio operator as a function of length of the hand :a) for different frequencies, b) for different types of antennas

The currents intensity that can be seen in both Table 1andFig.3aresignificant enough to pay attention to, especially since in some cases they exceed the allow able induced current of 100 mA at frequencies from100 kHz to 110MHz. The requirements for the sizes of induced current are written in the Directive2004/40/EC of the European Parliament (Directive, 2004).

Induced current, referred to in this article also appears in the head of the user. The author conducted a computer simulation on a centimeter model of the user's head operating a radio phone at a frequency of430MHz (T Dlugosz ;Central European Journal of Engineering. 2011, 1, 3, 253). The distribution of current induced in the head of the user shown in Figure 4, depends on various factors. One of themis the fact, that the person is wearing glasses, and the kind of material the frames are made of Figure5 shows the results of computer simulations carried out by the author ,showing the impact of plastic(Fig.5a)and metal(Fig.5b)frames on the distribution of the induced current.

a) b)

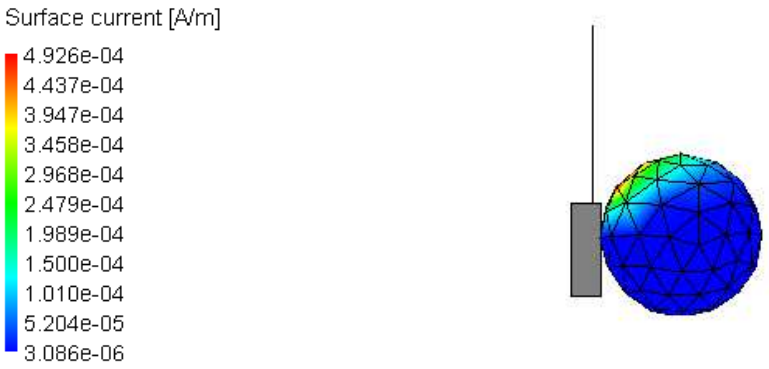


Fig. 4. Current induced in radiophone user's head: a) current distribution, b) legend

a) b) c)

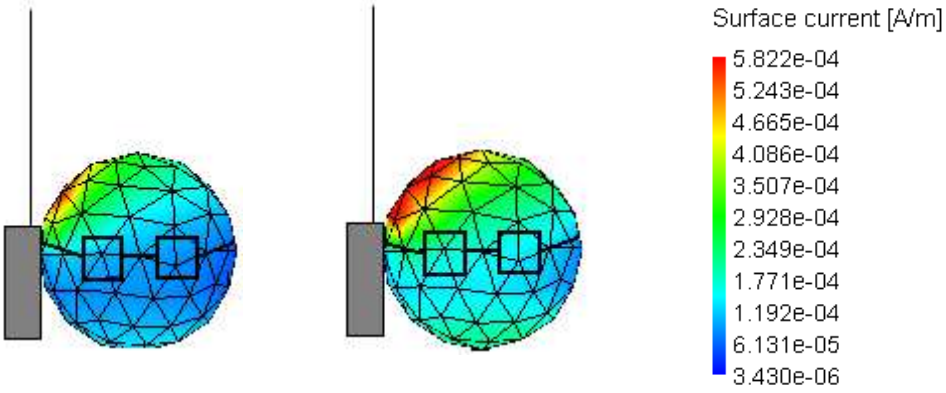


Fig. 5. Current induced in radiophone user's head who is wearing glasses: a) current distribution while wearing glasses with plastic frames, b) current distribution while wearing glasses with metal frames, c) legend

The results show that the presence of glasses on user's head increases the induced current in relation to the user who does not wear glasses. Additionally, there is an increase in the current when frames are made of metal.

Current's intensity in the user's head who is wearing metal framed glasses while using the radio phone is up to 1.5times higher than the intensity of the user wearing of plastic framed glasses.

CONCLUSION

The article discusses one of the properties used in the study of biological effects, which is the density of the current induced in the body .A thorough analysis was performed of the phenomenon of induced current in user's hand and head , pointing to possible additional risks like the presence of glasses. Wearing glasses can cause the increase of the current that will flow through operator's body. The presented result indicates the need for calculating the EMF's energy absorption from the radio antenna using exclusively SAR, but also points to the necessity of taking into the account the conducting currents in operator's hands or lips when dealing with EMF's energy absorption in the body of the operator and the possible effects of these devices on their operators. Analyzed issue draws attention to the significant problems associated with personal communication. The first is the lack of clarity in the light of existing rules, defining if the use of a cell phone or radio phone should be considered as occupational or non-occupational hazard .Strict interpretation of the rules leads to the need to determine the specific distance between the user of the device and other users or devices. Another important issue is the fact that most of the theoretical and experimental research applies to the power absorbed in the operator's body.

Analyzed currents induced in the operator's body are improperly ignored in the studies. There is no place for that kind of ignorance since the results show that the values of these currents are significant and often can be very close to the 100mA mentioned in the title of this publication. Regulatory agencies recognize the 100mAlimit required to your health's safety.

REFERENCES

[1] Directive 2004/40/EC of European Parliament and of Council of the minimum Health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields), (18th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), OJ. Nr L-184, **2004**

[2] CENELEC, "Basic standard for the calculation and measurement of electromagnetic field strength and SAR related to human exposure from radio base stations and for terminal stations for wireless telecommunication systems (110 MHz – 40 GHz)", **2003**, EN 50383.

[3] The Institute of Electrical and Electronics Engineers,"IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz", IEEE Std. C95.1 Edition, **2005**.

[4] Bienkowski, P., Długosz, T., Trzaska, H., „Forgotten currents?", *32nd Annual Meeting of the Bioelectromagnetics Society*, 14-18 June **2009**, Seoul, South Korea, CD Proceedings.

[5] Bienkowski, P., "The electromagnetic field generated by handheld radiotelephone", *Electrical Review*, No. 12, **2004**, pp. 1231-1233.

[6] Trzaska, H., "Electromagnetic Field Measurements in the Near Field", *Scitech Pub Inc.*, 2001.

[7] Bienkowski, P., Trzaska, H.,"Electromagnetic Measurements in the Near Field",*Scitech Pub Inc.*, **2011**.

[8] Dlugosz, T.,"Is always high-resolution human model in bioelectromagnetic modeling needed?"*Central European Journal of Engineering*, Vol. 1, No. 3, **2011**, pp. 253-256.