Study of the Thermal Impact of the Human Skin in the UMTS Network

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ABSTRACT: *In this work we studied the thermal impact of the human skin in the UMTS network. This paper addressed an interdisciplinary approach for designing of biological structures which is organized using the thermos visual system with infrared camera. We draw the data from the real life situation by leaving the computer based simulations. We kept a marginal distance between the used infrared camera and participants of this study. We found during the experimentation that there is no heating of the human skin even after 40 minutes of calling. It may be due to the biological mechanism for adaptation in different conditions and biological processes involved in the process.*

Keywords: Thermal Impact, Thermography, Human Body, Cell Phone, EMF, Health, Phone Call

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1. Introduction

As we tend to use mobile phones and numerous other wireless devices more and more intensively in our everyday life, certain concern about potential health effects related to their use is gaining more and more public attention. Despite international and national agencies have established safety guidelines about exposure to radiofrequency (RF) fields, public concern is still rising about potential harmful health effects related to RF field exposure.

In different studies are described different approaches how to find the answer of the question: are the cell phones unhealthy during a call (conversation) and how much time is the safety period for use of this technology to communicate [1-4]. One of the easiest and simple ways to investigate this topic is to use a thermography camera. Its applications are variety in medicine, security, industry etc [5-7]. The use of this technology would lead us to the right answer of the submitted question.

The theoretical analysis is based on the human anatomy and physiology [8]. If the size of some organ or some tissue is commensurate with the electromagnetic wavelength a resonance phenomenon appears. The depth of electromagnetic wave penetration in the material depends on the radio frequency and the properties of the respective tissue. In frequency range over 3 GHz the penetration is weakly and the main part of the wave energy get lose in the skin as heat treatment in this layer of the body. In frequency around 1 GHz the penetration is about 3 cm in depth and the wave energy could treat some organs as heat source which can deviate the temperature of operating differently of the normal temperature. In this case the heating proce-

procedure by the electromagnetic wave is dangerous because in such depth in the human body is very hard to do a self-thermal conditioning even in case the affected part is low blood irrigated.

If the frequency is even lower the wave penetration in the human body would be even deeper. The thermal impact of the electromagnetic wave (the transformation of this kind of energy into heat) is due to some active loss, dielectric loss and other losses.

The released thermal energy rise the temperature in some local part of the biological object. This leads to thermal difference between the neighboring organs and then is spread to the surrounding part of the body. This process of thermal self-regulation is forwarded by the blood circulation. That's why the parts of low blood circulation are mostly in danger of overheating, especially the eyes [8].

The experimental observation includes a design of the experimental process, selection of the technical equipment, test in standardized environment for all observer people and analysis of the results compared to the theoretical base.

2. Method of Experiment

The planning of the experiment includes clearing which region of the human head is more and direct affected by the electromagnetic field produced by the cell phone. The region of the human's head is defined as the plane set by the coordinates X0Z (top view of the head is shown on Figure 1.) which will be the main area of investigation- the profile zone around the human's ear.

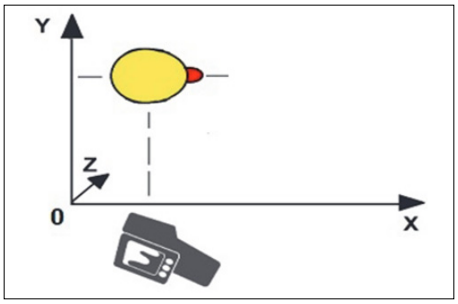

Figure 1. Schematic representation of the experimental process

The graphical schema of the corpus and antenna location in the experimental telecommunication device (Samsung Galaxy S7) is shown on Figure 2 [9].

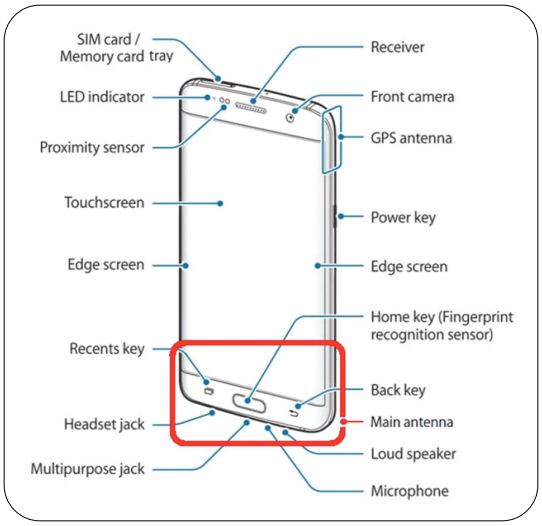

Figure 2. Front view of the used experimental cell phone (Samsung Galaxy S7) with antenna location

The thermal camera used in this experiment has parameters which are described in Table I. As it is shown, the temperature range and the thermal sensitivity meet the requirements for human body as an object of measuring.

Temperature Range in °F	-4°F to 1,202°F
Temperature Range in °C	-20°C to 650°C
IR Resolution	160 × 120 pixels
Thermal Sensitivity	< 0.07°C
Accuracy	±2°C
Spectral range	7,5 μm – 13 μm
Detector type	Uncooled FPA, 160 x 120 pxl160 x 120 pxl
Multi Spectral Dynamic	IR image with enhanced detail presentation
Imaging (MSX) MSX Resolution	320 × 240

Table 1. Parameters of the infrared camera used in the experiment

For the experimental purpose a conventional cell phone is used. The related parameters of this device are described in Table 2 [8]. During the phone conversation 3G network connectivity is used. The human holds the cell phone device all the time

2G GSM	GSM850, GSM900, DCS1800, PCS1900
3G TD-SCDMA	B34(2010), B39(1880)
3G UMTS	B1(2100), B2(1900), B4(AWS), B5(850)
4G FDD LTE	B1(2100), B2(1900), B3(1800), B4(AWS), B5(850), B7(2600), B8(900), B12(700), B18(800), B19(800), B20(800),B29(700), B30(2300)
4G TDD LTE	B38(2600), B39(1900), B40(2300), B41(2500)
Wi-Fi	802.11 a/b/g/n/ac 2.4G+5GHz, T80MU-MIMO
Bluetooth	Bluetooth v4.2
Bluetooth Profiles	A2DP, AVRCP, DI, HFP, HID, OGP, HSP, MAP,OPP, PAN, PBAP
Other connectivity	GPS, Glonass, NFC
SAR	1.59 W/kg (body) /1.03 W/kg (head)

Table 2. Technical Specification of the user cell phone

touching his own auricle. The exception of moments of not holding the device is when catching the thermal snapshots in a constant interval of 4 minutes when experimenting for 40 minutes in total. The reason to investigate for a total period of 40 minutes comes from the experience of the authors who are used to talk by their cell phones for such duration several times per week usually.

At all the time the objects of measurements use the conventional cell phone device only for vocal conversation. None of the other connectivity / functions of the device are allowed (all other technical connections are set to off) to be used, therefore only the circuit including the main antenna is spreading electromagnetic field to the body and to the telecom connectivity point in the range cell.

The experiment is made for 3 objects of measuring in a row. The three people are 21 years old who participated in the experiment; they were healthy with normal blood pressure in the range of 130/80 mm Hg and 75 heart beats per minute. All of them agreed to participate in this study after the warning that it may cause some decay of their health state in physical or mental field.

3. Results and Discussions

The global opinion of the population on the Earth is negative regarding to the impact of the cell phone to the human's physical health. Usually this opinion is according to rumour and no scientific or enough clear explanation how such conclusion is made. An easier to realize consequence for the human's body is such health issue as hearing loss due to the loud audio/sound level coming from the phone device speaker when it is such tuned regularly (every day of use in loud adjustment). On other side the electromagnetic field treatment (exposing) and its effect on the human's body and mind is not so easy to be estimated and explained. Here it comes the need of better understanding the theory and a practical investigation of this problem. In this paper the purpose of the authors is to verify how the electromagnetic field influence the thermal state of human's head skin and is this treatment leading to a dangerous outcome.

The process of thermography investigation on human's profile head skin can be represented as a graphical data. Figure 3 shows the current distribution of the temperature values for $\tau = 40$ min. This picture shows only the thermal data obtained by the investigated object.

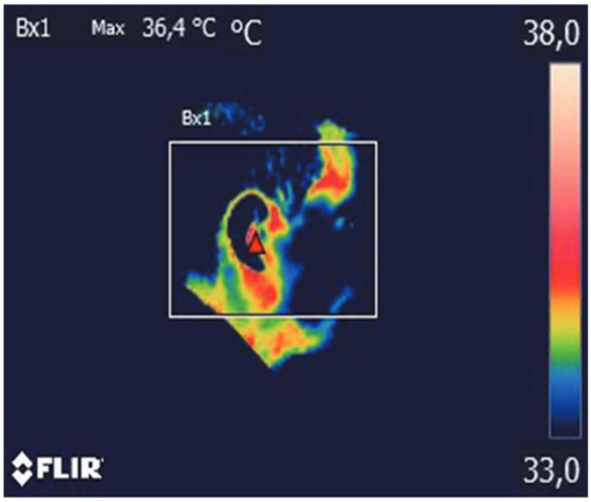

Figure 3. Temperature t[^{o}C] on the head profile plane for Object#2 in current time $\tau = 40$ min

The possibilities to report the results after thermographycal investigation and analysis on human's profile head skin can be represented as a thermal picture laid on the real picture of the scene. The amount of the thermal coloured parts on the picture depends on the given temperature range for the investigation.

Figure 4 shows the current distribution of the temperature values for $\tau = 40$ min for the same object, but as thermal data

obtained by the investigated object placed as colours distribution over the real picture.

The summarised temperature values measured on the head profile plane (X0Z) are showed on Figure 5 for period of 40minutes call regarding to the conditions described in the previous section.

The graphical data summarizing the temperature values deviation (Δt [° C]) between the current time and the beginning moment measured on the head profile plane for 40 minutes of call is shown on Figure 6.

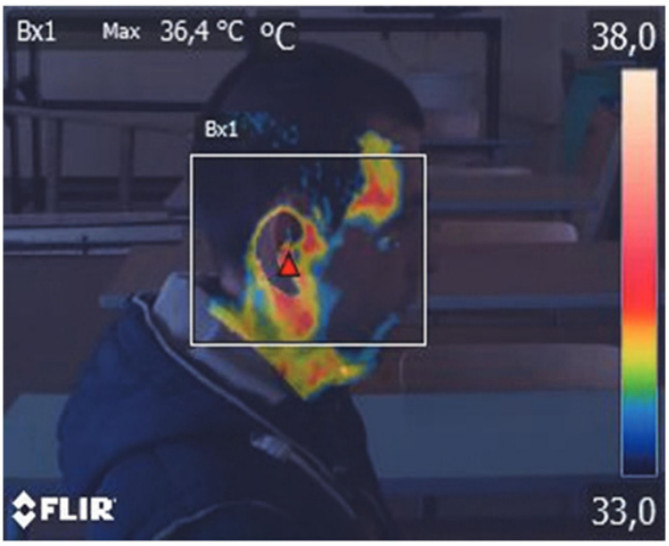

Figure 4. Temperature t[°C] on the head profile plane for Object#2 in current time $\tau = 40$ min

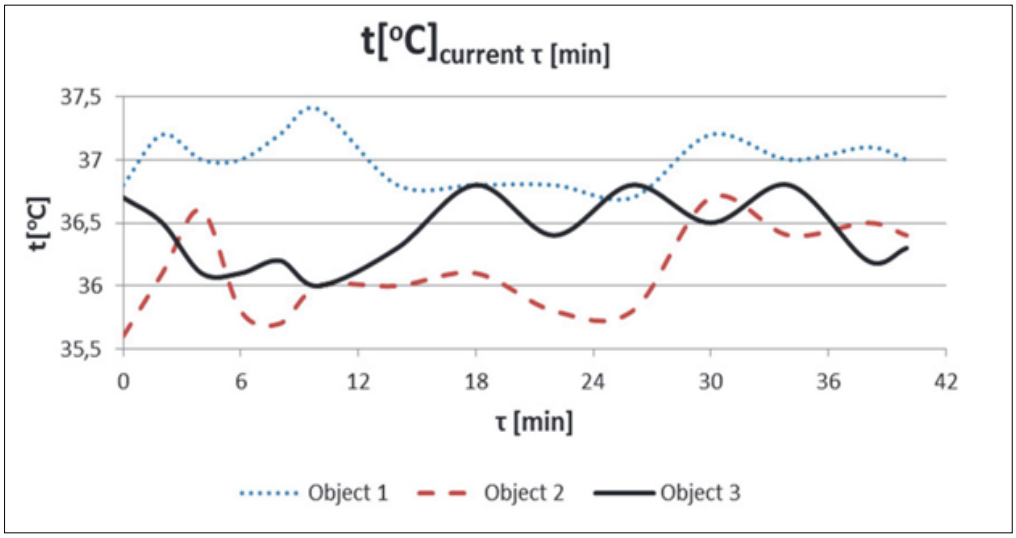

Figure 5. Temperature t[°C] on the head profile plane for Object#2 in current time τ [min]

In some cases the body temperature over than 37°C is considered as a state of ill health. In this study the thermal map shows that this marker of illness is partly displayed on the human's head on the profile plane (X0Z) and it doesn't affect large zone of the skin. The temperature of 37°C is passed over only for Object 1, whose initial temperature is higher than the other Objects. This is why the information from the temperature deviation on Fig. 6 is more informative regarding to the impact of the use of the cell phone to the human's skin temperature. The deviation Δt for the Object 1 is smaller than 1 degree. On other side, the

deviation of the temperature for the Object 2 is higher, but not very much than 1 degree. For Object 3 there is some initial decrease in the temperature compared to its first value and we believe this is due to some psychological reason or specific blood circulation in this head region. The obtained temperature data regarding to the Object 3 shows the same trend of deviation as the previews two, which leads to the idea of coincidence in the biological-thermal reaction between the three representatives.

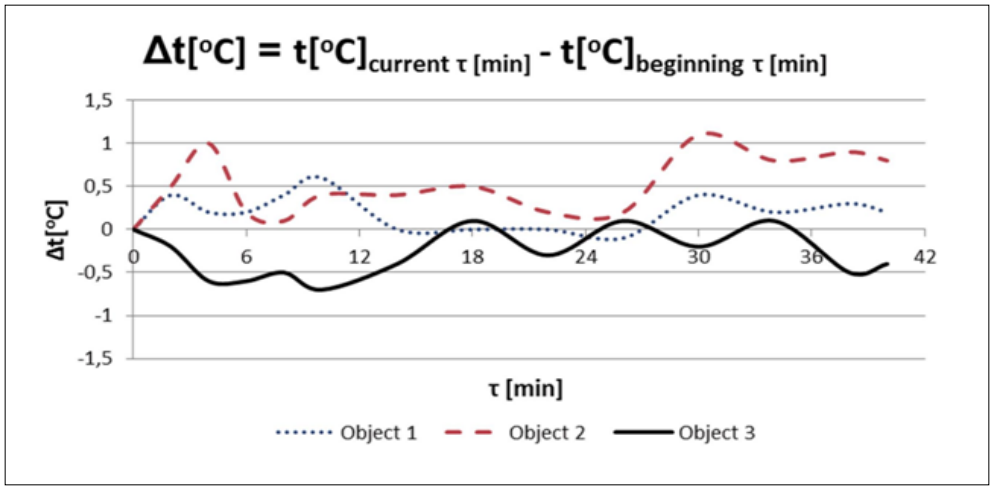

Figure 6. Temperature *deviation* Δt[°C] on the head profile plane in time domain τ [min]

4. Conclusion

The final conclusion of this scope is that at 2,1 GHz there is very low reflectance from the head skin layer but only about 40% or less of the falling EMW in RF spectrum will penetrate in the underlying tissues beneath the skin of the head. The absorbed EM energy is transformed into thermal and thus it will be diffused in a very short period of time because of the many blood vessels going in and out of the head. Because of that every amount of additional thermal energy induced by RF of mobile phones during call is scattered very quickly. In our opinion this is the reason for having warmer area of the head where the phone is situated (parietal area, near the ear) and the rest of the head remaining cooler.

The time period of 40 minutes in treatment with the electromagnetic field for vocal conversation through the conventional cell phone device is harmless regarding to the results obtained by the thermal-vision investigation.

In future work this problem can be examined closely regarding to the SAR and other conditions and how the electromagnetic field influence the tissues as a volume under the skin surface of the human's head.

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