Gazi University Journal of Science
GU J Sci
23(3):281-286 (2010)

GUJS
www.gujs.org

Measurement of Output Radio Frequency Field Generated by Mobile Phones with Applied Sound in Different Strengths & Frequencies

Elcin OZGUR*, Göknur GÜLER

Gazi University, Medical Faculty, Department of Biophysics, Besevler, 06500, Ankara

Received:04/03/2009 Revised:22/10/2009 Accepted:02/11/2009

ABSTRACT

Possible health risk associated with mobile telecommunication devices can be classified by dosimetry of the exposure. Dosimetry is an important but hard issue that is estimated by computational or experimental methods. Signal emitted from the mobile phones in different modulations such as talking or listening changes, so the level of exposure is different in different modulations. Talking and listening modulations of two different models of GSM 1800 MHz mobile phones were measured while modulated human speech, also pure tone with the intensity of 0-120 dB and frequency in between 125-8000 Hz applied through the phone. Our aim was to detect the minimum intensity of tone that changes the modulation of mobile phone from non-speaking mode to speaking mode, because it is known that there is parallel increase on the stress of the living things if the intensity of the sound is increasing. The data may be used for monitoring the daily exposure of the people using mobile phones, also defining the level of exposure at the laboratory experiments. It may be useful for the people for having individual precautions on using mobile phones in their daily lives.

Key Words: Radio Frequency Radiation, mobile phone, sound, stress, GSM

INTRODUCTION

Millions of people around the world use mobile phones as a communication tool. Computational and experimental studies demonstrated that fifty percent of radiation from cell phones is absorbed by the hand or the head [1]. Therefore, the possible health risk associated with mobile telecommunication devices, used close to the human head and in particular, effects on brain functions and the inner ear have been recommended for investigation [2,3]. Experiments for clarifying these effects should be designed, realized and characterized through numerical dosimetric procedures.

An appropriate dosimetry is needed for establishing safety factors for using mobile phones. Specific absorption rate (SAR) is a measure of the rate at which energy is absorbed by the body when exposed to a radio frequency radiation (RFR). Absorption and distribution of electromagnetic energy in the body is a very complex phenomena that depends on the mass, shape and size of the body; the orientation of the body with respect to the field vectors; and, the electrical properties of both the body and the environment. Since measuring SAR level is very difficult and expensive for each person having different characteristic of exposure, safety guidelines contain reference levels in electric field (E) or magnetic field (H) strength. Reference levels are derived from SAR levels

Corresponding Author: elcinozgur@gazi.edu.tr

that should not be exceeded using measurement and/or computational techniques. These levels are important on addressing perception and adverse indirect effects of exposure to RFR. In any particular exposure situation, measured or calculated values of any of these quantities can be compared with the appropriate reference levels [4]. The type of the RFR signal is also important for the dosimetry. Studies on health risk of mobile phone express that there are three different signal modulations for the Global System for Mobile communication (GSM) system widely used in mobile telephony as Basic, discontinuous transmission (DTX) and Talk. The main object about difference of these modulations is certainly related to difference of the power level of mobile phone emitting while signal transferring modes, namely they are classified with respect to condition of transferring the speech [5-7].

If a same mobile phone is considered, GSM Basic is active during talking phases and the most radiating power of mobile phone generates in this modulation. An important mode of operation for mobile radio systems is known as discontinuous transmission. In this mode the transmitter is switched on when a user begins to talk and switched off again when he stops. In other words, the GSM-DTX signal is used during the hearing modus of mobile phones. GSM-Talk generates temporal changes between GSM-Basic (active during talking phases) and GSM-DTX (active during listening phases) and simulates a typical conversation with average durations of 50 and 97 s for Basic and DTX, respectively [8].

In this sense, we designed an experiment to measure the output levels in the listening and talking modulations by using two types of mobile phones operating in GSM 1800 for addressing the reference level of exposure for people using mobile phones in their daily lives.

2. MATERIALS AND METHODS

The mobile phone radiation measurements were done in a sound proof room in constant temperature. Two identical mobile phones of Nokia 3210 (0.81 W/kg SAR) and Nokia 2100 (0.55 W/kg SAR) is used for the measurements. It is ensured that mobile phone is communicating the nearest base station whose line of site is 200 m, in other words the timing advance is zero. An audiometer (Interacoustics Clinical Audiometer AC 40) was used to produce pure tone, artificial sound not exist in nature in between 0-120 dB intensity and 125-8000 Hz frequency range. It can also modulate the any kind of voice to different frequencies and intensities. A woman and a man volunteers are used for simulating the voice for human. NARDA EMR 300, type 26.1 probe and spectrum analyzer were used as radiation measurement device. Measurements were taken for duration of 6 minutes per 2 seconds and the data saved to the computer connected to device via fiber optic cable. The whole data were averaged before statistical analysis executed by Kruskal Wallis method. Results are given as mean ± standard deviation and $p<0.05$.

Measurement Details

Measurement conditions are classified in five groups:
First of all, the difference between the condition of being “caller” and “called” phone is analyzed. One of the mobile phones is set as “caller phone”. It called the other one which is named as “called phone”. The measurements of called phone are performed in pure silent medium, then caller phone was measured while the other one is placed outside of the pure silent room. After analyzing the measurement data, we decided to measure the speaking and non-speaking emissions of called phone.
Second, measurements of mobile phone radiation were performed in pure silent medium for simulating the listening modulation. Third, female voice is applied to the mobile phones in order to simulate a female is talking on her mobile phone. After voice analysis of a woman speaker’s tone by phoneticians, we asked her to read the phonetic script continuously to a recorder during 6 minutes in the sound proof room, so she was the only sound source. This record is used for woman’s voice application to the mobile phone through the microphone of the audiometer by modulating both frequency and intensity. Then, this procedure is repeated by using a man's voice. Finally, pure tone is also applied through the mobile phone in range of audiometer operation as 0-120 dB intensity and 125-8000 Hz frequency ranges.

3. RESULTS

Results may be analyzed in five parts:
i. Measurement differences of “caller” and “called” phones:
It is found that there is no difference between the output electric field level of caller and called mobile phones of the same type ($p>0.05$). The level of “caller” and “called” phones of Nokia 3210 and Nokia 2100 are 7.7±0,2 V/m and 4.52±0.14 V/m respectively in pure slience.
ii. Measurements of the mobile phone radiation in listening modulation as pure slience:
The output level of listening emission is 7.7±0,2 V/m in pure silence for Nokia 3210 and 4.52±0.14 V/m for Nokia 2100.
iii. Measurements of the mobile phone radiation in talking modulations with different types of tones:
It is found that there is a significant increase in RFR level of mobile phone by application of “pure tone”, “woman voice” and “man voice” in certain frequencies and strengths with respect to “pure silence” for both types of mobile phones ($p<0.05$). However, the increase is independent of the voice type, namely difference in emission level by application of “pure tone”, “woman voice” and “man voice” in certain frequencies and strengths is statistically insignificant ($p>0.05$).
iv. Difference on the mobile phone radiation by applying tones in different strengths:

RFR levels were not statistically different for applying the tones in the range of 0 dB to 60 dB for Nokia 3210 and 0 dB to 40 dB for Nokia 2100 with respect to "pure silence" ($p>0.05$).
In other words, external E field values are 7.7 ±0.2 V/m for Nokia 3210 and 4,52±0,14 V/m for Nokia 2100 in these ranges of tones (Figure 1).

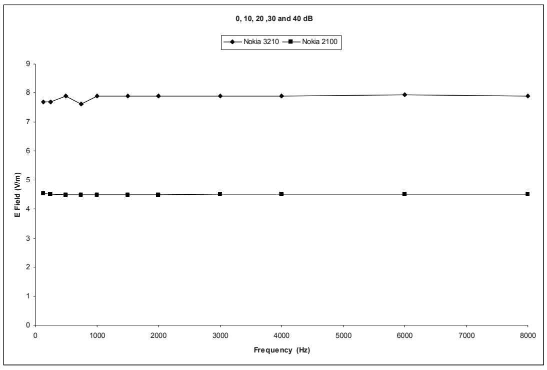

Figure 1. External electric field values (V/m) of speaking emission of 0, 10, 20, 30 and 40 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100.

v. Tone levels that make the radiation level increase:
50 dB sound which is the sound level in quiet restaurant inside is critical for Nokia 2100 since the E field level increased in the frequency range of 1,5 kHz and 4 kHz. The output level of RFR in this range increased to 14.15 ± 0.08 V/m for Nokia 2100 despite the fact that E field level is the same as listening modulation for Nokia 3210 (Figure 2).

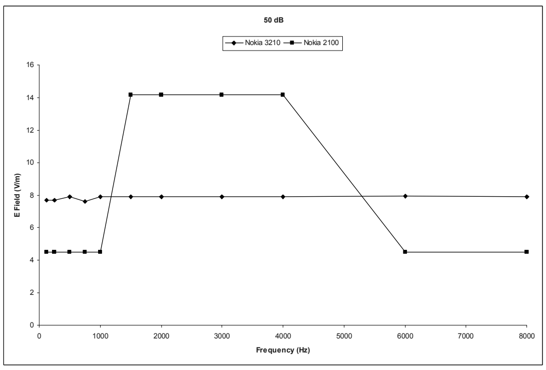

Figure 2. External electric field values (V/m) of speaking emission of 50 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

The critical intensity for Nokia 3210 is 60 dB which is the sound level of normal conversation, office or restaurant inside. 3 kHz and 4 kHz voices in the intensity of 60 dB increased the output level as 23.88 ± 0.11 V/m for Nokia 3210 although the increased level of emission (14.14 ± 0.09 V/m) was measured via applying the sound in the frequency range where the increase was determined is in between 750 Hz and 4 kHz for Nokia 2100 (Figure 3).

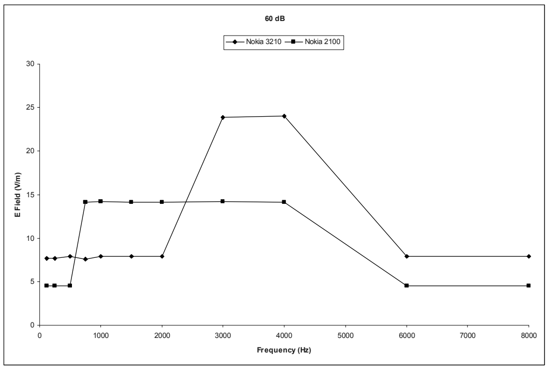

Figure 3. External electric field values (V/m) of speaking emission of 60 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

70 dB is loud as busy street traffic or vacuum cleaner at 3 m. For Nokia 3210, RFR increase to 24.13±0.11 V/m with the tones in between 1.5 kHz and 4 kHz, although 250 Hz-4 kHz frequencies applied to Nokia 2100 make the output level increase to 14.14±0.09 V/m. (Figure 4).

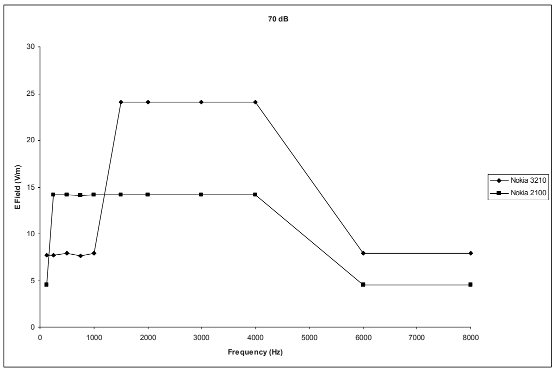

Figure 4. External electric field values (V/m) of speaking emission of 70 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

80 dB sounds which is noise of passing car at 3 m in the frequency range of 750 Hz to 4 kHz for Nokia 3210 and in the range of 250 Hz to 4 kHz for Nokia 2100 changed the output RFR level of mobile phone as 24.13±0.11 V/m and 14.14±0.09 V/m respectively (Figure 5).

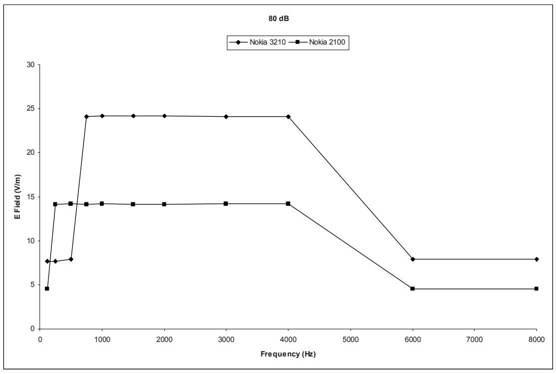

Figure 5. External electric field values (V/m) of speaking emission of 80 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

90 dB, arising by passing bus or truck at 3m and 100 dB, arising by passing subway train at 3 m. of 250 Hz to 4 kHz sounds for both Nokia 3210 and Nokia 2100 increase the E field level to 24.15±0.11 V/m and 14.16±0.08 V/m respectively (Figure 6-7).

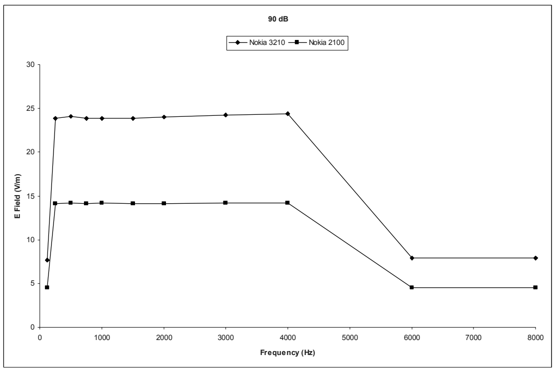

Figure 6. External electric field values (V/m) of speaking emission of 90 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

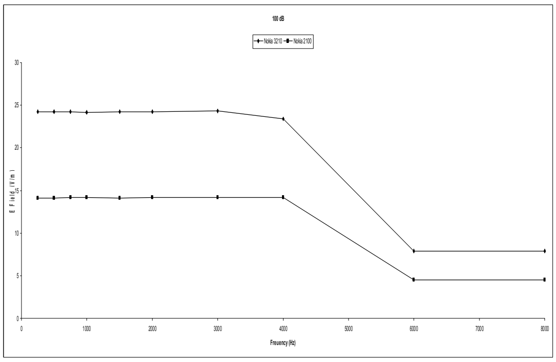

Figure 7. External electric field values (V/m) of speaking emission of 100 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

110 dB and 120 dB in 6 kHz sounds also change the RFR level of both mobile phones, Nokia 3210 and Nokia 2100 as 24.16±0.11 V/m and 14.16±0.10 V/m respectively (Figure 8-9).

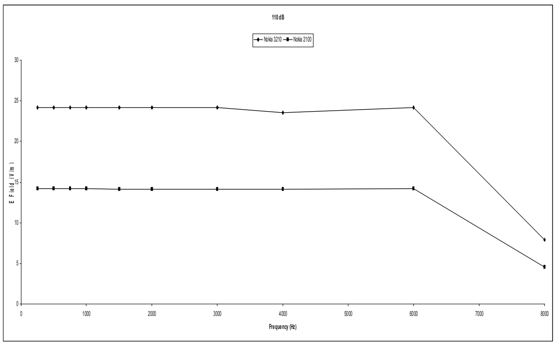

Figure 8. External electric field values (V/m) of speaking emission of 110 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

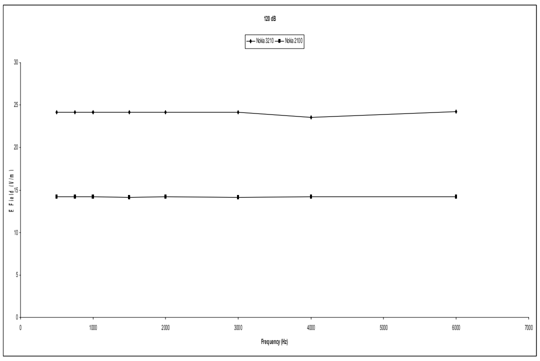

Figure 9. External electric field values (V/m) of speaking emission of 120 dB for average pure tone, man's and woman's voices generated by Nokia 3210 and Nokia 2100

4. DISCUSSION

Rapid grow of using mobile phone by adult, young people, children and the elderly cause to increase the radio frequency sources such as base stations and microwave links. This increase also causes public concern, scientists and experts to consider about the health effects of these devices in the last years.

Monitoring the public exposure to RFR scientifically is important for public health. Assessment of the radiation level from base station antennas is a significant scientific concern in order to monitor the level of radiation caused by base stations. There are measurement studies of the base stations in local areas for different countries [9-11]. These studies are valuable for laboratory applications for defining the level of exposure in animal, epidemiological or in vitro experiments. Furthermore, there are studies to express the relative exposure levels for mobile phone users by using computational or engineering methods. Kim et al [12] used way of neural network for estimating the exposure level and they concluded that epidemiologists can divide the subjects into exposed and non-exposed groups in a study investigating the relationship between exposure level and brain cancer in the future, provided that more knowledge between the cellular phone usage pattern and the exposure is available. Analyzing the type of mobile phone signal is also important for simulating the radiation level for experiments aiming at the investigation of biological effects of RFR. To this end, some researchers reported the characteristics of universal mobile telecommunications system (UMTS) signals and discuss the signal parameters with respect to their possible biological relevance in order to define a generic UMTS test signal for the laboratory applications [13].

The present study is conducted to measure the level of mobile phone radiation in which the source of exposure in the laboratory is directly mobile phone. There are studies in which the effect of RFR on brain, for instance the difference on EEG is analyzed in a group of people while using mobile phone [14]. For these types of studies, monitoring the level of mobile phone radiation is important for dosimetric analyses. In other words, the level of the mobile phone may change according to the condition as talking or listening modes.

In addition to this, this study may be used for monitoring the everyday usage of mobile phones. It is expressed that talking emission of the mobile phones are three times higher than the listening emission of mobile phones. Although the output radiation levels of mobile phones are directly related to their digital SAR values, their threshold level of delivering tone of speech level is also another parameter that may change the radiation level that the user of mobile phone expose.

Protection against adverse health effects of RFR requires that basic restrictions in SAR level are not exceeded. Reference levels of exposure that is measuring the environmental condition are provided for comparison with measured values of physical quantities; compliance with all reference levels given in these guidelines will ensure compliance with basic restrictions. These data may be helpful in the cases that SAR measurement is not possible to make in laboratory conditions.

Since the public concern is increasing about RFR issue, people have many questions on how to decrease the level of RFR exposure. The practical precautions should be set for the public use at the stage of public understanding. The experts on protection of RFR may use these data for publishing a public advice for using mobile phones.

REFERENCES

[1] Lin, J. C., "Hearing microwaves: the microwave auditory phenomenon" ***IEEE Antennas and Propagation Magazine*** 43:166–168 (2001).

[2] Lopresto, V., Pinto, R., De Vita, A., Mancini, S., Galloni, P., C. Marino, C., Ravazzani, P., Lovisolo, G. A., "Exposure Setup to Study Potential Adverse Effects at GSM 1800 and UMTS Frequencies on the Auditory Systems of Rats" ***Radiation Protection Dosimetry***, 123: 473–482 (2007).

[3] Takebayashi, T., Varsier, N., Kikuchi, Y., Wake, K., Taki, M., Watanabe, S., Akiba, S., Yamaguchi, N., "Mobile phone use, exposure to radiofrequency electromagnetic field, and brain tumour: a case-control study" ***British Journal of Cancer,*** 98:652-9 (2008).

[4] ICNIRP (International Commission on Non-Ionizing Radiation Protection). Guidelines for limiting exposure to timevarying electric, magnetic, and electromagnetic fields (up to 300 GHz). ***Health Physics*** 74(4):494–522 (1998).

[5] Capri, M., Scarcella, E.,Bianchi, E., Fumelli, C., Mesirca, P., Agostini, C., Remondini, D, Schuderer, J, Kuster, N, Franceschi, C., Bersani, F., "1800 MHz radiofrequency (mobile phones, different Global System for Mobile communication modulations) does not affect apoptosis and heat shock protein 70 level in peripheral blood mononuclear cells from young and old donors" ***International Journal of Radiation Biology,*** 80: 389 – 397 (2004).

[6] Wiart, J., Dale, C., Bosisio, A.V. and Le Cornec, A., "Analysis of the influence of the power control and discontinuous transmission on RF exposure with GSM mobile phones" ***Electromagnetic Compatibility, IEEE Transactions*** 42: 376-385 (2000).

[7] Erdreich, L. S., Van Kerkhove, M. D., Scrafford, C.G., Barraj, L., McNeely, M., Shum, M., Sheppard, A. R., Kelsh, M., "Factors that Influence the Radiofrequency Power Output of GSM Mobile Phones". ***Radiation Research,*** 168: 253–261 (2007).

[8] REFLEX-Project, "Risk evaluation of potential environmental hazards from low energy electromagnetic field exposure using sensitive in vitro methods" Report Final 274 (2004).

[9] Keow, M.A., Radiman, S., "Assessment of radiofrequency/microwave radiation emitted by the antennas of rooftop-mounted mobile phone base stations" ***Radiation Protection Dosimetry***, 121:122-7 (2006).

[10] Henderson, S.I., Bangay, M.J., "Survey of RF exposure levels from mobile telephone base stations in Australia" ***Bioelectromagnetics*** 27(1):73-6 (2006).

[11] Cooper, T.G., Mann, S.M., Khalid, M., Blackwell, R.P., "Public exposure to radio waves near GSM microcell and picocell base stations" ***Journal of Radiological Protection***, 26 :199-211 (2006).

[12] Kim, S.C., Nam, K.C., Kim, D.W., "Estimation of relative exposure levels for cellular phone users using a neural network". ***Bioelectromagnetics,*** 27 : 440-4, (2006).

[13] Ndoumbe' Mbonjo Mbonjo, H., Streckert, J., Bitz, A., Hansen, V., Glasmachers, A., Gencol, S., Rozic, D., "Generic UMTS Test Signal for RF Bioelectromagnetic Studies", ***Bioelectromagnetics,*** 25:415-425, (2004).

[14] Kramarenko, A.V., Tan, U., "Effects of high-frequency electromagnetic fields on human EEG: a brain mapping study", ***International Journal of Neuroscience***, 113:1007-1019, (2003).