

# Radiation Measurement for Global System for Mobile Communication Handset and Health Implication

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**ABSTRACT---** *In this study, the measurement of Electromagnetic Radiation of the GSM handset and health implication, measurements were conducted. GSM radiations are non-ionizing. Measurement of the magnetic radiation was carried out using a Radiation Meter. Several tests were carried out with different makes and models of GSM handsets to determine the radiation from the handset at different distances between the handset and the Radiation meter. Measurements were also taken for other household devices for the purpose of comparing the radiation to those of GSM handsets. The result shows that the radiation from GSM handsets is within the limit set by the International Commission on Non-Ionization Radiation Protection (ICNIRP) and do not pose any health hazard, although research is continuous. However, the radiations have some effects on the individual using the handset by causing some temperature rise if phone is used for a long time. It is therefore advisable not to use phone for more than 30 minutes without a break. Pregnant mothers however have to use the phone with extra care because of the foetus who is not fully formed.*

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## 1. INTRODUCTION

Global System for Mobile Communication (GSM) was introduced to Nigeria in 2001, since then there has been a tremendous increase in the number of base stations all over the country and individuals have bought several GSM handsets which are used every now and then. There is a concern over the health implication of antenna masts in residential areas and mobile phones on users. The incomplete knowledge of non-thermal mechanisms of interaction between biological systems and electromagnetic radiation creates opposition to the acceptance of the operation of RF transmitters near or inside urban areas

The electromagnetic spectrum encompasses both natural and human-made sources of electromagnetic fields. The frequency and wavelength characterize an electromagnetic field. In an electromagnetic wave, these two characteristics are directly related to each other: the higher the frequency the shorter the wavelength. It is to be noted that Ionizing radiation such as X-ray and gamma-rays consists of photons which carry sufficient energy to break molecular bonds. Photons of electromagnetic waves at power and radio frequencies have much lower energy that does not have this ability. However the GSM frequency range is in the non-ionizing range.

Electric fields exist whenever charge is present and are measured in Volts per meter (V/m). Magnetic fields arise from current flow. Their flux densities are measured in microTesla ( $\mu\text{T}$ ) or milliTesla (mT). At radio and microwave frequencies, electric and magnetic fields are considered together as the two components of an electromagnetic wave. Power density, measured in watts per square meter ( $\text{W}/\text{m}^2$ ), describes the intensity of these fields. Low frequency and high frequency electromagnetic waves affect the human body in different ways. Electrical power supplies and appliances are the most common sources of low frequency electric and magnetic fields in our living environment. Everyday sources of radiofrequency electromagnetic fields are telecommunications, broadcasting antennas and microwave ovens.

A wide range of environmental influences causes biological effects. 'Biological effect' does not equal 'health hazard'. Special research is needed to identify and measure health hazards. At low frequencies, external electric and magnetic fields induce small circulating currents within the body. In virtually all ordinary environments, the levels of induced currents inside the body are too small to produce obvious effects.

The main effect of radiofrequency electromagnetic fields is heating of body tissues. There is no doubt that short-term exposure to very high levels of electromagnetic fields can be harmful to health. Current public concern focuses on possible long-term health effects caused by exposure to electromagnetic fields at levels below those required to trigger acute biological responses.

Various measuring equipment with different characteristics are available for measuring electromagnetic radiation. WHO's International EMF Project was launched to provide scientifically sound and objective answers to public concerns about possible hazards of low level electromagnetic fields. It is expected that this paper will compare the levels of electromagnetic radiations from some handsets used in Nigeria to the threshold from International Commission on Non-Ionization and Radiation Protection (ICNIRP) [1,2]

## 2. ELECTROMAGNETIC FIELDS AND SPECIFIC ABSORPTION RATE

Electromagnetic waves carry energy as they propagate through space and they can transfer energy to objects in their paths. The rate of flow of energy in an electromagnetic wave is described by the Poynting vector  $S$

$$S = \frac{1}{\mu_0} E \times B \quad (1)$$

The magnitude of  $S$  represents the rate at which energy flows through a unit surface area perpendicular to the direction of wave propagation.  $S$  represents power per unit area. The unit of  $S$  is  $W/m^2$

$$\text{Since } B = \frac{E}{c} \quad \text{then } S = \frac{E^2}{c\mu_0} = \frac{cB^2}{\mu_0} \quad (2)$$

These equations apply at any instant of time.

Power transmitted is proportional to the square of the amplitude

$$\text{Intensity} = E \cdot H = \frac{E^2}{\eta} = \eta H^2 \quad (3)$$

Value of electric field is  $\eta$  times that of magnetic field. Energy stored in electric field per unit volume at any point is equal to energy stored in magnetic field.

Specific Absorption Rate is defined as the rate at which RF power is absorbed per unit mass by any part of the body. SAR is a function of conductivity,  $\sigma$ , mass density of the body,  $\rho$  and the electric field or magnetic field,  $E$ .

$$SAR = \int_{\text{sample}} \frac{\sigma(r)E(r)^2}{\rho(r)} dr \dots\dots\dots(4)$$

The SAR limit is 2.0W/Kg in Europe and 1.6W/Kg in US averaged over 10g of tissue.

Time averaged SAR value are determined for either 1g or 10g of simulated biological tissue in the shape of a cube for a 6 or 30-minutes period Commercial GSM phones constantly regulate the transmitted power to counteract varying attenuation along the mobile path and thus maintain a smaller range of received power levels at the base station receiver. GSM phones can adapt their transmission within a range of 30dB ( eg GSM 1800: 1-1000mW) SAR values of different commercial phones vary by a factor of 10-20 ( values of 0.1 -1.6W/Kg)

## 3. REVIEW OF PAST WORKS

Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health. The focus of international research is the investigation of possible links between cancer and electromagnetic fields, at power line and

The Federal Office for Radiation Safety in Germany recently measured the daily exposure to magnetic fields of about 2000 individuals across a range of occupations and public exposures. All of them were equipped with personal dosimeters for 24 hours. The measured exposure varied widely but gave an average daily exposure of 0.10  $\mu$ T. This value

is a thousand times lower than the standard limit of 100  $\mu\text{T}$  for the public and 200 times lower than the 500  $\mu\text{T}$  exposure limit for workers. Furthermore, the exposure of people living in the centers of cities showed that there are no drastic differences in exposure between life in rural areas and life in the city. Even the exposure of people living in the vicinity of high voltage power lines differs very little from the average exposure in the population.

Background electromagnetic field levels in the home are mainly caused by the transmission and distribution facilities for electricity or by electrical appliances. Electrical appliances differ greatly in the strength of fields they generate. Both electric and magnetic field levels decrease rapidly with distance from the appliances. In any event, fields surrounding household appliances usually are far below guideline limits. At operator positions the electric and magnetic fields of television sets and computer screens are hundreds of thousands times below guideline levels. Microwave ovens meeting the standards are not hazardous to health. As long as close public access to radar facilities, broadcasting antennas and mobile phone base stations is restricted, exposure guideline limits for radiofrequency fields will not be exceeded.

The user of a mobile phone encounters field levels that are much higher than any levels in the normal living environment. However, even these increased levels do not appear to generate harmful effects. Many surveys have demonstrated that exposure to electromagnetic field levels in the living environment is extremely low.

Electromagnetic radiations from GSM (Global Service for Mobile Communication) base stations were measured in the far-field region by using directional antennas (biconical-loghybrid, horn antenna) and isotropic electric field probes and detected signals were analyzed by using low-resolution bandwidth (30 Hz) spectrum analyzer and field probe meter respectively. Electric fields of the electromagnetic radiations were measured in x, y and z orthogonal directions with vertical and horizontal polarizations. Amplitude fluctuation of electromagnetic radiation of GSM base station were detected at long time interval (more than 8 hours) and analyzed using standard deviation and Allan variance statistics. The results and uncertainties of the electric field measurements by biconical-log hybrid antenna, horn antenna and electric field probe were compared. The measured electric field values of GSM base stations were compared to the value of reference levels for general public exposure to time-varying electric fields limits of ICNIRF' Guidelines.[3]

To this end, a number of sources have been identified to emit levels of EMF radiation such as power transmission lines, base transmitter stations (BTS), mobile phones and many household appliances, some of which have been classified as extremely low frequency (ELF) non-ionizing radiating devices. The global system of mobile telecommunications (GSM) revolution supports to a large extent the proliferation of mobile phones and random BTS sitting in developing countries of which EMF emissions can assume very dangerous dimensions for human health. This study is undertaken to investigate the dilemma posed by wireless telecommunication devices that emit EMF radiations e.g. mobile phones and its transceivers, as against their relevance. Correlations were arrived at concerning their indirect effects on human health, from which possible safety measures were proposed and relevant suggestions made. The need for continued research has been advanced and until a realistic risk assessment can be performed and fully integrated into safety guidelines, the responsibility lies with the public to garner more information about EMF waves and to exercise a degree of caution consistent with uncertain phenomena. This paper presents a research into how the GSM handsets in Nigeria conform to the radiation standard set by WHO.

Biological effect results from human exposure to EMF radiation. The tissues of human body are heated from these exposures. According to [4] exposure to from a Nokia GSM phone for 30minutes results to temperature increase of 0.7 to 2.9 $^{\circ}\text{C}$ , the temperature rise for Samsung was 0.3 $^{\circ}\text{C}$  to 1.1 $^{\circ}\text{C}$ . GSM radiation is a non-ionization radiation.

There is a substantial absorption of EMF energy from a phantom head.[5] The absorption was lower at a great distance between the phantom head and the GSM phone and was higher as the distance decreased. At 0cm distance of separation the EM absorption increased to about 59% of total radiated power for horizontal polarized dipole and less than 42% for vertically polarized dipole. It is possible for fetal exposure to 800MHz – 1900MHz radio frequency radiation from GSM phones to lead to behavioral and neuro-physical alteration that persist to adulthood.[6] Prenatal exposure to radiation on the brain may have profound effects on brain of the unborn baby, therefore pregnant women should avoid staying on phone for long.

The body of a GSM phone user affects the radiation characteristic or radiation pattern and Total Radiated Power (TRP) of the mobile handset. Upto 10db Standard Deviation difference has been found in TRP and this is due to free selection of talk position. Variable hand position and grip on handset are some of the major reasons for large differences.[7]

SAR in human tissues can be reduced by placing meta materials between antenna and head. Split Ring Resonators can be structurally arranged to make the permeability of the medium negative around 900 and 1800MHz GSM frequency bands.[8]

#### 4. METHODOLOGY

An Electromagnetic Field Tester model MT 2008-0026 with accuracy of  $\pm 3\%$  was used for the measurement. The equipment is turned on and the default is intensity detection of magnetic field radiation. The alarm rings if it is over two milligauss. Long press of 2 seconds of the Detection mode conversion on the tester will convert to electric field radiation mode..The tester is held or placed close to target testing area or Device-Under-Test (DUT) and moved closer slowly until it comes into contact with the item. As the equipment gets closer to the item, the intensity of electromagnetic field will increase and the alarm will ring more frequently and the digital meter displays the value of the measured quantity. During the detection a change is made to the angle and position of the equipment towards the item and the largest reading is obtained. However for the GSM radiation test, a GSM handset is placed on a table and is set at different angles and different distances from the radiation meter. A call is made to the GSM handset and the radiation is measured for before the call comes in and when answering is activated. The test is repeated for different types of handsets and later for other house hold equipment like the microwave oven.

#### 5. DISCUSSION OF RESULTS

The set-up for the experiment is as shown in Fig. 1.

The results obtained for different mobile handsets are as tabulated in table 1

From table 1 it can be seen that the ICNIRP threshold has not been surpassed. Therefore based on the ICNIRP standard, the mobile phones do not pose any danger from normal usage.



Fig.1 Set-up for measurement with DUT and Radiation Meter at different angles

TABLE 1: Electromagnetic Radiation Measurements

DEVICE UNDER TEST (DUT)	Radiation at 0cm distance to Test Meter	Radiation at 10-30cm distance to Test Meter
Nokia E 63 GSM handset	16mG	1mG
Nokia C1 GSM handset	20mG	1mG
LG GSM handset	20mG	1mG
SAMSUNG GSM handset	22mG	0.5mG
VCD	10mG	0.2mG
PHOTOCOPIER	40mG	2mG
MICROWAVE OVEN	200mG	10mG
VACUUM CLEANER	200mG	6mG
ELECTRIC IRON	3mG	0mG
WASHING MACHINE	30mG	2mG

## 6. CONCLUSION

Electromagnetic radiation has been measured on some GSM handsets and household appliances. The accuracy of the measuring device is  $\pm 3\%$ . The measured values of the GSM electromagnetic radiation did not show any excessive value compared to other household appliances. Although GSM handsets are used close to the ears, the radiation absorbed by the head is higher than those obtained from other household items like the oven, but the radiation is still less than within the limit set by ICNIRP,. It can then be said that although the radiation from GSM handsets have such effects like heating the body, thereby raising the temperature, they do not pose any dangers for now if used reasonably, i.e. for not more than say 30 minutes continuously. However, pregnant mothers have to avoid using phones for long periods since it could have an effect on the foetus who is still undergoing development.

## 7. REFERENCES

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