EFFECT OF MOBILE PHONE RADIATION ON BRAIN ACTIVITY GSM VS CDMA

Aruna Tyagi[1]*,Manoj Duhan[1]** and Dinesh Bhatia[2]***
[1]Department of Electronics and Communication Engineering
[2]Department of Biomedical Engineering
Deenbandhu Chhotu Ram University of Science and Technology, Murthal, Sonepat, Haryana-131039.
Email ID: - *aruna007_tyagi@yahoo.co.in,**duhan_manoj@rediffmail.com
***bhatiadinesh@rediffmail.com

Abstract: **A boon for better communication, cell phone usage nonetheless has many health hazards. Various studies indicate that the emissions from a cell phone can be extremely harmful, causing genetic damage, tumours, memory loss, increased blood pressure and weakening of the immune system. The fact that this radiation is invisible, intangible, and enters and leaves our bodies without our knowledge makes it even more intimidating. Global System for Mobile Communications (GSM) and Code Division Multiple Access (CDMA) are the two most prevalent second generation (2G) mobile communication technologies. This paper discusses on the analysis conducted to study the effect of electromagnetic radiation of two mobile phone technologies with different frequencies and power level via experimental works. The experiment was conducted in a laboratory using 10 human volunteers. The period of operation is 10 minutes as the talking time on the phone. Electroencephalogram is used to monitor and capture the brain signals during the experimental analysis for 10 minutes interval. The result shows that mobile phone serving GSM has the larger effect on brain compared to mobile phone serving CDMA.**

Keywords: **GSM, CDMA, 2G, Electromagnetic Radiation, EEG**

1. INTRODUCTION

Safety is a legitimate concern of the users of wireless equipment, particularly, in regard to possible hazards caused by electromagnetic (EM) fields. There has been growing concern about the possible adverse health effects resulting from exposure to radiofrequency radiations (RFR), such as those from mobile communication devices. Mobile communication is where signal is transferred via electromagnetic wave through radio frequency and microwave signals. This signal produces electromagnetic radiation in the form of thermal radiation that consists of harmful ionizing radiation and harmless non-ionizing radiation. When using mobile phone, electromagnetic wave is transferred to the body which causes health problems especially at the place near ear skull region where they are known to affect the neurones. The radiations interfere with the electrical impulses that two neurones connect each other with. This can lead to deafness and migraines. People using cell phones are prone to high blood pressure and other symptoms such as hot ears, burning skin, headaches and fatigue. There have been various studies into the connection between mobile phones and memory loss. Because of their smaller heads, thinner skulls and higher tissue conductivity, children may absorb more energy from a given phone than adults. International guidelines on exposure levels to microwave frequency limit the power levels of wireless devices and it is uncommon for wireless devices to exceed the guidelines. But these guidelines only take into account thermal effects, as non-thermal effects have not yet been conclusively demonstrated [3]. This paper shows that the non-thermal radiation affects the human brain. Global System for Mobile Communications or GSM is the world's most popular standard for mobile telephone systems. GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. GSM networks operate in a number of different carrier frequency ranges. GSM networks operate in the 900 MHz or 1800 MHz bands. Where these bands were already allocated, the 850 MHz and 1900 MHz bands are used instead Regardless of the frequency selected by an operator; it is divided into timeslots for individual phones to use. This allows eight full-rate or sixteen half-rate speech channels per radio frequency. These eight radio timeslots (or eight burst periods) are grouped into a TDMA frame. Half rate channels use alternate frames in the same timeslot. The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900 [2]. Code division multiple access (CDMA) is a channel access method used by various radio communication technologies. One of the basic concepts in data communication is the idea that it allows several transmitters to send information simultaneously over a single communication channel. This allows several users to share a band of frequencies. This concept is called Multiple Access. CDMA employs spread-spectrum technology and a special coding scheme where each transmitter is assigned a code to allow multiple users to be multiplexed over the same physical channel. The transmission power in the handset is limited to a maximum of 6 to 7 milli Watts [1]. Table 1.1 shows the specifications of GSM and CDMA mobile phone technologies, their power level and mode of transmission.

Table 1.1: Specifications of GSM and CDMA [1] [2].

MOBILE TECHNOLOGY	POWER LEVEL	MODE OF TRANSMISSION
GSM	1-2 watt	Burst
CDMA	6-7 mW	Continuous

2. LITERATURE REVIEW

A. ELECTROMAGNETIC RADIATION

Electromagnetic radiation is a form of energy exhibiting wave-like behaviour as it travels through space. Electromagnetic radiation has both electric and magnetic field components, which oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation. Electromagnetic radiation can be classified into ionizing radiation and non-ionizing radiation, based on whether it is capable of ionizing atoms and breaking chemical bonds Non-ionizing radiation is associated with two major potential hazards: electrical and biological [2]. Extremely high power electromagnetic radiation can cause electric currents strong enough to create sparks (electrical arcs) when an induced voltage exceeds the breakdown voltage of the surrounding medium. These sparks can then ignite flammable materials or gases, possibly leading to an explosion. The biological effect of electromagnetic fields is to cause dielectric heating. Complex biological effects of weaker non-thermal electromagnetic fields also exists, including weak Extremely Low Frequency magnetic fields [4],[5] and modulated Radio Frequency and microwave fields [6]. Magnetic fields induce circulating currents within the human body and strength of these magnetic fields depends directly on the intensity of the impinging magnetic field. These currents cause nerves and muscles to stimulate which in turn affects biological processes. The influence of the weak EM radiations on human can be realised as sequence of events which includes exposure to EM radiations which when absorbed modulates the biological field patterns, accumulation of energy and information into the body fluid, change in the functional activities of cell which finally results into some disease [7]. The number of mobile phone users has increased exponentially recently and it has become an important device in human daily life. Estimates suggest there are around 1.6 billion mobile phone users throughout the world and the numbers are increasing [8] and hence the level of background electromagnetic radiation. Figure 2.1 shows the effect of electromagnetic radiation on human head.

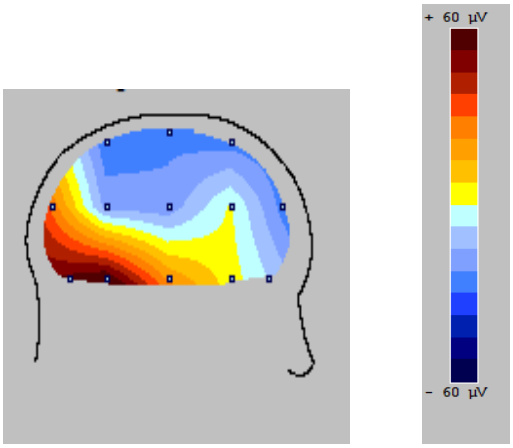

Figure 2.1: Effect of electromagnetic radiation on human brain

Figure 2.1 shows the level of electrical activities generated in brain. The voltage level ranges from blue to red and represents electrical activities ranging from minimum to maximum.

B. ELECTROENCEPHALOGRAM

Electroencephalography (EEG) is the recording of the brain's spontaneous electrical activity produced by the firing of neurons within the brain over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp. Spontaneous activity is measured on the scalp or on the brain and is called the electroencephalogram. The amplitude of the EEG is about 100 µV when measured on the scalp, and about 1-2 mV when measured on the surface of the brain. The bandwidth of this signal is from under 1 Hz to about 50 Hz. Spontaneous activity implies that activity goes on continuously in the living individual. Evoked potentials are those components of the EEG that arise in response to a stimulus (which may be electric, auditory, visual, etc.). The information transmitted by nerve is called an action potential. A stimulus must be thousand levels above a threshold level to set an Action potential. Very weak stimuli cause a small local electrical disturbance, but do not produce a transmitted Action potential. As soon as the stimulus strength goes above the threshold, an action potential appears and travels down the nerve. For a human being the amplitude of the Action potential ranges between approximately -60 mV and 10 mV.

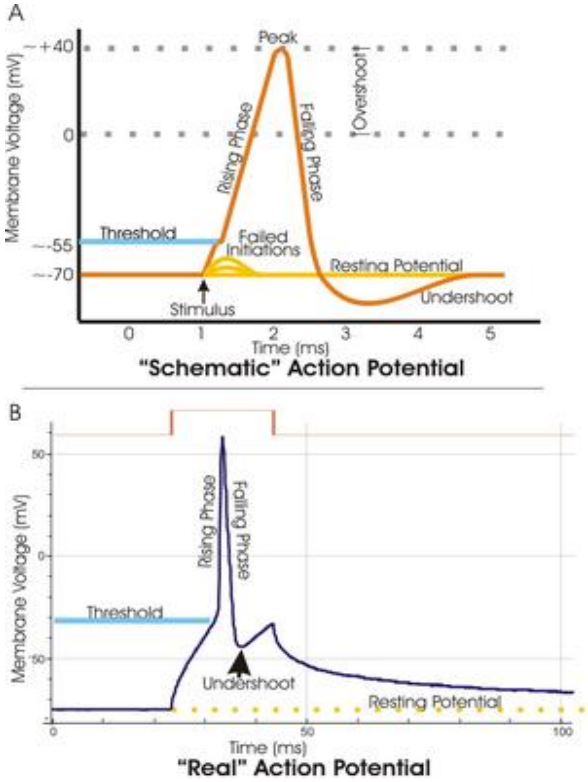

Figure 2.2: Action potential generated in brain in response to a stimulus [2]

Such signals are usually below the noise level and thus not readily distinguished, and one must use a train of stimuli and signal averaging to improve the signal-to-noise ratio. Electrical signals generated by the brain represent not only the brain function but also the status of the whole body. The assumption provides the motivation to apply advanced digital signal processing methods to the electroencephalogram (EEG) signals measured from the brain of human subject [9]. There are five major brain waves distinguished by their different frequency ranges. These frequency bands from low to high frequencies respectively are called delta (δ), theta (θ), alpha (α), beta (β), and gamma (γ).

Delta waves (δ) lie within the range of 0.5-4 Hz. These waves are primarily associated with deep sleep and may be present in the waking state. **Theta waves (θ)** lie within the range of 4-7.5 Hz. Theta waves have been and are associated with access to unconscious material, creative inspiration and deep meditation. **Alpha waves (α)** lies within the range of 8-13 Hz and are been thought to indicate both a relaxed awareness without any attention or concentration. **A beta wave (β)** is the electrical activity of the brain varying within the range of 14-26 Hz and is associated with active thinking, active attention, focus on the outside world, or solving concrete problems. The frequencies above 30 Hz correspond to the **gamma (γ)** range and are also called the fast beta wave and are associated with solving typical problems requiring more attention as compared to beta waves. Figure 2.3 shows the nature of waves of different frequency in EEG Spectrum.

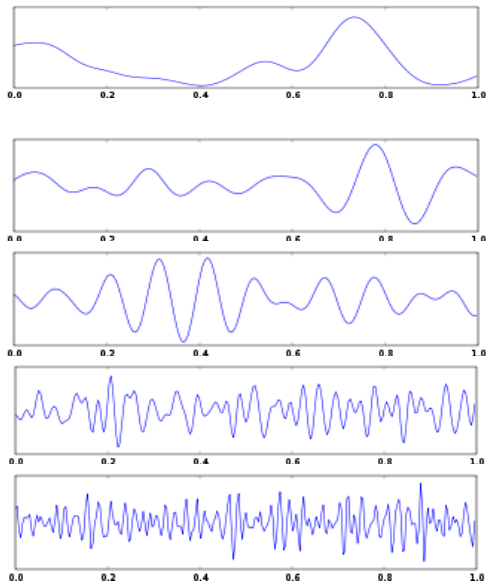

Figure 2.3: EEG Spectrum (δ, θ, α, β, γ)

Electroencephalogram (EEG) system consists of a number of delicate electrodes, a set of differential amplifiers (one for each channel) followed by filters. The computerized systems allow variable settings, stimulations, and sampling frequency, and some are equipped with simple or advanced signal processing tools for processing the signals. Correct EEG electrode placement is important to ensure proper location of electrodes in relation to cortical areas so that they can be reliably and precisely maintained from individual to individual. Figure 2.4 shows international 10-20 system for placement of electrodes on scalp for recording of electrical activities originating from the brain.

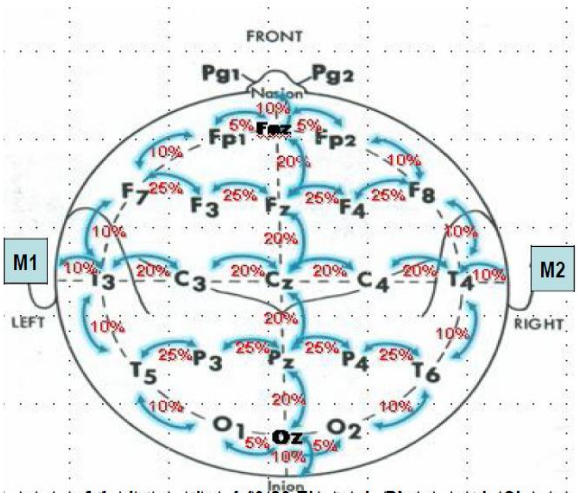

Figure: 2.4 International 10-20 Electrode Placement Systems[10]

3. METHODOLOGY

In this project electroencephalogram machine is used to capture the brain activity under three conditions, which are, without any radiations in the vicinity of volunteer, while using a GSM operated mobile phone and with a CDMA operated mobile phone as shown in figure 3.1. Data is recorded for duration of 10 minutes and the same experiment is performed with five different volunteers under same conditions.

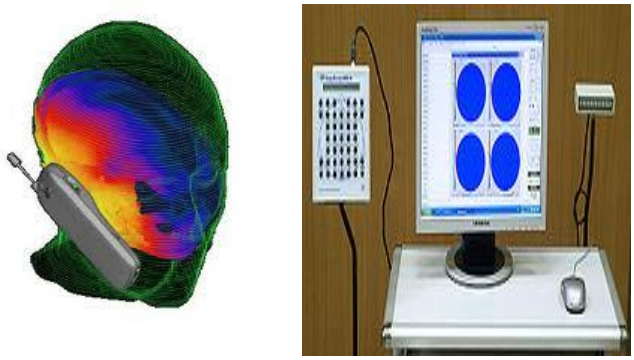

Figure 3.1: Setup for the Analysis of Electromagnetic Radiations of Mobile Phone

To examine the effect of electromagnetic radiations on human brain digital signal processing techniques are applied. Fast Fourier transform is calculated to obtain the power spectrum density of the acquired electrical signals originated in the brain in response to the stimuli impinged in the form of radiations emitted by the mobile phone. A fast Fourier transform (FFT) is an efficient algorithm to compute the discrete Fourier transform (DFT). An FFT computes the DFT and produces exactly the same result as evaluating the DFT definition directly; the only difference is that an FFT is much faster. DFT is defined by the form:

$$X_k = \sum_{n=0}^{N-1} x_n \, e^{-i2\Pi kn/N} \quad k = 0,1, \ldots . N$$

Evaluating this definition directly requires $O(N^2)$ operations: there are N outputs X_k, and each output requires a sum of N terms. An FFT is any method to compute the same results in $O(N \log N)$ operations.

4. RESULTS AND DISCUSSION

The result is shown in Table 4.1 and Figure 4.2. It shows that GSM operated phone has highest effect on brain activity as compared to a CDMA operated mobile phone.

Table 4.1: Average PSD Values Of Four Channels (CH1, CH2, CH3, And CH4) Of Montage For Three Conditions Of Recording

	CH1	CH2	CH3	CH4
GSM	13655	13914	20291	94619
CDMA	6482	3119	4361	4711
IDLE	3009	626	2512	3399

The result shows powers spectral density values for the three conditions of experiment that includes, idle with no radiation in vicinity, with GSM phone and with a CDMA phone. It can be seen from the table that PSD values with phone serving GSM technology has highest values whereas when no phone is present that is when there is no radiation in the vicinity of the subject, has the least values and values for the phone serving CDMA lies between GSM and Ile condition.

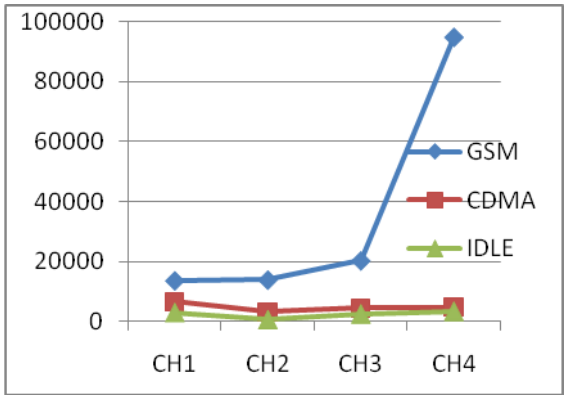

Figure 4.2: PLOT OF AVERAGE PSD VALUES OF FOUR CHANNELS OF MONTAGE

Analyses shows that mobile radiations effect human brain and GSM operated mobile phones has the higher effect on brain activity as compared to CDMA operated mobile phones. Globalisation is the new mantra. In this age, it is very difficult not to have technology. But as shown in this study, with every technology invented to facilitate human beings, there come certain hazards. The only way to beat these negative aspects of new technologies is again, a new but better technology. Electromagnetic radiation is everywhere. More and more wireless communication services are expected, so is the artificial electromagnetic radiation. It seems that there is no way to reverse this trend. Scientists and engineers must develop better and safer wireless systems and devices. Smaller cell size, better base station antennas and other more advanced technologies will allow future cell phones to radiate much lower power and make technology a real boon.

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