Effect of Mobile Phone Radiation on EEG Wave

D. S. Bhangari, A. C. Bhagali, R. V. Kshirsagar

Abstract—Electromagnetic radiation is one of the important aspect while studying the human biological characteristic and their variation. Here we have studied the effect of cell phone exposure to human body for duration of one minute.The brain activities are measured by EEG signals. The EEG waveform is measured before use of cell phone and while talking on cell phone. In this paper we have analyzed distance band for the position of mobile phone. The distance band is 1.8 inch to 2.2 inch. Here we also analyzed, for frequency 0.9 GHz to 1.8 GHz and it is observed temperature variation 0.36 °C to 0.71 °C.Her also we observed effect of penetration length, length changed from 0.1 cm to 1 cm. It is highlighted that if we use mobile phone in particular distance band, then effect in frequency variation is reduced.

Index Terms: Viberimage, Elecrtomagnetic Spectrum, EEG.

I. INTRODUCTION

Now a day, use of cell phone has enlarged to a large extent**.** As mobile phone comes close to the head i.e. near human brain, it is reported to have adverse effects on human health on large extent. Several investigations are reported in literature about the effect of mobile phone radiations on human health[1][2][3]. Some of the studies depict that long – term use of mobile phones can damage the health of an individual. It is associated with long illness such as brain tumors, Head ache, low sperm count & mobility, memory loss including dementia which can result towards Alzheimer's disease and concentration problem [4][5]. The above studies were conducted by using EEG signals; which is considered as linear signal and analysis is done on basis of it. Practically speaking, signal obtained from it, is non – predictive, non – linear and can be considered as random signal. An EEG signal during recording; generates lots of noise which can make the diagnosis process more difficult [6][2][7]. Therefore, proper preprocessing of signal is essential, which will take care of noise and artifact removal from recorded signal. Mobile Phones generates a modulated version of radio-frequency electromagnetic field (RF - EMF), which is a form of non – ionizing radiation. It can induce an electric field and a current in body [8].

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Mr.D.S.Bhangari, Electronics & Telecommunication, PCE, Nagpur , India..

Dr.A.C.Bhagali, Electronics & Telecommunication, ATS SBGI Miraj, Sangli, India.

Dr.R.V.Kshirsagar, Electronics & Telecommunication, PIGC, Nagpur ,India.

This strong electric field; depending on its frequency can warm up tissues or it can disturb neuronal functions. It can also cause oscillation of molecules depending on energy absorption from field to tissue. GSM handsets emits radio waves with peak power of 2

Watts. The radiation absorbed by the human body is measured using Specific Absorption Rate (SAR)[9][10][11].

The maximum power output from a cell phone is regulated by mobile phone standards and it is regulated by regulation agencies of that particular country[12]. The SAR limit allowed over a volume of 1 gram of tissue is fixed as 1.6 W/kg, in India. It is highlighted that microwaves from cellular phones may promote sleep and modifies brain activity. If cell phone is ON it radiates electromagnetic field [13].

Brain continuously generates wave, this waves are modulated with mobile radiation wave [14]. Here we have examined persons with EEG to find the distance band for the position of mobile phone. The distance band is 1.8 inch to 2.2 inch. if we use mobile phone in particular distance band, then effect in frequency variation is reduced [15][16].

Here we also analyzed, for frequency 0.9 GHz to 1.8 GHz and it is observed temperature variation 0.36 °C to 0.71 °C. Here also we observed effect of penetration length, length changed from 0.1 cm to 1 cm. In present study, state analysis as well as transient analysis is performed. In literature, analysis is done only for few frequencies which are used on phone as carrier frequency like 900MHz, 1800 MHz, 8 GHz, 10 GHz. Brain waves are measured using 32 channels EEG electrode which gives the better results as compared to previous results. In current study, when we keep mobile in the band it is safe for the human.

A. Brain wave Frequency

The biological characteristics of brain wave changes because of additional electromagnetic emission. The electromagnetic radiation is of rising importance in the study biological characteristic variations. The signal amplitude of EEG single is very small in the range of microvolt [3][15].

Figure 1 shows various frequency sub-bands, of EEG signals. It includes Delta frequency band having frequency of 3 Hz or below, Theta frequency band having frequency of 3.5 to 7.5 Hz, Alpha frequency band having frequency between 7.5 and 13 Hz and Beta frequency band having frequencies higher than 13 Hz [7].

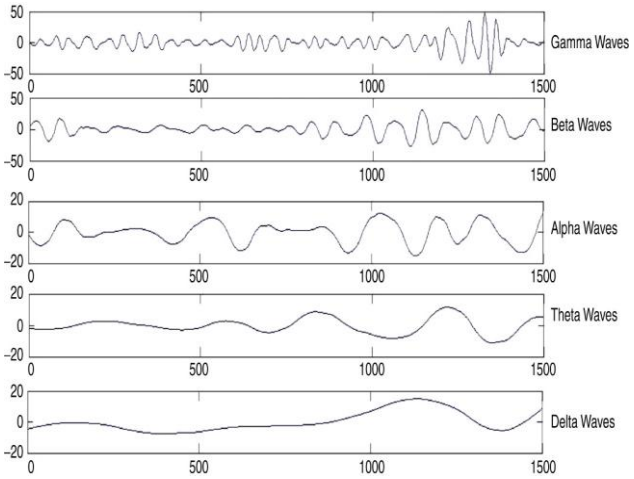

Fig 1 Brain Wave Ranges [5]

II. RELATED SURVEY

In many of the papers, it is clearly reported that there is a positive effect on biological tissues because of radiation.
In [14] has done the survey of all the reported systems with respect to effect of mobile phone radiation on human body. They investigated the effect of mobile phone radiation on cancer. The authors further reported that, long term effects must be observed to arrive at proper conclusion.

In [15] has done research on various features of EEG to be analyzed for testing the effect of mobile phone radiation on human brain. They concluded that analysis that combination of time frequency features will give greater significance in improved performance in classification. In [16] the authors had analyzed the opportunities and challenges in effect of mobile EEG different Neurodevelopment Disorders.

In [14], Infrared thermograph technique was incorporated to study biological tissue models by distributing millimeter wavelength electromagnetic energy absorption in surface layers. The research findings reported frequency dependent effects of millimeter wave electromagnetic radiation. In [15], give the millimeter wave absorption efficiency for human body considering clothing. They reported that 90-95% incident energy can be absorbed in the skin with dry clothing with an intervening air gap which acts as an impedance transformer.

In [16], researchers demonstrated interactions between a 60-GHz antenna array and the human body. They computed antenna reflection coefficient and radiations patterns and compared it skin-equivalent phantom. It has been shown that, in spite of the small distance between the antenna and the body, the impedance matching and antenna gain are almost not affected by the presence of the body.

In [16], authors highlighted that Mobile phones (MP) emit low-level electromagnetic fields which affects neural function in humans. They reported that it has an effect of MP exposure on EEG alpha power. In [13], authors concluded that the people who spend more than 50 minutes a day using a cell phone could have early dementia or other thermal damage due to the burning of glucose in the brain.

In summary, it is seen that there is effect of mobile phone radiation on human brain. The EEG is useful tool to detect the brain activities. There are various classes of EEG. There is heating effect due to mobile phone radiation. The heating effect may change the nature of EEG waves.

III. ANALYTICAL TREATMENT

When tissue is in electromagnetic field, as per high frequency heating, heat generates in the tissue, because of blood circulation tissue heat transfer to blood and heat from blood transferred to atmosphere.

$$x_{max} = \frac{1}{\sqrt{\pi}-1/L} \cdot \left\{ \mathrm{Ln}\left(L\sqrt{\lambda}\right) + \mathrm{Ln}\left(1+\left(\frac{\lambda-1/L^2}{q_0}\right)(T_0-T_e)\right)\right\} \quad (1)$$

Where,
X - distance from tissue surface to temp reached to normal
λ-wave length
L-microwave penetration depth in cm
$q_{0=}\ I_{0\tau/JLK}$
$I_{0\text{-wave}}$ intensity w/cm^2
τ-traction of energy transmitted into the tissue
J-mechanical equivalent of heat
K-coefficient of tissue heat conduction
T_0-temputure of arterial blood entering the tissue
T_e- tissue surface temperature

Here, power is calculated using high frequency heating equation.

$$P = 2\pi f \varepsilon_0 \varepsilon_r E^2 \quad (2)$$

E=Magnitude of Brain wave
f=frequency in Hz
Figure 2 & 3 shows the graph of Temperature 'T' verses Distance 'X' is plotted with various frequencies. The frequencies are specifically selected which are mobile carrier frequency like 900MHz, 1.8 GHz, 8GHz and 10 GHz. The microwave penetration depth in cm 'L' is kept fixed at 0.1 cm in figure 2.

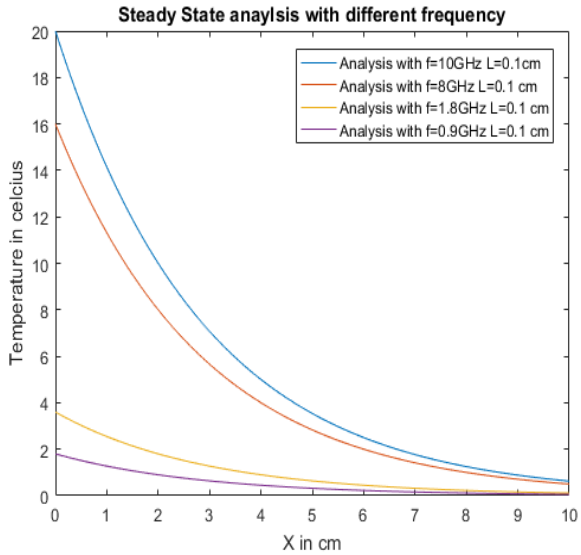

Fig.2 Steady state analysis with various mobile carrier frequencies and L=0.1

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From figure 2 it is observed that, when frequency is more and more, the temperature is more. One can prefer use of 900MHz band to minimize it. But in the today scenario of increasing data speed competition, the mobile evolution is taking place from 2G to 3G to 4G and 5G. So, minimizing the frequency is not feasible solution.

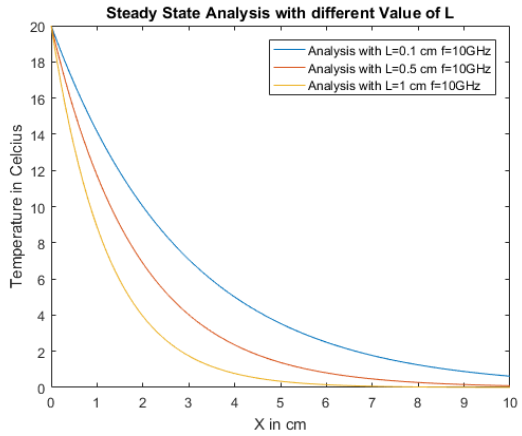

Fig.3 study with various L, f=10GHz

Figure 3 shows, the effect of variation in 'L' for 10 GHz frequency. The graph of Temperature 'T' verses Distance 'X' is plotted with f= 10 GHz. From figure 3, it is observed that when 'L' is greater, then 'X' is lower. The task is to find the optimal value of distance 'L'.

IV. TRANSIENT ANALYSIS

effect of mobile radiations. Fourier Transform can be used for obtaining the solution of transient analysis.

$$\frac{d^2T_\omega}{d\omega^2} - k^2T_\omega + q_0(x)\,T_\omega(i\omega) = 0 \qquad (3)$$

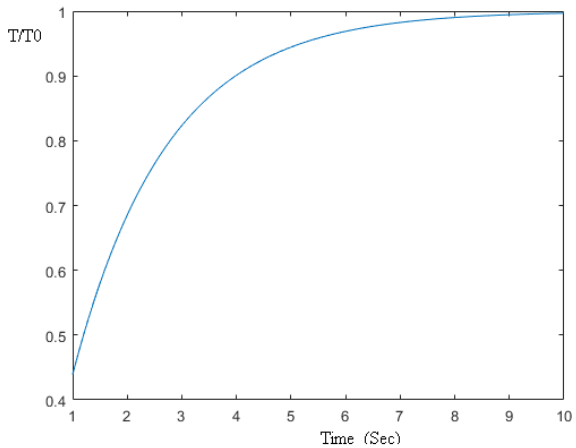

Fig. 4.Transient study with L=1, f= 8 GHz, Io=100mW

Table 1, shows the Physiological State and frequency bands associated with it.

Table. 1. Significance of EEG Waves

Physiological State	Frequency Band	Brain Waves, Hz	Body Vibrations
Sleep/Exhausted	Delta	Below 3	15 – 51
Drowsy/Tired	Theta	3.5 to 7.5	51 – 92
Relaxed	Alpha	7.5 – 13	92 – 153
Excited/Working	Beta	13 – 40	153 – 408

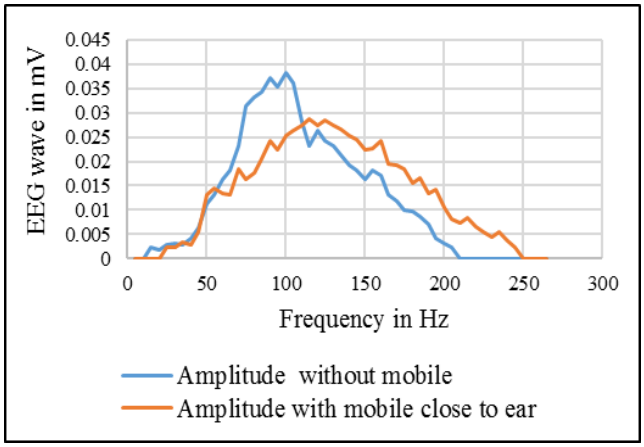

Fig 5: Histograms of human body Frequency Distributionwith mobile phone close to ear

The above Fig. 5. shows the significance of EEG waves and resultant amplitude of signal in mV considering the frequency of signal. The blue curve shows the amplitude of EEG signal without the mobile phone whereas red curve shows the amplitude of signal with use of mobile phone close to the ear of user. It can be seen that EEG amplitude of red curve decreases.

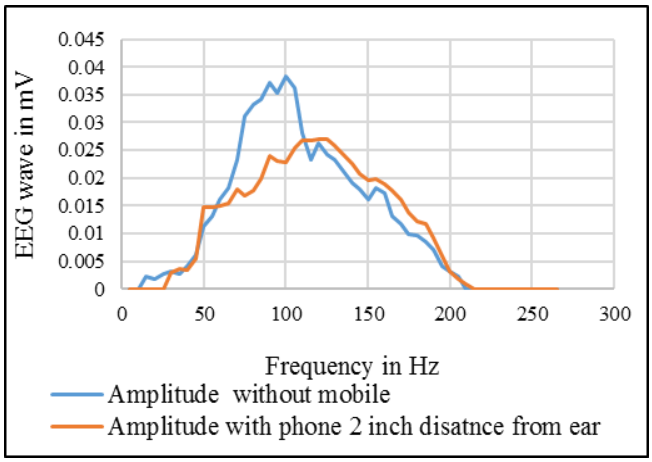

Fig 6: Histograms of human body Frequency Distribution with mobile phone 2 inch distance from ear

Similar to Fig. 5. above figure demonstrates the change in amplitude of EEG signal considering the 2 inch distance from ear of user. It is observed that for 2 inch distance, the amplitude almost remains the same for higher frequency form 150Hz to 200 Hz.

V. RESULTS

The observations are carried out on 5 persons, The EEG waveform is measured before use of cell phone and while talking on cell phone. The distance band is 1.8 inch to 2.2 inch. Here we also analyzed, for frequency 0.9 GHz to 1.8 GHz and it is observed temperature variation 0.36 °C to 0.71 °C.

Table 1 Mean Value of Freq.

	Age	Mobile phone Close to ear	Handset 1 inch Distance from ear	Handset 1.8 inch Distance from ear	Handset 2 inch distance from ear	Handset 2.2 inch distance from ear
Person 1						
before the talk	12	100.81	80.1	79.74	79.49	79.47
after the talk		116.33	90.2	86.9	86.65	86.43
Person 2						
before the talk	11	91.8	84.2	84.1	83.35	83.1
after the talk		107.08	94.7	91.56	90.45	89.99
Person 3						
before the talk	13	99.1	82.8	80.45	80.6	80.00
after the talk		117.7	93.3	88.05	87.8	87.18
Person 4						
before the talk	10	102.82	85.2	85	84.55	84.53
after the talk		119.4	95.8	92.51	91.76	91.54
Person 5						
before the talk	11	103.66	102.2	100.62	100.37	100.15
after the talk		118.4	114.3	107.99	106.74	105.52

The above results indicate the increase in the frequency of EEG signals. Basically, it can be observed that more use of mobile can increase the brain frequency of human. As we go on increasing the distance between human ear and mobile phone; the resultant frequency goes on decreasing. This concludes that one should hold the mobile at some particular distance from human ear. In present study, only 5 subjects were incorporated for study.

Table -2Mean Values of frequency

Person	Mobile phone Close to ear f in Hz	Handset 1 inch Distance from ear f in Hz	Handset 1.8 inch Distance from ear f in Hz	Handset 2 inch distance from ear f in Hz	Handset 2.2 inch distance from ear f in Hz
1	15.52	10.1	7.16	7.16	6.96
2	15.28	10.2	8.3	7.46	6.89
3	18.6	10.5	7.6	7.2	7.18
4	16.58	10.6	7.51	7.21	7.01
5	14.74	12.1	7.37	6.37	5.47
Mean	16.14	10.7	7.59	7.08	6.68

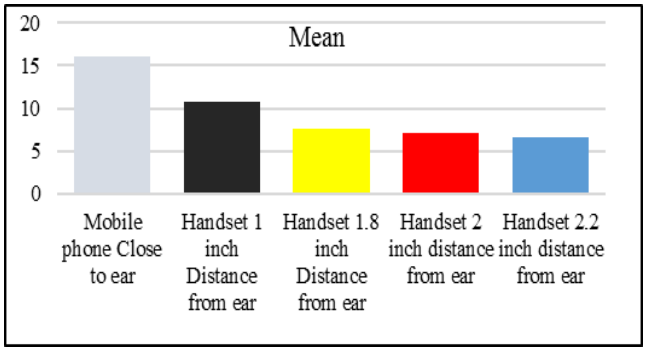

Fig 7: Delta means value of frequency in Hz

Figure 7 indicate the increase in Delta frequency of EEG signal. The standard range of delta band of EEG signal ranges from 1 to 4 Hz. But, it can be observed that use of mobile can increase the delta band frequency. Delta band of EEG is related deep sleep of an individual. Here, it is observed that increase in frequency results into alpha band; which is related with consciousness of an individual. Increase of frequency can hamper the consciousness of an individual. Along with this, it can also have adverse effects on human brain which can result into different brain dysfunctions such as Epilepsy, Alzheimer's & dementia, brain stroke and many more.

Table -3Variance and Standard Deviation of Frequency.

Parameter	Mobile phone Close to ear f in Hz	Handset 1 inch Distance from ear f in Hz	Handset 1.8 inch Distance from ear f in Hz	Handset 2 inch distance from ear f in Hz	Handset 2.2 inch distance from ear f in Hz
Variance	2.41	0.65	0.19	0.17	0.11
Standard Deviation	1.55	0.81	0.44	0.41	0.33

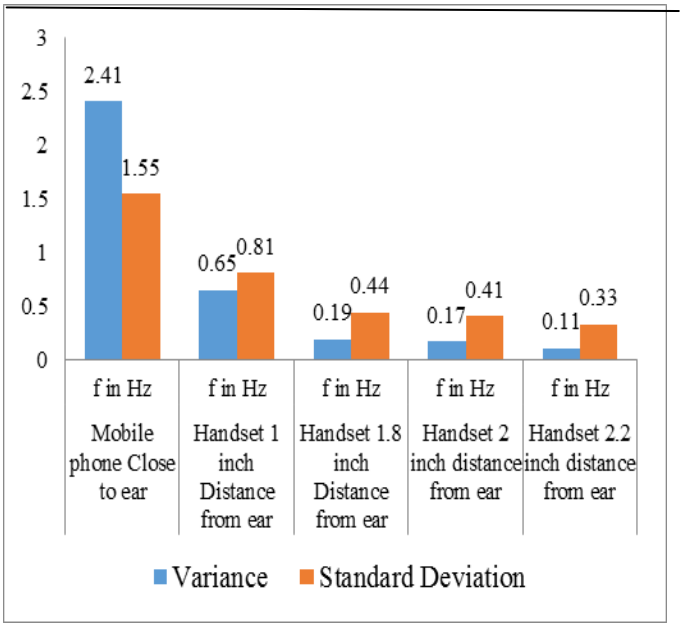

Fig 8: Variance and Standard Deviation of Frequency graph.

From fig. 8 and table 3 it is observed that the measure of variance and standard deviation of EEG frequency. If the phone is closer to the ear then variance is increased. For the distance of 2.2 inch the variance is lowest.

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VI. CONCLUSION

It is practically observed that and noted the brain wave frequency changes while use of cell phone. The average mean value of frequency increases to 16.14 Hz when mobile is close to ear. When mobile handset is carried between the optimized bands i.e. 1.8 inches to 2.2 inch, frequency variation is 7.11 Hz. If mobile handset is in between optimized distance band then heating power reduces since frequency variation is less. Here we also analyze, for frequency 0.9 GHz to 1.8 GHz and it is observed temperature variation 0.36 °C to 0.71 °C. Here also we observed effect of penetration length, length changed from 0.1 cm to 1 cm. It is highlighted that if we use mobile phone in particular distance band, then effect in frequency variation is reduced.

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