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# Coherence Analysis of ECG and EEG during Deep Sleep and Mobile Phone Usage

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**ABSTRACT**

*Coherence is used to study the relation between two signals. In this paper synchronization of Electroencephalogram (EEG) and its bands with Electrocardiogram (ECG) has been studied using wavelet coherence. The coherence analysis helps in determining the balance of the brain and its synchronization with the heart. The coherence between the various brain waves with the ECG are calculated when the subject is in deep sleep and the results show delta wave is coherent with the ECG signal. Similarly, ECG and EEG signals of young students are recorded while using mobile phone and their coherence values shows significance between ECG and the brain waves- alpha, beta and gamma waves during second generation (2G) and third generation (3G) reception and with beta during 2G and 3G reception mode.*

***Keywords- Electrocardiogram; Electroencephalogram; Haar Wavelet; Brain Waves; Coherence.***

## I INTRODUCTION

Biomedical signals are used by various scientists and researchers to study functioning of human body and to detect indications of various diseases. Electrocardiogram (ECG) and Electroencephalogram (EEG) signals help in determining heart and brain functioning. The electrical changes in these signals help in the study of human behaviour, mood, etc. EEG signal is composed of various frequency bands that define the state of human brain and body conditions. The various frequency bands of EEG signal include Delta (1.3~3.5Hz), Theta (3.5~7.5Hz), Alpha (7.5~12Hz), Beta (12~14Hz) and Gamma (14~35Hz) [1].

Coherence is a technique to study the inter relationship between two signals. The minimum value of coherence is 0 and the maximum value is 1. The values of coherence above 0.5 are considered to be significant. For the coherence study, various transforms are available. Fast Fourier Transform (FFT) has some limitations related to frequency and time components. Wavelet transform is effective for finding the coherence between two signals and uses continuous wavelet transform (CWT).

The large signal is analyzed at the local level by using wavelets. The coefficients of the wavelet show the point of discontinuities in the signal. Wavelets analysis scales the signal and then shifts it and helps in compressing the signal also without any loss of quality.

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## II LITERATURE SURVEY

The literature includes the study of ECG, EEG signals, wavelets analysis, various brain waves and the effect of mobile phones.

The biomedical signals carry information of behaviour of living system characterized by correlation, coherence and phase synchrony [2]. In biomedical signal processing, the continuous and the discrete transform have been used to find its various parameters [3]. It is possible to estimate heart rate variability (HRV) from ECG without R-wave detection as difference of two R-wave peaks [4]. HRV is used to indicate neurocardiac fitness and function of autonomic nervous system. HRV can predict heart disease, stress and emotions [5]. The mental stress is a major risk of hypertension, heart diseases and death. HRV and morphologic variability can be used to detect mental stress with high accuracy of 90% for stress detection [6]. In [7], EEG waves are used for communication between computers and humans. The study shows the use of Time Frequency Analysis to classify mental tasks using EEG [7]. Power spectra of EEGs can be used to know about the EEG and the relations between simultaneous recordings from different parts of the brain while awake and asleep [8]. EEG is used to treat brain disorders like epilepsy and thus EEG needs to be studied carefully to detect epilepsy. In [9], EEG is processed by AR (autoregressive) method to obtain EEG spectra. Out of various methods AR estimation is the optimal method for spectral estimation of EEG signals, according to its performance characteristics to detect epileptic seizure [9]. EEG can be classified using DWT and FFT. For processing autocorrelation and wavelet analysis have been used. The filtered EEG data is used for study using wavelet transform to reject undesired frequencies and discriminate EEG waves using DWT. This method is efficient and can distinguish between EEG waves easily [10]. The alpha wave is having range 8-13 Hz and is seen in wakefulness and in highly stressful situations. Delta is seen in deepest stages of sleep, Theta in light sleep and drowsiness, Alpha in relaxed and effortless alertness and Beta in mental concentration and focus. All four types of brain waves play a vital role in our healthy life [11]. A filtering method can be used to classify and track EEG waves by using bandpass filter to estimate center frequency of each EEG wave [12]. The Independent component analysis (ICA) is useful for EEG artifacts suppression in EEG signals by using wavelet thresholding. The wavelet enhanced ICA (wICA) has been proposed to reduce distortions in EEG corrected by ICA decomposition and used wavelet thresholding to recover low amplitude neural activity [13]. The correlation between autonomic nervous activities and EEG, analyzed using FFT for extracting delta, beta and sigma power has been determined. The EEG frequency can be used to recognize sleep and its quality. The researches done shows that low frequency signals i.e. delta band is related to the sleep activity. The interference from various sources are also to be minimized when acquiring the EEG or ECG signal [1]. The wavelet analysis is far better than available time frequency analysis methods for generating wavelet features and makes better use of wavelet's time resolution [14]. The effect of mental task and acoustic stimuli on brain wave is studied in [15]. The amplitude of the alpha wave is decreased by 15~20% during mental task and listening to unpleasant sound as compared to the rest state. The result suggested that the low-alpha wave reflects stressed brain states and can be used to measure mental stress [15]. In [16], Welch method and MVDR (Minimum Variance Distortion less Response) method are used to calculate coherence function. In Welch method peak in the amplitude of cross-

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power spectrum represents a common frequency in both signals though components with that frequency appear at different time in analyzed signals [16]. Wavelet method helps to identify various frequencies of ECG wave like QRS, T and P wave and also an optimum method in a noisy signal [17]. The field generated by the heart is 5000 times stronger than magnetic field of the brain and 60 times greater than electrical field of the brain. Heart Rate Variability occurs for emotional changes due to change in blood, electromagnetic and sound pressure and carried throughout the body for synchronization with the heart. Generally alpha waves are synchronized to external stimuli like sound and light flashes. As the coherence increases it increases mental and emotional stability, physiological and metabolic energy efficiency and thus the health [18]. The wavelet coherence can be used to study heart rate fluctuations related to respiration. Thus fluctuations in heart rate can be studied by coherence and cross- spectrum of respiration and HRV using Fast Fourier Transform. High HRV indicates abnormalities in ECG showing arrhythmias [19]. The wavelet transform has been used for distinguishing frequency bands and for using different resolution during decomposition using different thresholds for de-noising signal and image [20]. The magnitude and phase of the wavelet coherence provide the information regarding the cognitive activities. This method is very effective and is used in biomedical signal analysis, speech and communications. Even the synchronization is correlated with cognitive processes. Morlet wavelet has been used for magnitude and phase coherence study. There exists different degree of coherence for different regions of brain [21]. Author has used coherence to know the level of neural EEG synchronization that helps to understand cognitive processes of Chinese and English sentences in different regions of brain [22]. The association at a particular frequency gives coherence between ECG and EEG signals having range between 0 and 1. Further in future EEG signal may be estimated from ECG signal using PSD estimation (Welch method) [23]. The normal amplitude values associated are P-wave - 0.25mV, Q-wave - 25% R wave, R-wave - 1.60mV and T-wave - 0.1 to 0.5mV, for duration are P-wave interval: 0.11s, QRS interval: 0.09s, P-R interval: 0.12 to 0.20s, S-T interval: 0.05 to 0.15s and Q-T interval: 0.35 to 0.44s and heart beat is in range 60 to 100 beats/minute. The results show that wavelet transform analyze 99.8% of ECG wave [24]. The coherence represents functional relationship between ECG and EEG signals at different respiration rates and heart rates and in different postures like sitting, standing and supine [25]. The coherence results in [26] show that the reference power or amplitude effects coherence, correlation and phase synchrony. The interactions between deep sleep EEG power band and HRV with aging is tested. As a result the author found more deep sleep in young man than middle ones without altering the relationships [27]. Due to major depressive disorder the interaction is altered between delta sleep power and cardiac sympatho-vagal indexes and this may increase cardiovascular disorders [28]. The proposed methos in [29] evaluates person's stress level and handles normal and abnormal cardiac conditions. The extracted features are compared with the standard rules to determine the risk of stress level of the patient. The results of ECG and EEG of same person can help in determining the levels of stress and various types of depression in a person like Major Depression, Atypical Depression, Psychotic Depression, Dysthymia and Manic Depression [29]. The higher coherence in ECG spectra shows happier and less stressful life. The higher coherence in ECG frequencies helps in managing mental and emotional state and stressful events [30]. There are interrelations between psychological, cognitive, emotional systems and neural communication in the human and reveal heart-brain interactions and harmonious synchronization. The concept reveals role of heart in biochemical, biophysical and energetic interactions [31]. This shows interaction of heart

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and brain to regulate cognition and emotional states. Consciousness is the basis for synchronization of brain and heart that affects creativity, emotions and decision making. Self- induced positive emotions changes heart rhythm to fluent waves. Thus coherent body condition symbolizes the working of body parts in harmony in time and space coordination. If we learn to maintain our coherence we can self- regulate, improve long term and short term memory, increase focus, reaction time and ability to process information and thus higher test scores. Synchronization with heart synchronizes heart, brain and emotion and makes them balanced [32]. The temporal coupling between neural signals helps in tracking cerebral dynamics by using coherence metric. Using wavelets to Fourier Coherence coupling can be measured to study relationships between various cortices in brain. The window size is inversely proportional to the frequency for wavelet transform [33]. In neurocardiology heart's effects on brain and brain's effects on the heart can be studied. The effects on the heart contribute to many neurological conditions like hemorrhage, cerebral infarction, epilepticus, head trauma, sudden infant death and death during asthma attacks, death related to cocaine and alcohol. These may be linked to stress [34]. There are radiation effects of GSM mobile held in hand on EEG either on standby mode or switched off. The radiations from phone effect EEG decreasing alpha and increasing beta in on condition. The results show increased mental activity as in increased concentration. There is increased delta, theta and beta and decreased alpha though only alpha and beta are significant [35]. The effect of mobile phone on cardiac electrical activity can be evaluated by analyzing heart rate variability (HRV), time intervals QT, P dispersions etc. The author concluded that mobile phone has no effect on heart rate, blood pressure and cardiac electrical activity (P-wave and QT dispersions) parameters and does not cause any significant effect on the HRV parameters. The author could not measure frequency-domain parameters of HRV [36]. So Wavelet Analysis has ability to analyze changing transient signals, image analysis and communication systems which is far better than Fourier Transform to provide localized temporal and frequency transformation. The wavelet analysis helps in relating Fourier coefficients to local or global behaviour of a function instead of using frequency spectrum [37].

## III WAVELET COHERENCE

Coherence shows the value of relationship between two signals at a particular frequency. Mathematically, calculated by auto and cross power spectral estimates of the required signals and then magnitude squared coherence is calculated. The coherence measures correlation relationship between frequency band of EEG and ECG and phase spectrum displays the difference between the frequency bands that are in common. Wavelet Coherence is a time-frequency method that overcomes the limitations of conventional coherence and provides time-varying coherent analysis using Continuous wavelet transform (CWT) for flexibility. The wavelet transform and the coherence analysis together help to quantify synchronization of the signals. The wavelet transform uses a window according to the frequency shorter for higher frequencies and vice versa [33] thus the coherence is also inversely proportional to frequency that helps in quantifying time varying coherence. From the data set, wavelet coherent spectrum is computed, the magnitude defines the degree of coherence and phase tells the direction of information flow between two channel signals [21]. Coherence gives the degree of association or relationship of frequency between the EEG and ECG signals at a particular frequency and thus is a function of frequency. The value of coherence ranges between 0 and 1 to show the correspondence of the two signals.

The synchronization of the two biomedical signals ECG and EEG is represented by phase coherence and magnitude squared coherence (MSC) used power spectral density.

$$Coherence\ (t,f) = \frac{\left|\sum_{i=-\Delta}^{\Delta} PW_{xy}(t,f,i)\right|^2}{\sum_i PW_{xx}(t,f,i)\sum_i PW_{yy}(t,f,i)} \quad (1)$$

Wavelet cross-spectrum is given by the below equation.

$$PW_{xy}(t,f) = W_x(t,f)W_y^*(t,f) \quad (2)$$

where 't' is the time around which the coherence is calculated, f is frequency, 'i' is the index, 'x' represents the ECG signal, 'y' represents the EEG signal, PW represents wavelet power spectral density, '$PW_{xy}$ represents cross power density and '$PW_{xx}$ and $PW_{yy}$ represent auto power density. The summations are carried around a variable segment size that is inversely proportional to frequency [2].

## IV METHOD

In the experimental work the data has been collected in two ways:

1. ECG and EEG signals are taken from MIT-BIH database [38] for a person in deep sleep as shown in Fig. 1 and 2.
2. ECG and EEG signals are taken from a person talking on mobile phone using 2G and 3G signals. Fig. 3 and 4 shows the ECG and EEG signals acquired when the subject is not using any kind of mobile phone and is termed as Ideal condition. Similarly, Fig. 5& 6 shows the recorded ECG and EEG signals when the subject is using GSM mobile phone in the transmission mode called 2GTx. The signals from the usage of mobile phone in the reception modes are shown in Fig. 7 & 8 and are called as 2GRx. Similarly, figures 9 to 12 are recorded when the subject is using 3rd generation mobile phone. The ECG is recorded in the laboratory when the subjects made their normal routine calls. All the precautions regarding the grounding of the instruments etc is taken care of. Other mobile except involved during the recording was allowed. No external radiations are given to the subjects and it is a single blind study.

The ECG and EEG signals are obtained from the MIT-BIH database for a person in deep sleep. These signals are having sampling frequency of 360 Hz. The duration of the signal is 10s and has 3600 samples but here for experiment only 2500 samples have been considered. The coefficients are saved for further processing of the signal. Then the EEG signal is divided in its various frequency bands using Direct-Form –II, second order, stable bandpass filter IIR Butterworth filter having 15 sections, thus giving a total filter order of 30. In this process we have used sampling frequency of 360 Hz. Then the coherence is calculated between ECG and EEG and ECG and the different frequency bands of EEG wave one by one using MATLAB code.

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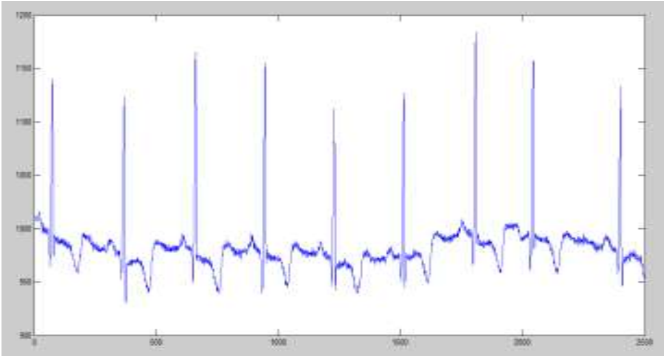

**Figure1. ECG Signal (MIT BIH)**

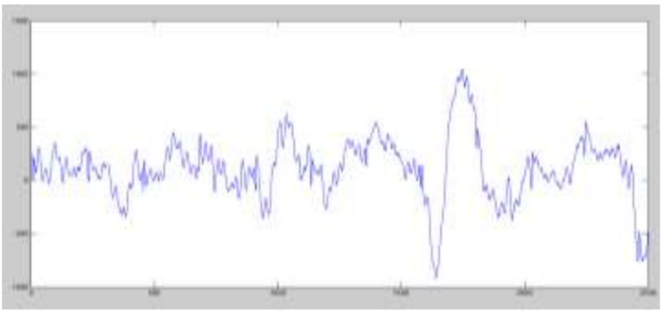

**Figure 2. EEG Signal (MIT BIH)**

The ECG and EEG signals are obtained from a subject under study using 2G and 3G mobile phone under different conditions i.e. ideal, signal transmission (2G and 3G both) and signal reception (2G and 3G both). In all the cases 2500 samples have been used for the study.

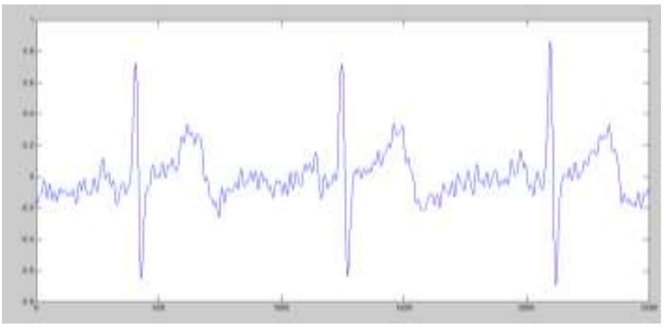

**Figure 3. ECG Signal Ideal**

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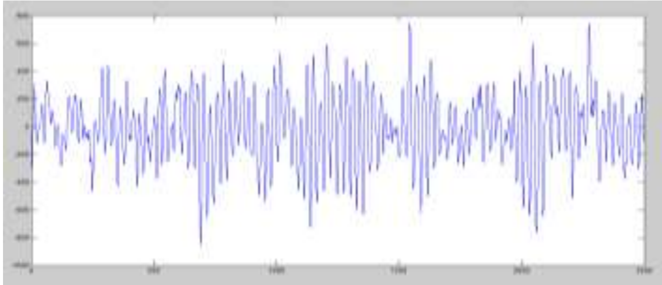

**Figure 4. EEG Signal Ideal**

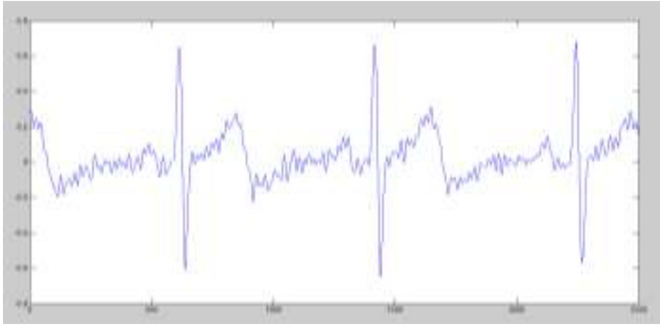

**Figure 5. ECG Signal 2GTx**

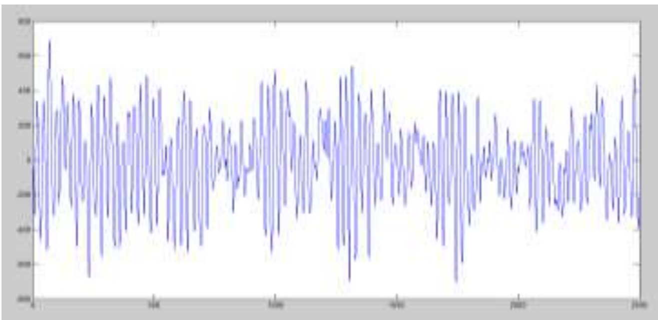

**Figure 6. EEG Signal 2GTx**

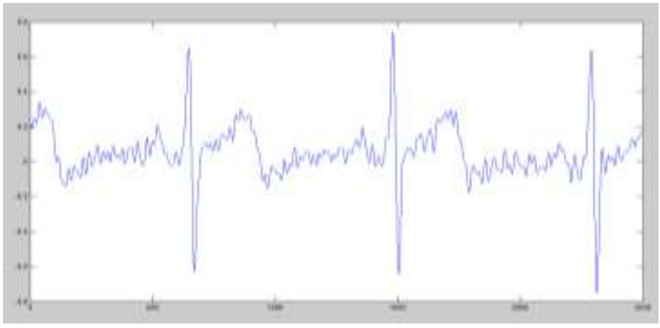

**Figure 7. ECG Signal 2GRx**

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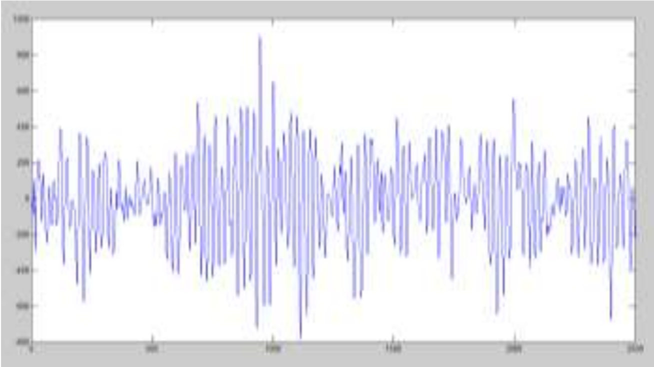

**Figure 8. EEG Signal 2GRx**

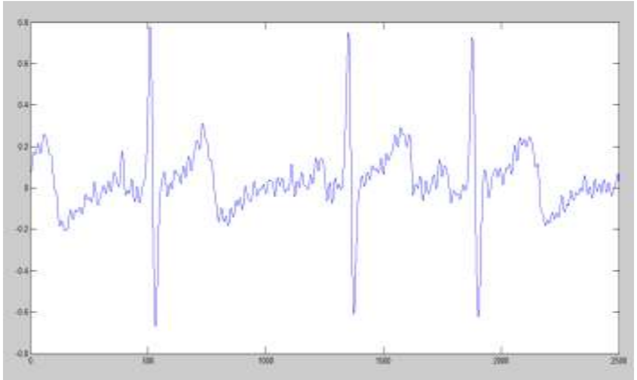

**Figure 9. ECG Signal 3GTx**

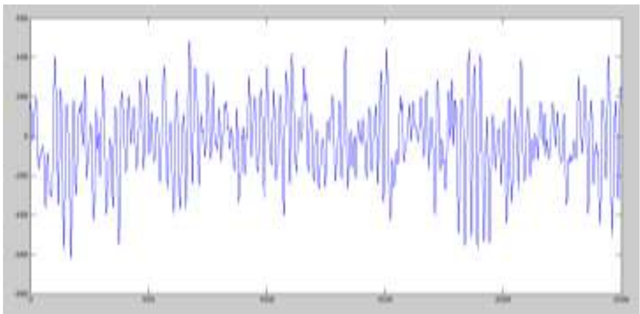

**Figure 10. EEG Signal 3GTx**

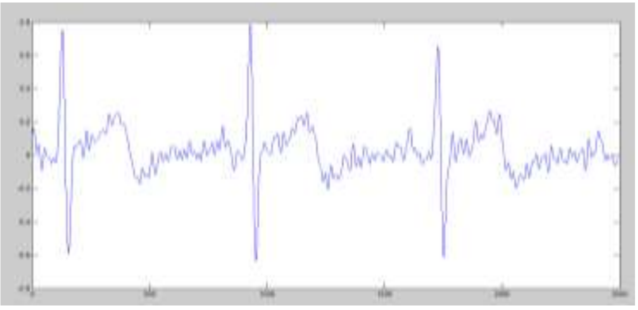

**Figure11. ECG Signal 3GRx**

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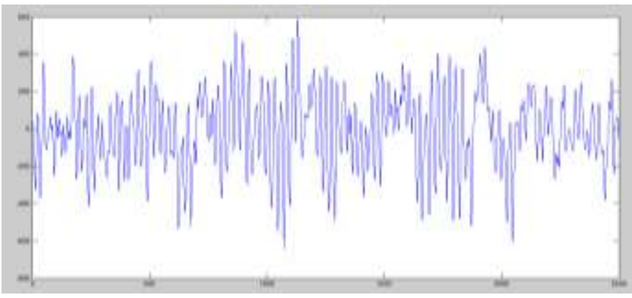

**Figure12. EEG Signal 3GRx**

## V RESULTS AND DISCUSSION

*A. Analysis of the signals in sleep condition*

The coherence is calculated between ECG and EEG signal to study the extent of synchronization to highlight association between these biomedical signals to show the influence and the relation of one signal over another. For deep sleep signal the coherence is maximum between ECG and EEG delta band as shown in Fig. 13 to 18.

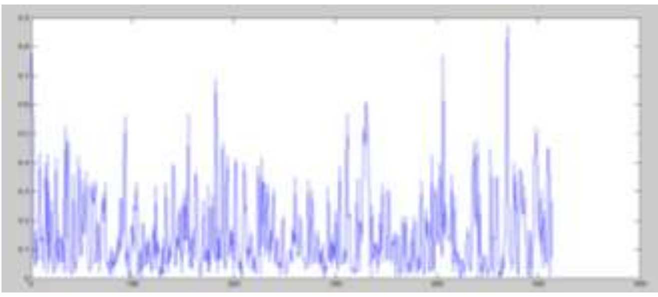

**Figure 13. Coherence between ECG and EEG signal (MIT BIH)**

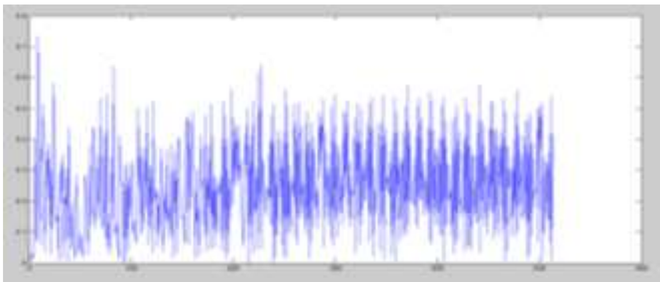

**Figure 14. Coherence between ECG and EEG delta wave (MIT BIH)**

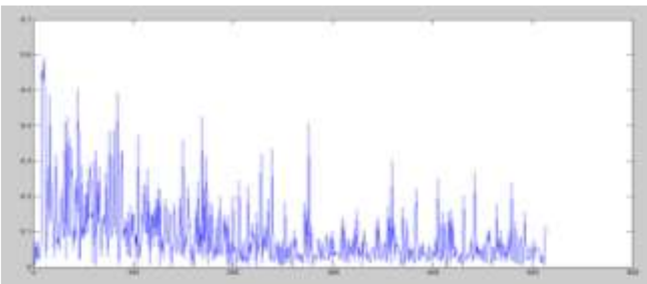

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**Figure 15. Coherence between ECG and EEG theta wave (MIT BIH)**

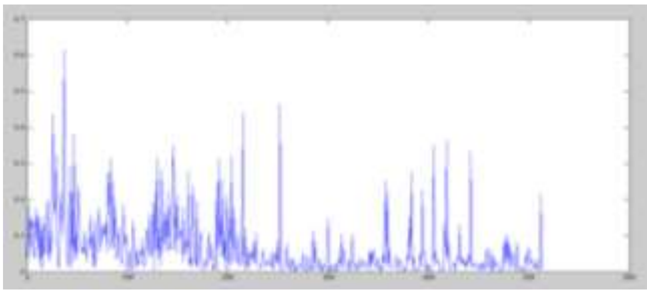

**Figure 16. Coherence between ECG and EEG alpha wave (MIT BIH)**

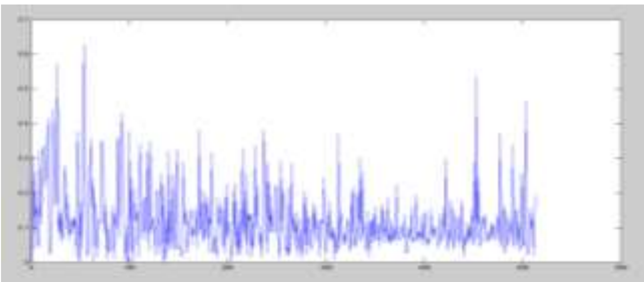

**Figure 17. Coherence between ECG and EEG beta wave (MIT BIH)**

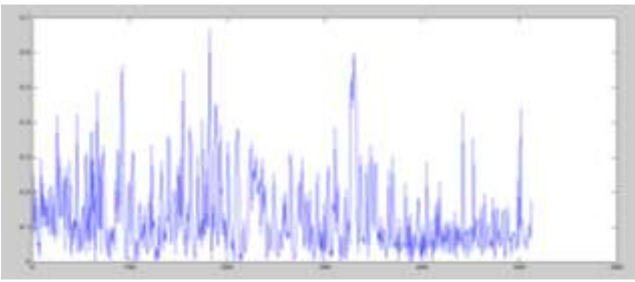

**Figure 18. Coherence between ECG and EEG gamma wave (MIT BIH)**

### B. Analysis of the signals in Ideal condition

The result of the coherence of the ECG and EEG signal acquired in the state when the subject is in relaxed state and not using the mobile phone. The various signals so obtained are shown in Fig. 19 to 24. The value of the coherence is varying upto 0.07.

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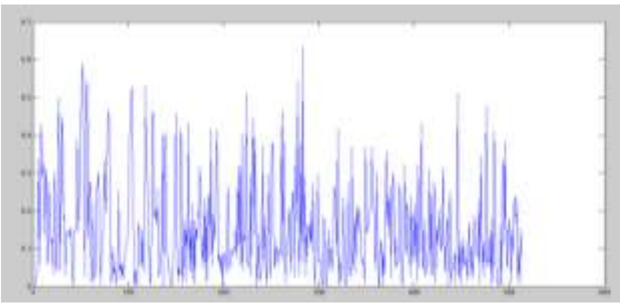

**Figure 19 Coherence between ECG and EEG signal (Ideal)**

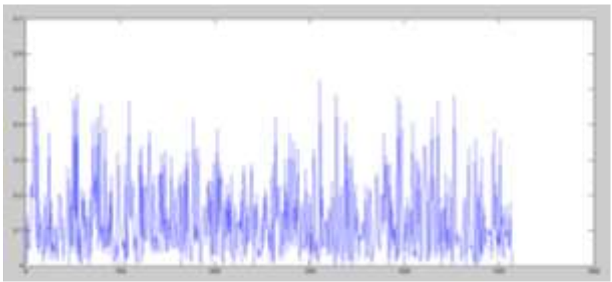

**Figure 20. Coherence between ECG and EEG delta wave (Ideal)**

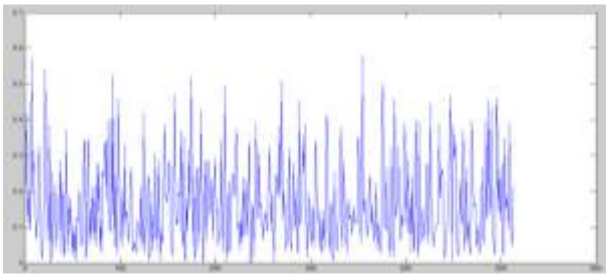

**Figure 21. Coherence between ECG and EEG theta wave (Ideal)**

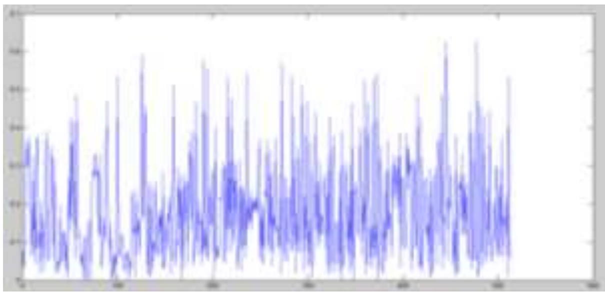

**Figure 22. Coherence between ECG and EEG alpha wave (Ideal)**

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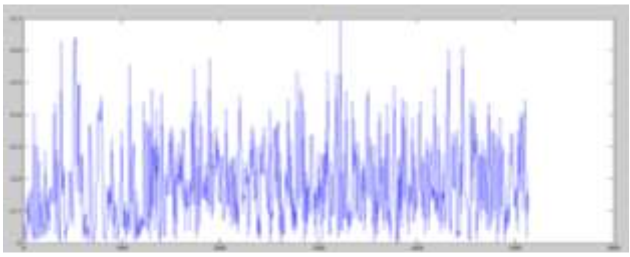

**Figure 23. Coherence between ECG and EEG beta wave (Ideal)**

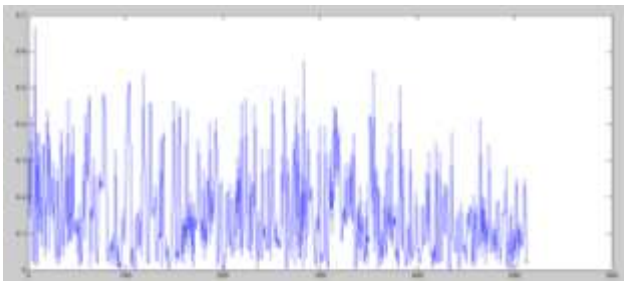

**Figure 24. Coherence between ECG and EEG gamma wave (Ideal)**

*C. Analysis of the signals in 2G Mobile Phone Transmission Mode*

The result of the coherence of the ECG and EEG signal acquired in the state when the subject is using 2G mobile phone in the calling mode. The various signals so obtained are shown in Fig. 25 to 30. The value of the coherence is varying upto 0.07.

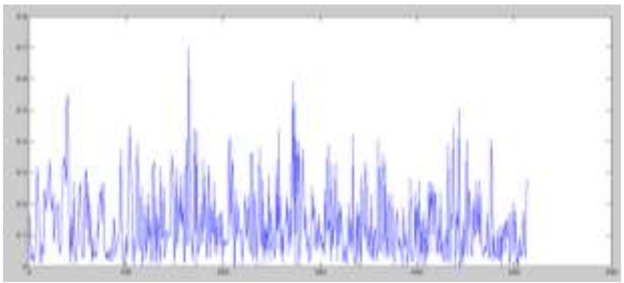

**Figure 25. Coherence between ECG and EEG signal (2GTx)**

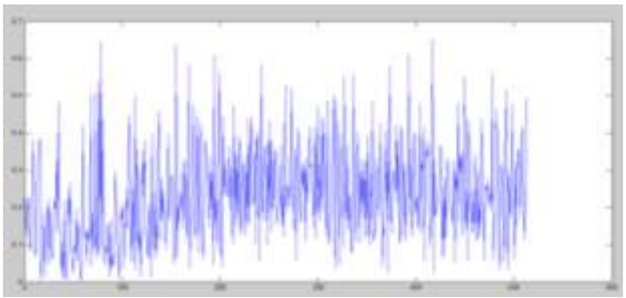

**Figure 26 Coherence between ECG and EEG delta wave (2GTx)**

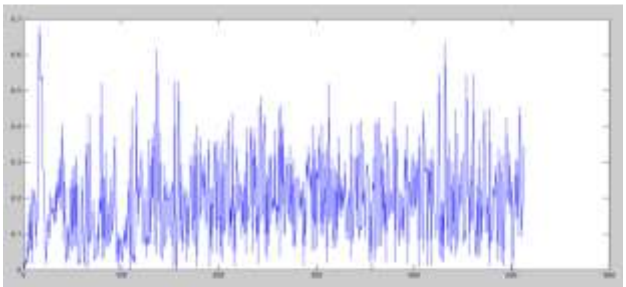

**Figure 27. Coherence between ECG and EEG theta wave(2GTx)**

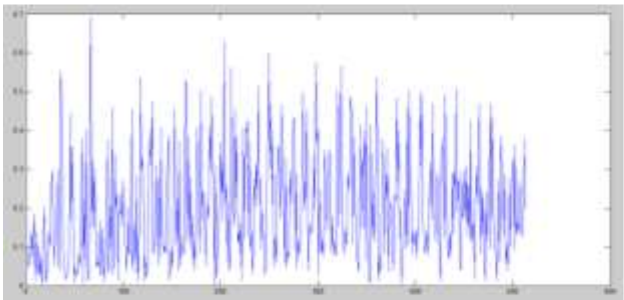

**Figure 28. Coherence between ECG and EEG alpha wave (2GTx)**

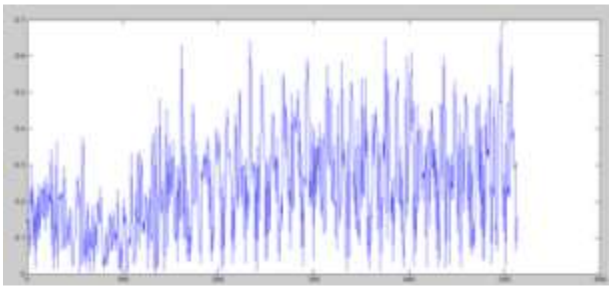

**Figure 29 Coherence between ECG and EEG beta wave (2GTx)**

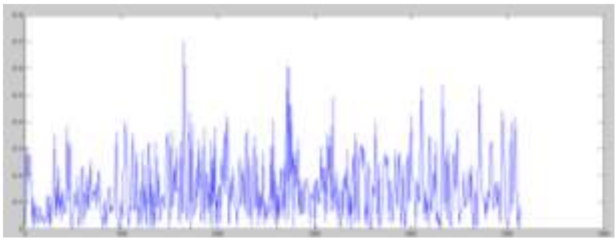

**Figure 30. Coherence between ECG and EEG gamma wave (2GTx)**

*D. Analysis of the signals in 2G Mobile Phone Reception Mode*

The result of the coherence of the ECG and EEG signal acquired in the state when the subject is using 2G mobile phone in the receiving mode. The various signals so obtained are shown in Fig. 31 to 36. The value of the coherence is varying upto 0.07.

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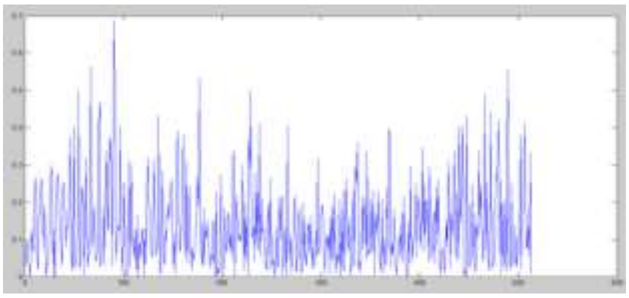

Figure 31 Coherence between ECG and EEG signal (2GRx)

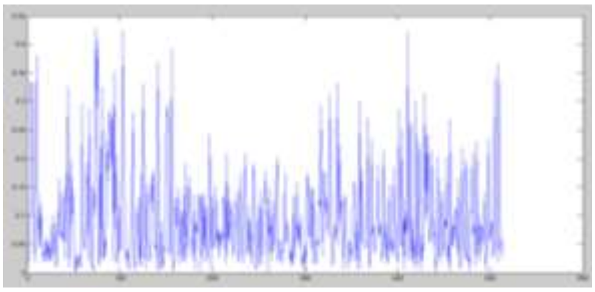

Figure 32 Coherence between ECG and EEG delta wave (2GRx)

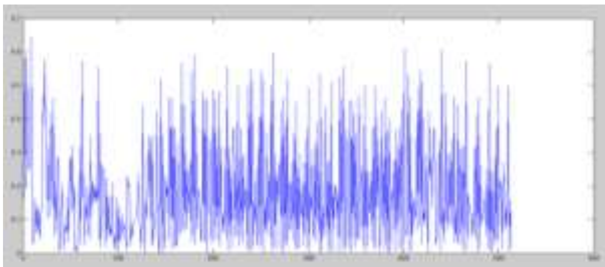

Figure 33 Coherence between ECG and EEG theta wave (2GRx)

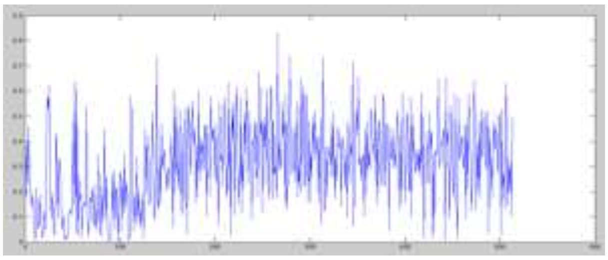

Figure 34 Coherence between ECG and EEG alpha wave (2GRx)

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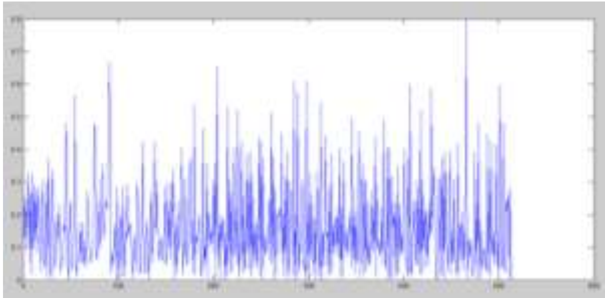

**Figure 35 Coherence between ECG and EEG beta wave (2GRx)**

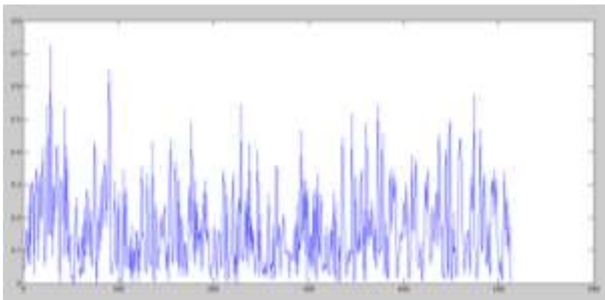

**Figure 36 Coherence between ECG and EEG gamma wave (2GRx)**

*E. Analysis of the signals in 3G Mobile Phone Transmission Mode*

The result of the coherence of the ECG and EEG signal acquired in the state when the subject is using 3G mobile phone in the calling mode. The various signals so obtained are shown in Fig. 37 to 42. The value of the coherence is varying upto 0.07.

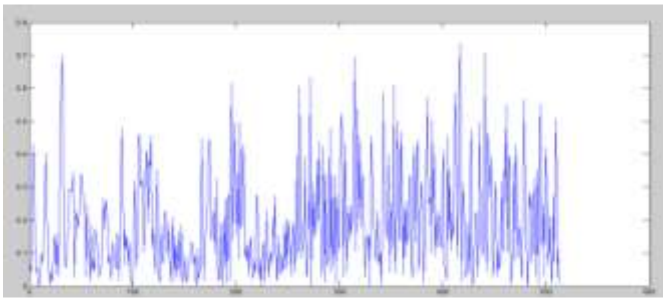

**Figure 37. Coherence between ECG and EEG signal (3GTx)**

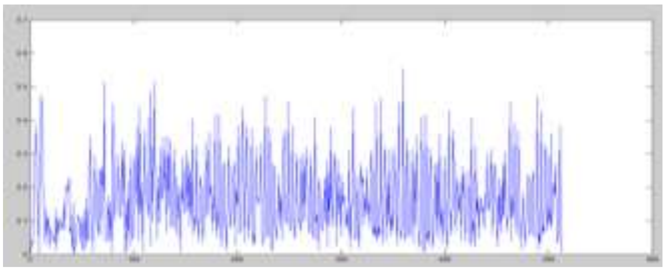

**Figure 38. ECG and EEG delta wave (3GTx)**

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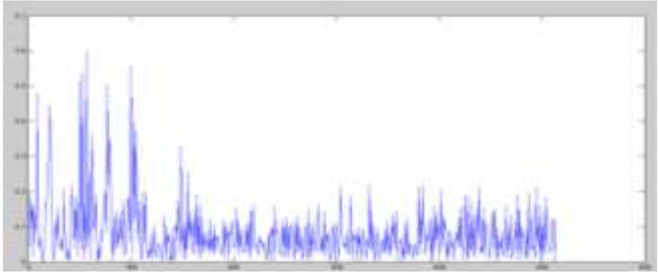

**Figure 39. ECG and EEG theta wave (3GTx)**

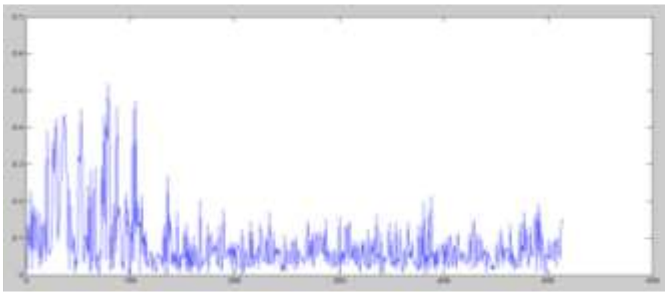

**Figure 40. ECG and EEG alpha wave (3GTx)**

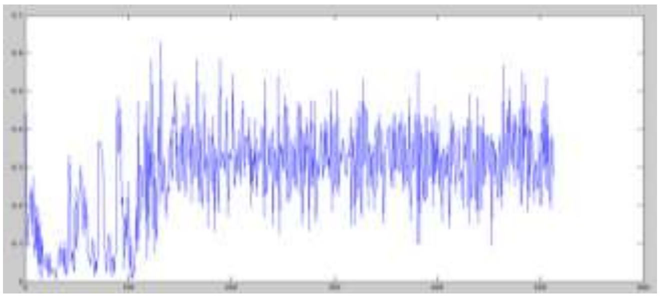

**Figure 41. ECG and EEG beta wave (3GTx)**

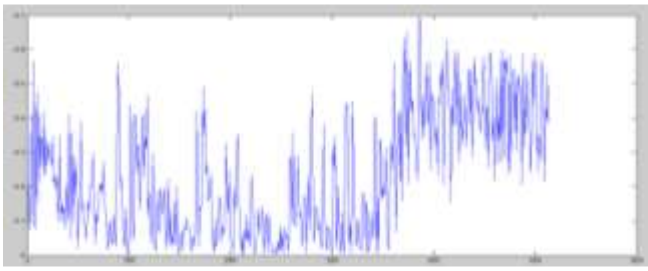

**Figure 42. ECG and EEG gamma wave (3GTx)**

*F. Analysis of the signals in 3G Mobile Phone Reception Mode*

The result of the coherence of the ECG and EEG signal acquired in the state when the subject is using 3G mobile phone in the receiving mode. The various signals so obtained are shown in Fig. 43 to 48. The value of the coherence is varying upto 0.07.

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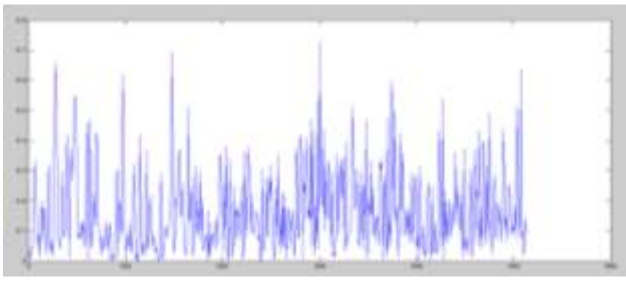

**Figure 43. ECG and EEG signal (3GRx)**

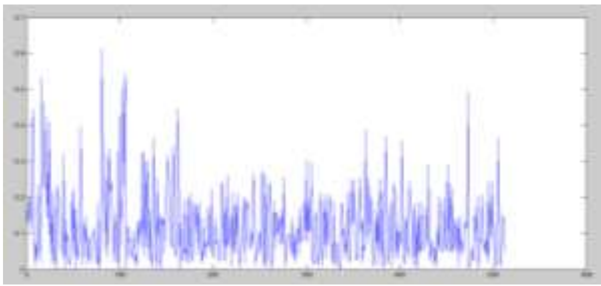

**Figure 44. ECG and EEG delta wave (3GRx).**

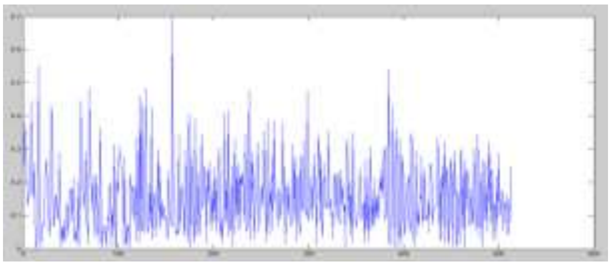

**Figure 45. ECG and EEG theta wave (3GRx).**

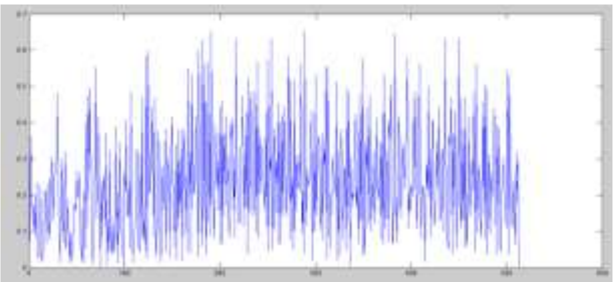

**Figure 46. ECG and EEG alpha wave (3GRx)**

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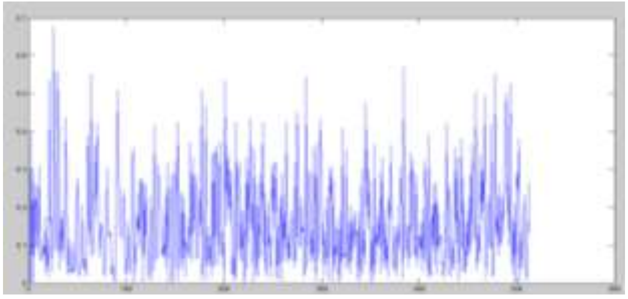

**Figure 47. ECG and EEG beta wave (3GRx)**

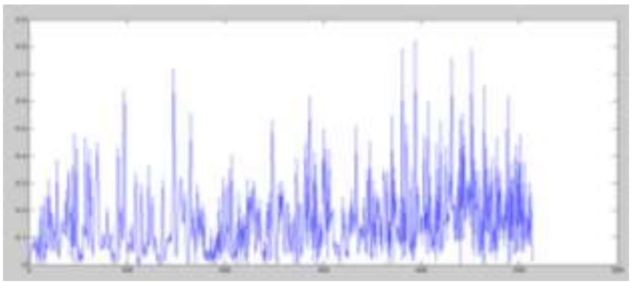

**Figure 48. ECG and EEG gamma wave (3GRx)**

**Table 1: Mean Coherent Values**

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| S.No. | Parameter Signal | Mean |
|---|---|---|
| 1 | ECG &EEG Coherence (in deep sleep) | 0.1561 |
| 2 | ECG & DELTA Coherence (in deep sleep) | 0.2501 |
| 3 | ECG &THETA Coherence (in deep sleep) | 0.0867 |
| 4 | ECG & ALPHA Coherence (in deep sleep) | 0.0637 |
| 5 | ECG & BETA Coherence (in deep sleep) | 0.1217 |
| 6 | ECG & GAMMA Coherence (in deep sleep) | 0.127 |
| 7 | ECG & EEG Coherence (ideal condition) | 0.1518 |
| 8 | ECG & DELTA Coherence (ideal condition) | 0.1311 |
| 9 | ECG & THETA Coherence (ideal condition) | 0.1645 |
| 10 | ECG & ALPHA Coherence (ideal condition) | 0.1768 |
| 11 | ECG & BETA Coherence (ideal condition) | 0.1863 |
| 12 | ECG & GAMMA Coherence (ideal condition) | 0.1525 |
| 13 | ECG &EEG Coherence (2G transmission) | 0.1355 |
| 14 | ECG & DELTA Coherence (2G transmission) | 0.2298 |
| 15 | ECG & THETA Coherence (2G transmission) | 0.1951 |
| 16 | ECG & ALPHA Coherence (2G transmission) | 0.1978 |
| 17 | ECG & BETA Coherence (2G transmission) | 0.2405 |
| 18 | ECG & GAMMA Coherence (2G transmission) | 0.1478 |
| 19 | ECG & EEG Coherence (2G reception) | 0.1359 |
| 20 | ECG & DELTA Coherence (2G reception) | 0.0934 |
| 21 | ECG & THETA Coherence (2G reception) | 0.1841 |
| 22 | ECG & ALPHA Coherence (2G reception) | 0.3064 |
| 23 | ECG & BETA Coherence (2G reception) | 0.1632 |
| 24 | ECG & GAMMA Coherence (2G reception) | 0.1602 |
| 25 | ECG & EEG Coherence (3G transmission) | 0.1899 |
| 26 | ECG & DELTA Coherence (3G transmission) | 0.1607 |
| 27 | ECG & THETA Coherence (3G transmission) | 0.0816 |
| 28 | ECG & ALPHA Coherence (3G transmission) | 0.0822 |
| 29 | ECG & BETA Coherence (3G transmission) | 0.2813 |
| 30 | ECG & GAMMA Coherence (3G transmission) | 0.2301 |
| 31 | ECG & EEG Coherence (3G reception) | 0.1633 |
| 32 | ECG & DELTA Coherence (3G reception) | 0.1170 |
| 33 | ECG & THETA Coherence (3G reception) | 0.1571 |
| 34 | ECG & ALPHA Coherence (3G reception) | 0.2359 |
| 35 | ECG & BETA Coherence (3G reception) | 0.1594 |
| 36 | ECG & GAMMA Coherence (3G reception) | 0.1598 |

The mean squared coherence between various biomedical signals has also been calculated and depicted in table 1. The results show the coherence between various signals and the extent of coherence can be seen by the mean values calculated for all the samples of a signal. These values show that under deep sleep condition, delta wave of EEG is highly coherent with ECG and the EEG alpha wave is least coherent with ECG as the person is sleeping and not awake. In case of the subject in ideal condition though the person is not doing anything but aware of the surroundings and the process of signal recording show that EEG beta wave is highly coherent with ECG. The delta wave is least coherent with ECG as the person is awake. In case of 2G mobile phone use with signal transmission, the results show that EEG beta wave is highly coherent with ECG and the EEG gamma

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wave is least coherent with ECG and the person is not doing any learning process while in signal transmission. In case of 2G mobile phone use with signal reception, the results show that EEG alpha wave is highly coherent with ECG and theta wave is least coherent with ECG. In case of 3G mobile phone use with signal transmission, the results show that EEG beta wave is highly coherent with ECG and the theta wave is least coherent with ECG. In case of 3G mobile phone use with signal reception, the results show that alpha wave is highly coherent with ECG and delta is least coherent with ECG. The coherence of alpha waves during 3G mobile phone use is in more coherence during signal transmission and reception as compared to that in case of 2G. There is maximum value of coherence during 2G signal reception and 3G signal transmissions.

## VII CONCLUSION

The communication between the heart and brain is a dynamic and two-way relationship that works in co-ordination of all the body organs affecting their functions. The association of brain and heart is understood by using mean squared coherence to show the influence of biomedical signals. MATLAB has been used for the study and analysis of various biomedical signals i.e. ECG and EEG and various frequency bands of EEG like delta, theta, alpha, beta and gamma. The coherence between two signals is maximum if the value of mean squared coherence is 1 and thus all the values more than 0.5 are considered and is minimum if the value of mean squared coherence is 0 showing the signals are independent of each other and thus all the values less than 0.5 are not considerable. The coherence of different waves show during deep sleep, delta wave is highly coherent with the ECG signal. When analyzed during the usage of phone, it is observed that the coherence is maximum with the alpha, beta and gamma waves during the 2G and 3G transmission the high coherence is with the beta wave and during 2G and 3G reception, alpha wave is more coherent.

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