ANALYSIS OF ELECTROGASTROGRAM SIGNAL

Dissertation submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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DECLARATION BY THE SCHOLARS

We hereby declare that the work reported in the B-Tech thesis entitled **“Analysis of Electrogastrogram Signal”** submitted at **Jaypee University of Information Technology, Waknaghat, India,** is an authentic record of our work carried out under the supervision of **Mr. Pardeep Garg, Assistant Professor, Grade II.** We have not submitted this work elsewhere for any other degree or diploma.

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2nd May, 2017

SUPERVISOR'S CERTIFICATE

This is to certify that the work reported in the B-Tech. thesis entitled "**Analysis of Electrogastrogram Signal**", submitted by **Saloni Goel, Kirti Garg and Shubham Gupta** at **Jaypee University of Information Technology, Waknaghat**, **India,** is a bonafide record of their original work carried out under my supervision. This work has not been submitted elsewhere for any other degree or diploma.

Mr. Pardeep Garg

2nd May, 2017

LIST OF ABBREVIATIONS

EGG	Electrogastrogram/Electrogastrography
PSD	Power Spectral Density
FFT	Fast Fourier Transform

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ACKNOWLEDGEMENT

While performing our project, we had to take the help and guideline of some respected persons, who deserve our greatest gratitude. The work done till date under this project gives us much pleasure. We would like to show our gratitude to **Mr. Pardeep Garg, Assistant Professor, Jaypee University of Information Technology, Waknaghat, District Solan** for giving us a good guideline for this project throughout numerous consultations and introducing us to the methodology of work. We would also like to expand our deepest gratitude to all those who have directly and indirectly guided us in writing this project.

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We would also like to thank Mr. JKL Prasad from AD instruments, New Delhi for his valuable suggestions related to our project.

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ABSTRACT

Now a day's most of the people around the world face problems because of various eating and stomach disorders. Generally the procedure of endoscopy is followed for the detection of such problems but it is a tedious, expensive as well as an invasive technique and thus EGG is gaining immense popularity in this field as it is a cost-effective as well as a non-invasive technique. Due to these features EGG has become an attractive tool among researchers to study about the different kind of gastric disorders which can be analyzed with the help of simply placing the electrodes on the surface of the stomach of the patient.

This project is divided into two parts. First is the collection of data which is followed by the second one which is analysis of the received EGG signal. The analysis of an EGG signal is difficult and visual interpretation of this signal is unreliable. Thus the analysis is done in MATLAB by application of various spectral analysis techniques like FFT, Welch, and Burg. Further the results obtained have been analyzed and compared for respective techniques applied.

CHAPTER 1

INTRODUCTION

The process of analyzing the data of the stomach muscles or the nerves that control the muscles collected with the help of electrodes is known as Electrogastrography and the received signal is known as Electrogastrogram.

W.C. Alvarez was the first one to publish about EGG in the year 1921 and he recorded the EGG signal of a human by placing two electrodes on the abdominal surface of a little old woman and then connected these electrodes to a sensitive string galvanometer. The results obtained were in the form of a sinusoidal like EGG with a frequency of about 3 cycles per minute (cpm).

The second person to do some work related to EGG was Harrison Tumpeer in the year 1926. He made use of limb leads to record the muscular gastric activity of a 5 week old child suffering from pyloric stenosis and his results were similar to that of an ECG signal changing slowly.

In the year 1974, Stevens and Worrall were the first ones to apply spectral analysis technique to the EGG signal with the help of Fourier Transform.

In the year 1978, R.L. Telander et al performed the EGG procedure on humans for the first time.

In the year 1989 Chen et al developed a modified spectral analysis technique which was based upon the adaptive auto-regressive model. This method provided results with high frequency resolution and precise information about the frequency variations of the myo-electric activity in the stomach.

However the progress in this field has been slow because of lack of understanding and also difficulty in data collection. Abnormality in the stomach arises mainly due to stomach ulcers, bradygastria, tachygastria, vomiting, dyspepsia and many other such diseases and as a result the digestion process in the stomach slows down. Thus if we get an abnormal EGG then it makes sure that one or two of the above symptoms are the reason for this abnormality. Normally the patients with no abnormality have normal rhythm and they also exhibit a post-meal increase in the power of the signal received which is not true in the case of patients with some kind of abnormalities in the stomach muscles.

1.1 LITERATURE OVERVIEW

Electrogastrography is a recent technique to gain knowledge about any kind of stomach abnormality. It is a non-invasive as well as cost-effective technique which is in contrast to the already existing techniques namely common endoscopy which is very painful and capsule endoscopy which is very costly for the detection of stomach abnormalities. This technique is similar to Electrocradiography. Here we record the myo-electrical rhythm of the stomach whereas in electrocardiography the movements of the heart muscles are recorded and analyzed. However the electrodes used for the electrocardiography can be used for recording the eletrogastrogram of a patient. The analysis of an EGG signal is done with the help of calculation of the dominant frequency which is the frequency corresponding to the dominant peak in the complete EGG recording and the dominant peak which is the highest power obtained in the EGG recording. The EGG signal frequency is recorded in cycles per minute (cpm) which is a medical standard and the corresponding power is measured in decibels (dB).

The EGG signal varies from about 100µV to 400µV and the frequency of the EGG signal lies in the range of 0.9 to 9 cpm or 0.015 to 0.15 Hz. Based on this frequency range the eletrogastrogram signal is classified in three parts namely Bradygastria (0.5-2 cpm), Normal Rhythm (2-4 cpm) and Tachygastria (4-9 cpm).

The complete EGG procedure takes about 2 hours to be completed and it is performed in three phases by placing the electrodes on the stomach of the patient. At first we have the preprandial phase which refers to the fasting state. In this phase the data is recorded for a period of about 30 minutes. Next is during intake of meal. The meal to be taken by the patient can be either non-caloric (400 ml water) or liquid (250 ml yogurt) or caloric (pancake). The data in this phase is recorded for a period of about 5-10 minutes but it is not usually analyzed because of a lot of disturbances. The last phase is the postprandial phase which refers to the state of digestion that is after intake of meal. The data in this phase is collected for about 60 minutes.

Normally the power of the EGG signal after intake of meal that is in the post-prandial phase increases as compared to before intake of meal that is pre-prandial phase but this appears as a contradiction in the case of abnormal EGG rhythm.

1.2 BENEFITS OF EGG

The digestive system plays a very important role in the functioning of the human body. Today most of the people in the world suffer from various gastric disorders due to improper digestion and other abnormalities in the stomach.

Thus EGG proves to be non-invasive, cost-effective as well as a painless procedure for detection of abnormal myo-electrical rhythm of the stomach. It also acts as a preliminary investigation procedure without any need of the endoscopy which is in contrast to EGG a very painful process. Another benefit of EGG is that as soon as the patient finishes with the complete procedure he/she can return to their normal routine activities.

1.3 DRAWBACKS OF EGG

Unlike EMG (Electromyography) and ECG (Electrocardiogram) there is no unique database for the EGG signal and due to lack of understanding the growth in providing a specific solution for various health issues analyzed by EGG test has been very slow.

1.4 MOTIVATION INVOLVED

The EGG signal unlike other signal like that of ECG, EMG and EEG has no specific pattern and thus visual interpretation of such a signal is highly difficult as well as unreliable and due to this the growth in this area has been very slow although the first recording of the EGG signal was done in the year 1921. However there is a boost in this research area from the past two decades considering all its advantages.

So in order to contribute towards proper analysis of the EGG signal and providing good results for the same this topic has been undertaken.

CHAPTER 2

ANATOMY OF THE STOMACH

2.1 INTRODUCTION

The stomach is a part of the gastrointestinal tract and is an organ responsible for digestion located between the oesophagus and the duodenum. It has a J shape and also features a lesser and greater curvature. The stomach is one of the major organs of the abdomen. It is mostly protected by the lower portion of the rib cage and it lies in the epigastric and umbilical regions. The exact shape, size, and position of the stomach can vary from person to person. It is very common for thin people to have stomach extending into the pelvic region.

The main function of the stomach is the processing of food which is associated with complex motility patterns. Contractions of the smooth muscles of the stomach generate four responses.

1. The muscles of certain regions of the stomach relax to accommodate the meal after the ingestion of a meal.

2. During digestion of the meal, gastric contractions mix the meal.

3. During digestion of the meal, gastric contractions are coordinated with motor activity of the pylorus and upper small intestine so that gastric contents are emptied into the duodenum in a regulated and orderly manner.

4. During the inter-digestive state, forceful, periodic contractions sweep all remaining gastric contents into the duodenum.

2.2 ANATOMICAL CHARACTERISTICS

Based on the anatomical considerations the stomach can be classified into four main parts namely the fundus, the corpus, the antrum, and the pylorus.

2.2.1 FUNDUS

Fundus is the area of the stomach which lies above the level of cardial orifice. It helps in accommodation of food by providing a reservoir for the food without an excessive increase in the intra-gastric pressure. The shape of the fundus is dome-shaped.

2.2.2 CORPUS

Corpus is the region where the enzyme pepsin is produced. At the great curvature of corpus. the gastric pacemaker is situated.

2.2.3 ANTRUM

It is a pyloric part where the hormone Gastrin is produced. Also mixing and grinding of food takes place in the antrum.

2.2.4 PYLORUS

Pylorus is the valve between the stomach and duodenum and thus helps in connecting the two. It also helps in controlling the emptying of the stomach contents into the duodenum.

2.2.5 BODY

The large central superior portion in the stomach is known as the body of the stomach. It lies below the fundus and is the main part of the stomach.

2.2.6 CARDIA

Cardia is the superior opening of the stomach and is the point connecting the esophagus and the stomach. Thus it provides a passage for the food to pass into the stomach.

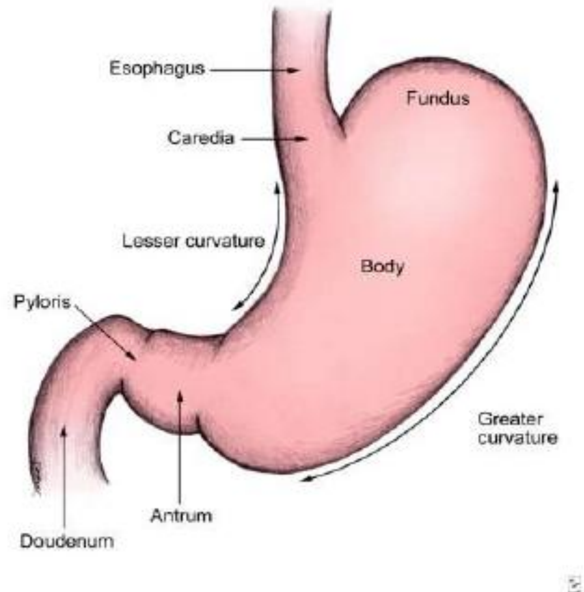

Figure 2.1: Anatomy of the stomach [G.]

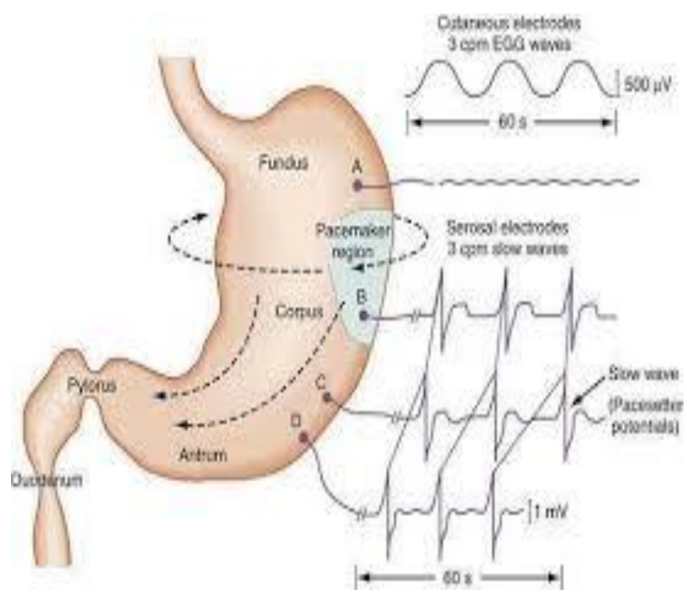

Figure 2.2: Pacesetter activity in the stomach [H.]

The gastric pacesetter generates an electrical signal in the stomach every 20 seconds which travels towards the antrum, and in response to a caloric challenge, it creates powerful peristaltic contractions that force the antral contents towards the pylorus thereby providing assistance in grinding and mixing of food.

2.3 NORMAL GASTRIC MYOELECTRICAL ACTIVITY

The electrical activity in the stomach muscles is generated along the gastro-intestinal tract. The highest frequency of the gastric activity is recorded in the corpus whereas the lowest is recorded in the antrum. However it has been noticed that in case of normal operations a uniform frequency is obtained in the entire stomach region because the muscular activity in the corpus with the highest frequency paces the entire stomach into the same higher frequency.

However the frequency of normal slow waves is dependent on the type of species because it is around 3 cpm in the case of humans and 5 cpm in the case of dogs.

CHAPTER 3

CLASSIFICATION OF EGG SIGNAL

The eletrogastrogram analysis basically revolves around the calculation of the dominant frequency which is measured in cycles per minute (cpm) and the dominant peak which is measured in decibels.

The EGG signal generally varies from about 100µV to 400µV in amplitude and about 0.9 cpm to 9 cpm in the case of frequency. Based on this frequency the EGG signal is broadly classified into three main categories.

3.1 BRADYGASTRIA

Bradygastria refers to a decreased rate of electrical pace-setter activity in the stomach which means that the pace of digestion is reduced as compared to the normal operation. This decreased rate of frequency varies from 0.5 cpm to 2 cpm for a period of at least a minute. This can be related to nausea, gastroparesis, irritable bowel syndrome, and functional dyspepsia.

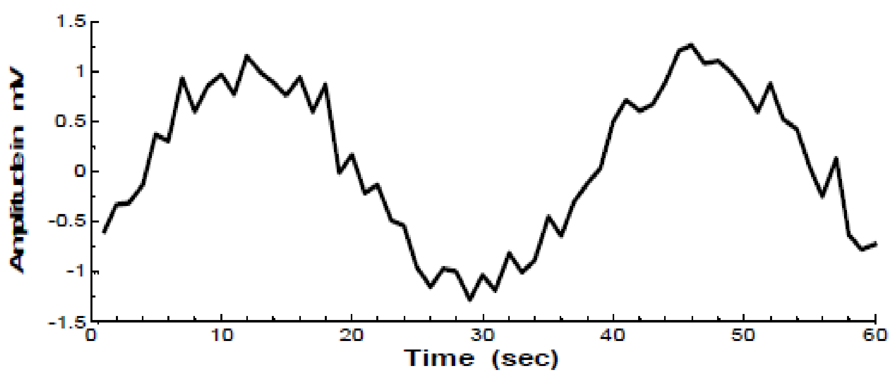

Figure 3.1: Plot for Bradygastria [I.]

3.2 NORMAL RHYTHM

Normal rhythm refers to proper functioning of the stomach muscles. Here the electrical signal is generated after every 20 seconds in the second and the rate at which digestion takes place varies from 2 cpm to 4 cpm.

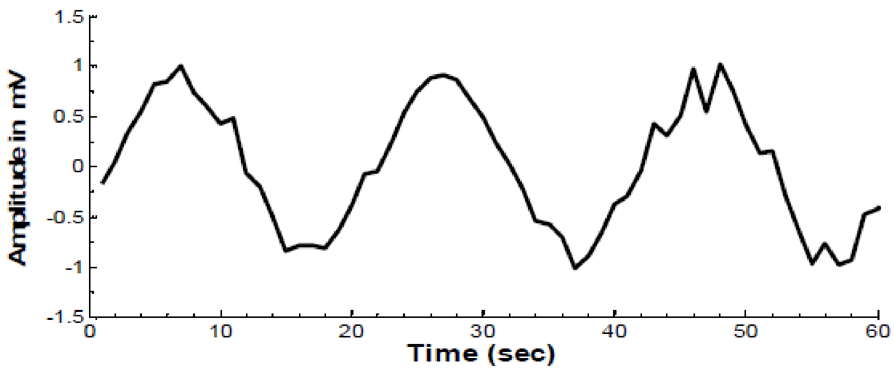

Figure 3.2: Plot for Normal Rhythm [I.]

3.3 TACHYGASTRIA

Tachygastria refers to an increase in the rate of digestion which means increase in the rate of electrical pace-setter activity in the stomach as compared to the normal operation. This increased rate of frequency varies from about 4 cpm to 9 cpm for at least a minute.

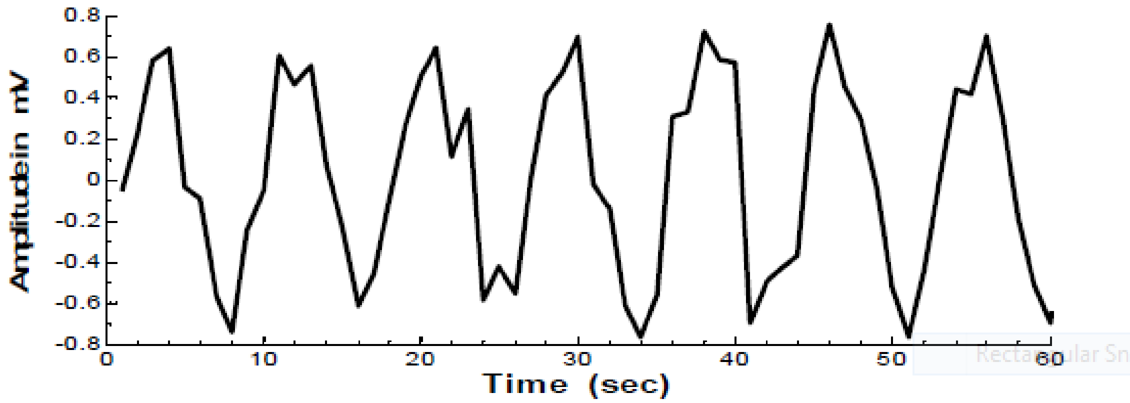

Figure 3.3: Plot for Tachygastria [I.]

CHAPTER 4

EGG TEST PROCEDURE

The EGG test is generally performed when there is a suspicion that the muscles of the stomach or the nerves that control these muscles are not working properly. In case we get an abnormal EGG signal then it is sure that there is problem with the myo-electrical rhythm of the stomach.

The complete EGG procedure takes about 2 hours and it is done in three different parts.

4.1 PREPRANDIAL PHASE

Pre refers to before and prandial refers to of or relating to food. Thus preprandial refers to the state of the patient when he/she is fasting. In this phase the data is recorded for duration of about 30 minutes.

4.2 DURING INTAKE OF MEAL

In this phase the data is collected while the meal is ingested in the patient. The meal can be of three types.

4.2.1 NON-CALORIC

A non-caloric meal refers to the meal which contains fewer calories as compared to the calories used by the body to break them down. Such a kind of meal can include 400 ml of water.

4.2.2 LIQUID

A liquid meal can be referred to as 250 ml of yogurt or custard.

4.2.3 CALORIC

A caloric meal refers to a full-course meal which contains all the nutrients, fats and essential vitamins. Example of such a meal can be pancakes and chapatti.

Thus while intake of meal the data is usually collected for the duration of about 5 minutes to 10 minutes. However it is not analyzed because of a lot of disturbances and high level of interferences.

4.3 POSTPRANDIAL PHASE

Post refers to after and prandial refers to of or relating to food. Thus postprandial refers to the state of the patient where digestion is taking place in the stomach. In this phase the data is recorded for duration of about 60 minutes to 120 minutes.

CHAPTER 5

PLACEMENT OF ELECTRODES

EGG test is a very difficult process because of difficult analysis. Thus things like placement of electrodes on the abdomen of the patient need to be done with utmost care and accuracy so as to get better results. Thus the following points must be taken care of.

5.1 PREPARATION OF SKIN

Before the electrodes are placed on the surface of the stomach the skin must be cleaned thoroughly in order to insure that the maximum impedance between the pair of electrodes is less than 10 kilo **Ω**. In order to do so, the skin is abraded with a sandy preparation like jelly until it turns pinkish in colour and then a thin layer of electrode jelly is applied on the surface of the stomach for about a period of a minute to let the jelly penetrate into the skin. Finally the electrodes are placed as per the requirements and the excessive jelly is wiped out.

5.2 ELECTRODE POSITION

The EGG signal can be recorded with the help of regular ECG electrodes. Thus, for the recording the myo-electrical rhythm of the stomach, three electrodes are used.

5.2.1 FIRST ELECTRODE

The first electrode is placed in between the line joining the middle of the navel and the chest bone.

5.2.2 SECOND ELECTRODE

The second electrode is placed 5 cm upwards at an angle of 45 degrees with reference to the first electrode.

5.2.3 THIRD ELECTRODE

The third electrode which is the ground electrode is placed at the left costal region with respect to the first active electrode.

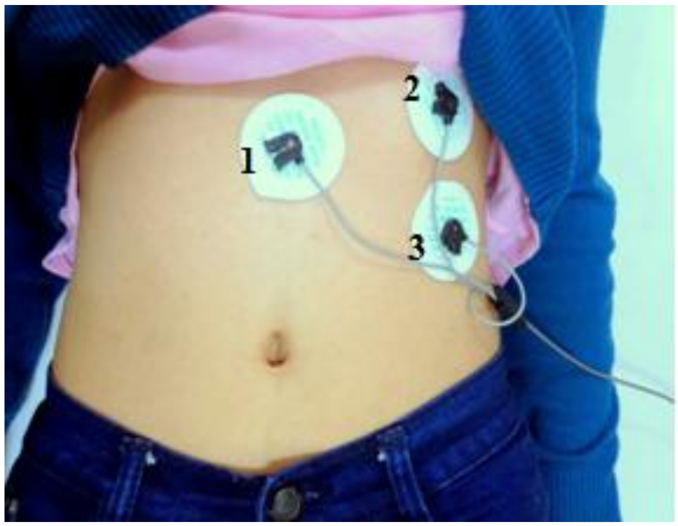

Figure 5.1: Position of electrodes

CHAPTER 6

POSITION OF SUBJECT

The subject should be in a supine position that is the subject should be in a comfortable position lying down with hands at sides. It should be taken care that the subject doesn't sleep, talk, or participate in any other physical activity. The position of the subject should be the same in case of multiple sessions. Also the readings taken at the time of any kind of unavoidable motion artifacts like coughing or sneezing should be removed at the earlier stage as it will be very difficult to remove them at later stages of processing of data.

Figure 6.1: Subject position

CHAPTER 7

RECORDING SETUP OF THE EGG SIGNAL

The data has been collected from National Institute of Technical Teachers Training & Research (NITTTR, Chandigarh) with the help of "myo-trace" machine under the supervision of Dr. Lini , H.O.D. of the Electrical Department and Mr. Yogender (Research scholar).

The myo-trace machine was connected with 4-channels each having 3 electrodes out of which only one channel was used as per the requirements and this machine was connected with the computer via Bluetooth. The data for the preprandial phase was recorded for duration of 15 minutes and the data for the postprandial phase was recorded for duration of 30 minutes. The data was obtained in the form of excel sheet with the help of "MyoResearch XP MT400 4CH Master Edition 1.08.38-Master Mode-Measurement Monitor" software, which was preinstalled in the computer. This inbuilt software gave us the voltage versus time readings. This data was then analyzed in Matlab by taking short segments of the same.

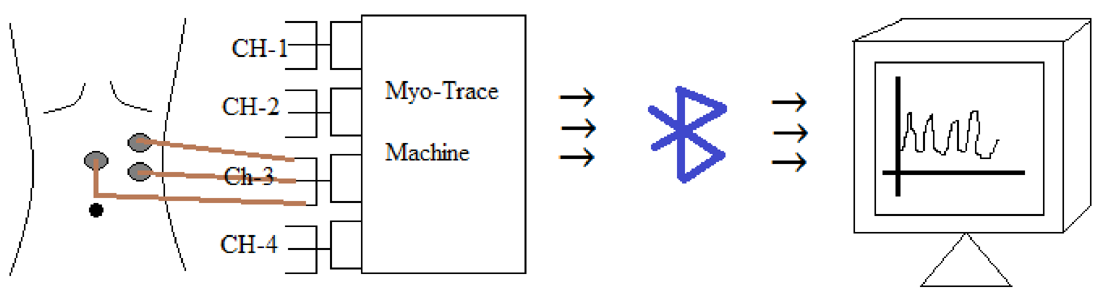

Figure 7.1: Overview of the recording setup

Figure 7.2: Myo-Trace machine

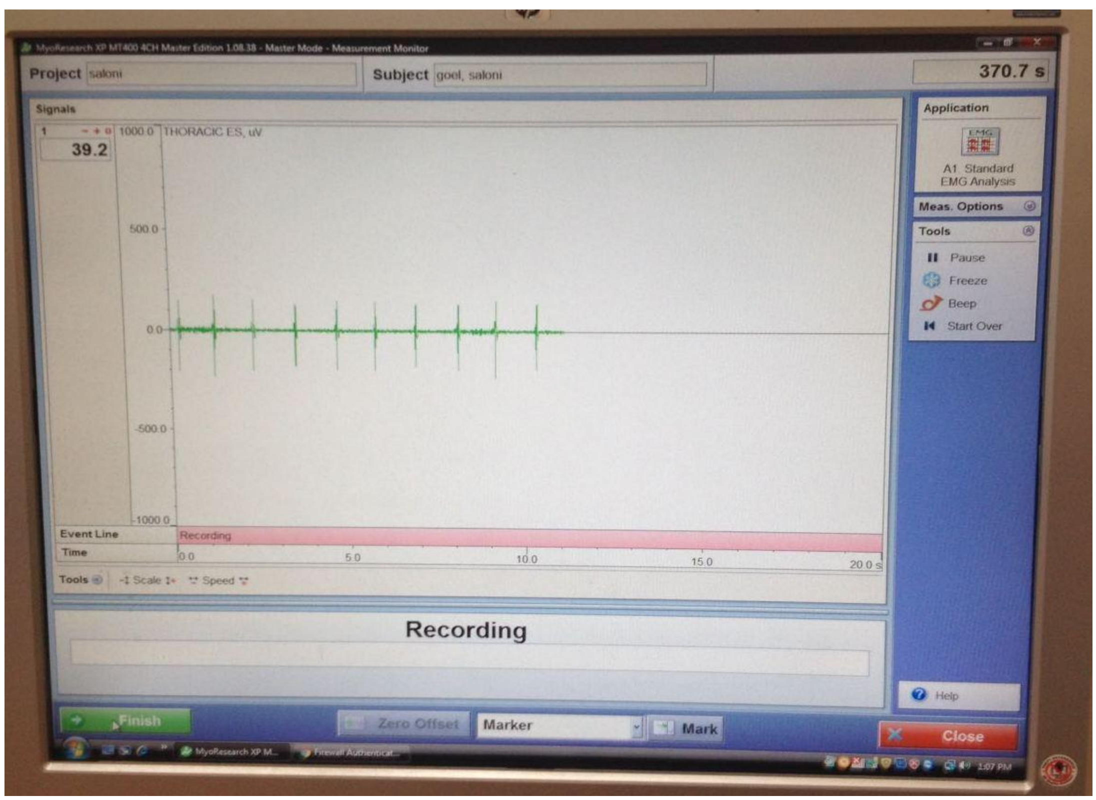

Figure 7.3: Real time recording of the EGG signal

Table 7.1: Voltage-time readings in excel form

PREPRANDIAL DATA		POSTPRANDIAL DATA	
TIME	AMPLITUDE	TIME	AMPLITUDE
0	3.25795	0.002	-4.20243
0.001	0.81811	0.003	-1.13939
0.002	-7.42813	0.004	4.3504
0.003	-3.76474	0.005	8.00532
0.004	1.42626	0.006	6.18526
0.005	-1.01358	0.007	5.87452
0.006	-3.46067	0.008	6.79195
0.007	-9.56389	0.009	7.10269
0.008	-10.7802	0.01	8.31607
0.009	-11.6997	0.011	6.18526
0.01	-5.90051	0.012	4.95709
0.011	-2.5412	0.0129	6.79195
0.012	6.92133	0.0139	5.26783
0.0129	5.08964	0.0149	3.12222
0.0139	4.78557	0.0159	1.30216
0.0149	2.95387	0.0169	0.38473
0.0159	2.33848	0.0179	0.38473
0.0169	7.22541	0.0189	-0.22196
0.0179	0.20272	0.0199	-4.80911
0.0189	-4.67697	0.0209	-8.46404
0.0199	-9.56389	0.0219	-7.85735
0.0209	-7.7322	0.0229	-10.9056
0.0219	-3.46067	0.0239	-6.64398
0.0229	-2.5412	0.0249	-8.16809

CHAPTER 8

METHODS USED

8.1 FOURIER TRANSFORM

The raw signal that is obtained using the myo-trace machine is a voltage-time signal. No further information can be extracted from that signal. In such case it becomes important to convert the time domain signal into frequency domain signal. The frequency spectrum of the signal gives us the frequency components existing at that signal. When we take the Fourier transform we get to know the existence of different frequency components in the signal. The “fft” command used here computes the discrete Fourier transform of the signal using fast Fourier transform algorithm.

The simple Fourier transform of any signal can be given as

$$F(S) = \int_{-\infty}^{\infty} f(t) e^{-2\pi i S t}\, dt$$

where f *(t*) is the time-domain signal and *F(s)* is its Fourier transform.

Similarly, the inverse Fourier transform can be given as

$$f(t) = \int_{-\infty}^{\infty} F(S) e^{2\pi i S t}\, dS$$

But the simple Fourier transform (i.e. the continuous Fourier transform) deals with time domain signal of infinite duration into a continuous spectrum of infinite number of sinusoids. But we usually require the Fourier transform of a finite length signal. So to get the finite number of sinusoids we prefer the use of discrete Fourier transform over continuous Fourier transform.

The discrete Fourier transform of any arbitrary signal is given by

$$X_k = \sum_{j=0}^{N-1} x_j e^{-2\pi ijk/N}$$

Inverse discrete Fourier transform is given by

$$x_j = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{2\pi ijk/N}$$

Where X_k is the discrete Fourier transform of signal x_j.

8.2 THE WELCH METHOD

The Welch Method is a non-parametric estimator of the power spectral density (PSD). It is also known as the Periodogram method.

In this method the PSD of the signal is computed by first splitting the signal into smaller segments, then estimating the PSD of each segment and finally averaging over these estimates so as to reduce the variance of the estimated PSD.

Let us assume the m_{th} windowed, zero-padded frame from the signal *x* is given by

$x_m(n) \triangleq \omega(n)x(n+mR)\ where\ m = 0,1,2,\dots,K-1$

Here $R$is the size of segmented window and K is the total number of frames. This means that the Periodogram of the m_{th} block can be written as

$$P_{x_m,M}(\omega_k) = \frac{1}{M}\left|\sum_{n=0}^{N-1} x_m(n)e^{\frac{-j2\pi nk}{N}}\right|^2$$

Thus the Welch Power Spectral Density can be written as

$$\widehat{P_{xx}^{w}}(\omega_k) \triangleq \frac{1}{K}\sum_{m=0}^{K-1} P_{x_m,M}(\omega_k)$$

8.3 THE BURG METHOD

The Burg method is a parametric estimator of the power spectral density. It is an order recursive least square lattice method which is based on the minimization of forward and backward errors in linear predictors.

Let the data be x(n), n=0,1,2,...,N-1 and let the forward and backward linear prediction estimates of order m be:

$$\hat{x}(n) = -\sum_{k=1}^{m} a_m(k)x(n-k)$$

$$\hat{x}(n-m) = -\sum_{k=1}^{m} a^*{}_m(k)x(n+k-m)$$

$a_m(k), 0 \leq k \leq m-1, m = 1,2, \ldots\ldots, p$ are the prediction coefficients.

The forward error can be given by : $f_m(n) = x(n) - \hat{x}(n)$.

While the backward error can be given by : $g_m(n) = x(n-m) - \hat{x}(n-m)$.

Thus the least square error is

$$\varepsilon_m = \sum_{n=m}^{N-1} [|f_m(n)|^2 + |g_m(n)|^2]$$

The error is to be minimized with the help of prediction coefficients, subjected to they satisfying the Levinson-Durbin recursion given by:

$a_m(k) = a_{m-1}(k) + K_m a^*_{m-1}(m-k) \quad for\ all \quad 1 \leq k \leq m-1\ and\ a \leq m \leq p$

where $K_m = a_m(n)$ is the m_{th} reflection coefficient in the lattice filter realization.

The forward prediction error $f_m(n)$ and backward prediction error $g_m(n)$ in the terms of reflection coefficients are given as:

$$f_m(n) = f_{m-1}(n) + K_m g_{m-1}(n-1)$$

$$g_m(n) = K_m{}^* f_{m-1}(n) + g(n-1)$$

$$for\ all\ m = 1,2,3, \dots, p$$

Thus,

$$\widehat{K_m} = \frac{-\sum_{n=m}^{N-1} f_{m-1}(n) g_{m-1}^{*}(n-1)}{\frac{1}{2}\sum_{n=m}^{N=1}[|f_{m-1}(n)|^2 + |g_{m-1}(n-1)|^2]} \qquad for\ all \quad m = 1,2,3, \dots, p$$

The numerator term $-\sum_{n=m}^{N-1} f_{m-1}(n) g_{m-1}^{*}(n-1)$ is an estimate of cross-correlation between the forward and backward prediction errors.

The denominator term $\frac{1}{2}\sum_{n=m}^{N=1}[|f_{m-1}(n)|^2 + |g_{m-1}(n-1)|^2]$ is the sum of forward error and backward error.

Thus the Burg Power Spectral Density can be written as

$$P_{xx}^{BU}(f) = \frac{\widehat{E_p}}{\left|1 + \sum_{k=1}^{p} \widehat{a_p}(k) e^{-j2\pi fk}\right|^2}$$

8.4 BLOCK DIAGRAM OF THE PROJECT

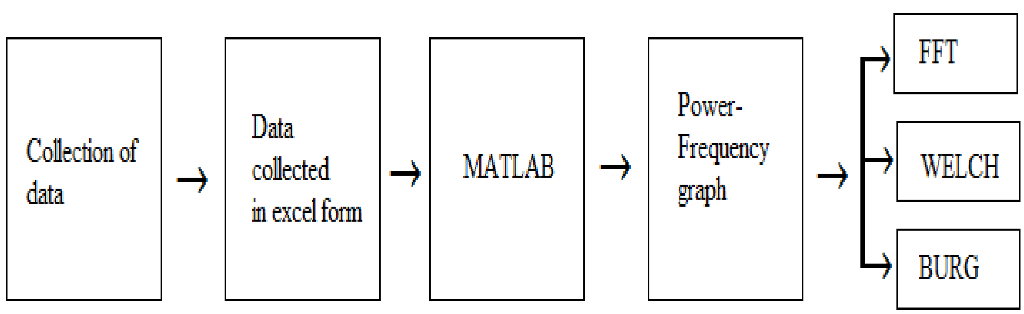

Figure 8.1: Flow chart of the work done

CHAPTER 9

RESULTS AND DISCUSSION

9.1 PLOTTING THE DATA

The data collected was plotted in MATLAB after importing it from the excel sheet.

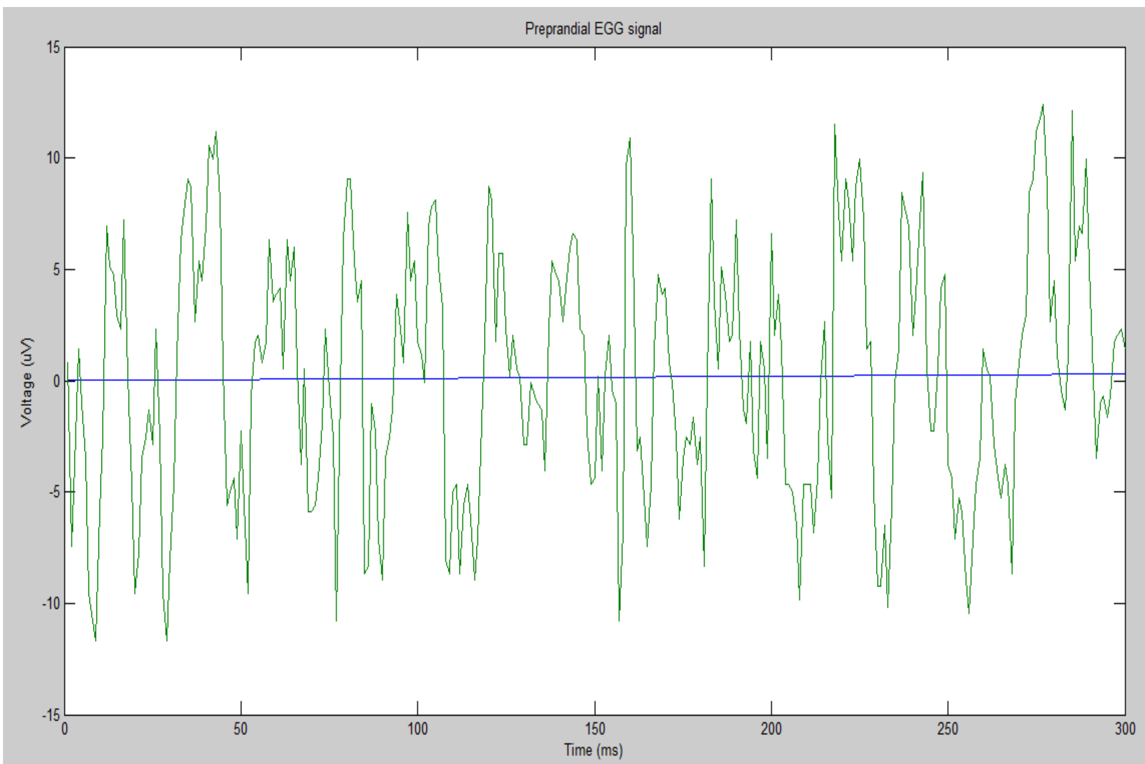

Figure 9.1: Voltage-time graph of EGG data (Preprandial phase)

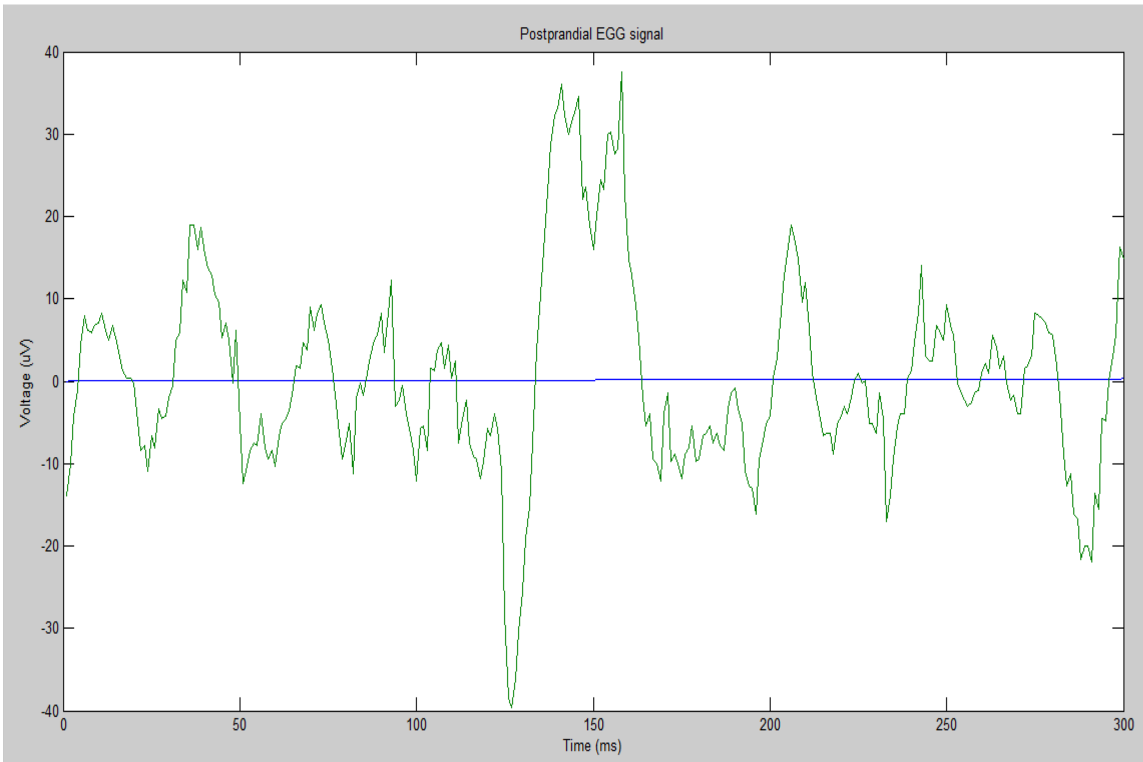

Figure 9.2: Voltage-time graph of EGG data (Postprandial phase)

From the above two plots it is clearly evident that there is an increase in the amplitude in the postprandial phase which is about 40µV as compared to that in preprandial phase which is about 20µV.

9.2 THE FFT

9.2.1 FFT FOR THE PREPRANDIAL PHASE

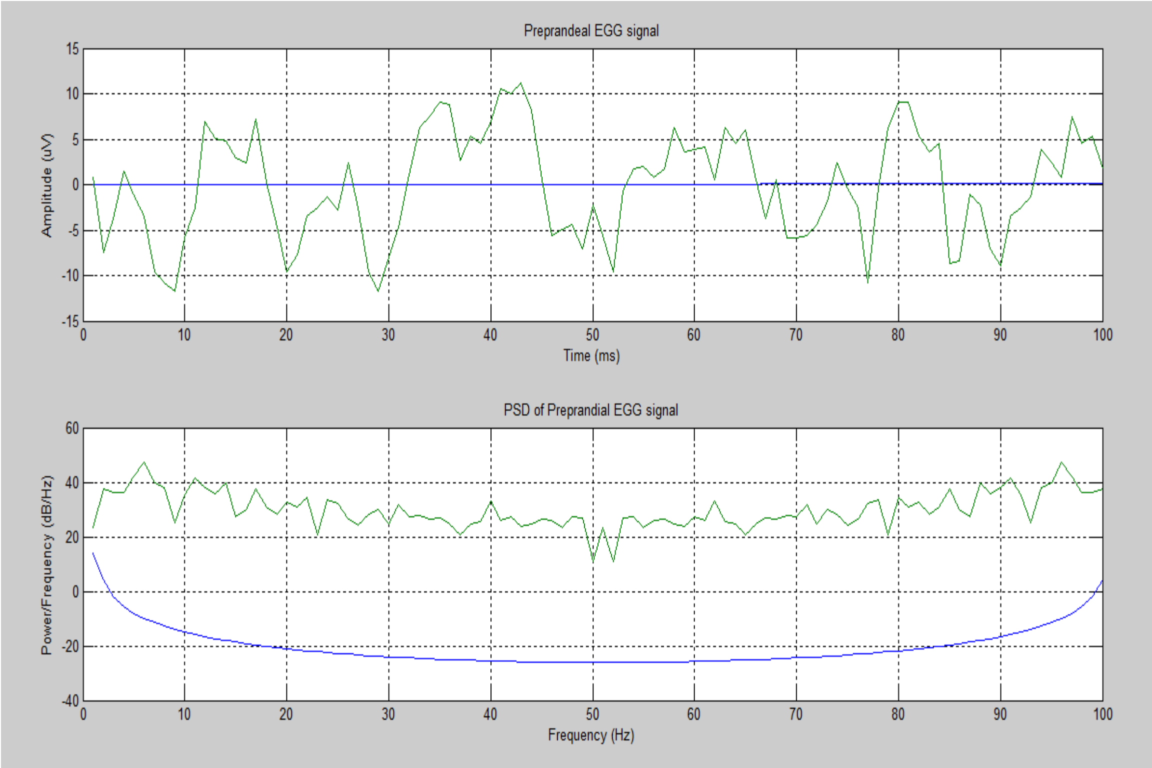

Figure 9.3: PSD of preprandial phase using fft for 100 samples

From the above figure we can see that the maximum amplitude of the preprandial EGG signal is 11.2 µV while the maximum power is 47.15 dB.

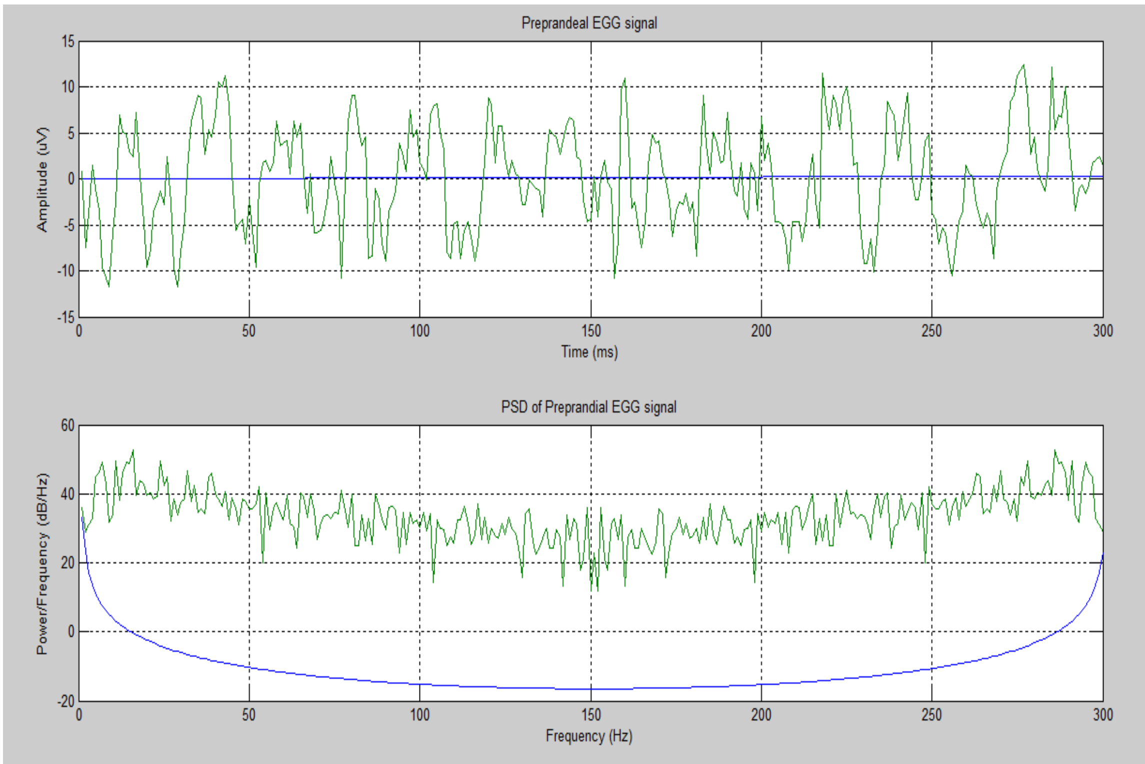

Figure 9.4: PSD of preprandial phase using fft for 300 samples

From the above figure we can see that the maximum amplitude of the preprandial EGG signal is 12.4 µV while the maximum power is 52.8 dB.

9.2.2 FFT FOR THE POSTPRANDIAL PHASE

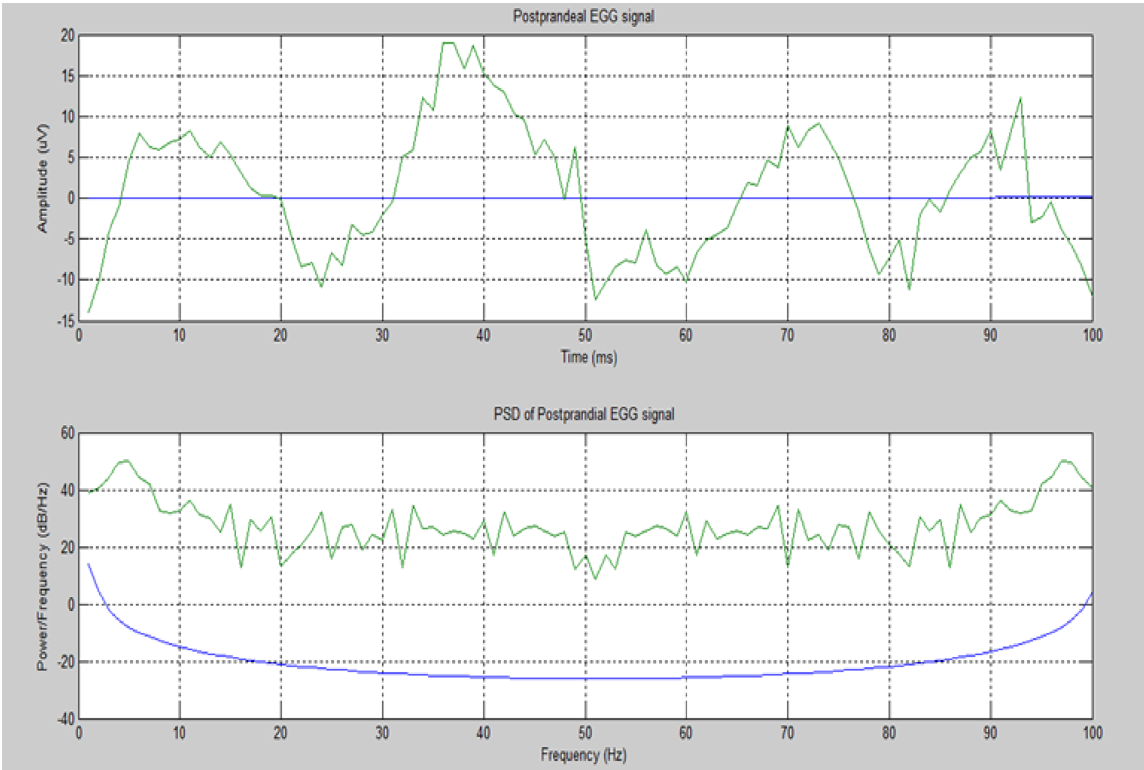

Figure 9.5: PSD of postprandial phase using fft for 100 samples

From the above figure we can see that the maximum amplitude of the preprandial EGG signal is 19.0 µV while the maximum power is 49.9 dB.

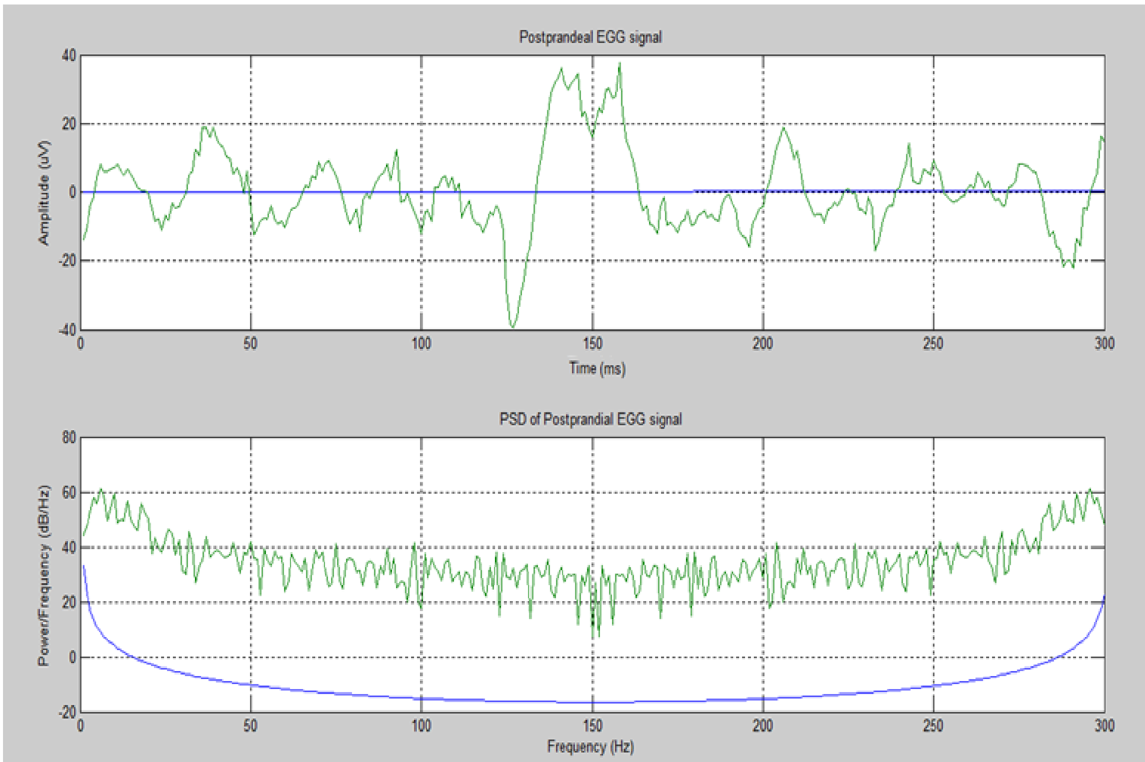

Figure 9.6: PSD of post-prandial phase using fft for 300 samples

From the above figure we can see that the maximum amplitude of the preprandial EGG signal is 37.5 µV while the maximum power is 61 dB.

9.3 THE WELCH METHOD

9.3.1 THE WELCH PSD FOR THE PREPRANDIAL PHASE

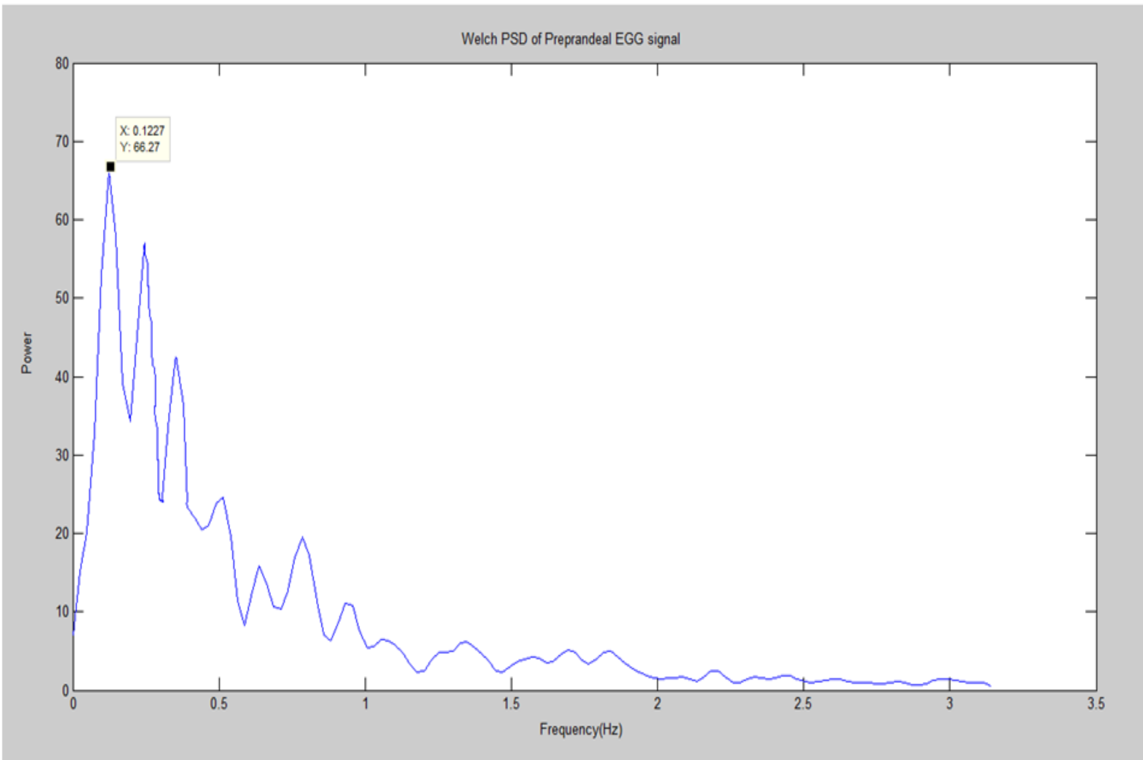

Figure 9.7: Welch PSD of preprandial phase

From the above figure we can see that for the preprandial EGG signal the dominant peak is at 36.42 dB at 7.362 cpm i.e. 0.1227 Hz.

9.3.2 THE WELCH PSD FOR THE POSTPRANDIAL PHASE

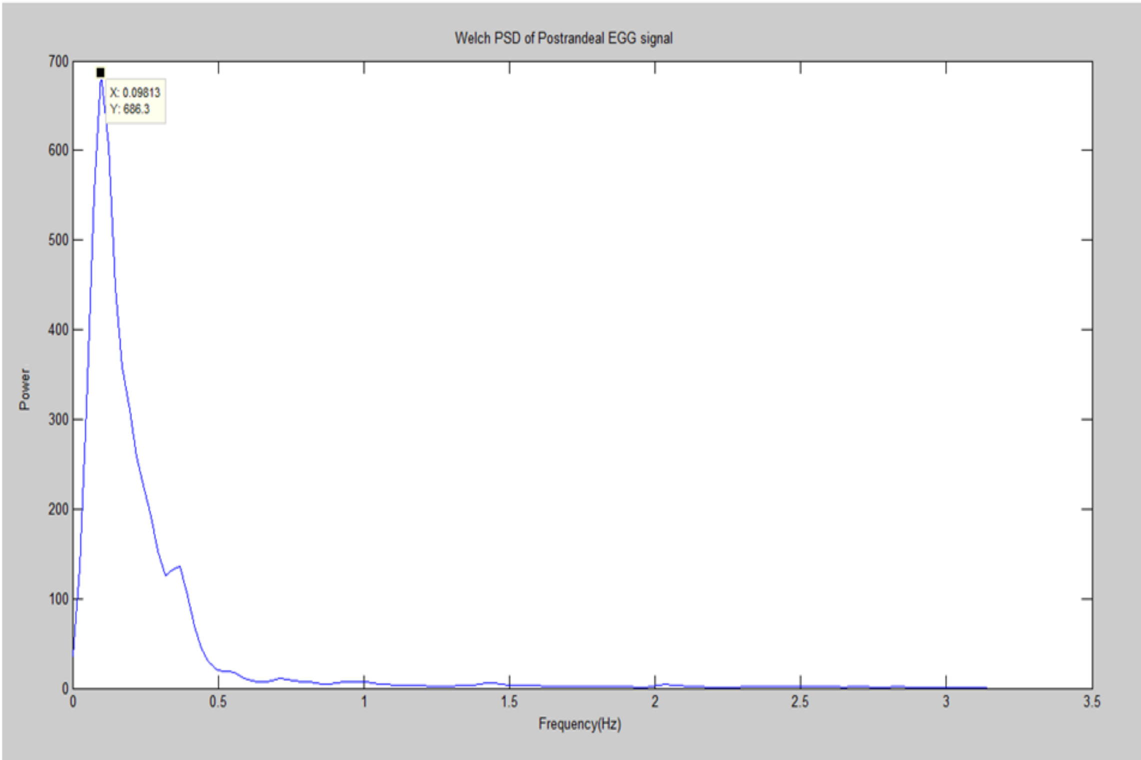

Figure 9.8: Welch PSD of postprandial phase

From the above figure we can see that for the postprandial EGG signal the dominant peak is at 56.73dB at 5.887 cpm i.e. 0.09813 Hz.

9.4 THE BURG METHOD

9.4.1 THE BURG PSD FOR THE PREPRANDIAL PHASE

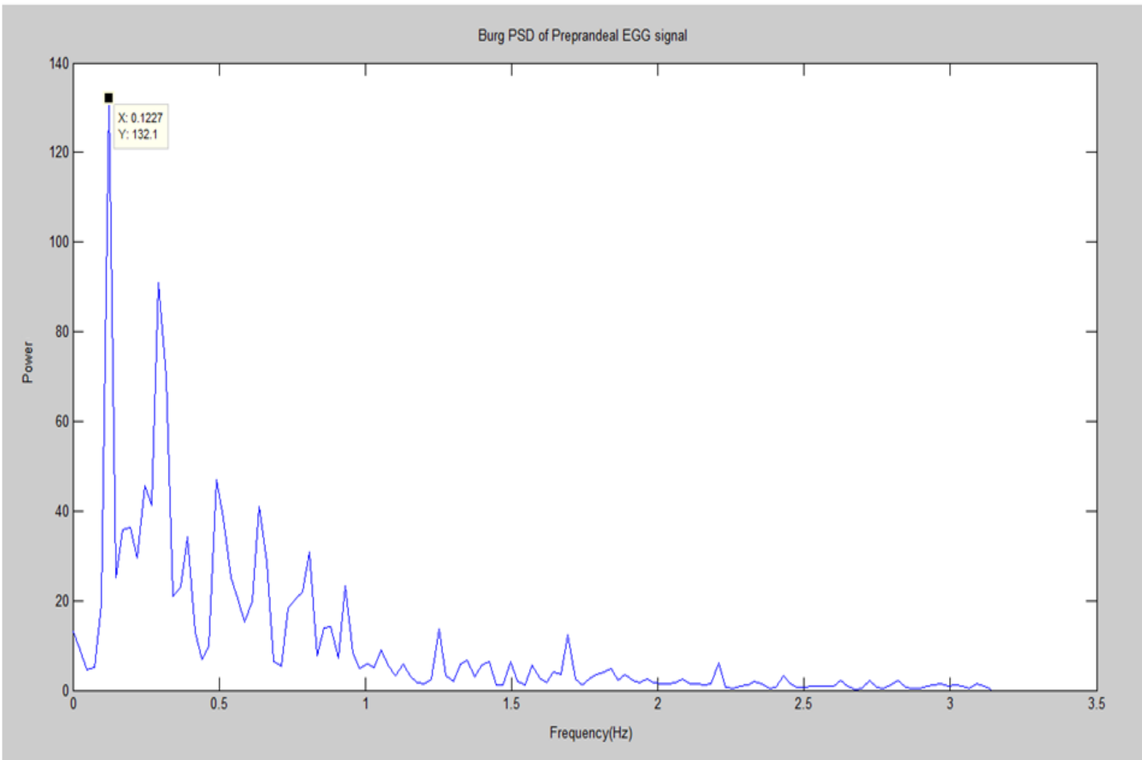

Figure 9.9: Burg PSD of preprandial phase

From the above figure we can see that for the preprandial EGG signal the dominant peak is at 42.41dB at 7.362 cpm i.e. 0.1227 Hz.

9.4.2 THE BURG PSD FOR THE POSTPRANDIAL PHASE

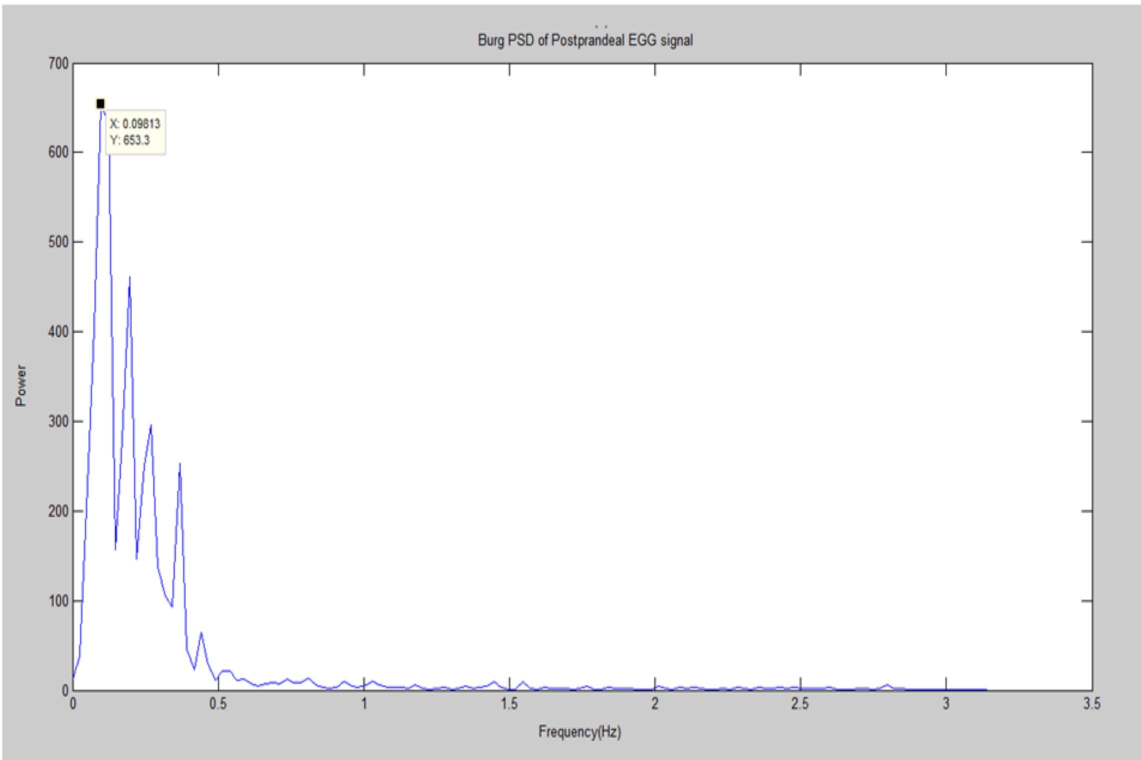

Figure 9.10: Burg PSD of postprandial phase

From the above figure we can see that for the postprandial EGG signal the dominant peak is at 56.30dB at 5.887 cpm i.e. 0.09813 Hz.

9.5 COMPARISON OF RESULTS

Table 9.1: Comparison of results obtained using three methods

Methods (↓)	**Pre-Prandial Phase**		**Post-Prandial Phase**	
	Dominant Frequency(cpm)	**Dominant power(dB)**	**Dominant Frequency(cpm)**	**Dominant power(dB)**
FFT	Couldn't be determined	49.9	Couldn't be determined	61
The Welch Method	7.362	36.42	5.887	56.73
The Burg Method	7.362	42.41	5.887	56.30

From the above table it is quite evident that the dominant power and dominant frequency obtained using the Welch and the Burg method are closer in values with each other.

1. The dominant frequency could not be determined when we used the simple FFT but remarkable results were obtained as we shifted to other transforms.
2. The rise in dominant power can be observed in postprandial phase than in the pre-prandial phase in all the three methods.
3. The dominant frequency obtained for both preprandial and the postprandial phase using both Welch and Burg methods is exactly the same.
4. The dominant powers obtained for both preprandial and the postprandial phase using both Welch and Burg methods are quite closer in values.

CHAPTER 10

CONCLUSION

This report gives us a detailed study of the human stomach and methods to find out the problems of the stomach mainly focusing on EGG. It gives a brief study of human stomach and its functions and tells us about the methods being used to detect gastric disorders these days. After comparing with all other techniques we come to know that the best suited technique is the EGG and not much work has been done in this area. So we have tried to compare the signal obtained with its different transforms. After comparing it can be observed that the results obtained after applying Welch and Burg methods were almost similar. Moreover the subject taken was suffering from Tachygastria as the dominant frequency lies in the range 5-9 cpm.

The report is divided into 10 chapters. The first chapter deals with the history, benefits and drawbacks of Electrogastrography. Apart from that it also deals with the motivation involved in taking up this project. The second chapter deals with the anatomy of stomach and discusses in detail the characteristics and functioning of stomach and its different parts. The third chapter is about the EGG signal and its classification based on the rhythm. The fourth chapter is about the EGG test procedure and different stages of the EGG test. The fifth chapter deals with placement of electrodes while the sixth chapter tells us about how and in which conditions the subject should be kept. The seventh chapter explains the recording setup and machine used to record the EGG signal. The eighth chapter discusses the detailed explanation of all the three methods used along with their mathematical formulas. The ninth chapter includes all the plots obtained by applying those methods which are discussed in chapter 8. The comparison of results obtained is also done in the ninth chapter only.

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