

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/305318994>

# Brain Controlled Wheelchair using LabVIEW

Thesis · May 2013

DOI: 10.13140/RG.2.1.4303.7686

CITATIONS

0

READS

2,029

2 authors, including:



**Agneev Guin**

KTH Royal Institute of Technology

6 PUBLICATIONS 0 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



Terrain Classification to find Drivable Surfaces using Deep Neural Networks [View project](#)

**A PROJECT REPORT**  
on  
**BRAIN-CONTROLLED WHEELCHAIR**  
**USING LABVIEW**

*Submitted in partial fulfillment for the award of degree*

of  
**BACHELOR OF TECHNOLOGY**  
in  
**INSTRUMENTATION AND CONTROL**

by  
**Agneev Guin: 1060910012**  
**Bidyut Bikash Baishya: 1060910035**

*Under the guidance of*

**Mr. R. Narayanamoorthi**  
(Assistant Professor, Department of Instrumentation and Control)



**FACULTY OF ENGINEERING & TECHNOLOGY**

S.R.M. Nagar, Kattankulathur – 603203  
Kancheepuram Dist.

MAY 2013

## **BONAFIDE CERTIFICATE**

Certified that this Project Report titled **“BRAIN-CONTROLLED WHEELCHAIR USING LABVIEW”** is the bonafide work of **AGNEEV GUIN (Reg. No.: 1060910012)** and **BIDYUT BIKASH BAISHYA (Reg. No.: 1060910035)** who carried out the project work under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or to any other candidate.

Signature of the Guide

Mr. R. Narayanamoorthi

Signature of the HOD

Dr. A. Vimala Juliet

Signature of the Internal Examiner

Signature of the External Examiner

Date:

## **ACKNOWLEDGEMENT**

We express our gratitude to the university management and to all those who have directly or indirectly helped us in the successful completion of our project. We thank sincerely and profusely to all ICE staff members of our university for their valuable guidance.

We express our sincere thanks to Dr. C. MUTHAMIZHCHELVAN, Director, Faculty of Engineering & Technology, SRM University, for his enriching thoughts and profound knowledge which brought our project work to its completion.

We express our heartfelt gratitude and thanks to Dr. A. VIMALA JULIET, Professor and Head, Department of Instrumentation and Control for her technical support and valuable suggestions.

We are very grateful to our guide Mr. R. Narayanamoorthi who laid the time bound program for the successful completion of this project. He initiated, channelled our thoughts and extended timely suggestions for which we are deeply indebted to him. We are grateful to him for comments and insights in the preparation of this project and its report.

Last but not the least; we are deeply indebted to our parents for what we are today. This project would not have been a reality without their love and support.

## **DECLARATION**

We hereby declare that the Project Report titled “**BRAIN-CONTROLLED WHEELCHAIR USING LABVIEW**” is the original work carried out by us under the supervision of Mr. R. Narayanamoorthi, Department of Instrumentation and Control, SRM University, Kattankulathur. This project has not been submitted earlier in part or full for the award of degree or diploma.

Agneev Guin  
(1060910012)

Bidyut Bikash Baishya  
(1060910035)

Place: SRM University

Date:

# **CONTENTS**

<b>Chapter No.</b>	<b>Title</b>	<b>Page No.</b>
	<b>LIST OF ABBREVIATIONS</b>	<b>vii</b>
	<b>LIST OF FIGURES</b>	<b>viii</b>
	<b>ABSTRACT</b>	<b>x</b>
<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1. Objective	<b>1</b>
	1.2. Motivation	<b>1</b>
	1.3. Implementation	<b>2</b>
	1.4. The brain actuated wheelchair	<b>3</b>
	1.5. Advantages	<b>4</b>
	1.6. Disadvantages	<b>4</b>
	1.7. Applications	<b>4</b>
<b>2</b>	<b>PRINCIPLES OF ELECTROENCEPHALOGRAM</b>	<b>5</b>
	2.1. The nature of EEG signals	<b>5</b>
	2.2. 10-20 system of Electrode placement	<b>6</b>
	2.3. Working of EEG	<b>7</b>
	2.4. Source of EEG activity	<b>7</b>
	2.5. EEG wavegroups	<b>8</b>
	2.6. Comparison of the EEG wavegroups	<b>9</b>

<b>3</b>	<b>RMS BRAIN VIEW PLUS EEG-24</b>	<b>10</b>
	3.1. The device	<b>10</b>
	3.2. Experimentation	<b>11</b>
	3.3. Montages designed	<b>12</b>
	3.4. Pattern in the EEG waves	<b>13</b>
	3.5. Exporting the values in the MS Excel sheet	<b>17</b>
<b>4</b>	<b>MIND CONTROL DEVICE</b>	<b>19</b>
	4.1. Neurosky Mindwave Mobile Headset	<b>19</b>
	4.2. Neurosky technology	<b>19</b>
	4.3. Hardware	<b>20</b>
	4.4. Product Specifications	<b>20</b>
	4.5. The ThinkGear chip	<b>21</b>
	4.6. Technical Specifications	<b>22</b>
	4.7. eSense™ Meters	<b>22</b>
	4.8. Applications	<b>22</b>
<b>5</b>	<b>LABVIEW DRIVERS – NEUROSKY AND NI MYDAQ</b>	<b>24</b>
	5.1. Neurosky Driver	<b>24</b>
	5.1.1. Neurosky Brain Computer Interface	<b>24</b>
	5.1.2. Software required	<b>25</b>
	5.1.3. Supported Hardware	<b>26</b>
	5.2. NI myDAQ Driver	<b>26</b>

<b>6</b>	<b>LABVIEW FOR MEASURING AND PROCESSING THE BRAIN’S EEG SIGNALS</b>	<b>27</b>
	6.1. About LabVIEW	<b>27</b>
	6.2. NeuroFeedback through LabVIEW FP	<b>27</b>
	6.3. LabVIEW Program for the MindWave Mobile	<b>28</b>
<b>7</b>	<b>NI MYDAQ FOR H-BRIDGE DRIVEN DC MOTOR</b>	<b>32</b>
	7.1. Overview	<b>32</b>
	7.2. Purpose	<b>32</b>
	7.3. DC motor explanation	<b>32</b>
	7.4. H-Bridge explanation	<b>33</b>
	7.5. Set Up Hardware	<b>34</b>
	7.6. Software Instructions	<b>35</b>
	7.7. How it works	<b>35</b>
<b>8</b>	<b>ELECTRIC WHEELCHAIR</b>	<b>36</b>
<b>9</b>	<b>CONCLUSION</b>	<b>38</b>
	<b>REFERENCES</b>	<b>39</b>



## **LIST OF ABBREVIATIONS**

ALS	Amyotrophic Lateral Sclerosis
BCI	Brain Computer Interface
DAQ	Data acquisition
ECG	Electrocardiography
EEG	Electroencephalography
EMG	Electromyography
EOG	Electrooculography
IDE	Integrated Development Environment
IDIAP	Institut de Recherche Idiap, Research Institute
MND	Motor Neurone Disease
RMS	Recorders & Medicare Systems Pvt. Ltd.
SCI	Spinal Cord Injury
UART	Universal Asynchronous Receiver/ Transmitter
UI	User Interface
VI	Virtual Instrumentation

## LIST OF FIGURES

<b>Figure No.</b>	<b>Figure</b>	<b>Page No.</b>
1.1	Analysis of the cases of Paralysis and Spinal Cord Injuries	1
1.2	The mechatronic design of the brain-actuated wheelchair	3
2.1	A segment of a multichannel EEG of a subject performing a task	5
2.2	International 10-20 Electrode Placement	6
2.3	EEG electrodes placed on the scalp of subject	7
2.4	EEG Pattern recording	8
2.5	Comparison of Various Brain Waves	9
3.1	Brain View Plus (24-Channel EEG)	10
3.2	Main Screen of RMS SuperSpec EEG 2.1 ACQUISITION	11
3.3	The subjects being tested with various pre-set conditions	12
3.4	Setting up the BP Longitudinal Montage	13
3.5	Spike in the occipital channel O1 at 11:00	14
3.6	No change related to right signal at 11:30	15
3.7	The right signals gave a spark at 11:35	15
3.8	Stop signal not prominent at 12:00	16
3.9	Tools Menu in SS EEG 2.1 and the Export Data Dialog Box	17
3.10	The analysis of the left and right signals in the Excel format	18
4.1	The NeuroSky Mindwave Mobile device	19
4.2	Screenshot of the Brainwave Visualizer application	23
5.1	The Neurosky headset	24
5.2	Signal status for the Neurosky headset	25
5.3	VI Program to determine the Blink Strength	25
5.4	LabVIEW Neurosky Driver	26
5.5	NI ELVISmx Instrument Driver	26
6.1	The MindWave Mobile Tutorial to determine the measure of Attention	28

6.2	LabVIEW BD for the Neurosky data acquisition and verification	28
6.3	LabVIEW BD for the Neurosky data acquisition	29
6.4	LabVIEW BD for the Neurosky driver stop and direction set for wheelchair	29
6.5	LabVIEW BD for the Neurosky headset Blink Detection and Blink Strength	29
6.6	Front panels for the Raw EEG waves Function Node	30
6.7	LabVIEW FP & BD for the ThinkGear data logging using Call Library	30
6.8	LabVIEW BD for the ThinkGear Single Sample Raw EEG signal acquisition	31
6.9	LabVIEW BD for the ThinkGear Multiple Sample Raw EEG signal acquisition	31
7.1	Magnetic diagram explaining the operation of a simple two-pole DC motor	33
7.2	H-Bridge schematic designed in Multisim	34
7.3	Breadboard implementation of H-Bridge	34
7.4	Connecting the H-bridge for the controlling of the motors	35
8.1	The model of the wheelchair	37
8.2	LabVIEW FP for the motor control of the Wheelchair	38

## ABSTRACT

This project describes a non-invasive Brain-actuated Wheelchair which acquires the signals from various electrodes placed according to the International 10-20 electrode setup for Electroencephalograph (EEG). The brain signals are processed to determine the direction of the movement of the wheelchair. It has been shown that the patient is able to achieve EEG controlled cursor, limb movement, a prosthesis control and even has successfully communicated by means of a Brain-computer Interface (BCI). The signals are detected to observe the path to estimate the movement of the wheelchair. The specific signals have been observed for the sensing of the left and right directions. A very prominent disturbance has been observed in the signal from P3 and T5 electrodes for the left turn signal and a similar disturbance is observed for the P4 and T6 electrodes for the right turn signal. The work presented here mainly uses simple unipolar electrode to capture EEG from the forehead to build a control for electric wheelchairs through Bluetooth for paralyzed patients. We have normalized  $\beta$ ,  $\alpha$ ,  $\theta$  and  $\delta$  waves to construct two signals such as meditation and attention. Additionally, we can also extract the eye-blinking signals from BCI. Therefore, attention and eye-blinking signals can be collected as the control signals through a Bluetooth interface and an electrical interface is used for the electric wheelchair. Brain-computer interfaces (BCI) do not rely on muscular activity and can therefore provide communication and control for people with devastating neuromuscular disorders such as the amyotrophic lateral sclerosis, brainstem stroke, cerebral palsy and spinal cord injury.

# CHAPTER 1

## INTRODUCTION

### 1.1. OBJECTIVE

As a result of a variety of accidents or diseases such as a spinal cord injury (SCI) or amyotrophic lateral sclerosis (ALS), many people suffer from a severe loss of motor function. These people are forced to accept a reduced quality of life, depending on the care of other individuals. Even though useful human-computer interfaces based on speech or biometrics have been developed to communicate with computers, most of them are aimed at providing people without disabilities with more convenient or advanced means, while neglecting individuals with severe disabilities. Thus, the needs for a novel interface to help the disabled leading a more improved life have been addressed, and corresponding effort has also been made in the fields related to rehabilitation engineering and user interface (UI) development.

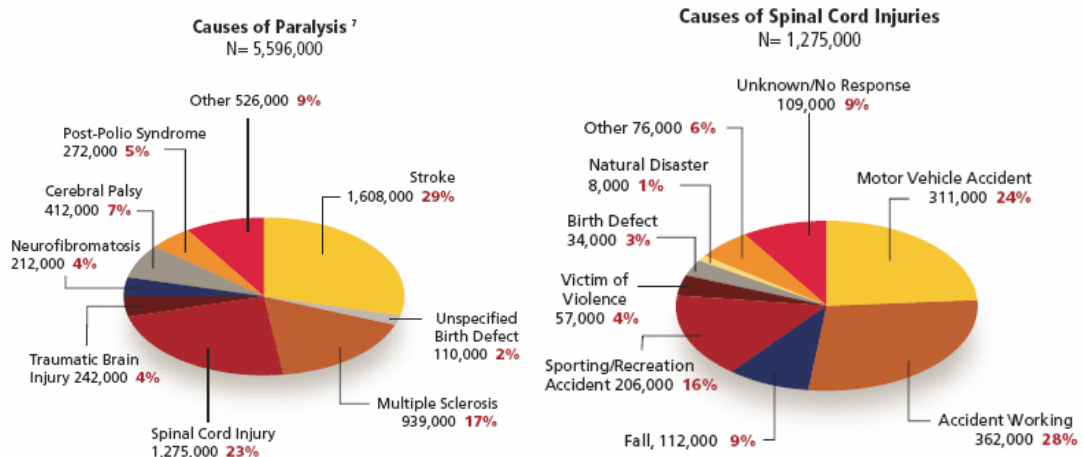


Figure 1.1: Analysis of the cases of Paralysis and Spinal Cord Injuries

### 1.2. MOTIVATION

The motivation of the EEG-controlled wheelchairs is to facilitate assistance in mobility in order to accomplish complex navigational tasks in realistic environments for the

paralyzed patients. It includes the development of automatic navigation strategies and personalized interactive assistance to enable the patients to move effectively and easily.

One attempt attracting considerable attention in those fields involves the utilization of bio-signals such as an electroencephalogram (EEG) or electromyogram (EMG); obtainable from the human body as a means for interaction with the surrounding world. In the field of brain-computer interface (BCI), meaningful information derived directly from a user's brain activity has been used to manipulate systems. However, despite the definite advantage unique to EEG signals that allows a system to be controlled only by one's thoughts, the poor signal-to-noise ratios in the spontaneous EEG signals and the lack of consistency in the signal patterns still make their application impractical.

### **1.3. IMPLEMENTATION**

The brain waves have a tendency to react to any stimuli provided but the amount of change of the microvolt acquired from the EEG varies in each and every individual. The only similarity in the signals is the section of the brain which responds to the similar kind of stimuli. All these waves also have an inter dependency as the transfer of the signals are observed by the neurons and every neuron sends the data to every other neuron in its neighbour and finally the shortest possible route to that part of the brain is decided and followed.

Recently there has been a large impulse on the research and development of brain-controlled devices for rehabilitation. Following the brain-actuated robot control, there have been some attempts to develop a brain-actuated wheelchair. Some devices follow the clinical protocol where the EEG signals are synchronized with external cues, using one of the common event-related potentials (Evoked potentials in the human brain associated with external stimuli). For example, the wheelchair concept developed jointly by Leuven and IDIAP. This device was based on an asynchronous protocol that analyses on-going EEG activity to determine the subject's mental state, which can change at any time. The system deciphers the subject's steering directions (forward, right and left) and uses an obstacle avoidance system that executes the navigation.

## 1.4. THE BRAIN ACTUATED WHEELCHAIR

The project is an improvement done to the already present brain-actuated wheelchair. The impression of this chair is the quick fixation of the headset to the person's head and the connection through the Bluetooth allowing free movement with respect to a computer or LabVIEW module fixed onto the wheelchair. LabVIEW software provides an easy software making and supports in the controlling of the wheels of the wheelchair. The main modules and the information flow among them are given in Figure 1.2.

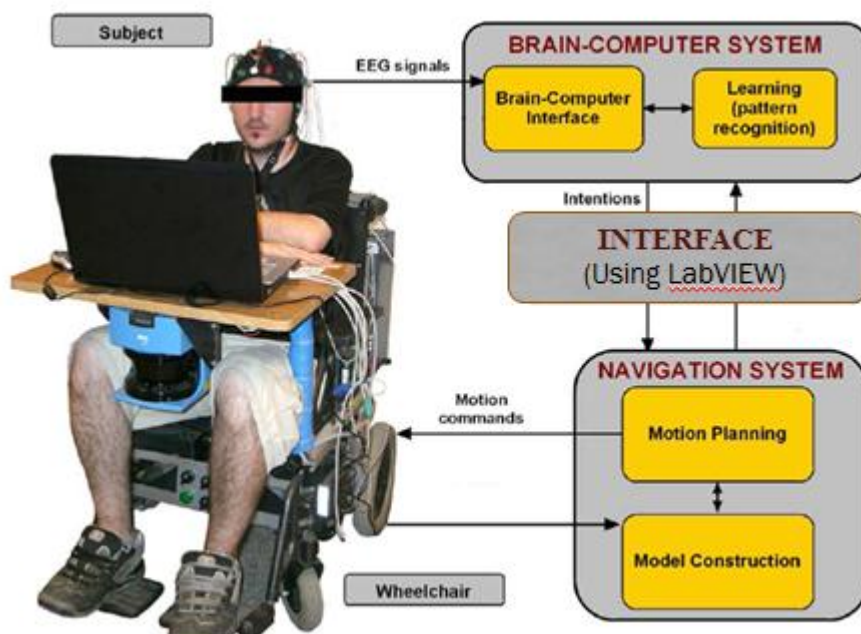


Figure 1.2: The mechatronic design of the brain-actuated wheelchair

The simple construction of the setup allows the voltages from the electrodes to be read by the EEG setup and the corresponding values to be displayed on the computer. The data can directly be sent to LabVIEW software where the values are manipulated according to the requirements and then the coding is done to interface the wheelchair with respect to the signals acquired. The navigation system finalises on the functioning of the motors and selects the control using the software.

In this paper, we proposed a novel and simple technology incorporate interactivity value in a wireless BCI system and a drive circuit to control the electric wheelchair. In the

proposed BCI system, it has a compact size with low power consumption. And, the proposed BCI system allows human and machine to communicate easily and supplies real-time to translate brain and eye-blinking waves to commands of the drive circuit like “turn direction”, “moving forward”, or “stop” to control the wheelchair.

### **1.5. ADVANTAGES**

- The wheelchair without the tiresome turning of the wheels is a simple step ahead of the electric wheelchairs.
- It may prove beneficial for every individual for locomotion purposes without the need of manual labour.
- The simultaneous EEG acquisition may detect any substantial improvement in the condition of the body.

### **1.6. DISADVANTAGES**

- The fixing of the electrodes must be done before any further course.
- The mental state must be stable at all times.
- Some training is must before it is fully efficient and used for practical purposes.

### **1.7. APPLICATIONS**

- The developments in the field of brain-computer interface are a juvenile step towards the improvements of the wheelchair.
- The wheelchair controls only 2 wheels whereas the same condition may be used to drive a car with 4 wheels.
- The functionality of the brain can be used to trounce many other manual works at industries as well as at house-hold levels.
- The day-to-day gadgets may be evolved to work using mind waves.



## CHAPTER 2

### PRINCIPLES OF ELECTROENCEPHALOGRAM

Electroencephalography (EEG) is the measurement of electrical activity produced by the brain as recorded from electrodes placed on the scalp. Just as the activity in a computer can be perceived on multiple different levels, from the activity of individual transistors to the function of applications, so can the electrical activity of the brain be described on relatively small to relatively large scales. At one end are action potentials in a single axon or currents within a single dendrite, and at the other end is the activity measured by the scalp EEG.

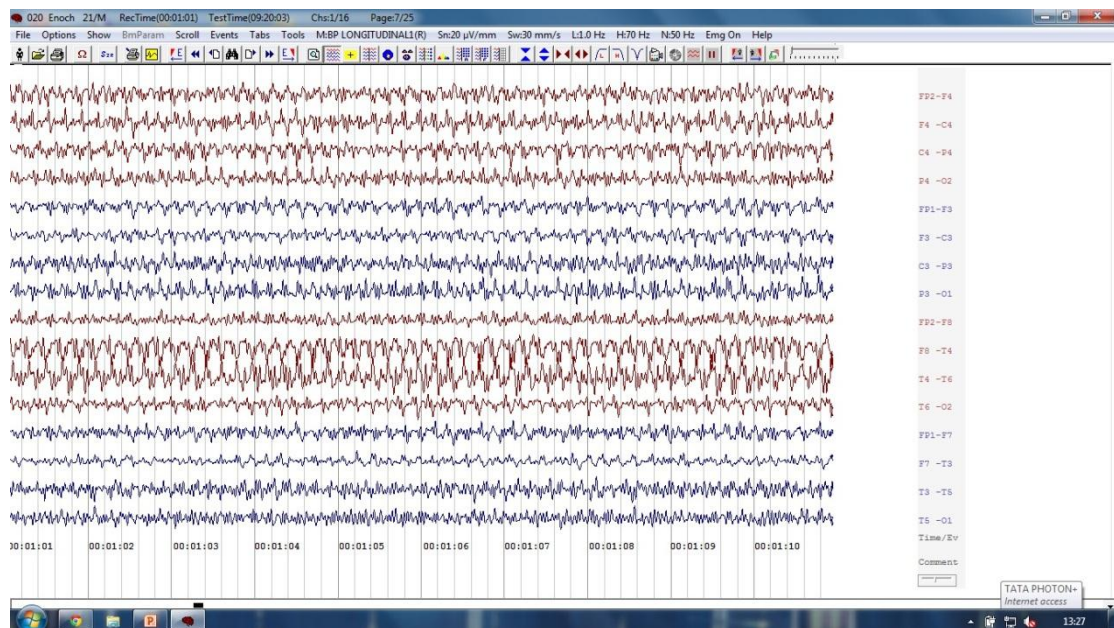


Figure 2.1: A segment of a multichannel EEG of a subject performing a task

#### 2.1. THE NATURE OF THE EEG SIGNALS

The electrical nature of the human nervous system has been recognized for more than a century. It is well known that the variation of the surface potential distribution on the scalp reflects functional activities emerging from the underlying brain. This surface potential variation can be recorded by affixing an array of electrodes to the scalp, and measuring the voltage between the pairs of these electrodes, which are then filtered,

amplified and recorded. The resulting data is called the EEG. Figure 2.1 shows waveform of a 10 second EEG segment containing 24 recording channel pairs when the subject was asked to close his eyes first and then open his eyes, thus we have two spikes and these waveforms can be processed and used in switching applications like switching the lights OFF and ON.

## 2.2. 10-20 SYSTEM OF ELECTRODE PLACEMENT

The electrode locations and names are specified by the International 10-20 system as shown in Figure 2.2 for most clinical and research applications.

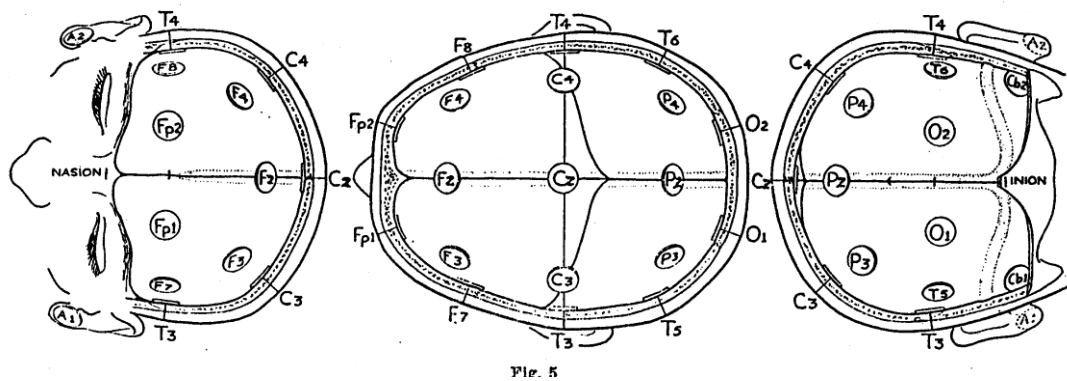


Figure 2.2: International 10-20 Electrode Placement

The “10-20” system is a widely used method to describe the location of scalp electrodes in the context of an EEG experiment. This system is based on the relationship between the location of an electrode and the underlying area of cerebral cortex. The “10” and “20” refer to the fact that the actual distances between adjacent electrodes are either 10% or 20% of the total front-back or right-left distance of the skull. Each site has a letter to identify the lobe and a number to identify the hemisphere location. The letters F, T, C, P and O stand for Frontal, Temporal, Central, Parietal and Occipital respectively. Note that there exists no central lobe; the “C” letter is only used for identification purposes only. A “z” refers to an electrode placed on the midline. Even numbers (2, 4, 6, and 8) refer to electrode positions on the right hemisphere, whereas odd numbers (1, 3, 5, and 7) refer to those on the left hemisphere.

### 2.3. WORKING OF EEG

Modern EEG acquisition techniques collect the underlying electrical patterns from the scalp and digitize them for computer storage. Electrodes conduct voltage potentials as microvolt level signals, and carry them into amplifiers which magnify the signals approximately ten thousand times. The use of this technique depends mainly on electrodes positioning and electrodes contact, thus electrodes are generally constructed from conductive materials like gold and silver chloride, with a diameter of approx. 1cm. The subjects must use a conductive gel on the scalp to maintain an acceptable signal to noise ratio.



Figure 2.3: EEG electrodes placed on the scalp of subject

The Figure 2.3 shows the experiment being carried out with a subject. The electrodes are placed on the scalp with the conductive gel.

### 2.4. SOURCE OF EEG ACTIVITY

Scalp EEG measures summated activity of post-synaptic currents. While it is post-synaptic potentials that generate the EEG signal, it is not possible to determine the activity within a single dendrite or neuron from the scalp EEG. Rather, surface EEG is the summation of the synchronous activity of thousands of neurons that have similar spatial orientation, radial to the scalp. Currents that are tangential to the scalp are not picked up by the EEG. The EEG therefore benefits from the parallel, radial arrangement of apical dendrites in the cortex.

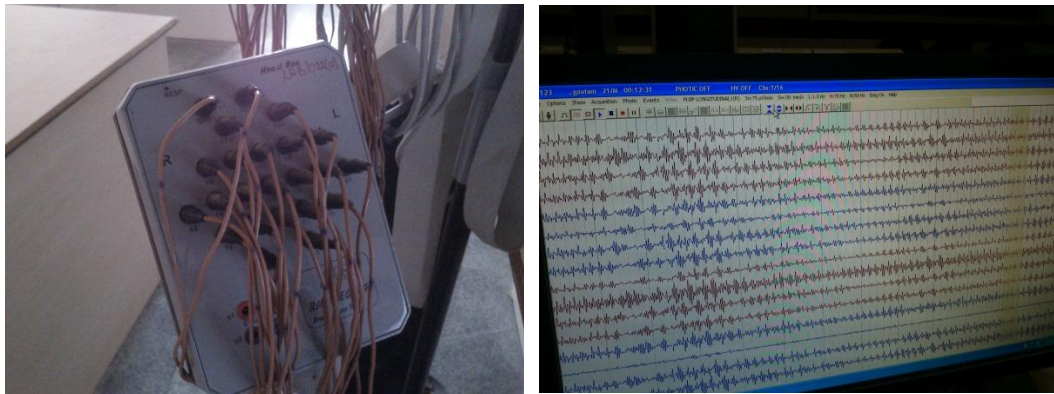


Figure 2.4: EEG Pattern recording

## 2.5. EEG WAVEGROUPS

Specific brain wave frequency ranges can be associated with mood or thought patterns.

- Delta: 1-4 Hz. The slowest waves are delta waves which occur when we are in deep sleep.
- Theta: Frequencies below 8 Hertz are considered theta waves. While these seem to be some of the least understood frequencies, they also seem to be associated with creative, insightful thought. When an artist or scientist has the "aha" experience, there's a good chance he or she is in theta.
- Alpha: Alpha frequencies are from 8 to 12 Hertz and are commonly associated with relaxed, meditative states. Most people are in an alpha state during the short time immediately before they fall asleep. Alpha waves are strongest during that twilight state when we're half asleep and half awake.
- Beta: Beta frequencies (above 12 Hertz) coincide with our most "awake" analytical thinking. If you are solving a math problem, your brain is working at beta frequencies. Most of our waking hours as adults are spent in the beta state.
  - Beta 1 : 13 – 20 Hz, Perception, Thinking, Mental Activity
  - Beta 2 : 20 – 30 Hz, Tension, Anxiety, Excitement
- Mu: 8 – 12 Hz. These waves diminish with movement or the intention to move. They are located in the sensory motor cortex.
- Gamma: 26 – 100 Hz. These waves come in a stream of consciousness. These are located in prefrontal cortex and left temporal lobe.

## 2.6. COMPARISON OF THE EEG WAVE GROUPS

Type of wave	Location	Frequency	Normal state
Delta	Frontally in adults, posterior in children	0.5 – 4 Hz	Deep sleep, Coma
Theta	Temporal cortex	4 – 8 Hz	Trance, Dreams
Alpha	Posterior regions of head, both sides, higher in amplitude on dominant side. Central sites (C3 – C4) at rest.	8 – 13 Hz	Relaxation with eyes closed but still awake
Beta	Frontally evident on both sides, symmetrical distribution	13 – 30 Hz	Beta 1 : 13 – 20 Hz Perception, Thinking, Mental Activity

Table 2.1: Comparison of various EEG waveforms

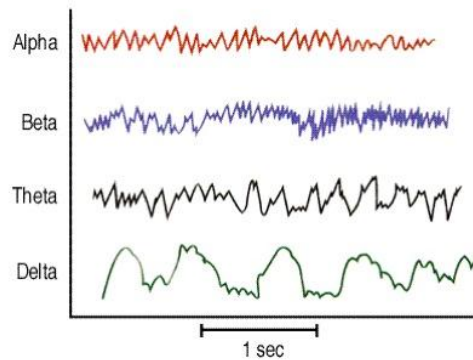


Figure 2.5: Comparison of Various Brain Waves

## CHAPTER 3

### RMS BRAIN VIEW PLUS EEG-24

#### 3.1. THE DEVICE

Most of the Neurological divisions and Diagnostic Centre are equipped with this reputed & reliable EEG acquisition device of the manufacturer model RMS BRAIN VIEW PLUS EEG 24 CH (Video) Machine (PC-based). The highlight of the unit is to record the electrical activity of the Brain and analysis operable for neurological disorders. All the signal conditioning is done in the Adaptor box of the unit. The use of this diagnostic technique has proved to be very helpful in studying epilepsy and convulsive disorders and in localizing lesions in the cerebrum.



Figure 3.1: BRAIN VIEW PLUS (24-Channel EEG)

This device has the following features:

- Simultaneous data acquisition and analysis of the same patient
- Unlimited online and offline montage and filter reformatting
- Brain mapping with advanced features
- Event marking with review and printing options
- EEG synchronous Video Recording (optional)
- Also available in portable model



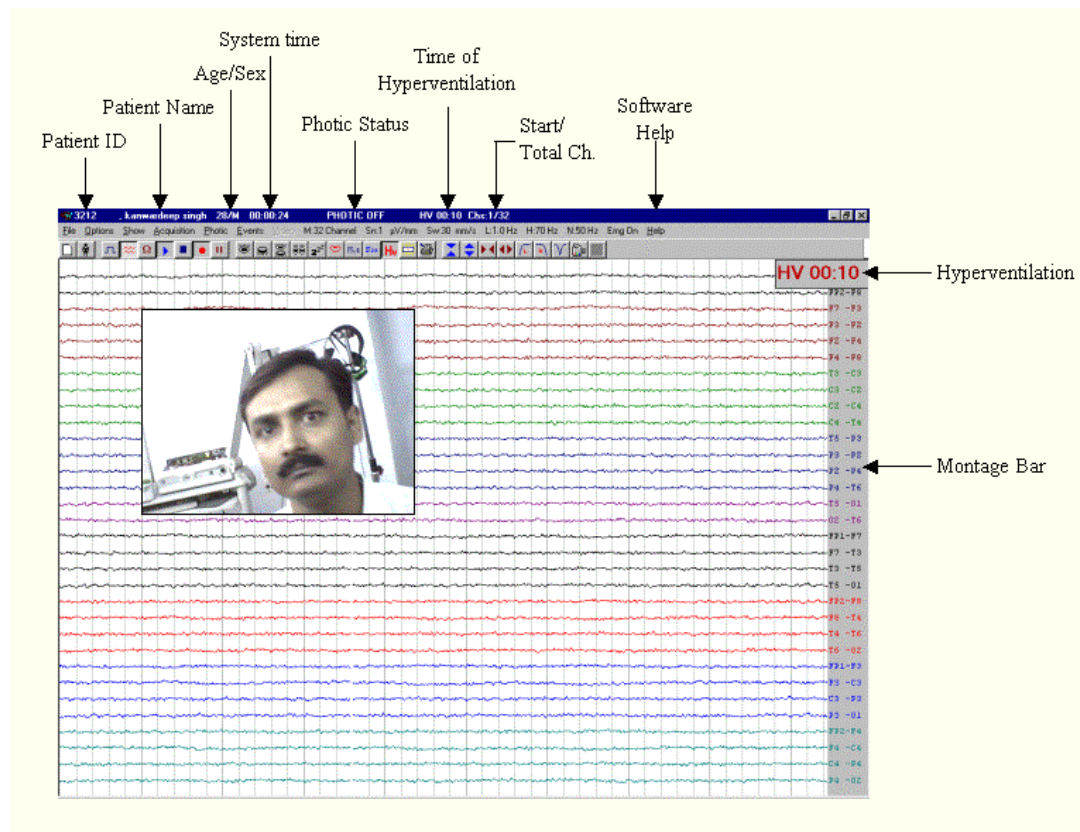


Figure 3.2: Main Screen of RMS SuperSpec EEG 2.1 ACQUISITION

### 3.2. EXPERIMENTATION

- In a research project the most important part is the experimentation and the analysis of the results. In this project, we intended to conduct initial experiments, tests to read the brain generated electrical waves due to the electrical activity which can be measured non-intrusively using an EEG.
- The work space provided for experimentation was well in accordance with the required work environment. The work space where we conducted the experiments was a free and un-congested space, it had Clean, Fresh-air supply, it was designed completely noise proof and during experimentation we had very little or no external disturbance such as creaking floors, squeaking doors etc.
- For the purpose of conducting these experiments, test and conducting training sessions; we had three test subjects.

- Mr. Gautam Vaid, 21, a healthy male who is really inquisitive and intelligent. He is a computer science student with a great love for music, problem solving and has a passion to do research. He also has a very good English vocabulary and is a voracious reader.
- Mr. Phani Teja, 21, an all-round sportsperson who is very enthusiastic about his passions. He loves to dance and is an active participant in many cultural activities.
- Mr. Amoatey Enoch Tetteh, 25, is a football player and is passionate about imparting knowledge. He became a clear subject with the Nigerian accent and giving the test a foreign exposure as well.
- We came to know the above mentioned information about them after having a series of conversations with them analysing their psychological backgrounds
- The test carried out was a normal experiment with EEG to read the various waveforms, their patterns and changes caused by the change in thoughts of direction change or the movement of the eye in that particular direction.



Figure 3.3: The subjects being tested with various pre-set conditions

### 3.3. MONTAGES DESIGNED

- Since an EEG voltage signal represents a difference between the voltages at two electrodes, the display of the EEG for the reading encephalograph may be set up in one of several ways. The representation of the EEG channels is referred to as a *montage*. When EEGs are used, we switch between montages during the recording in order to highlight or better characterize certain features of the EEG.



- We used the SuperSpec EEG software to select the montages –
- The class of montage is designated as follows: longitudinal bipolar (LB), transverse bipolar (TB), or referential (R). (Bipolar derivations are also sometimes called “differential”). The numeral to the left of the point indicates the number of channels. Montages are designed for 16, 18, and 20 channels.

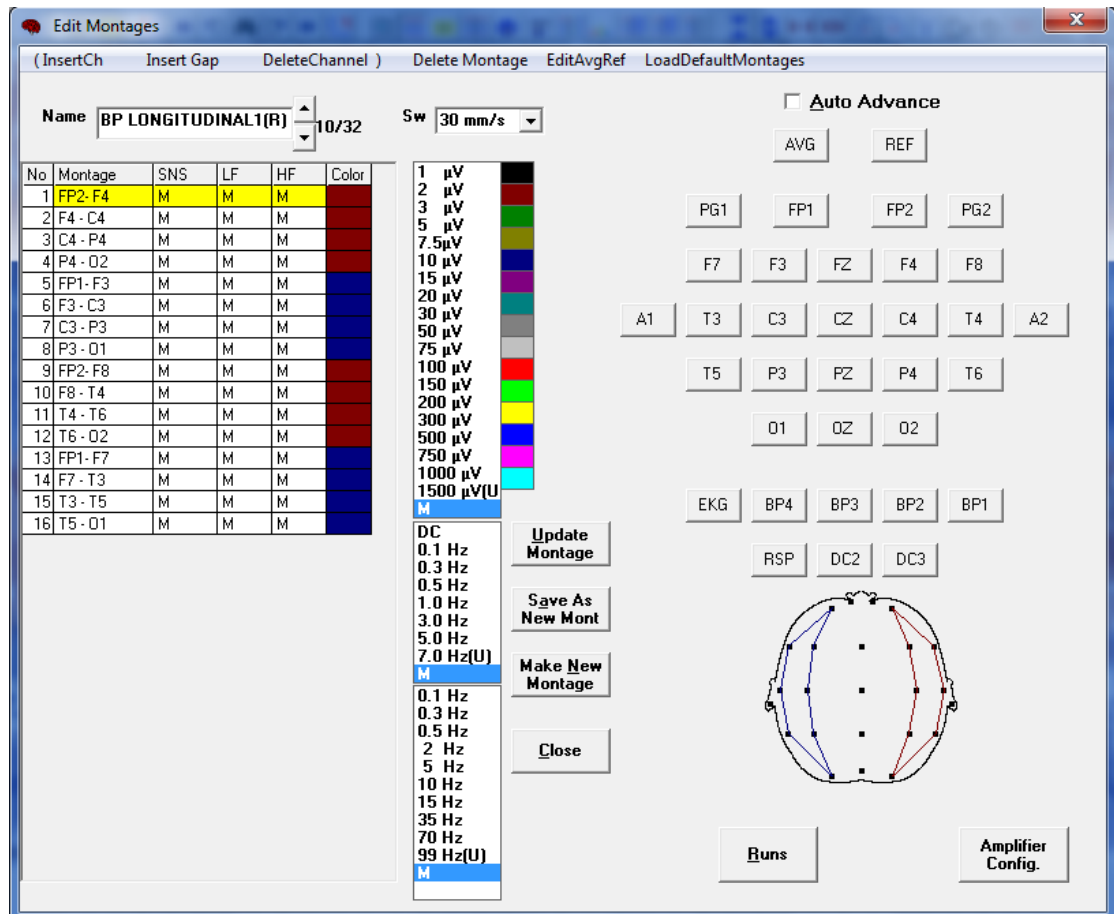


Figure 3.4: Setting up the BP Longitudinal Montage

### 3.4. PATTERN IN THE EEG WAVES

- The EEG waves seem to be having a particular pattern in case of each electrode. Each of the electrodes has a share in the representation at an instant of time. An experiment done with one electrode at a time shows that all other electrodes except the one in use have almost the same values only with little variations.

- The next sets of experiments were an attempt to find out the patterns in the waveforms from various channels. This was done by determine the change in the selected channel at any particular instant.
- The subject was firstly told to only think about a particular direction for 30 seconds and switch his thoughts to the other direction after the time interval.
- This criterion didn't turn as good condition for the detection of the signals.
- The subject was then told to turn his eye in the direction such that he looks in the direction in which he wants to move.
- The following curves were observed when the subject changed his eye direction in the desired pattern of 30 seconds each.
- The signals generated are not prominent when the subject is told only to think about a particular direction, say, left or right. But the waves produced gave an exclusive variation when the subject thinks about a particular direction and concentrates onto an image of the same direction placed in front of him.

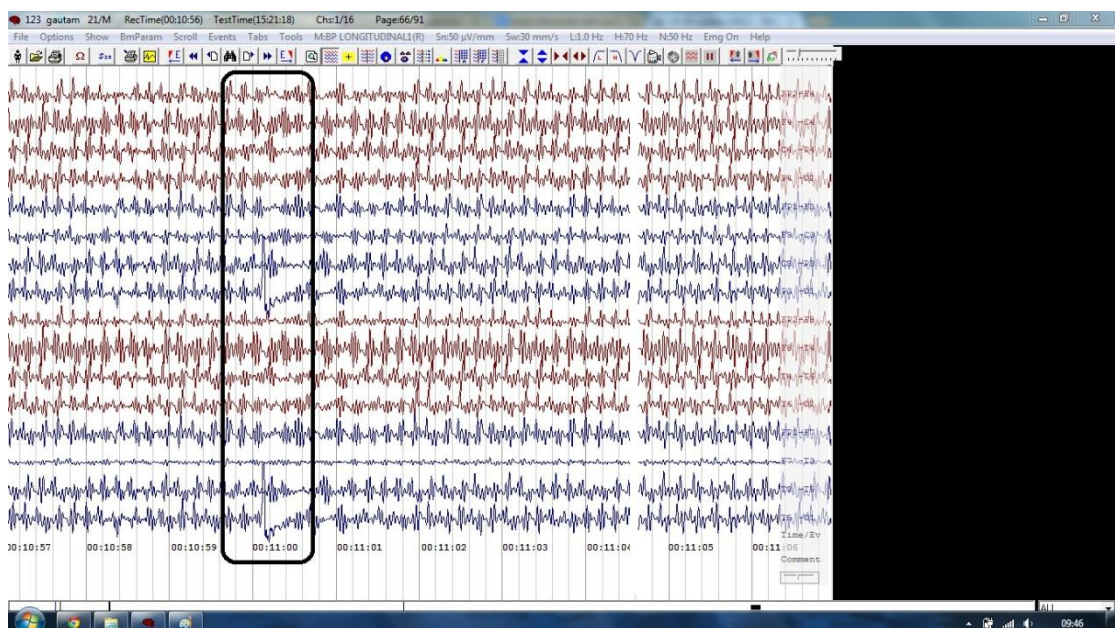


Figure 3.5: Spike in the occipital channel O1 at 11:00

- A very distinguishable and prominent change in the left side occipital node is observed when the person switches his eyes towards the left side. There is no other noticeable change in any of the other electrodes.

- The same spike is seen in both the graphs of the O1 electrode and the odd numbers clearly indicate that the change is observed only in the left side of the brain.

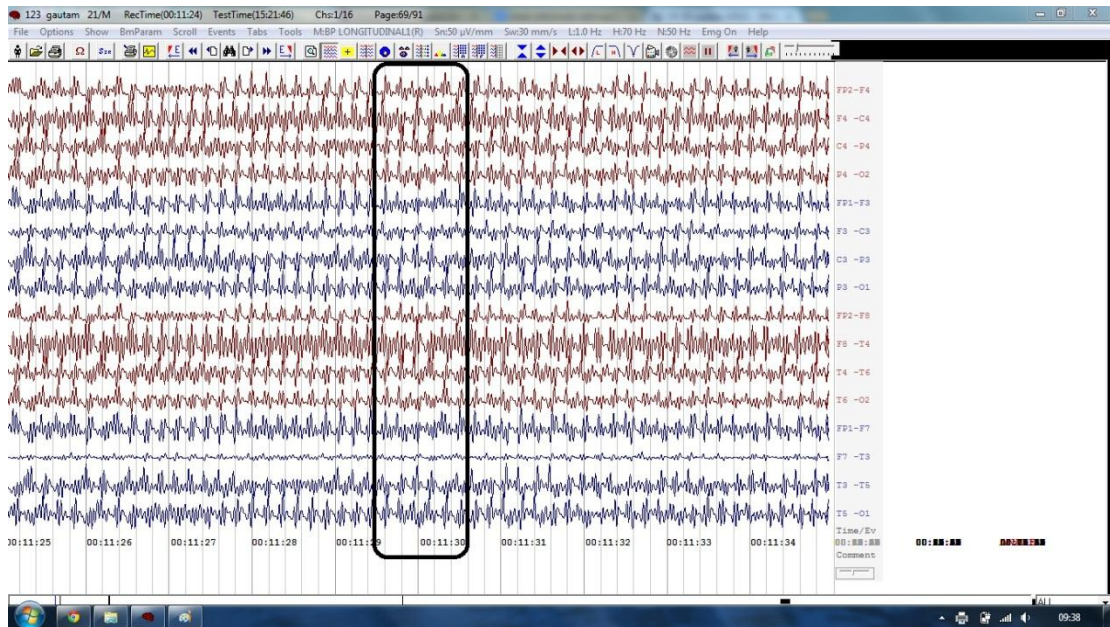


Figure 3.6: No change related to right signal at 11:30

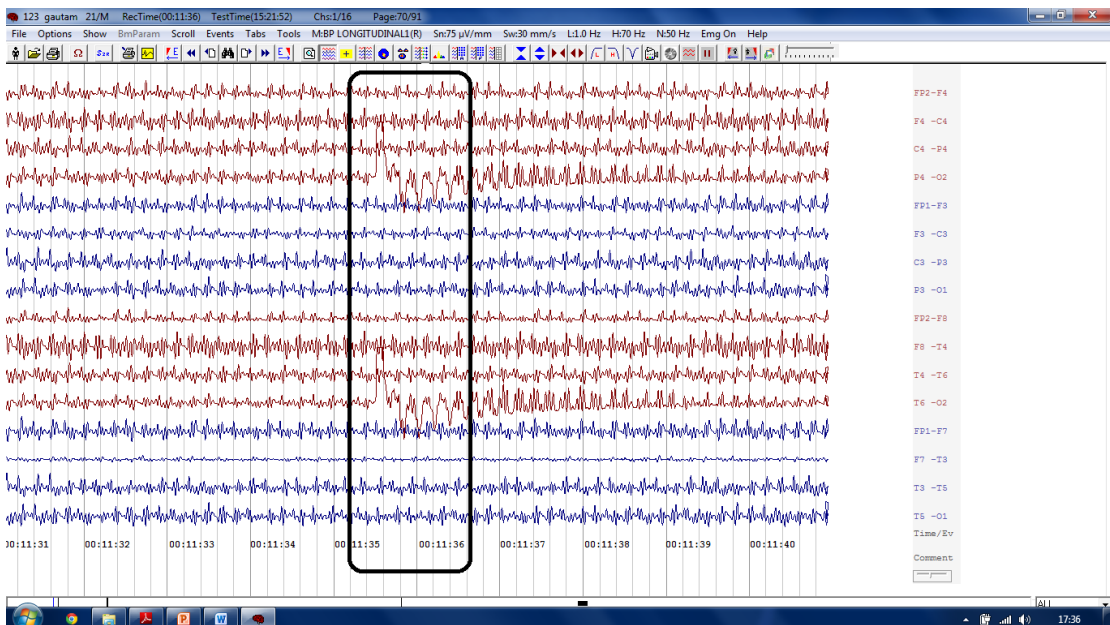


Figure 3.7: The right signals gave a spark at 11:35

- Unlike the left signals observed at 11:00, there is no distinguishable spike or mark witnessed at 11:30.
- All of them seemed to remain at the same conditions with no special characteristics.
- At about 5 seconds after the subject had been told to change his eye direction, there was a distinct change in the right occipital nodes, O2. The graph can easily be seen as a special instant to note the right signals.
- These signals didn't provide just a jerk but it dropped down to normal gradually only. They may not be used exactly the same way as the left occipital nodes.

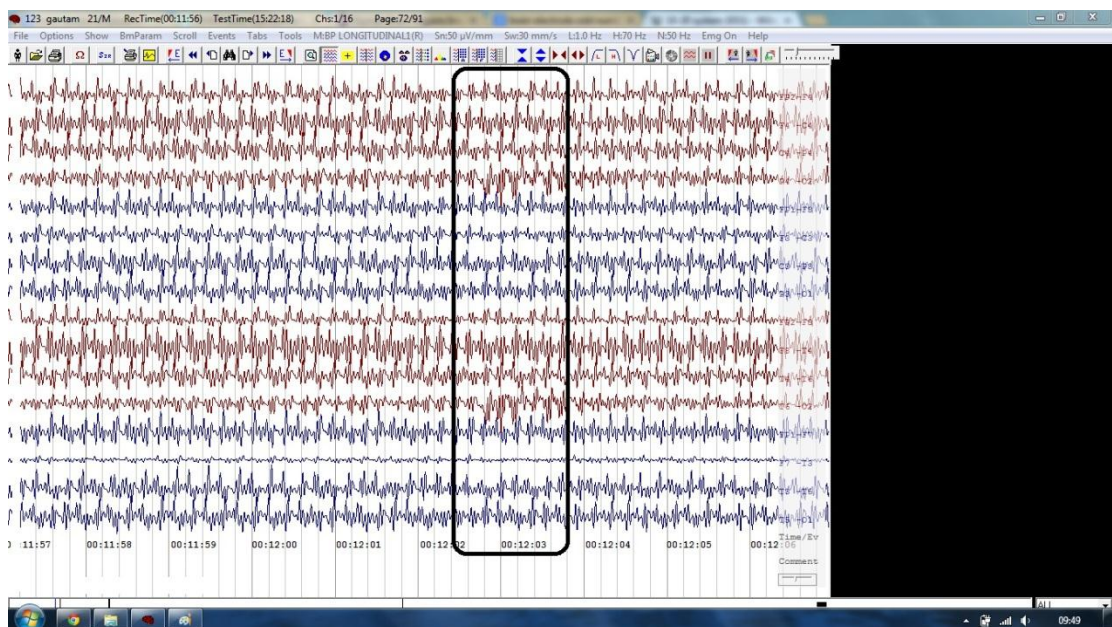


Figure 3.8: Stop signal not prominent at 12:00

- The stop signal didn't assure a very prominent signal and became a threat to the project as a STOP is definitely needed when a subject wants to stop the wheelchair.
- Thus, these cannot be used as a useful effort for the wheelchair to perform successfully.



### 3.5. EXPORTING THE VALUES IN THE EXCEL SHEET

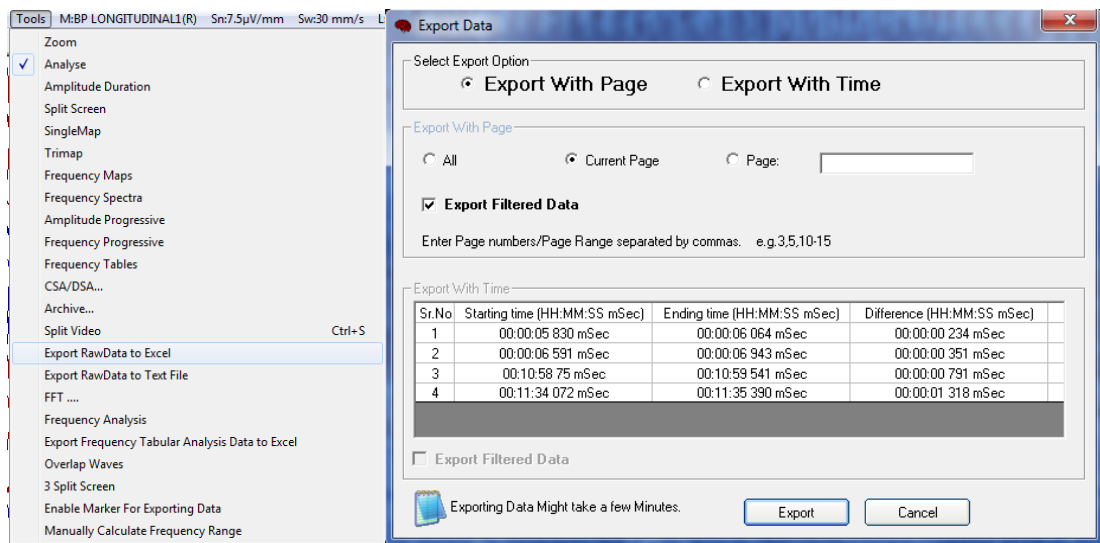


Figure 3.9: Tools Menu in SS EEG 2.1 and the Export Data Dialog Box

- The SuperSpec EEG 2.1 software allows the user to transfer its data from the electrode values to Microsoft Excel.
- This can be done only when the values have already been stored by ACQUIRE.
- The ANALYSE can be done in real-time with the ACQUIRE but the exporting needs to have the file stored in .eeg format.
- This type of .eeg file cannot be read by any other EEG file reader.
- All the values are stored in an .eeg file and a corresponding .tdms file is created along with other .dat files.
- This Excel sheet can easily be read by LabVIEW and configured for the respective values obtained in the occipital nodes.
- Once the data is saved, this software allows the transfer of the values from the tools menu.
- This is a disadvantage as it creates a time-lag due to the manual saving of the file into the Excel sheet
- All the results obtained from the RMS proved a very successful experiment to observe the direction signals yet the condition of the time-lag proved a hindrance for the wheelchair.
- The outputs of the EEG signals already observed are given in the next page.

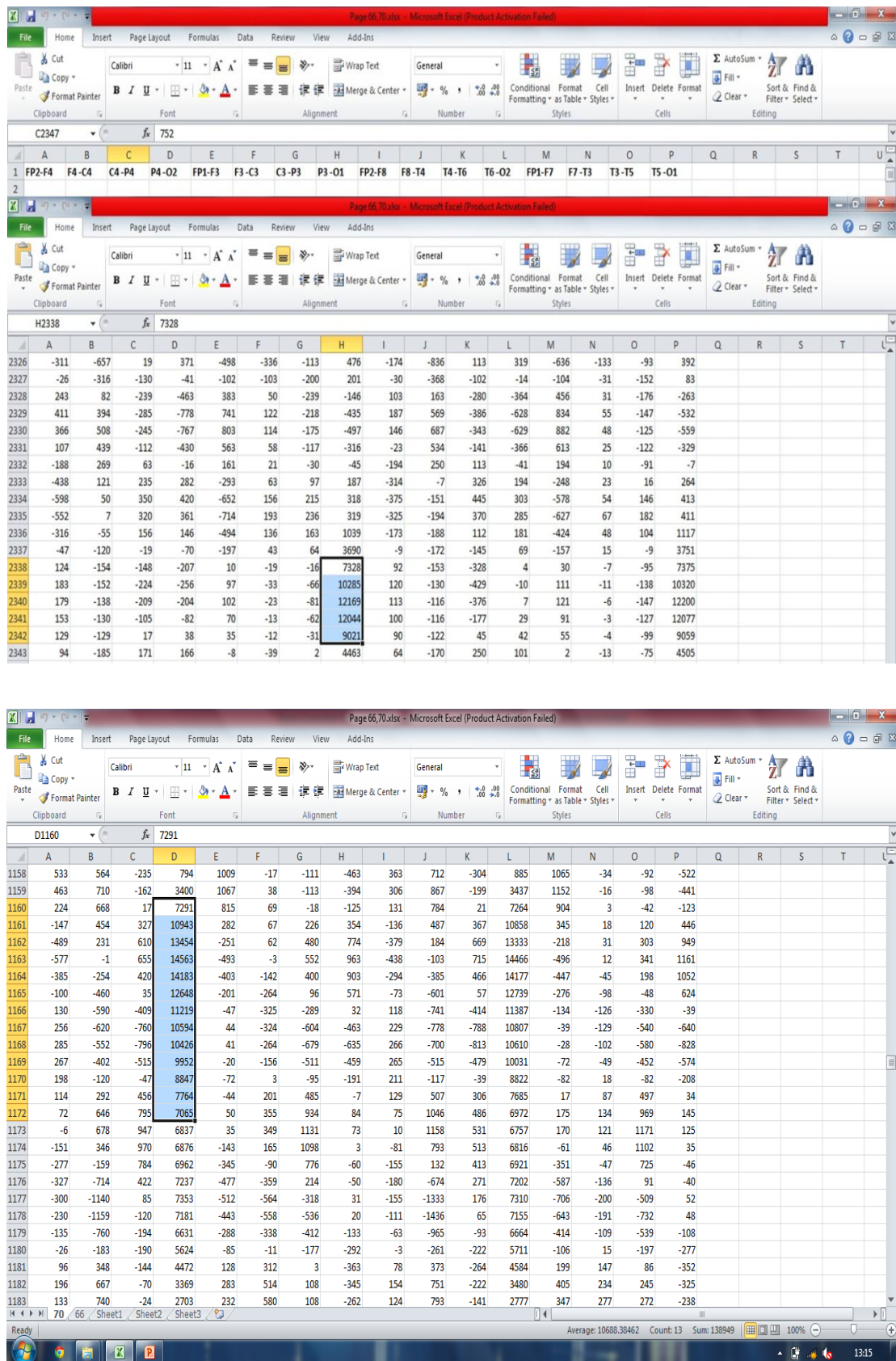


Figure 3.10: The analysis of the left and right signals in the Excel format

## **CHAPTER 4**

### **MIND CONTROL DEVICE**

#### **4.1. NEUROSKY MINDWAVE MOBILE HEADSET**



Figure 4.1: The NeuroSky Mindwave Mobile device

NeuroSky is a company that has developed advanced ASICs for acquiring electroencephalography (EEG), simplifying the challenge of adding EEG to instruments and products for education or even entertainment. NeuroSky has several headsets for sale featuring their ThinkGear chip that acquire EEG through a single dry sensor electrode. The major advantage of the Neurosky headsets are the quick and easy setup - put the headset on like a pair of headphones and you are ready to go. Traditional gel bases EEGs can take up to 30 minutes to start acquiring data while the NeuroSky headsets are ready to go in seconds.

#### **4.2. NEUROSKY TECHNOLOGY**

Your brain is constantly producing electrical signals while it operates, as the cellular components of the brain (neurons) communicate with each other. At a macro scale, they produce a range of frequencies that scientists have found related to particular mental states. For example, a sleeping person's brain produces an abundance of delta waves,

whereas an alert and awake person concentrating hard on something will produce far more beta waves.

The Mindwave headset picks up the brain's electrical activity and divides the signal by frequency into various types of waves, allowing it to infer the mental state. For the most of the non-scientific apps however, it primarily reads how relaxed (as measured by alpha/theta waves) or concentrated (as measured by beta/gamma waves) the user is.

### **4.3. HARDWARE**

The Mindwave headset is a slim, matte black/light blue plastic device which fits comfortably, if not unobtrusively, over the left ear. The primary sensor sits on your forehead pretty comfortably, although it will take a minute or two to adjust it the first time one puts it on. The ear clip is likewise pretty comfortable, and the whole apparatus has the advantage of easily allowing one to wear over-ear headphones at the same time if he so chooses.

It connects via Bluetooth to any device, and works with most modern operating systems (Windows XP or newer, Mac OS X 10.6.5 or newer) and mobile devices running android or iOS. Its battery life is rated at 8-10 hours with a single AAA battery.

### **4.4. PRODUCT SPECIFICATIONS**

- A great introduction to brain-computer interface
- Works with iOS and Android mobile devices as well as Mac & PC
- Headset safely measures and outputs the EEG power spectrums, eSense meters (attention/meditation), and eye blinks
- Grounds via an ear clip; sensor arm rests on the forehead above the eye (FP1 position)
- MindWave Mobile
  - Uses the TGAM1 module
  - Automatic wireless pairing
  - Single AAA Battery
  - 8-hours battery run time



- Bluetooth v3.0 Class 2 (10 meters range). Bluetooth dongle not included.
  - Static Headset ID (headsets have a unique ID for pairing purposes)
  - iOS and Android support
- Measures
  - Raw-Brainwaves
  - Processing and output of EEG power spectrums (Alpha, Beta, etc.)
  - Processing and output of NeuroSky proprietary eSense meter for Attention, Meditation, and other future meters
  - EEG/ECG signal quality analysis (can be used to detect poor contact and whether the device is off the head)
- Physical
  - Weight: 90g
  - Sensor arm up: height: 225mm x width: 155mm x depth: 92mm
  - Sensor Arm down: height: 225mm x width: 155mm x depth: 165mm
- Bluetooth
  - BT Version: 3.0
  - BT Output Power: Class 2
  - BT Minimum Voltage: 1.0V
  - BT Range: 10m range
  - BT Power Consumption: 80mA (when connected and transmitting)
  - Low Battery Indicator 1.1V
  - UART(Serial): VCC, GND, TX, RX
  - UART Baudrate: 57,600 Baud

## 4.5. THE THINKGEAR CHIP

The stainless alloy dry sensor collects neural signals, inputting them into our ThinkGear chip, which processes the signal into a usable data stream. A monumental hurdle lies in distinguishing brain signal from the noise that comes from ambient electricity, muscle movement, etc. Such interferences are digitally filtered. Raw brain signals are amplified and processed—delivering concise input to the device. Emotional state algorithms, coded within the chip memory, come from both NeuroSky as well as research

institutions and universities. NeuroSky technology accurately measures brainwaves today, but is busy in labs throughout the world advancing development in new biosensor areas of emotional Electroencephalogram (EEG), Electromyogram (EMG), Electro-Oculogram (EOG) and Electrocardiogram (ECG).

## **4.6. TECHNICAL SPECIFICATIONS**

The ThinkGear TGAM1 ASIC module is a chip that can integrate into any BCI form factor. The TGAM1, which includes the TGAT ASIC, is 2.79cm x 1.52cm x 0.25cm, weighs 130mg and communicates its output through a UART interface at configurable baudrates of 1200, 9600 or 57600. Products such as Mattel's Mindflex and Star Wars Force Trainer use the TGAM1.

## **4.7. eSENSE™ METERS**

For all the different types of eSenses (i.e. Attention, Meditation), the meter value is reported on a relative eSense scale of 1 to 100. On this scale, a value between 40 and 60 at any given moment in time is considered “neutral. A value from 60 to 80 is considered “slightly elevated”, and may be interpreted as levels being possibly higher than normal (levels of Attention or Meditation that may be higher than normal for a given person). Values from 80 to 100 are considered “elevated”, meaning they are strongly indicative of heightened levels of that eSense.

An eSense meter value of 0 is a special value indicating the ThinkGear is unable to calculate an eSense level with a reasonable amount of reliability. This may be (and usually is) due to excessive noise as described in the POOR\_SIGNAL Quality section above.

## **4.8. APPLICATIONS**

The Mindwave's responsiveness is pretty impressive, even to fairly subtle mental/emotional states. This is fairly apparent even in the tutorial, but becomes most obvious in one of the simplest app bundled with the headset, the Brainwave Visualizer. We noted that concentration in particular responds immediately and obviously to mental

distractions; even something as simple as turning away for a moment to check the time, or look around for the source of a noise behind you is pretty clearly reflected in concentration as the Mindwave measures it.



Figure 4.2: Screenshot of the Brainwave Visualizer application

## CHAPTER 5

### LabVIEW Drivers – Neurosky and NI myDAQ

#### 5.1. NEUROSKY DRIVER

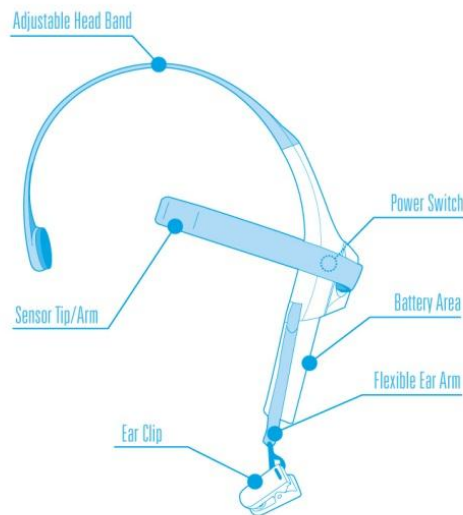


Figure 5.1: The Neurosky headset

##### 5.1.1. NeuroSky Brain Computer Interface

NeuroSky develops low cost easy to use ASICs for acquiring electroencephalography (EEG) from users through a wireless headset. The major advantage of the dry sensor is the time it takes to set up. Traditional gel bases EEGs can take up to 30 minutes to start acquiring data while the NeuroSky headsets are ready to go in seconds. The disadvantage to the dry sensor electrodes is an increase in the impedance contact the sensor has with the scalp. This can cause low amplitude signals to not be fully represented in the acquired data.

A LabVIEW - NeuroSky Driver has been developed that allows users to easily acquire data and access the full functionality of the system level driver provided by NeuroSky.

NeuroSky provides a dynamic linked library (DLL) with a set of functions written in C that access the virtual com port that runs with the headset. Instead of accessing the

specific DLL functions, LabVIEW users can now use the LabVIEW - NeuroSky Driver to easily access data from the NeuroSky driver in minutes.



Figure 5.2: Signal status for the Neurosky headset

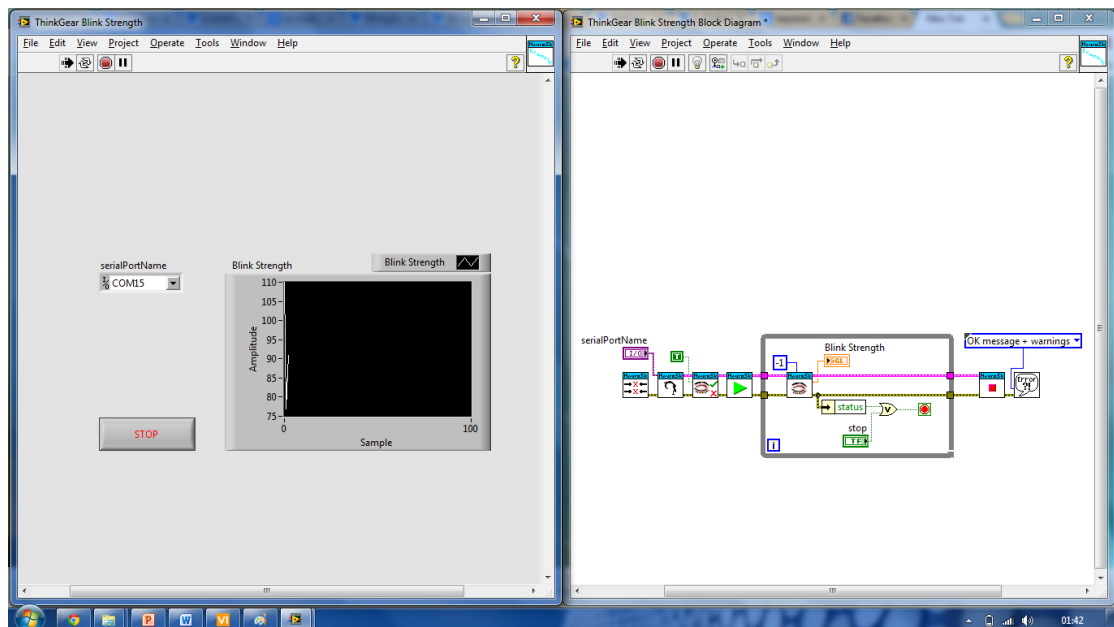


Figure 5.3: VI Program to determine the Blink Strength

### 5.1.2. Software Required:

- LabVIEW 2010 or above
- VI Package Manager by JKI
- LabVIEW - NeuroSky Driver for LabVIEW
- NeuroSky driver included with the headset

### 5.1.3. Supported Hardware:

- The MindWave headsets are the only headsets that have been tested with the driver.

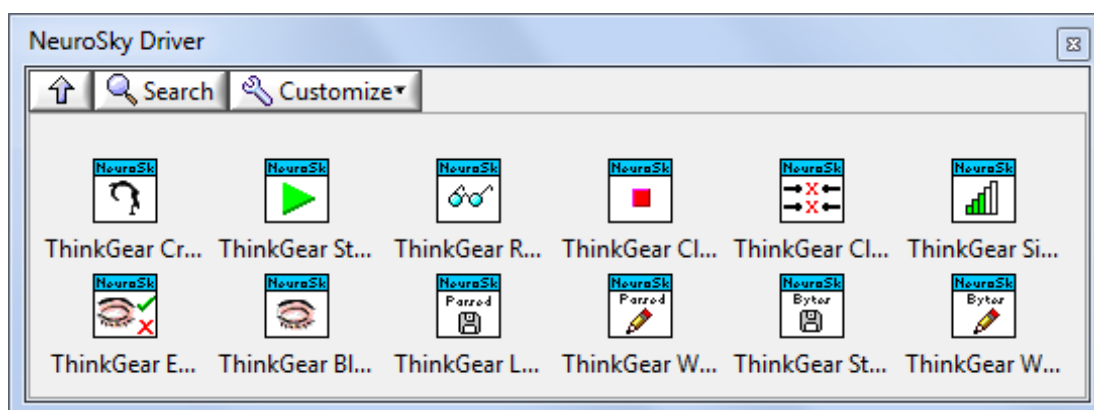


Figure 5.4: LabVIEW Neurosky Driver

## 5.2. NI myDAQ Driver

The NI ELVISmx Instrument Launcher provides access to the NI ELVISmx SFP instruments, additional featured instruments, documentation and online resource links, and personal file access. When you install the NI myDAQ device, the NI ELVISmx Instrument Launcher automatically opens. To manually open the Instrument Launcher, navigate to Start»All Programs»National Instruments» NI myDAQ»NI ELVISmx Instrument Launcher. This opens the suite of LabVIEW SFP instruments.

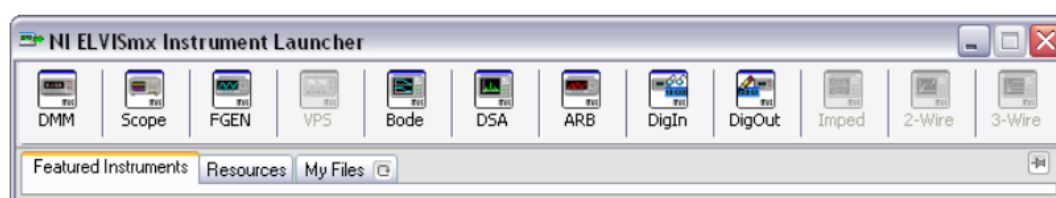


Figure 5.5: NI ELVISmx Instrument Driver

## **CHAPTER 6**

### **LABVIEW FOR MEASURING AND PROCESSING THE BRAIN'S EEG SIGNALS**

#### **6.1. ABOUT LABVIEW**

LabVIEW is graphical programming environment. Programs in IDE are called Virtual Instruments (VIs), consists of a Block Diagram (BD) and a Front Panel (FP). A BD provides a graphical code development environment whereas a FP allows the user to interact with a VI. It provides an efficient and easy-to use environment for code development especially when the user needs to interact with the program and visualize the results. Unlike text-based programming languages like C which follow a control flow execution model, the environment of programming follows a dataflow execution model.

After an extensive and exceedingly informative session with Dr. Praveen Kumar of Tranquil Minds Psychiatric clinic of SIMHANS (Samhita Institute of Mental Health and Neuro Sciences Pvt. Ltd) in Hyderabad, one comes to understand that Scalp EEG picked up from sensors placed on the forehead is in actuality a summation of brainwaves of different frequencies and artefacts such muscle activity, eye blinks, pulse signals and line noise. Extracting useful artefacts from raw EEG signal and transforming it into a useful control output is done by processing it in LabVIEW. The FP provides for a useful tool for providing Neurofeedback to the user.

#### **6.2. NEUROFEEDBACK THROUGH LABVIEW FRONT PANEL**

Neurofeedback, also called biofeedback, is a treatment where EEG equipment is used to present real-time records of brain activity. This enables to training yourself, for instance to become more concentrated or relaxed, by altering your brain wave patterns over time.

The subject's task is usually to keep the bar above a certain threshold, indicated here by the horizontal black line. Typically, one training session like this lasts for about 5-10

minutes and needs to be repeated 10-20 times depending on the patient to get the wanted effect.

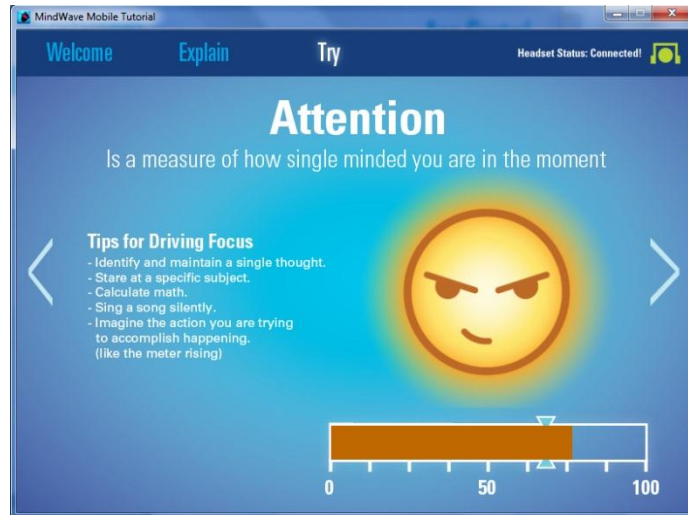


Figure 6.1: The MindWave Mobile Tutorial to determine the measure of Attention

### 6.3. LabVIEW Program for the Neurosky MindWave Mobile Headset

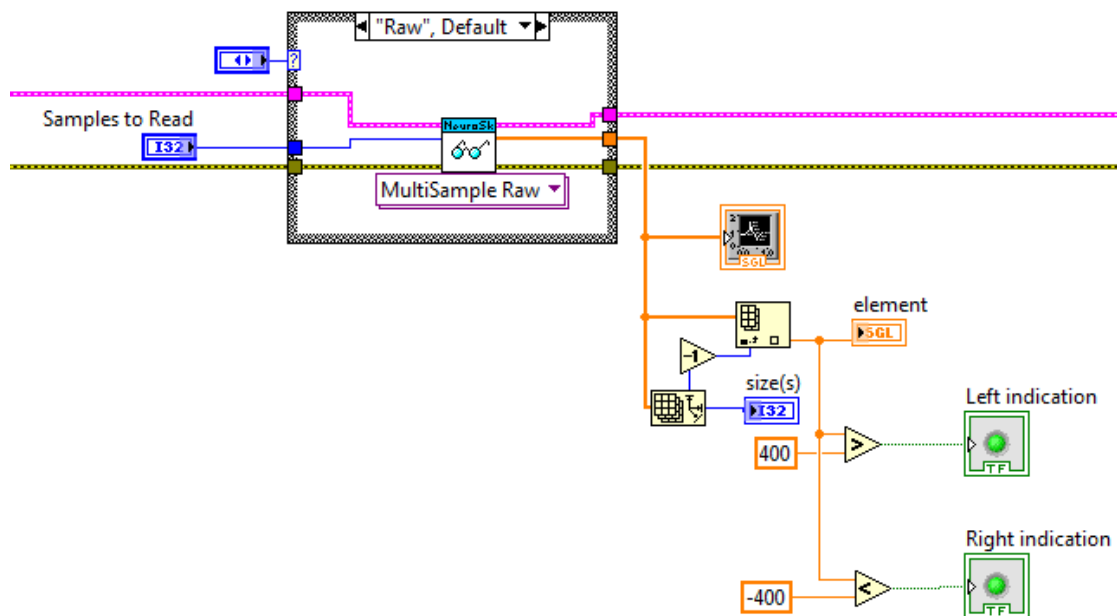


Figure 6.2: LabVIEW BD for the Neurosky data acquisition and verification



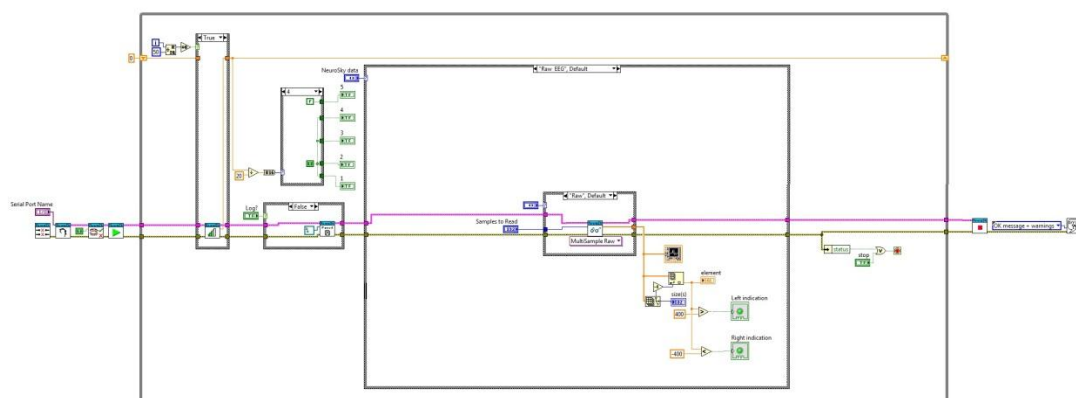


Figure 6.3: LabVIEW BD for the Neurosky data acquisition

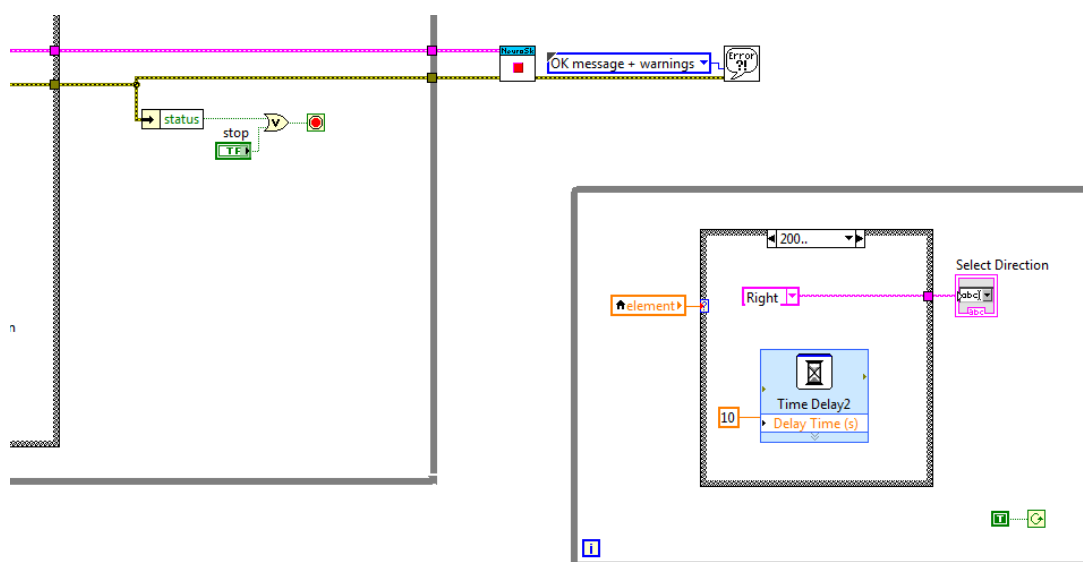


Figure 6.4: LabVIEW BD for the Neurosky driver stop and direction set for wheelchair

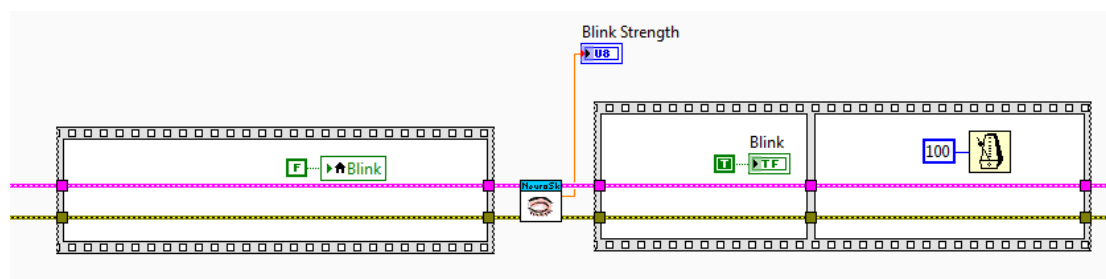


Figure 6.5: LabVIEW BD for the Neurosky headset Blink Detection and Blink Strength

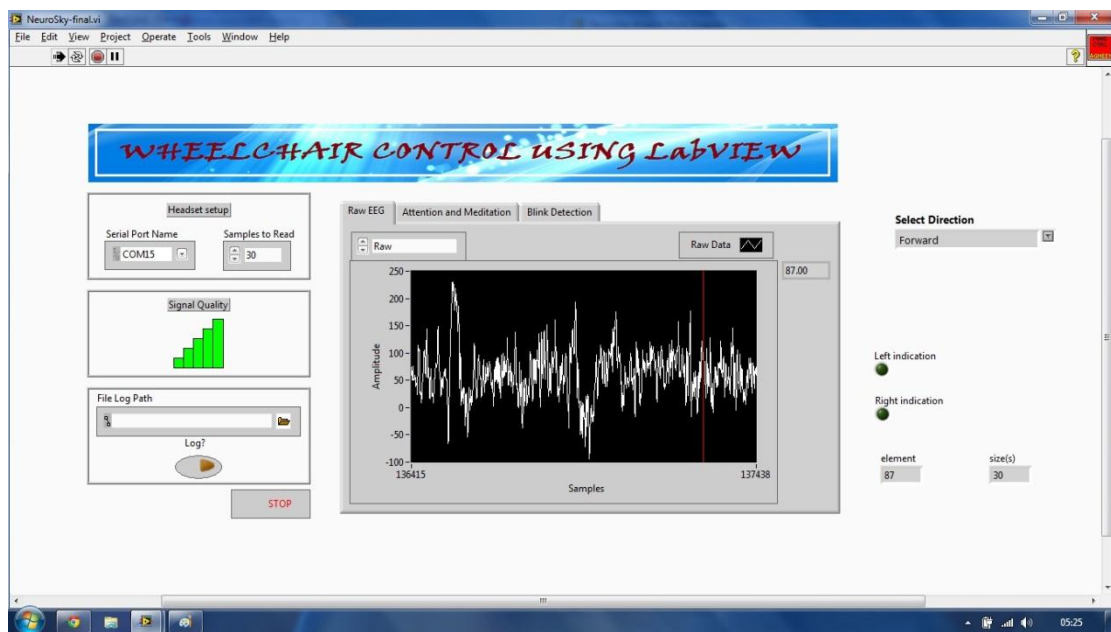


Figure 6.6: Front panels for the Raw EEG waves

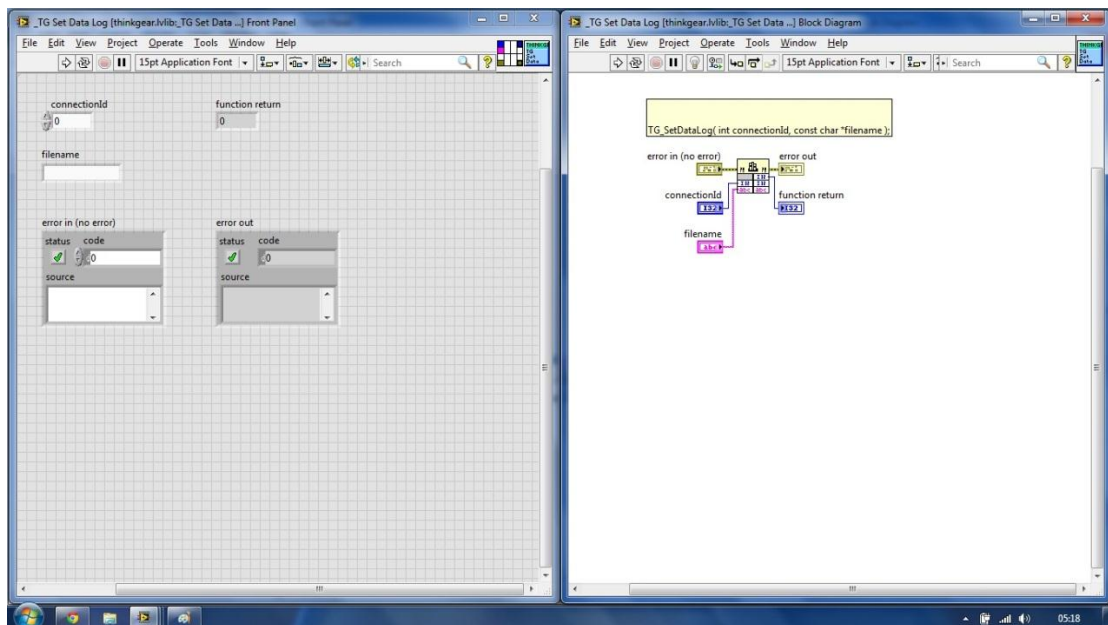


Figure 6.7: LabVIEW FP & BD for the ThinkGear data logging using Call Library Function Node

The screenshot displays the LabVIEW Block Diagram for the 'NeuroSky Read Raw NeuroSky Event into Toolkit' VI. The diagram is organized into several nested loops and error handling structures. Key components include:

- Inputs:** 'NeuroSky Task In' (K10) and 'ConnectSerial' (K11) are the primary input controls.
- Control:** 'Samples to Read' (K12) is a numeric control that determines the number of samples to process.
- Timing:** A 'TimeOut' (K13) is set to 1000, which is used in a 'Wait (ms)' block to manage the timing of the data read.
- Data Flow:** The data is read from the serial port and then processed through a 'Read timed out' block (K14) and a 'Read timed out' block (K15) to handle potential timeouts.
- Output:** The final processed data is sent to 'Data Out' (K16).
- Error Handling:** The diagram includes multiple 'No Error' labels and error clusters to manage and report any issues during the data reading process.

The diagram is enclosed in a large green border, and the overall structure is designed to be robust and easy to integrate into a larger application.

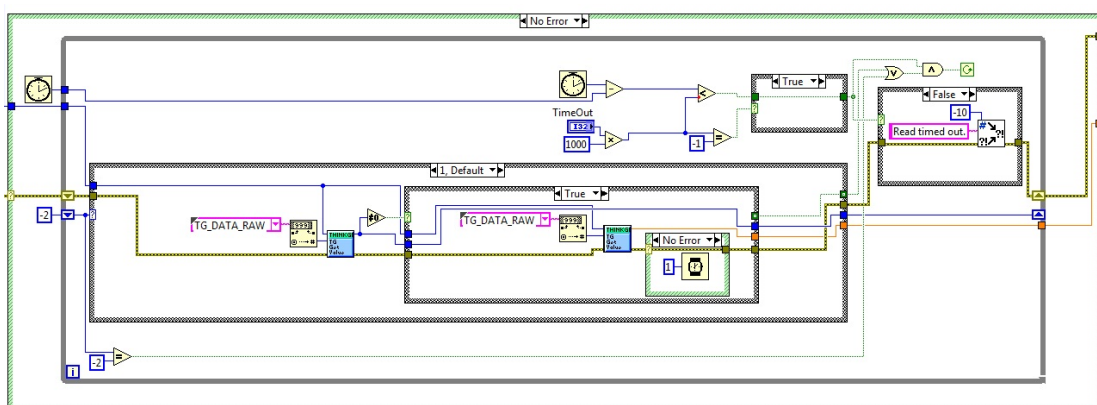


Figure 6.9: LabVIEW BD for the ThinkGear Multiple Sample Raw EEG signal acquisition

## **CHAPTER 7**

### **NI myDAQ FOR H-BRIDGE DRIVEN DC MOTOR**

#### **7.1. OVERVIEW:**

DC motors are commonly used in applications ranging from robotics to medical devices. DC motors convert electrical power into mechanical power in a fairly simple manner. While the theory behind how an electric motor works is relatively straight forward, actually utilizing the motor in a circuit is a bit more nebulous. There are a number of ways to control the power and direction of a DC motor. We create a motor driver using an H-bridge to control the direction of the motor in either direction.

#### **7.2. PURPOSE:**

We use the NI myDAQ to implement an H-bridge to control a DC motor. Basic theory of how a DC motor operates will be presented along with how an H-bridge allows the user to programmatically control the direction and state of the motor.

#### **7.3. DC MOTOR EXPLANATION**

There are two main parts of a DC motor: the stator, which is stationary and includes coils of wire called field coils, and the armature, which rotates around the stator. The armature also has coils of wire wrapped around it, and the ends of each wire coil terminate at one end of the armature. These points of termination are called commutator segments. The commutator is where brushes make electrical contact and supply the current needed to rotate the armature. To make this clearer, refer to Figure 2 below.

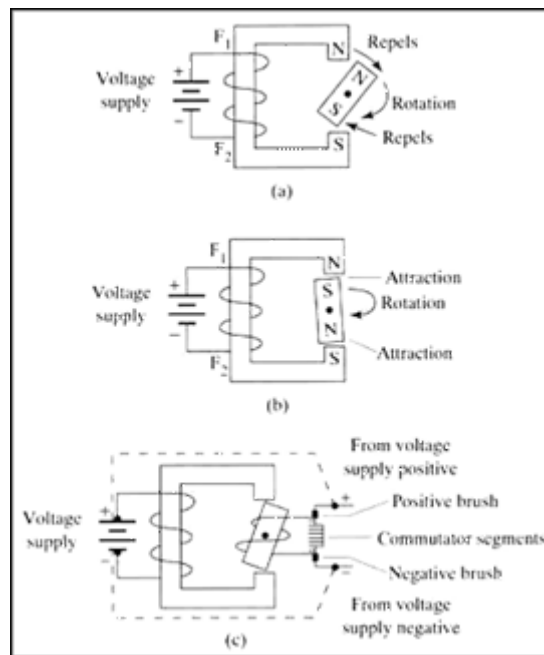


Figure 7.1: Magnetic diagram explaining the operation of a simple two-pole DC motor

In this simple two-pole motor, the stator is the coil of wire connected to the voltage supply on the left and will be referred to as the field coil. The bar magnet on the right represents the rotating armature. In part (a), the North Pole of the armature repels the North Pole of the field coil, which causes the armature to rotate toward the South Pole of the field coil as shown in part (b). Before the armature can lock in place in the more attracted position, however, the polarity of the armature must be switched. Part (c) shows the armature as an electromagnet whose polarity is changed by reversing the direction of current flow through the armature.

#### 7.4. H-BRIDGE EXPLANATION

An H-bridge is an excellent beginner's DC motor driver circuit. It is composed of four bipolar transistors arranged in an "H" shape, which allows a user to electronically command the motor to move forward, reverse, brake, and coast. Figure 7.2 shows the schematic of an H-bridge made in Multisim. The four diodes are included to ensure that excess motor energy is dispersed when the motor is set to stop or coast in order to protect the H-bridge. Without diodes, a spike in motor voltage could damage transistors.

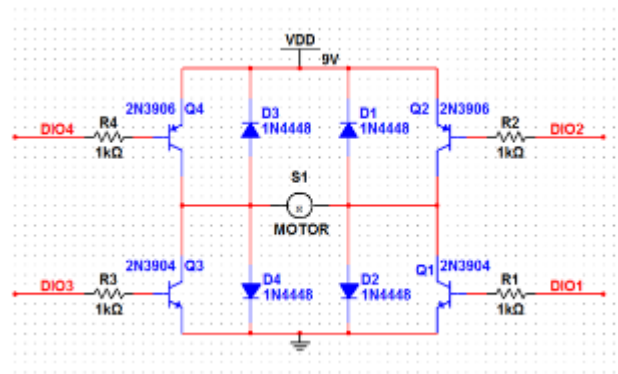


Figure 7.2: H-Bridge schematic designed in Multisim

Each of the transistors is connected to a separate Digital I/O pin on the myDAQ in order to control what state the motor is in. For example, when 5V is applied to R3 and R4 and when both R1 and R2 are grounded, current flows from R3 right through the motor and through R2 to ground. How does the motor change direction? When R1 and R2 are instead set to 5V and R3 and R4 are grounded, current flows in the opposite direction through the motor.

### 7.5. SET UP HARDWARE:

The power rails should be connected to the terminals of a 9V battery while DIO1-4 should be connected to the corresponding digital IO pins of the myDAQ or ELVIS II board. The battery is used to provide enough current to the motor.

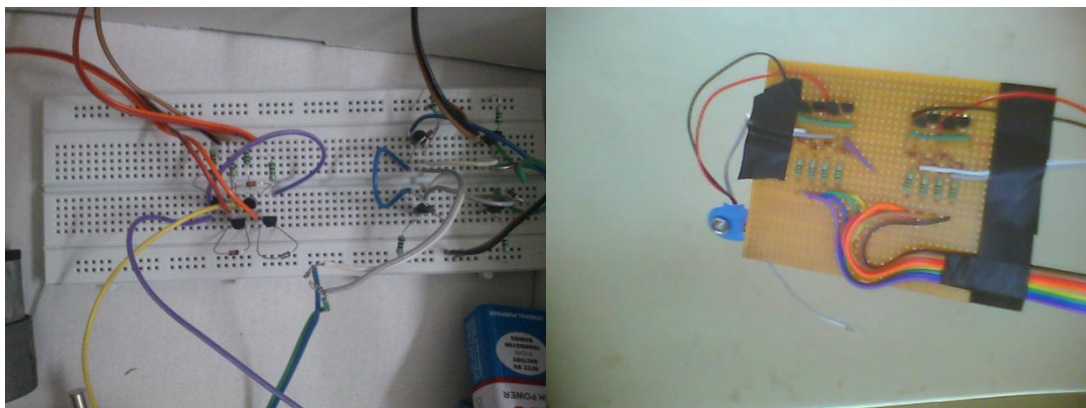


Figure 7.3: Breadboard implementation of H-Bridge

## 7.6. SOFTWARE INSTRUCTIONS:

In order to control the direction of the motor, we need to programmatically set specific pins to 5V and ground. In order to do this, Select Command, four LEDs, a physical channel selector, and a Stop button from the drop down menu.

## 7.7. HOW IT WORKS:

Open Measurement and Automation Explorer. Under the Devices and Interfaces section, find the myDAQ icon. Note what device number it has been assigned (“Dev1” etc.). On the front panel of “H Bridge Motor.vi,” select lines 1-4 on your device. Once this is done, your VI is ready to run.

When you run this VI and select “Forward,” R3 and R4 will light up, indicating that power is currently being applied to those resistors. If you then select “Reverse,” R1 and R2 should instead light up. This gives you a visual representation of how current is flowing in your circuit.

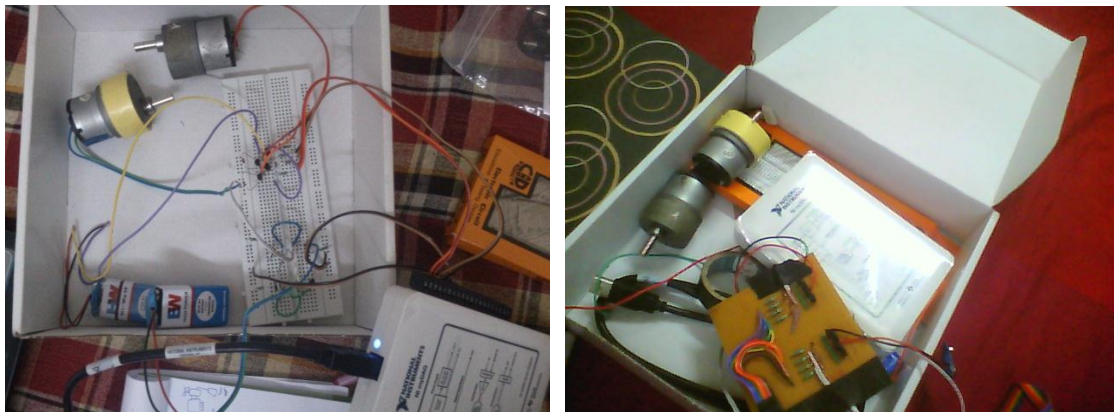


Figure 7.4: Connecting the H-bridge for the controlling of the motors.

## CHAPTER 8

### ELECTRIC WHEELCHAIR

Electric wheelchairs have been considered as one of important mobility aids for the elderly as well as the physically impaired patients. Clinicians pointed out that approximately 50% of patients including paralyzed patients cannot be able to control an electric wheelchair by conventional methods. Especially, people getting MND can only use the eyes and brain to exercise their willpower. In the context, EEG-controlled wheelchairs are a mobility aid especially suitable for the paralyzed patients that are unable to operate the electric wheelchair completely.

When the patients have suffered from MND, their muscle does be gradually wasting and weakness and then their body is frozen. The main type of MND is named Amyotrophic Lateral Sclerosis (ALS). Because of the famous American baseball star Lou Gehrig died of this disease, it is also called Lou Gehrig's disease. Their words, swallowing and respiration are dysfunctional until respiratory failure and death. The disease can infringe upon anyone, but more common in the age of 40-70 years old. The development of the disease is rapid and ruthless. Generally, the average life expectancy of survival is between 2-5 years after onset. Because sensory nerves have not been violated, it does not affect the patient's intelligence, memory or feeling.

There are numerous interfaces between human and machines to utilize input devices such as mouse, keyboards or joysticks. Recently, a number of biological signals have been utilized as hands-free interfaces, names brain-computer interface (BCI) to machines like electromyogram (EMG) and electroencephalogram (EEG). The paralyzed patients cannot operate objects or communicate their needs, even though their mental capabilities are integral. Therefore, the precious reason promoted us to design a BCI system and a drive circuit by using the paralytic patients' brain waves to control electric wheelchairs and to help them to move freely in their daily life. There is a rising tendency in the growing recognition requirements of BCI systems. The existing BCI systems focus on developing new superior control and communication technologies for those with strict neuromuscular disorders.



An electric wheelchair towards a BCI-based control was proposed by Cho et al. They utilized a software named ACQUIRE and a complex acquiring system for the data acquisition process. For these electric wheelchairs, they did not use any wireless interface in their system. This paper describes EEG-controlled wheelchairs through a Bluetooth interface. The study focussed on paralyzed patients who can use eyes and brain to exercise their willpower.



Figure 8.1: The model of the wheelchair

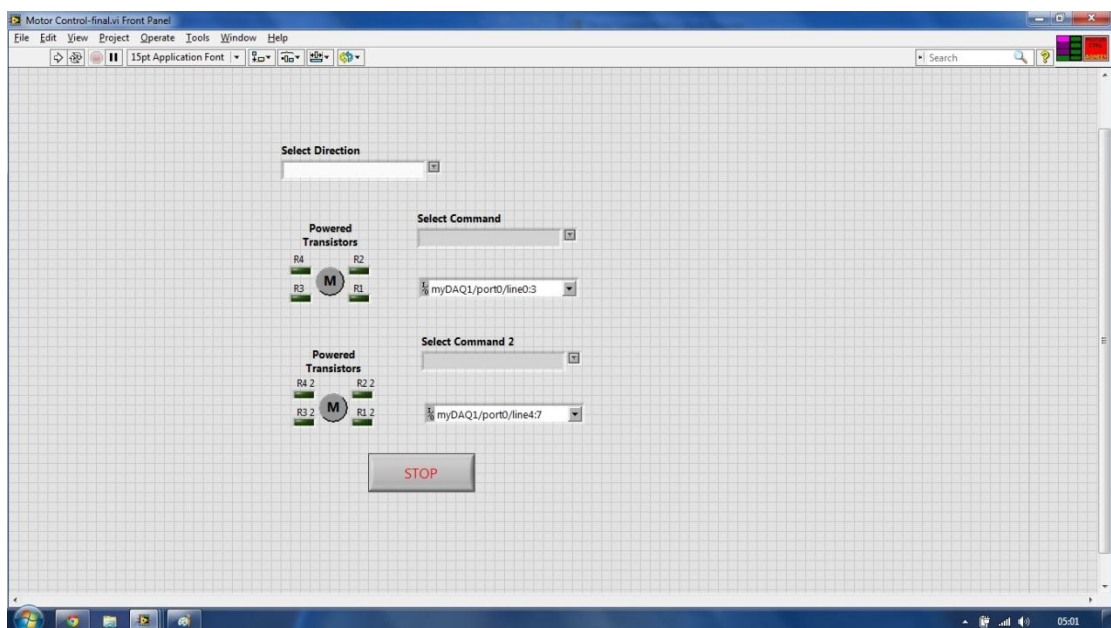


Figure 8.2: LabVIEW FP for the motor control of the Wheelchair

## **CHAPTER 9**

### **CONCLUSION**

In conclusion to the project, the employment of brain controlled wheel chair aids to the patients suffering from conditions which make them physically unable to control their muscles efficiently. The technology brings back the integrity of the patient as they can use their healthy brain even if their body has degraded and moreover, it would keep their mind active.

It is quite probable that in the future most of our appliances will be controlled directly through our wishes or the brain and this project stands as an affirmation to that vision. Signals from the brain can be further studied and the technology can be refined to bring about more specific results.

The scope of the project was primarily to establish the motion through no physical motion on part of the user and it has been successful in doing so but it has also laid a foundation for many applications which would greatly improve the standard of life for all.

## REFERENCES

1. Benjamini, Y. and Y. Hochberg (1995) Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society, Series B (Methodological)*, 57(1): p. 289-300.
2. Delorme, A. and S. Makeig (2004) EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *J Neurosci Methods* 134(1): p. 9-21.
3. G Schalk, D McFarland, T Hinterberger, N Bribaurmer, and J Wolpaw (2004) "BCI2000: a general-purpose brain computer interface (BCI) system," *IEEE Transactions on Biomedical Engineering*, pp. 1034-1043.
4. H. Zhang, C. Guan, and C. Wang (June 2008) "Asynchronous P300-Based Brain- Computer Interfaces: A Computational Approach with Statistical Models," *IEEE Transactions on Biomedical Engineering*, vol. 55, no. 6, pp.1754–1763.
5. McKinnon, K.I.M. (1999) Convergence of the Nelder-Mead simplex method to a non-stationary point. *SIAM J Optimization*, 9: p. 148-158.
6. Shivaraman.R, SRM University (April 2007), "A Study on the Feasibility of the Implementation of Brain Computer Interface by Encephalon Mapping Technique using Electroencephalogram".
7. Torsten Felzer (2001) "On the Possibility of Developing a Brain-Computer Interface (BCI)" Technical University of Darmstadt, Department of Computer Science.