Wheelchair - Brain Computer Interface

Akhil V[1], Akshay Balachandran[2], Anusha Ashok[3], Ganapathy U E[4], Sowmya J[5]

Department of Electronics and Communication Engineering

[1,2,3,4] UG Scholars, Nitte Meenakshi Institute of Technology, Bangalore

[5] Asst. Professor, Nitte Meenakshi Institute of Technology, Bangalore

ABSTRACT *– Brain Computer Interface (BCI) is the interface between the human brain and a device or a machine. It has been used to design assistive technology for disabled patients/users such as those affected with locomotive impairments. In this paper we design a BCI based system which works on eye blinks detected from Electroencephalogram (EEG) signals of the users. Here, the EEG signals are obtained by using simple gold-plated EEG electrodes which is then used to control a wheelchair. This system has been successfully tested on various users and desired outputs have been obtained.*

Keywords *– Brain Computer Interface (BCI), Electroencephalogram, EEG, Amplification, Arduino UNO, Eye blink, Electrodes, OP-AMPs, Wheelchair.*

I. INTRODUCTION

Millions of people around the world suffer from Amyotrophic lateral sclerosis (ALS) and Mobility impairment among which many of them rely upon wheelchairs to get on with the daily activities of life. However many patients are not prescribed to use wheelchair either because they are physically unable to control the chair manually or because of lack of safety. However, these issues can be overcome by empowering the wheelchair with technology such that the people benefit from the Smarter Wheelchair. Technology provides a great scale of safety and additional assistance to the patient's such that they are able to get along with the activities efficiently. The electrical activities of the brain can be monitored in real time using different approaches. The output of the brain computer interface is the Electroencephalogram (EEG) signals which are synthesized and decoded using on-board sensing techniques. One important application of Electroencephalogram (EEG)-based brain computer interfaces (BCIs) is wheelchair control, which has attracted a great deal of attention because brain-controlled wheelchairs have the potentials to improve the quality of life and self-independence of the disabled users. We are motivated to design this technology such that this innovative technology can provide a helping hand to paralytic patients who are unable to communicate to their near and dear ones. Hence, this technology has brought out an innovative technique, for paralytic or disabled patients to communicate and navigate independently.

II. WORKING METHODOLOGY

The primary step in a BCI system is the acquisition of EEG signals. In this project we use gold plated EEG electrodes to obtain these signals. The electrodes are placed on the user's forehead on two specific spots (based on trials) and one on the leg (as a reference electrode). The two electrodes on the forehead measures the potential difference between the signals obtained and the electrode on the leg serves as the ground electrode. The signals so obtained are in micro-volts range and required some amount of amplification for the further steps. Hence these signals are then given to an amplification-filter circuit. We used an instrumentation amplifier which amplifies the difference between the two input signals obtained from the electrodes placed on the forehead and then provides amplification with ample gain. Any noise present in these signals is then removed by the filtering components following the amplifying components in the same circuit. The controller that we used in this project is an Arduino UNO. The amplified and noise-less signals from the user are viewed real-time in the serial plotter of Arduino UNO. An algorithm is developed such that a short-duration eye blink moves the wheelchair forward and a long-duration eye blink moves wheelchair backward. Thus the objective of our project is satisfied. Hence, by adding more number of movements to this system, it could be used by disabled patients who have lost the ability to move around independently and would prove to be a boon in their lives.

III. BLOCK DIAGRAM

The block diagram shown below describes the method in which the signal acquisition, amplification, signal analysis and the control of wheelchair is taken place after undergoing various processes. The detailed explanation and analysis is done below:

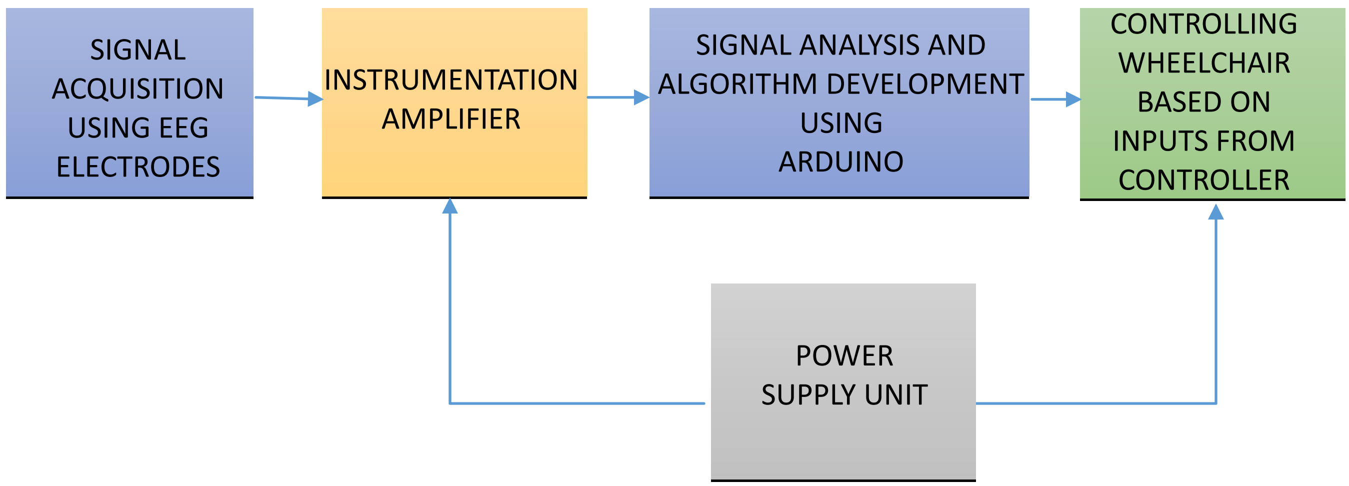

Fig. 1 - BLOCK DIAGRAM

IV. FUNCTIONS OF EACH BLOCK

The block diagram shown in Fig. 1 is explained step by step where the importance of each block or unit is described as below. The detailed explanation is as follows:

A. Gold-Plated EEG Electrodes

Fig. 2 shows the Gold Plated EEG electrodes that are used for signal acquisition from the patient's / user's brain. The EEG signals are acquired by fixing electrodes on two spots on the user's forehead. The acquired signal is then passed through an instrumentation amplifier which amplifies the signal in terms of volts from micro volts.

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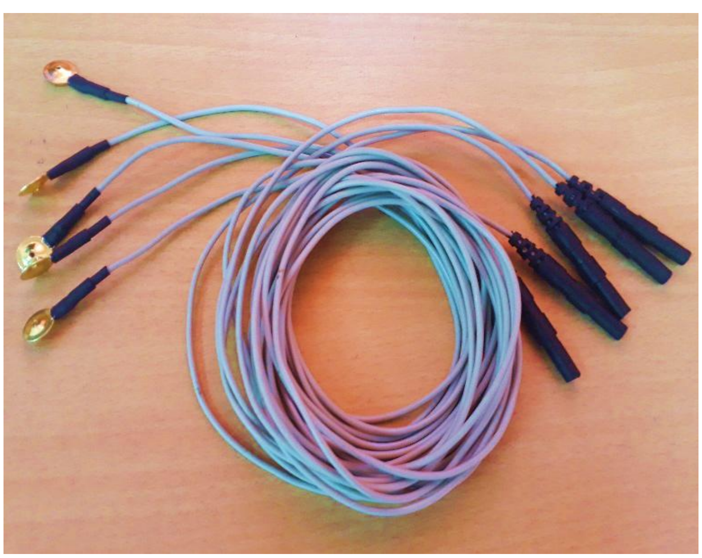

Fig. 2 – Gold-plated EEG Electrodes

B. Instrumentation Amplifier

Fig.3 shows an instrumentation amplifier consisting of OP-AMPs and various active and passive devices. Initially, the signals from the EEG electrodes are given as differential inputs to the amplifier. The input is always given in terms of micro volts (approx. 1µV) and upon amplification, the obtained signal will be in volts (approx. 24V). The amplifier consists of three stages, where the **gain of the first stage, G_1 = 25.38** and is calculated using the formula $\frac{R3}{R2}(1+\frac{2*R1}{R2})$, **gain of the second stage, G_2 = 48** and is calculated using the formula $1+\frac{R2}{R1}$ and similarly the **gain of the third stage, G_3 = 34** and is calculated using the formula $1+\frac{R2}{R1}$. The amplifier also consists of a filter circuit that is used to eliminate any kind of noise that occur within the amplifier during signal amplification.

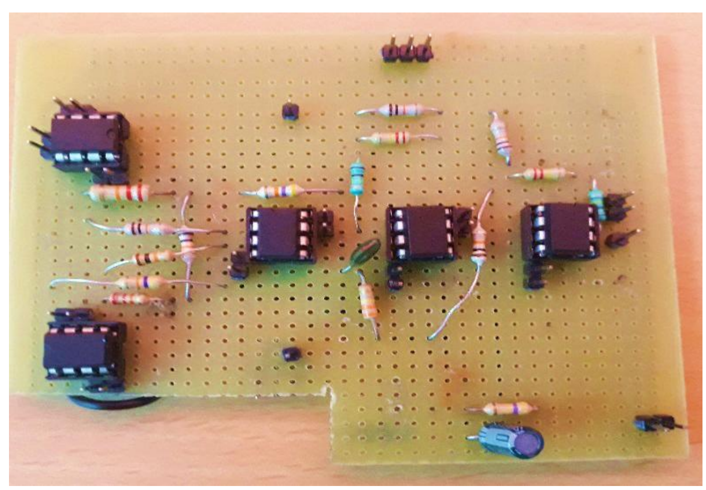

Fig.3 – Instrumentation Amplifier

C. Microcontroller – Arduino UNO

The signals obtained from the circuit have to be analyzed to control the wheelchair. The microcontroller Arduino UNO has analog ports which serve as the input for amplified and filtered analog EEG signals. The variation in the EEG pattern for the blinks of a person is detected using the microcontroller and the duration for the eye blinks are calculated. The microcontroller, further based on the duration decides the forward and backward movement of the wheelchair. The potential values of EEG for eye blink changes from one person to other. Hence the algorithm consists of a training process where the change in potential values is first learned by the program for 15 seconds where the patient / user upon whom the testing procedure happens is asked to blink. The algorithm identifies the variation in the voltage and is further used to compare with the real time signals. A value equal to the value identified while training trigger the Arduino to control the motion of wheelchair. The waveforms in Fig. 4 and Fig. 5 gives the EEG pattern were the former has short duration eye blinks and the latter has a long duration eye blink. Based on the duration of the eye blink, the microcontroller can trigger the motor driver on the wheelchair for its movement.

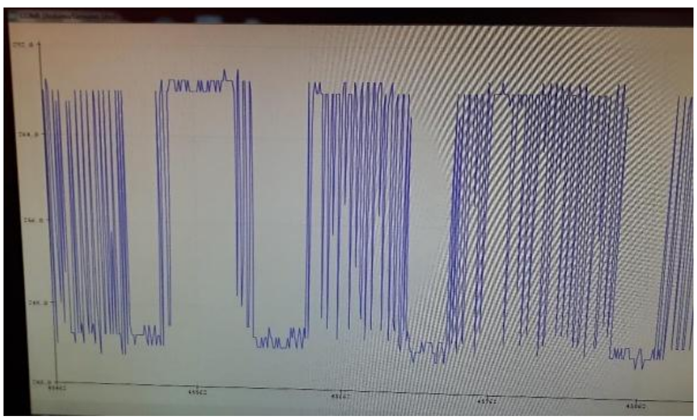

Fig. 4 – Short duration eye blink (Short Blink)

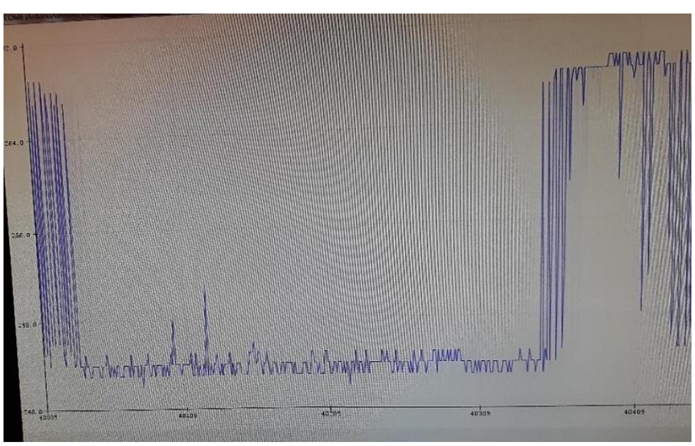

Fig. 5 – Long duration eye blink (Long Blink)

D. Controlling Wheelchair

The final step is to control the wheelchair using inputs obtained from the controller. After analyzing and developing algorithm for movement of wheelchair based on eye blinks, it is necessary to implement this on the wheelchair such that it can move according to the inputs given from the Arduino (microcontroller). In order to move the wheelchair forward and backward, it is necessary to operate the motors in clockwise and anti-clockwise directions. This can be performed with the help of motor drivers. The driver that we use in this project is L293D IC (Fig. 5). This is a 16 pin IC consisting of pins such as Enable, VCC, VSS, ground, input and output terminals. The IC has two sets on Enable pins, one on either side. We can activate these pins depending on the number of motors we have. This IC consists of two H-bridges on either side. This H-bridge circuit helps the voltage to flow in either direction. This principle helps the motor to move in clockwise or anticlockwise direction thus acting like a switch. Here, the outputs from digital pins of the Arduino are given as inputs to the motor driver Such that combination 1,0 moves motor in clockwise direction, combination 0,1 moves motor in anti-clockwise direction and 1,1 makes the motor idle. The outputs of the motor driver are given to the respective motors. The grounds are shorted together. The VSS terminal provides supply to the motor and the VCC terminal is used to provide supply for operation of IC. VSS can range from 5V to 36V and the range of VCC is around 5V. Thus, we can control the movement of the wheelchair by using the above mentioned steps. Fig.6 shows the pin diagram of L293D motor driver.

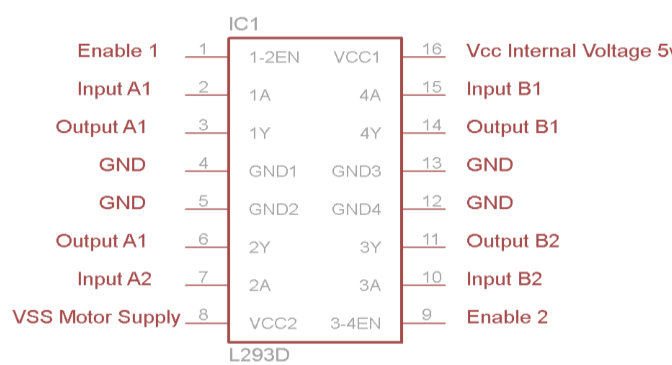

Fig. 6 – Pin Diagram of L293D

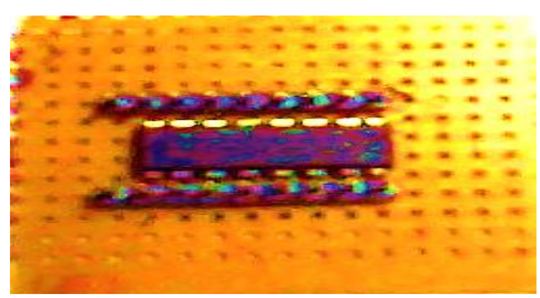

Fig. 7 - ***Designed L293D DC Motor Controller***

V. FEASIBLITY AND UTILITY

Considering the increase in number of patients suffering from a condition in which he/she is awake and aware but cannot move or speak because almost all the muscles in the body except for the eyes are paralyzed, this project provides a large utility through increasing advancements in technology. The project will require two EEG electrodes which are placed on the head (non-invasive method) unlike systems which requires 14 EEG electrodes and electrodes which are placed inside the head (invasive method). The project also uses simple devices like IC's for amplification and driving the motor which is easily available in the market. Hence, the project is implemented in low cost and can support economically weaker sections in the society. The project is also useful to elderly people (senior citizens) to make them more self-dependent. Therefore with the utilization of technology, it is possible to overcome the need of being dependent on people with real concerns.

VI. CONCLUSION

One who has mastered technology has mastered the generation. The project is implemented such that it provides a helping hand for disabled people and it can also be extended in terms of usability to senior citizens and other differently abled people to ease their activities based on mobility. The project also shed light on the emotional side of a differently abled people as it helps them socialize and brings them out of their secluded state.

VII. REFERENCE

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