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A Low cost Brain Computer Interface Module and EEG Analysis Using MATLAB

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Abstract: A brain-computer interface, or BCI, is a modality for human-computer interaction whereby a person may control an external device using brain signals without muscular intervention. One of the most widely used signals is the electroencephalogram (EEG), since it has excellent temporal resolution, can be measured non-invasively, and is comparatively inexpensive and simple to acquire. The design itself is based on three main components: an Analog Front End, a Microcontroller, and data acquisition and classification system (software). This work will show that by interfacing these three main embedded devices, the results of a proven clinical EEG system can be replicated.

Keywords: Brain Computer Interface, Analog Front end, EEG, MATLAB Analysis

I. INTRODUCTION

There are several disorders which seriously disrupt the mechanism of the nervous system, provoking severe motor disabilities in the people who undergo one of them. Among the disorders that impair the neural pathways or the muscles themselves are:

(1) Amyotrophic lateral sclerosis, which is a nervous system disease that impairs the neurons in the brain and the spinal cord;
(2) brainstem stroke, that arises when the blood suddenly stops flowing through the brain;
(3) brain or spinal cord injury, which occurs when the cord tissue is torn or pressed down on the nerve parts that carry signals;
and (4) cerebral palsy, that is evoked when some areas of the brain that control movement do not develop correctly [1]. To date, these disorders do not have a cure, and eventually some of them increase the injury level in the patients.

For such patients, one of the most noteworthy proposed technologies has been the Brain-Computer Interfaces (BCI), which give rise to a communication means between individuals with severe motor disorders, and their external world via the measurement of the electroencephalographic (EEG) activity. Electroencephalography (EEG) is used for many clinical, medical applications, and is becoming widely used in the development of commercial applications.

A BCI system senses, amplifies and processes the user's EEG signals; it highlights and extracts the useful electrophysiological mechanisms encoded in the signal; and finally, it converts these extracted features into logical control signals for managing the actions of a device of interest. A BCI transforms bioelectrical brain signals, modulated by mental activity (e.g. imagination of hand movement) into a control signal.

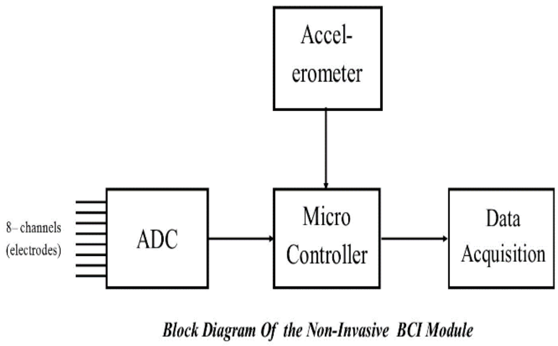

Fig 1 Block Diagram of BCI

II. EEG SIGNAL ACQUISITION

The EEG is acquired through the placement of electrodes on the scalp, which follow the scalp's change in electrical potential. The potential difference between electrodes can then be amplified to a workable level, at which point it is typically digitized and stored on a computer for analysis.
With good Ag-AgCl electrodes, de offset voltages are surprisingly low, maximally in the order of 10 mV. With electrodes other than Ag-AgCl such as tin, plain silver and stainless steel, the offset voltages are in the order of maximally a few hundred mV. Now you cannot randomly place the electrodes on the scalp, the 10-20 system is the internationally recognized method to describe the location of the scalp electrodes. The system is based on the relationship between the location of the electrode and the underlying area of cerebral cortex. The numbers 10 and 20 refer to the fact that the distance between adjacent electrodes is either 10% or 20%, as shown in fig 2, of the total front-back or right-left distance of the skull.
Using an ADC with a high dynamic range (many effective bits), and with a high sample rate, is attractive because it makes the system applicable for a broad range of bio potential measurements. Hence the ADC chosen for this

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work was the ADS1256 from Texas Instruments.[8] This is a low cost, 24 bit (or less, depending on speed) Sigma Delta ADC with a Serial Peripheral Interface (SPI) for interconnection with a host microprocessor. The ADS1256 also incorporates a Programmable Gain Amplifier which facilitates "range changing" for different input signal ranges. There are 4 differential (8 single ended) inputs available. The SPI interface of the ADS1256 allows a host processor to read and set values in internal configuration registers such as setting the actual sampling rate, controlling the multiplexer and reading converter status. The Controller used for this Project is Scilabs 8051f340, it has SPI and inbuilt ADC. Accelerometer Adxl335 is used to observe any head movements and use it for controlling the devices. The Proposed System and its coding flow chart is given in fig.5 and Fig 3 respectively.

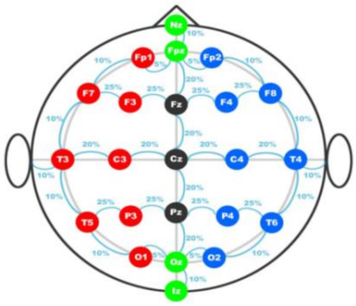

Fig 2 10-20 System for Electrode Placement [2]

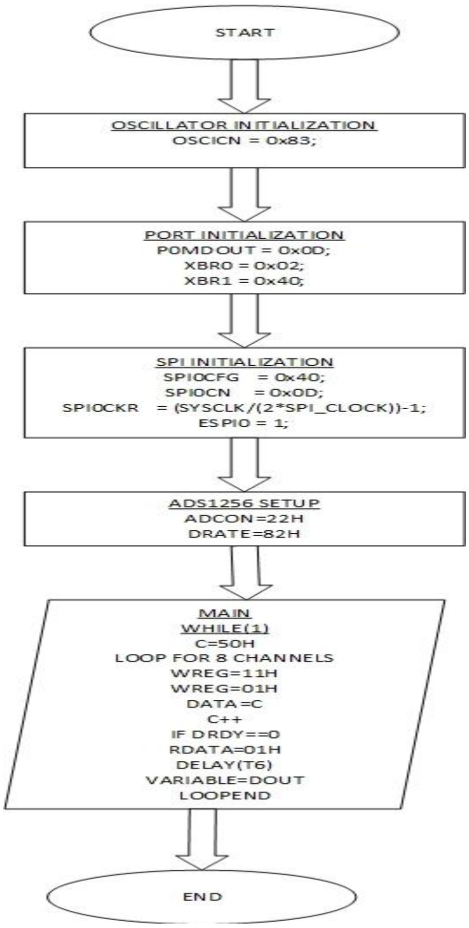

Fig 3. Flow chart for Data Acquisition

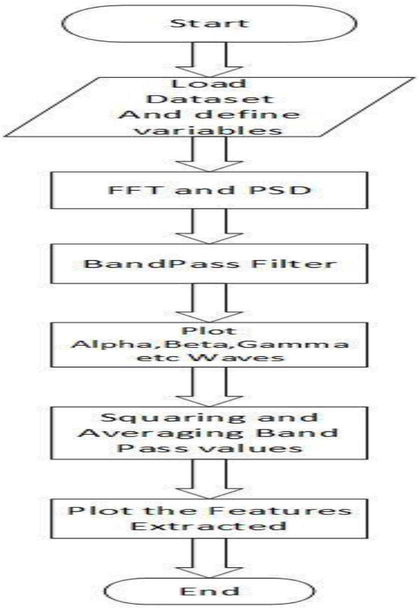

Fig 4 MATLAB Code Flowchart for differentiating brain Wave

III. EEG SIGNAL ANALYSIS

MATLAB is presently used in most research centers and is widely considered the tool of choice for developing and, often, applying computational methods in cognitive neuroscience and beyond. MATLAB itself allows easy prototyping of complex algorithms. For instance, the implementation of LDA projection requires 286 lines of C++ code in the Open Vibe toolbox, whereas in MATLAB it can essentially be implemented as the single line >> result =sign (w'*x-b), x being the data, w the weights and b the bias factor. This is one reason why many new computational methods are tested under MATLAB before implementing them in a more structured application-oriented language. For EEG Analysis we need extract features One of the most used methods to estimate the power EEG signal has been proposed by Graz-BCI group, and it can be summed up in three steps [4]: (1) band-pass filtering of all event-related trials, (2) squaring of the amplitude samples to obtain power samples, (3) averaging samples over time segments usually of one-second length. This method is known as Band Power (BP) and it has been implemented as feature extractor method.

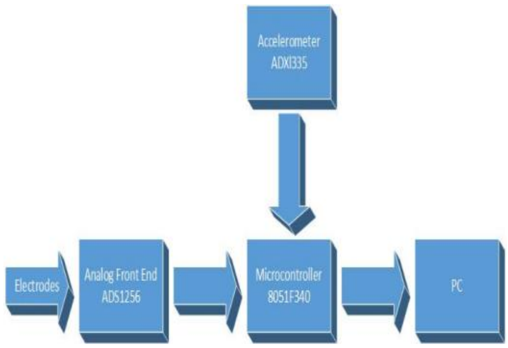

Fig 5 Proposed System

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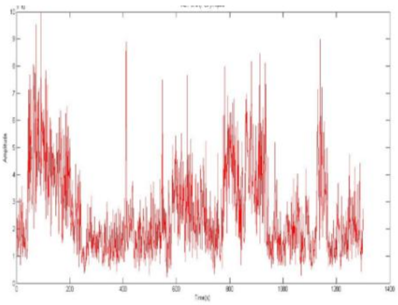

Fig 6 Alpha Wave (8-12 Hz)

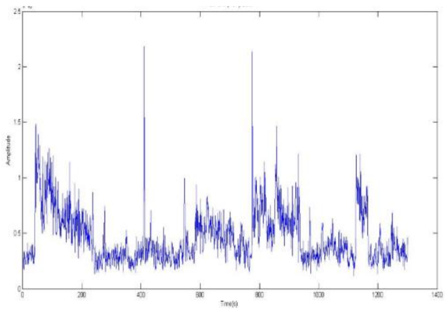

Fig 7 Beta Wave(13-60Hz)

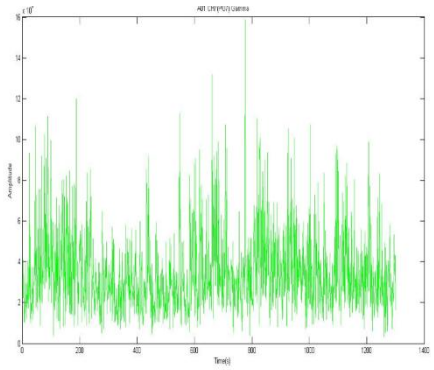

Fig 8 Gamma Wave(4-7Hz)

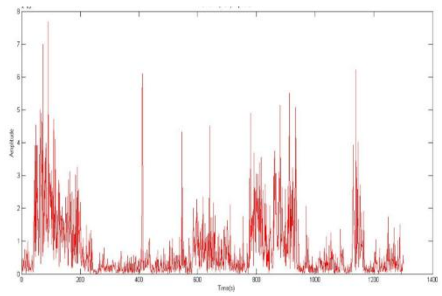

Fig 9 Alpha wave Band Power

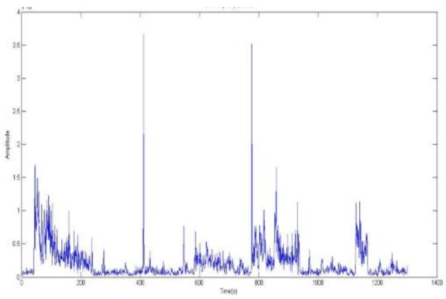

Fig 10 Beta Wave Band Power

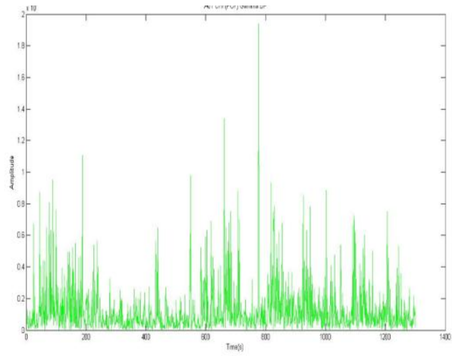

Fig 11 Gamma Wave Band Power

Fig 6-11 shows the single channel wave differentiation. We can get these waves for multichannel data values as well. After this, Feature classifications techniques are used for ultimate decoding of the EEG Signals.

CONCLUSION

This novel design concept provides ways to take an existing solution and improve its portability and adaptability, without compromising the accuracy of the system as a whole. This is a low cost solution in biomedical devices.

FUTURE EXPANSION

This design can be made wireless by using Bluetooth or Wi-Fi and transferring data wirelessly to PC or any remote place.

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