

Single Lead EEG Acquisition System For Health Care Applications

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Abstract—It is very much difficult to call the patient every time to have EEG test, when a physician wants to examine the outcome of the diagnosis. Currently, there are many data acquisition schemes for monitoring the signals from the psyche and designed to perform EEG in the Recording Room. But, this system extends a design of portable circuitry for rapid and convenient use in health care. High gain precision instrumentation amplifier is designed in hardware and that the output is connected to the analog input of NI myDAQ which is interfaced via USB to computer. Filters are coded in NI Labview and applied to the signal to have smooth analysis. This system can amplify signals more and better noise eliminating options compared to other commercial EEG data acquisition systems. Portable Single lead EEG system is very much used to observe patients suffering from brain damage or any injuries in the brain at home or in the conveyance.

Keywords—Acquisition, EEG, Electrodes, Filters, NI myDAQ.

I. INTRODUCTION

Electroencephalography (EEG) is a test used for monitoring and measuring the different electrical activities of the brain. Brain consists of millions of neurons. The discharges of neurons induces different amount of potential over the scalp for different states of subjects alertness, external stimuli and so on. This brain electrical activity is acquired using electrodes which are placed over the scalp. These electric discharges would be in the order of microvolts. It can be acquired in the order of millivolts when recording is taken using subdural electrodes. As EEG bio potentials are in the order of microvolts are very much prone to get contaminated with other bio potentials like artifacts and noise. Although, approximately 0.5 to 30 Hz of frequency range are considered in clinical interest to treat various brain disorders. Long time tendency to occurrence of seizures in particular region may result in brain disorder like Epilepsy and Grandmal etc.

A. EEG Frequencies:

Along with the position of the electrode the brain frequencies are changed so EEG waveforms are classified into five sets (alpha, beta, theta, and delta) [1, 2, 5]. The characteristics of different frequencies and their state of occurrence, outcomes and their abnormalities are classified below.

- Alpha waves
 - Occur in the frequency range of 8 and 13 Hz.

- Region: Alpha waves are observed better in posterior and occipital regions.
- Outcome of this frequency: Alpha waves are found in normal person when they are relaxed and resting position. These waves can disappear when we can open the eyes or alert position where there attention is directed to specific work.
- Abnormality: If present in frontal regions may suspect as depression and attention problems.
- Beta waves
 - Occur in the frequency range of 13-30 Hz, sometimes it can extend to 50Hz.
 - Region: These frequency range found in parietal and frontal region of the scalp.
 - Outcome of this frequency: Beta wave activities are present when the person is in tension and intense mental activity with their eyes open.
 - Abnormality: Deficient beta may rise to lack of concentration and problem solving.
- Theta waves
 - Occur in the frequency range of 4 to 8 Hz with large amplitude.
 - Region: These mainly occur in the parietal and temporal regions.
 - Outcome of this frequency: Theta waves are abnormal in small children when awake and adults during sleep.
 - Abnormality: If seen in awake adults
- Delta waves
 - Occur in the frequency range of 0.5 to 4 Hz with high amplitude.
 - Region: They occur within the cortex and also they are found in central cerebrum, mostly parietal lobes.
 - Outcome of this frequency: Delta is normal in infants and occurs during sleep in adults.
 - Abnormality: If seen in awake adults.
- Gamma waves
 - Occur in the frequency range of 36-44 Hz.

- Region: In general the slowest cortical rhythms is related to an ideal brain that occur in a location of cortex.
- Outcome of this frequency: During short-term memory matching for recognized sounds, objects and other sensations.
- Abnormality: when for continuous for a long time

The graphical representation EEG frequencies are shown below Fig.1.

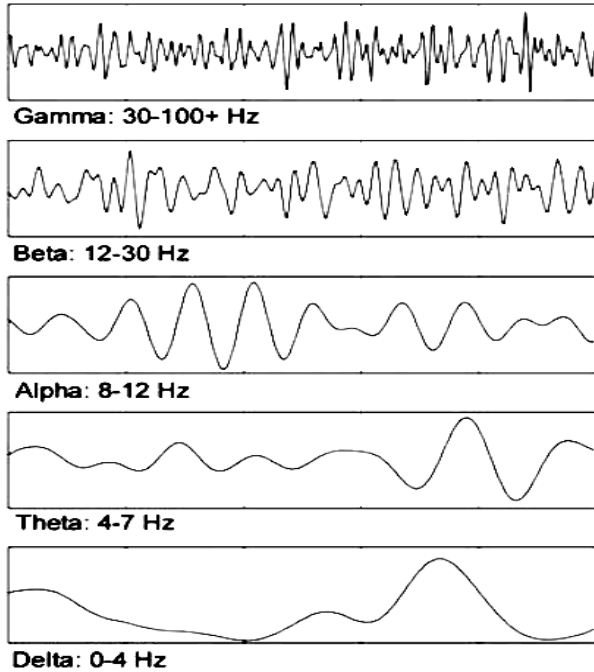


Fig. 1. Graphical representation of EEG Frequencies.

B. EEG Health Applications:

EEG can be used to monitor and diagnose different Neuro parameters. The major health applications is shown below but not limited [2, 3].

- To monitor cognitive engagement (alpha rhythm).
- To monitor alertness, coma and brain death.
- To analyse brain development.
- Locate areas of damage following head injury, stroke, tumour, etc.
- Investigate sleep disorder and physiology.

II. SYSTEM CONSTRUCTION

To acquire the EEG signal and to have better examination and analysis, International Federation of Clinical Neurophysiology (IFCN) suggested a standard for secure acquisition of EEG for clinical practices. The American Clinical Neurophysiology Society has suggested the usage of a minimum of 21 electrodes in acquisition system called International 10-20 [1]. This standard gives location and

naming of electrodes placed over the scalp. The electrodes placed on the left hemisphere of the scalp are named in odd numbers, while the right hemisphere named with even numbers. Differential gain of the two neighboring electrodes forms a channel called bipolar montage. It can be called as referential montage when acquisition with a common reference. Electrodes which are positioned over the scalp act as a transducer gives the resulting output as a voltage over a period of time. Midline electrodes are marked as Z while, other points marked as Front polar (Fp), central (c), Parietal (P), Occipital (O) and Temporal (T).

The single lead EEG acquisition system is constructed to have simple and low noise acquisition. This consists of a high gain instrumentation amplifier followed by on-screen filtering, which is coded in NI Labview. The flow diagram of the acquisition process is shown below Fig. 2.

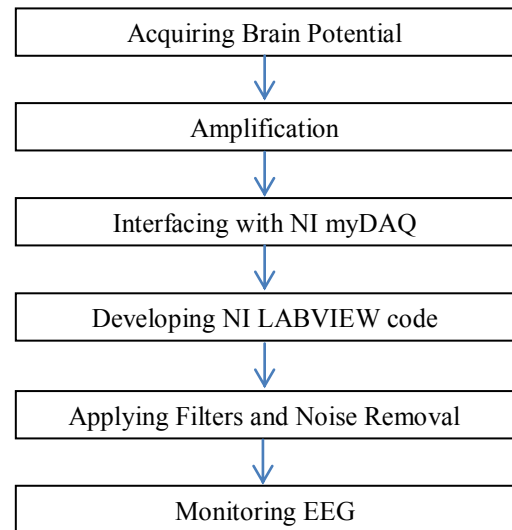


Fig. 2. Flow diagram of EEG Acquisition system design.

The single lead EEG system is very much used to monitor while mobile treatment and it is greatly helpful in study of particular brain disorder at particular region. The stages of development of single lead EEG system using NI myDAQ are described.

This single lead EEG acquisition system is designed to specific target group who is unable and not willing to have the conventional complex EEG test at medical centre. This system can also have the possibility to the physician to monitor patient EEG remotely.

A. Amplification and Filtering

Amplification of the bio-potential plays vital role in EEG acquisition process. Because the brain signal obtained over the scalp has potential in order of micro volts, which is very much difficult for the physician to analyze and interpret.

Instrumentation amplifier has excellent accuracy and high common mode rejection ratio (CMMR) has very low offset voltage of 50uv and low drift voltage. High CMMR can able to amplify low difference signals [5, 8]. Instrumentation amplifier

consists of two different stages. First stage consists of high impedance for both input terminals and gain will be fixed with adjusting resistor value R_G . In the second stage, it consists of differential amplifier which varies in polarity and amplitude. Thus, it gives high performance and precision in acquiring EEG signal. The overall gain of the instrumentation amplifier depends on adjusting R_G , where it is inversely proportional to output gain. The schematic diagram of the instrumentation amplifier is shown below in Fig. 3.

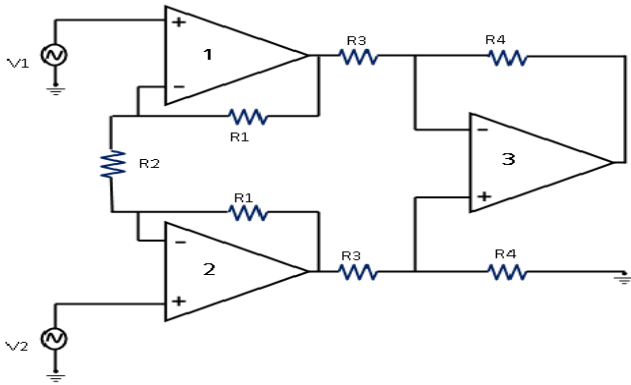


Fig. 3. Schematic diagram of Instrumentation Amplifier.

Gain of the amplifier is given as

$$V_0 = (V_2 - V_1) \frac{R_4}{R_3} \left[1 + \frac{2R_1}{R_2} \right] \quad (1)$$

Therefore the differential gain G is

$$G = \frac{R_4}{R_3} \left[1 + \frac{2R_1}{R_2} \right] \quad (2)$$

B. Filtering:

Although EEG signals are very weak so that they can easily contaminate with noise and other artifacts. Therefore, it is necessary to improve the signal by applying filters. All filters applied on to the analog output of the instrumentation amplifier are coded in Lab view. As 0.5 to 33 Hz of frequency is considered in clinical applications, band pass filter is used to reject a different frequency which does not match with clinical range. The filtered output can be monitored in the waveform chart located on the front panel.

C. Interfacing with NI myDAQ

NI myDAQ is a data acquisition system which contains Analog Input (contains 2 channels with 16 bits), Analog Output (also contains 2 channels with 16 bits and also contain 3.5 mm stereo jack), Digital I/O (8 DIO lines), counters (counter, timer), Integrated DMM (V, A, Ohm) and power supply (+/- 15 V) [11].

Data acquisition is the process of measuring the electrical potential or physical process such as current, voltage, temperature, etc. Data acquisition can be done with different types of sensors. NI myDAQ is the hardware that connects the analog output of the amplifier to the computer via USB. In this scenario, the analog output of the instrumentation amplifier is

connected to the analog input of the NI myDAQ i.e., A0. Where myDAQ is interfaced and powered via USB to computer.

D. Developing Labview Code

The code is developed in NI Labview, using DAQ assistant in the measurement I/O palette in the rear panel. Here, the required analog input slot has to be selected as A0. The resultant output can be monitored in the waveform chart of the front panel. Entire Labview code is placed in while loop to have continuous acquisition. The code developed in NI Labview for acquisition of EEG is shown in Fig. 4.

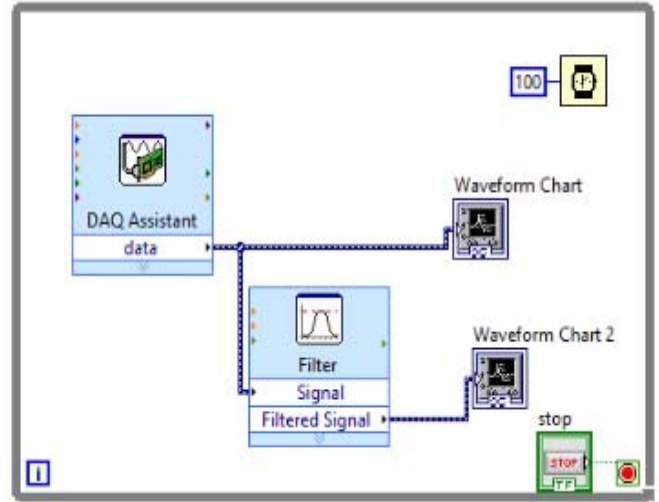
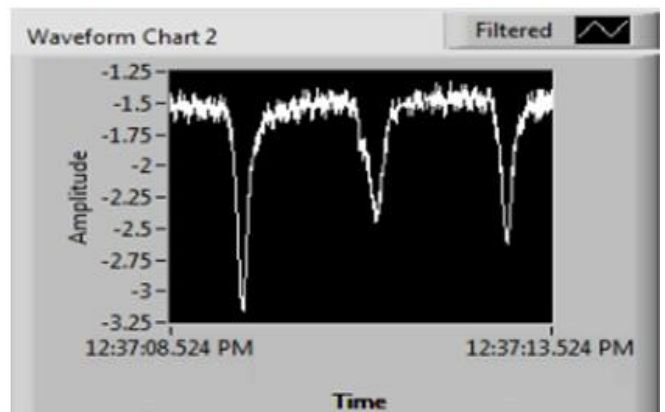


Fig. 4. myDAQ using Lab View.

III. RESULTS

After developing the circuitry and interfacing with NI myDAQ. The data is processed in NI Labview development software. The electrode is placed on the forehead and reference electrode on the left ear of the participant. Now, the participants were asked to blink an eye. Using this system the blink artifact in EEG signal can be monitored efficiently. The contamination of Blink artifact into the frontal region of EEG is displayed in the waveform chart, which is shown in below Fig. 5.



Scale: X-axis Time (s), Y-axis Amplitude (v/div)

Fig. 5. Blink acquisition in frontal region.

IV. CONCLUSION

A single lead EEG amplifier with active electrodes is designed and implemented using NI LABVIEW with interface of NI myDAQ. The Portable EEG acquisition is used to record the brain activity at a particular point or on specific lobe. It is very much useful to observe the seizures at a particular point on the psyche. Design is tested and verified on number of participants. The clear and precise acquisition depends on the filtering stages for the reduction of noise and to have better EEG signal.

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