Characterisation and Separation of Brain Wave Signals

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Abstract—**Neurons in the brain communicate through electrical impulses that give rise to both electrical and magnetic fields which are categorized into five different band limits. These waves can be measured outside the skull through an Electroencephalogram. The utilisation of brainwave detection in other areas such as biomedical engineering and gaming industry is yet to be explored. Categorisation of different rhythms of brainwaves and brainwave pattern analysis make it easier to identify the mental status of a person. This research aims to develop a hardware and software that is tested using function generators to simulate the EEG signal from the brain. It is observed that the initial results based on the above that the device performs as expected and hence can be used as brain wave signal measuring device.**

Keywords— Brain wave, EEG, Signal processing

1. Introduction

The human brain can be sub divided into four structures each with a different set of functions [1]. Each movement, perception and thought that we execute has a distinct neural activation pattern. An Electroencephalography (EEG) is a record of this brain activity and characterizes the field potentials ensuing from the combined activity of many neuron impulses. It is measured through surface electrodes placed on the skin of the scalp. There are five different band limits for the brain wave, namely delta, theta, alpha, beta and gamma. These identifiers are characterized based on the frequency range which is normally from 1Hz to 60Hz, with amplitudes of 10 to 100 microvolts [2].

Although EEG has been in use for a relatively long time, little research has been made into the recognition of brainwave patterns and the separation of brainwaves and categorizing them [3]. Moreover the current apparatus available for measuring EEG waves are bulky thus restricting the flexibility of operating conditions and the movement of the user.

This research is aimed to create a device that can acquire brainwaves, identify and differentiate between the different frequencies consisted in the signal with the help of a signal processing software and is also portable thus giving a wider range of operation. The study aspires to provide a better understanding of a person's mental and physical action through the development of a real time brainwave scope. Such a device enable discerning various human afflictions such as a person's mental health by measuring the stress levels and hence provide proper counseling. Real time gaming is another advent that this technology enable by providing the method of creating mind control games.

2. Research Methodology

Figure 1 above shows the graphical user interface developed through LABVIEW that displays the real time brainwave signal and the separate components.

The block diagram in Figure 2 indicates the different stages of obtaining the signal and analyzing it to component categories based on its characteristics. The signal is obtained from five different signal generators each of which represent a band of the brainwave signal. It is then passed through a signal conditioning circuit consisting of a 60Hz notch filter, used for eliminating the noise accumulation from the 60 Hz power supply. Since brainwaves are between the frequencies of 3Hz-60Hz the signal passes through a 60Hz low pass filter and a 3Hz high pass filter.

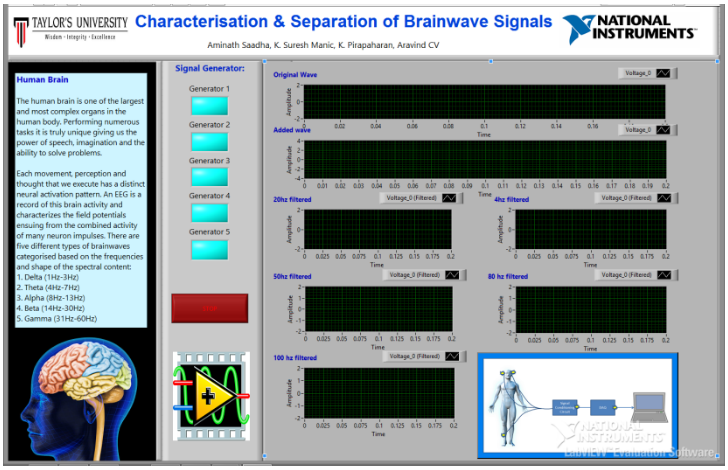

Fig. 1 Graphical user interface developed for the system.

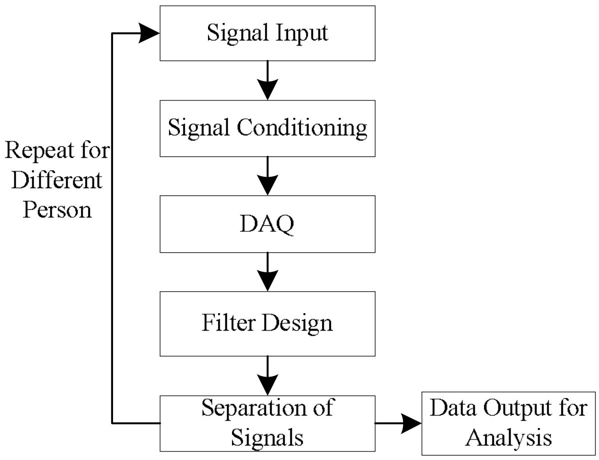

Fig. 2 Methodology used in this brainwave separation analysis.

This removes other frequency bands that are acquired through the sensor. Butterworth filters constructed using LM741 amplifier is used for a smoother response and unity gain in order to eliminate any noise amplification.

The conditioned signal then passes through DAQ 6009, a data acquisition device used for simple data logging and portable measurement. The Nyquist Shannon sampling theory states that the sampling frequency must be twice that of the highest frequency of the signal hence for brainwaves giving a sampling rate of 120 Hz [5]. However for a better reconstruction of the signal since it is of very small amplitude, 15mV a much higher sampling rate of 5 kilo-samples per second is used. Signals that are sampled from the Data Acquisition (DAQ) are sent to a signal processing software, LABVIEW [3]. Within this platform the signals are then added up which represents the actual EEG signal from the brain. Band pass filters are then implemented through the software to analyze the signal and separate it into the components frequencies. Tests are conducted to evaluate the software and assess whether the five different filters in the setup perform correctly.

In test 1, two case studies are conducted since the device is intended to be used for people with different personality, meaning that the brainwaves vary from person to person. In the first case signals are all within the frequency band of the band pass filter. This test assumes that all the frequencies of brain waves are present in this signal and tests the detection of all the frequencies. In case 2 the signal from a signal generator is changed so that it does not fall in any filter category. This signal assumes that the subject does not produce one frequency of brain wave at that moment and all other frequencies are being detected. Table 1 shows the frequency of signal from each signal generator for the two cases. A second test is designed to check whether the intensity of the brain wave is detected by the software. For this study the amplitude of the 4Hz signal generator is increased from the input while the amplitude of other frequencies is maintained constant.

TABLE 1. Case studies conducted to test the design.

Case	Signal Generator frequency (Hz)				
	1	2	3	4	5
1	4	20	50	80	100
2	4	20	50	120	100

3. Results Analysis

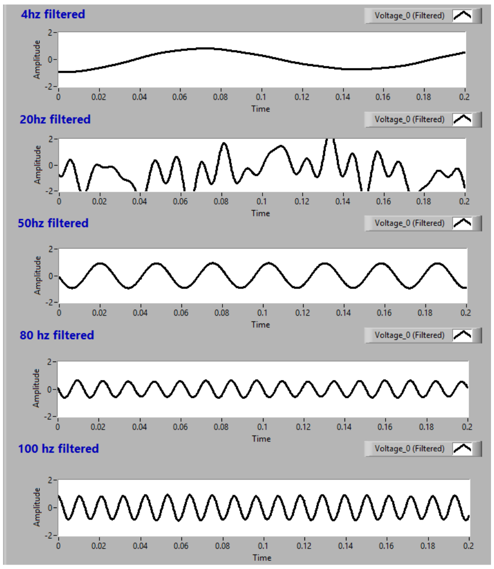

Fig. 3 Results for test 1 case 1

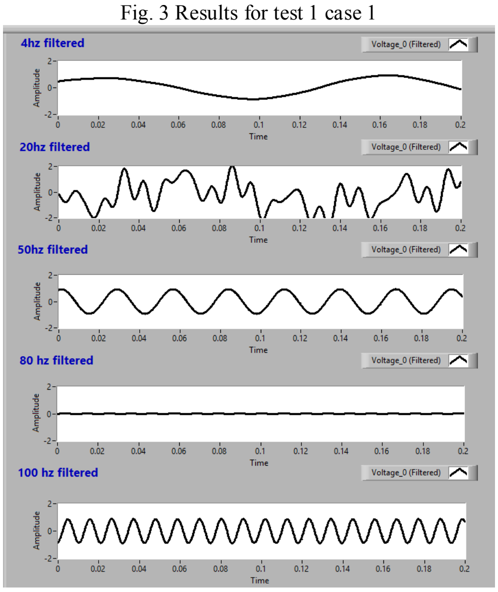

Fig. 4 Results for test 1 case 2

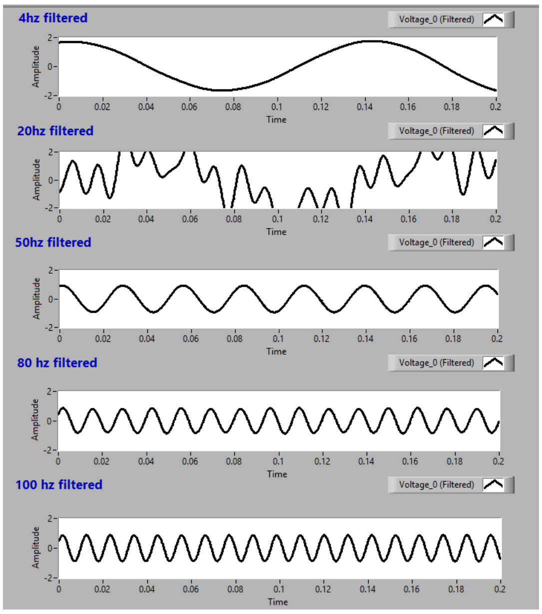

Fig. 5 Results for intensity test.

Figure 3 shows the results from test 1-case 1, where all the signals are detected as shown by their representative amplitudes. However in figure 4 which displays the results for case 2 the amplitude for the 80Hz signal is almost null indicating that there is no signal and that the filters function as expected.

Figure 5 displays the results for test 2 where the detection of intensity of a signal is detected. As expected the amplitude which corresponds to the intensity of the wave is increased which is shown in the greater amplitude of the signal.

7. Conclusions

The results from the initial test with signal generators indicate that the software and hardware built for the experiment are performing as expected. The filters that are implemented in the LABVIEW software filters out each band of the signal from the mixed signal which comprises the original input signal. For further studies the signal generators are to be replaced with the electrode and tested to visualize the actual brain waves in real time.

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