Constructing a System for Measuring Brain Wave

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Abstract: In medical treatment, electro-encephalogram (EEG) is used to diagnose the pathological change of human body and reveal the state of mind. The brain wave machines used in medical treatment belong to the system of multi channels and they are too expansive to obtain. The purpose of the thesis is to design a set of analytical system with eight channels for the general physiological examining.

The main structure of the system is based on LabVIEW operation, including pre-amplifier, systematic examining procedure of brain wave. The measurement data was recorded by data acquisition card. It recorded the instantaneous frequency and amplitude for analyzing mainly. The later section of the article focused on the usability of the self-developed brain wave machine. We achieved the testing affairs by measuring the electro-encephalogram of 14 normal persons.

Key-Words: EEG; LabVIEW, Brain wave

1 Introduction

The brain is the most mysterious section of the human body, the brain control all action of organ in the body. The brain consists of nerve cell and the existence electric field changes among the nerve cell.

EEG is a summation of electrical activities generated by cortical neurons, and is recorded from the scalp for clinical use. Nowadays, EEG is accepted as the most harmless technology in diagnosing this widespread illness.

But the brain wave machines used in medical treatment belong to the system of multi channels and they are too expansive to obtain.

The purpose of the paper was to design a set of analytical system with eight channels for the physiological measuring. Using chlorine silver electrode which diameter of the disc is 0.7 cm.

And the later section of the article focused on the usability of the self-developed Measurement system of brain wave.

2 Material and Methods

2.1. Recording in human subject

EEGs were recorded from fourteen adults 7 males, 7 females who were students of academic institutes in kaohsiung. All volunteers were healthy without epilepsy.

They were seated in a chair and read the Magazine of recreation for testing. Exploring cup electrodes were fixed to scalp at F3, F4, C3, C4, P3, P4, O1 and O2 according to the International 10-20 system of the International Federation, and all electrode were referenced to the ipsilateral ear electrode (A1 or A2).
2.2. Introduction of brain wave

The structure of the brain, is included in skull, hard meninx, spider’s membrane, cerebrospinal fluid (CSF), soft meninx etc. And the top layer of the brain is a grey matter, nerve cell body is mostly concentrated here, contains about 100 billion or more nerve cell body altogether. And EEGs were electric field change of brain nerve cell, the electric difference about 1~100uV, the frequency range among 0.5-100 Hz [2].

The electroencephalographic (EEG) signals, was discovered in 1924 by Hans Berger [1], represent the tracings of summated cortical electrical activity collected by applying EEG electrodes on the scalp.

According to the International 10-20 system, it divides the frequency of the brain wave into four frequency bands, including δ-band activity between 0.5 and 4 Hz, θ-band activity is between 4 and 8 Hz, α-band activity is between 8 and 13 Hz, and β-band activity is between 13 and 22 Hz.

2.3. Constructing the Measurement system based on LabView

For this purposed, the researcher planned to design the system by LabView system, including a multichannel preamplifier, systematic examining procedure of brain wave.

2.3.1. Design a multichannel preamplifier

The amplitude of biological signals are very small, the range from 1uV to 100uV, In order to makesure brain wave signal can Accurate measurement, it must use preamplifier to Enlarge the signal. This researcher adopts the chip - LM324 to design a eight channels preamplifier. The preamplifier was composed of two-stage OP-Amps, the preamplifier that feature with high input impedance of 10⁹ to 10¹³Ω, low input bias current, low input offset current and wide bandwidth about 1 MHz. It is designed as a voltage follower with unity gain. In our design, the value of amplifier gain is the ratio of 1 (R2/R1). The first-stage amplifier gain is 2, and the second-stage amplifier gain is 201. The multichannel amplifier total gain is 402, and find from relevant research, some researcher use this chip to design preamplifier, too.

![Diagram of amplifier](image)

2.3.2. Measures system of brain wave

Labview is an application development program that uses a graphical programming language, G, to create programs as a block diagram form.

A personal computer (pentium 4 3.0G) with 1024MB of RAM and 80GB of hard disk capacity was equipped with a data acquisition card (PCI-6221, National Instruments) under a Microsoft XP environment. The PCI-6221 card has a fast (up to 250kHz sampling rate) 16-bit analog-to digital converter. This set-up met our specifications and was sufficient for multichannel recording and analysis. The card was configured for eight differential analog input channels. The card was connected to a CB-68LP box. This was a passive component allowing the connecting electrode cables to the card.

The sampling rate of the EEG channel was 250HZ. EEG data were amplified with the bandstop filter setting of 55-65 HZ and order 3 and the bandpass filter setting of 8-13 HZ order 3, and the sampling interval was 4 ms. The measurement systememnt recorded the data of instantaneous frequency and amplitude for analyzing.

3 Results

3.1. Result of the preamplifier value

The preamplifier is completed, this experiment is to prove the gain value of preamplifier. This research offers a signal with regular frequency and voltage, in
order to compare gain value of preamplifier to theory value.

This experiment offered 11 Hz sine wave with 0.04 volts for each channel. Result of the preamplifier value as follows:

Table 1. Results of the preamplifier value

<table>
<thead>
<tr>
<th>CHANNEL NAME</th>
<th>FREQ</th>
<th>FREQ ERROR</th>
<th>Volts</th>
<th>GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3</td>
<td>10.999</td>
<td>0.001</td>
<td>16.268</td>
<td>406.700</td>
</tr>
<tr>
<td>F4</td>
<td>10.999</td>
<td>0.001</td>
<td>16.013</td>
<td>400.325</td>
</tr>
<tr>
<td>C3</td>
<td>11.000</td>
<td>0.000</td>
<td>15.914</td>
<td>397.850</td>
</tr>
<tr>
<td>C4</td>
<td>11.000</td>
<td>0.000</td>
<td>16.202</td>
<td>405.050</td>
</tr>
<tr>
<td>P3</td>
<td>11.001</td>
<td>0.001</td>
<td>16.329</td>
<td>408.225</td>
</tr>
<tr>
<td>P4</td>
<td>11.001</td>
<td>0.001</td>
<td>16.298</td>
<td>407.450</td>
</tr>
<tr>
<td>O1</td>
<td>11.000</td>
<td>0.000</td>
<td>16.235</td>
<td>405.875</td>
</tr>
<tr>
<td>O2</td>
<td>10.999</td>
<td>0.001</td>
<td>16.211</td>
<td>405.275</td>
</tr>
</tbody>
</table>

The detailed value of the preamplifier are listed in Table 3.1. As shown in Table 3.1. Colum 1 is the channel name, and the range of the frequency error is less than 0.001, and the gain of the preamplifier are from 397.85 to 408.225. The gain error is from -1.03% to 1.54%.

3.2. Constructing brain wave amount measurement based on LabVIEW

3.2.1. The processes of brain wave measurement system

Using LabVIEW 7.1 software to design the measurement system, the detailed as the followings:

1. Multichannel setting
   To open the LabVIEW 7.1 DAQ assistant, and setting eight analogy inputs channel in differential way.

2. Setting of the sampling rate
   The sampling rate is 250Hz for each channel, and STR (Samples To Read) setting is 250. In this way, the system will automatic store data from each channel each second.

3. Reducing 60Hz interference
   DAQ assistant connected with bandstop filter Butterworth order=3, for reducing the signal of 60HZ in the environment.

4. Choice the range of the brain wave signal
   DAQ assistant connected with Butterworth order=3, and setting frequency range to record the signal of the brain signal.

CONSTRUCTION

Fig. 2. construction of teh system

5. The storing of the record
   Linking amplitude measurements component of the LabView to the measured objects, it stored the instantaneous signal to the data, and then recorded in EXCEL for analyzing.

3.3. Recorded EEG signal by the measurement system

3.3.1. Research object

In order to prove the measurement system being used to record EEG signal, the researcher seek 14 adults 7 males, 7 females who were students of academic institutes in kaohsiung participated in experiments, the age from 18 to 25 years old. All volunteers were healthy without epilepsy.
3.3.2. The environment controlling

Choose the general classroom or the meeting room environment, etc. Noise value must be lower than 70dB, temperature is controlled among 24~29 degrees Centigrade, and the humidity is controlled among 60%~75%.

3.3.3. Electrode position

Exploring cup electrodes were fixed to scalp at F3, F4, C3, C4, P3, P4, O1 and O2 by the International 10-20 system. And, all electrodes were referenced to the ipsilateral ear electrode (A1 or A2). The EEG data were amplified with the band-pass filter setting of 55-65 Hz order 3 and the ones of 8-13 Hz order 3. The sampling interval was 4 ms.

3.3.4. Results of The Experiments

This experiment recorded signal using the self-developed brain wave machine. The sampling rate of the channel was 250Hz, and the signal were amplified with band-pass filter setting of 55-65 Hz order 3, to reduce 60Hz interference. And using band-pass filter setting of 8-13 Hz order 3, to record α wave which frequency value 8~13 Hz. The measurement system recorded the α wave of instantaneous amplitude for analyzing. And judge the value equal to the theory value (By the knowledge of the reference [2], brain electric potential value is about 1 uV to 100 uV).

### Table 2. Result of Experimental

<table>
<thead>
<tr>
<th>Channel name</th>
<th>Minimum (uV)</th>
<th>Maximum (uV)</th>
<th>Average (uV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3</td>
<td>15.379</td>
<td>27.822</td>
<td>21.446</td>
</tr>
<tr>
<td>F4</td>
<td>15.674</td>
<td>28.513</td>
<td>20.712</td>
</tr>
<tr>
<td>C3</td>
<td>11.858</td>
<td>27.008</td>
<td>18.466</td>
</tr>
<tr>
<td>C4</td>
<td>15.010</td>
<td>27.068</td>
<td>19.474</td>
</tr>
<tr>
<td>P3</td>
<td>15.545</td>
<td>33.793</td>
<td>21.860</td>
</tr>
<tr>
<td>P4</td>
<td>14.534</td>
<td>29.909</td>
<td>21.918</td>
</tr>
<tr>
<td>O1</td>
<td>14.934</td>
<td>29.558</td>
<td>23.018</td>
</tr>
<tr>
<td>O2</td>
<td>14.326</td>
<td>47.000</td>
<td>26.652</td>
</tr>
</tbody>
</table>

As shown in Table 2, first column is the channel name and the average voltage value was 18 uV to 27 uV, equal to the theory value.

This experiment the measurement system can examine brain wave signal correctly.

4 Discussions

The main purpose of the paper was to design an EEG machine with 8 channels of measuring brain wave. For the highly precision measurement, we should choose the high quality DAQ with multiple channels. It would be suitable for medical science and accurate clinical research.

5 Conclusions

The purpose of this paper was to design a set of analytical system with eight channels for the physiological measuring. The system including a eight channels pre-amplifier, self-developed brain wave measurement system based on labview. In the section of the results, we can know that the measurement results fit the experienced knowledge. Based upon this result, it proved that measurement system can be use to record EEG signal.

Reference
