BRAIN WAVE CONTROLLER FOR STRESS REMOVAL AND AUTOMATION OF AUTOMOBILE IGNITION TO PREVENT DRIVING UNDER INFLUENCE

[CONTROLLING BRAINWAVES USING EMBEDDED SYSTEMS]

K.KABILAN
Department of ECE, NANDHA ENGINEERING COLLEGE

ABSTRACT

Stress is a prevalent and costly problem in today's workplace. It is the harmful physical and emotional response that occurs when there is a poor match between job demands and the capabilities, resources, or needs of the worker. Persistence of stress results in cardiovascular disease such as depression, concentration and memory loss.

Addiction is one of the chronic disorders that are characterized by the repeated use of substances or behaviors despite clear evidence of morbidity secondary to such use. It is a combination of genetic, biological / pharmacological and social factors. Example: gambling, alcohol drinking, taking narcotic drugs and certain mannerisms. The therapies at present consume time.

About 24% of the accidents taking place are due to drunken drive. A driver subjected to long drive falls sleepy and ends up in accident.

In this paper we briefly discuss about the brain wave and brains reaction during stress, addiction and drunk. This paper also explains you the basic task of Brainwave Controller, that how stress, addiction is identified with the help of brainwave and how these are controlled using the principle binaural beats. Also we have designed a device to detect the brainwaves and process it to determine whether it is addiction or stress. In addition to controlling of brainwaves, it also has a feature to avoid an individual who consumes alcohol to drive a vehicle. This paper promises to be an economical solution for the people who suffer from stress, addiction and to prevent accidents.

I. INTRODUCTION

Driving Under Influence (DUI):

Driving under the influence of alcohol (operating under the influence, drinking and driving, impaired driving) or other drugs is the act of operating a vehicle (including boat, airplane, or tractor) after consuming alcohol or other drugs. DUI or DWI are synonymous terms that represent the criminal offense of operating (or in some jurisdictions merely being in physical control of) a motor vehicle while being under the influence of alcohol or drugs or a combination of both. It is a criminal offense in most countries as it contributes to some of the major accidents. Now let us consider few basic concepts upon which this project is largely based upon.

Blood alcohol content or blood alcohol concentration (abbreviated BAC) is the concentration of alcohol in a person's blood. BAC is most commonly used as a metric of intoxication for legal or medical purposes. It is usually expressed in terms of volume of alcohol per volume of blood in the body. That is a unit-less ratio commonly expressed as parts per million (PPM) or as a fractional percentage. That is a decimal with 2-3 significant digits followed by a percentage sign, which means 1/100 of the previous number (E.g., 0.0008 expressed as a percentage as 0.08%). Since measurement must be accurate and inexpensive, several measurement techniques are used as proxies to approximate the true parts per million measure.

Some of the most common are listed here: (1) Volume of alcohol per volume of exhaled breath (E.g. 0.08 mL/L), (2) Mass per volume of blood in the body (E.g.: 0.08 g/L), and (3) Mass of alcohol per mass of the body (E.g.: 0.08 g/Kg). After one drink you reach your peak after 30 minutes and you should wait a few hours before you drive. The number of drinks consumed is often a poor measure of BAC, largely because of variations in weight, sex, and body fat.

Ignition Interlock System:

An ignition interlock device or breath alcohol ignition interlock device (IID and BIID) is a mechanism, like a breathalyzer, installed to a motor vehicle's dashboard. Before the vehicle's motor can be started, the driver first must exhale into the device, if the resultant breath-alcohol concentration analyzed result is greater than the programmed blood alcohol concentration, usually 0.02% or 0.04%, the device prevents the engine from being started. At random times after the engine has been started, the IID will require another breath sample. The purpose of this is to prevent a friend from breathing into the device, enabling the intoxicated person to get behind the wheel and drive away. If the breath sample isn't provided, or the sample exceeds the ignition interlock's preset blood alcohol level, the device will log the event, warn the driver and then start up an alarm (e.g., lights flashing, horn honking, etc.) until the ignition is turned off, or a clean breath sample has been provided. A common misconception is that interlock devices will simply turn off the engine if alcohol is detected; this would, however, create an unsafe driving situation and expose interlock manufacturers to considerable liability. An interlock device cannot turn off a running vehicle, all that an Interlock device can do is interrupt the starter circuit and prevent the engine from starting...

II. Principle

The principle behind this device is *Binaural Beats*. Binaural beats or binaural tones are auditory processing artifacts, which are apparent sounds, the perception of which arises in the brain independent of physical stimuli. The brain produces a similar phenomenon internally, resulting in low-frequency pulsations in the loudness of a perceived sound when two tones at slightly different frequencies are presented separately, one to each of a subject's ears, using stereo headphones. A beating tone will be perceived, as if the two tones mixed naturally, out of the brain. The frequency of the tones must be below about 1,000 to 1,500 hertz. The difference between the two frequencies must be small (below about 30 Hz) for the effect to occur; otherwise the two tones will be distinguishable and no beat will be perceived.

Binaural beats can influence functions of the brain besides those related to hearing. This phenomenon is called frequency following response (FFR). The concept is that if one receives a stimulus with a frequency in the range of brain waves, the predominant brain wave frequency is said to be likely to move towards the frequency of the stimulus (a process called entrainment). Human hearing is limited to the range of frequencies from 20 Hz to 20,000 Hz, while the frequencies of human brain waves are below about 40 Hz. To account for this, binaural beat frequencies must be used.

According to this view, when the perceived beat frequency corresponds to any of the brainwave frequencies, the brain entrains to or moves towards the beat frequency. For example, if a 315 Hz sine wave is played into the right ear and a 325 Hz one into the left ear, the brain is supposed to be entrained towards the beat frequency 10 Hz. Alpha range is usually associated with relaxation, this is supposed to have a relaxing effect. Some people find pure sine waves or *pink noise* unpleasant, so background music (e.g. natural sounds such as river noises) can also be mixed with them.

III. Construction And Working

A. Block diagram

The General block diagram of controlling addiction/stress is shown in the figure 4.

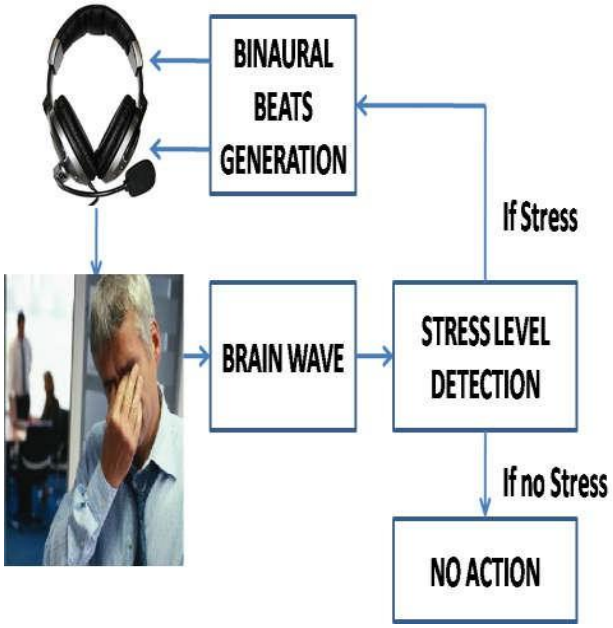


Fig. 4 General block diagram to control addiction / stress

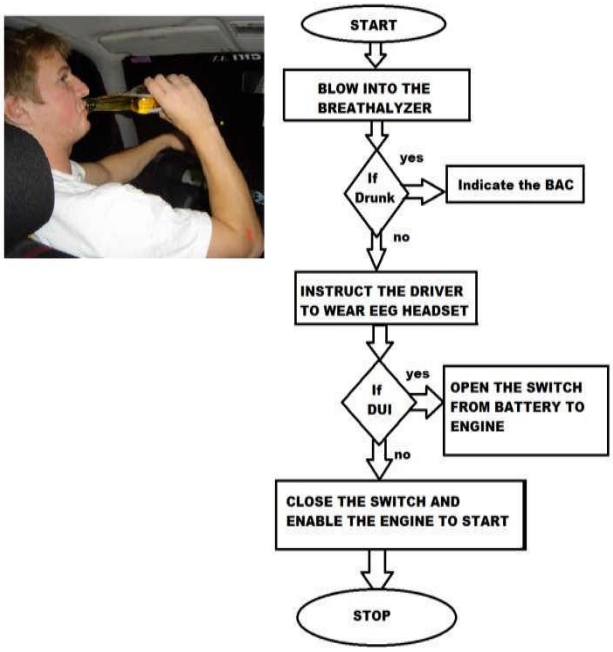


Fig. 5 General block diagram to avoid DUI

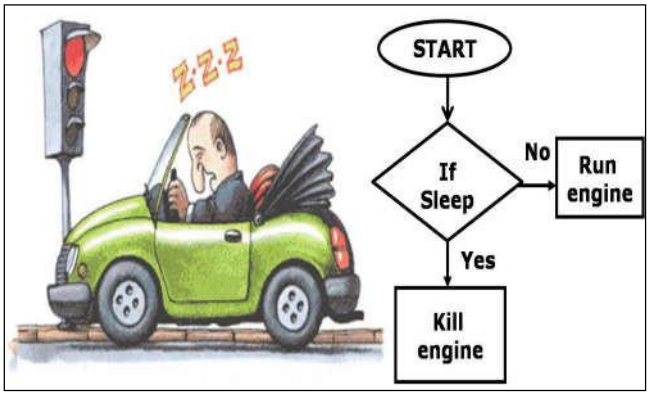


Fig. 6 General block diagram to avoid accidents

The block diagram used in implementation of brainwave controller with all its modes is given in figure 7.

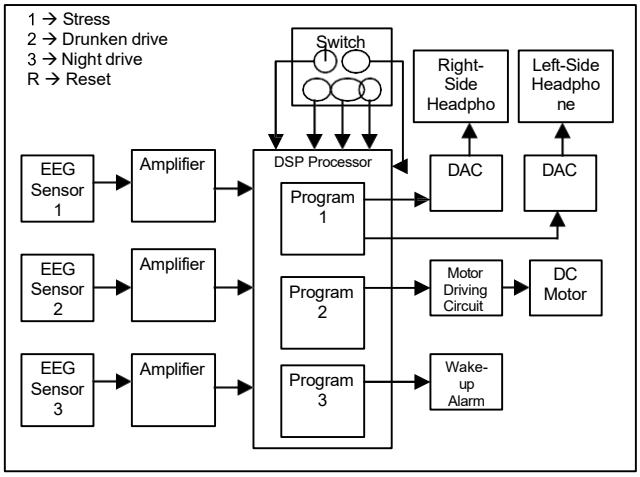


Fig. 7 General block diagram of Brainwave controller

B. EEG Sensors

EEG sensors is used to measure the electrical equivalent signal of brain wave.It consist of a 0.7 inch diameter hard plastic outer disc housing with a pre-jelled Silver chloride snap style post pellet insert. These sensors do not contain any latex. Figure 8 shows the representation of Ag/Agcl EEG sensor.

Fig. 8 Electroencephalography (EEG) sensors

Fig.9 EEG Fabricated Headset

The sensor sends the analog brainwave signal into the instrumentation amplifier circuit.

C. Instrumentation Amplifiers

The amplitude of analog brainwaves is in between the range of 150 – 250 micro volts (μV). This is very low. For processing, at least amplitude above 2 volt is needed. For this a high gain and low noise amplifier is needed. For that instrumentation amplifier with high gain and high CMRR ratio is employed.

Here one operational is not enough to produce this much high gain. So a series of amplifier is cascaded to give required gain. The gain of an individual inverting operational amplifier is given by.

$$\text{Gain } (A) = -R_2/R_1$$

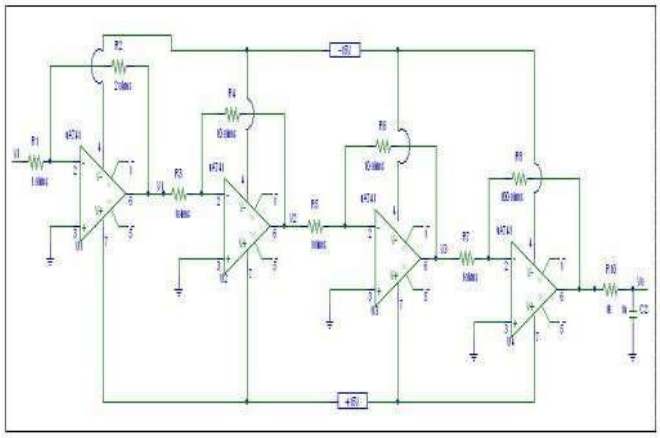


Fig.9 Circuit diagram of cascaded inverting amplifier with a gain of 20,000. (Designed in Pspice)

Here we are using four inverting amplifier cascaded as shown in figure 9. Let the gain of each inverting amplifier from left to right be A_1, A_2, A_3 and A_4. And let V_i and V_o be the input and output voltages of the amplifier.

Now,

$A_1 = (-R_2/R_1)$
$= (-2/1)$
$= -2$
$A_2 = (-R_4/R_3)$
$= (-10/1)$
$= -10$

$A_3 = (-R_6/R_5)$
$= (-10/1)$

$= -10$
$A_4 = (-R_8/R_7)$
$= (-100/1)$
$= -100$
*all resistors are in kilo ohm

Now Total Gain of the amplifier (A_{eff}),

$A_{eff} = A_1 * A_2 * A_3 * A_4$
$A_{eff} = (-2)*(-10)*(-10)*(-100)$
$A_{eff} = 20, 000$

Therefore,

$V_o = Vi * A_{eff} * V_i$
$= 15 * 10^{-5} * 20, 000$ V
$V_o = 3\ V_i$

Hence an amplifier with gain 20,000 is designed using basic operational amplifier.

D. DSP Processor

The Amplified EEG signal is given to TMS320C6713DSP Processor where it has a pre-defined program to select a range of frequency from 1 – 50 Hertz. Then that selected range is converted from analog to digital samples. The DSP processor has a definite program according to different modes selected from the switch. There are 3 modes with which we can use this device.

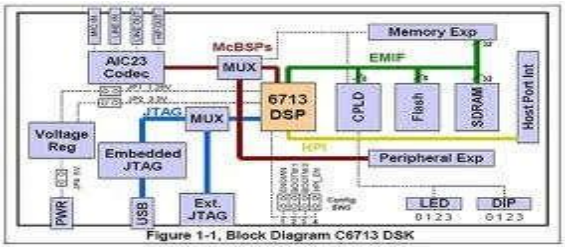
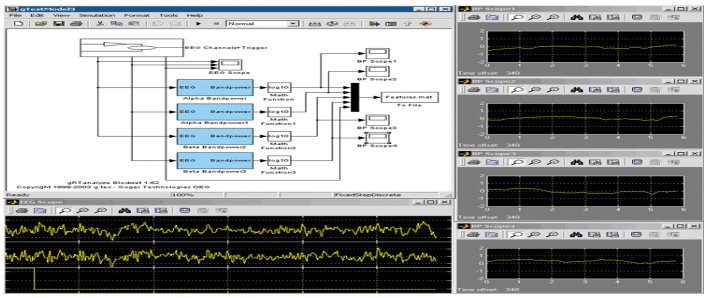
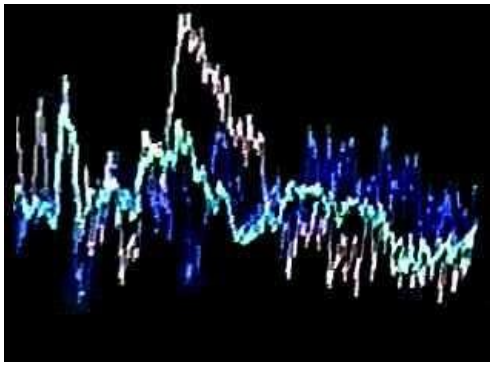


Figure 1-1, Block Diagram C6713 DSK

E. Simulation:

The following simulation images indicate the recorded brainwave using 2 EEG electrodes:





1. ***Mode - 1: Controlling addiction / stress:***

In mode 1 the DSP processor checks for the frequency range between 32 – 40 Hertz. If the range is between 32 – 40 Hertz, it is considered that the person is under addiction/stress and the processor runs a look-up table which contains the digital samples of binaural beats. The samples produce sine wave with a difference of 10 Hertz. These two waves are sent to each side of headphone.

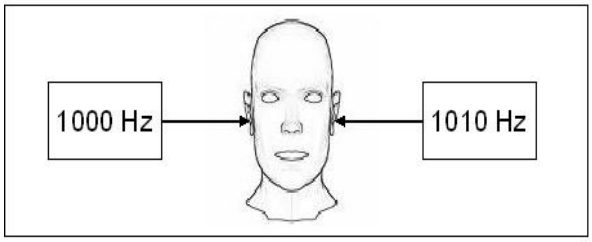


Fig.10 Block Diagram – Sending two similar tones with difference in frequency.

This generates the binaural beats. This is given to the ears . As the difference in these two waves is 10 Hz which is below 20 Hz, it cannot be detected by the human ear. But there is a neuron called afferon neuron inside the ear which senses this 10 Hz and sends it to brain as a stimulus. Now this stimulus entrains the brain to generate a stimulus of brainwaves similar to the supplied stimulus thereby reducing the brainwaves from 32 – 40 Hz to 9 – 14 Hz making the mind relaxed.

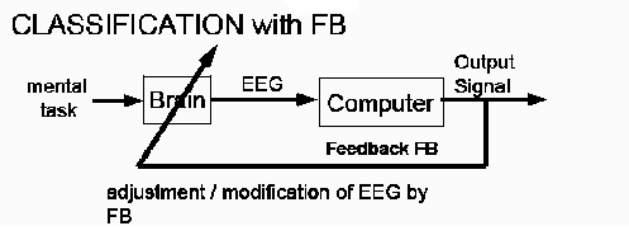
2. ***Mode – 2: Avoiding DUI*** *:*

When the switch is turned to mode 2, the device is connected to internal circuitry of a vehicle. Firstly, an Ignition Interlock Device (IID) is placed in an automobile and it is made mandatory for the driver to exhale in to the breathalyzer to switch on the automobile's engine. Here, the Blood Alcohol Level (BAC) of the driver is analyzed and in case of high BAC the engine does not start. If BAC is low, then a specially fabricated Electroencephalograph (EEG) headset (which contains EEG sensors according to international 10 -20 system) should be placed in the driver's head to analyze the driver's brainwaves. By analyzing the driver's brainwaves, the risk of driving under the influence of drugs is reduced. Here the BAC is measured as per the international threshold value of 0.04ml/L. Once the BAC is declared low, then the driver has to take up the drug test, which involves the usage of EEG headset in order to detect the brainwave activity of the driver. Unless and otherwise the driver has his brain wave levels at alpha or beta mode, the engine will not start.

3. ***Mode – 3: Night drive:***

When the switch is turned to mode 3, the device is used to avoid sleep while long night drive. Here the individual must wear a cap at all times. This cap is embedded with EEG sensors as explained in mode 2. Here too DSP processor checks whether the signal has frequency below 7 Hertz which means the individual is nearly asleep.

If such is the case, the processor triggers an alarm, so that accidents can be avoided. This alarm could be of any form. For example it could be horns honking or the audio system playing loud music or enabling specific alarm device to perform the waking up operation.



IV. Conclusion

Firstly, the brainwaves are controlled by the principle of binaural beats and frequency following response thereby controlling addiction or stress by making the mind relaxed temporarily. Secondly, the brainwaves are continuously monitored to avoid drunken drive in a vehicle. Thirdly, the brainwaves are continuously monitored to falling asleep while driving long distance in a vehicle. Though all the above applications are discreet to each other, it is absolutely useful to use a same device for all the three purposes.

V. Merits

1. The whole device is light weight and can be carried anywhere.
2. The whole device including sensors and headphone is cheap and costs only about Rs. 1500 and slightly above.

VI. Demerits

Those meeting any of the following criteria should not use binaural beats

1. Epileptics
2. Pregnant women
3. People susceptible to seizures
4. Pacemaker users
5. Photosensitive people.

VII. Future enhancements

1. The concept of *frequency following response* can be further researched to ease communication with deaf and dumb individuals.
2. The concept of *binaural beats* can be further used to study the resonance of brain during brain diseases.

References

1. *'Detection of seizures in epileptic and non-epileptic patients using GPS and Embedded Systems' by Abhiram Chakraborty – Ukranian Journal of Telemedicine and medical Telematics (TOM 3 No.2 pp 211)*
2. *'Automated realtime interpretation of brainwaves' by Kenneth George Jordan US patent*
3. *'Method and apparatus for changing brain wave frequency' by John L Carter US patent 5036858*
4. *en.wikipedia.org/wiki/ binaural beats*
5. *en.wikipedia.org/wiki/Addiction*