ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization   Vol. 5, Special Issue 4, March 2016

National Conference on Signal Processing, Instrumentation and Communication Engineering (SPICE' 16)

Organized by

Dept. of ECE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

Brain Computer Interface for Smart Home Control

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ABSTRACT: This project discuss about how to control home devices using a non invasive brain computer interface (BCI). The ambitious goal of a BCI is finally the restoration of movements, communication and environmental control for handicapped people. The Electroencephalographic signals (EEG) recorded from the brain activity using the Mind wave headset are encoded with the help of MATLAB, and the decision making which enables the control of devices is done with the help of arduino module. The user will control various devices in a smart home by using their attention. BCI is a system that captures the brain electrical activity in the form of EEG signal and translates those specific features of the signal that represents the intent of the user into computer readable commands. These commands can control and operate an electronic device. Hence the electroencephalography (EEG) signals produced by the brain electrical activity can be trained and used to control the home appliances or any digital device. This application will be very useful especially for disabled people with special needs [1].

KEYWORDS: Brain computer interface, Brain wave sensor, EEG, Bluetooth, Mat lab, Arduino.

I. INTRODUCTION

The human brain is made up of billions of interconnected neurons, the patterns of interaction between these neurons are represented as thoughts and emotional states. Every interaction between neurons creates an electrical discharge, alone these charges are impossible to measure from outside the skull. However, the activity created by hundreds of thousands concurrent discharges aggregates into waves which can be measured. Different brain states are the result of different patterns of neural interaction. These patterns lead to waves characterized by different amplitudes and frequencies, for example waves between 12 and 30 hertz, Beta Waves, are associated with concentration while waves between 8 and 12 hertz, Alpha Waves, are associated with relaxation and a state of mental calm. Here home appliances are controlled automatically according to the brain signal. The brain signals are collected using a brain wave sensor. Using these signals the home appliances can be controlled. This brain wave sensor consists of 3 main parts. They are dry electrodes, signal conditioning circuit and inbuilt RF transmitter. Dry electrodes are used to absorb the brain waves. This signal is analog in nature. For further processing these analog signals should be converted to digital form. Signal conditioning stage will do this conversion. The next part is inbuilt RF transmitter. It converts this digital signal into packet of data. This data packet is transmitted through Bluetooth transmitter. Here the received data packets are processed using mat lab tool. M script or math script is an interface program for brain wave. The output of matlab is given to the arduino module for automatic control of appliances [4].

II. PROJECT OVERVIEW

The project is operated with human brain assumptions and the on off condition of home appliance is based on change in the neural activities of the brain., and the wave measuring unit will receive the brain wave raw data and it will convert into signal using MATLAB GUI platform. Then the instructions will be sending to the home section to operate the modules (bulb, fan) [2].

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BRAIN COMPUTER INTERFACE SECTION

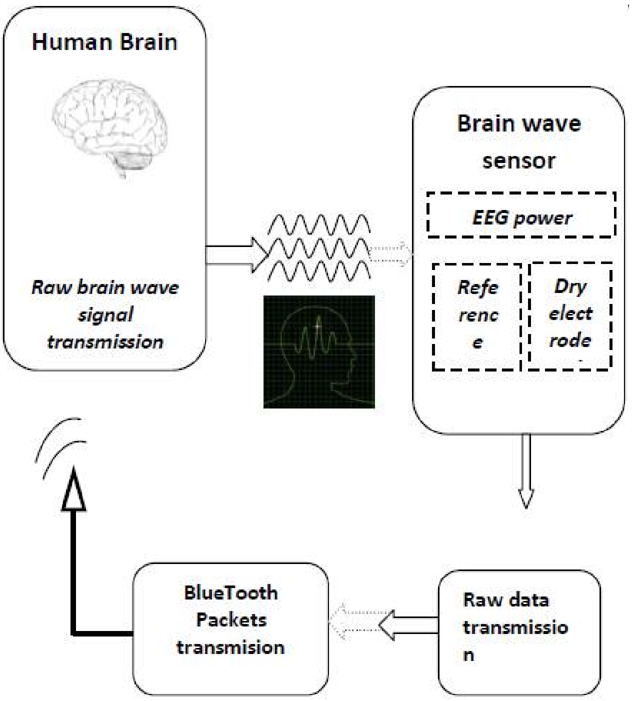

Fig. 1: Brain computer interface section

The last century of neuroscience has greatly increased our knowledge about the brain and particularly, the electrical signals emitted by neurons firing in the brain. The patterns and frequencies of these electrical signals can be measured by placing a sensor on the scalp. The mind tool line of headset products contains Nuerosky Think Gear Technology, which quantify the analog electrical signals commonly referred to as brain waves. These brain waves are collected using the brain wave sensor. The dry electrode of brain wave sensor is used to absorb the brain waves, these brain waves are initially processed using signal conditioning circuits and these signals is transmitted to the next stage in packets using the inbuilt Bluetooth transmitter.

DATA PROCESSING UNIT

The data processing is done in the matlab. The packets of data transmitted from the brain wave sensor are received through the computer's inbuilt Bluetooth receiver and these data packets are processed using matlab tools. We can analyse the status of different types of brain waves in the matlab GUI in real time, and according to the intensity of brain waves corresponds to a particular thought we can set values in matlab database. And these values are transmitted serially to the next section.

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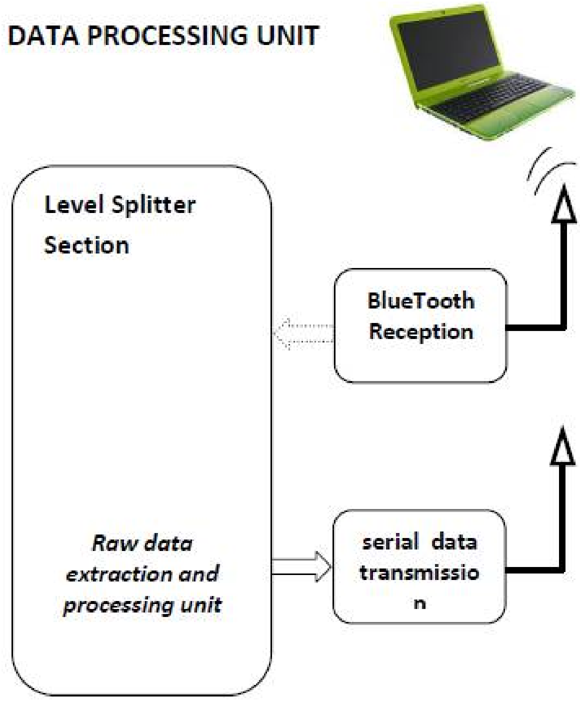

Fig. 2: DATA processing unit

HOME SECTION

This section consists of an arduino module. The serially transmitted data from the matlab is received via UART pins. The loads such as bulb, fan etc are connected to the general purpose input output pins of the microcontroller. The microcontroller in the arduino is pre-programmed to take decisions according to the data received. These decisions are then carried out to control the different home appliances.

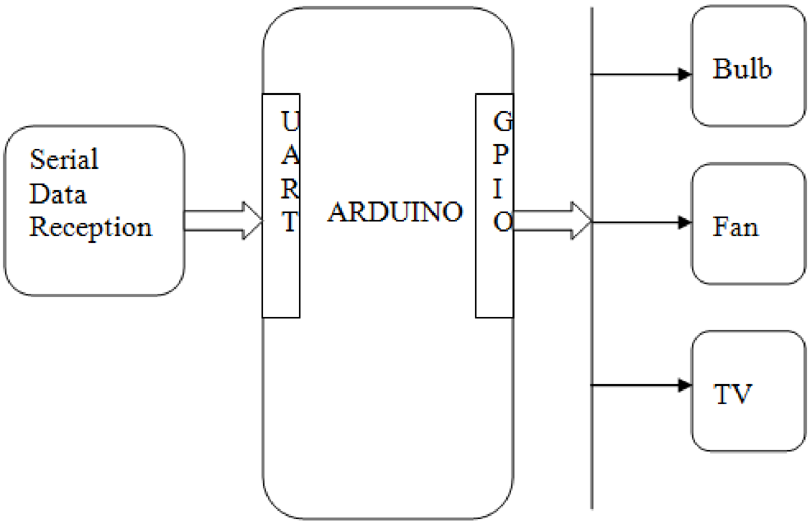

Fig 3: Home section

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III. DESIGN AND IMPLEMENTATION

This project uses two important platforms. 1. Coding Platform and 2. Execution Platform, These platforms are discussed below

Coding Platform:

In this project a brain computer interface system is used which will do the key role in the entire operation. For the BCI system, we are using the MATLAB and for brain wave sensor and Processor communication neurosky is used. The BCI will process in the following way. For calculating the blinking levels attention levels and concentration levels we need to use a brain wave sensor. Initially we have to take the data from the brain by using neurons position and should store in the brain wave sensor. The supportable sensor in the MATLAB is given in the form of the following data function [3].

connectionId1 =calllib('Thinkgear','TG_GetNewConnectionId');

Initially we need to check that sensor is connected or not. The mind wave sensor software will provide the information about the sensor connection. If the sensor is connected we are entering in to the MATLAB section for checking the blinking levels attention levels and concentration levels of person [3].

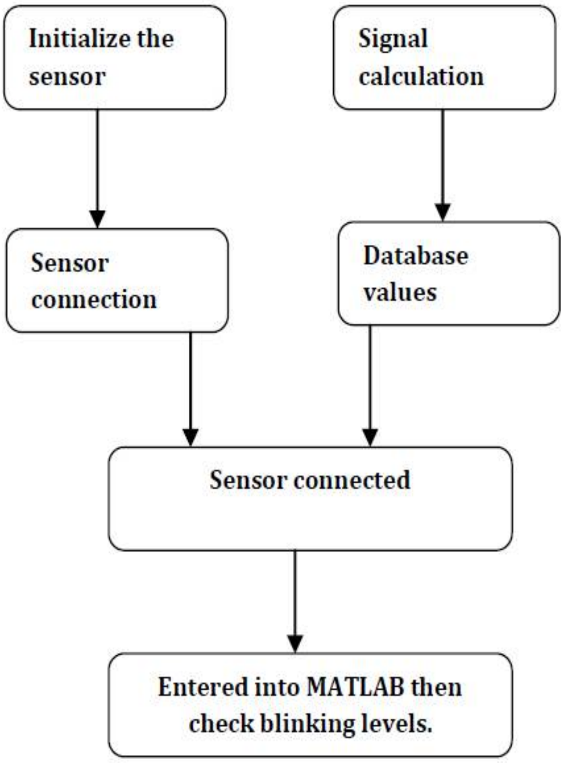

Fig. 4: BCI Software architecture

Once the blinking levels will calculated it will be send to MATLAB. Whenever MATLAB reads a blinking values it will convert into digital values because for micro controller understanding purpose the values should be in digital format. After calculating the blinking values, we need to check whether it will cross the set point in the database. As an acknowledgement we will get the following help dialogue [3].

```
if(data_BLINK (j) > 90)
if(Drive mode == 1)
fopen(serial One);
fopen("Blink.exe");
```

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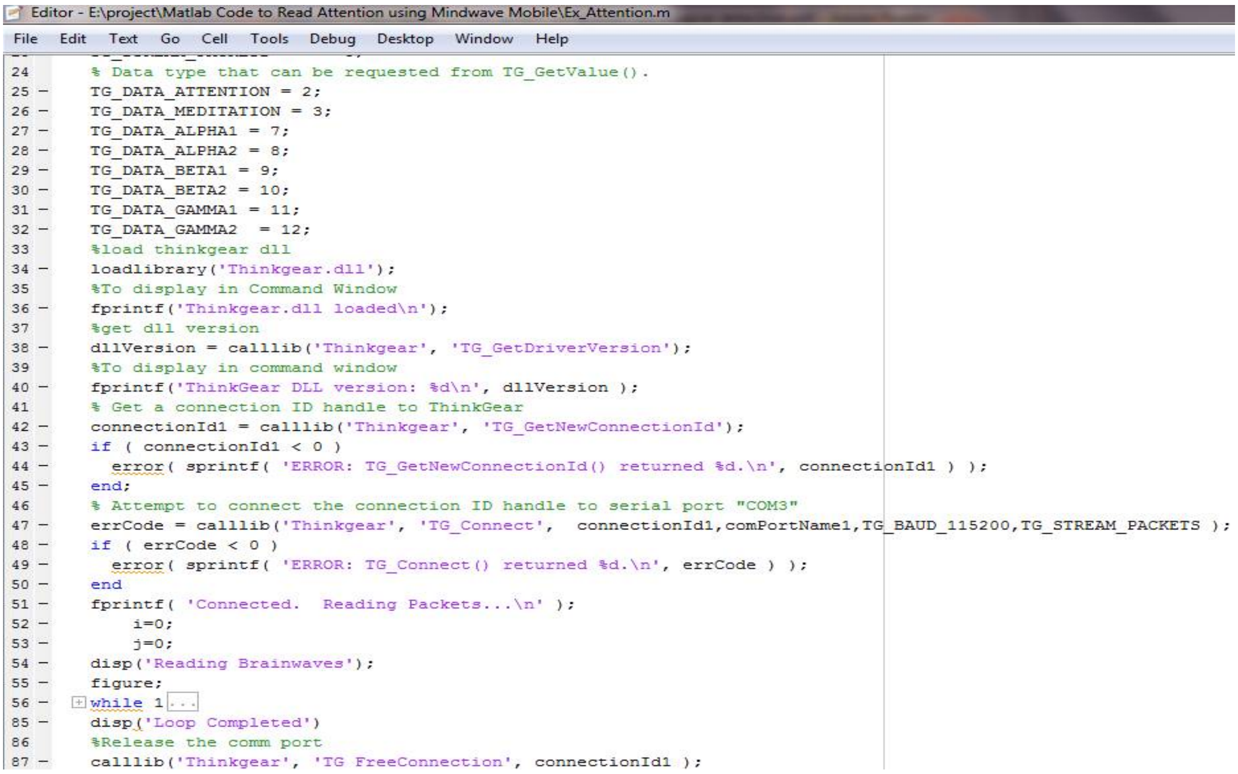
fclose (serial One);
End

Then pre-processing will be done within the blinking levels and the database values which involves, Similarity checks and probability finding. Here similarity checking is nothing but the comparison between two blinking values by calculating the change between the input and data base values. Then the result will be shown on the MATLAB.

```
if(data_BLINK (j) > 90)
  %            if(Drive mode == 1)
                fopen (serial One);
                fwrite (serialOne,'Q');
                fclose(serial One);
  %            end
         end
```

Drowsiness, eyes open and eyes closed are closely connected to alpha activity. once sleepiness forces the eyes to shut, alpha waves are strongest encephalogram brain signals have reported that in sleepiness state alpha activity mainly seems in os space and particularly magnitude of alpha2 wave like a better alpha band (11~13Hz) increases. However, supposing traditional adults have their eyes open notwithstanding they drowse, alpha changes of can't be explain one thing logically [3].




```
% Data type that can be requested from TG_GetValue().
TG_DATA_ATTENTION = 2;
TG_DATA_MEDITATION = 3;
TG_DATA_ALPHA1 = 7;
TG_DATA_ALPHA2 = 8;
TG_DATA_BETA1 = 9;
TG_DATA_BETA2 = 10;
TG_DATA_GAMMA1 = 11;
TG_DATA_GAMMA2  = 12;
%load thinkgear dll
loadlibrary('Thinkgear.dll');
%To display in Command Window
fprintf('Thinkgear.dll loaded\n');
%get dll version
dllVersion = calllib('Thinkgear', 'TG_GetDriverVersion');
%To display in command window
fprintf('ThinkGear DLL version: %d\n', dllVersion );
% Get a connection ID handle to ThinkGear
connectionId1 = calllib('Thinkgear', 'TG_GetNewConnectionId');
if ( connectionId1 < 0 )
  error( sprintf( 'ERROR: TG_GetNewConnectionId() returned %d.\n', connectionId1 ) );
end;
% Attempt to connect the connection ID handle to serial port "COM3"
errCode = calllib('Thinkgear', 'TG_Connect',  connectionId1,comPortName1,TG_BAUD_115200,TG_STREAM_PACKETS );
if ( errCode < 0 )
  error( sprintf( 'ERROR: TG_Connect() returned %d.\n', errCode ) );
end
fprintf( 'Connected.  Reading Packets...\n' );
    i=0;
    j=0;
disp('Reading Brainwaves');
figure;
while 1...
disp('Loop Completed')
%Release the comm port
calllib('Thinkgear', 'TG FreeConnection', connectionId1 );
```

Fig. 5: BCI running image

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Execution Platform:

This half consists of an Arduino Uno microcontroller board as the main unit.The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kilo Ohms. In addition, some pins have specialized functions.The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX).

An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library. The Arduino Uno can be programmed with the Arduino software (download). Select "Arduino Uno from the **Tools** > **Board** menu (according to the microcontroller on your board). For details, see the reference and tutorials. The ATmega328 on the Arduino Uno come pre burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files). You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.

In here the data received from the matlab is compared with the values in the arduino database and according to the data received the fan or bulb is turned on/off.

Wireless Platform:

BCI system: The main purpose of the current chapter is to review recent advances within the EEG field. to grasp these developments it'll initial be necessary to detail the physiological basis of the EEG signal. After, vital problems related to knowledge acquisition, signal process, and quantitative analyses are going to be mentioned. the most important portion of the chapter are going to be dedicated to reviewing rising supply localization techniques that are shown to localize EEG activity while not postulating a priori assumptions concerning the amount of underlying sources. As we are going to discuss, maybe the best advancements within the EEG field within the last 5-10 years are achieved within the development of those localization techniques, especially once utilized in concert with high-density EEG recording, realistic head models, and different purposeful neuro imaging techniques [2].

The time unit temporal resolution of electroencephalogram permits scientists to analyse not solely fluctuations of electroencephalogram activity (i.e., increases/decreases) as operate of task demand or subject samples however conjointly to differentiate between practical repressive and excitant activities. Low frequencies (e.g., delta and theta) show massive synchronic amplitudes, whereas electroencephalogram frequencies (e.g. beta and gamma) show tiny amplitude owing to high degree of asynchrony within the underlying somatic cell activity. In adults, the amplitude of normative electroencephalogram oscillations lies between ten and a hundred. Within the following section, a quick review of varied electroencephalogram bands and their supposed practical roles are going to be given [2].

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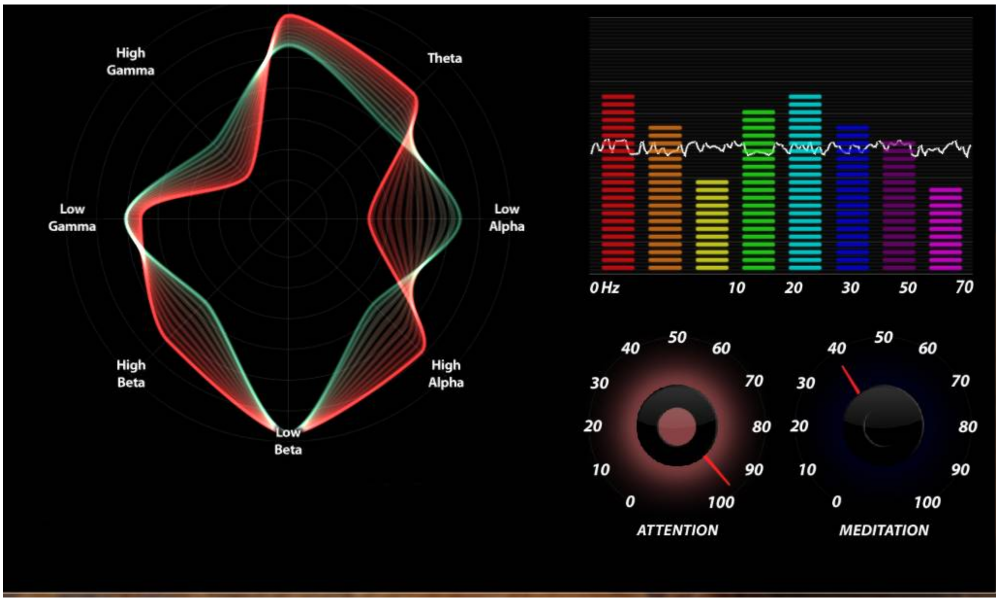

Fig. 6: Sensor wave indicator

IV. SIMULATION ANALYSIS USING MATLAB

A neuro sky product called brain wave sensor is used for collecting brain signals. A Bluetooth receiver is connected to the computer where these raw brain signals are extracted and processing using mat lab platform. M script /math script is used to interface brain wave output with mat lab and produce output waveform with respect to time .The program is written in program window and run the program & output is taken from mat lab platform which consists of 2 signals. The mat lab command window shows the signal strength of attention and blink signals. The output waveform shows the attention & blink signals in x-axis and time in y-axis [6].

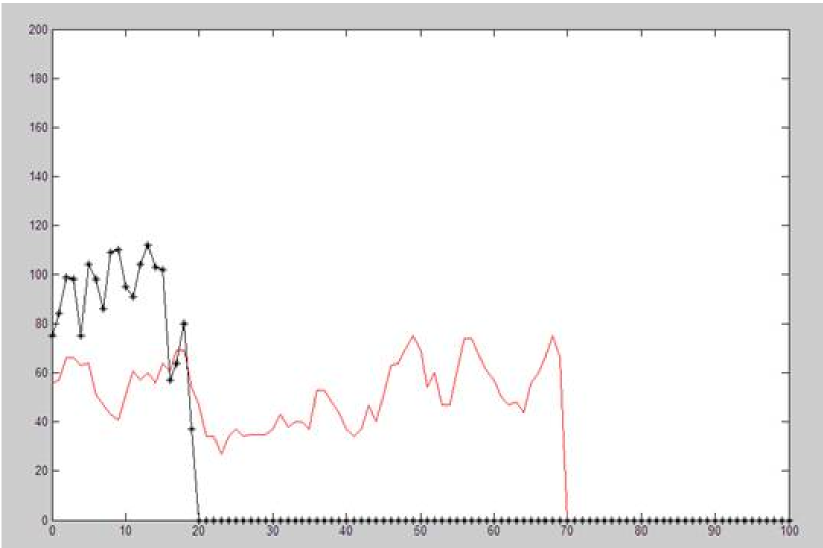

Fig. 7: Mat lab figure window

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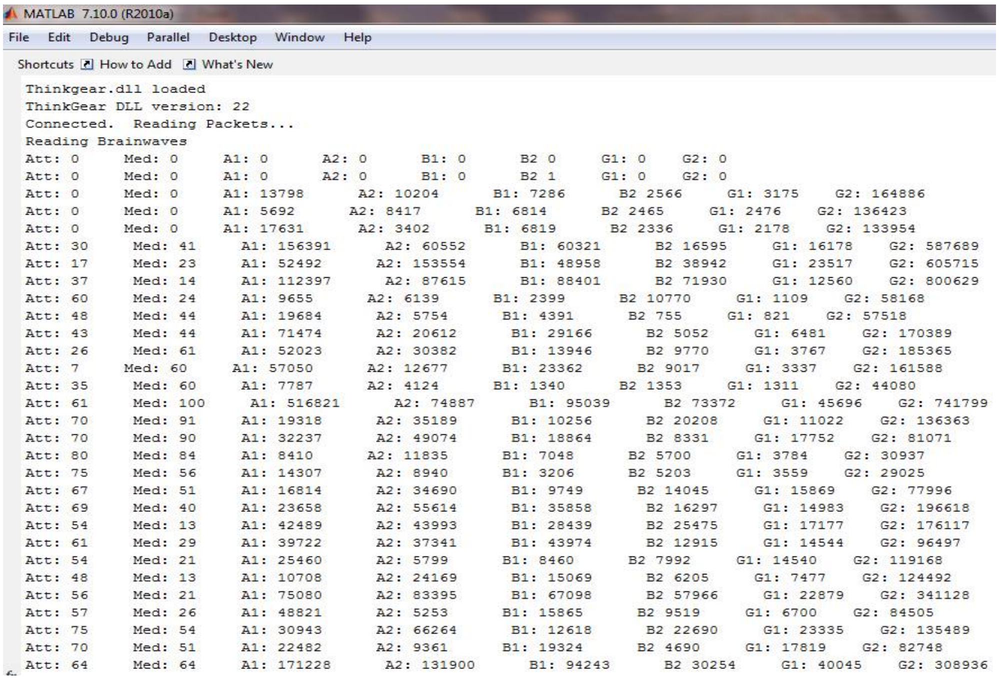

Fig. 8: Mat lab output window

V. CONCLUSION

This project is dealing with the signals from brain. Different brain states are the result of different patterns of neural interaction. These patterns lead to waves characterized by different amplitudes and frequencies. The signal generated by brain was received by the brain sensor and it will divide into packets and the packet data transmitted to wireless medium (blue tooth).the wave measuring unit will receive the brain wave raw data and it will convert into signal using MATLAB GUI platform [5].

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