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# Non Invasive Electroencephalograph Control for Smart Home Automation

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**ABSTRACT:** A brain-computer interface (BCI) is a new communication channel between the human brain and a digital computer. The ambitious goal of a BCI is the restoration of movements, communication and environmental control for disabled people. This paper deals with an electroencephalogram (EEG) based brain-computer interface,in order to control smart home applications. It is an artificial system that bypasses the body's normal efficient pathways, which are the neuromuscular output channels. Different brain states are the result of different patterns of neural interaction. These patterns leads to waves, characterized by different amplitudes and frequencies. Every interaction between neurons creates a minuscule electrical discharge. The signals generated by brain was received by the brain sensor and it is divided into packets and this packet data is transmitted to wireless medium (bluetooth). The wave measuring unit will receive the brain wave raw data and will convert into signal. Then the instructions will be send to the home section to operate the modules. In this paper , main aim is to develop a thought controlled smart home system. Non-invasive BCI devices were used to capture EEG signals. The EEG signals are transmitted via Bluetooth to the interface computer. Here, the home automation is controlled by human brain assumption. This gives a new pathway to natural communications and control engineering.

**KEYWORDS:** Brain Computer Inteface, Electroencephalography, ElectroCorticoGraphic, Peripheral Interface Controller, Analog to Digital Converter.

## I.INTRODUCTION

Between 40 to 50 million people in the world report some kind of disability. A brain computer interface, which does not require any muscle activity for device manipulation. It is a feasible control mechanism for this population. A brain computer interface (BCI) is a real time communication system designed to allow users to voluntarily send messages or commands without sending them through the brain's normal output pathways,and allows people to communicate without movement. People can send information simply by thinking. Everybody can imagine how useful would be a system that could know accurately what the user desires to do just by reading his scalp potential. There are two main BCI approaches: the invasive one that is based on ElectroCorticoGraphic (ECoG) data or single neuron recording and the non-invasive one that is based on EEG data.

For generations, humans have fantasized about the ability to communicate and interact with machines through thought alone or to create devices that can peer into a person's thoughts. These ideas have captures the imagination of humankind in the form of ancient myths and modern science fiction stories. However only in recent decades have advances in neuroscience and brain sensing technologies which allow us to monitor the physical processes within the brain that correspond with certain forms of thought. Modern brain sensing technologies provide a variety of methods for detecting specific forms of brain activity. Several papers have been written on recognizing EEG signal differences during different mental calculations. These papers suggest that different parts of the brain are active during different types of mental calculation, and if these different tasks may be accurately recognized, they could be used in a BCI.

BCI is a sytem that captures the brain electricity activity in the form of EEG signals; and translates those specific features of the signal that represents the intent of the user into and operate devices.This technology is developing very rapidly, as it has innumerable uses. The most important of which is improving the quality of life of humanbeings in general and elderly and disabled people in particular. In invasive type, an IC is implanted in the brain

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by surgey. Hence people prefer non invasive BCI which involves only wearing of a headset or cap equipped with an active electrode system.

## II.BRAIN COMPUTER INTERFACE

BCI system provides a direct communication pathway a human or animal brain and an external device.The design of BCI is divided into three modules:
A) Single Channel Amplifier
B) Data processing and Storage
C) Electrical isolation and shielding requirements

A. **Single Channel Amplifier**: The amplification may be fine-adjusted to the appropriate voltage level for the data capture microcontroller's analog-to-digitalconverters (ADC).

1)Interface: The interface begins at the surface electrode locations. Each electrode is attached to the skin using a conductive electrode cream to lower electrode-skin impedance.The electrode material is chosen such that it will not interact technically with electrolytes of the skin. The electrodes are connected to a shielded cable that carries their signal into one channel of the electrophysiological amplifier. Depending on the montage, configuration each electrode measurement is referenced to one relatively bio-electrically isolated electrode(monopolar) or each electrode is referenced to another electrode within the montage (bipolar). For each channel, the reference electrode voltage is subtracted from the signal electrode voltage using a precision instrumentation amplifier. This interface amplifier must have a high input impedance, gain, common mode rejection ratio, low offset voltage,and very small bias current. To facilitate this design,the amplifier require low operating voltage and an output is referenced to an internal ground.

2)Filtering*:* The signal from the interface stage was notch filtere to remove the 60-Hz main noise and then low pass filtered with a 50-Hz second order Butterworthfilter. These filters were implemented using passive resistor capacitor elements.

3)Amplification: The interface amplifier was specified with a very low offset voltage. However, this still may result in a non-zero output from common-mode input and high amplification. To compensate for this offset, a zero-trim stage may be included, or if the electrical specifications permit,then the signal may be AC coupled. The signal was amplified to a peak-to-peak voltage and the level is shifted within the range and is given to an analog-to-digital (ADC) converter in the next stage.

B. **Data Processing and Storage**: Two primary goals of this ambulatory BCI system is data collection using non-volatile storage, and on-line real time processing and control[3]. A single processing unit could be used; however, employing a parallel processing configuration enabled the system to be more flexible in design and programming with less computationally powerful microcontrollers.

C. **Electrical Isolation and Shielding Requirements**: For this type of application, electronic devices standards require the isolation of the subject from the supply mains.Electrical isolation may be achieved by incorporating electro-optical isolation components. In addition to the safety considerations, there are significant shielding and grounding considerations for a device that must
1) Measure signals in the mV range with respect to an external reference.
2) Amplify and shift the signal with respect to an internal floating reference.
3) Output an isolated signal that is referenced to ground.

## III.SYSTEM ARCHITECTURE

The system architecture for home appliance controller with EEG based BCI is shown in fig.1. The system consist of brain computer interfacing system, data processing unit and a home appliance controller. The brain computer interfacing system consist of human user with a mind sensing headset. The user generates task and makes decision on execution according to the protocol. The task is performed by the home appliances when it receives commands from BCI. It generates instructions based on user intention. This paper focuses on the home appliance controlling strategy in achieving accurate switching and control.

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The brain computer interfacing unit consist of a mind sensing headset which track the brain response/signals. The signal converted to digital data send to the Controller (PIC) through wireless connection. Controller collect the data and take decision with respect to the received data / signals. The controller send data to the GPIO corresponding to the received signals from EEG Headset. The GPIO control the devices with respect to the data from the controller.Then the switching and control of devices is made possible. Initially the LED will be in off state. When data is received LED will light.

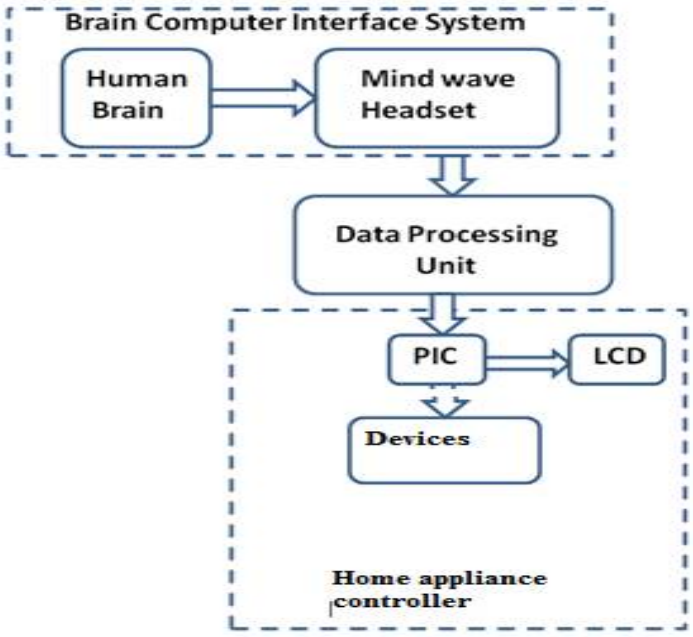


Fig.1 System architecture home appliance controller with EEG-BCI

EEG stands for electroencephalography. It is the neurophysiologic measurement, via the use of electrodes on the scalp, of the electrical activity of the brain[2]. The electrodes are carefully placed on certain areas of the brain in order to collect voltages. The resulting traces of voltages from the brain are called an electroencephalogram. Before electrodes are placed on the scalp, a conductive gel is usually applied to the skin to reduce impedance. Normally, each pair of electrodes is connected to the input of a differential amplifier which allows for amplification of about 60-100 dB of voltage gain. The resulting voltage signal is then passed through high-pass and low-pass filters, which are normally set at 0.5 Hz and 35-70 Hz, respectively. Electro galvanic signals are filtered out by the high-pass filter while electro myography signals are filtered out by the low-pass filter. The final signal is then displayed on a computer screen or oscilloscope. Although it is a very powerful method of collecting brain activity, EEG also has several limitations. Scalp electrodes are not sensitive enough to pick up individual action potentials. Instead, they actually pick up the activity of large groups of neurons. This is because the large groups of neurons emit larger voltage values that an individual neuron[4]. Another limitation of EEG is the fact that it has limited anatomical specificity[5]. Also, EEG is the only method to directly measure electrical activity. Major advantage of EEG signal is it has high resolution. Another advantage, which leads to our decision to use EEG, is its relative scalability.

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## IV.CIRCUIT DIAGRAM

PIC16F877A is the heart of the system. The operating voltage of the PIC microcontroller is 5V. It is fed from the power supply section .The available 230V supply is stepdown by means of a step down transformer. Rectification is done by the brige rectifier. Ripples are eliminated by means of capacitors.7805 IC is the regulation IC.

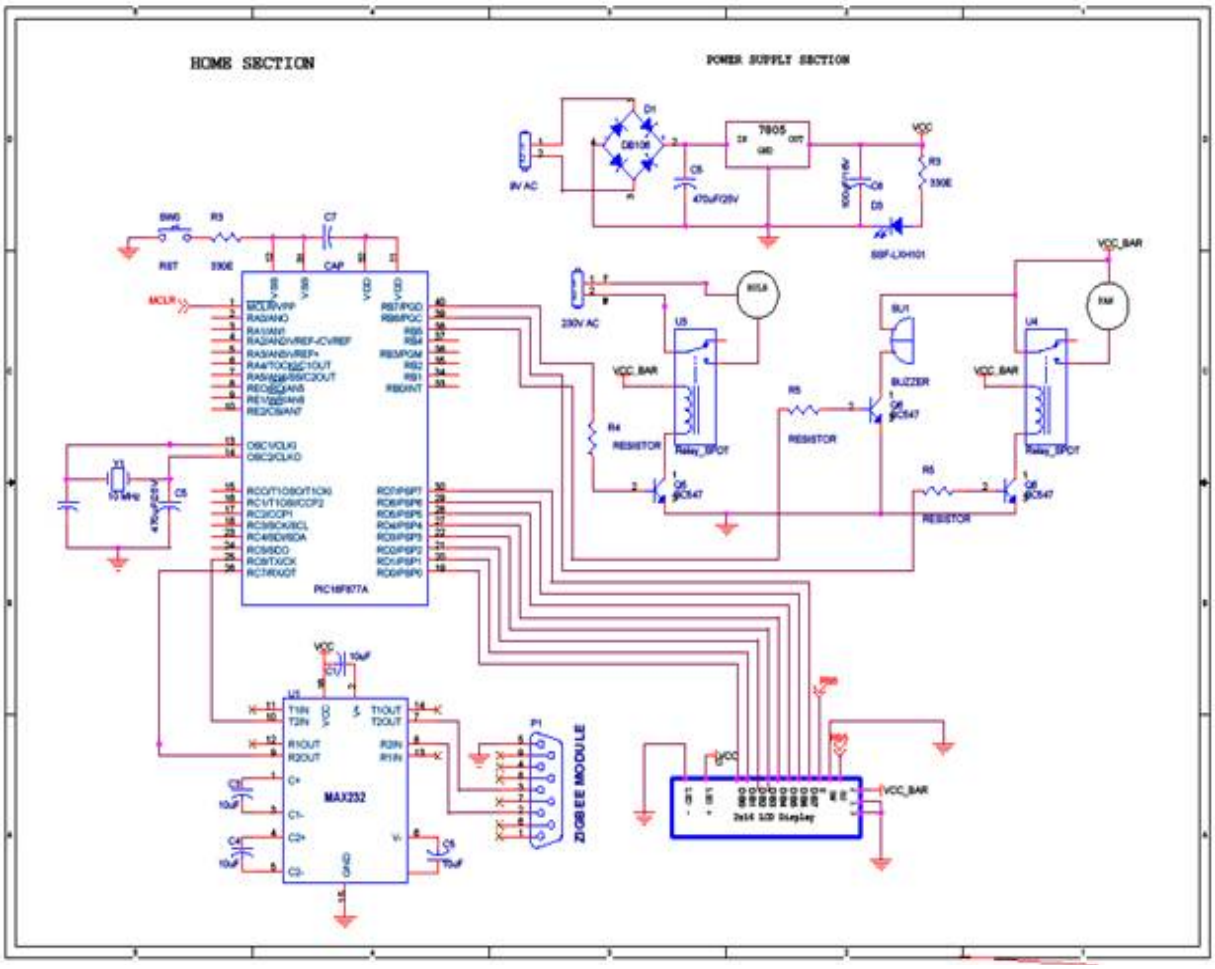


Fig.2 Circuit Diagram

For operating the appliances module like fan and bulb, relay switch is used.The input of the bulb is taken from pin number 40 of the PIC.And that of buzzer and fan are from pin number 38 and 39 respectively. For controlling the buzzer direct supply is given. MAX 232 is for the interfacing purpose of voltages of Zigbee module and PIC.Clock signal for the operation of PIC is fed by the crystal oscillator having a frequency of 10 MHZ. Current operations will be displayed on the LCD screen.

## V. SIMULATION &RESULTS

According to the control strategy the navigation and positioning of the system can be done using attention,eye blink and meditation rate[1]. The sensor placed in the scalp of the head touches the contact in the forehead and the reference point that located in the ear clip. The sensor collects the brain wave signals and process to digital signals in the on-board chip. Attention, meditation and eye blink rate can be calculated by using the mind wave headset. The simulation was performed in proteus platform.

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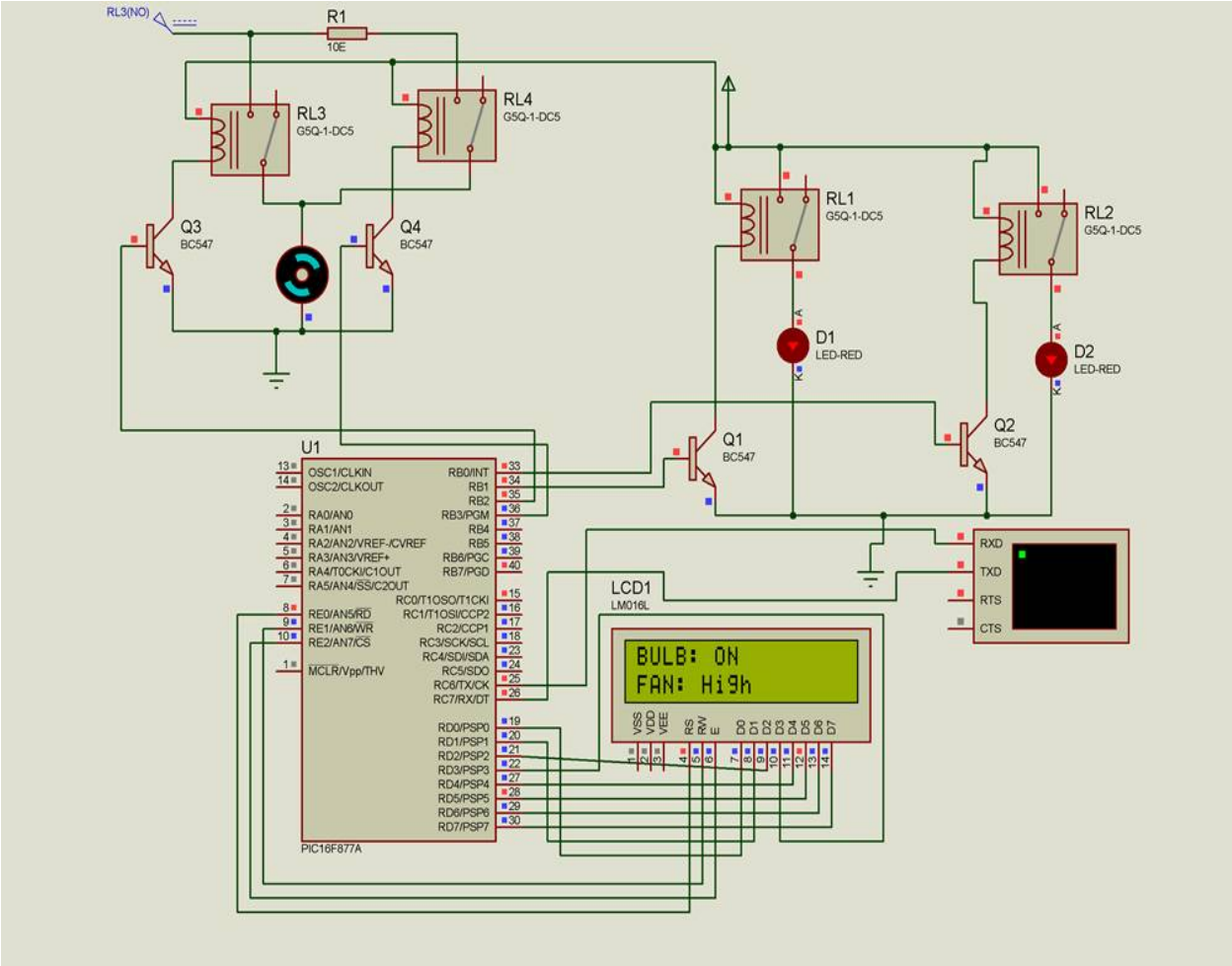


Fig.3 Simulation Diagram

For each persons the attention,meditation,eyeblining rate will be different.The below values are of a person. In our proposed system - attention, meditation, eyeblinking rates are tracked for operating bulb,buzzer,fan respectively. That is the operation and controlling of the system using BCI can be done in three ways-attention, eyeblink and meditation. In this paper we are selecting all the above three using mind sensing headset.

| | | |
|---|---|---|
| Attention>80 | Transmit 1 | Bulb on |
| Attention<40 | Transmit 1 | Bulb off |
| Eye Blink>80 | Transmit 3 | Fan on-high speed |
| Eye Blink<60 | Transmit 4 | Fan on-low speed |
| Eye Blink<40 | Transmit 5 | Fan off |
| Meditation>80 | Transmit 2 | Warning alarm on |
| Meditation<40 | Transmit 2 | Warning alarm off |

A graph is plotted which represent the attention and eye blink rate.The figure shown below represents the graph of eye blinking and attention values at different time instants. In case of attention, the upper cut off value of that

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person is 80 and the lower cut off value is 40. If the attention signal tracked by the brain is greater than the upper cut off value (80), the bulb will turn on.And if the value of attention is less than lower cut off value(40) bulb will turn off. In case of eye blinking, the upper cut off value of that person is 80 and the lower cut off value is 20. If the value is greater than the upper cut off value(80) fan will turn on at high speed.If value is less than the lower cut off value(40) fan will turn off.There is an intermediate cut off value for the lower speed of fan(60).If the eye blinking rate is less than 60 fan will be at low speed.

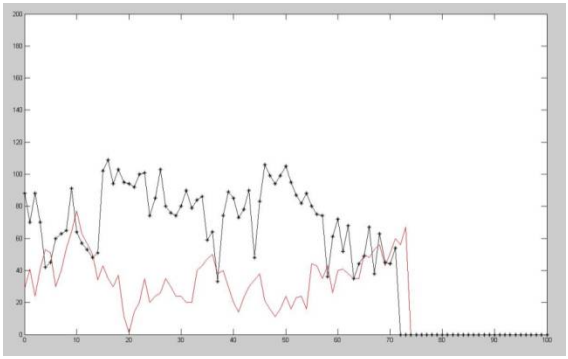

Fig.4 Time Vs Amplitude of attention and eye blink

The figure below represents the graph of eye blinking and meditation values at different time instants.Meditation value has been tracked for operating the buzzer.And the eye blinking value has been tracked for operating the fan. In case of meditation, the upper cut off value of that person is 80 and the lower cut off value is 40. If the value is greater than the upper cut off value(80),buzzer will turn on.If the value is less than the lower cut off (40) buzzer will turn off.

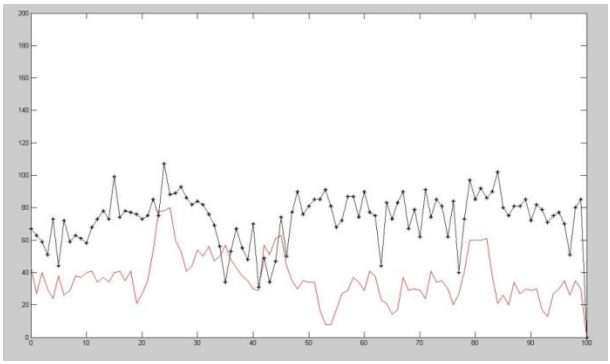

Fig.5 Time Vs Amplitude of meditation and eye blink

## VI. HARDWARE

The brain signal is acquired by the sensor called Mind wave head set. The mind wave headset sensor is placed at the human scalp which acquire the brain signal. The sensor also act as the transmitter which transmit the brain signal by converting in to digital pulses. It contains a dongle device which act as the receiver. The dongle device receives the transmitted signal by using a zig-bee pair and applied to a microcontroller. Depending upon the brain signal strength from the sensor the microcontroller operate the switching and control of home appliances.

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Fig.6 BCI based home appliance controller

## VII.CONCLUSION

Brain computer interfaces intended to translate ''thought into action'' with brain activity only. BCI research ensures long-held hope and expectation of thought and emotion detection and translation from brain states. In the present study, the proposed system is an EEG based BCI system with EEG sensors for sensing brain signals and a microcontroller for processing EEG signal and to control the devices. In addition, to demonstrate its use by an EEG-based home appliance control system.By decoding the brain wave signal, prototype model of "HOME APPLIANCE CONTROLLER" will work according to the coded signal. It is an achievement to the disabled person.

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