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# A Brain Computer Interface for Smart Home Control

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***Abstract:*** ***A new communication channel called brain computer interface (BCI) which is between the brain of human and a digital computer. Its goal is to restore movements, restoring communication, restoring environmental control for disabled people. The natural communication and control is alternated using this system. The neuromuscular channels which are the efficient pathway of our human body are bypassed by BCI's artificial system.***

***The varying patterns which are produced due to neural interactions results in the different states of brain. The different patterns of waves having different ranges of frequencies and amplitudes are produced by the patterns of neural interaction which is performed by using multiple neurons. These interactions with the neurons lead to the electrical discharge in smaller ranges. This project deals with brain signals which are sensed by the sensor in the head. These signals are divided into packets of data which are then will be transmitted into a wireless medium such as Bluetooth. The unit which is measuring the brain wave will receive the raw data from the sensor and it is interfaced to microcontroller. The output data from the microcontroller is sent to the operation process in home section such as modules of bulb and fan. Depending on the alpha and theta wave amplitudes, the on, off condition of home appliances is varied. This helps in the easy operation of home electrical appliances for aged people and paralyzed patients. Since smart technologies are becoming very popular in recent times, this kind of application of smart technology in home control finds very useful and helpful.***

***Keywords: BCI, EEG, Neural interaction, Virtual reality.***

## I. INTRODUCTION

Today, the advancement in information and sensor technology increases the convenience to needy people by developing the commercial products with the help of research studies. This gave way to the development and growth of smart houses which involves in providing different modes of environmental control [1]. A BCI functions by measuring the brain activity and analyzing them to control and operate external devices. The slow cortical potentials from the cortical region and the oscillations in the different bands of EEG, the evoked potentials all together determine the BCI. There is a wide range of applications of BCI systems in the real world. Its basic application can be a cursor movement on computer screen and the control of external devices.

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Till date realization was done upto the development of oscillatory EEG systems which is having a maximum of 5 degrees of freedom and slow cortical potentials based BCI systems.

The degree of freedom determines the accuracy of BCI. If the degree of freedom is 2, then the information that is transferred will be higher. The systems based on the steady state visually evoked potential have the ability to select different targets [4]. The analyses of frequency response in EEG limit this ability of SSVEP. EEG waveforms are generally classified according to their frequency, amplitude, and shape, as well as the sites on the scalp at which they are recorded. The spontaneous electrical activity from the brain is recorded using EEG. This records the brain waves over a period of time using the electrodes placed in the scalp.

## II. MATERIALS AND METHODS

### A. HARDWARE REQUIREMENT

It comprises of detailed information about the set of design specifications. The hardware design consists of the selection of system components as per the requirement, the details of subsystem that are required for the complete implementation of the system and full hardware schematic for the PCB layout. In the later stage design of the circuit and its testing has been carried out [7]. It involves the components selection, components description and hardware details of the system design.

This project includes the following components:

- PIC microcontroller
- RFM transceiver
- MAX 232
- EEG electrode
- Relay
- RPS
- LCD

### B. SOFTWARE REQUIREMENT

- Proteus
- CCS compiler

### C. POWER SUPPLY SECTION

Input voltage given is 230V. The device cannot withstand with 230V of power supply so the voltage is reduced using the step down transformer. But the Alternative current will remain same so rectifier is being used which converts an alternating current into a direct one by allowing a current to flow through it in one direction [5]. After rectification process, there will be some amplitude variation present in a DC power supply due to insufficient filtering, so capacitors are used for the filtering process [6].

In order to avoid noise in the circuit again filters are placed. Finally, the output is obtained.

### D. STEP DOWN TRANSFORMER

When A.C. is supplied to the primary winding of the transformer it can be either step-down or step- up depending on the D.C. needed. In our circuit the transformer of 230V/0-5V are used to perform the step-down operation where a 230V A.C. appears as 5V across the secondary winding [8].

Fig.1 shows the power supply circuit of the project.

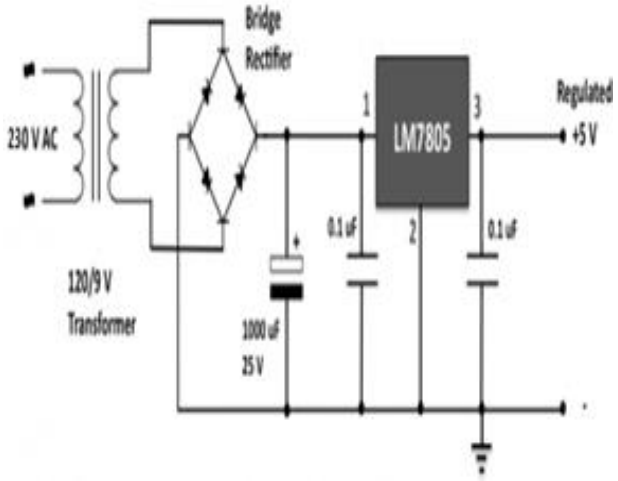


**Fig.1. Power supply circuit**

The bottom position of the transformer becomes negative and the top becomes positive during one input alteration. There will be reverse in this positive negative direction during the next input alteration [9]. The circuit of power supply and power sources are isolated between them in addition to the process of stepping down A.C voltages.

### E. PIC MICROCONTROLLER

The microcontroller used here is PIC microcontroller which is most widely used in the application of modern technologies, machine control applications, devices used for measurement, research purpose and in experimental set up [10]. This is mainly due to the presence of increased range of application, due to its lowest price, due to its high quality and ease of application. The other name of microcontroller is “Computer on a Chip”. PIC was developed as Peripheral controller. In order to carry the instructions, PIC Microcontrollers uses a separate program memory bus which is 14 bit. In order to carry the data, PIC Microcontrollers uses a separate data memory bus which is 8 bit. [3].

#### 1) Microcontroller - PIC18F4520

The optimized architecture of C compiler has an instruction set which is an optional extended one that is designed for optimizing the code of re-entrant. It also have flash program memory in enhanced manner with 100,000 erase/write cycle and with EEPROM memory of typically 10lakhs erase/write cycle. This microcontroller has interrupts with priority levels and software controlled self programmable technique. The retention period of flash/data EEPROM is typically 100 years. In addition to these it has a Hardware Multiplier of 8 x 8 Single-Cycle [11].

The rotation of rotor, which involves the axle and commutator, is carried out with respect to the stator. The rotor consists of windings (generally on a core), the commutator. Fig.2 shows the pin diagram of PIC controller.

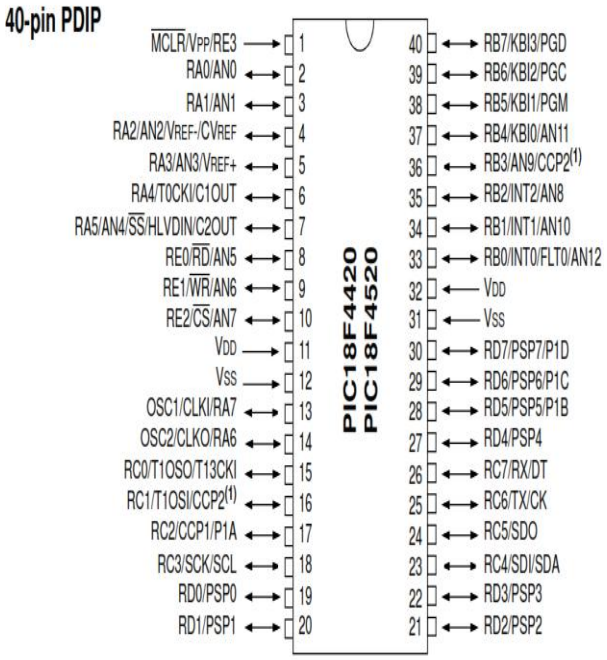


**Fig.2. Pin diagram of PIC controller**

### F. LCD (Liquid Crystal Display)

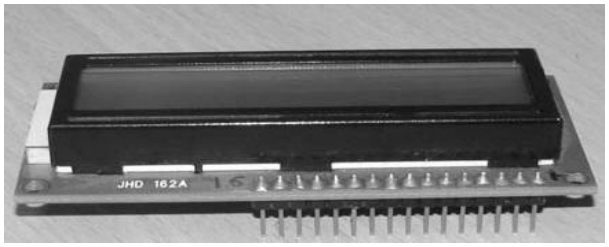


**Fig.3. LCD display**

The Liquid Crystal Display which is shown in the figure 3 is an electronic display module. It finds a variety of applications in electronic module. A very basic module of 16x2 LCD display is a commonly used one in various circuits and devices. It is preferred over multi segment LEDs and seven segments [12]. This is because LCDs are more economical and do not have any limitations for special character display and custom character display, animations and many others. It can be programmed very easily.

### G. RFM75

A Gaussian frequency shift keying is the modulation method which is used in RFM75 that operates at the frequency of ISM frequency band which is at 2400-2483.5 MHz working at the transmission mode of burst mode transmission.

This GFSK transceiver finds application in ultra low power consumption where it uses upto 2Mbps air data [2]. Using a simple MCU as a radio system, the full operation by the embedded packet processing engines can be enabled. MCU interference can be avoided in the reliable link using auto knowledge and auto re-transmission. RFM75 can be operated as a receiver or as a transmitter in TDD mode.

The frequency resolution used in the RF channel frequency is 1MHz.

## III. METHODOLOGY

Using the changes in the cognitive state of the user, there occurs an automatic control of home environment. The use of EEG machines which is an expensive one and the use of personal computers which is a bulky one can be avoided by using the basic module of wireless signal acquisition and signal processing module. It involves analysis of Brain wave signal. Home appliances are controlled by using EEG signals. By averaging the EEG responses, a potential is created which is called Event-related potentials (ERPs). This potential is used in various applications such as cognitive psychology, cognitive science and research. This proposed system is self controlled and have good operating facility. It contains Wireless transceiver communication which helps in the fast and quick transmission. EEG signal is recorded using the electrodes placed over the scalp. The recorded signal is amplified using the preamplifier and the noises are removed using noise attenuator. The processed signal is sent to the PIC microcontroller and the signal from the microcontroller is given to the transceiver. The transceiver at the home control end will receive this signal and depending on the processed signal the light and bulb will switch ON or OFF. Fig.4 and 5 shows the block diagram of brain computer interface and home appliance control. Fig.6 shows the prototype model of the proposed work.

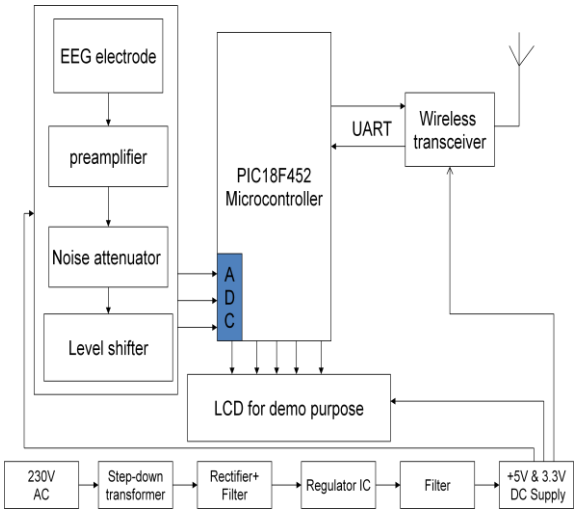


**Fig. 4 Block diagram for brain computer interface system**

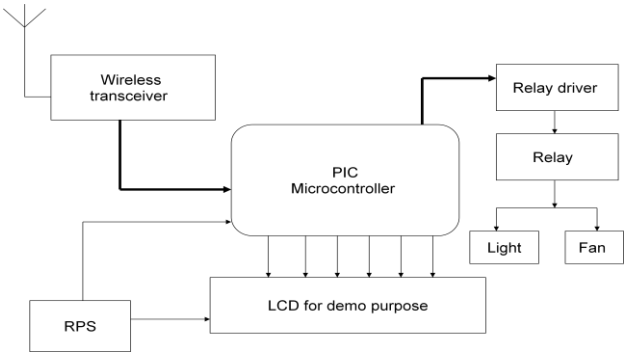


**Fig. 5 Block diagram for home control system**

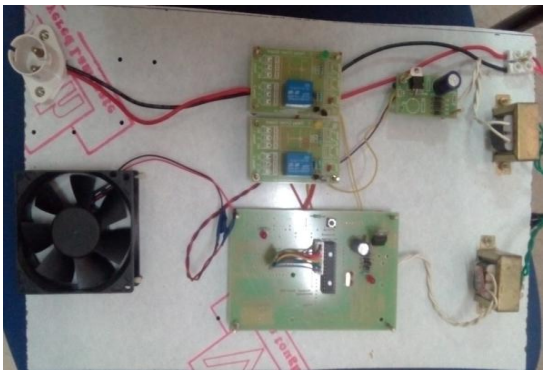

**Fig. 6 Prototype model**

## IV. RESULT ANALYSIS

Depending on the frequency of brain waves, the electric appliances like fan and bulb within a room will be operated. When the frequency increases, the presence of alpha wave is detected. This shows that the person is in active state. In this condition, the fan and bulb will be switched ON. When the frequency decreases, the theta wave will be detected and the person is in sleep state. In this condition, the fan and bulb will be switched OFF. When this method of operating the electric home appliances using brain wave signals is performed for 20 subjects, we obtain an accuracy of 82%. Table 1 shows the ON and OFF condition of light and bulb for the different states of a person.

**TABLE I : SWITCHING ON AND OFF OF ELECTRIC APPLIANCES DEPENDING ON THE STATE OF A PERSON**

| SUBJECT | FREQUENCY (Hz) | STATE | ELECTRIC APPLIANCES | |
|---|---|---|---|---|
| | | | *LIGHT* | *BULB* |
| Subject 1 | 9Hz | Active | ON | ON |
| Subject 2 | 11Hz | Active | ON | ON |
| Subject 3 | 5Hz | Sleep | OFF | OFF |

| | | | | |
|---|---|---|---|---|
| Subject 4 | 10Hz | Active | ON | ON |
| Subject 5 | 4HZ | Sleep | OFF | OFF |
| Subject 6 | 7Hz | Sleep | OFF | OFF |
| Subject 7 | 10Hz | Active | ON | ON |

## V. CONCLUSION

This paper shows how the electric home appliances are controlled using the changes in the cognitive state of the user by acquiring and analysing the EEG signals. The acquired EEG signals are processed in the transmitter module which is placed at the transmitter end (i.e) over the scalp and also processed in the receiver module which is placed at the home. The processed signals controls the electric appliances like fan and bulb, when to switch ON and when to switch OFF.

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