A Review on Wireless Multichannel EEG Recording System

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Abstract—This paper describes a wireless multichannel EEG recording system. EEG is a recording of the electrical activity of the brain which is recorded from the scalp. The system has two parts first is transmitter and second is receiver. The transmitter consists of electrodes, preprocessing section, processing unit, switches and Zigbee module. The receiver consist of Zigbee module, display section, processing unit, memory, switches and LCD. The captured EEG signals are amplified, filtered and are converted to digital by using A/D converter built in MSP430 microcontroller. The digital signals are transmitted via Zigbee to receiver side. Upon receiving these digital signals by Zigbee module can be displayed on PC via serial port. The features of this system are portability and low power consumption.

Key words: Electrodes, Amplifier, MSP430, Zigbee Module, PC, LCD

I. INTRODUCTION

EEG (Electroencephalography) is a recording of the electrical activity of the brain which is recorded directly from the scalp [6]. It is completely non-invasive technique that can be applied to patient repeatedly. The neurologist Hans Berger in1924 has discovered the presence of electrical activity of the brain and that is represented on paper [1].

EEG signals are recorded by using electrodes that are placed on scalp according to 10-20 international system as shown in following figure.

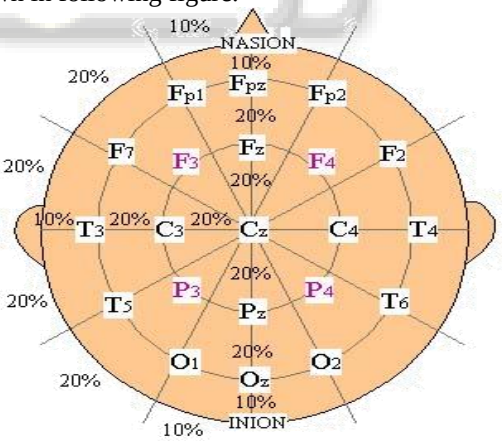


Fig. 1: 10-20 system placement of electrodes with landmarks.

The amplitude of EEG signals received from above electrodes is very low which range between 0.5 to 100µv which is 100 times less than ECG signal [1]. Also the noise is added due to surrounding electrical devices and also the tissues of the body to the electrode voltages. Hence, there is need for preprocessing of EEG signals [3]. So, collected electrode signals are amplified and then given to filter circuitry for removal of noise. Then signals are digitized using microcontroller and displayed on PC.

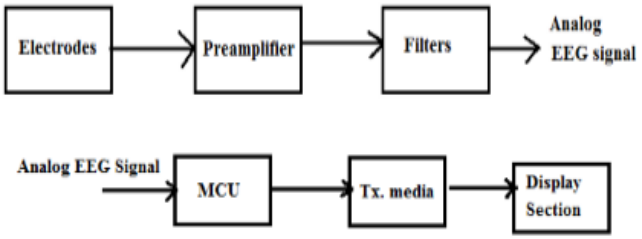
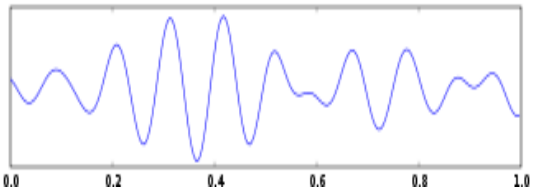
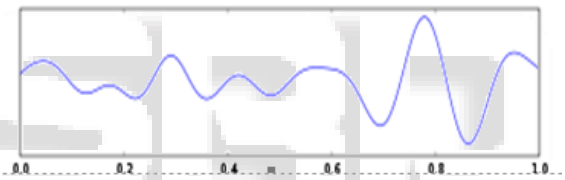


Fig. 2: Preprocessing of EEG signals.

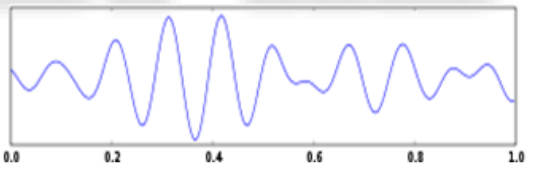
The EEG signals have five frequency rhythms and are categorized in to following frequency bands Delta (0.5-4Hz), Theta (4-7Hz), Alpha (8-13Hz), Beta (14-30Hz) and Gamma (>30Hz) [2].



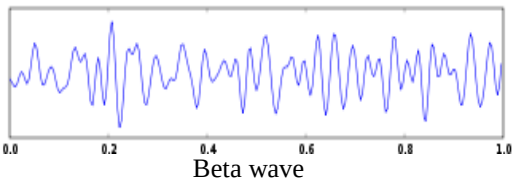
Delta wave



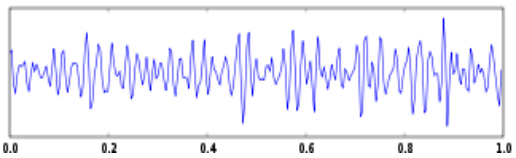
Theta wave



Alpha wave



Beta wave



Gamma wave

Fig. 3: Brain wave samples.

The mostly studied signal of human brain is alpha rhythm which occurs better in the posterior and occipital regions [1]. This rhythm is useful in treatment of stress, depression etc. [8].

II. LITERATURE SURVEY

In past decade it has been seen that EEG recording system consists of different amplifiers, filters, microcontrollers and associated transmission, storage and display system. In which few amplifiers were manufactured using CMOS technology, but due to high cost and noisy performance it is not suitable for clinical applications. So, the amplifiers are designed using AD620, instrumentation amplifier etc. which are easy to implement than CMOS IC technology [6].

And for analog to digital conversion different controllers are used like PIC, MSP430 etc. that have been reported in the following survey.

Hyem Saadi, Merzak Ferroukhi and Mokhtar Attari [2] have presented a single channel wireless EEG recording system which has two parts analog and digital. The analog part consists of DRL circuit, protection circuit, preamplifier, BPF and Gain amplifier. The EEG signal captured by electrodes is given to protection circuit. Then the EEG signal will be amplified by using instrumentation amplifier and that signal is given to BPF to remove the noise. Afterwards the signal is processed to gain amplifier to increase the strength of the signal [2].

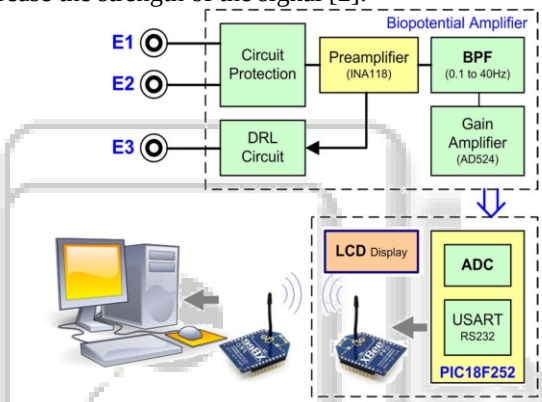


Fig. 4: Block diagram of the wireless EEG recording system [2].

Lin zhu, Haifeng Chen, Xu Zhang, Kai Guo, Shujing Wang, Yu wang, Weihua Pei, Hongda Chen [6] have presented portable multichannel EEG signal acquisition system, which consist of scalp electrodes, instrumentation amplifier , passive HPF, main amplifier, active LPF and for AD conversion they have used MSP430MCU. In this paper the digital data transmitted to PC by means of wires.

Harrison, R. R; and C. Cameron have presented a low power low noise CMOS amplifier for neural recording applications [7] in which amplifiers for EEG acquisition has designed using CMOS technology.

III. PROPOSED SYSTEM

With respect to above survey some system [2] for analog to digital converter they have used PIC18F252 microcontroller which is 8 bit, 28 pins, 23 i/o pins and 5 ADC channels. MSP430 microcontroller is advantageous than PIC18F252 because it has 16 bit architecture, 32 i/o pins and l2 ADC channels. And MSP430 has low power consumption than the PIC.

Some system [7] consists of different amplifiers. They have designed by using CMOS IC technology but due to high cost and noisy performance these amplifiers are not suitable for clinical applications. So an attempt has been made in this paper such that amplifier is designed using instrumentation amplifier which has low cost and low noise.

In some system [6] EEG data is transferred to PC by using wire which is difficult to monitor or take care of patients which are at home. So there is need to develop wireless EEG recording system.

Hence to overcome these issues we are proposing a portable and wireless EEG recording system. The heart of the proposed system is MSP430 microcontroller which consumes low power for many applications. The proposed system which composed of Transmitter and Receiver is as shown in following Figure 5 and Figure 6 respectively. The transmitter consists of various sections such as electrode, preprocessing, switches, processing unit, and transmission section. The proposed block diagram of receiver as shown in figure6 consists of different sections like receiver, display, processing unit, memory and switch section. Zigbee protocol is used for receiving data.

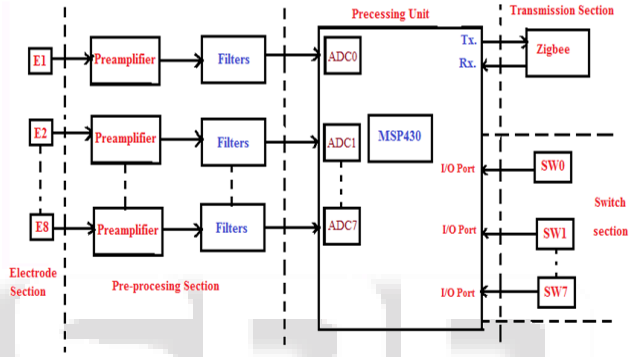


Fig. 5: Proposed block diagram of transmitter.

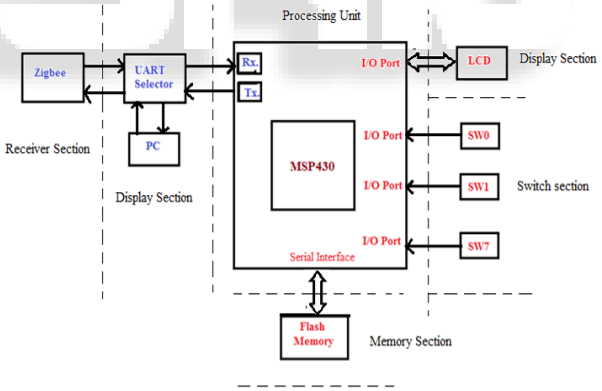


Fig. 6: Proposed block diagram of receiver.

The Electrode section consists of passive electrodes which are placed on scalp according to 10-20 international system. This system gives standard format for placement of electrodes on the scalp. The 10-20 indicate that the percentage distance between two electrodes [1].

The EEG signals collected from electrodes have very low amplitude in µv range (0.5µv to 100 µv) so it is difficult to analyze these signals. Hence, these signals are amplified up to required range for analysis and process [4]. So, the instrumentation amplifier (INA122) is selected because it has high input impendence, high CMRR and high gain. Its single register sets gain from 5V/V to 10000V/V.

$$G = 5 + (200k\Omega)/Rg \quad (1)$$

After amplification the signals are given to filter. Because noise from the surrounding tissues of the body and disturbance from the nearby electrical sources is added to

the electrode voltages. So, preprocessing of these signals is mandatory. So, to obtain the desired specifications the sub filters are cascaded i.e. low pass filter, high pass filter and notch filter [3].

After preprocessing the EEG signal is sent to the 10 bit analog to digital converter which is built in MSP430 microcontroller from Texas Instruments. We selected ultra low power MSP430F2272 microcontroller to reduce the power. It requires low supply voltage from 1.8v to 3.6v. Its CPU has 16 bit RISC architecture. After digitizing the EEG signals are transferred to transmission zigbee module which will send them to the wireless zigbee module at receiver side. Then receiver zigbee module transfers data to MSP430 via UART selector. MSP430 controller takes input data from UART and makes further processing on it. The digital data is stored in flash memory then it will be displayed on PC via serial port. Here the switches are connected to I/O port of microcontroller at transmitter side are used particularly to display selected electrodes data on LCD and PC. And the switches connected to receiver side are used to record the EEG data.

IV. Conclusion

We are proposing portable wireless multichannel EEG recording system using MSP430F2272 microcontroller and the system is advantageous to all involved in the use of EEG for clinical diagnosis. The system is battery operated so it is easy to handle and can be moved from one place to another. Due to wireless system it is possible to take care of patients who are at home or they will be observed continuously by doctors. The heart of the system is MSP430F2272 microcontroller which consumes low voltage from 1.8V to 3.6V and consumes ultra low power.

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