HIGH PRECISION MONITORING OF BRAIN DISORDERS USING EEG

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Abstract

Mind control is no longer a mystical practice. In recent year's scientists, doctors and engineers have been investigating the use of brain, and muscle tissue electrical signals to control computers. In Electroencephalogram (EEG) and electromyography (EMG), waves read of the brain and muscle tissue respectively, can be amplified and digitized to be analyzed and processed by a personal computer. Technology to acquire such signals requires low noise operation and careful design. Electroencephalography is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from the ionic current flows within the neurons of the brain. Wearable Electroencephalography available today is small devices that can record EEG on the head for days, weeks, or months at a time. Such miniaturized units could enable prolonged monitoring of chronic conditions such as epilepsy and greatly improve the end user acceptance of BCI systems. For low-power, easy to use, portable systems, the channel count should be minimized without affecting the diagnostic accuracy. The upper frequency information can be used to obtain noise estimates that can in turn be used to 'clean up' the signal. The signals from the electrodes are amplified and digitized via an analog to digital converter, and it is transmitted to the computer using ZIGBEE module and further analysis is made.

Index Terms: EEG, epilepsy, electrodes, scalp, polysomnography.

I. INTRODUCTION

EEG refers to the recording of brain's spontaneous electrical activity over a short period of time, usually 20-40 minutes, as recorded from multiple electrodes placed on the scalp [1]. In conventional scalp EEG, the recording is obtained by placing electrodes on the scalp with a conductive gel or paste, usually after the preparing the scalp area by light abrasion to reduce impedance due to dead skin cells [2]. Many systems typically use electrodes, each of which is attached to an individual wire. Some systems use caps or nets into which electrodes are embedded; this is particularly common high-density arrays of electrodes are needed. High density arrays can contain up to 256 electrodes more or less evenly spaced around the scalp. Electrode locations and names are specified by the international 10-20 systems for most clinical and research applications. 10-20 systems actual distance between adjacent electrodes either 10% or 20% of the total front-back or right-left distance of the skull. A person's EEG and muscle stimulation can be measured and recorded. Direct relation between mental thought and physical motion will improve communications with lacking motor skills, and much more. EEG signals are measured by placing several electrodes on the head around the brain. Between certain electrodes, a potential difference is measured and converted into a waveform (EEG signal).Diagnostic applications generally focus on the spectral content of EEG, that is, the type of neural oscillations that can be observed in EEG signals. In neurology, the main diagnostic application of EEG is in the case of epilepsy, coma, encephalopathy and brain death, studies of sleep and sleep disorders. EEG is a valuable tool for research and diagnosis when millisecond range temporal resolution (not possible with CT or MRI) is required [3][4][5]. A typical adult human EEG signal is about 10 microvolt to 100 microvolt in amplitude when measure from the scalp. EEG testing can be used to diagnose brain disorders, head injuries, tumors, causes of confusion, and other brain related abnormalities [6]. EEG testing can be used to diagnose neurological disorders and muscle injuries. These tests have already proven to be a great benefit to the health industry, but they are just scratching the surface of this blooming technologies potential. The future applications of EEG and EMG are as awe inspiring as they are concerning. Imagine if EEG and EMG became so precise that a computer automatically knew what you were thinking. Disabled people could communicate freely and gain motor control from assisting robotics. Virtual reality video games could be played by simply thinking about the desired action [7]. The list of possibilities is endless, and in time, we will likely wonder how we ever lived without this technology. EEG may also use to monitor Depth of anesthesia, Cerebral perfusion in carotid endarterectomy, Used in Intensive Care Units.

II. ELECTRODE TECHNOLOGY

The electrical charge of the brain is maintained by trillions of neurons. Neurons are electrically polarized by membrane transport proteins. Neurons are constantly exchanging ions to maintain resting potential and to propagate action potentials [8]. When the wave of ions reaches the electrodes on the scalp, they can push or pull electrons on the metal on the electrodes because the metal conducts the push and pull of electrons easily, the difference in this push or pull voltages between two electrodes can be measured by a voltmeter. Recording of these voltages over the time duration gives the EEG. The electric potential generated by single neuron is very small to be picked up by EEG. Various electrodes used are Wet or Contact Electrodes,Dry or Non-Contact Electrodes and Flexible Electrodes.

A.EEG Electrodes

EEG electrodes are placed on the scalp by using a EEG sticker and the other ends of the wire are connected to the EEG amplifier[9]. The fundamental component or element that is common to all electrode is metal electrolyte interface. The metal is the material which the electrode is composed of and the electrolyte is conducting solution or gel.The charged ions which flows due to the neural activity taking place in brain is absorped by the electrode[10]. There are two electrodes in which one acts as the reference electrode and other as the major electrode. The signals are collected in it. The difference in the signal are collected and given to the operational amplifier which amplifies this microvolot sized signal[11].

B.EEG Amplifier

EEG Amplifier is used to amplify the brain waves by using the operational amplifier CA3140[12]. We can amplify the signal by two ways- one by using transistor and other by using positive feedback or negative feedback. Here we are using the operational amplifier to amplify the microvolt sized signal to 1000 or more times.

C.Power Consumption

If the overall device is assumed to have a volume of 1 cm3 (a common aim for body area network applications) and half of this space is reserved for a custom made battery of energy density of 200 Wh/L, 100 mWh of energy is stored. For 30 days operation, the average power consumption must be less than 140 µW.A front-end system with measured 25 µWpower consumption per channel is representing the current state-of-the-art performance. For a typical transmitter that consumes 50 nJ/b transmitted, transmitting each channel consumes approximately 120µW. To realize high-quality wearable EEG systems, significantly better performance is required on all fronts, and this represents a major challenge. Historically, the capacity of off-the-shelf batteries has doubled only every 5–20 years and so, capacities are unlikely to reach satisfactory values in the near future. In some circumstances, battery recharging or changing is feasible and can extend battery life indefinitely. However, ensuring user compliance to reliably and regularly charge batteries is a major issue. This also goes against the concept of wearable EEG systems being easy to use: it is no longer enough simply to wear the EEG unit, battery maintenance now has to be performed. Idealized systems must simply work. This is particularly illustrated when working with people with learning difficulties or with military personnel who may be out of contact for large periods of time. Here user recharging of batteries is by no means a trivial operation and is unlikely to be feasible. Power-scavenging techniques in which power is harvested from the ambient environment of the user, e.g., from body heat or movement, is a potentially useful technique for overcoming the power issues. It is believed that such techniques may harvest up to 100 lW, significantly relaxing the power constraints, and describes a two-channel EEG system powered by body heat alone. The drawback of this is that the power source will not scale to a large number of channels and is non constant, which may present regulatory issues.

III.BLOCK DIAGRAM

The block diagram of the proposed system consists of electrode, EEG amplifier, PIC microcontroller, UART, ZIGBEE, LCD display.The EEG waves from the brain are detected by the electrodes. The electrodes are placed on the scalp, over a EEG sticker. The outputs from electrodes are sized in micro volts, so the signal has to be amplified. The Amplifier stage is used to amplify the voltage of the incoming signal. The amplified signal is in the range of 0 to 2volts. The signal is amplified about thousands and thousands of times. This signal is an analog signal. This analog signal has to be converted into digital for processing in microcontroller, so the signal is given to the ADC. The PIC microcontroller has inbuilt analog to digital convertor. The conversion process is carried out here and thus the analog signal is converted into digital format. The converted signal is given to the microcontroller for further process to be carried out and then it is stored in the memory. The stored data is transmitted to the Personal Computer through UART in the microcontroller using ZIGBEE.

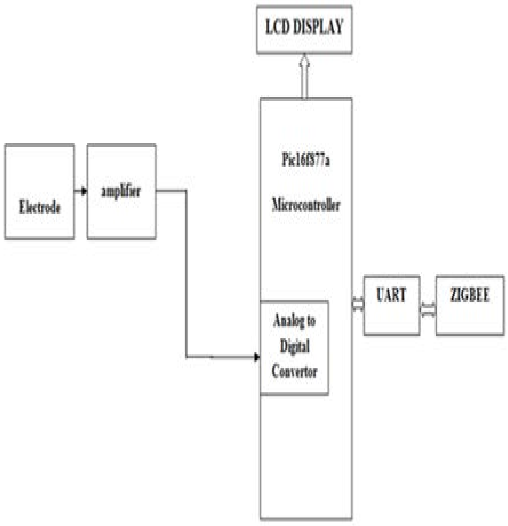

Fig:3.1 Block Diagram

IV.APPLICATIONS

(a) SLEEP DISORDERS: Sleep disorders affect more than 70 million people in the United States. The impact of this is huge: 20% of road accidents involving serious injury are sleep related and the annual cost of sleep disorders in the United States is hundreds of billions of dollars . Despite this, diagnosis of sleep disorders is difficult and resources limited. In the United Kingdom, the overall waiting time from referral to sleep study can be up to three years[12].Diagnosis typically uses polysomnography (PSG) that monitors multiple body functions such brain activity (EEG), heart rhythm [electrocardiogram (ECG)], and reparatory function during sleep. The requirements for wearable EEG for sleep studies are slightly different to those for epilepsy studies. Principally, the duration of operation will be shorter: 24 h at a time is usually sufficient to cover all night and daytime sleep. However, if anything, the devices have to be even less cumbersome so that the subject’s sleep is not disturbed. Thus, the device and its interconnections should be even smaller, and the use of wearable EEG devices is essential.

(b) EPILEPSY: Epilepsy is a common and serious neurological disorder characterized by recurrent seizures that significantly affect quality of life. In addition to this diagnostic aim of wearable EEG, in recent years, there has been a significant amount of interest in the use of portable EEG in closed-loop epilepsy treatment systems. The aim of such systems is to predict, within some suitable prediction horizon, when a seizure is likely to occur and then take preventative action. This action may be via electrical neural stimulation or antiepileptic drug release. In addition to the five obstacles mentioned earlier, closed-loop systems must have a high level of accuracy while keeping the computational complexity low for real-time operation on a portable device where the power available from small batteries is limited[13]. Further, the treatment must be effective and rapid, and one that benefits from being automated rather than just run continuously.

V.RESULT

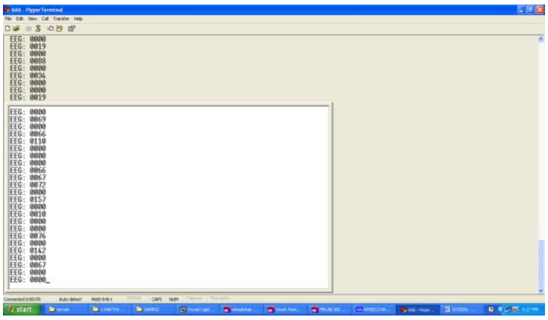

Fig:5.1 Result obtained in computer via communication port.

(A) RESULT USING PROTEUS SOFTWARE

The result shows the transferring and receiving of the varying EEG voltages (displayed in LCD) using proteus software.

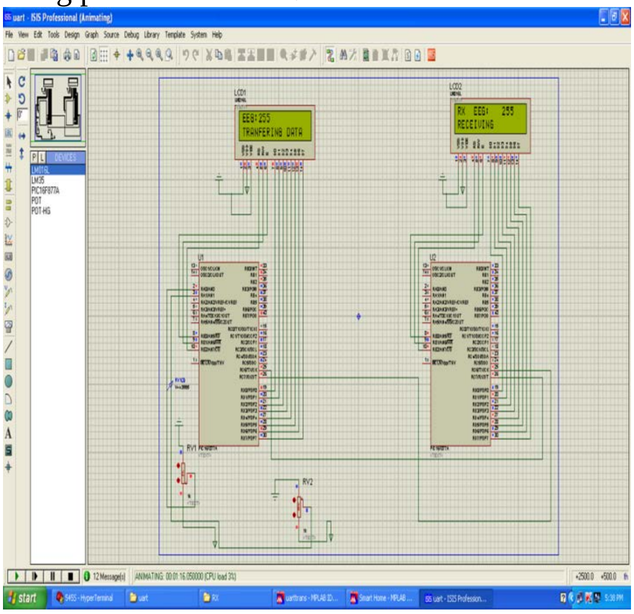

Fig:5.2 EEG Voltage Level: 255

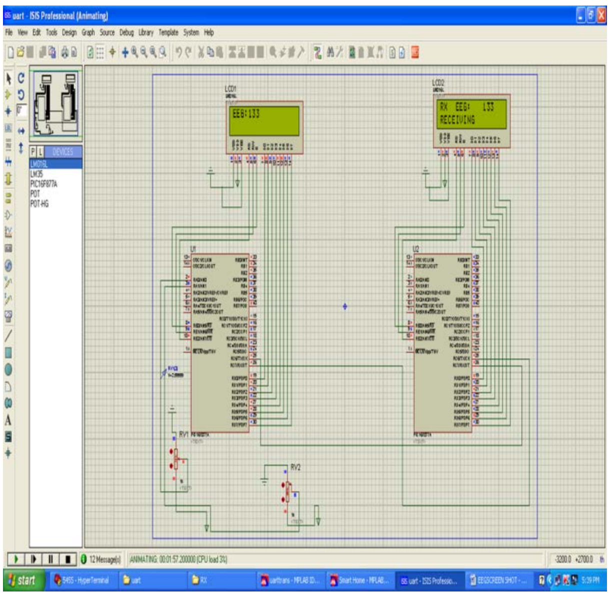

Fig:5.3 EEG Voltage Level: 133

VI.CONCLUSION

Present ambulatory EEG systems typically have up to 32 channels and can operate for 24 hours without recharging. Wireless systems offer around 8 channels and lost for 12 hours. Wireless transmission of the EEG data from the wearable recorder is not necessarily an intrinsic requirement of wearable EEG for medical applications such as epilepsy diagnosis, which is usually done after collecting all the signals. Wired connections between electrodes will still be required to form the EEG recording channels, but wireless transmission of the EEG signal off the body is desirable to enable miniaturization. To remove cumbersome wires, wireless solutions are mandatory. Current long term EEG monitoring is generally carried out as an inpatient in combination with video recording with long cables to an amplifier and recording unit or is ambulatory. Thus we designed a wearable EEG which is portable and compact so that the patient can go about their normal daily life during the recording. Also, the voltage levels are monitored using the wearable electroencephalography.

REFERENCES

[1]Alexander J. Casson, David .Yates, Shelagh J.M.Smith, John S.Duncan, Esther Rodriguez-Villegas,"Wearable Eectroence phalography" in IEEE Enginnering in medicine and Biology Magazine,May/June 2010,pp 44-56.

[2] A. J. Casson, S. Smith, J. S. Duncan, and E. Rodriguez-Villegas, ''Wearable EEG: What is it, why is it needed and what does it entail?,'' in Proc. IEEE Engineering in Medicine and Biology Society, EMBC, Vancouver, Aug. 2008,pp. 5867–5870.

[3]A. J. Casson and E. Rodriguez-Villegas, ''Toward online data reduction for portable electroencephalography systems in epilepsy,'' IEEE Trans. Biomed.Eng., vol. 56, no. 12, pp. 2816–2825, 2009.

[4] A. J. Casson and E. Rodriguez-Villegas, ''Data reduction techniques to facilitate wireless and long term AEEG epilepsy monitoring,'' in Proc. 3rd Int. IEEE EMBS Conf. Neural Engineering, EMBS NER, HI, May 2007, pp. 298–301.

[5]C. D. Binnie and H. Stefan, ''Modern electroencephalography: Its role in epilepsy management,'' Clin. Neurophysiol., vol. 110, no. 10, pp. 1671–1697, 1999.

[6]D. Smith, B. A. Defalla, and D. W. Chadwick, ‘‘The misdiagnosis of epilepsy and the management of refractory epilepsy in a specialist clinic,’’ QJM, vol. 92, no. 1, pp. 15–23, 1999.

[7]D. C. Yates and E. Rodriguez-Villegas, ‘‘A key power trade-off in wireless EEG headset design,’’ in Proc. 3rd Int. IEEE EMBS Conf. Neural Engineering, EMBS NER, HI, May 2007, pp. 453–456.

[8]E.Waterhouse, ‘‘New horizons in ambulatory electroencephalography,’’ IEEE Eng. Med. Biol. Mag., vol. 22, no. 3, pp. 74–80, 2003.

[9]F.Gilliam, R.Kuzniecky, and E.Faught, ‘‘Ambulatory EEG monitoring,’’ J.Clin.Neurophysiol., vol. 16, no. 2, pp. 111–115, 1999.

[10]G. Deuschl and A. Eisen, Eds., Recommendations for the Practice of Clinical Neurophysiology: Guidelines of the International Federation of Clinical Physiology, 2nd ed. Amsterdam: Elsevier, 1999.

[11]G. L. Krauss and R. S. Fisher, The Johns Hopkins Atlas of Digital EEG: An Interactive Training Guide. Baltimore: The Johns Hopkins Univ. Press, 2006.

[12]H. R. Colten and B. M. Altevogt, Eds., Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem. Washington, DC: National Academies.

[13]S. J. M. Smith, ‘‘EEG in the diagnosis, classification, and management of patients with epilepsy,’’ J. Neurol. Neurosurg.Psychiatry, vol. 76, no. 2, pp. ii2–ii7, 2005.