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VLC for Reliable Transmission of EEG Signal

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Abstract: Presence of radio frequency (RF) in the surrounding will show radiation impact on human health. Implementation of such RF in the hospitals where people are getting treatment for better health is not an advisable solution. Even though RF offers more mobility, its radiative emissions and interference will show adverse effects on patients. In this paper, we devise an effective method of using visible light communication (VLC) for observing data in medical field. The electroencephalography (EEG) signals which reflect the electrical activity of brain are transmitted using VLC. The transmission of data is carried through Binary modulation, non-return to zero(NRZ) technique with the aid of red, green, blue components of LED. The Information Dispersion Algorithm(IDA) technique is used for encryption and secure transmission of data. The LED photodiodes are implanted at both the transmitting and receiving terminals and color filters are installed. The implementation results show using visible light for data transmission is a reliable and hazardless method for monitoring patient health.
Keywords: Visible light communication, Non-Return-Zero, Information Dispersion, LED, Biomedical data, EEG.

I. INTRODUCTION

Using RF technology for monitoring and transmission of bio-medical data become the most widespread method in the medical industry. This extensive usage of Radio-frequency spectrum is due to immense flexibility it offers. These radio waves also have a dark-side, they produce adverse impact on human health by emitting immense radiation. This hazardous nature of RF become a serious hurdle for using them. Biological effects that result from heating of tissue by RF energy are often referred to as "thermal" effects. It has been known for many years that exposure to very high levels of RF radiation can be harmful due to the ability of RF energy to heat biological tissue rapidly. This is the principle by which microwave ovens cook food. Exposure to very high RF intensities can result in heating of biological tissue and an increase in body temperature.

Visible light communication (VLC) is an evolving technology which uses visible light of electromagnetic spectrum to transmit data. It uses the wavelength region of 400nm-780nm in the spectrum. As the naturally available light spectrum is used for data transmission it produces no hazardous effects on human health. It supports high data rates, compared with the conventional RF based wireless technologies. The visible light spectrum is 1,000 times larger than the entire 300 GHz of radio, micro wave and mm wave radio spectrum, so there is a big untapped reservoir of resources for wireless systems. Phosphor coated white LEDs which are mostly used in all commercial lighting devices can deliver up to about 100 Mbps. More expensive red, green, blue (RGB) LEDs can deliver up to about 5 Gbps, and allow control of color. The experienced data rate in a network where multiple users must share the bandwidth is significantly lower than the maximum headline data rate in WiFi systems.

The EEG waveform is most utilized signal that measures the electrical brain rhythms and has huge capability to detect the cause of diseases. Currently most of EEG equipment in industry were based on RF transmission technologies. In a wireless based EEG equipment, the performance depends upon on the mode of communication used for transmission of data. However, these RF based wireless systems suffer from various drawbacks, such as signal loss and line frequency interference due to multi-frequency of EEG. To overcome the interference issues associated with EEG signal transmission using RF, we propose a VLC based EEG signal transmission using Binary Modulation and Information Dispersion Algorithm. In the proposed VLC based system, captured EEG signal is processed and transmitted via parallel data streams of red, blue and green colors from RGB LEDs. The VLC transmission technology using color clusters proved to be efficient and reliable. To transmit healthcare data that requires high precision, we utilize all three components of a RGB LED simultaneously for data transmission.

II. PROPOSED SCHEME

The EEG signal recorded is modulated using Binary Modulation and Non-Return-Zero technique is transmitted through red, green and blue color of a RGB LED. The data to be transmitted is distributed across all the three LED’s for simultaneous and parallel transmission of data. Information Dispersal Algorithms is applied for secure and reliable transmission and storage. This method uses a significantly smaller memory overhead and delivers better performance but provides only incremental confidentiality. By utilizing this algorithm, it is not possible to explicitly reconstruct data from less than the required number of fragments. Receiver comprises

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of three photodiodes installed, each being equipped with an individual color filter. Each color filter receives the modulated data from the specified color only. The received signal from each photodiode is demodulated and then compared with the signals received from the other photodiodes. Finally, the EEG signal gets reconstructed from the received data at receiver operating at a remote distance from patient.

III. BLOCK DIAGRAM

The below figure shows the schematic diagram of the propose scheme for EEG signal monitoring using VLC

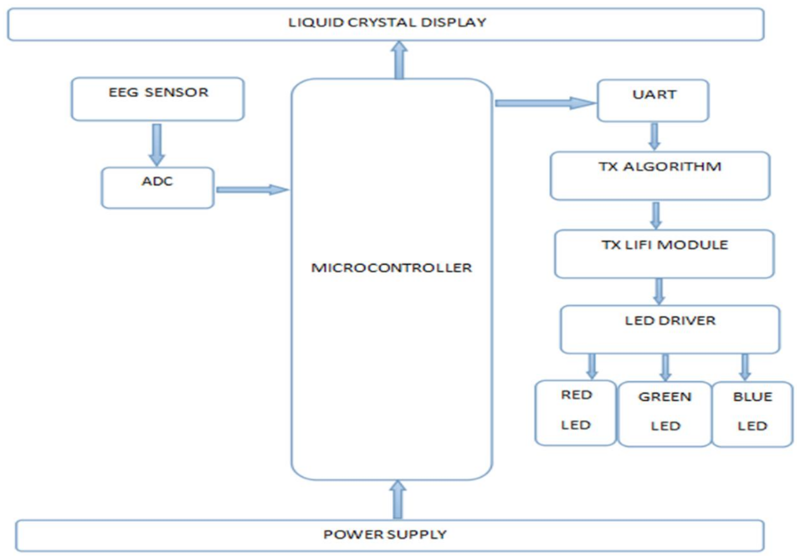

Figure 1: Block diagram of EEG sensor and LIFI transmitter

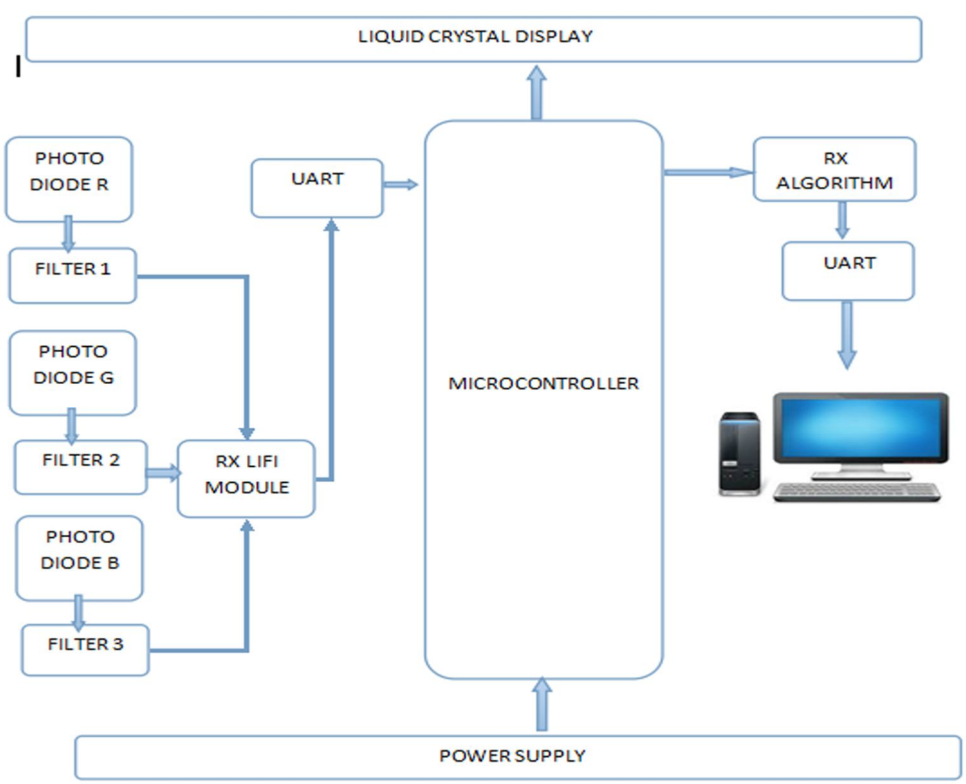

Figure 2: Block diagram of RGB receivers Arrangement and LIFI receiver modules.

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IV. LIGHT FIDELITY

Light-Fidelity (LiFi) takes visible light communication (VLC) further by adopting light emitting diodes (LEDs) to implement fully networked wireless systems. Synergies are harnessed as lights become LiFi attocells resulting in enhanced wireless capacity for the Internet-of-Things (IoT), 5G and beyond.

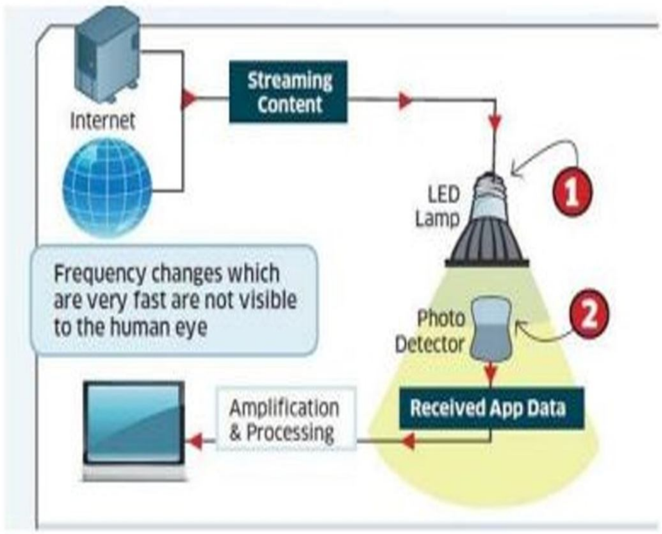

Figure3. Illustration of LIFI working[4]

The LiFi is a consequence of the natural tendency to move to higher frequencies in the electromagnetic spectrum. LiFi uses LEDs for high speed communication, and speeds of over 3 Gbps from a single micro LED have been demonstrated earlier. Given that there is an extensive
deployment of LED lighting in homes, offices and streetlamps because of their energy-efficiency, there is an added benefit for LiFi cellular deployment in that it can build on an existing infrastructure. Moreover, the cell sizes can be reduced further compared to mm wave communication leading to the concept of LiFi attocells. LiFi attocells are an additional network layer within the existing heterogeneous wireless networks, and they have zero interference from, and add zero interference to, the radio frequency (RF) counterparts such as femtocell networks. A LiFi attocell [4] network uses the lighting system to provide fully networked wireless access.
Fragmenting and Dispersing of data over different physical locations through several transmission paths by information dispersion algorithm(IDA) is most secure method of transmission of data over LIFI. IDA provides significantly smaller memory overhead and better performance and confidentiality. By implementing IDA it is not possible to explicit reconstruct data from less than required amount of fragments. IDA acts as light weight algorithm that provides both spectral efficiency and simplicity with a computational level of data confidentiality.
In a LIFI network , the placement of the Access Points affects the system performance. The light from a neighboring Access Point causes interference which limits the signal-to-interference -plus noise ratio(SNR). The data must be encoded by means of intensity modulation(IM)/direct detection(DD).Frequency reuse is modelled with a parameter X. For example X=3 means that the available modulation bandwidth is divided into three equal parts each part is assigned to an AP in a way that the geometric re-use distance of the same part of the bandwidth is maximized. Since lighting and wirelesss data communication are combined the placement of the optical Aps is mainly determined by the lighting design, The effect of the location of APs is evaluated for four different scenarios as shown in fig4.Circles in the figure represent coordinates of the optical access points(Aps) , which are also the room lights, while the dots represent the position of the end user terminals. Different deployment scenario studied are: (a) Hexagonal network model. (b) Point to Point network model. (c) Square network model. (d) Matern type 1 hard core point process network model.

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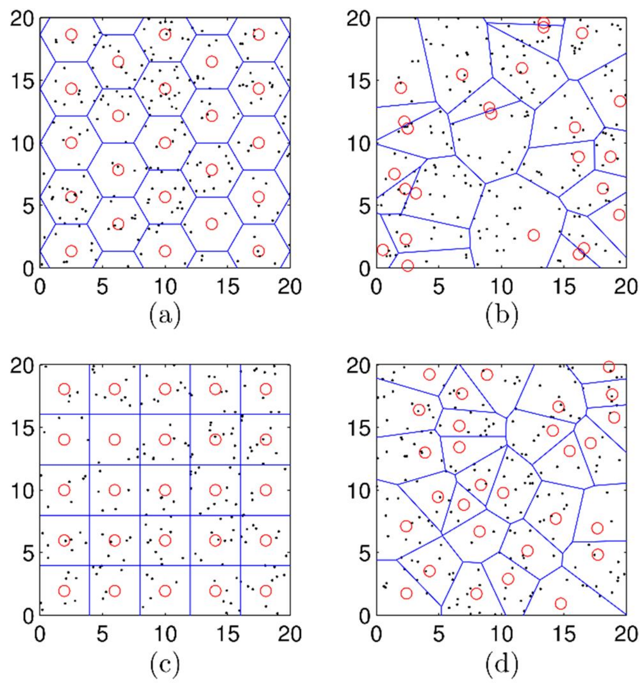

Figure4: Spatial distribution of Access Points [4]

V. COMPONENTS USED

A. Eeg Sensor

This sensor is used to get EEG signal from the patient, it consists of electrodes placed on the scalp. The system use the electrodes connected to individual wires.

B. Armlpc2148

This microcontroller is used for processing and guiding the data to respective ports.

C. LIFI Module

The LIFI module is used at both the terminals. Transmitter LIFI module accepts the data from the EEG sensor and modulates the LED light in accordance to signals. Receiver LIFI module receives the signal from the LIFI transmitter and send it to user interface for monitoring.

VI. APPLICATIONS

Light Fidelity find applications in diverse fields. If used effectively light present around us acts as a great source of data transferring medium, offering higher data speeds and reliability at affordable rates. Here we are trying to investigate few fields that light fidelity can show its impact.

A. Education systems

The LIFI technology developed can be used to interface all the equipment in an educational institution at a blazing speed.

B. Medical Field

The operation theatres and other facilities in a hospital can be equipped with LIFI technology which provides radiation free environment in hospitals.

C. Industries

In an hazardous environment like chemical industries where radiation can show effect WIFI can't be implemented. In this cases LIFI become handy which can be used to transfer data from machines to control rooms.

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VII. CONCLUSION & FUTURE SCOPE

The data transmission scheme for EEG signal transmission using VLC is proposed. The scheme shows excellent reliability of the critical biomedical EEG data transmission without any RF radiation in hospital areas. Along this proposed system can transmit not only the EEG data but also other biomedical data simultaneously.

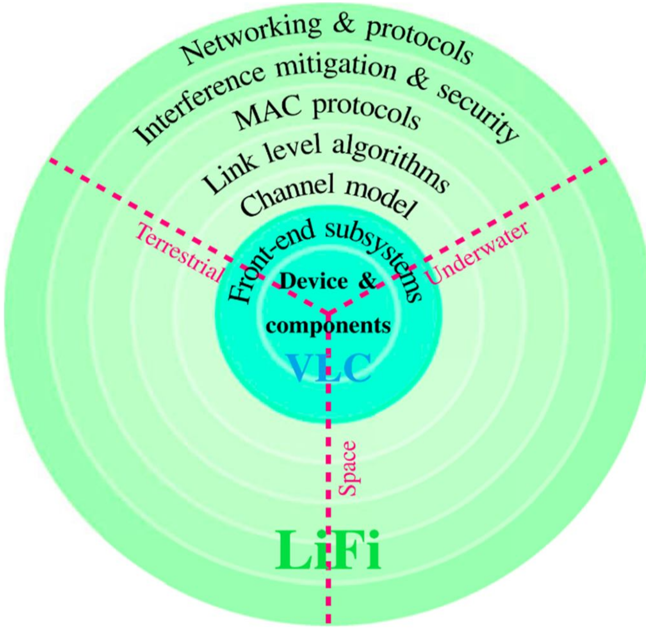

Figure 5: Essential LiFi building blocks: Visible Light Communication (VLC) requires a subset of the building blocks and forms the inner core[4] .

LIFI provides a completely new layer of wireless connectivity within existing heterogeneous radio frequency (RF) wireless networks. LIFI supports multiuser access and enables roaming. It is therefore, a truly mobile system. Multiuser access and mobility support in LIFI require unique building blocks, LIFI is merging as more suitable networks in next generation healthcare services in the hospital. Using this technology in medical field makes diagnosis faster and allows to access the internet along with the radio waves – based devices.

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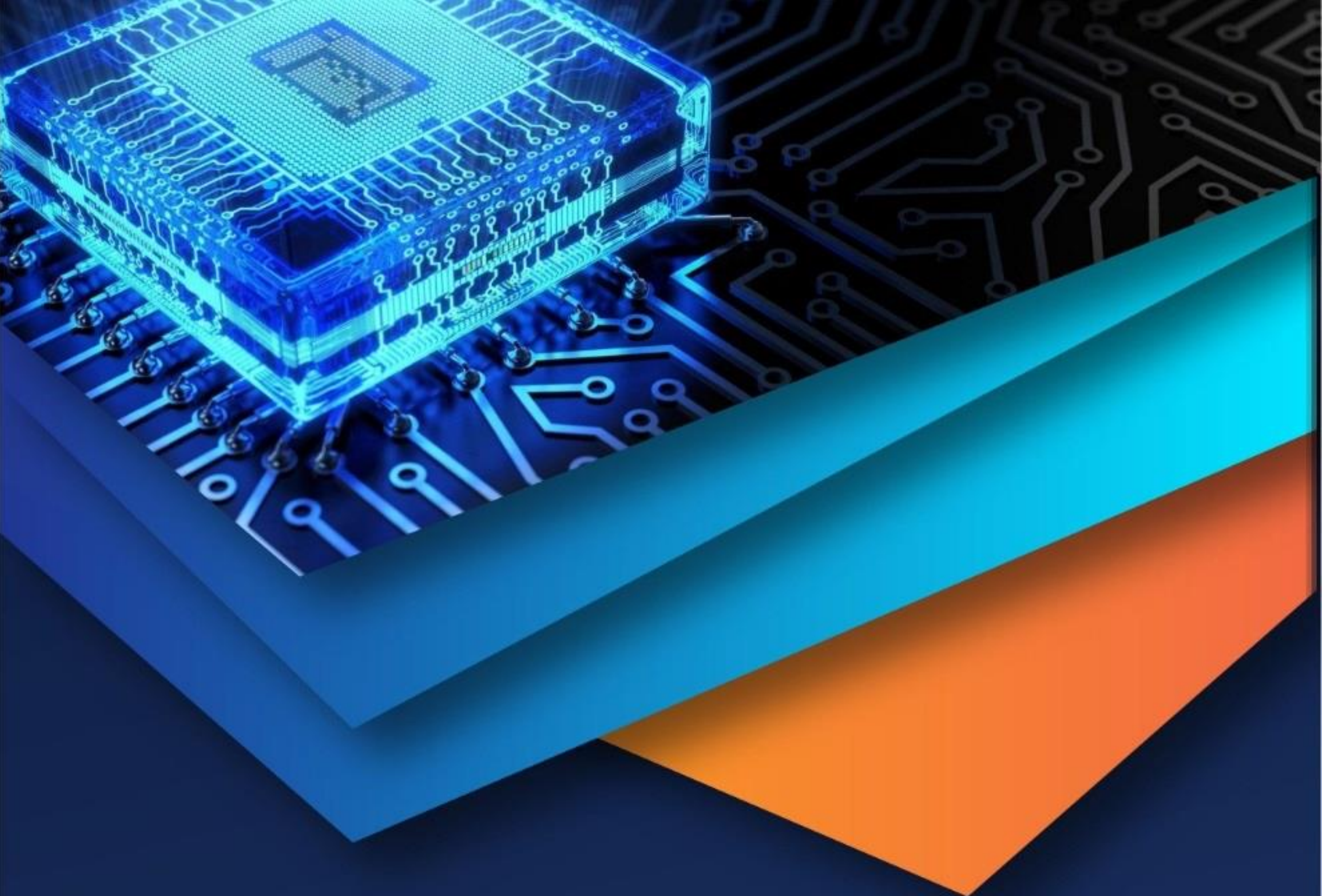

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