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Design and Implementation of Real Time Embedded Health Monitoring System using Li-Fi technology

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Abstract: Now a day, health and patient monitoring is very tedious job to do. The monitoring personnel have to watch continuously. They have to keep monitoring the patients, who are admitted in Intensive Care Unit (ICU). These patients are in serious illness conditions and can't be said what happens in next instance to them and today increasing the number of patients in the ICU due to many increasing fatal diseases. These diseases are threatening the population all over the world. Doctors need more conscious about the patient health status. The health monitoring system proposed here gives doctor continuously updated health information of patient using various sensors used to monitor health of patient. It allows doctors to monitor patient over the long distance and also to consult others. Li-Fi technology is used here in to update information quickly and it can be viewed at monitor of the doctor. Simultaneously it also records the data of patient in the CPU. This data can be viewed through the internet for reference while consulting the patient.

Keywords: Health Monitoring, Light Fidelity(Li-Fi),ARM7,ECG, SpO2, Accelerometer.

I. INTRODUCTION

The electronics technology has entered almost in all aspects of day-to-day life, and the medical field is not exception for that. The need for well-equipped hospitals and diagnostic centers is increasing day by day as the people are becoming more conscious about their health problems. In biomedical fields special units are used, such as intensive care unit or coronary care unit. All of these units are designed to offer the advantage of the low Nurse – Patient ratio and concentration of the equipment and the resources needed; to take care of critically ill or seriously injured units. The medical world today faces two basic problems when it comes to patient monitoring, firstly the need of healthcare providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved. As the technologies are advancing it has become feasible to design to home based vital sign monitoring system to display, record and transmit signals from human body to any other location. This paper discusses the aspects of acquisition of physiological Parameters like ECG Temperature, Pulse rate, pre-processing them and displaying them in a graphical user interface for being viewed by the doctor and also observe the clinically useful data, Firstly on bedside monitor and secondly on Doctors computer or monitor which contains a application of monitoring signal.

This system is expected to monitor patient under critical care more conveniently and accurately for diagnosing which can be interfaced with computer to bring it under a network system widely for the doctor to monitor the patient's condition sitting in his own office without being physically present near to the patient's bed. In second section describes system representation, third section describes Hardware description of system, fourth section describes implementation of system algorithm using arm7LPC2138,fifth section describe LiFi technology to monitor patient, sixth section describes result and last section describes future scope and conclusion. Here we are utilizing the LiFi technology to multiple numbers of patients by a single responsible person. This can reduce the efforts to monitor patients personally in the intensive care unit (ICU).

II. LITERATURE SURVEY

Presently, there are two approaches to creating white light. Mixed-color white light which mixes the multicolor LED's and Phosphor-converted white light which uses phosphors together with a short-wavelength LED. The three scientists Isamu Akasaki, Hiroshi Amano and Shuji Nakamura produced bright blue light beams from their semi-conductors in the early 1990s, they triggered a fundamental transformation of lighting technology. Red and green diodes had been around for a long time but without blue light, white lamps could not be created. Despite considerable efforts, both in the scientific community and in industry, the blue LED had remained a challenge for three decades.

They succeeded in creating a bright source LED using excitation of a phosphor so that the blue light is converted to white light. For their achievement they are rewarded by Nobel Prize in Physics in 2014. This LED can be efficiently used as a Li-Fi source and reduces the cost of emerging Li-Fi market by having very long lifetime (100 000 hours).

For improvisation of optical receiver scientist proposed optoelectronic integrated circuit (OEIC) receiver that has been analysed theoretically. A simplified noise model of the receiver has also been developed. Results have been presented for an OEIC receiver based on InGaAs MESFET supposed to be fabricated with matured InGaAs-InP MMIC technology. Theoretical results based on a simplistic noise model reveal that the proposed OEIC receiver has superior performance characteristics over the existing optical receivers.

They can be used in different machines to communicate with each other for fast data interpretation. The electronics technology has entered almost in all aspects of day-to-day life, and the medical field is not exception for that. The need for well-equipped hospitals and diagnostic centers is increasing day by day as the people are becoming more conscious about their health problems. In biomedical fields special units are used, such as intensive care unit or coronary care unit. All of these units are designed to offer the advantage of the low Nurse – Patient ratio and concentration of the equipment and the resources needed; to take care of critically ill or seriously injured units.

The body parameters are processed by ARM processor, it will display to the patient on LCD and Waveforms on Patient side Personal Computer using MATLAB. The same data on computer it can be viewed by physician in two ways. All of these units are designed to offer the advantage of the low Nurse – Patient ratio and concentration of the equipment and the resources needed; to take care of critically ill or seriously injured units. The medical world today faces two basic problems when it comes to patient monitoring, firstly the need of healthcare providers present bedside the patient and secondly the patient is restricted to bed and wired to large machines.

The Literature survey also included the study of various components of an electro-cardio-gram signal, their typical voltage values and time intervals. It was also necessary to study the various components required for generation and processing of electrocardiogram signal. The different algorithms for correlation and heart rate detection were studied and evaluated. Also the technicalities involved in use of Digital signal Processor, its interfacing with PC and ECG generation circuit were studied.

III. BLOCK DIAGRAM

This system can be represented by the block diagram shown in fig.1.

This work is aimed at producing a cost effective, smart, secured and safe health monitoring system. We have built a prototype model which as shown in above block diagram. Following is the hardware description.

1. *ARM 7 module* **-** In our system we are using LPC2138. It acts as the major controller unit of the system. Input from various sensors like ECG, LM35, SpO2, Accelerometer and pulse rate is given to this unit on which it process according to the programming and gives processed digital signal to Li-Fi transmitter . It needs 3.3V to drive the ARM7 module.

2. *Power supply unit*-. To drive ARM7 we require 3.3V and for various sensors and we require 5V to drive ECG, LM35, SpO2, Accelerometer and pulse rate etc. So to do this we will have to build variable power supply unit using voltage divider circuit and regulator ICs like regulator IC 7805 and amplifier 317 .

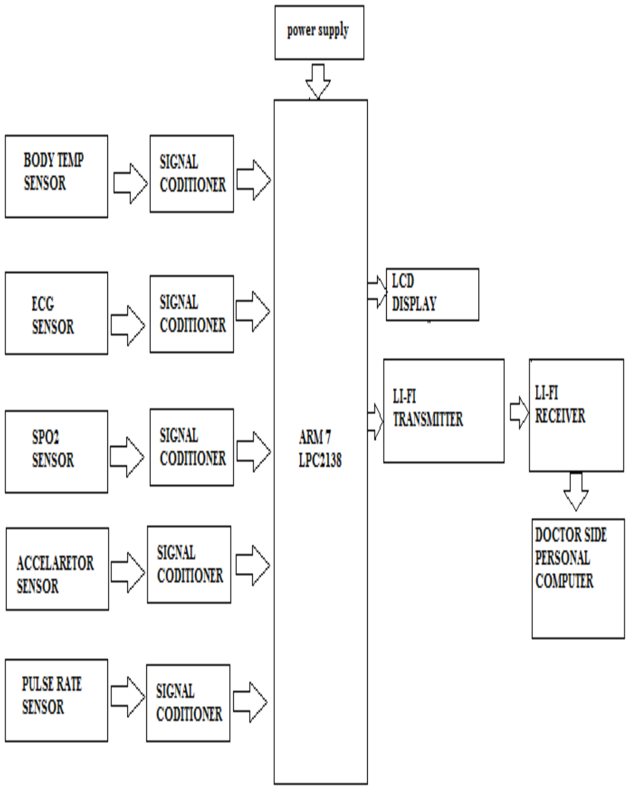

Fig.1. Block Diagram of whole system

3 *ECG Sensor*-Heartbeats are triggered by bioelectrical signals of very low amplitude generated by a special set of cells in the heart (the SA node). Electrocardiography (ECG) enables the translation of these electrical signals into numerical values, enabling them to be used in a wide array of applications. Our sensor allow data acquisition not only at the chest (“on-the-person”), but also at the hand palms (“off-the-person”), and works both with pre-gelled and most types of dry electrodes. The bipolar configuration is ideal for low noise.

4. *SpO2 sensor* **-** SpO2 stands for peripheral capillary oxygen saturation, an estimate of the amount of oxygen in the blood. More specifically, it is the percentage of oxygenated hemoglobin (hemoglobin containing oxygen) compared to the total amount of hemoglobin in the blood (oxygenated and non-oxygenated hemoglobin).SpO2 is an estimate of arterial oxygen saturation, or SaO2, which refers to the amount of oxygenated hemoglobin in the blood.

5. *Temperature Sensor*-The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01§C of the surface temperature.

6. *Accelerometer* **-** The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-

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sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The user selects the bandwidth of the accelerometer using the CX, CY, and CZ capacitors at the XOUT, YOUT, and ZOUT pins. Bandwidths can be selected to suit the application, with a range of 0.5 Hz to 1600 Hz for the X and Y axes, and a range of 0.5 Hz to 550 Hz for the Z axis.

7. *LED*- As LED is more commonly used source for room lighting, it is also used in Li-Fi as a data source more sophisticatedly and efficiently to generate data streams. As compare to the IR LED which generate a single data stream with 10-20 kbps speed, these LED's generates a thousands of data streams spreading all over the room where the light can reach with a very fast rate. The potential of these LED's can be increased by using some Luminaire Design Optimization techniques. Recently the R & D centre of pure VLC has achieved 3.5Gbps of data rate from a single color micro LED operating at 5mW with a 1m distance and 1.1Gbps of data rate at 10m at 5mW.

8. *Pulse rate sensor*- Heart rate data can be really useful whether you're designing an exercise routine, studying your activity or anxiety levels or just want your shirt to blink with your heart beat. The problem is that heart rate can be difficult to measure. Luckily, the Pulse Sensor Amped can solve that problem. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications.

9. *Liquid Crystal Display*-LCD is used in a project to visualize the output of the application. We have used 16x2 LCD which indicates 16 columns and 2 rows. So, we can write 16 characters in each line. So, total 32 characters we can display on 16x2 LCD. LCD can also used in a project to check the output of different modules interfaced with the microcontroller. Thus LCD plays a vital role in a project to see the output and to debug the system module wise in case of system failure in order to rectify the problem

10. *Li-Fi Transmitter and Receiver*- Li-Fi, is a bidirectional, high speed and fully networked wireless communications, using visible light and can be a very good complement to RF communication (Wi-Fi or Cellular network), or can even serve as a replacement in contexts of data broadcasting.

Li-Fi basically known as ―light fidelity is an outcome of twenty first century research. It is a 5G visible light communication system that uses light from light-emitting diodes (LEDs) as a medium to deliver networked, mobile, high-speed communication in a similar manner as Wi-Fi. Li-Fi could lead to the Internet of Things, which is everything electronic being connected to the internet, with the LED lights on the electronics being used as Li-Fi internet access points. Visible light communications (VLC) works by switching bulbs on and off within nanoseconds, which is too quickly to be noticed by the human eye. This can be obtained by fitting a Li-Fi chip, to turn the light bulb into a high speed broadband communication device. Although Li-Fi bulbs would have to be kept ON to transmit data, the bulbs could be dimmed to the point that they were not visible to humans and yet still functional. Li-Fi has an amazing feature to think about i.e. - one light bulb of 1 watt can produce internet streaming of media in nearly 5 laptops.

Components List
- ARM7 LPC2138 controller
- LCD
- Power LEDS
- Temperature sensor LM35
- ECG sensor
- RS-232
- Spo2 sensor
- Pulse rate sensor
- Li fi transmitter and receiver
- Amplifier 317
- Regulator IC 7805

Software's Used
- Proteus 7
- Keil Micro vision 4
- Visual studio

IV.WORKING

The Module-wise working is explained below;

1. ***Biomedical Sensors-***

• *Temperature Sensor –*
The temperature sensor here is LM 35 . It can be seen as below.It converts the temperature of human body radiated into the voltage waveform.We can derive the temperature by manupulating the voltage output level when it is given to ARM processor.

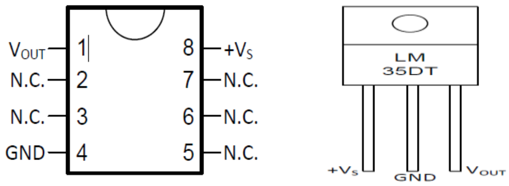

Fig 2. Temperature sensor lm 35

• *ECG sensor-*
Sample high-resolution ECG trace taken from the electrodes directly on top of the skin over the chest. The entire sequence of PQRST waves can be clearly seen and the signal is comparable to that obtained through adhesive contact sensors.

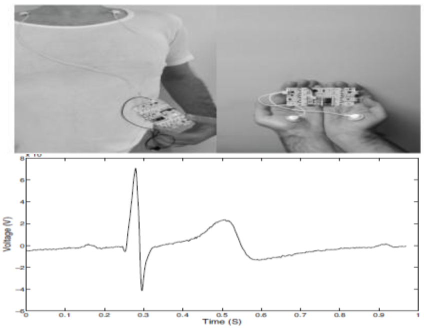

Fig 3. ECG Sensor

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We present a wireless body sensor network for high quality EEG/ECG recordings utilizing non-contact electrodes. The full schematics for building the simple, low noise capacitive electrode are presented. Future work will focus on miniaturizing and better packaging the electrode as well as reducing the power consumption of the digital and wireless transmitter components.

• *SpO2 Sensor-*

SpO2 stands of Saturation of Peripheral Oxygen. Pulse oximeters measure oxygen saturation. Oxygen enters the lungs and then is passed on into blood. The blood carries the oxygen to the various organs in our body. The main way oxygen is carried in our blood is by means of haemoglobin. If a finger is placed in between the light source and the light detector, the light will now have to pass through the finger to reach the detector. Part of the light will be absorbed by the finger and the part not absorbed reaches the light detector.

The amount of light that is absorbed by the finger depends on many physical properties and these properties are used by the pulse oximeter to calculate the oxygen saturation. The amount of light absorbed depends on the concentration of the light absorbing substance, Length of the light path in the absorbing substance, oxyhaemoglobin and deoxyhemoglobin absorbs red and infrared light differently.

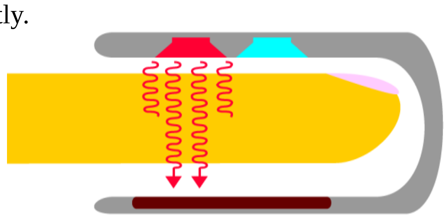

Fig. 4. SpO2 sensor working

• *Pulse Rate Sensor-*

The pulse rate sensor interfaced within the system will keep on monitoring the pulses of the person in order to secure that the person is safe. If pulse rate is fast that will indicate that either the person is not safe or he/she have some health issues. So on the basis of the output provided by the pulse rate sensor, we can track the health issues of the person.

• *Accelerometer –*

The ADXL335 is a complete 3-axis acceleration measurement system.

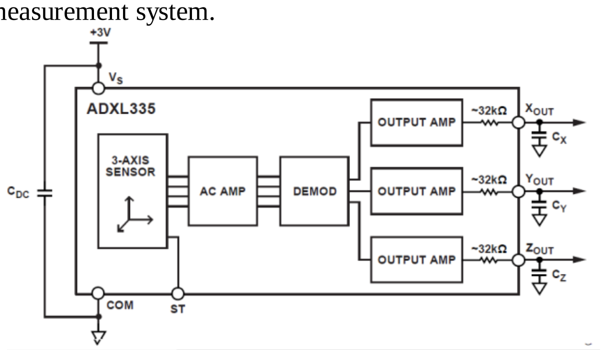

Fig 5.Functional block diagram of Accelerometer

The ADXL335 has a measurement range of ±3 *g* minimum. It contains a polysilicon surface-micro machined sensor and signal conditioning circuitry to implement an open-loop acceleration measurement architecture. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

2. ARM 7-

The µC is the final decision making body on the system. The logic is developed and then the program is burned inside the microcontroller and the other peripherals are accessed via microcontroller only.

Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory. The ARM7TDMI-S processor also employs a unique architectural strategy known as Thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue.

3. Li-Fi transmitter and Receiver –

The working of Li-Fi is very simple. There is a light emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use an array of LEDs of perhaps a few different colours, to obtain data rates in the range of hundreds of megabits per second. The block diagram of Li-Fi system is shown in fig below.The working of Li-Fi is based on VLC, which uses visible light for data transmission. The visible light spectrum has wider range of hundreds of THz of free bandwidth, which is 10,000 times more than RF spectrum up to 30GHz. It uses LED to generate data stream which is connected to the internet or cellular system. As per the data stream the LED flickers at high rate which is not recognized by human eye.

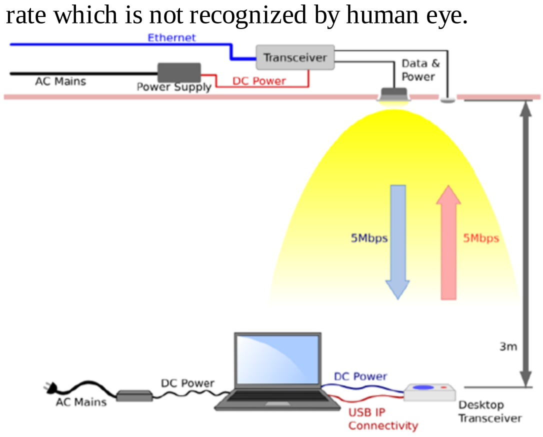

Fig 6.working principle of LiFi technology

V. ADVANTAGES

- Speed of the Li-Fi communication is high, hence it reduces the time.
- Due to high speed of the system we can send more accurate and less noise signal compared to the previously existing system.
- *Capacity:* Visible light spectrum is 10000 times bigger than RF spectrum. It is predicted that will we run out of the RF spectrum by 2020.

- *Security:* Light cannot penetrate walls, but radio waves can, thus security is higher in using Li-Fi.
- *Efficiency:* The 1 million radio masts base stations consume a lot of energy, which indeed is used to cool the base stations and not to transmit radio waves. These base stations have poor efficiency up to only 5%.Whereas Li-Fi uses the 2.4 billion led lamps which offers a much higher efficiency.
- *Transmission of data:* Wi-Fi transmits data serially and Li-Fi transmits thousands of data streams parallely thus offering higher speed
- *Infrastructure:* It is already existing. Inexpensive devices, mostly powered by LED, so it is cost effective, compared to base stations

VI.APPLICATIONS

- In the hospitals where the RF waves is not used.
- In the home resided patient monitoring.
- In the Wearable devices like wrist watches.

VII. CONCLUSION

The electromagnetic spectrum shrinking continuously the Li-Fi system will going to provide a greener, safer, better and healthier future for communication system. When this system will be developed each light source can be used as a Li-Fi application means where is a light there is a internet. Also it will shapes the better future for human kind by reducing the energy consumption, data as well as light at low cost, minimal cellula infrastructure and creating the employments opportunities at large scale. In short the Li-Fi system will be going to change the scenario of wireless communication in many greener ways.

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