

# “CREATION AND IMPLEMENTATION OF A CLOUD-BASED IOT-BASED MEDICAL MONITORING SYSTEM”

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## Abstract:

The design and development of a cloud-based healthcare patient monitoring system is the main topic of this essay. In the conventional approach to patient monitoring, nurses record the physiological data of their patients on paper. These nurses work in shifts, therefore the most recent information about the patient might not always be fully communicated from the departing to the arriving nurse. Physiological data that was manually recorded is frequently used to make diagnoses, while recent medical records are often ignored when writing prescriptions. Such a traditional approach notes diagnoses and recommendations against the law, making it impossible for professionals to acquire simple access to a patient's record. In such a situation, accurately diagnosing the patient and providing the appropriate care can be challenging. This results in the store's growth going forward, at least in an intensive care unit. With this kind of technology, the patient's regular activities are captured as space-time records of biological events, kept for as long as the professionals deem necessary, and then disconnected. To provide the populace with a portable, battery-operated telemetric device for use in both rural and interior parts of the nation. To provide these patients the option of receiving ongoing patient monitoring in addition to remote medical examinations. Demonstrates the process and fundamentals of how sensors and actuators are connected to a processor so that it can process the signal and display the physiological parameters of the patient in a proper graphical format on a monitor using Java programming. The signal is then connected to a wireless sensor network and sent to a web server for the benefit of experts who are present on a different side.

**Keywords:-** *IoT, ICU unit, Cloud Computing,*

## I. INTRODUCTION

The Internet of Things (IoT) connects set of anyone, anything, any service, and any network. IoT is used to globalize the patient data. IoT is useful in many applications such as healthcare, water level indicator, security, HMIS (Hospital management integrates service) etc. Monitoring of biological parameters such as body temperature and ECG/heart rate are acquire using low power sensors etc. These signals are properly processed by an ultra- low power process or before the transmission to node unit.[27]

Vital parameters of patients health are sent to cloud computing technology using network connectivity. Applications related to Health-care, utilizing vital body sensors that help to generate a bulk of data which are needed to be stored for processing in upcoming years. Cloud computing technology combines with the(IoT) Internet of Things concept and helps for maintaining and processing of vital data on-line instead offline .Software related low power design approach with a case study of low power/energy i.e. power critical, biomedical application low power telemedicine system is then analyzed.[2]

IoT is used to globalize the patient data. It is useful in many applications such as healthcare, water level indicator,

security, Patient healthcare framework (PHF) etc. [27]. The patient's physiological data is sent to far away thus, an examiner/ doctor can able to see the details from never the less of location. Doctors can take the reference of these studies, case study of the patient while advise

The therapy, medicines to the two leant. Patient's real time health status can be stored in the cloud. Our aim is to develop advanced Real time telemedicine system by using an ultra-low power processor and low power biomedical sensors. To Increase battery life using appropriate circuitry & proper coding technique. Validation of designed system for measurement of temperature, heartbeats, blood pressure and ECG. [27]

To facilitate population living in rural as well as interior part of the country with portable battery operated telemedicine unit. To provide flexibility to such patients to have distant medical checkups as well as continuous patient monitoring

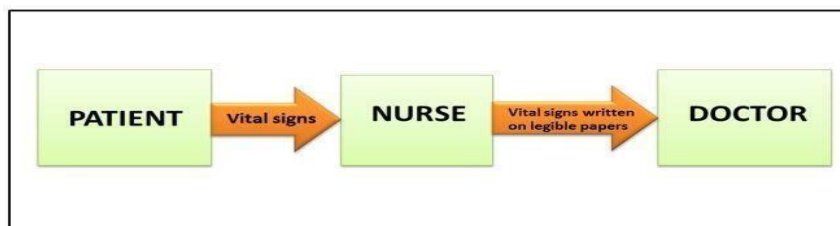


Figure-1 Traditional Monitoring System

Specifically each year, about four million patients with acute diseases are admitted to Intensive Care Units (ICUs), only in the United States out of which around 15 percent of them do not survive. This might be due to sudden cardiac arrests and heart attacks, which is the main cause of death in the world and its treatment is a challenge for the health-care team and medical technology scientists. Moreover, Monitoring critically ill patient is quiet difficult and demanding task mainly due to the reasons like inbuilt critical illness, the complexity and the wide range of physiological complications, the rapid variations in the patient's status and the "disturbance" produced by the ICU environment as well as nursing routine. In addition to the sere sons, it is important to note that in the ICU setting; many times there is lack of bedside monitoring equipments to acquire different physiological signals from different organs of the patient. This kind of Multi-modality bed side monitoring may help physicians to identify bio-patterns, reflecting patient's situation under a certain treatment and the effects of the treatment. However, implementing multi-parameter monitoring in modern ICUs may have to face number of following difficulties

There is a need for developing open sensors and middleware components that allow transparent integration and plug-and-play interoperability of monitoring devices and systems as shown in figure 1.2. The use of communications standards seems to be an efficient way to solve these problems. Most stakeholders in hospital information systems, medical devices and telemedicine scenarios agree that standard-based solutions are needed to foster the development of these markets and improve the service provided to patients. However, it is frequently claimed that it is not feasible to develop such systems because of either costs or lack of development of the standards.

People who require health care system are increasing day by day while the available resources remain the same. Especially, a country like Germany faces the problems, that medical experts such as cardiologists do not pay much attention towards rural areas. As a result, patients from those areas are required to travel for long distances for medical checkups. Hence, even a simple check up is connected with significant cost and efforts. Cardiac arrest is considered as one of the major contributor to sudden and unexpected death in the modern stressful lifestyle around the globe.

As per the database provided by World Health Organization (WHO), different heart diseases kills almost seventeen million people around the globe every year along with twenty million people are at a risk of sudden heart failure. Although, some of these lives can be saved with supreme care and cardiac surgery provided within few golden hours immediately after cardiac arrest . But every time it is not possible to provide immediate medical help, may be due to the constraints of long distances, transport facilities, money etc.

## 1.2 CONTRIBUTIONS

Advancement in Computer science and information technology have opened a new window of research in the field of bio-medical applications. Accordingly, many researchers, with their keen interest and continuous efforts in this area, have come out with many fruitful results in the form of various biomedical instruments to be used in the hospitals for clinical purposes. These researchers, with the growing technology have brought new revolution in the field of medical electronics, as a result of which, most of the big hospitals are equipped with an advanced biomedical machines. Due to this, medical experts can diagnose the patients correctly by having proper analysis of the bio signals obtained from these advanced machines.

Since the middle of 1990's, Rapid progress in information technology enabled the researchers to retrieve relevant information from databases on the internet very speedy. In medical contexts, the speed of innovation is not as fast as commerce. One reason is that patient information has to be protected as, such information may be used for illegal purposes. Since the beginning of the 21 st century, several technologies generated the different possible conditions for data security and retrieval. Furthermore, rapid progress in web technologies motivated researchers to design and implement a good user interface for decision support thereafter. As a part of case study, an internet- based decision support system was developed that time in one of the University Campus especially for neurological diseases and was consisting four different components. The first one being a web based system for home doctors which support writing an introduction letter to the university hospital. Second one was a diagnostic and therapeutic report on the patient who was introduced by home doctors and admitted to the university hospital. Third component was used to provide reports on medical images and pathological examinations. Lastly, the fourth being the one which makes a decision support for neurological diseases. [81] In the field of patient monitoring, there have been several implementation experiences based on medical devices standards such as the X73 family of standard. Most of the telemedicine systems implemented are based on the X73 family of standards. These standards are changing very fast, because of both the market and industry demand to adapt to new functional requirements and to the wireless communication technologies (i.e. Bluetooth, Zigbee, Wi-Fi, RFID etc.). The field of electronic healthcare records (EHRs) has also brought several implementations of standard-based systems.

Looking at remarkable contributions by several researchers in the medical field, for the benefit of society, especially living in rural as well as interior part of the world, an advanced low power real time telemedicine system is therefore developed and described. This thesis provides strategic study to design, develop and analyze the low power real time biomedical telemetry system using an ultra-low power processor like MSP432, Low power sensors and an optimum associated circuitry. Analysis and overview of such a system is carried out with respect to biomedical telemetry system.

### Criteria for Choosing Microcontroller

While choosing a microcontroller, firstly ensure that it meets the requirements and also is cost effective. It should be checked and ensured that an 8-bit, 16-bit or 32-bit microcontroller can very well handle the computing needs of a task. Additively, the following points should be considered while selecting a microcontroller

- Speed: The highest speed that the microcontroller can support.
- Packaging: This is important in terms of space, assembling, and prototyping the End-product. So it should be checked whether it is 40-pin DIP (Dual-inline-package) or QFP (Quad flat package)
- Power Consumption: This is an important criteria for battery-powered products.
- Amount of RAM and ROM: on the chip.
- Count of I/O pins and Timers: on the chip.
- Cost per Unit: This is important in terms of final cost of the product in which the microcontroller is to be used.

Further, one should make sure that, the tools such as compilers, debuggers, and assemblers are available with the microcontroller. Also the most important of all is that a microcontroller should be purchased from a reliable source.

The system presented in this paper is a proof-of-concept design to show that it is feasible to create end-to-end standard based patient monitoring solution for ICU environments. The system uses ISO/IEEE 11073 (X73) based medical devices in the bedside environment and EN13606 to communicate the information to an Electronic Healthcare Records server (EHR server). The components of this system (sensors, gateway, EHR server etc.) can be replaced individually

by equivalent standard-based devices with no need of system reconfiguration hence, providing interoperability to the bedside equipment's.

The system shown in figures 2.10 describes the overall system architecture of mobile (moving) telemedicine system and comprises of a telemedicine unit and base unit. The telemedicine system is responsible for collecting and transmitting biological signals and still images of the patients to the base unit (or doctors location). At base unit user can monitor biological signals or still images coming from the telemedicine unit, thus keeping a continuous online communication with patient location. When the base unit is located in the hospitals (especially in emergency handling or in home telecare), a hospital data base unit can be integrated in the system in order to record information concerning the cases handled. The doctors can retrieve medical history when required. However, such systems may suffer with Lack of flexible and integral telemedical Linkage between various mobile telecommunication systems, high link cost between global mobile services, wireless transmission data rates especially for 2G and 3G etc.

MSP432P401-R Controller and ARM Controller: A Comparative Analysis

The new 32-bit MSP432 MCU platform from Texas Instruments leverages its more than 20 years of low- power leadership and expertise to provide maximum performance of an embedded system with optimal power efficiency. This MSP432P-401R MCU platform is built around the high performance ARM Cortex-M4Core, featuring DSP extensions and an integrated floating-point engine. It is the most power-efficient process or available today. Hence, for better power budgets the ARM Cortex-M4 Family microcontrollers (MSP432) can be a better choice. They are easy to use and energy efficient. The cortex-M4 family is also optimized for cost and power sensitive MCU and mixed signal devices. Therefore for applications related with Biomedical signal processing these MCUs are best to use. However, the MSP432 and Arm controllers are compared in the following table 4.3to justify that the telemedicine system using MSP432 processor can be more power efficient than the system using ARM based LPC2148 controller.

### 1.3 Comparison between MSP432 and ARM based LPC 2148 controller.

ARM Based LPC 2148 MCU	Cortex Core MSP432 as MCU
LPC 2148 is 32 bit controller	MSP432 is 32 bit MCU with 32 bit program bus
It uses Von Neumann Architecture data and instruction fetch share same bus	It uses Harvard Architecture where separate data and instruction buses can be used
This has RISC architecture	RISC, thumb and thumb2 mode operation.
In ARM Based LPC 2148 MCU 16-bit and 32-bit both instruction sizes are possible with 3-stage pipelining	In Cortex Core MSP432 16-bit and 32-bit both instruction sizes are possible with 3-stage pipelining
It has Only 2 modes i.e. .active and low power	MSP 432 has Active, Low LPM0, LPM3, LPMx.5 power modes which are ultra-low power modes.
LPC 2148 has Old parallel JTAG	ARM JTAG in 4-wire and 2-wire modes debug interface is available in MSP 432
No CPU based math and DSP support is provided by LPC 2148	Hardware Multiplier and Divider, DSP extension, and integrated FPU units are provided by MSP432

### 1.4 MSP BASED WIRELESS MODULE REALIZATION

The block schematic of low power wearable patient monitoring module implemented using cortex-M4 core, ultra-low power high performance processor i.e. MSP432P401-R is depicted in figure 5.5. It comprises of an advanced one wire digital thermometer (DS18B20), a low power ECG sensor module (AD8232) and a Bluetooth module (HC04) associated with RS232 and 16\*2 LCD display.

following Diagram shows actual working of sensors along with necessary hardware required for making Wireless wearable health monitoring module, there are many sensors are available but very few are compatible on PCB layout like LM35 Sensor, Heartbeat Sensor, ECG sensor i am using in my research project as LM35 Sensor, Heartbeat Sensor and ECG Sensor are under working process on Wireless wearable health monitoring module we are using ultra low power cortex on built analog to digital converters,UART1,UART2 for sending and receiving data whole data is carried out and passes to used global via Bluetooth, GSM Module or global data sender as WiFi Module this whole data can be collected and reprocess for cloud data storage as cloud computing environment can save the data of each patient by unique ID number.

all biomedical data and important consideration of patient health were save on cloud computing technology and wherever it necessary everywhere and anywhere doctors or Experts can retrieve the data for further analysis and treatment needed for best diagnosis we can send this data to remotely located expert or Doctor of that concern he could give the suggestions, advice for best result and without any interruption for future use it can be securely save on cloud environment.

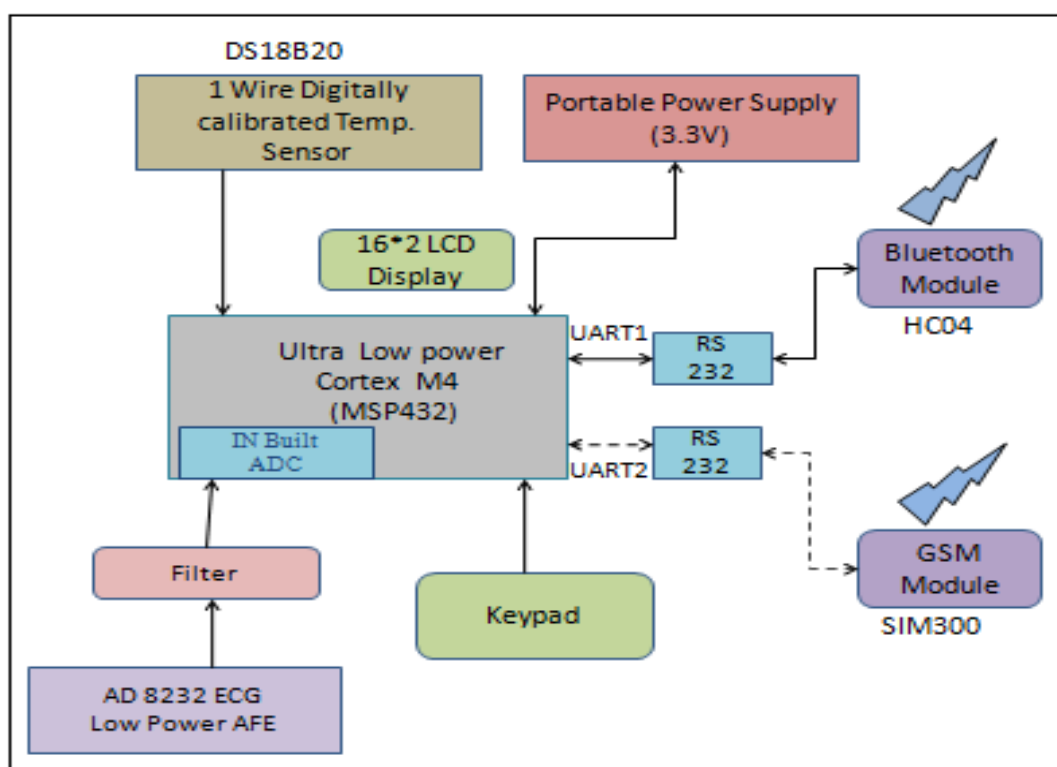


Figure 2.1: Wireless wearable health monitoring module

The GSM (SIM1200) if connected directly to the wearable module the power consumption will be extensively increased. As an alternative, an intermediate Tran's receiver module may be developed separately to receive the physiological signals accumulated by sensors and processed by MSP432P401-R MCU wirelessly via Blue-Tooth. This Trans receiver unit consists of Bluetooth module (HC04), GSM module (SIM 1200), central processing unit and local display monitor. The physiological signals from patient are accumulated and processed by MSP432P401-R to get transferred to the separate transmitter unit wirelessly via Bluetooth. Block diagram in figure 5.6 shows the wireless transmission unit to transmit the patient's physiological signals, processed by MSP432P401-R at wearable unit itself. It consists of Bluetooth module (HC04) and GSM module (SIM 300 or SIM 1200), central processing unit and local display monitor. The physiological signals from patient will be received globally on the smart phones with the help of GSM module used.



**1.5 The GSM Based ECG Tele-Alert System:[24]**

The model shown in figure 2.11 consists of an ECG bio amplifier that picks up the bio signal and then converts into electrical signal which are provided to low pass filter. LPF Output is digitized by an A/D converter, and then programmed in AT89C52 Microcontroller followed by the GSM MODEM.

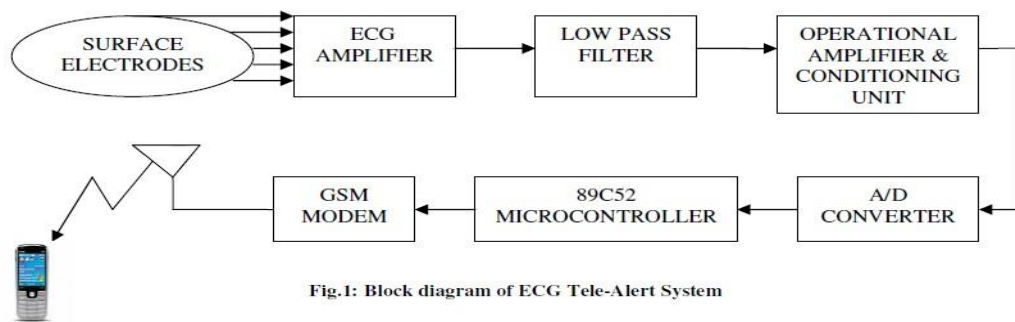


Fig.1: Block diagram of ECG Tele-Alert System

The patient (client) and the caretaker (doctor) can be located anywhere in the globe having 2G cellular network coverage. The primary purpose is to monitor patient’s cardiac activity. Hence, when the patient’s cardiac level goes beyond the threshold, the system discussed alerts the doctor by sending an alert SMS to the doctor’s mobile through the GSM MODEM.

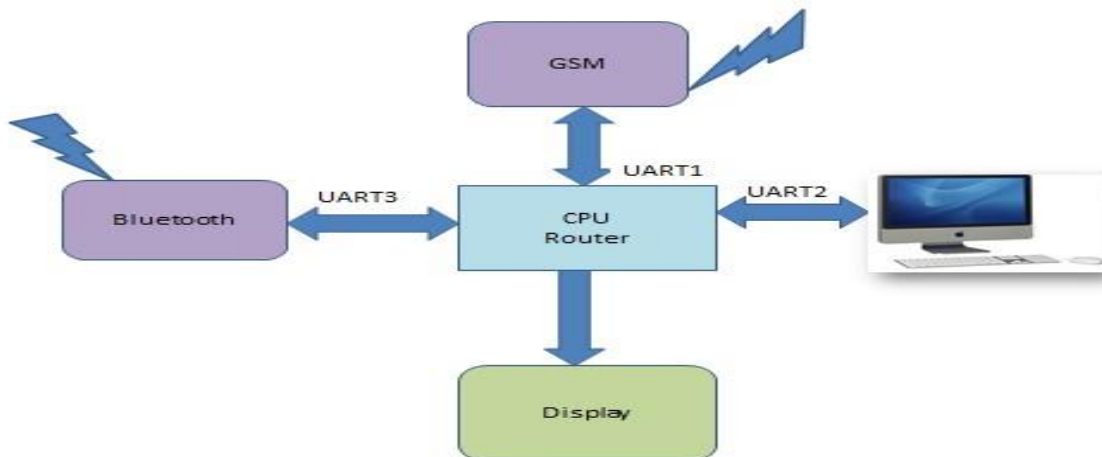


Figure - 2.2GSM MODEM

## 2. Hardware Description

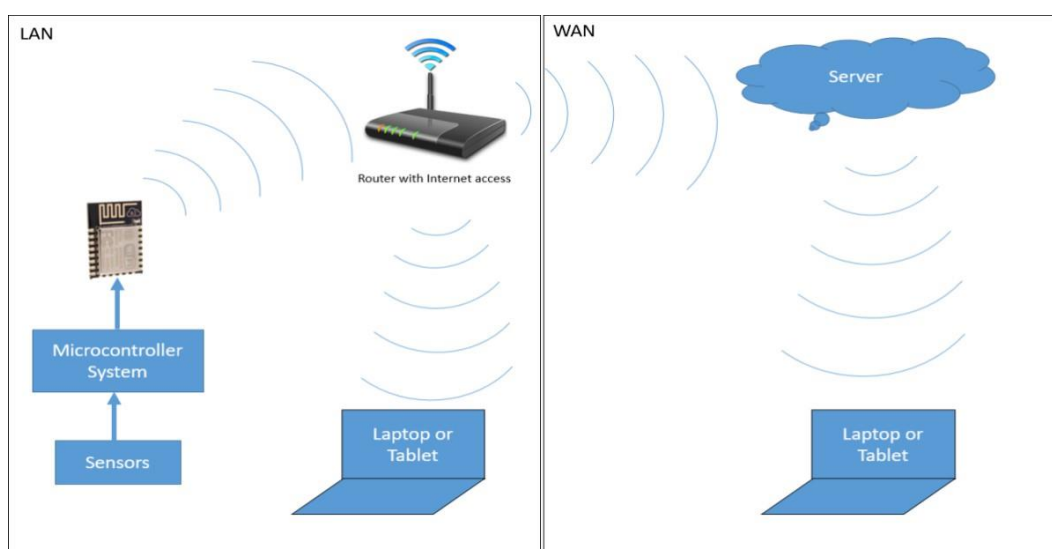
### 2.1 MSP432P401-R as the Heart of Wearable Data Acquisition Module

It is the first MSP432 family device featuring low-power performance with an ARM Cortex-M4F core. 32-bit MSP432P401-R from Texas Instruments that influences about 20 years of its low-power governance and proficiency to provide maximum performance with optimal power efficiency. EXP MSP432P401-R MCU target board consists of high performance ARM Cortex-M4F core MSP432P401-R processor along with an emulator and an energy trace unit as shown in figure 5.8. It is featured with DSP extensions and an integrated floating-point engine and is the most power-optimized processor available now a day.

MSP432P401-R and the XDS110-ET Emulator MCU are isolated by the isolation block comprising of switch S-101 and the jumpers provided next to it.

#### Tran receiver Module

The physiological signals of the patient extracted by different sensors are provided to highly efficient Wi- Fi module (ESP 12-E) connected to the UART of MSP 432 MCU. The physiological signals accumulated at Wi-Fi module are channelized for local and global transmission as shown in following figure 5.13 ECG signal is transmitted at higher transmission rate compared to other signals like temperature, Blood pressure etc. This creates data buffering problem for the limited internet access availability with an examiner. This necessitates the requirement of leased (dedicated) internet access at receiving end (i.e.at doctor's end).



(a) Local Communication

(b) Global Communication

### 2.2 Working Methodology

Microcontroller transmits the physiological data (acquired from sensors) via ESP12E using specific static URL/IP and Port. The different steps followed for local (LAN) as well as global (WAN) communication are mentioned below. So as to setup remote access, initially static website domain and space is purchased to run a global server. A website with required GUI is then created Physiological data is then acquired using Internet protocols i.e., TCP/IP or UDP. Acquired bio-signal information is then sent to particular running server with specific IP and Port. The complete bio-signal information is then available globally on Computers, Laptops, Tablets or Smart Phones etc.

To avoid excessive data buffering problem ECG signal which is the continuous running signal and will have far more samples to receive than other signals which are transmitted. Temperature, Blood pressure which are therefore

transmitted at regular intervals keeping sufficient time gap between two successive measurements.

Like on-premise storage networks, cloud storage uses servers to save data; however, the data is sent to servers at an off-site location. Most of the servers you use are virtual machines hosted on a physical server. As your storage needs increase, the provider creates new virtual servers to meet demand on another end of receiving data as the availability of digital devices and network connectivity like WiFi module has been collected send to cloud server, whenever necessary we can access the physiological data of Patient and send to the Expert present on any location as needed for further treatment and diagnosis.

#### Sensor Modules

This section starts with the brief explanation of heart beat sensor followed by the detailed study of best suited low power digital temperature sensor DS18B20 which does not require any extra hardware such as amplifier, ADC etc. is presented. ECG sensor module AD8232 with minimum associated hardware.

#### Heart Beat Sensor

Heart beat sensor is designed to provide the digitized heart beat value. When the heart beat detector works, the beat LED flashes in with each heartbeat. This digital output can be connected to microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger at each pulse. The sensor consists of a super bright red LED and light detector as shown in figure4.2

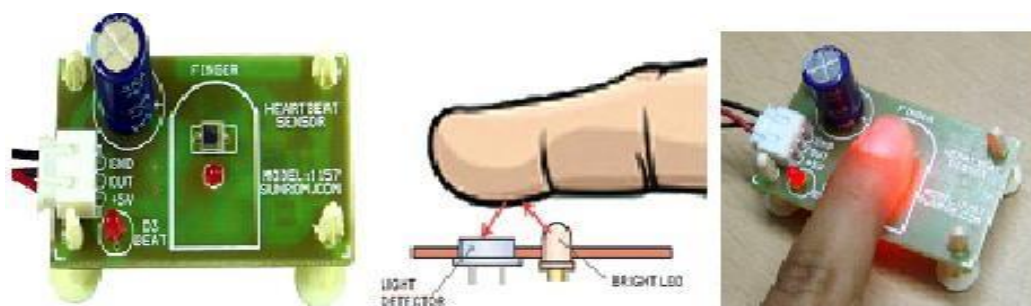
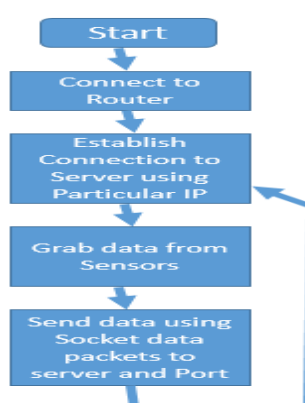


Figure.5.6 Working principle of heart beat sensor module

### 2.3 Logic for Connection Establishment between ESP12-E & Server



The flow chart in figure 5.15 depicts the procedure to establish the wireless connectivity between Wi-Fi module (ESP8266/ESP12-E connected to wearable DAS hardware) and the server for local as well as global communication. Once this is achieved the process of real time physiological data transmission starts.

### 2.4 Result and Output



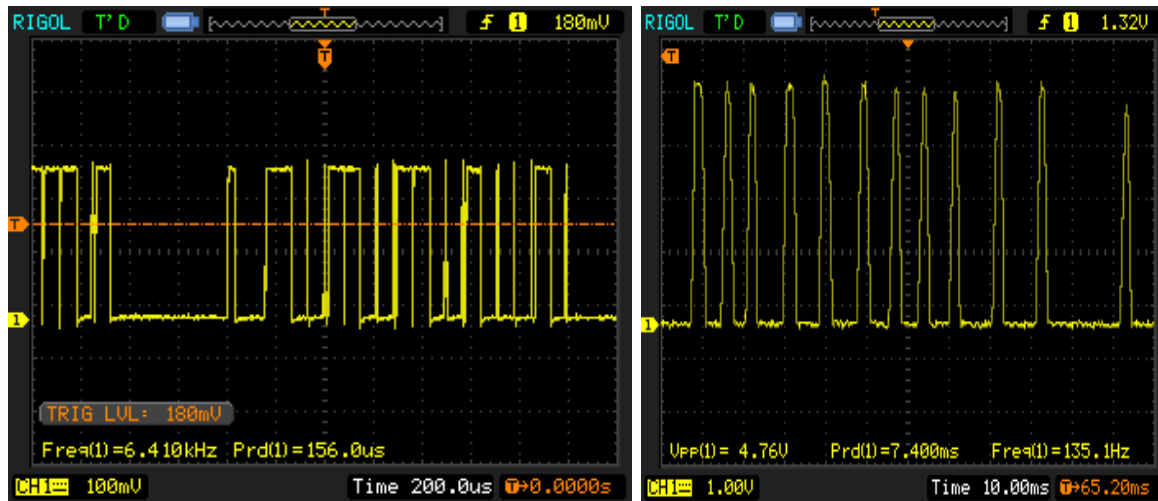


Figure 5.7 Temperature sensor outputs for (a) MSP430 and (b) LPC 2148

The one bit digital thermometer gives the digital pulse output, the amplitude of which is proportional and calibrated in degree Celsius. This is shown in figure 6.2. Waveforms depicted in figure 6.3 shows the output of Heart beat sensor. The total no. of such pulses per minute are measured by microcontroller and transmitted. The waveform shown in figure 6.4 illustrates as to how the digital data is transferred serially from microcontroller to the Bluetooth module via RS232 unit.

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