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MOBILE HEALTHCARE SYSTEM

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Abstract: This research paper focuses on a wireless healthcare system. Here we have used various sensors[4] to measure vital parameters like body temperature, pulse rate, blood oxygen saturation (%Spo2) and ECG. During the COVID-19 pandemic, keeping track of your oxygen levels and temperature had proven to be essential[11] hence this system will keep track of the patient's vitals[5]. This system is also designed for those patients who are bed ridden and need monitoring continuously[11]. Hence, this system can help their caretakers monitor them remotely. These parameters are measured at the patient's end and will be transferred wirelessly[4] to a remote display with help of transceiver modules. The Arduino controller on the patient's end is integrated with all the sensors and a transceiver module. The remote display is connected with another Arduino controller with the transceiver module. Through this module we receive all the signals post processing and are displayed on the TFT display. This system has shown promising and accurate results for a portable healthcare system.

Keywords—*Heart rate, Body temperature, Electrocardio- gram (ECG), Oxygen saturation*

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I INTRODUCTION

In the medical industry, it is critical to keep track of a patient's physiological signals while they are being treated. Heart rate, blood glucose, ECG, temperature, and other physio- logical signs are all significant. Monitoring each patient for 24 hours is a difficult task for doctors and medical professionals. We provide a technique for collecting physiological signals and transferring them to personal computers. Patients can be examined by a doctor or other paramedical professionals from a central observation facility or from their own computer. Traditional bedside patient monitoring systems are still in use in many hospitals today. There are certain technological limits to the patient monitoring systems that are now available. This system is quite costly, and it also involves the hiring of additional personnel to manage it. Electronics and infor- mation technology are rapidly evolving, resulting in a more powerful health-care system. Heart rate, blood glucose, ECG, temperature, and other physiological signals are critical vitals in the hospital. A technique is adopted in which patients' physiological signals are sent to personal computers. Four sensors are used in this patient monitoring system: heart rate, SPO2, ECG and temperature. These four sensors capture physiological signals from the patient and send them via a communication module to the doctor's or other paramedical staff's computer or smartphone.

There are at least four Vital parameters in the human body:

1) Pulse rate - The pulse rate is measured by the times the heart contracts in a minute. It is important for checking the condition of the heart and detection of any cardiovascular diseases.

2) SPO2 Oxygen Saturation - SpO2, also known as oxygen saturation, is a measure of the amount of oxygen- carrying hemoglobin in the blood relative to the amount of hemoglobin not carrying oxygen. The body needs there to be a level of 95 to 99% oxygen in the blood or it will not function as efficiently.

3) Temperature - On an average a normal body's tempera- ture is 98.6°F (37°C). Studies show that the normal body temperature can also lie between 97°F (36.1°C) to 99°F (37.2°C). [6]Having a temperature over 100.4°F (38°C) usually means you have a fever that is caused by an infection or illness.

4) Electrocardiogram - An electrocardiogram (ECG) de- tects an electrical signal that is generated by the heart while contracting and records it to identify various heart conditions. Electrocardiograph is a machine that records the person's ECG and as a result prints a strip of the ECG.

All governments are increasingly concerned about the ef- fects of ageing populations on health-care administration. According to projections, the global population of adults aged 65 and more would reach 761 million by 2025, more than doubling from 1990. This ageing population is mostly affected by several chronic ailments. Different chronic conditions, such as diabetes, congestive heart failure, and other disorders, demand the monitoring of patients' physiological signals. The integration of all of these equipment, as well as wireless communication, in medical applications for home healthcare, is the premise for this work.Patients are no longer confined to a

single healthcare facility where they are monitored by medical devices. Not only will wireless connection provide them with secure and accurate monitoring, but it will also allow them to roam about freely.

II.EXISTING APPROACHES

The papers that we reviewed were focused on individual equipment for measurement of the vitals[11]. These methods are mostly non invasive and help the staff of a hospital to get accurate readings of a patient. Through our research we have noticed that, evolution of electronics and information technology is resulting in more powerful systems in the health- care systems.Current advances in technology has led to use of wearable sensors[2], smart gadgets etc. for health monitoring. Remote Patient Monitoring (RPM) implements a concept[3] which raises a lot of interesting possibilities, and helps to address different issues continually faced with effective patient administration. Some notable issues are managing patients in remote areas, monitoring (elderly) patients in their own homes and saving hospital bills[5]. Remote health monitoring, based on non-invasive and wearable sensors, actuators and modern communication and information technologies offers an efficient and cost-effective solution that allows the elderly to continue to live in their comfortable home environment instead of expensive healthcare facilities[2]. Our proposed system mainly focuses on continuous and remote monitoring of a patient. Using technologies of wireless sensor network and Radio frequencies this system tries to simplify the patient monitoring for home as well as hospital uses . Our goal is to build a system which is not only affordable to common man but also equally efficient and making the diagnosis as easy as possible for the concerned doctors.

III.MOBILE HEALTHCARE SYSTEM

For building a compatible system we have divided this system into two parts. First which has one Arduino controller and is interfaced with all the required sensors. The system uses disposable electrodes to observe the ECG wave in order to reduce noise in the ECG signal. The interfaced transceiver module will transfer the data acquired to the TFT display wirelessly to a remote location. Second part of the system includes: an Arduino controller, the TFT display and the transceiver module. The transceiver module receives the data from the first part of the system and displays it on the TFT display. The TFT display is divided into sections for presenting the data. Fig 1 represents the functional block diagram of the proposed system and in Fig 2 the flow of the system is shown.

A.Temperature Sensor

The temperature sensor that is used here is MCP9808[6]. It is a Grove I2C protocol following sensor and is used for integrating with the microcontroller. I2C uses the best features of SPI and UARTs. Giving us an advantage of connecting many slaves to one master like SPI this proves to be useful when it is required to have multiple microcontrollers logging data over a single memory card or it is displaying data on a single LCD screen. As mentioned earlier this module has master slave configuration which is defined by the SDA (Serial Data) is the line for the master and slave to send and receive data and SCL (Serial Clock) is the line that carries the clock signal. The MCP9808 Temperature sensor is actually a digital temperature sensor, so the sensor has two metal electrodes placed closely.

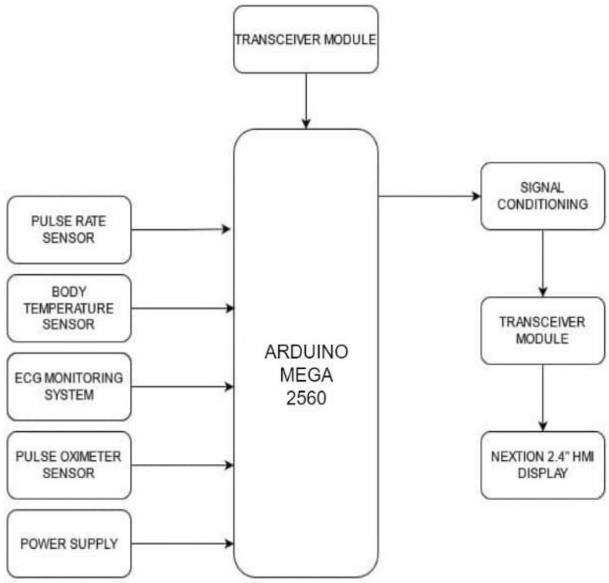

Fig. 1. Block Diagram of the

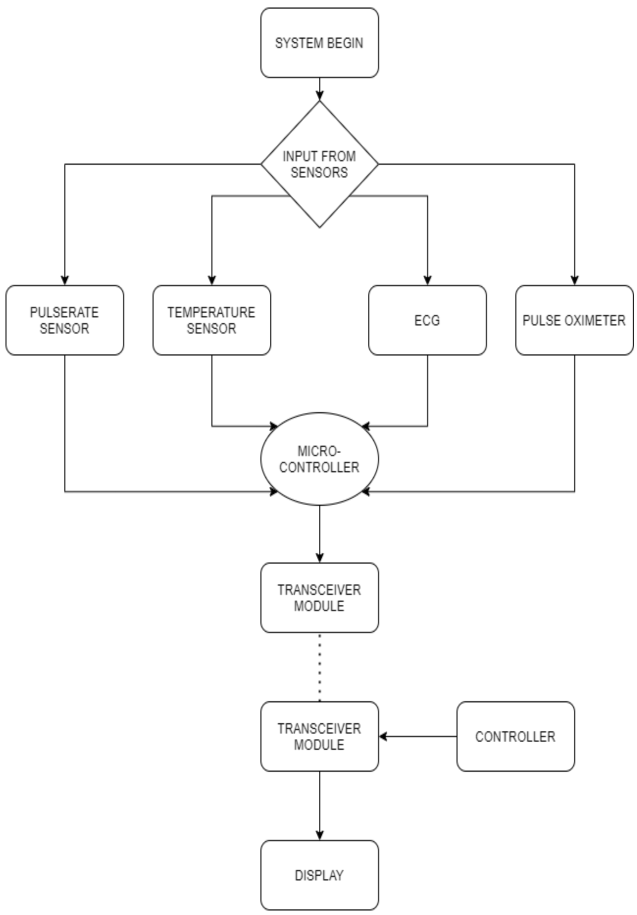

Fig. 2. Flow of the Proposed System

As soon as the temperature varies the resistance between the two electrodes changes. This change in resistance results in a change of output voltage. This voltage is then calculated using a common factor to give us the body temperature in fahrenheit. This temperature value can be converted to degree celsius using the formula (XF-32) x 5/9. Although it takes about 10 to 15 seconds to get the actual body temperature.

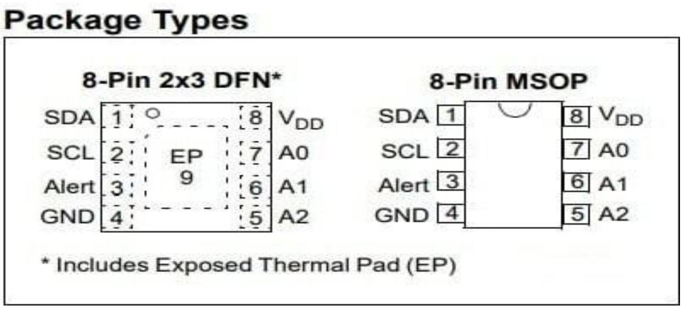

Fig. 3. Internal Diagram of the Temperature Sensor

B.Pulse Oximeter Sensor

The MAX30102 sensor has an integrated pulse oximeter and also a heart rate sensor module. It comprises a red LED with an infrared LED along with a photo detector and optical components with low-noise electronic circuitry in addition to ambient light suppression. Few Features of a MAX30102 is that it has a 1.8V power supply and a 5.0V power supply used for the internal LEDs for acquisition of heart rate and blood oxygen saturation in wearable devices which are worn on the fingers. The I2C standard is a compatible communication interface which can transmit the values that are collected to the microcontroller which then calculates the heart rate and blood oxygen saturation. Moreover the module shuts down through a chip and also puts it on standby mode when the current is close to zero although the power supply is constantly maintained. When a person breathes in air, the oxygen rich air oxygenates the blood flowing through the lungs and then the oxygenated blood is carried to other parts of our body and it is carried by a substance called hemoglobin. For getting a pulse oximeter reading, we place our finger tip on the sensor and beams of light are passed through the blood in the finger for measuring the amount of SPO2 which is indicated by the amount of light absorbed by the oxygenated and the deoxygenated blood. The sensor has two types of LEDs, one that emits red light and the other which emits infrared light. Red light is absorbed more and infrared light is passed by deoxygenated blood. On the contrary, red light is passed more and infrared light is absorbed more by oxygenated blood. The primary function of the sensor that is used here is that it absorbs the levels from both sources and stores them as buffers which can be read through I2C protocol. The MAX30102 sensor also has an inbuilt pulse rate sensor. And for measuring pulse rate only infrared light is required. As the heart pumps oxygenated blood resulting in more volume of blood and as the heart is relaxing the volume of blood also lowers. Hence, by knowing the difference between the time periods between the volume of blood we can determine the pulse rate .

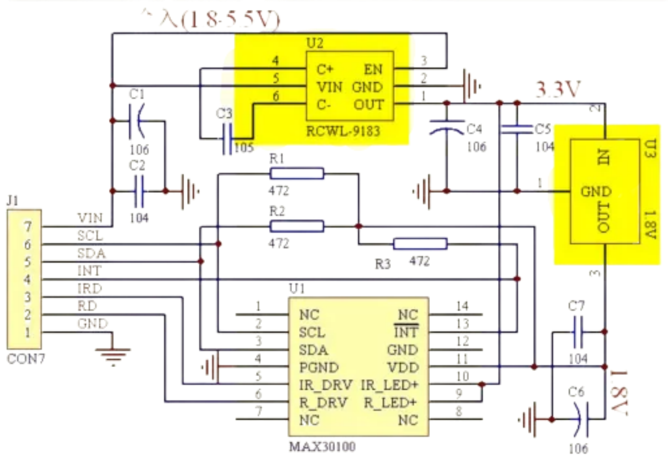

Fig. 4. Internal Diagram of the Pulse Oximeter Sensor

C.Electrocardiogram (ECG) Sensor

ECG[1] is a biopotential signal and it can be measured by various biopotential measuring devices such as AD8232[7]. AD8232 is designed for integrated signal conditioning for measuring ECG and is used for other biopotential measure- ment applications as well. It is also designed for extracting, amplifying, and filtering biopotential signals that are smaller in magnitude, in noisy conditions which are created by motion of the electrodes hence it is suggested for the patient to be resting well and not moving constantly or remote electrode placement where the electrodes are farther from the natural blood flow. It is designed in such a fashion that allows the use of an ultra low powered analog-to-digital converter (ADC) and also an embedded microcontroller to obtain an output signal easily. This module can execute a two-pole high pass filter for terminating motion artifacts as well as the electrode half-cell potential. The existing filter is coupled with an instrumentation architecture which allows large gain and high pass filtering within a single stage hence saving a lot of space and cost.

D.Transceiver Module

The transceiver module that this system uses is the nRF24L01[8]. This module is a single chip radio transceiver for the world wide 2.4 - 2.5 GHz ISM band. This module has a fully integrated synthesizer, a power amplifier, a crystal oscillator, a demodulator, modulator and Enhanced ShockBurst™ protocol engine. The output power, frequency channels and protocol setup are effortlessly programmable through a SPI Interface. The consumption of current by this module is very low which is only 9 mA with output power of -6 dBm and 12.3mA in RX mode[9]. It works on SPI Communication Protocol.

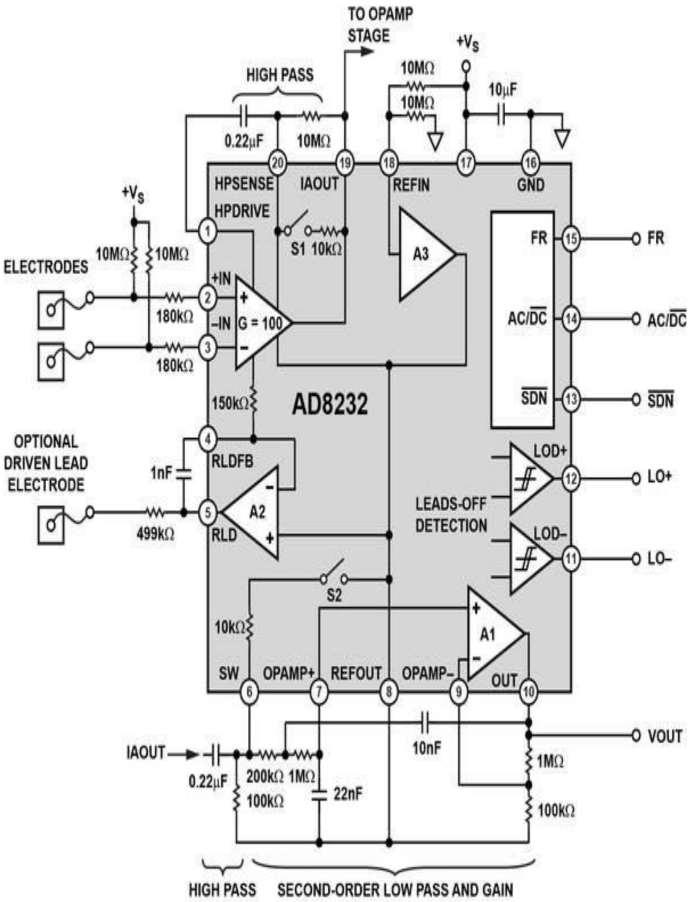

Fig. 5. Internal Diagram of the ECG Sensor

SPI Protocol stands for Serial Peripheral Interface. Whichis a synchronous serial communication interface for short distance communications and is primarily used in embedded systems. The module can range upto 100 meters if it is used in open spaces with lesser baud rate. This module is capable of using 125 various channels, giving a possibility of having 125 independent working modems within a place. Each channel can communicate with each other up to 6 other units at the same instance because each channel can have up to 6 addresses. This module consumes 12 mA of power during transmission and when compared to other components, this module uses lesser power than a LED. The module operates within the range of 1.9 V to 3.6 V and the other pins can tolerate the 5 V logic hence it can directly be connected tothe Arduino as well without any use of logic converters. Inthe module 3 pins are allocated for SPI communication which need to be connected to the Arduino. Pins CSN and CE have the flexibility to be connected to any digital pin of the Arduino because these pins are used for setting the module in a standbyor active mode and switching between transmit or command mode as well. The remaining pin is called an interrupt pin which is not being used.

E.TFT Nextion Display

The Nextion Display we are using is the basic version of dimensions 2.4". The Nextion has a built-in ARM microcontroller that controls the display, for example it takes care of generating the buttons, creating text, storing images or changing the background[10]. The Nextion communicates with any microcontroller using serial communication at a 9600 baud rate in our case the Arduino Mega. This is a HMI display so it needs to be programmed in order to make the display an interactive one. The frontend of the display can be designed using the software Nextion editor, all the objects needed to display are directly available as functions such as waveform, integer, text,etc. However some variables require a different type of programming. The backend programming can be done using the arduino mega from which it will be taking all the values to be displayed. This display used the UART protocol for communicating with the microcontroller.There are 4 pins available: the Vcc, Gnd, Rx and Tx. While for uploading the frontend file onto the display there are multiple feasible ways one of them includes using a memory card as the display has a separate card slot[12]. Two way communication can be done by using buttons programmed to do a specific task according to the user.

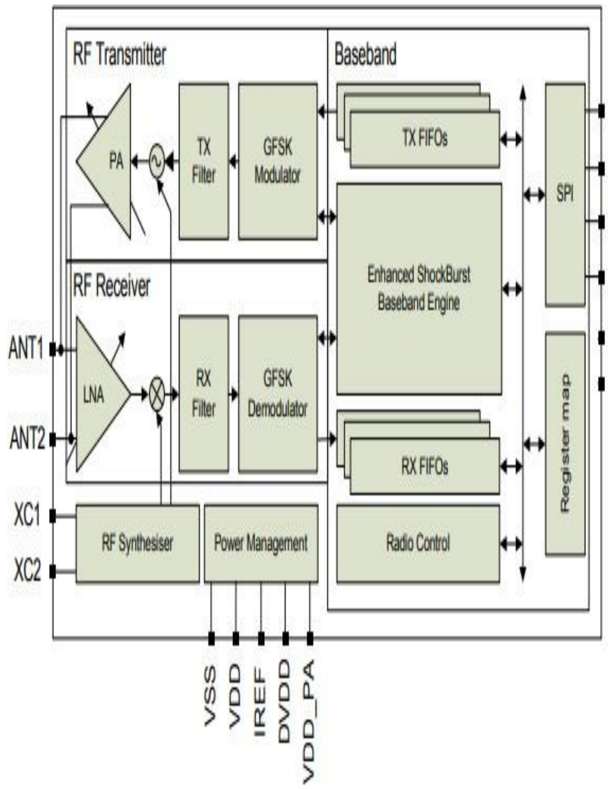

Fig. 6. Internal Diagram of nRF24L01

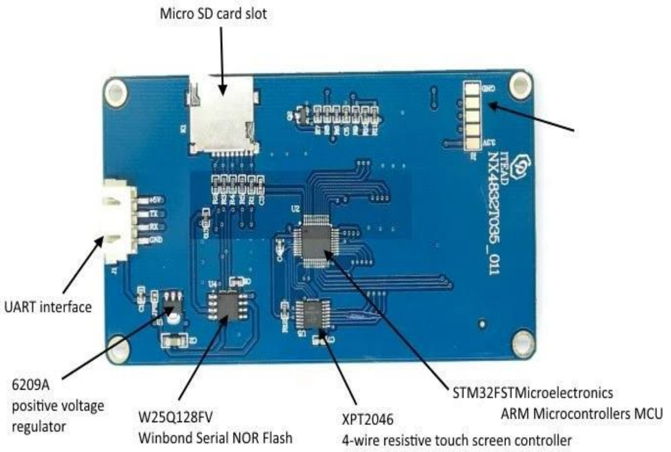

Fig. 7. TFT Nextion Display

F.Data Processing through Arduino

Most of the sensor modules gave us direct values of the required vitals like the temperature sensor and the ECG value,etc. However it needed some conversion like the ob- tained temperature values were in Fahrenheit, which needed to be converted to celsius using the formula(xF-32)x5/9 for better convenience. The ECG sensor gave direct analog values and did not require much post processing as the values had already been filtered using the LPF available on the sensor module. The MAX30102 sensor uses different methods to measure the pulse rate and the Spo2 levels. The time intervals between the flow of oxygenated blood is counted to measure the pulse rate. Although the pulse rate needs to be measured in beats per minute (BPM). Inorder to convert the measure time interval to BPM a formula is used

BeatsPerMinute = 60/(delta/1000.0)

where delta is is difference between the total number of mil- liseconds the program has run and the milliseconds measured at the last beat.

longdelta = millis() − lastBeat lastBeat = millis()

While for measuring the SpO2 levels the difference in the transmitted and the received IR and red LED signals is calculated.Initial 100 readings are used to calculate the Heart rate and SpO2 so as to avoid any errors before displaying the final values. From these 100 readings first 25 are dumped in the memory and the latest 75 are shifted to the top. So every time new 25 readings are measured to calculate the Heart rate and SpO2 levels.The nextion display only supports strings and integers to display but does not support float values. So to display float values we need to mask them as Characters to serially transmit them to the Nextion display.

G.System Overview

The system consists of various sensors integrated together to a single microcontroller to obtain all the raw vital information. The whole system can be divided into 4 parts based on their working like the Setup unit, the sensing and processing unit, the transmission unit and the last is the display unit. The system begins with setting up all the sensors to start sensing and the controller is supplied with all the necessary libraries. Using various transmission protocols like the I2C and the SPI the data from the sensors enters the controller for post pro- cessing. This is the 2nd unit, the sensing and processing unit. Conversion of data from one form to another, making the data usable by using various formulas ,calculating the final required vital data from raw information,etc all this post processing is done in this unit. The next unit is the transmission unit where all this accumulated data is sent wirelessly from one controller to another using the authorized radio frequency. The transceiver module used the SPI protocol to communicate with the other module present on the receiving end. The data is sent serially one by one and it works in a loop so the data is sent unless the power is cut off. The last unit is the display unit , on the receiver's side there is no processing required as all the data is transmitted in its final state. The Nextion HMI display is connected to the receiving microcontroller and the data is sent using the UART from the controller to the Display. The frontend of the display is designed according to the data being received. The ECG is displayed in the form a wave using the function available on the nextion editor.

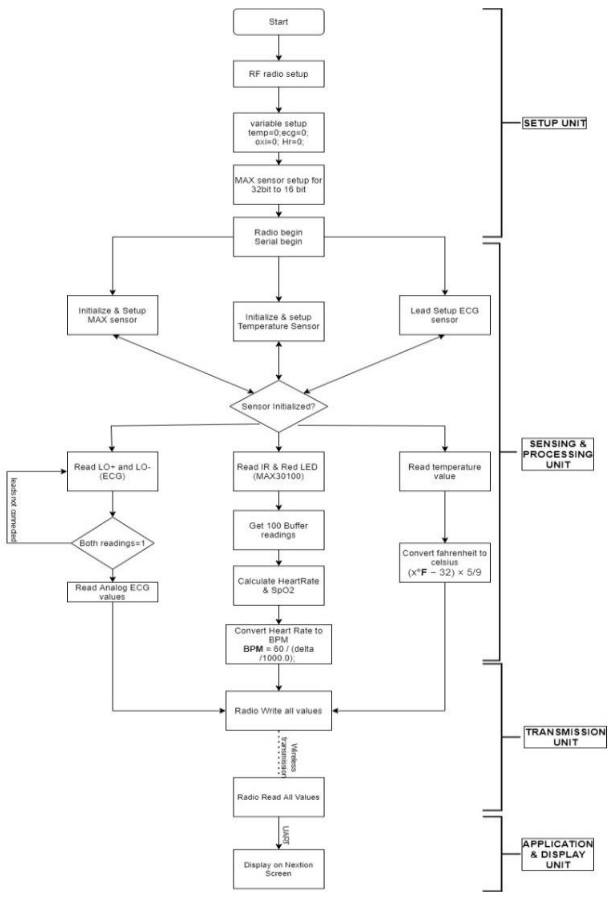

Fig. 8. Block Diagram of the Proposed System

All the other values are displayed on the side. These are being continuously updated to get the real time state of the patient. The display will have different pages, wherein each page will have the information regarding the critical values of the displayed values and the possible diagnosis of the values along with important information like the ambulance number or the number of the patient's emergency contact.

H.Significance of the system

The compactness and portability of our system makes it a unique one, as currently there are no devices or methods in the market which measure more than one parameter and are small in size. We are measuring temperature, oxygen level in blood(Spo2), heart beats and ECG. All these data are simultaneously displayed on a TFT touch screen which not only tells you the measured reading but will also guide and warn you about any unusual readings or spikes that the system may detect during the measuring process, and also tells you about your current conditions with a user-friendly interface that can be operated by anyone having knowledge about smartphones. After that you may visit your family doctor for better diagnosis and treatment if necessary. By these four vitals we can diagnose most causes of discomfort among patients. Our system shows accuracy of 95-98% which is at level compared to industry grade sensors that are stand alone or available in our smartphone or measuring devices for consumer uses, in the medical field the more the accuracy the better the results for patients. Real time monitoring is very efficient for elderly people as their condition are not always good, our system tries to eliminate last minute hustle as if there is some minor problem then you will have plenty of time to visit your physician and get all the necessary test done and can also share the data that has been captured by the device. Our system is wireless so that in a hospital all the concerned data from the patients admitted in different wards can be sent to the doctors directly connected through the same Wifi-network. Another unique aspect that we are implementing here is using a transceiver module to transmit our data to our TFT screen where all the available products in the market use IoT or any other kind of communication protocol for transmission of data. Due to the compactness of our system it can be used as a wearable option which is a better alternative to the available products in the market as they measure only one or two parameters whereas our system is capable of measuring four or more parameters so more information for better diagnosis. The small size and features make it applicable to many areas such as for monitoring elderly people, for military purposes (soldiers deployed in higher altitude measuring their health condition in base camp) and for better and healthy lifestyle.

IV.PERFORMANCE MEASUREMENT

The Following tables consists of readings taken using various subjects at different timings: According to the case studies done using local subjects the average error rate for the pulse rate measurement comes to be around 0.0275, while for the SpO2 measurement the average error rate is 0.02. So the overall accuracy of the whole system considering the pulse oximeter is around 98-99%. The slight difference in the readings can be caused due to interference of the atmospheric components around the finger in the proposed system. Isolation can be done in the proposed system by placing the sensor in an enclosed finger-like structure which can be 3d printed . This will help the sensor to be intact and stable while measuring the vitals and also avoid any external interference.

TABLE I
READINGS OF PULSE RATE SENSOR

Pulse Rate(Market)	Pulse Rate (Proposed system)	% Error
66	68	0.02%
84	84	0%
72	77	0.05%
97	93	0.04%

TABLE

II READINGS OF SPO2

SpO2(Market)	SpO2(Proposed system)	% Error
95	97	0.02%
96	100	0.04%
97	96	0.01%
98	99	0.01%

V.CONCLUSION

In this Paper a system is proposed to measure some vital biomedical parameters like the Pulse rate , SpO2, Body temperature and the ECG of a particular patient. This is a Wireless Health Monitoring system which can replace some available gadgets like smart fitness bands and watches etc, as the proposed system has additional advantages like complex parameters including ECG and also remote patient monitoring can be done. This can be used both for hospital as well as home purposes for patients needing 24x7 health monitoring. Remote monitoring can help doctors or concerned family members to observe the patient sitting in a different room . This system can also be modified to communicate 2 ways in order to introduce IOT ,and using internet or gsm modules can also help upload the data online for doctors to access this data sitting anywhere around the globe. Our proposed system gives an overall accuracy of about 97-98% making it suitable for medical purposes. Additional features include introduction of various health charts to have a reference while monitoring the vitals as well as contact information of various hospitals ,ambulances and family members for emergency situations.

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