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RESEARCH ARTICLE

IMPLEMENTATION OF IOT BASED PATIENT HEALTH MONITORING SYSTEM USING ESP32 WEB SERVER

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Abstract

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The focus of this project is to implement an intelligent health care system based on internet of things (IOT) for the measurement of the vital signs like pulse rate, temperature, spo2, using (ESP32 div kit) for wireless wearable sensor controller and ESP32 server. With the system proposed, the doctor can save work time to visit the patients that responsible about them and any facilitates monitoring the huge number of patients. The WI-FI technology is utilized as a communication tool to allow transmission the data remotely. The data of patient are sent to the web server to be stored in the database and view the data on the web page anywhere and anytime using smart devices and alert the doctor to any abnormal state. This work with the intelligent health care system provide an efficient medical service, by collecting and recording the information that include heart rate, temperature and spo2 that enable the doctor to monitor this patient with flexibility and confidence. Also, we highlight the challenges in the implementation of IoT health monitoring system in real world.

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Introduction:-

IoT is making any objects internally connected in the recent decade and it has been considered as the next technological revolution. Smart health monitoring mechanism [1, 2], smart parking [3], smart home [4], smart city [5], smart climate [6], industrial sites [7], and agricultural fields [8] are some of the applications of IoT. The most tremendous use of IoT is in healthcare management which provides health and environment condition tracking facilities. IoT is nothing but linking computers to the internet utilizing sensors and networks [9, 10]. These connected components can be used on devices for health monitoring. The used sensors then forward the information to distant locations like M2M, which are machinery for computers, machines for people, handheld devices, or smartphones [11]. It is a simple, energy-efcient, much smarter, scalable, and interoperable way of tracking and optimizing care to any health problem. Nowadays, modern systems are providing a fexible interface [12], assistant devices [13], and mental health management [14] to lead a smart life for the human being.

In recent times, many health monitoring systems have been developed to monitor the health condition of tients. We are reviewing some recent works developed in this field. In this review, all the systems have been classified based on the priority of hardware components, that is, which components have been used more than the others.

Therefore, all the systems have been categorized into three different categories as follows:

1. Sensor-based health monitoring systems.
2. Smartphone-based health monitoring systems

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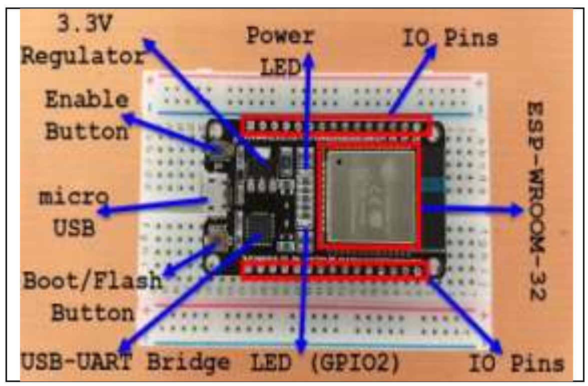
3. Microcontroller-based health monitoring systems.

Hardware components
1. ESP32 microcontroller (Wi-Fi module/ web server)
2. DS18B20 sensor (Body temperature sensor)
3. DHT11 sensor (Room temperature & humidity sensor)
4. MAX30100 sensor (Pulse oximeter & heart rate sensor)
5. Resistor, jumper Wirer & Breadboard

Software components
Arduino IDE

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espressif Systems, the developers of the famous ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth.The good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun. This makes designing hardware around ESP32 very easy as you require very few external components. The ESP32 microcontroller is shown in below figure-

ESP32 microcontroller

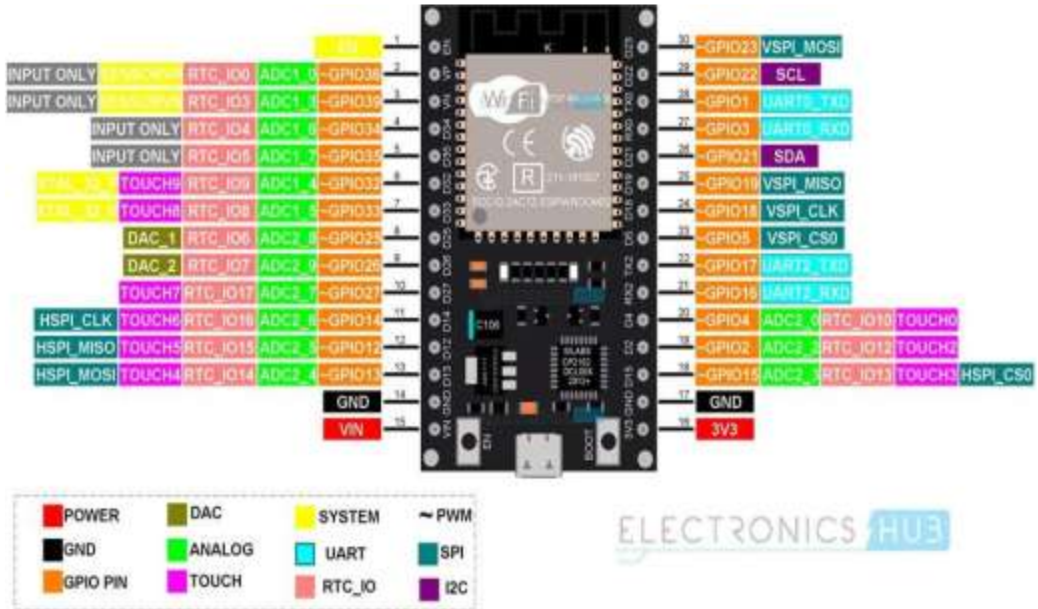


ESP32 Board

The ESP32 Board consists of the following:
1. ESP-WROOM-32 Module
2. Two rows of IO Pins (with 15 pins on each side)
3. CP2012 USB – UART Bridge IC
4. micro–USB Connector (for power and programming)
5. AMS1117 3.3V Regulator IC
6. Enable Button (for Reset)
7. Boot Button (for flashing)
8. Power LED (Red)
9. User LED (Blue – connected to GPIO2

An interesting point about the USB-to-UART ICis that its DTR and RTS pins are used to automatically set the ESP32 in to programming mode (whenever required) and also rest the board after programming.

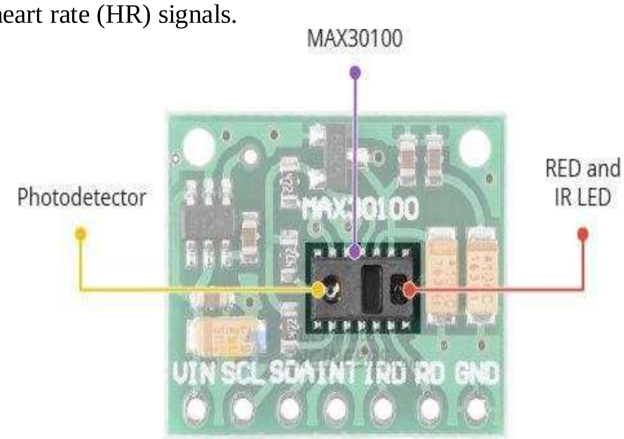
Pin out of ESP32 Board:
I will make a separate dedicated tutorial on ESP32 Pin out. But for the time being, take a look the pin out diagram of the ESP32 Development Board.



This pin out is for the 30 – pin version of the ESP Board. In the pin out tutorial, I will explain the pin out of both the 30 – pin as well as the 36 – pin version of the ESP Boards.

Interfacing MAX30100 Pulse Ox meter and Heart Rate Sensor:

The module features the MAX30100 – a modern, integrated pulse ox meter and heart rate sensor IC, from Analog Devices. It combines two LEDs, a photo detector, optimized optics, and low-noise analog signal processing to detect pulse oximetry (SpO2) and heart rate (HR) signals.



On the right, the MAX30100 has two LEDs – a RED and an IR LED. And on the left is a very sensitive photodetector. The idea is that you shine a single LED at a time, detecting the amount of light shining back at the detector, and, based on the signature, you can measure blood oxygen level and heart rate.

Power Requirement

The MAX30100 chip requires two different supply voltages: 1.8V for the IC and 3.3V for the RED and IR LEDs. So the module comes with 3.3V and 1.8V regulators. This allows you to connect the module to any microcontroller with 5V, 3.3V, even 1.8V level I/O.

One of the most important features of the MAX30100 is its low power consumption: the MAX30100 consumes less than 600µA during measurement. Also, it is possible to put the MAX30100 in standby mode, where it consumes only 0.7µA. This low power consumption allows implementation in battery powered devices such as handsets, wearables or smart watches.

On-Chip Temperature Sensor
The MAX30100 has an on-chip temperature sensor that can be used to compensate for the changes in the environment and to calibrate the measurements.

This is a reasonably precise temperature sensor that measures the 'die temperature' in the range of -40˚C to +85˚C with an accuracy of ±1˚C.

I2C Interface: The module uses a simple two-wire I2C interface for communication with the microcontroller. It has a fixed I2C address: 0xAEHEX (for write operation) and 0xAFHEX (for read operation).

FIFO Buffer
The MAX30100 embeds a FIFO buffer for storing data samples. The FIFO has a 16-sample memory bank, which means it can hold up to 16 SpO2 and heart rate samples. The FIFO buffer can offload the microcontroller from reading each new data sample from the sensor, thereby saving system power

Interrupts:
The MAX30100 can be programmed to generate an interrupt, allowing the host microcontroller to perform other tasks while the data is collected by the sensor. The interrupt can be enabled for 5 different sources:

1. Power Ready: triggers on power-up or after a brownout condition.
2. SpO2 Data Ready: triggers after every SpO2 data sample is collected
3. Heart Rate Data Ready: triggers after every heart rate data sample is collected.
4. Temperature Ready: triggers when an internal die temperature conversion is finished.
5. FIFO Almost Full: triggers when the FIFO becomes full and future data is about to lost.

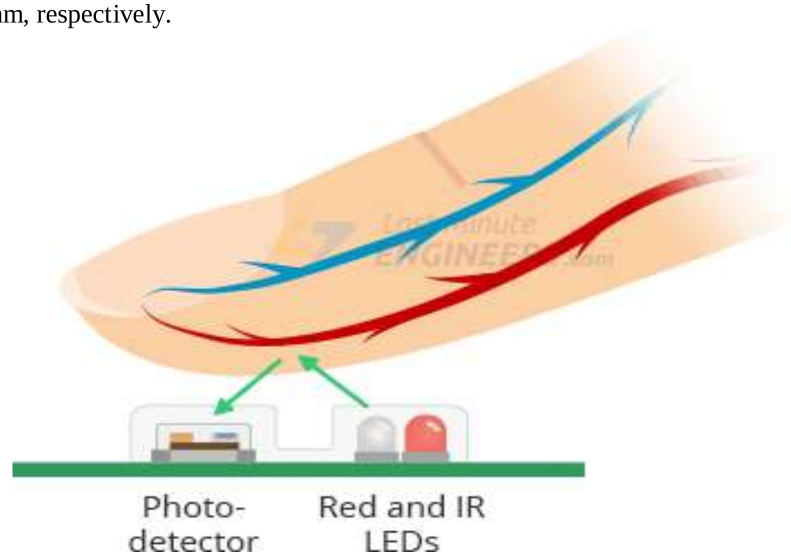
The INT line is an open-drain, so it is pulled HIGH by the onboard resistor. When an interrupt occurs the INT pin goes LOW and stays LOW until the interrupt is cleared.

Technical Specifications
Here are the technical specifications:

Power supply	3.3V to 5.5V
Current draw	~0.7µA (during standby mode
Red LED Wavelength	660nm

IR LED Wavelength	880nm
Temperature Range	-40˚C to +85˚C
Temperature Accuracy	±1˚C

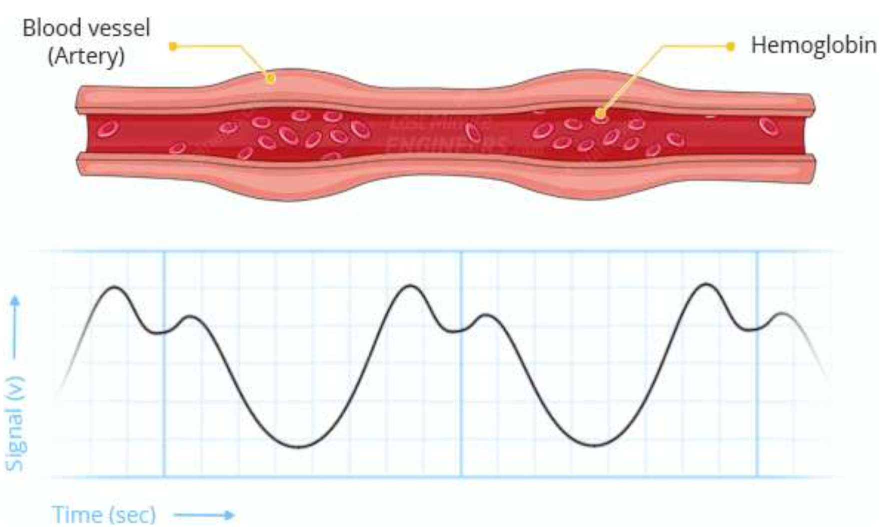
Working principle of MAX30100 Pulse Oximeter and Heart Rate Sensor :
The MAX30100, or any optical pulse oximeter and heart-rate sensor for that matter, consists of a pair of high-intensity LEDs (RED and IR, both of different wavelengths) and a photo detector. The wavelengths of these LEDs are 660nm and 880nm, respectively.



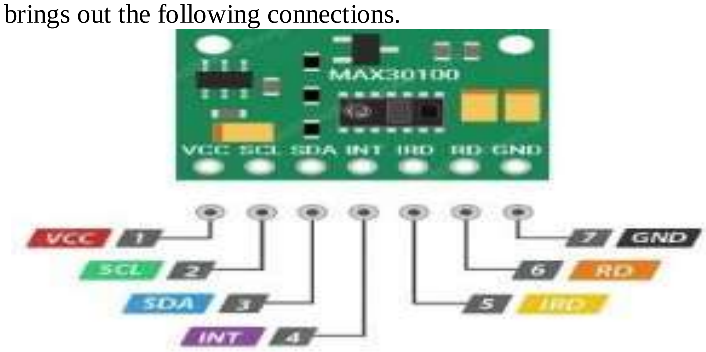
The MAX30100 works by shining both lights onto the finger or earlobe (or essentially anywhere where the skin isn't too thick, so both lights can easily penetrate the tissue) and measuring the amount of reflected light using a photo detector. This method of pulse detection through light is called Photoplethysmogram.

The working of MAX30100 can be divided into two parts: Heart Rate Measurement and Pulse Oximetry (measuring the oxygen level of the blood).

Heart Rate Measurement:
The oxygenated hemoglobin (HbO2) in the arterial blood has the characteristic of absorbing IR light. The redder the blood (the higher the hemoglobin), the more IR light is absorbed. As the blood is pumped through the finger with each heartbeat, the amount of reflected light changes, creating a changing waveform at the output of the photodetector. As you continue to shine light and take photo detector readings, you quickly start to get a heart-beat (HR) pulse reading.



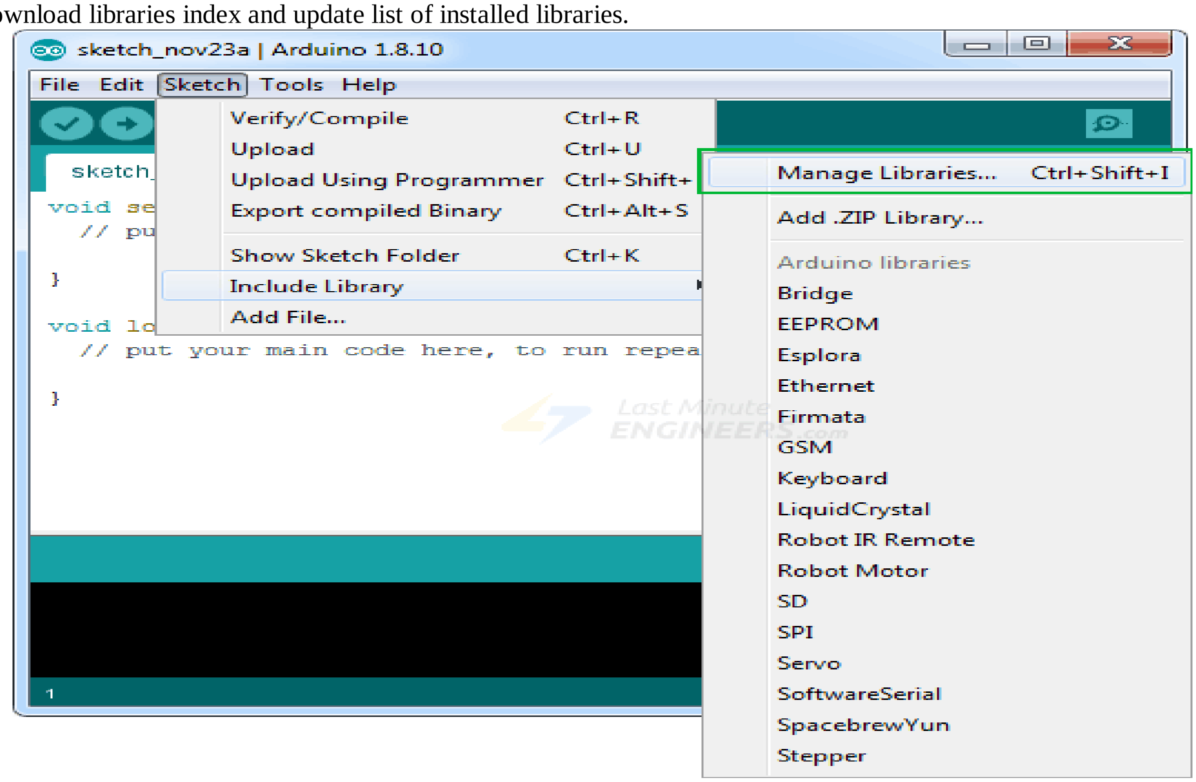
MAX30100 Module Pinout
The MAX30100 module brings out the following connections.

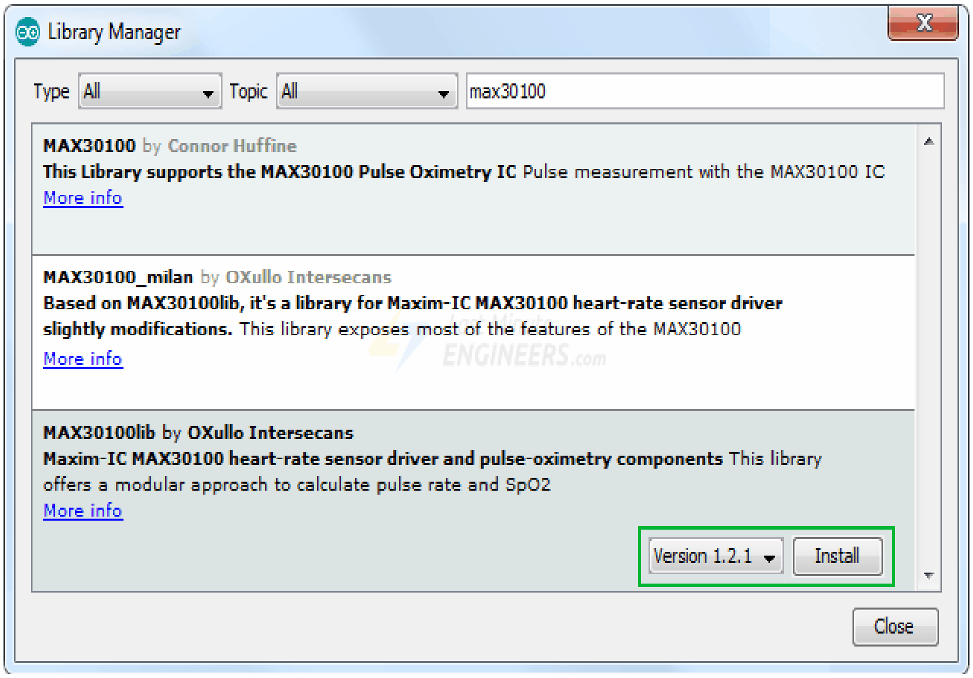


VIN is the power pin. You can connect it to 3.3V or 5V output from your Arduino.
SCL is the I2C clock pin, connect to your Arduino's I2C clock line.
SDA is the I2C data pin, connect to your Arduino's I2C data line.
INT The MAX30100 can be programmed to generate an interrupt for each pulse. This line is open-drain, so it is pulled HIGH by the onboard resistor. When an interrupt occurs the INT pin goes LOW and stays LOW until the interrupt is cleared.
IRD The MAX30100 integrates an LED driver to drive LED pulses for SpO2 and HR measurements. Use this if you want to drive the IR LED yourself, otherwise leave it unconnected.
RD pin is similar to the IRD pin, but is used to drive the Red LED. If you don't want to drive the red LED yourself, leave it unconnected.GND is the ground.

Library Installation:
There are several libraries available for the MAX30100 sensor. However, in our example, we are using the one by OXulloIntersecans. This library exposes most of the features of the MAX30100 and offers simple and easy to use functions to calculate pulse rate and SpO2. You can download this library from within the Arduino IDE Library Manager.

To install the library, navigate to the Sketch > Include Library > Manage Libraries… Wait for Library Manager to download libraries index and update list of installed libraries.



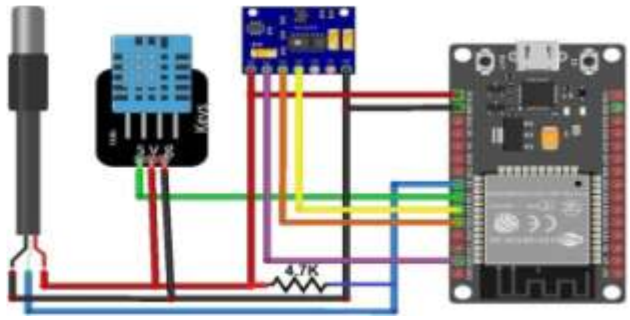


Filter your search by typing max30100. There should be a couple entries. Look for MAX30100lib Library by OXullo Inters cans. Click on the entry, and then select Install.

DS18B20 Temperature Sensor
DS18B20 is 1-Wire interface Temperature sensor manufactured by Dallas Semiconductor Corp. The unique 1-Wire Interface requires only one digital pin for two way communication with a microcontroller.The sensor comes usually in two form factors. One that comes in TO-92 package looks exactly like an ordinary transistor. Other one in a waterproof probe style which can be more useful when you need to measure something far away, underwater or under the ground.

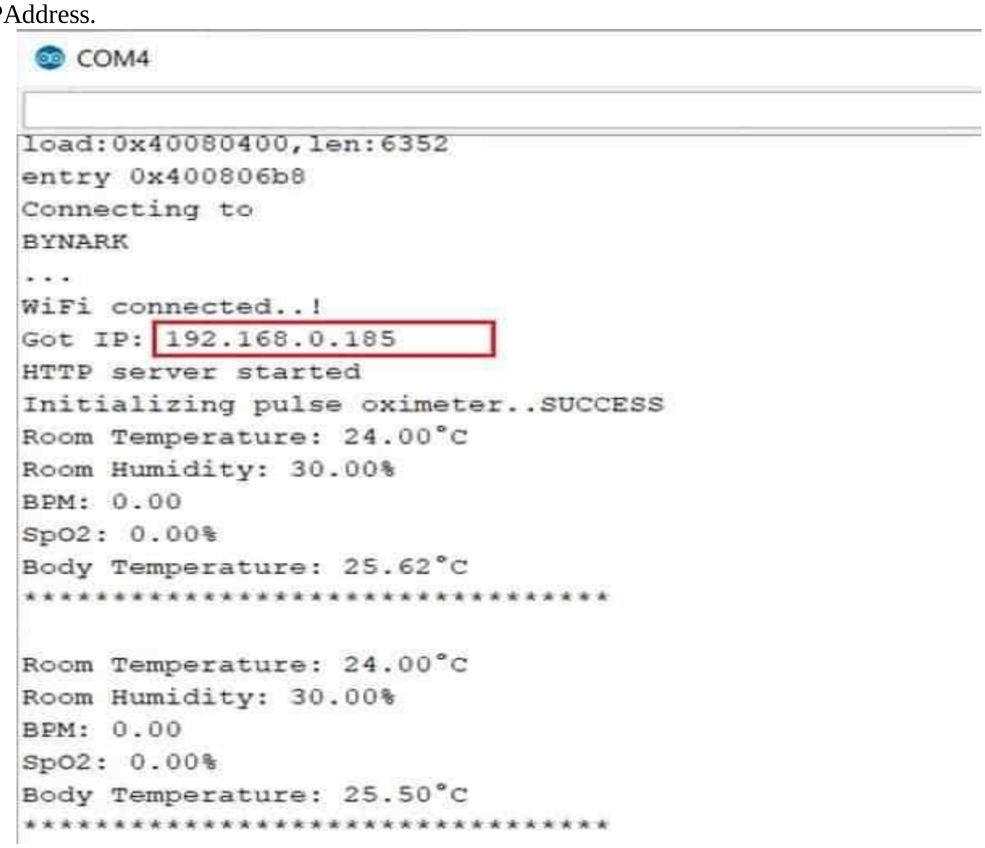
Types Of DS18B20 Temperature Sensor
DS18B20 temperature sensor is fairly precise and needs no external components to work. It can measure temperatures from -55°C to +125°C with ±0.5°C Accuracy.

Circuitdiagram:
IoT Based Patient Health Monitoring on ESP32 Web Server. Now let us begin with thedesigning of IoT Based Patient Health Monitoring on ESP32 Web Server. So the circuitdiagramforinterfacingMAX30100, DHT11 & DS18B20 withESP32 isgivenbelow.



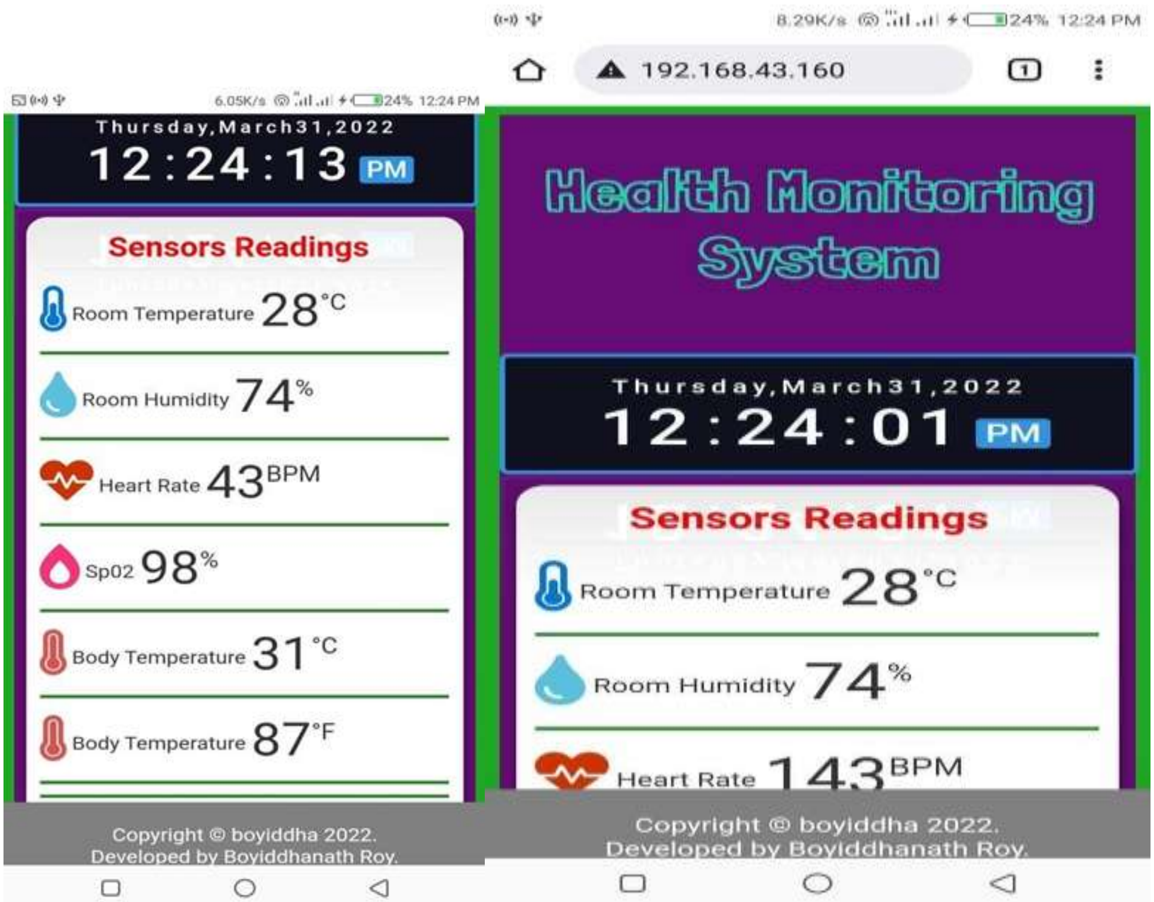
All the sensor can work at **3.3V VCC**. So connect their VCC to 3.3V Power Supply. ConnecttheGNDtoGND.MAX30100isanI2CSensor, soconnectitsSDA&SCLpinto**GPIO21** &**GPIO22**. Connect its INT pin to **GPIO19** of ESP32. The output pin of DHT11isconnectedto **GPIO18** ofESP32.Similarly, theoutputpinofDS18B20isconnectedto **GPIO5** of ESP32. A 4.7K pull-up resistor is connected between output pin & VCC pin ofDS18B20.

Results andworking oftheProject:
Oncethecodeisuploaded, youcanopentheserialmonitor. TheESP32willtryto connecttoanetwork. Onceconnected, it will displaytheIPAddress.

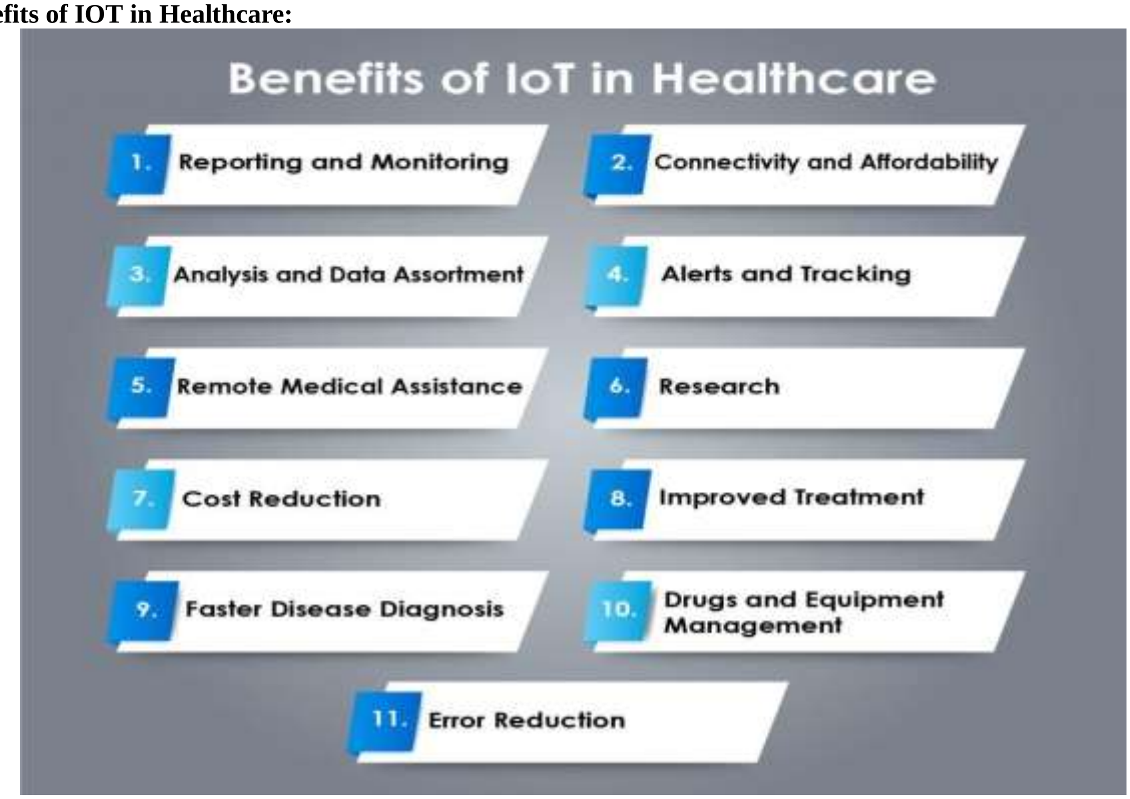


CopytheIPAddressandpasteitonanyoftheWebBrowserandhitenter.Youwill seetheroomtemperature, roomhumidity,HeartRate,BloodOxygenLevel,BodyTemperature,etc.

SimilarlyyoucanalsoviewthePatientHealthStatusonMobilePhone.SimplecopytheIPAddressand paste on thebrowserofMobile Phone.



Benefits of IOT in Healthcare:



Conclusion:-

The Internet of Things is considered now as one of the feasible solutions for any remote valuetrackingespeciallyinthefieldof healthmonitoring. Itfacilitatesthattheindividualprosperity parameter data is secured inside the cloud, stays in the hospital are reduced forconventional routine examinations and most important that the health can be monitored anddisease diagnosed by any doctor at any distance. In this paper, an IoTbased health monitoringsystemwasdeveloped.Thesystem monitoredbodytemperature,pulserateandroomhumidity andtemperature using sensors, which are also displayed on mobile .These sensorvalues are then sent to a medical server usingwireless communication. These data are thenreceived in anauthorized personals smart phone with IoT platform. With thevalues receivedthedoctor then diagnosethe diseaseand thestateof health of thepatient.

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