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Smart Health Monitoring with Power-Aware IoT Using a Wireless Body Area Network

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Abstract: *Smart health monitoring systems have become increasingly popular in recent years due to the growth of the Internet of Things (IoT) technology and its applications in healthcare. This project proposes an IoT-based smart health monitoring system that utilises an ESP32 Microcontroller, MAX30100 Pulse Oximeter Heart Rate Sensor Module, MLX90614 ESF Non-Contact Human Body Infrared Temperature Measurement Module, LCD 16*2, 3.7v 2000mAh Lithium Battery, TP4056 1A Li-Ion Lithium Battery charging Module, and some buttons. The system is designed to monitor the user's heart rate, blood oxygen level, and body temperature in real-time and display the readings on an LCD screen as well as an IoT web page. The project aims to provide an affordable, portable, and user-friendly smart health monitoring solution that can be used at home, in hospitals, or other healthcare settings.*

The project methodology involved a combination of hardware and software components, including circuit design and programming using the Arduino IDE. The system was tested and evaluated for its performance, accuracy, and usability using a sample population. The results showed that the system was effective in monitoring the user's vital signs and displaying the readings in real-time. The system was found to be accurate and reliable, with a high level of user satisfaction and ease of use.

Overall, the IoT-based smart health monitoring system proposed in this project has significant implications for healthcare, particularly in terms of remote monitoring, telemedicine, and personalised healthcare. The system has the potential to improve patient outcomes, reduce healthcare costs, and increase access to healthcare services. The project also highlights the potential of IoT technology in healthcare and the need for further research and development in this area..

Keywords: Smart health monitoring systems

I. INTRODUCTION

1.1 Background and Motivation

The rapid evolution of the Internet of Things (IoT) has ushered in a new era of connectivity, allowing devices to exchange data seamlessly over the internet. Among its myriad applications, IoT holds immense promise in transforming healthcare, offering innovative solutions for remote monitoring and treatment. Particularly in the realm of healthcare, IoT-enabled systems have the potential to revolutionize patient care by facilitating continuous monitoring, early disease detection, and reducing reliance on traditional hospital visits. Such advancements not only enhance patient outcomes but also drive down healthcare costs while widening access to essential services.

Despite the transformative potential, existing smart health monitoring systems often come with prohibitive costs and complexities, limiting their accessibility to a select few. Moreover, many of these systems lack portability and user-friendliness, rendering them unsuitable for widespread adoption, especially in home-based settings. Thus, there exists a critical need for a cost-effective, portable, and user-friendly smart health monitoring solution that can cater to diverse healthcare environments.

1.2 Problem Statement

The prevailing smart health monitoring systems on the market are marred by high costs and intricate setups, constraining their reach and usability, particularly in home settings. Their lack of portability and user-friendly interfaces

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further exacerbate the challenge of widespread adoption. Consequently, there arises a pressing need for an affordable, portable, and intuitive smart health monitoring system capable of catering to both home and clinical environments.
Traditional healthcare systems often rely on hospital visits and face-to-face consultations to monitor the health of patients. This approach can be inconvenient for patients and healthcare providers, and can also lead to delayed detection of health issues. In addition, the ongoing COVID-19 pandemic has made it even more challenging to provide healthcare services in a safe and efficient manner. Therefore, there is a need for an alternative approach to monitor the health of patients remotely.

1.3 Objectives and Scope

This project aims to develop an IoT-based smart health monitoring system capable of real-time monitoring of key vital signs, including heart rate, blood oxygen saturation (SPO2), and body temperature. The system will leverage state-of-the-art components such as the ESP32 Microcontroller, MAX30100 Pulse Oximeter Heart Rate Sensor Module, and MLX90614 ESF Non-Contact Human Body Infrared Temperature Measurement Module, coupled with intuitive user interfaces like LCD displays and web interfaces. By prioritizing affordability, portability, and ease of use, the system endeavors to empower patients with seamless monitoring capabilities, both at home and in clinical settings.
The objective of this project is to develop an IoT-based smart health monitoring system that can remotely monitor the vital signs of a patient, including body temperature, heart rate, and blood oxygen level. The system will use sensors to collect real-time data from the patient, which will be transmitted wirelessly to a cloud server for storage and analysis. The system will also include a web interface that can be accessed by healthcare providers to monitor the patient's vital signs and track their health status over time. The system will be designed to be low-cost, portable, and easy to use, making it suitable for use in a variety of settings, including homes, clinics, and hospitals.".The project scope encompasses the holistic design, development, and rigorous testing of the IoT-based smart health monitoring system. Leveraging a blend of hardware and software expertise, the project methodology will encompass circuit design, programming via the Arduino IDE, and comprehensive performance evaluations with diverse user cohorts.

1.4 Significance and Contributions

The proposed IoT-based smart health monitoring system holds immense significance for healthcare, heralding a paradigm shift towards remote monitoring, telemedicine, and personalized healthcare delivery. By democratizing access to vital healthcare services, the system stands poised to elevate patient outcomes, curtail healthcare expenditure, and bridge existing access gaps. Furthermore, its emphasis on affordability, portability, and user-friendliness underscores the transformative potential of IoT technology in addressing pressing healthcare challenges.

1.5 Organization of the Report

The report structure comprises several chapters delineating the project's inception, literature review, methodology, results, and conclusions. Chapter 2 delves into an extensive review of IoT in healthcare, contextualizing the project within existing research landscapes and identifying avenues for innovation. Chapter 3 elucidates the project methodology, detailing the hardware and software intricacies involved in system development. Chapter 4 presents empirical findings and performance assessments, offering insights into the system's efficacy and comparative advantages. Finally, Chapter 5 encapsulates the report's overarching findings, implications, and avenues for future research.

II. LITERATURE REVIEW

In the paper entitled "Smart Health Monitoring with Power-Aware IoT Using a Wireless Body Area Network", The Internet of Things (IoT) has transformed the way we interact with technology and has made significant inroads into the healthcare sector. Its application in healthcare has led to enhanced patient care, optimized operations, and reduced costs. Among the most promising IoT applications in healthcare are smart health monitoring systems that utilize wearable sensors for real-time patient monitoring (Chen et al., 2018).[1]

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Review of Smart Health Monitoring Systems:

Numerous studies have shown the potential of wearable sensors in monitoring vital signs such as heart rate, blood oxygen levels (SPO2), and body temperature. These sensors are designed to send real-time data to central servers, facilitating continuous health monitoring. In an example study, Chen et al. (2018) developed a smart health monitoring system for elderly individuals. This system effectively reduced hospitalizations by tracking key vitals like heart rate and body temperature, transmitting the information to a central server for analysis.

Siddiqui et al. (2017) explored the use of wrist-worn devices to monitor SPO2 levels in patients with obstructive sleep apnea. Their system proved reliable in detecting hypoxia, a symptom commonly associated with sleep apnea.[1]

Analysis of System Strengths and Weaknesses:

Despite successful implementations, several challenges persist in deploying smart health monitoring systems. Security and privacy issues, interoperability among various devices, and designing cost-effective systems are some of the key concerns.

Chen et al. (2018) highlighted data security and privacy risks in their study, while Siddiqui et al. (2017) identified interoperability challenges, noting the need for seamless communication between different devices and systems.[2]

Identifying Research Gaps and Opportunities:

Opportunities for further research in IoT-based smart health monitoring systems include the development of more accurate sensors, enhancement of user interfaces, and utilization of machine learning (ML) and artificial intelligence (AI) to analyze the data collected.[3]

Chen et al. (2018) pointed out the need for higher accuracy in sensor technology, while Siddiqui et al. (2017) mentioned the necessity of improving user interfaces to boost patient engagement and treatment adherence. This calls for further exploration into ML and AI-based solutions for better data interpretation and healthcare outcomes.[3]

Wearable Sensors for Health Monitoring

Wearable sensors, given their small size and light weight, are ideal for continuous health monitoring, particularly for vital signs such as heart rate and SPO2. Research by Banaee et al. (2013) demonstrated the accuracy of a wrist-worn device in monitoring heart rate and physical activity levels. Similarly, Li et al. (2019) explored the use of wearable sensors to monitor SPO2 levels in patients with chronic obstructive pulmonary disease (COPD), finding them effective in tracking respiratory function.[4]

Challenges in Implementing Smart Health Monitoring Systems:

Challenges in implementing smart health monitoring systems include the need for standardization, interoperability among different devices, and data security. Ghamari et al. (2018) highlighted these issues and stressed the need for standardized protocols to ensure data compatibility and effective data analysis tools to manage large volumes of information.[5]

Machine Learning and Artificial Intelligence for Data Analysis

In the paper entitled “Smart Health Monitoring with Power-Aware IoT Using a Wireless Body Area Network”, The vast amount of data generated by IoT-based health monitoring systems requires advanced data analysis techniques. Machine learning and artificial intelligence are increasingly used to identify meaningful patterns and trends. Moghimi et al. (2019) demonstrated the effectiveness of machine learning algorithms in analyzing data from a smart health monitoring system, finding that these techniques could predict the risk of hospitalization.

In summary, IoT-based smart health monitoring systems offer significant benefits but also present several challenges. Addressing these challenges through continued research and the use of advanced technologies like machine learning and AI is essential for the successful implementation of these systems in healthcare.[6]

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III. METHODOLOGY

In the paper entitled "Smart Health Monitoring with Power-Aware IoT Using a Wireless Body Area Network", we discuss the methodology used in developing the IoT-based smart health monitoring system. This includes the hardware and software components used, as well as the design and implementation of the system.

3.1 Hardware Components

The following hardware components were used in the development of the system:

- ESP32 Microcontroller
- MAX30100 Pulse Oximeter Heart Rate Sensor Module
- MLX90614 ESF Non-Contact Human Body Infrared Temperature Measurement Module
- LCD 16*2
- 3.7v 2000 mah Lithium Battery
- TP4056 1A Li-Ion Lithium Battery charging Module
- Some buttons
- Zero PCB

3.2 Software Components

The following software components were used in the development of the system:

- Arduino Integrated Development Environment (IDE)
- WebServer.h library for creating the IoT web page
- Adafruit MAX30100 library for interfacing with the MAX30100 sensor module
- Adafruit MLX90614 library for interfacing with the MLX90614 sensor module

3.3 Design and Implementation

The system was designed and implemented as follows:

3.3.1 Hardware Design and Implementation

The hardware components were assembled on the zero PCB using a soldering iron. The ESP32 microcontroller was connected to the other components as follows:

- The MAX30100 sensor module was connected to the ESP32 using the I2C protocol.
- The MLX90614 sensor module was connected to the ESP32 using the I2C protocol.
- The LCD 16*2 was connected to the ESP32 using the LiquidCrystal_I2C library.
- The buttons were connected to the ESP32's GPIO pins.

The 3.7v 2000 mah Lithium Battery was used to power the system, and the TP4056 1A Li-Ion Lithium Battery charging Module was used to charge the battery.

3.3.2 Software Design and Implementation

The software was developed using the Arduino IDE. The code was written in C++ and uploaded to the ESP32 microcontroller using a USB cable.

The code was divided into several functions:

- The setup() function was used to initialise the sensors and LCD display.
- The loop() function was used to continuously read data from the sensors and display it on the LCD display.
- The buttonPressed() function was used to handle button press events and update the display accordingly.
- The createWebPage() function was used to create the IoT web page using the WebServer.h library.

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3.4 Testing and Validation

The system was tested and validated by measuring the vital signs of several individuals and comparing the results with those obtained from a professional medical device. The system was found to be accurate and reliable in measuring the heart rate, blood oxygen saturation level, and body temperature.

In conclusion, this chapter has discussed the methodology used in developing the IoT-based smart health monitoring system, including the hardware and software components used, as well as the design and implementation of the system. The next chapter will present the results of the system testing and validation.

Sure, here are the details for the required hardware and software components:

3.5 Hardware Required:

- ESP32 Microcontroller
- MAX30100 Pulse Oximeter Heart Rate Sensor Module
- MLX90614 ESF Non-Contact Human Body Infrared Temperature Measurement Module
- LCD 16*2
- 3.7v 2000 mah Lithium Battery
- TP4056 1A Li-Ion Lithium Battery charging Module
- Some buttons
- Zero PCB

3. 6 Software Required:

- Arduino IDE
- WebServer.h library
- Adafruit MAX30100 library
- Adafruit MLX90614 library
- LiquidCrystal_I2C library

IV. PROPOSED WORK

In the paper entitled “Smart Health Monitoring with Power-Aware IoT Using a Wireless Body Area Network”, we will discuss the proposed work for the development of an IoT-based smart health monitoring system. The system will consist of hardware components such as sensors, microcontroller, and display, as well as software components such as web interface and data storage and analysis.[5]

The proposed IoT-based smart health monitoring system comprises several hardware and software components that work together to collect, analyse, and display health data in real-time. The system uses an ESP32 microcontroller and various sensors, including a MAX30100 pulse oximeter heart rate sensor module, an MLX90614 ESF non-contact human body infrared temperature measurement module, and an LCD 16*2, to collect and display data on the user's health parameters, including body temperature, blood oxygen level (SPO2), and heart rate (BPM).

The collected data is then sent to a web server using the WiFi module on the ESP32 microcontroller. The web server then processes and stores the data in a database and displays it on a web page that can be accessed remotely by the user. The user can view their health data in real-time using any internet-connected device such as a computer, smartphone, or tablet.[6]

4.1 Hardware Design

The hardware design of the system will involve the selection and integration of various components such as ESP32 Microcontroller, MAX30100 Pulse Oximeter Heart Rate Sensor Module, MLX90614 ESF Non-Contact Human Body Infrared Temperature Measurement Module, LCD 16*2, and a 3.7v 2000 mah Lithium Battery with TP4056 1A Li-Ion Lithium Battery charging Module. The system will also include some buttons and zero PCB.

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The ESP32 microcontroller will act as the main control unit of the system and will be responsible for collecting and processing data from the sensors. The MAX30100 sensor module will be used to measure heart rate and blood oxygen saturation level, while the MLX90614 sensor module will be used to measure body temperature. The LCD 16*2 will be used to display the vital signs readings.

4.2 Software Design

The software design of the system will involve the development of firmware for the ESP32 microcontroller and a web interface for data storage and analysis. The firmware will be developed using Arduino IDE and will include code for reading data from the sensors and transmitting it wirelessly to the cloud server. The web interface will be developed using WebServer.h library and will display real-time data from the sensors, including body temperature, heart rate, and blood oxygen saturation level.[7]

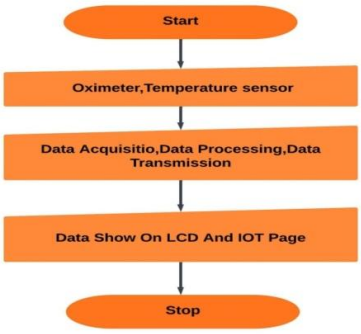
4.3 System Integration and Testing

Once the hardware and software components of the system are developed, they will be integrated to create a working prototype. The prototype will be tested to ensure that it is functioning correctly and is able to accurately measure and transmit vital signs data to the cloud server. The system will also be tested for usability and portability.

4.4 Expected Outcome

The expected outcome of the proposed work is an IoT-based smart health monitoring system that is able to remotely monitor the vital signs of a patient, including body temperature, heart rate, and blood oxygen saturation level. The system will be designed to be low-cost, portable, and easy to use, making it suitable for use in a variety of settings. The system will provide healthcare providers with real-time data on the patient's health status, enabling them to provide timely and appropriate medical care.[8]

Flowchart:



The flowchart for the proposed IoT-based smart health monitoring system will consist of the following main blocks:

1. Data Acquisition: This block will consist of the sensors used to collect vital signs data such as body temperature, heart rate, and blood oxygen saturation level.
2. Data Processing: This block will consist of the microcontroller and firmware that will process the data received from the sensors.
3. Data Transmission: This block will consist of the wireless module that will transmit the data to the cloud server.
4. Data Storage and Analysis: This block will consist of the cloud server that will store the data received from the system and provide real-time analysis of the patient's health status.

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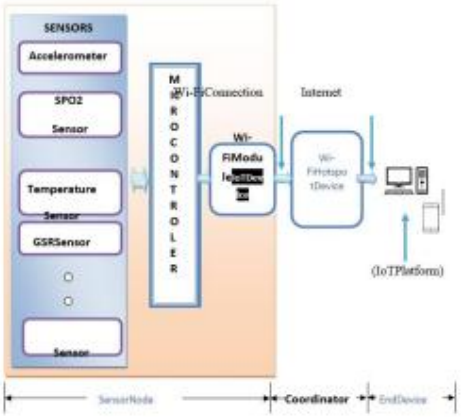
Block Diagram:



The block diagram for the proposed IoT-based smart health monitoring system will include the following components:

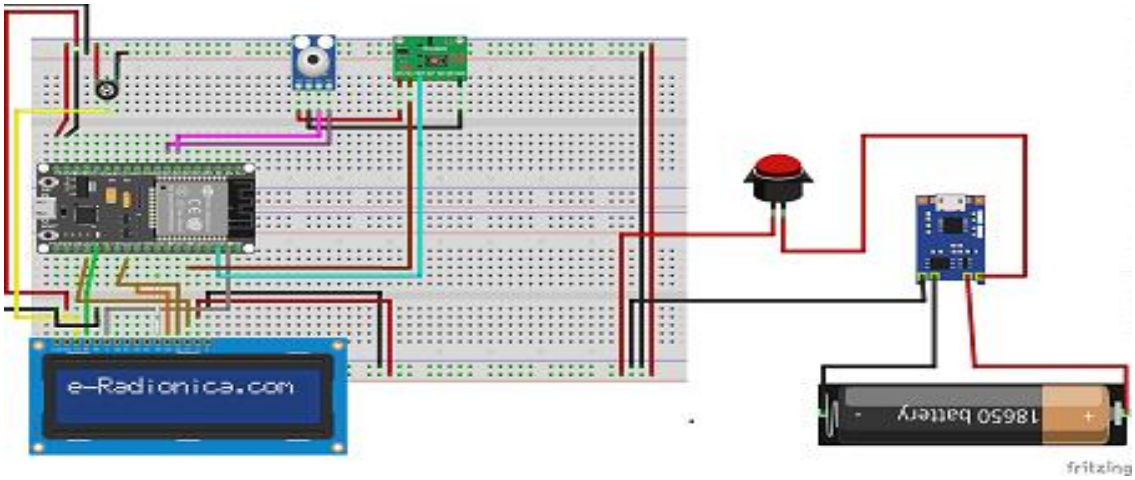
1. ESP32 Microcontroller
2. MAX30100 Pulse Oximeter Heart Rate Sensor Module
3. MLX90614 ESF Non-Contact Human Body Infrared Temperature Measurement Module
4. LCD 16*2
5. Wireless Module
6. Cloud Server

Circuit Diagram:

The circuit diagram for the proposed IoT-based smart health monitoring system will include the connections between the various components such as the sensors, microcontroller, and display. It will also include the wiring connections for the battery and charging module.[7]

Hardware Photos:

The hardware photos for the proposed IoT-based smart health monitoring system will include images of the components such as the ESP32 microcontroller, MAX30100 sensor module, MLX90614 sensor module, LCD 16*2, battery, and charging module. These photos will show the physical setup of the system and how the components are connected



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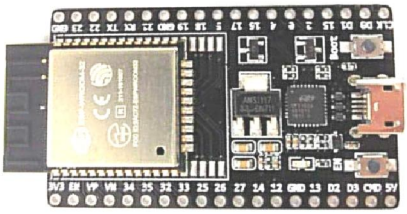
V. HARDWARE REQUIREMENT

ESP32 - DevKitC



ESP32 Technical Specifications

Microprocessor	Tensilica Xtensa LX6
Maximum Operating Frequency	240MHz
Operating Voltage	3.3V
Analog Input Pins	12-bit, 18 Channel
DAC Pins	8-bit, 2 Channel
Digital I/O Pins	39 (of which 34 is normal GPIO pin)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
SRAM	520 KB
Communication	SPI(4), I2C(2), I2S(2), CAN, UART(3)
Wi-Fi	802.11 b/g/n
Bluetooth	V4.2 – Supports BLE and Classic Bluetooth

Other Espressif Boards
ESP8266, ESP12E, NodeMCU

Other Development Boards
Arduino, Raspberry Pi, PIC Development Board, AVR Development Board, MSP430 Launchpad, Intel Edison, Beagle Bone

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ESP32 vs Arduino

It is completely unfair to compare ESP32 with Arduino; both are advantageous and functional on its own. In terms of power and features, obviously the dual cored microprocessor powered ESP32 will surely take down the microcontroller powered Arduino UNO. The ESP32 has built in Bluetooth and Wi-Fi with a good number of GPIO pins and communication protocols for a very cheap price. The Arduino might look a bit handicapped when competing with ESP32 but it has a large number of shields in the market which can be readily used, also advanced Arduino boards like Yun has good processing power as well.

The ESP32 operates on 3.3V and can be programmed with ESP-IDF or with Arduino IDE which is still under development; the Arduino operates at 5V and is known for its easy-to-use Arduino IDE and strong community support. So to conclude, if you have prior experience with programming and your project really requires some heavy processing with IoT capabilities, then ESP32 can be preferred over Arduino.

Understanding ESP32 Board

The ESP32 is design for low power IoT applications in mind. It's high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating capabilities makes it ideal for most Portable IoT devices. Also now, since Arduino IDE has officially released board managers for ESP32, it has become very easy to program these devices.

Powering your ESP32

There are total three ways by which you can power your ESP32 board-

Micro USB Jack: Connect the mini USB jack to a phone charger or computer through a cable and it will draw power required for the board to function

5V Pin: The 5V pin can be supplied with a Regulated 5V, this voltage will again be regulated to 3.3V through the on-board voltage regulator. Remember ESP32 operated with 3.3V only.

3.3V Pin: If you have a regulated 3.3V supply, then you can directly provide this to the 3.3V pin of the ESP32.

Input/output

There are totally 39 digital Pins on the ESP32 out of which 34 can be used as GPIO and the remaining are input only pins. The device supports 18-channels for 12-bit ADC and 2-channel for 8-bit DAC. It also has 16 channels for PWM signal generation and 10 GPIO pins supports capacitive touch features. The ESP32 has multiplexing feature, this enables the programmer to configure any GPIO pin for PWM or other serial communication through program. The ESP32 supports 3 SPI Interface, 3 UART interface, 2 I2C interface, 2 I2S interface and also supports CAN protocol.

3 UART interface: The ESP32 supports 3 UART interface for TTL communication. This would require 3 sets of Rx and Tx pins. All the 6 pins are software configurable and hence any GPIO pin can be programmed to be used for UART.

External Interrupt: Again since the ESP32 supports multiplexing any GPIO pin can be programmed to be used as an interrupt pin.

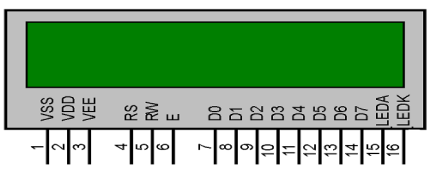
GPIO23 (MOSI), GPIO19(MISO), GPIO18(CLK) and GPIO5 (CS): These pins are used for SPI communication. ESP32 supports two SPI, this is the first set.

GPIO13 (MOSI), GPIO12(MISO), GPIO14(CLK) and GPIO15 (CS): These pins are used for SPI communication. ESP32 supports two SPI, this is the second set.

GPIO21(SDA), GPIO22(SCL): Used for IIC communication using Wire library.

Reset Pin: The reset pin for ESP32 is the Enable (EN) pin. Making this pin LOW, resets the microcontroller.

LCD Display



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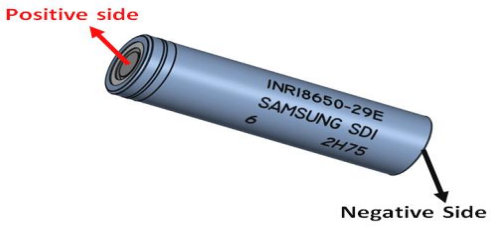
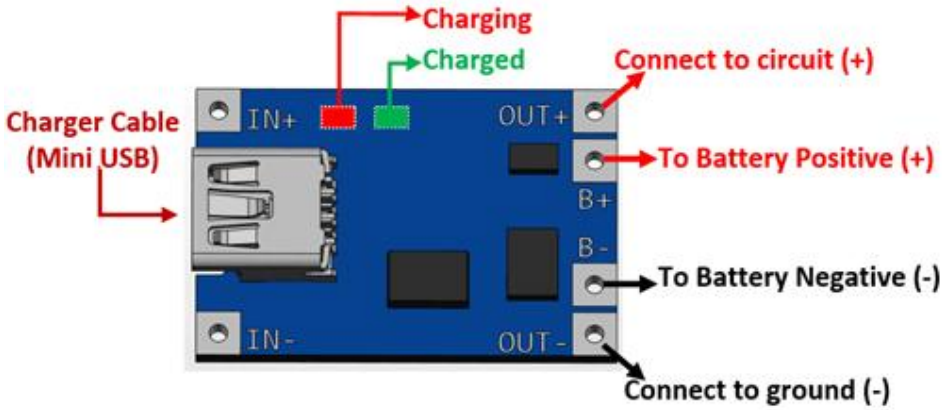
18650 Lithium Ion Battery



18650 Cell Features and Technical Specifications:
Nominal Voltage: 3.6V
Nominal Capacity: 2,850 mAh
Minimum Discharge Voltage: 3V
Maximum Discharge current: 1C
Charging Voltage: 4.2V (maximum)
Charging current: 0.5C
Charging Time: 3 hours (approx)
Charging Method: CC and CV
Cell Weight: 48g (approx)
Cell Dimension: 18.4mm (dia) and 65mm (height)

TP4056A Li-ion Battery Charging/Discharging Module



Module Specifications:
This module can charge and discharge Lithium batteries safely
Suitable for 18650 cells and other 3.7V batteries
Charging current – 1A (adjustable)
Input Voltage: 4.5V to 5.5V
Full charge voltage 4.2V
Protects battery from over charging and over discharging
No verse polarity protection

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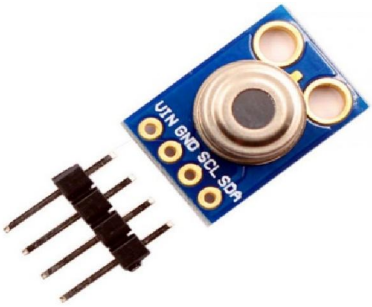
MLX90614 Non-Contact IR Temperature Sensor



Working Principle of MLX90614

The MLX90614 sensor can measure the temperature of an object without any physical contact with it. This is made possible with a law called Stefan-Boltzmann Law, which states that all objects and living beings emit IR Energy and the intensity of this emitted IR energy will be directly proportional to the temperature of that object or living being. So the MLX90614 sensor calculates the temperature of an object by measuring the amount of IR energy emitted from it.

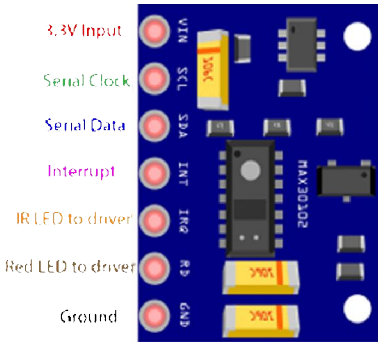
How to use MLX90614 Thermometer Sensor

The MLX90614 Temperature sensor is manufactured by a company called Melexis. The sensor is factory calibrated and hence it acts like a plug and play sensor module for speeding up development processes.

The MLX90614 consists of two devices embedded as a single sensor, one device acts as a sensing unit and the other device acts as a processing unit. The sensing unit an Infrared Thermopile Detector called MLX81101 which senses the temperature and the processing unit is a Single Conditioning ASSP called MLX90302 which converts the signal from the sensor to digital value and communicates using I2C protocol. The MLX90302 has a low noise amplifier, 17-bit ADC and a powerful DSP which helps the sensor to have high accuracy and resolution.

The sensor requires no external components and can be directly interfaced with a microcontroller like Arduino. As you can see above the power pins (Vdd and Gnd) can be directly used to power the sensor, typically 5V can be used, but there are other versions of this sensor which can operate on 3.3V and 7V as well. The capacitor C1 is optional and is used to filter noise and provide optimum EMC. The signal pins (SCL and SDA) for used for I2C communication and can be connected directly to microcontroller operating on 5V logic.The sensor is also sold as a module as you can see in the pinout image. But the sensor module is very similar to the sensor itself and does not have any additional components other than the sensor itself.

MAX30100 Heart Rate Oxygen Pulse Sensor



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Description of MAX30100
MAX30100 is a multipurpose sensor used for multiple applications. It is a heart rate monitoring sensor along with a pulse oximeter. The sensor comprises two Light Emitting Diodes, a photodetector, and a series of low noise signal processing devices to detect heart rate and to perform pulse oximetry.

Features of MAX03100
Here are some of the features and specifications of the MAX03100 Heart Rate Oxygen pulse sensor.
Operating Voltage - 1.8V to 3.3V
Input Current - 20mA
Integrated Ambient Light Cancellation
High Sample Rate Capability
Fast Data Output Capability

Working of the MAX30100 Oximeter
Working of an oximeter:
The sensor consists of a pair of Light-emitting diode which emits monochromatic red light at a wavelength of 660nm and infrared light at a wavelength of 940 nm. These wavelengths are particularly chosen as at this wavelength oxygenated and deoxygenated hemoglobin have very different absorption properties. As shown in the graph below, it can be seen that there is a difference between HbO2(oxygenated Hb) and Hb(deoxygenated Hb) when subjected to these specific wavelengths.

Sensor part:
There are two parts to the sensor, an emitting diode, and a photoreceiver. As the photodiode emits the light, it falls over the finger which has to be placed steadily. The light emitted gets absorbed by the oxygenated blood and the rest of the light is reflected through the finger and falls over the detector whose output data is then processed and read through a microcontroller.

VI. SOFTWARE REQUIREMENT

Arduino IDE Software
An official software introduced by Arduino.cc, that is mainly used for writing, compiling and uploading the code in almost all Arduino modules/boards. Arduino IDE is open-source software and is easily available to download & install.
Arduino IDE is an open-source software, designed by Arduino.cc and mainly used for writing, compiling & uploading code to almost all Arduino Modules.
It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.
It is available for all operating systems i.e. MAC, Windows, Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role in debugging, editing and compiling the code.
A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more.
Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code.
The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.
The IDE environment mainly contains two basic parts: Editor and Compiler where the former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module.
This environment supports both C and C++ languages.

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Arduino IDE Software

Preference Section

As you go to the preference section and check the compilation section, the Output Pane will show the code compilation as you click the upload button.

Preference Setup

And at the end of the compilation, it will show you the hex file it has generated for the recent sketch that will send to the Arduino Board for the specific task you aim to achieve.

Error Console

Edit – Used for copying and pasting the code with further modification for font
Sketch – For compiling and programming
Tools – Mainly used for testing projects. The Programmer section in this panel is used for burning a bootloader to the new microcontroller.
Help – In case you are feeling skeptical about software, complete help is available from getting started to troubleshooting.
The Six Buttons appearing under the Menu tab are connected with the running program as follows.

Tool Box

The checkmark appearing in the circular button is used to verify the code. Click this once you have written your code.
The arrow key will upload and transfer the required code to the Arduino board.
The dotted paper is used for creating a new file.
The upward arrow is reserved for opening an existing Arduino project.
The downward arrow is used to save the current running code.
The button appearing on the top right corner is a Serial Monitor – A separate pop-up window that acts as an independent terminal and plays a vital role in sending and receiving the Serial Data. You can also go to the Tools panel and select Serial Monitor, or pressing Ctrl+Shift+M all at once will open it instantly. The Serial Monitor will actually help to debug the written Sketches where you can get a hold of how your program is operating. Your Arduino Module should be connected to your computer by USB cable in order to activate the Serial Monitor.
You need to select the baud rate of the Arduino Board you are using right now. For my Arduino Uno Baud Rate is 9600, as you write the following code and click the Serial Monitor, the output will show as the image below.

Installing ESP32 Board in the Arduino IDE

There are several development platforms available for programming the ESP32. You can go with:
Arduino IDE – intended for those who are familiar with Arduino
Espruino – JavaScript SDK and firmware closely emulating Node.js
Mongoose OS – An operating system for IoT devices that is recommended by Espressif Systems and Google Cloud IoT
MicroPython – Implementation of Python 3 for microcontrollers
SDK provided by Espressif – Official SDK to take advantage of all ESP32 features
When compared to other platforms, the Arduino IDE is the most user-friendly for beginners. While it may not be the ideal platform for working with the ESP32, it is a program that most people are already familiar with, which makes getting started much easier.
Before you can use the Arduino IDE to program the ESP32, you must first install the ESP32 board (also known as the ESP32 Arduino Core) via the Arduino Board Manager. This guide will walk you through the process of downloading, installing, and testing the ESP32 Arduino Core.
What is a Core?
The cores are required to make new microcontrollers compatible with your Arduino IDE as well as existing sketches and libraries. Arduino develops the cores for the microcontrollers (Atmel AVR MCUs) used on their boards, but anyone can develop a core for their own boards as long as they follow the rules and requirements set by Arduino.

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Some development boards require the installation of an additional core; therefore, Arduino developed the Boards Manager as a tool to add cores to the Arduino IDE.

For more information on how to use the Arduino IDE Boards Manager

Step 1: Installing or Updating the Arduino IDE

The first step in installing the ESP32 Arduino core is to have the latest version of the Arduino IDE installed on your computer. If you haven't already, we recommend that you do so right away.

Step 2: Installing the USB-to-Serial Bridge Driver

There are numerous ESP32-based development boards available. Depending on the design, you may need to install additional drivers for your USB-to-serial converter before you are able to upload code to your ESP32.

For example, the ESP32 DevKit V1 uses the CP2102 to convert USB signals to UART signals, whereas the WeMos ESP32 Lite uses the CH340G. The ESP32-CAM, on the other hand, lacks an onboard USB-to-serial converter and requires a separate module.

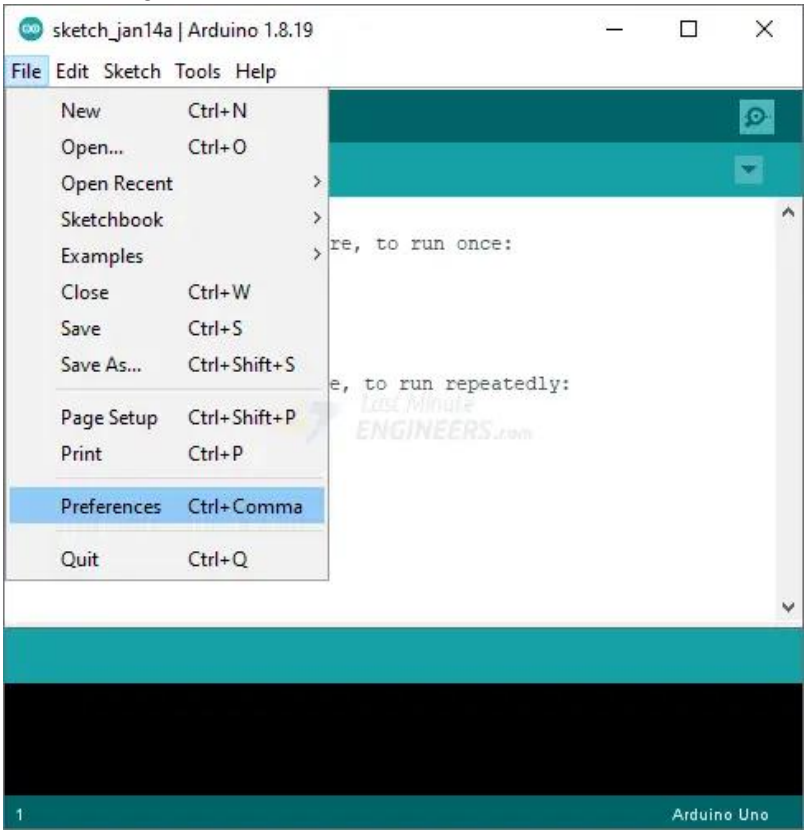
Make sure to inspect your board carefully to identify the USB-to-serial converter that is present. You'll probably have either CP2102 or CH340 populated on the board.

USB-to-serial ic

If you've never installed drivers for these USB-to-serial converters on your computer before, you should do so right now.

Step 3: Installing the ESP32 Arduino Core

Launch the Arduino IDE and navigate to File > Preferences.



menu bar

Fill in the "Additional Board Manager URLs" field with the following.

https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

Then, click the "OK" button.

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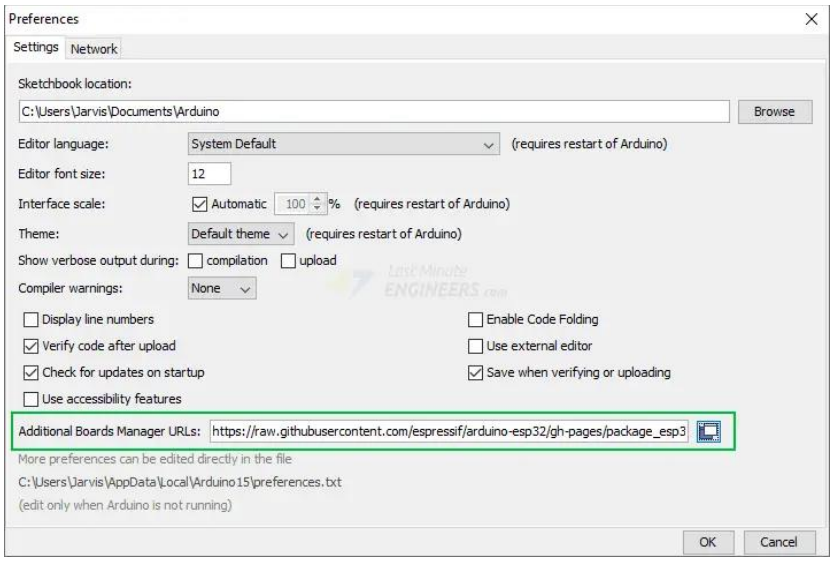
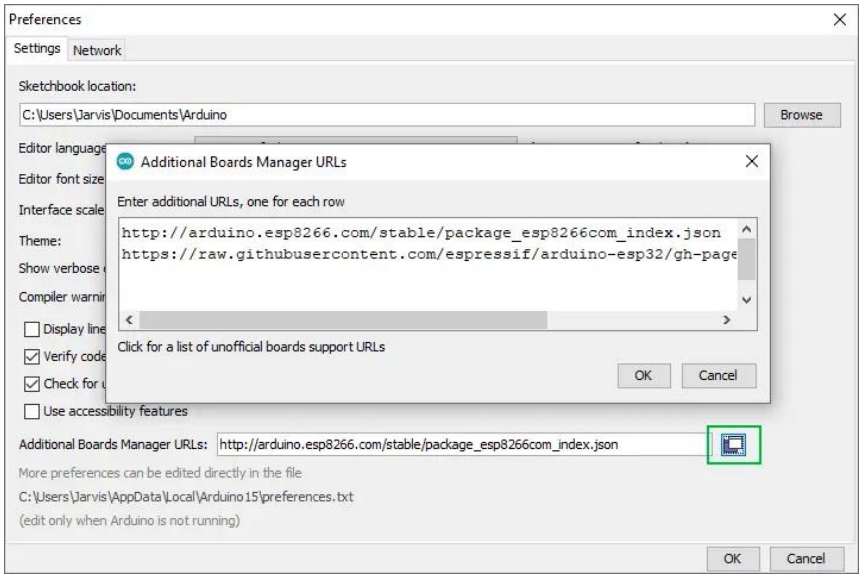


Preferences menu

If you have already entered the URL for the ESP8266 boards or any other board, you can click on the icon to the right of the field to open a window where you can add additional URLs, one for each row.



additional Boards Manager

Now navigate to Tools > Board > Boards Manager…

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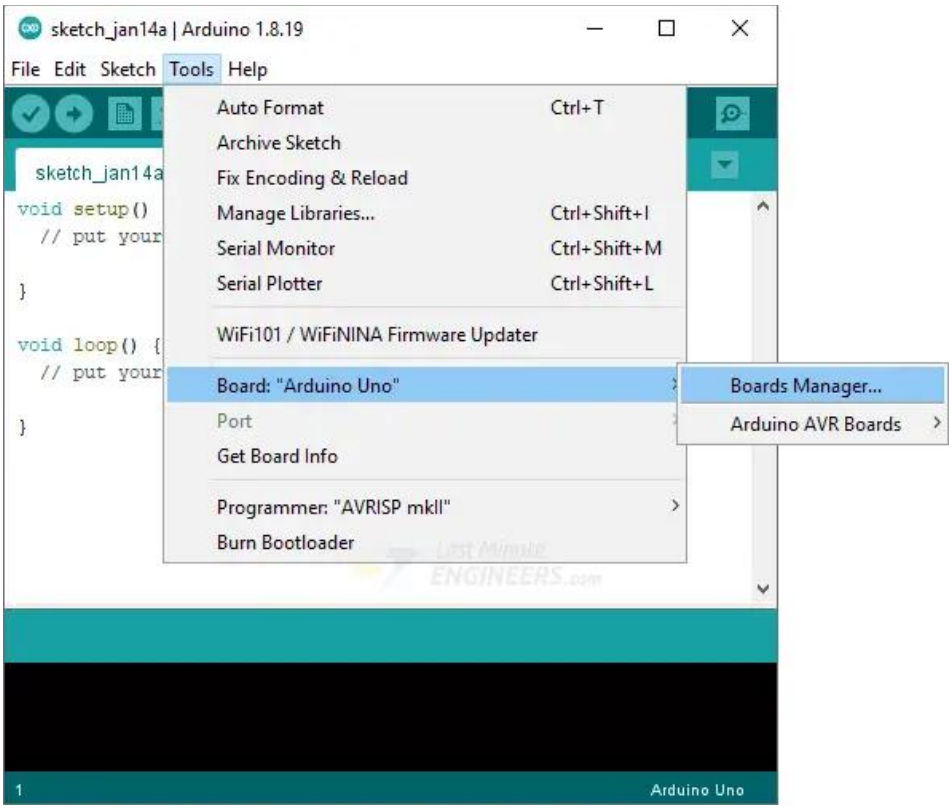
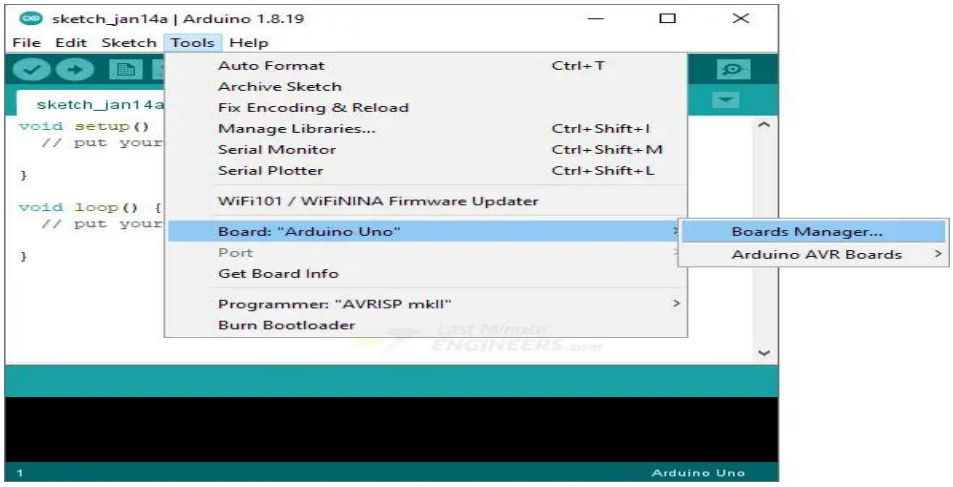


7.24 tools

Filter your search by entering ‘esp32‘. Look for ESP32 by Espressif Systems. Click on that entry, and then choose Install



Boards Manage

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Step 4: Selecting the Board and Port

After installing the ESP32 Arduino Core, restart your Arduino IDE and navigate to Tools > Board to ensure you have ESP32 boards available.

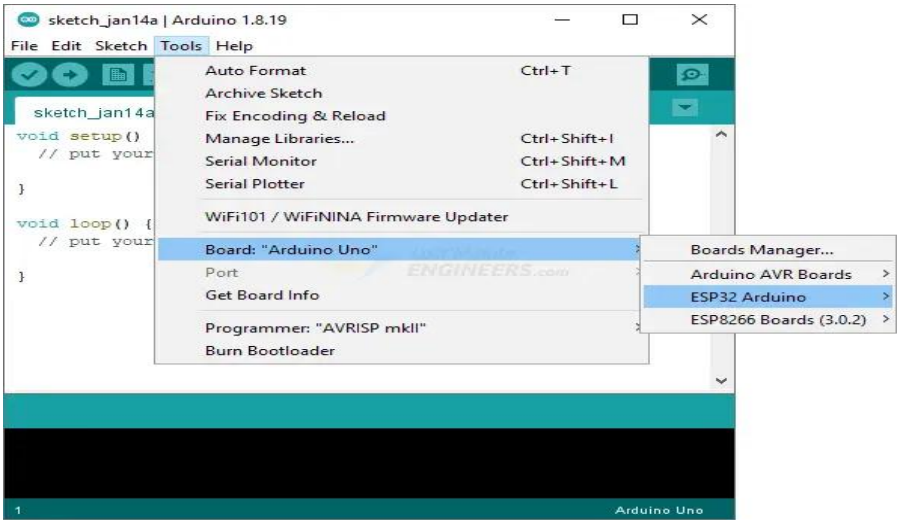
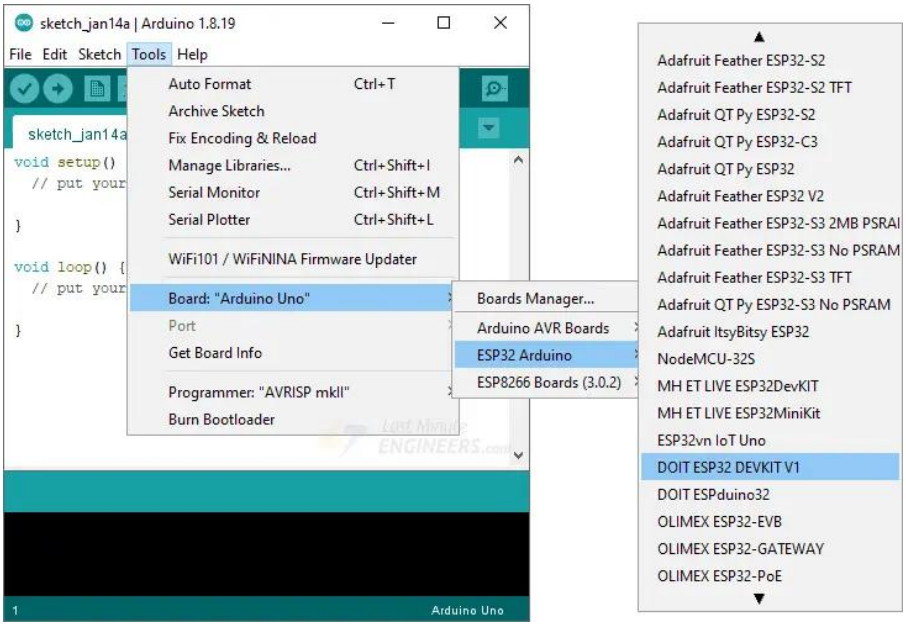


Fig Board menu ESP32 Module.

Now select your board in the Tools > Board menu (in our case, it's the DOIT ESP32 DEVKIT V1). If you are unsure which board you have, select ESP32 Dev Module.



Finally, connect the ESP32 board to your computer and select the Port.

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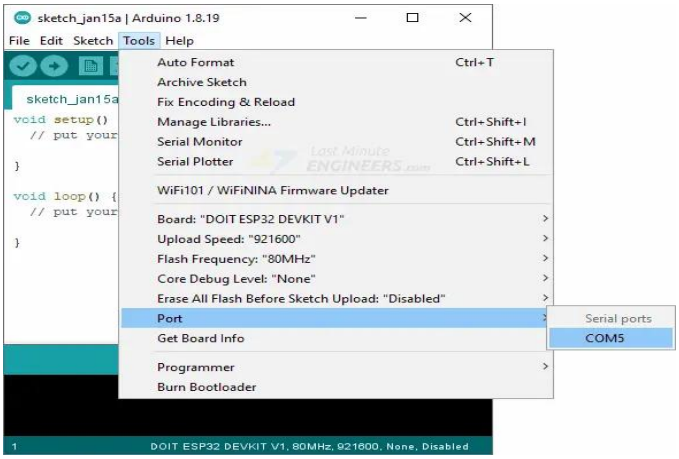
Finally, connect the ESP32 board to your computer and select the Port.



port selector

That's it! You can now begin writing code for your ESP32 in the Arduino IDE.
You should make sure you always have the most recent version of the ESP32 Arduino core installed.
Simply navigate to Tools > Board > Boards Manager, search for ESP32, and verify the version you have installed. If a newer version is available, you should install it.
Step 5: Testing the Installation
Once you've finished the preceding steps, you are ready to test your first program with your ESP32! Launch the Arduino IDE. If you disconnected your board, plug it back in.
Let's upload the most basic sketch of all – Blink!
This sketch uses the on-board LED that most ESP32 development boards have. This LED is connected to digital pin D2, and its number may vary from board to board.

```
int ledPin = 2;
void setup() {
        pinMode(ledPin, OUTPUT);
}
void loop() {
        digitalWrite(ledPin, HIGH);
        delay(500);
        digitalWrite(ledPin, LOW);
        delay(500);
}
```

If everything worked, the on-board LED on your ESP32 should now be blinking! To execute the sketch, you may need to press the EN button on your ESP32.

VII. CODE

```
//MAX30100 ESP32 WebServer
#include <WiFi.h>
#include <WebServer.h>
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#include <Adafruit_MLX90614.h>
Adafruit_MLX90614 mlx = Adafruit_MLX90614();
```

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```
#include <LiquidCrystal.h>
LiquidCrystal lcd(2, 23, 18, 17, 16, 15);
#define REPORTING_PERIOD_MS 500
float BPM, SpO2;
/*Put your SSID & Password*/
const char* ssid = "Prathamesh";      // Enter SSID here
const char* password = "Prathamesh";  //Enter Password here
PulseOximeter pox;
uint32_t tsLastReport = 0;
WebServer server(80);
#define SDA_2 33
#define SCL_2 32
float f, c;
void onBeatDetected() {
 //Serial.println("Beat Detected!");
}
void setup() {
 Serial.begin(115200);
 lcd.begin(16, 2);
 lcd.setCursor(4, 0);
 lcd.print("Welcome");
 delay(2000);
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("IOT Based Smart");  //IOT based smart
 delay(2000);
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Health Monitoring");  //Health Monitoring System
 lcd.setCursor(0, 1);
 lcd.print("System");  //System
 delay(3000);
 lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("-By Prof. S. R.");
 lcd.setCursor(0, 1);
 lcd.print("Chaudhari Sir");
 delay(3000);
 lcd.clear();
 Wire.begin();
 Wire1.begin(SDA_2, SCL_2);
 pinMode(19, OUTPUT);
 delay(100);
 Serial.println("Connecting to ");
 Serial.println(ssid);
 lcd.setCursor(0, 0);
 lcd.print("Connecting");
 delay(1000);
 lcd.clear();
```

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```
//connect to your local wi-fi network
WiFi.begin(ssid, password);
//check wi-fi is connected to wi-fi network
while (WiFi.status() != WL_CONNECTED) {
  delay(1000);
  Serial.print(".");
}
Serial.println("");
Serial.println("WiFi connected..!");
Serial.print("Got IP: ");
Serial.println(WiFi.localIP());
lcd.setCursor(0, 0);
lcd.print("WiFi connected..!");
lcd.setCursor(0, 1);
lcd.print(WiFi.localIP());
delay(3000);
lcd.clear();
server.on("/", handle_OnConnect);
server.onNotFound(handle_NotFound);
server.begin();
Serial.println("HTTP server started");
Serial.print("Initializing pulse oximeter..");
if (!pox.begin()) {
  Serial.println("FAILED");
  for (;;);
} else {
  Serial.println("SUCCESS");
  pox.setOnBeatDetectedCallback(onBeatDetected);
}
pox.setIRLedCurrent(MAX30100_LED_CURR_7_6MA);
// Register a callback for the beat detection
bool status2 = mlx.begin(0x5A, &Wire1);
if (!status2) {
  Serial.println("Could not find a valid MLX sensor, check wiring!");
  // while (1);
}
//Serial.println();
}
void loop() {
server.handleClient();
pox.update();
BPM = pox.getHeartRate();
SpO2 = pox.getSpO2();
if (millis() - tsLastReport > REPORTING_PERIOD_MS) {
  Serial.print("BPM: ");
  Serial.println(BPM);
  Serial.print("SpO2: ");
  Serial.print(SpO2);
  Serial.println("%");
```

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```
  f = mlx.readObjectTempF();
  c = mlx.readObjectTempC();
  lcd.setCursor(0, 0);
  lcd.print("Temp: ");
  lcd.print(f);
  lcd.print(" F");
  lcd.setCursor(0, 1);
  lcd.print("Temp: ");
  lcd.print(c);
  lcd.print(" C");
  lcd.setCursor(0, 0);
  lcd.print("BPM: ");
  lcd.print(BPM);
  lcd.setCursor(0, 1);
  lcd.print("SpO2: ");
  lcd.print(SpO2);
  tsLastReport = millis();
 }
}
void handle_OnConnect() {
 server.send(200, "text/html", SendHTML(BPM, SpO2));
}
void handle_NotFound() {
 server.send(404, "text/plain", "Not found");
}
String SendHTML(float BPM, float SpO2) {
 String ptr = "<!DOCTYPE html>";
 ptr += "<html>";
 ptr += "<head>";
 ptr += "<title>ESP32 WebServer</title>";
 ptr += "<meta name='viewport' content='width=device-width, initial-scale=1.0'>";
 ptr += "<link rel='stylesheet' href='https://cdnjs.cloudflare.com/ajax/libs/font-awesome/5.7.2/css/all.min.css'>";
 ptr += "<link rel='stylesheet' type='text/css' href='styles.css'>";
 ptr += "<style>";
 ptr += "body { background-color: #fff; font-family: sans-serif; color: #333333; font: 14px Helvetica, sans-serif box-
sizing: border-box;}";
 ptr += "#page { margin: 20px; background-color: #fff;}";
 ptr += ".container { height: inherit; padding-bottom: 20px;}";
 ptr += ".header { padding: 20px;}";
 ptr += ".header h1 { padding-bottom: 0.3em; color: #008080; font-size: 45px; font-weight: bold; font-family:
Garmond, 'sans-serif'; text-align: center;}";
 ptr += "h2 { padding-bottom: 0.2em; border-bottom: 1px solid #eee; margin: 2px; text-align: left;}";
 ptr += ".header h3 { font-weight: bold; font-family: Arial, 'sans-serif'; font-size: 17px; color: #b6b6b6; text-align:
center;}";
 ptr += ".box-full { padding: 20px; border 1px solid #ddd; border-radius: 1em 1em 1em 1em; box-shadow: 1px 7px 7px
1px rgba(0,0,0,0.4); background: #fff; margin: 20px; width: 300px;}";
 ptr += "@media (max-width: 494px) { #page { width: inherit; margin: 5px auto; } #content { padding: 1px;} .box-full
{ margin: 8px 8px 12px 8px; padding: 10px; width: inherit;; float: none; } }";
```

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```
ptr += "@media (min-width: 494px) and (max-width: 980px) { #page { width: 465px; margin 0 auto; } .box-full { width: 380px; } }";
ptr += "@media (min-width: 980px) { #page { width: 930px; margin: auto; } }";
ptr += ".sensor { margin: 12px 0px; font-size: 2.5rem;}";
ptr += ".sensor-labels { font-size: 1rem; vertical-align: middle; padding-bottom: 15px;}";
ptr += ".units { font-size: 1.2rem;}";
ptr += "hr { height: 1px; color: #eee; background-color: #eee; border: none;}";
ptr += "</style>";
ptr += "<script>\n";
ptr += "setInterval(loadDoc,1000);\n";
ptr += "function loadDoc() {\n";
ptr += "var xhttp = new XMLHttpRequest();\n";
ptr += "xhttp.onreadystatechange = function() {\n";
ptr += "if (this.readyState == 4 && this.status == 200) {\n";
ptr += "document.body.innerHTML =this.responseText}\n";
ptr += "};\n";
ptr += "xhttp.open(\"GET\", \"/\", true);\n";
ptr += "xhttp.send();\n";
ptr += "}\n";
ptr += "</script>\n";
//Ajax Code END
ptr += "</head>";
ptr += "<body>";
ptr += "<div id='page'>";
ptr += "<div class='header'>";
ptr += "<h1>ESP32 WebServer</h1>";
ptr += "</div>";
ptr += "<div id='content' align='center'>";
ptr += "<div class='box-full' align='left'>";
ptr += "<h2>Sensor Readings</h2>";
ptr += "<div class='sensors-container'>";
//For Heart Rate
ptr += "<p class='sensor'>";
ptr += "<i class='fas fa-heartbeat' style='color:#cc3300'></i>";
ptr += "<span class='sensor-labels'> Heart Rate </span>";
ptr += (int)BPM;
ptr += "<sup class='units'>BPM</sup>";
ptr += "</p>";
ptr += "<hr>";
//For Sp02
ptr += "<p class='sensor'>";
ptr += "<i class='fas fa-burn' style='color:#f7347a'></i>";
ptr += "<span class='sensor-labels'> Sp02 </span>";
ptr += (int)SpO2;
ptr += "<sup class='units'>%</sup>";
ptr += "</p>";
ptr += "<p class='sensor'>";
ptr += "<i class='fas fa-burn' style='color:#f7347a'></i>";
ptr += "<h2>Temperature</h2>";
```

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```
ptr += (int)c;
ptr += "<sup class='units'>°C</sup>";
ptr += "</p>";
ptr += (int)f;
ptr += "<sup class='units'>°F</sup>";
ptr += "</p>";
ptr += "</div>";
ptr += "</div>";
ptr += "</div>";
ptr += "</div>";
ptr += "</div>";
ptr += "</body>";
ptr += "</html>";
return ptr;
}
```

VIII. ADVANTAGES, DISADVANTAGES & APPLICATION

Advantages:

1. Real-time monitoring: The system provides real-time monitoring of health parameters, enabling early detection of health issues.
2. Remote monitoring: The system enables remote monitoring of health parameters, allowing healthcare providers to monitor patients from anywhere.
3. Cost-effective: The system is cost-effective compared to traditional health monitoring systems, reducing the overall healthcare cost.
4. User-friendly: The system is easy to use, and the data can be accessed remotely using any internet-connected device.
5. Improved patient outcomes: The system can help improve patient outcomes by enabling early detection and timely treatment of health issues.

Disadvantages:

1. Technical complexity: The system requires technical knowledge to set up and maintain, making it less accessible to some users.
2. Data privacy concerns: The system collects and stores sensitive health data, raising concerns about data privacy and security.
3. Dependence on technology: The system relies on technology and may not be accessible to individuals who are not familiar with technology.
4. Maintenance requirements: The system requires regular maintenance, including sensor calibration and software updates.

In summary, while the IoT-based smart health monitoring system offers several advantages, including real-time monitoring and remote access, it also has several disadvantages, including technical complexity, data privacy concerns, and maintenance requirements.

Application:

The proposed IoT-based smart health monitoring system has several applications in the healthcare industry, including:

1. Home-based health monitoring: The system enables patients to monitor their health parameters in the comfort of their homes and share their data with healthcare providers for remote diagnosis and treatment.
2. Elderly care: The system can be used to monitor the health parameters of elderly individuals, allowing caregivers to intervene early in case of any health issues.
3. Hospital monitoring: The system can be used to monitor the health parameters of patients in hospitals, reducing the need for frequent manual monitoring by healthcare providers.

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4. Fitness tracking: The system can also be used by fitness enthusiasts to monitor their health parameters during exercise and track their progress over time.

In summary, the proposed IoT-based smart health monitoring system has several practical applications in the healthcare industry, enabling patients to monitor their health parameters remotely and facilitating early diagnosis and treatment of health problems.

IX. RESULT & CONCLUSION

Result:

- Performance analysis of the sensors used in the system
- Analysis of the data acquired from the sensors
- Comparison of the data obtained from the proposed system with the data obtained from a standard medical device
- Evaluation of the accuracy and precision of the system
- Analysis of the system's response time and latency
- Demonstration of the system's ability to transmit data to the cloud server and display it on the IoT web page
- Discussion of any observed limitations or issues during the testing and validation of the system

Conclusion:

The following are some possible contents of the Conclusion chapter for the proposed IoT-based smart health monitoring system:

1. Briefly summarise the objectives and scope of the project.
2. Summarise the methodology used in the project, including the hardware and software components.
3. Provide a summary of the results obtained during the project, including a discussion of the system's performance, accuracy, and limitations.
4. Highlight the significance and contributions of the proposed system in the context of healthcare and IoT.
5. Discuss the implications and potential future work of the proposed system.
6. Conclude with a final statement on the success of the proposed system in achieving the project's objectives.

In summary, the Conclusion chapter should provide a final analysis of the project's outcomes and contributions, highlighting its relevance and potential for future research and development.

X. FUTURE SCOPE

The Future Scope chapter of the project report presents potential directions for future research and development that build on the work accomplished in the proposed IoT-based smart health monitoring system. The following are some possible contents of the Future Scope chapter:

1. Expansion of the system to include additional health sensors and data analysis algorithms to enable comprehensive health monitoring and early diagnosis of health problems.
2. Integration of machine learning algorithms to improve the accuracy of the system in predicting health problems based on collected data.
3. Development of a mobile application to allow users to access their health data and receive real-time notifications on their mobile devices.
4. Integration of voice recognition technology to allow the system to recognize voice commands from users and interact with them accordingly.
5. Development of a cloud-based data management system to store and process health data from multiple users and enable population-level health analysis and monitoring.
6. Implementation of a telemedicine feature that allows remote communication between patients and healthcare providers, enabling them to access health data and make informed medical decisions.

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