IOT based heart beat sensor

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***Abstract*- The project proposes heart rate monitoring system integrated with IOT technology. The objective of this project is detecting the heartbeat of the patient for monitoring the risk of heart attack and the regular checkup. Monitoring body health parameter is very important for us to make sure our health is in excellent condition. Heart rate (HR) is a vital parameter and is considered for this device. This project describes the design of a low-cost heart rate monitoring device from fingertips. The system comprises of heart rate module, Android application and bluetooth module. The heart rate (HR) module picks up heart rate signal by a non- invasive technique photoplethysmography the signal is send wirelessly to computer or android application using bluetooth module. This system can be incorporated as a part of telemedicine constituent. The information received from heart rate module is saved and viewed for further medical usage.**

***Index Terms*- IOT, nodeMCU, android, heart rate sensor.**

I. INTRODUCTION

Heart beat sensors give digital output of the heart beat when a finger is placed on it. When the heart beat detector starts working, the light emitting diode (LED) blinks for every heartbeat. The LED output is in digital form, which is further processed by the microcontroller to measure beats per minute (BPM) rate. As blood passes through the finger, the light get modulated, and this phenomenon is used for counting the pulse. The heartbeat sensors are microcontroller based SMD design.

Heart beat sensor can be used to study the various heart's function in a simple and efficient manner. This sensor senses the blood flow through the fingertip. The clip is used for fingertip in between on body surface within the thumb and index finger. The out signal is amplified and inverted. Noise signal is removed using frequency filters. From this signal helps the heart rate is measured. Though the heart rate, which is averaged as 72 per minute, varies from person to person to some extent. The heart rate is even more for children. A person who have more physical activity will have a different heart rate than a person performing normal activity or in rest.

II. COMPONENTS

- NODE MCU
- MAX30102
- LCD (12C)
- I2C SERIAL INTERFACE ADAPTER

NODEMCU

ESP32-WROOM-32 is a powerful, generic Wi-Fi+BT+BLE MCU module which has a wide variety of applications, like low-power sensor networks, voice encoding, music streaming and MP3 decoding etc. The core of this module is the ESP32- D0WDQ6 chip which is embedded and it is designed to be scalable and adaptive. It has two CPU cores which are individually controlled. The CPU clock frequency ranges from 80 MHz to 240 MHz. It is advisable that the user power off the CPU and use the low-power co-processor to constantly monitor the peripherals for changes or crossing of thresholds. ESP32 has peripherals like capacitive touch sensors, Hall sensors, SD card interface, Ethernet, high-speed SPI, UART, I2S and I2C. It also integrates Bluetooth, Bluetooth LE and Wi-Fi.The sleep current of the ESP32 chip is less than 5 µA. This makes it suitable for battery powered and wearable electronics applications. ESP32 supports a data rate of up to 150 Mbps, and 20.5 dBm output power at the antenna which ensures the widest physical range. Free RTOS with LwIP; is the operating system chosen for ESP32.

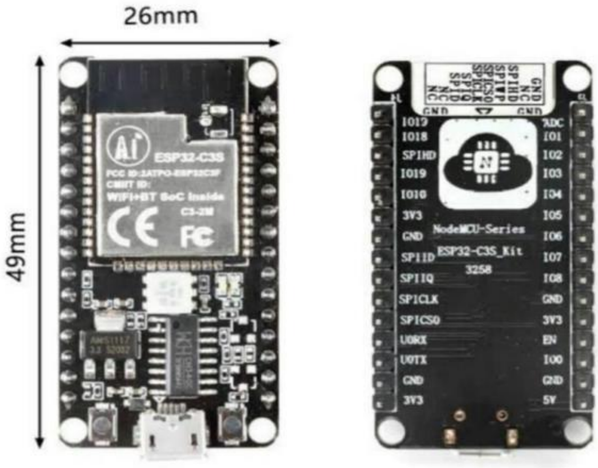

Fig-1: Node MCU

MAX30102

The MAX30102 is a module in which both pulse oximetry and heart-rate monitor are integrated into a single module. It consist of internal LEDs, photodetectors, some optical elements, and an electronics for ambient light rejection with very low noise. The MAX30102 is a complete system which provides an ease with the design-in process for both mobile and wearable devices. It requires a single 1.8V power supply for the MAX30102and a separate 3.3V power supply for the internal LEDs. Communication with other divices is made through a standard I2C-compatible interface. It is possible to shut down the module through software with zero standby current, and allows the power rails to always remain powered.

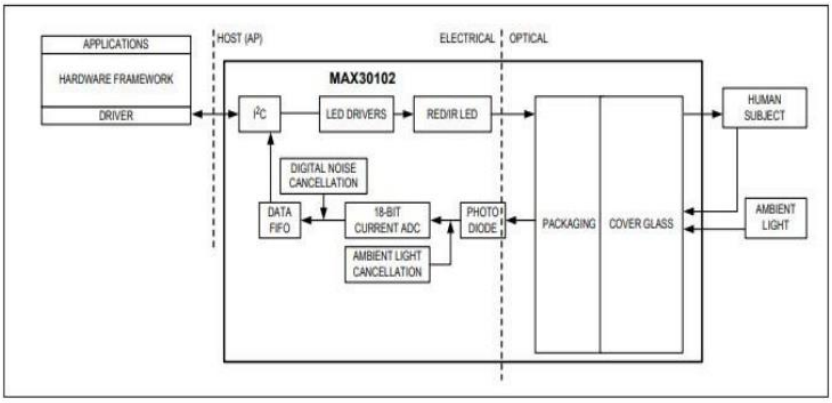

Fig-2: MAX30102

MAX30102 Sensor: Features and Benefits

The MAX30102 sensor offers a range of features and benefits that make it an ideal choice for various applications:

1. **Heart-Rate Monitor and Pulse Oximeter Sensor**: The MAX30102 is designed as a combined Heart-Rate Monitor and Pulse Oximeter Sensor, providing a comprehensive solution for monitoring vital signs.
2. **Compact and Integrated Design**: With dimensions of just 5.6mm x 3.3mm x 1.55mm, this 14-pin optical module is remarkably compact. It incorporates an integrated cover glass for optimal and robust performance.
3. **Efficient Power Management**: The MAX30102 operates on ultra-low power, making it suitable for mobile devices. Its programmable sample rate and LED current settings enable efficient power management.
4. **Low-Power Heart-Rate Monitoring**: With power consumption of less than 1mW, the MAX30102 ensures minimal impact on battery life in portable devices.
5. **Low Shutdown Current**: When in shutdown mode, it consumes a mere 0.7μA, typically preserving power when not in use.
6. **Fast Data Output**: The sensor boasts fast data output capabilities, enabling real-time monitoring and analysis of vital signs.
7. **High Sample Rates**: It supports high sample rates, allowing for accurate and detailed data collection.
8. **Motion Artifact Resilience**: The MAX30102 sensor exhibits robust resilience against motion artifacts, ensuring reliable readings even during movement.
9. **High Signal-to-Noise Ratio (SNR)**: Its high SNR contributes to precise and clear signal detection.

10. **Wide Operating Temperature Range**: With an operating temperature range spanning from -40°C to +85°C, the MAX30102 is suitable for various environmental conditions.

I2C LCD Display: Enhanced Interface
The I2C 16x2 Arduino LCD Screen presents an efficient solution for displaying information with several advantages over traditional parallel displays:Utilizing an I2C communication interface, it simplifies the connection to an Arduino or similar microcontroller. This 16x2 character display presents white characters on a blue background, ensuring readability.One notable advantage is the reduction in the number of required pins on the Arduino, as compared to the LCD 1602 Parallel LCD Display. With I2C communication, it is possible save valuable pins, allowing for more flexible and efficient use of microcontroller.MAX30102 sensor and the I2C LCD display are valuable components with unique features, making them indispensable tools in various electronic and monitoring applications.

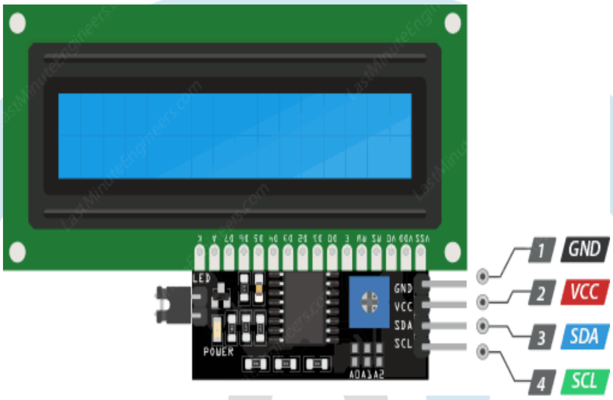

Fig-3: I2C LCD Display

I2C serial interface adapter
Communication Protocol of the MAX30102 Sensor
The MAX30102 employs a robust communication protocol, characterized by the following key features:
1. **8-Bit Data Transmission**: Data sent to the MAX30102 consists of 8-bit words, each accompanied by an acknowledge clock pulse.
2. **Master-Slave Interaction**: When a master device communicates with the MAX30102, it initiates the process by sending the appropriate slave address followed by a sequence of nine clock pulses (SCL).
3. **Synchronous Data Transfer**: Data transmission from the MAX30102 occurs in synchronization with the clock pulses generated by the master.
4. **Acknowledgment**: After each byte of data is transmitted, the master acknowledges its receipt, ensuring data integrity.
5. **Communication Sequences**: Every read operation begins with a START (S) or REPEATED START (Sr) condition, followed by a not acknowledge, and concludes with a STOP (P) condition.
6. **SDA and SCL Functionality**: SDA serves as both an input and an open-drain output, while SCL functions solely as an input.
7. **Pullup Resistors**: To maintain signal integrity, pullup resistors (typically greater than 500Ω) are required for both SDA and SCL.
8. **Multiple Masters Consideration**: If multiple masters share the bus, or if a single master has an open-drain SCL output, a pullup resistor is essential for SCL to prevent voltage spikes.
9. **Optional Series Resistors**: Series resistors in line with SDA and SCL are optional but can protect the MAX30102's digital inputs from high voltage spikes on the bus lines and reduce crosstalk and undershoot of the bus signals.

MAX30102 features a versatile I2C/SMBus-compatible, 2-wire serial interface involving a serial data line (SDA) and a serial clock line (SCL). These lines facilitate communication with a master device at clock rates of up to 400kHz. The master initiates and controls data transfer, ensuring efficient and reliable communication with the MAX30102 sensor.

III. CIRCUIT DIAGRAM

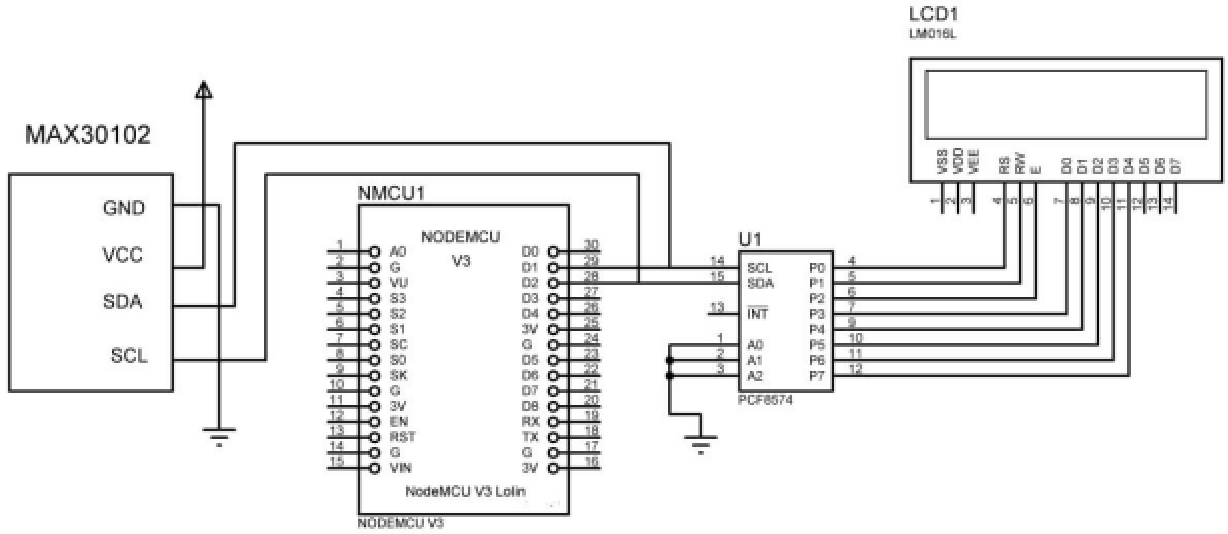

Fig-4: Circuit Diagram

To measure heart rate, the use of only the IR LED is sufficient, as it capitalizes on the fact that oxygenated hemoglobin has a higher absorption rate for infrared light. Heart rate is essentially the time interval between two consecutive heartbeats. As blood circulates throughout the human body, it undergoes compression in capillary tissues. Consequently, the volume of these capillary tissues temporarily increases but decreases after each heartbeat. This variation in capillary tissue volume directly impacts the infrared light detected by the sensor, causing it to fluctuate after each heartbeat.

The functionality of this sensor can be verified by placing a human finger in front of it. When a finger is positioned in front of the pulse sensor, it alters the reflection of infrared light based on changes in blood volume within the capillary vessels. During a heartbeat, the blood volume in the capillary vessels rises, subsequently decreasing after each heartbeat. Consequently, this fluctuation in volume is reflected in the LED light emitted by the sensor. This variation in LED light is used to measure the heart rate of the finger. This phenomenon is commonly referred to as a "Photoplethysmogram."

This method leverages the sensitivity of the sensor to changes in infrared light absorption caused by blood volume fluctuations, providing an effective and non-invasive way to monitor heart rate.

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IV. **BLYNK ANDROID APP**.

Blynk is a versatile application designed for use on both Android and iOS devices, enabling the control of various IoT-based applications through smartphones. It empowers users to create customized graphical user interfaces for their IoT applications. In this guide, through the setup of the Blynk application to monitor BPM (Beats Per Minute) and SPO2 (Oxygen Saturation) over Wi-Fi using a NodeMCU ESP8266. To get started, follow these steps:

1. **Download Blynk Application**: Begin by downloading and installing the Blynk Application from the Google Play Store for Android users. iOS users can find and download it from the App Store.
2. **Open Blynk Application**: Once the installation process is complete, open the Blynk app on the smartphone.
3. **Create an Account**: To use the Blynk app, fiest create an account. Sign up using the email address and create a secure password.

By completing these steps, the Blynk app ready on the smartphone and be prepared for setting up monitoring of BPM and SPO2 using the NodeMCU ESP8266 device. This is a fundamental part of creating IoT-based health monitoring system.

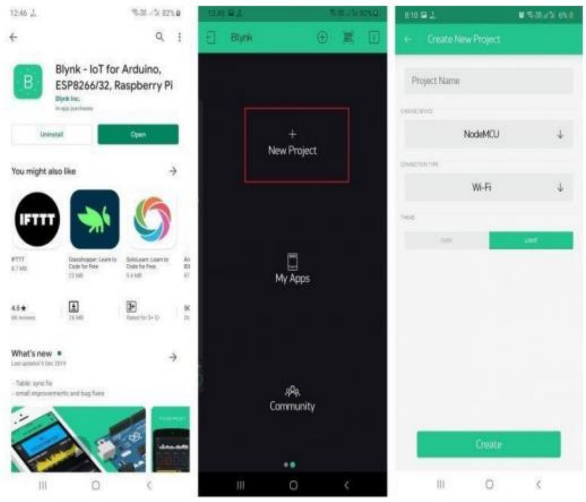

Fig-5: BLYNK android app view

V. CONCLUSION

The IoT-based heart rate sensor has proven to be highly effective in monitoring critical vital signs, especially in patients with pulmonary diseases. Its ability to transmit data remotely enables a significant reduction in the need for physical doctor visits. As detailed in the research paper, the system utilizes both Arduino for signal processing and ESP01 for wireless connectivity. There are several potential enhancements and future developments for this system:

1. **Integration of Functions**: A promising avenue for improvement involves consolidating the functionalities of both Arduino and ESP01 onto a single microcontroller. This integration would not only streamline the device but also reduce its form factor, making it more practical and portable.
2. **Dedicated Mobile Application**: The development of a dedicated mobile application aimed at aiding doctors and caregivers in monitoring a patient's heart rate is a valuable addition. This application should meet the following requirements:

- **Cross-Platform Compatibility**: Ensure that the mobile app is compatible with all major operating systems, such as Android and iOS, to reach a broader audience of users.
- **Efficient Resource Usage**: Design the application to be resource-efficient, consuming minimal power and storage. This is crucial for optimal performance and user convenience.
- **Alerting System**: Implement a robust alerting system within the application to promptly notify doctors or caregivers of any abnormal heart rate readings. This can significantly enhance patient safety and timely intervention.

By addressing these potential enhancements, the IoT-based heart rate monitoring system can become an even more valuable tool in the field of healthcare, offering efficient remote monitoring and timely interventions for patients with pulmonary diseases.

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