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Monitoring Vital Signs of Human Hear Based on IOT

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https://dx.doi.org/10.46649/110420-02

Abstract—**In this paper, the design of a device to monitoring the heart rate and the level of oxygen in the blood (Spo2) in real-time from anywhere as vital signs to represent heart disease by using internet of things (IoT). The size of the designed device is small and can be wearable on the human body, anyone using this device can move during monitoring vital signs of heart. In this study, the sensor type used is the MAX30100 connected to the microprocessor (ESP32). The device measures heart rate and Spo2 values to the patient and sends the measured values to the server by using the MQTT protocol via Wi-Fi technology. The doctor or the person who monitors the patient's status can access the measured data through a program that has been designed. This program is installed on the phone or computer to display the measured data in real-time.**

Keywords— **IOT, MQTT, ESP32, Spo2, heart rate.**

I. Introduction

Using IOT technology can connect any non-living object to the Internet to control and analyze it in real-time from anywhere [1],[2]. Although the medical industry is advanced but cannot provide assistance to everyone. This is due to two reasons, the first reason is the high price for medical treatment, another reason is medical help not available everywhere. One of the important vital signs must monitor is the heart, to knowing heart health must measuring two vital signs are the oxygen rate in blood and heart rate [3]. Measurement of the oxygen rate in blood for early detection of hypoxia [4]. In some cases, required continuous monitoring of blood oxygen for patients with chronic disease or the elderly. Monitoring can be in real-time and from anywhere remotely because this monitoring is called health/home care monitoring based on the concept of IOT [5].

Our proposed system uses the MAX30100 sensor that allows the detection of the oxygen rate in blood and heart rate. The proposed system for monitoring blood oxygen and heart rate in real-time using the MQTT protocol. The development of pulse oximeter technology is important to its high mobility, low energy, wireless communication, and low price [6]. There are some researchers worked on design a low-cost blood oxygen meter, but it does not support the application of remote monitoring [7]. The measurement results can only be seen on a projector. Other studies [8],[10] were carried out to design a wireless monitor with access to the local area only. References [11],[12] related to measuring the heart rate based on IOT, but did not use any of them a device to measure the level of oxygen in the blood.

In many cases, there are patients in someplace and the medical expert need to monitor patients' status remotely in real-time and continuously. So, need a wearable device can monitor heart rate and blood oxygen level in real-time across the global internet. In this paper, discussed the application of IOT technology to monitor patient vital signs such as heart rate and blood oxygen level. Doctors, medical experts, or people who care about the patient's status can monitor vital signs in real-time from anywhere depending on the proposed design.

II. PROPOSED SYSTEM ARCHITECHTURE

The system designed shown in Fig. 1 consists of a sensor to measure the heart rate and blood oxygen level (MAX30100), which connects to a microprocessor (ESP32) by using the synchronous serial communication protocol inter-integrated circuit (I2C) is one of the communication protocols used in embedded systems. ESP32 access the internet via gateway by using Wi-Fi technology using MQTT protocol. The system has been

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designed to measure the heart rate and blood oxygen, measured data is sent to the server. The doctor or the person who monitors the patient's status can see the measurement results in real-time from anywhere. Also, the measured data is stored in a server. Saving results in a server as a database gives opportunity to redisplay it again to know the progress of the patient's health.

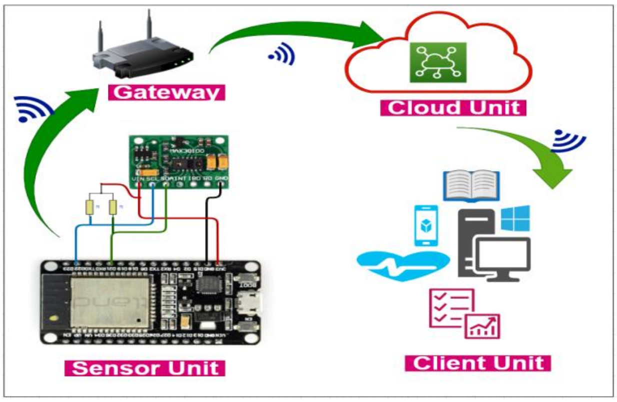

Fig. 1 The system designed

III. INTER-INTEGRATED CIRCUIT (I2C) PROTOCOL

There are many serial protocols used, which are divided into synchronous and asynchronous protocols. The synchronous serial communication protocol I2C will be used to connect sensor MAX30100 with ESP32. I2C consider one of the communication protocols used in embedded systems that have one data transmission line, meaning this protocol is a bidirectional line that the data is sent in one direction (half-duplex). In this protocol, either master (ESP32) send and slave (MAX30100) receive or vice versa. This protocol needs only a 2-wire line, one line to clock to perform synchronization, and the other line to transfer data between master and slave. Therefore, the main feature of I2C is reducing the number of wire. Possesses only two bus lines are required a serial data line (SDA) and a serial clock line (SCL). Always the master sends the message to the slave to generated the start of the connection and the slave answers. The slave cannot send a message without being there request from the master. Also, the master generates the clock in this protocol. Every slave has a unique address so there is no need for an additional line to specify. The communication process between master and slave is done depending on the unique address of the slave. If the master wants to talk to a slave only sent the address for the slave in the message. One of the advantages of this protocol is the True multi-master bus including collision detection, arbitration (using wire-AND) and clock synchronization to prevent data corruption. As a result of using the wire -AND, have two pull-up resistors for the clock line and the data line. The line is always in a high state so that every master or all slave does the output buffer in the output open drain state. Anyone who sends data on the line will make the output open drain go to the ground and pull the line to a low state.

A) SDA and SCL signals

The standard I2C protocol will explain in this sub section. There are 2-wire : SCL and SDA are connected in the case of wire-AND. That means the bus is always in high condition, have an open-drain in the first node and the second node as well as any node-link open-drain. If any node wants to operation the output will go to the ground, zero output will be displayed on the SCL or the SDA. In this case, the bus generated by the charge or the output is low, whether in SCL or SDA. This means it works like an AND. Which one of them is set to zero, the result will be zero in order for one to come up with the necessary two nodes on the bus put the bus in a high condition and this is the prevailing situation to the line that will always be in a high state. The fig.2 shows the SCL line, as see it in the case of high SCL, the data on the SDA must be in the case of data line stable (data valid) so that can read it when the SCL is high. when the SCL is low, this means cannot read it. because the data can be changed if the SCL is low (change of data allowed). So always when want to read data in the case of a high SCL, in this case, know data stable and valid and can read it.

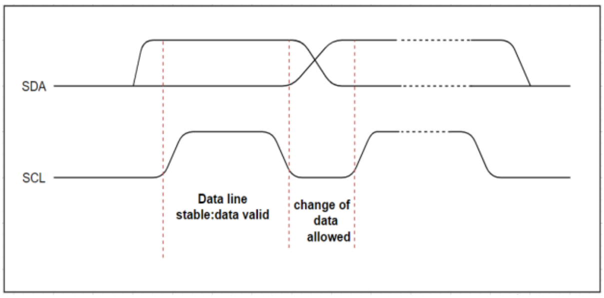

Fig.2 SDA and SCL signals

B) Start and stop conditions

Timing diagram (Start and stop conditions) are shown in fig.3 . In start conditions, SCL is in high and SDA states convert from high to low. The data changes when the SCL is low. In the state of stop condition when the SCL is in a high and SDA state, it is converted from low to high. Any frame or transmission is required in of I2C bagging at the start and end at the stop. The master is responsible for generating the start and stop condition. The first time the start condition the bus will be in a busy state. The first stop condition will happen shortly after the bus returns in a free condition. First the start condition after that send a stop condition, but can send back the start condition, also can send back more than start condition until reaching the end of the transmission send a stop condition.

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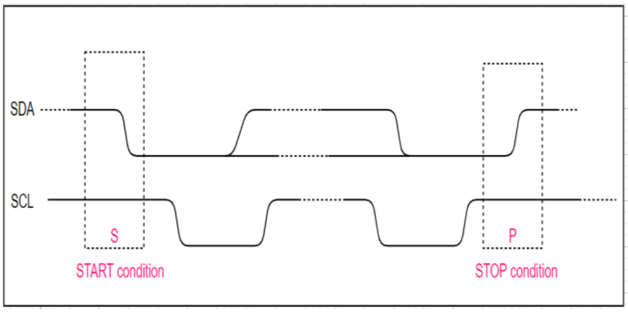

Fig.3 timing diagram (start and stop conditions)

IV. SENDING DATA TO CLOUD USING MQTT PROTOCOL

MQTT is a lightweight protocol the name is an abbreviation for Message Queuing Telemetry Transport, it is derived from the history of development and does not have a message queue function despite its name. MQTT protocol uses an intermediary server called a broker. The client sending the information as a message send to the broker with a topic indicating the category of the information. Another client can receive the message from the broker by specifying this topic. Fig.4 shows intercommunication network using MQTT protocol.

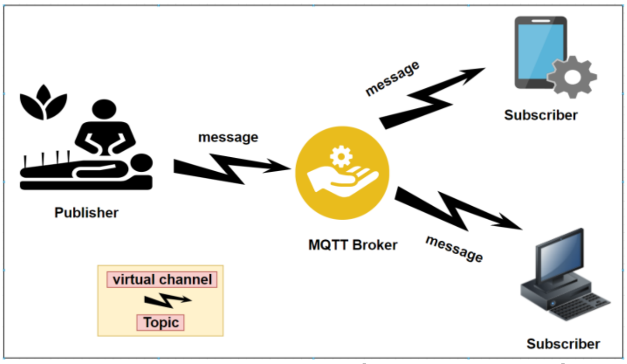

Fig.4 intercommunication network using MQTT protocol

C) Message

The basic unit of MQTT communication is a message. Information exchanged between devices, whether data or commands. The message is accompanied by key information "topic" to sort and identify it.

D) Topic

This is the key information for sending and receiving messages, and specifies the type of message. It can be specified in a hierarchical structure separated by / (slash). When publishing or subscribing to a message, must always specify a topic. Clients (sensor devices) on each floor of the office publish measurements with their own topic. Clients who want to receive can specify the required topic and receive the data.

E) Publish / Subscribe model

The basic communication mechanism of MQTT, which transmits information in a manner similar to the distribution of books. The client sending the information, also known as the Publisher, publishes the message with the topic. Instead of specifying a destination, the book is sent to a broker-like server called a broker. Clients affiliated with the store, clients called Subscribers connected to the broker, can receive information by specifying the topic they want to subscribe to it.

In this way, Publisher publishes information without specifying a destination, and multiple subscribers can select and receive only messages of interest to each topic. Each client (Device) can be both a Publisher and a Subscriber. This makes it possible to configure a many-to-many intercommunication network using MQTT protocol as shown in fig.4. However, communication that specifies a specific device is not possible. Since brokers do not have a message accumulation function, past messages cannot be subscribed. Publisher and Subscriber are independent, and no access information is notified to Publisher.

F) Broker

A server that constitutes a node for MQTT communication. The broker is responsible for receiving and filtering all messages, determining which devices are interested in the topic, and sending messages to all subscribed clients.

There are also many MQTT Brokers from OSS (Open Source Software), and there are differences in the functions and specifications implemented, so it is necessary to consider them in advance.

As you can see, a major feature of MQTT is that, unlike traditional client / server architectures, the recipients and message publishers are separated. Publishers and subscribers do not need to know each other. The connection between them is handled by the broker.

V. RESULTS AND DISCUSSION

Fig. 5 shows the flow diagram of the proposed system . Patients should place a finger on the sensor probe. On the probe, there is a source that emits light and a receiver works as a light detector (photodiode). The light source on one side of the probe will emit red light (650nm) spectrum and infrared light (950nm) spectrum through the tips of the finger. After that, the light transmitted through the finger is detected by the photodiode. Through the change in the intensity of the light that is measured, the heart rate and the percentage of oxygen in the blood are obtained. Then the measured digital value is sent to a server. After that, the doctor or the person monitors the patient's status can enter the server and view the data graphically through a program that has been designed and installed on the mobile phone or personal computer in real-time from anywhere.

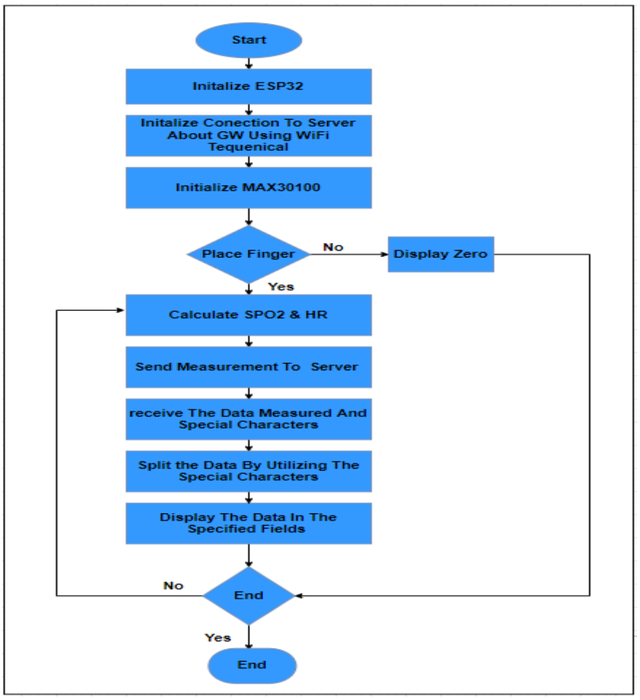

Fig. 5 The flow diagram of the proposed system.

Fig. 6 shows practical connection of the device. Fig.7 shows the results of the measurement data on the serial monitor to the Arduino IDE. The measure data for a male patient is 25 years old. Fig.8 shows a screenshot of the graphical user interface for the program, which is designed to display the measured data for heart rate and blood oxygen level on the server from mobile and computer. When the patient monitors the status places a finger on the sensor, the sensor reads the data and sends it to the server through the Wi-Fi technology. Wi-Fi embedded within the microcontroller (ESP32) and sends it using the MQTT protocol. The doctor or the person who monitors the patient's status can obtain the measurement data by subscribing to the topic where can view this data in a graphical user interface in real-time from anywhere. So we used an application that was designed and installed on the mobile or computer to display these measured values from the sensor. Through the results obtained, use IOT to improve health care services will contribute greatly to raising the efficiency of health institutions in patient care and monitoring health status from anyplace. Also will help the patient in reviewing his health status and obtain the advice of a doctor who supervises him from anywhere and at any time.

VI. CONCLUSION

In this paper, proposed a system for monitoring heart rate and blood oxygen level based on the MQTT protocol in real-time from anywhere. The measured data is sent to the server successfully and can be widely accessed through the Internet. A program designed and installed on the mobile phone and the personal computer is used to capture the heart rate and blood oxygen level (MAX30100). The doctor or anyone interested in the patient's status can enter to the server and display the data measured from any internet-enabled device using the MQTT protocol by subscribing to the same topic MQTT.

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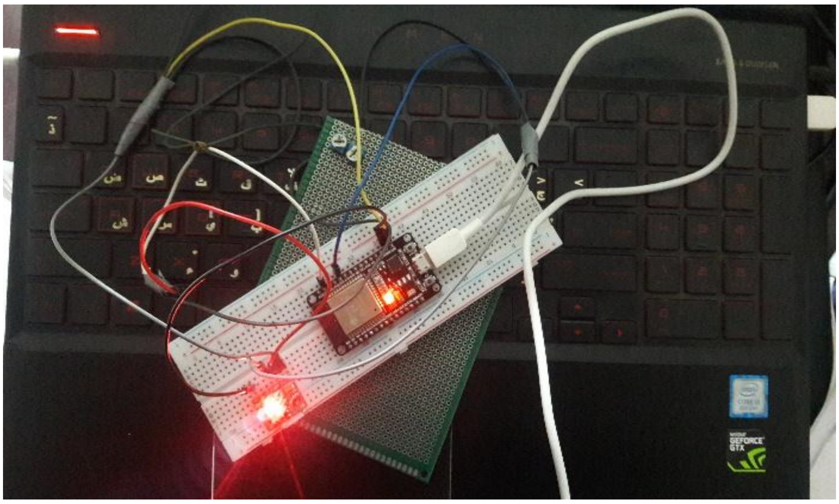


Fig.6 practical connection of the IOT system

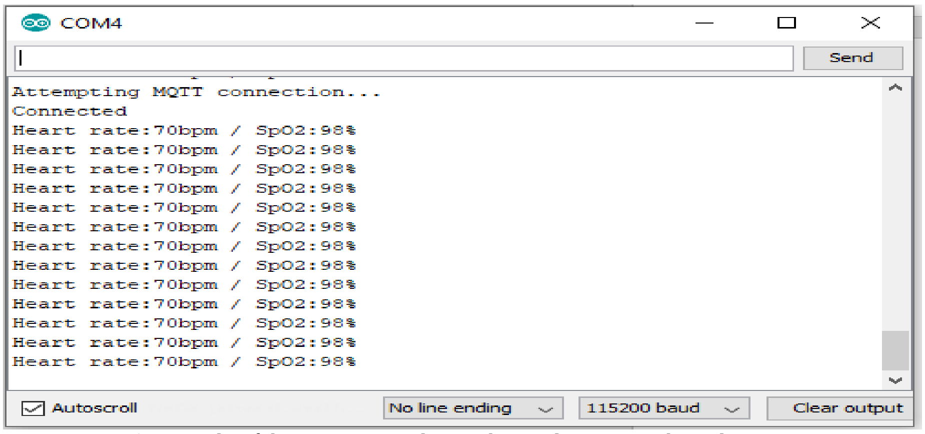
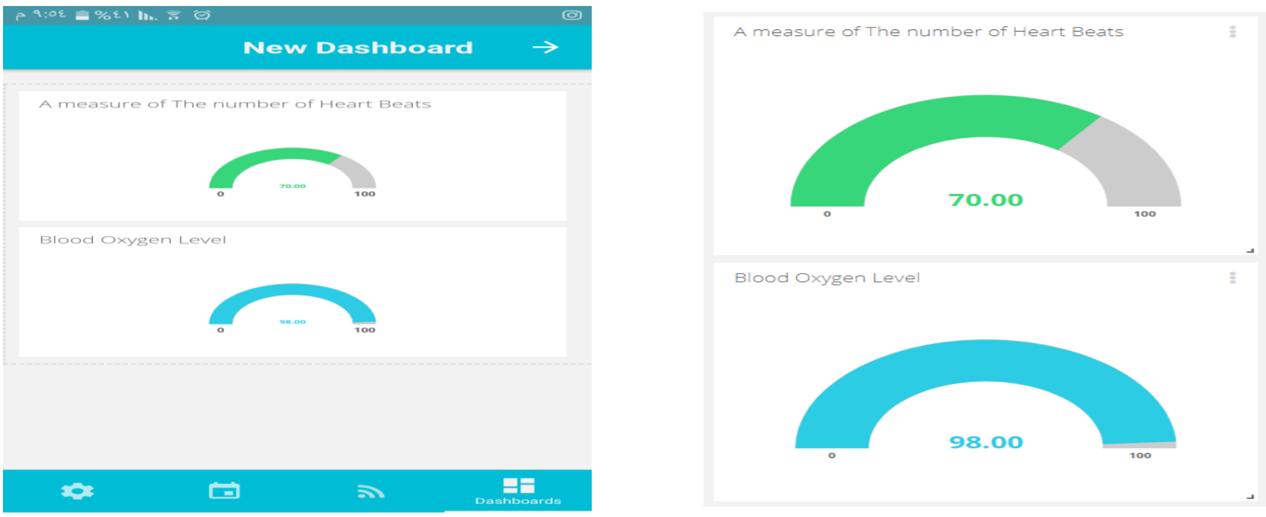


Fig.7 Results of the measurement data on the serial monitor to the Arduino IDE



(a) (b)

Fig.8 (a) the measured data for heart rate and blood oxygen level on the server from mobile, :(b) the measured data for heart rate and blood oxygen level on the server from computer.

ATU-FJIECE, ISSN – 2708-3985, Volume: 1, Issue 02 , April 11 , 2020,