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DESIGN REAL-TIME MONITORING AND ALARMING SYSTEM WITH LOW POWER CONSUMPTION FOR PATIENT HEALTH

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Master Thesis

Supervisor

Asst. Prof. Dr. Çağatay AYDIN

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by

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This is to certify that we have read this thesis and that in our opinion, it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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Ali Adil Manhal AL-Janabi

DEDICATION

At first, I would like to give praise and thank the creator of the heavens and earth, The Greatest, Allah, and our kind prophet Mohammed (Peace be upon him), I would like to dedicate and give my great appreciation to my parents, who did their best and sacrificed in everything to facilitate my academic and scientific duties. I would like to thank my brothers, my sister, my wife, my daughter (Yusur), colleagues. With my best wishes and regards.

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ABSTRACT

DESIGN REAL-TIME MONITORING AND ALARMING SYSTEM WITH LOW POWER CONSUMPTION FOR PATIENT HEALTH

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This thesis presents the design and implementation of a low power consumption controller and alarming system for monitoring patient health in real-time. The proposed device is equipped to help people to monitor their health by measuring the heartbeat rate, oxygen level in the blood and body temperature. This device will be worn to hand and will be connected to Android Smartphone (via Bluetooth). The Smartphone will show the data directly using an application that is developed for this project. After detecting the disease, a buzzer is running and the application will send an emergency SMS to the doctor. The control card is built using Atmega328P and components which are required in order to produce this device due to low power consumption. The implementation results show that the proposed device is able to get information from the patient with low power consumption comparing with a device in the literature.

Keywords: Health monitoring, Atmega328p, Sensors, Low Power, Bluetooth.

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LIST OF ABBREVIATIONS

WBSN : Wireless Body Sensor Network

SMS : Short Message Service

GSM : Global System for Mobile

WWSS : Wearable Wireless Sensor System

WHMS : Wireless Health Monitor System

MCU : Microcontroller Unit

LIBO : Lithium Polymer Battery

ReTiHA : Real-Time Health Control Act

RAM : Random Access Memory

NiCad : Nickel–Cadmium Battery

1. INTRODUCTION

1.1 GENERAL OVERVIEW

The development of new diagnostic techniques and medication discoveries is due to population increasing in the world. This rapid increase in population growth leads to increase the need of the new solutions for the chronic diseases such as congestive heart failure, sleep apnea, cancer, type 2 diabetes and chronic obstructive pulmonary disease [1], [2]. On the other hand, there is a lack of skilled and professional staff with a rising need for people that could provide medical care. At the same time, data and communication knowledge is becoming one of the basics every day needs for the citizens. For example, doctors and nurses already have mobile phones such as cell phones, pagers, private digital assistants and various devices. Citizens are able to take advantage of modern mobile surveillance devices to provide them personal care, individual treatments, and tele-consulting systems [1], [3]. The new technologies and radio frequency applications have led to an increase interest in wireless communications for commercial use. The advanced technologies used in integrated circuits (ICs), as well as the advancement of physiological sensors and wireless technology, enable us to take advantage of these technologies to develop small physiological monitoring devices, which are lightweight, consumes low energy and intelligent. Through these devices could be formed as a wireless antenna network, by using this new technique enables us to get the physiological measures to improve the quality of monitoring in easy and convenient way.

1.2 MOTIVATION

The Real-Time Health Monitoring presented in this thesis that was specifically developed for make people help patients easier' heart rate tracking remotely patients 'and oxygen saturation in blood and temperature. Sensor network for real-time wireless patient monitoring can be able to protect oxygen deficiency and prevent it from serious complications of patients under observation. In case of the brain is not receiving sufficient oxygen, previous cases are named cerebral hypoxia [4], [5]. It can measure the heart rate, oxygen level in the blood, body temperature and predict the illness. By sending data to the smartphone, if a particular patient's health parameter degraded the threshold value, a buzzer running, and send SMS to doctor mobile number using a standard GSM module. A doctor is going to be continuously contacted which use GSM and could also obtain the patient's personal data by sending SMS to the central server. Now we can decrease cost, and energy spending as much as possible. On the other hand, we can develop and improve group efficiency by creating a monitoring system in real-time [4].

1.3 PROBLEM STATEMENT

This thesis is focus on an important feature which to be work more with Wireless Health Monitor System (WHMS) to improve the health care systems, so to be able to observe the advance or expansion of a possible medical crisis and be able to avoid it. In addition to decreasing largely health care expenses, particularly among patients with chronic diseases competent of getting care at home, and to attend a patient with chronic cardiac diseases when an increase in blood pressure potentially permits to look for help before the onset of a cardiac attack. To achieve this objective the components of the WHMS need to be recognized. Our real-time WHMS has the most important specifications of components as detailed below:

1. Wireless Health Monitor Device Size: The size of our WHMS must be suitable for achieving our purposes and also being easy to wear, and also contain all necessary components.

2. Sensors: The type and number of sensors are very important to get the required data. Otherwise our decision about the patient’s situation will be incorrect.

3. Control Application: We need a control application that is able to transmit data to the WHMS and get data from the smartphone for the patient. The control application must be easy to use and must show the data clearly.

1.4 OBJECTIVE

Design the proposed device is for measuring the heart pulse, oxygen level and body temperature for older people. The device is worn by hand and connecting with Android-powered smartphone via Bluetooth for data transmission. The smartphone will show the data directly using an application that is designed for this purpose. This WHMS device consists of microcontroller, sensors, smartphone, wireless network, and Android application. There are two main objectives to implement our research:

1. To make a wireless sensor network for monitoring patient in real-time can measure the heart pulse, oxygen level and body temperature for older people. Hence the device should be lightweight.

2. Build a system that operates at low power consumption and low cost.

1.5 THESIS OUTLINE

The General Overview, Motivation, Problems statement and Objectives are explained in the first chapter.

Chapter two is about the general overview of wireless feeler networking to monitoring patient in real-time and related works with them.

Chapter three consists of a mechanism that's been used in our work, the sensor and different components which used in the proposed system.

Chapter four we explained the programming part of the thesis. The microcontroller programming and smartphone application in detail.

Chapter five is the result and discussion of the thesis and comparing with a related work of the thesis.

Chapter six is the conclusion and future works of the thesis.

2. LITERATURE REVIEW

2.1 INTRODUCTION

A popular topic nowadays is the health monitoring systems and a significant research area. Many applications using wireless monitoring techniques have been developed such as hospital, sports training, military, and activity monitoring system. The improvement of wearable and the constant checking framework for elderly individuals who are beyond 60 years old are powerless against mishaps surpassing 60%. The proposed device will help specialists or relatives to monitor the highly sensitive situation of the patient or older who have been considered. The indispensable indications of the wellbeing condition, which is a significant measure in the wellbeing control framework, comprise of pulse, body temperature, blood oxygen levels, and circulating strain. That gives us a decent outcome in the body by utilizing quantities of sensors.

2.2 MEDICAL SENSORS

The sensors are devices used to sense and react to signals which are created from the physical surroundings. The input can be specific, such as heat, light, humidity, movement or stress or one of the many other phenomena. Overall output is a signal that can be changed into a screen to read it or send it electronically by the network or for added processing. There are many types of medical sensor, for example, ECG sensor which is working by placing two electrodes on the body skin and measuring the voltage difference between them, pressure sensor which is using the piezoelectric effect of dielectric medium to measure the value of pressure, a max sensor which is computing the ratio of absorption of infrared and red-light passing through a thin part of the human body to measure blood oxygen saturation with heart rate, and temperature sensor which is using the variations in the physical properties of materials to measure the temperature of the body.

2.2.1 ECG Sensor

The electrocardiogram sensor is a device used to set up- a wireless sensor network, transmit heart signals from a patient to a computer for monitoring and storing. Figure 2.1displays the block diagram of the ECG system. This device is employed for low cost and power and full mobility of patients by eliminating noise from the patient’s mobility by connecting these nodes together.

This design is prepared by three sensors, of the ECG. Figure 2.2 displays the three lead and bio signal amplifier. in which every node goes to a patient to get a sample from the waves of heart. After taking a sample of the heart wave sent to the other nodes which access the gate. The entry gate is often connected to a dominant node private digital assistant or computer. Finally, the samples are sent to the computer to check and collect the results to be presented. Wireless ECG proposed by [6].

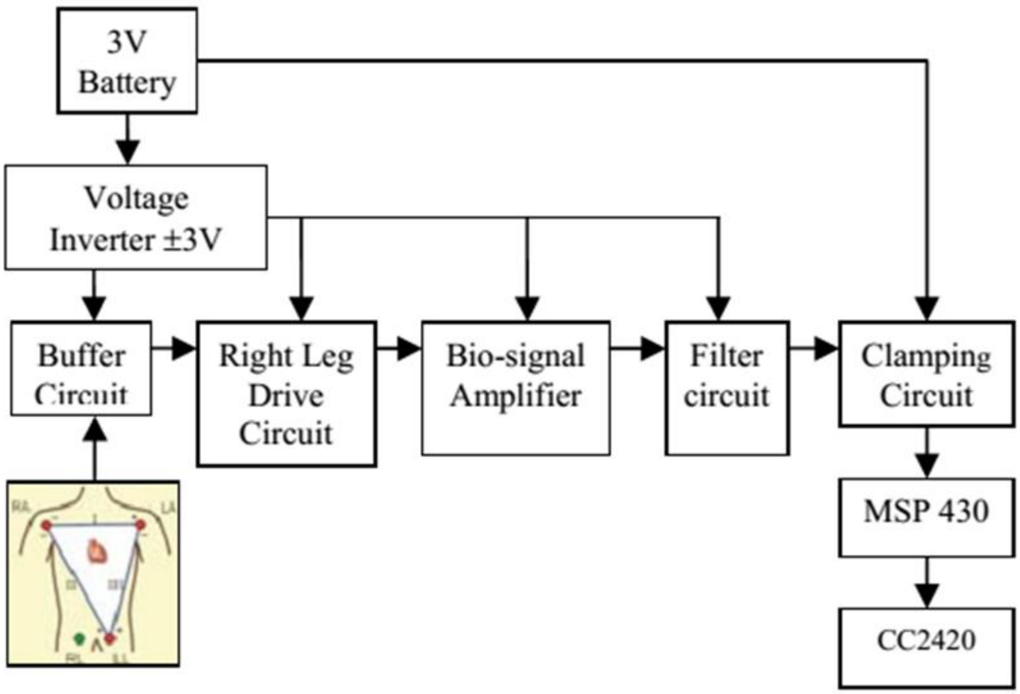

Figure 2.1: Wireless ECG System [6].

Figure 2.2: Bio Signal Amplifier and Signal Lead [6].

2.2.2 Optical Fiber Pressure Sensors

Fiber optics have inherent focal points which is reasonable to their little size and obstruction from electromagnetic meddling nature, making them appropriate for remote control. Figure 2.3 displays the fiber optic sensor. It has functional advantages because of its size which is really small, and also its immunity to the interference of electromagnetic devices and their suitability for remote monitoring and multiplexing together with being lightweight and flexible. Figure 2.4 the physical structure of Pressure Sensors. This implies the sensor can be replaced directly inside a patient [7]. The working standard of the past sensors relies upon the Fabry-Perot (FPI) [7], [8]. What's more Fiber Bragg Grating (FBG) methods [7], [9]. Its performance and highlights are similar and superior to commercially obtainable possible electrical pressure sensor. The utilization of electronic signal makes the optical sensors safe to radiofrequency (RF) signal, making them extraordinarily helpful. Optical sensors can likewise be sanitized, without effecting their properties. In the medical field, the response of a sensor to a physical stimulus and transmits a resulting impulse. In this way, the essential reason for a sensor framework is to precisely gauge a signal that empowers the well-being of a patient to be determined [7].

Figure 2.3: Fiber Optic Pressure Sensor [7].

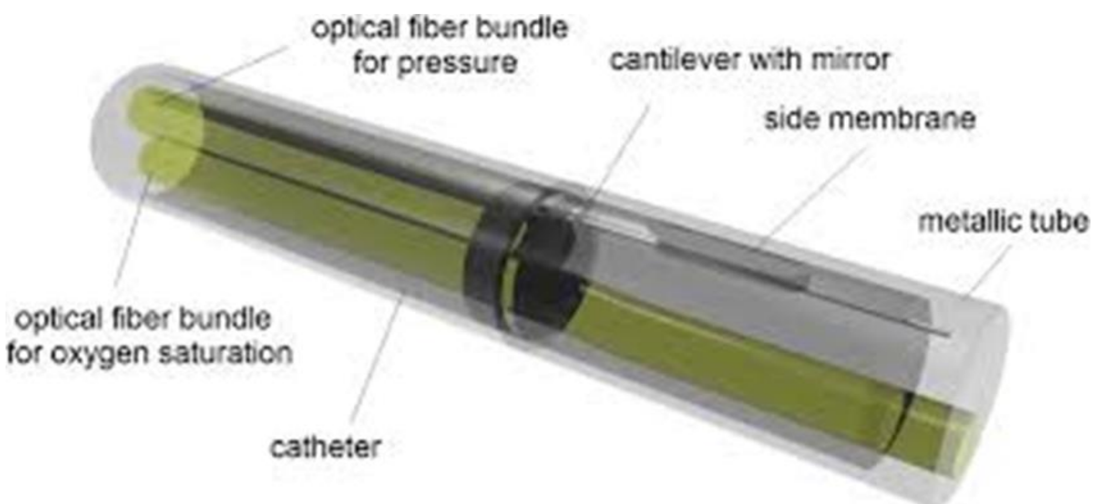

Figure 2.4: Fiber-Optic Pressure Sensors for Biomedical [7].

2.2.3 Max Sensor

It is a sensor to calculate the heart rate and pulse oximetry. Figure 2.5 displays the max sensor with component. It is made of two LEDs, improved optics, photo-detecting, and lower noise processor to observe the heart rate signals and pulse oximeter. One of the LED emits a red light and the other emits infrared radiation for pulse rate, infrared light is going to be used and both of them calculate the oxygen blood level. When the heart pumps blood to the body, an increase in oxygenated blood leads to more blood. During the comfort of the heart, the amount of oxygenated blood decreases. We can measure the time between increasing and decreasing pulse rate calculation. [10].

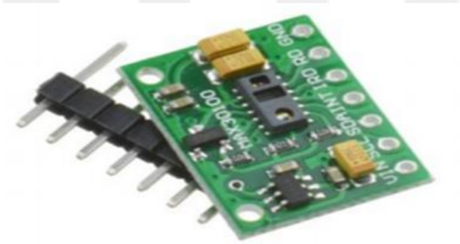

Figure 2.5: Max Sensor [10].

2.2.4 Body Temperature Sensor

The temperature sensor is a precise IC that is used for accurate temperature sensation. Figure 2.6 displays the physical structure of temperature sensor, Typically, a thermocouple or RTD, that provides for temperature measurement through an electrical signal. An RTD (Resistance Temperature Detector) is a variable resistor that will change its electrical resistance in direct proportion to changes in temperature in a precise, repeatable and nearly linear manner. A thermocouple (T/C) is made from two dissimilar metals that generate an electrical voltage indirectly proportional to variations in temperature. Figure 2.7 displays the electronic circuit of temperature sensor. The sensor has a benefit greater than linear temperature sensors calibrated in Calvin. The user does not need to put a large static effort, only a suitable scale of Celsius [11].

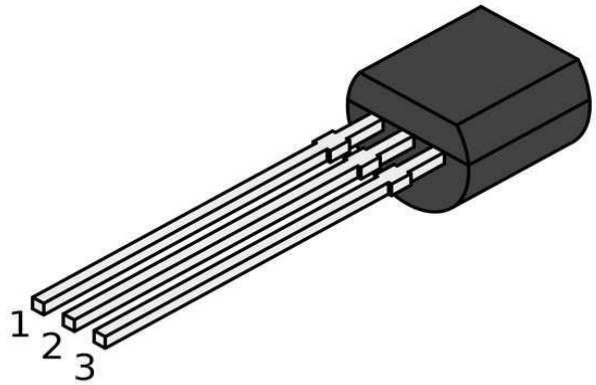

Figure 2.6: Temperature Sensor [11].

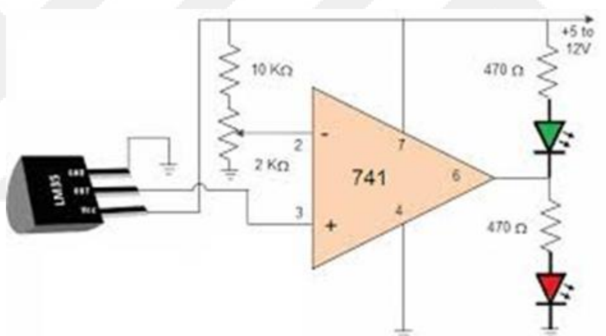

Figure 2.7: Block Diagram Temperature Sensor [11].

2.3 RELATED WORK

There are too many studies which have been suggested to set up a wireless sensor network to monitor patients in real-time in the literature. In this section, we investigated the existing researches.

"The real-time monitoring and detection of heart attack, using Wireless Sensor Network" had been proposed by [12]. They have verified the full information from a Wearable Wireless Sensor System (WWSS) is designed to continuously capture and transmit the ECG signals to the patient's mobile phone. Therefore, the checkup is offered to a doctor to show the record and offer the appropriate instruction for the patient distantly. This study can also propose the design of heterogeneous wireless networks for continuous transmission from a wearable wireless sensor system to a central point (CDC). The suggested system by the included lively data compilation that combines heart signals with a systematic algorithm based on the perceived health risks of each patient.

By using "enhanced real-time multi-patient monitor classification depend on the networks of wireless sensor", the researcher [4]. Improved the power management of the real-time multi-patient monitor system. Wireless Personal Area Network (WPAN) was developed by adopting Digital Signal Processing (DSP) in the proposed system, that gives us a chance to monitor 20 patients in real-time. This system is low in energy consumption, and used for long distances, and would be appropriate for poor countries where there were no frameworks depend on Internet phone lines and the Global Positioning System (GPS). The utilization of the XBEE and PIC1 8F2550 interchanges processor to do the surveillance system that has reliability and small size based on intelligence.

In 2012," real-time health monitoring system on a wireless sensor network" had been proposed [13]. This system is used to monitor the patient remotely and monitor the vital signs of oxygen saturation and heart rate. Using ZigBee wireless technologies that the researcher to implement the system. This study used a program that can adjust power management, sensor modules are designed to run on low power, according to power source scenarios and current power operation. Figure 2.8 displays general block diagram of system [13].

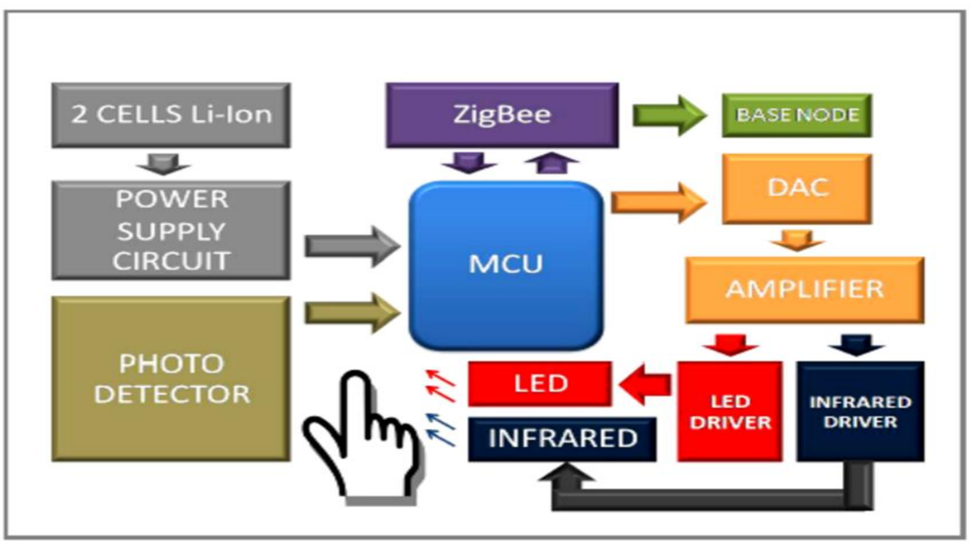

Figure 2.8: Block Diagram Showed System Architecture [13].

In 2013," a real-time multi-patient monitoring system" has been proposed [14]. They examine the efficiency and improve the real-time by using ZigBee node configured as co-coordinator. If the patient's vital signs are below normal or higher, an alert is triggered to warn the patient of the patient's health problems by means of a whistle device via ARM server. In addition to sending an SMS to the doctor's phone number in advance using the standard GSM module connected to ARM server. The doctor can communicate continuously with the patient via an ARM server using GSM Module and can obtain medical information for the patient's record by sending an SMS only to the central ARM server. So in this research has been able to reduce cost, power consumption and treatment time greatly. At the same time, this study has been able to increase the efficiency of the inspection by making the device more powerful in real-time.

By using "E-health monitoring architecture", the researcher [15]. Improved value-added services adopted the "Real-Time Health Control Act" (ReTiHA), and the health control of older persons by their families outside the home. This study designed a device to monitor the patient for one person at home or several people in the hospital and health units. Figure 2.9 displays block diagram of E-Health Monitoring. It's used of mobile devices to enable us to transfer data over the Internet reducing the overall cost of the system [15].

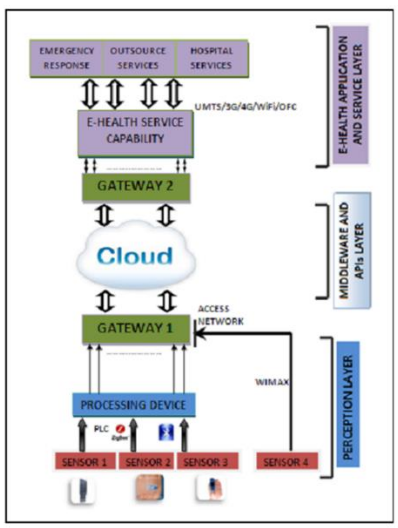

Figure 2.9: E-Health Monitoring Architecture [15].

In 2014, “Remote Monitoring of Patients Health by using Wireless Sensor Networks” had been proposed by [16]. The researched have tested the application of wireless technologies to reduce the doctor's visit to the home only in critical cases. Its identifies the patient's vital signs through monitor the sensors, and then transfer data to the Personal Digital Assistant (PDA), using ZigBee technology and using 3G connections. The advantage of this system is to increase communication coverage and speed. The scheduling of primary data is limited to increasing the rate of transmission of physiological signals that improve the bandwidth measurement rate. The procedure reduces the delay in sending physiological biomarkers and improves them to become more bandwidth. At present, wireless technology is very important in health care, with the increased use of mobile phones and wireless networks.

Medical sensors connected to a microcontroller checks whether the patient is in good health or not by scanning the vital parameters. Figure 2.10 displays the block diagram and component of the Health Monitoring. If the medical results are abnormal, the embedded unit will use the phone of the patient to transmit data to the medical center, the doctor inform the patient about what to do to prevent anything dangerous from happening and save the patient's life [17].

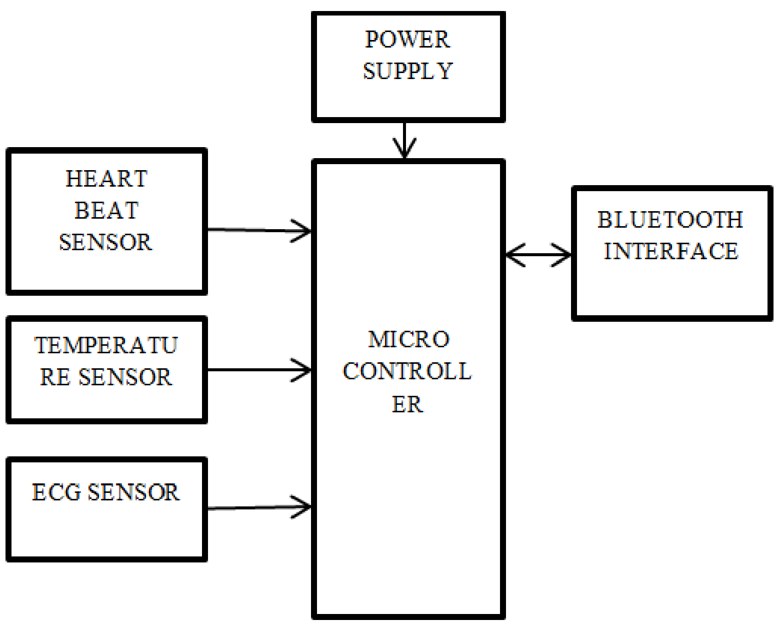

Figure 2.10: Block Diagram Showed Health Monitoring and Alarming [17].

“The Wireless Sensor Network for Health Care Monitoring in Hospitals via Mobile” suggested by [18]. To use a mobile phone application by setting up a wireless sensor network for medical surveillance. So, it is proposed a central server will be able to read patient data received from the sensors and send it to the mobile phone application. Figure 2.11 displays the component of the health care monitoring in hospitals. The potential advantages of utilizing remote sensor arrange in healthcare applications, so it can easily access updated patient data anytime, anywhere. This framework associated with the Internet and easy to wear. The quick reaction to crises is through by utilizing this framework. This study can provide amenities for both patients and health care providers [18].

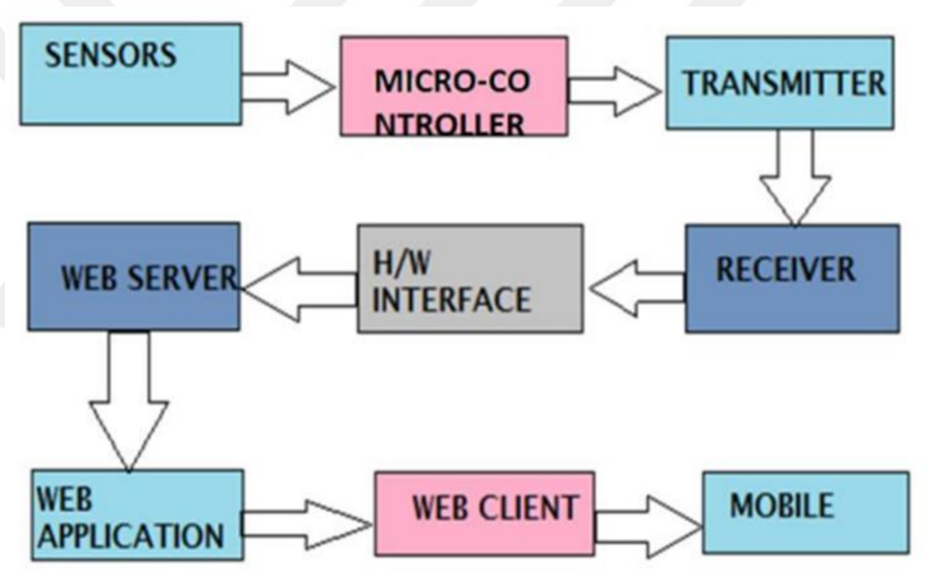

Figure 2.11: Block Diagram Showed the Health Care Monitoring in Hospitals Via Mobile [18].

"The fast ambulatory system for cardiac patients using GSM network and ECG signal" had been suggested by [19]. In the early identification of the critical condition in cardiac performance, this study can give sufficient opportunity to help the patient with heart failure. Through the filter response and a limited ECG, the framework creates alarms to the screen when the time range of the complex QRS wave is exceeded in the ECG signal. They use a low-pass FIR filter to pass the normal range to send an emergency alarm via a GSM mobile phone. Figure 2.12 displays the structure of the system [19].

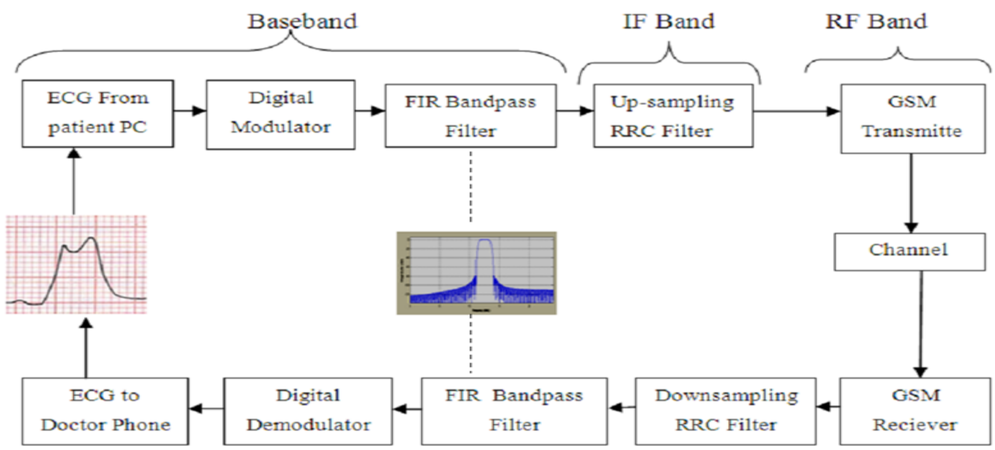

Figure 2.12: Design for ECG Transportation Using the GSM System and MATLAB [19].

This research is focus on patients wireless monitoring in hospitals. The aim of this research is also to build an initial wireless control system. This study is the most appropriate techniques for building the most effective wireless health surveillance systems. The sensor nodes and receiver were designed. The android phone act as a gateway to receive and forward the data from the sensor to the receiver. Bluetooth Low energy was used to communicate between sensor nodes and android phone. The researcher used Wi-Fi through sensor readings at the beginning of the Arduino Serial Monitor and then send it to the node. Sensor readings are displayed on an Android phone as well as on the website [20].

In 2017, “Design and Implementation of Real-time Wireless Sensor Networks based on multi-patient health care monitoring system"[21]. Its collecting data which provided by the sensor and sends them to the base station. The attached sensors on the patient's body form a network of wireless sensors (WBSN) and that gives us the ability to detect heart rate and blood pressure.

By using the “Application and Design of Patient Temperature Acquisition System Based on Wireless Sensor Network”. It can check the temperature of the patient's body on a Wide-scale efficiently, learn and know the phenomenon of irregular temperature. The researcher can to remote temperature sensor arrange by using the ZigBee for the site, measured the temperature, and gather and record clinical information on temperature. The temperature observed system is accomplished through the (RS-232) sequential and the PC. The PC gets information, shows it and rules it through a sequential port. The framework demonstrates that it is possible to achieve the acquisition, control and transmission of a multitude of temperature signals and send alarm at abnormal temperature.

In this way, it can have used the framework broadly in the clinical estimation, and to be good for generalization in a big hospital with a large number of patients. The ZigBee together framework is based with respect to the equipment and programming usage of the framework for temperature checking, through streamlining of the terminal securing hub of scaling down and low power use. The exploratory outcomes demonstrated that the study can address the issues of estimation precision and direct checking of patients on an enormous scale [22].

In 2017, "a real-time healthcare monitoring system using wireless sensor network" had been proposed by [23]. Through an examination of the set-up, evaluation, and implementation of the portable WHMS, it found a range of medical sensors connected to a controller embedded with the wireless communication module. The scanning of the medical sensors for the built-in controller if the patient's health is normal or not. When an abnormal condition occurs, the combined units send measured signals to the medical center via the Internet. Through patient health indicators, the doctor sends medical advice and examined the results and check that the system if its accurate clear in control and reliability in communication and can be used as a portable medical group to monitor patients.

"The Design of Medical Applications using Wireless Sensor Networks" was suggested by [24]. Through this evolution, low-cost wireless sensors have been introduced. The small size of this technique enables us to inject it even in the human body to health care. This development had a tremendous impact on the medical healthcare scenario. Small sensor devices enable us to easily replace traditional equipment and procedures. The wireless sensors provide continuous monitoring, avoid dangerous situations and take appropriate precautions for emergency situations. By identifying very important design constraints such as safety, delay, accuracy, and privacy in these applications, this study looking for appropriate solutions to improve technology in wireless sensors. Various applications allow the researcher to monitor the patient and alert doctors and caregivers in critical situations if there is a risk to the patient. The small size of the sensor does not affect the patient's daily routine.

"The wearable low-power health-monitoring instrumentation based on a Programmable System-On-Chip" had been suggested by [25]. The purpose of the research is to find and set up a system containing a small portable device connected to sensors to detect the activity of the autonomic nervous system, that can control temperature, skin resistance, and heart activity. Figure 2.13

displays the component and features of system. The (PSoCTM) device consists of a digital block and an 8-bit microcontroller unit (MCU) on a single chip, dynamic, configurable with mixed-signal arrays. In order to make lower (CPU) consumption, these indicators are included in the (PSoC) engineering device for real-time detection. [25].

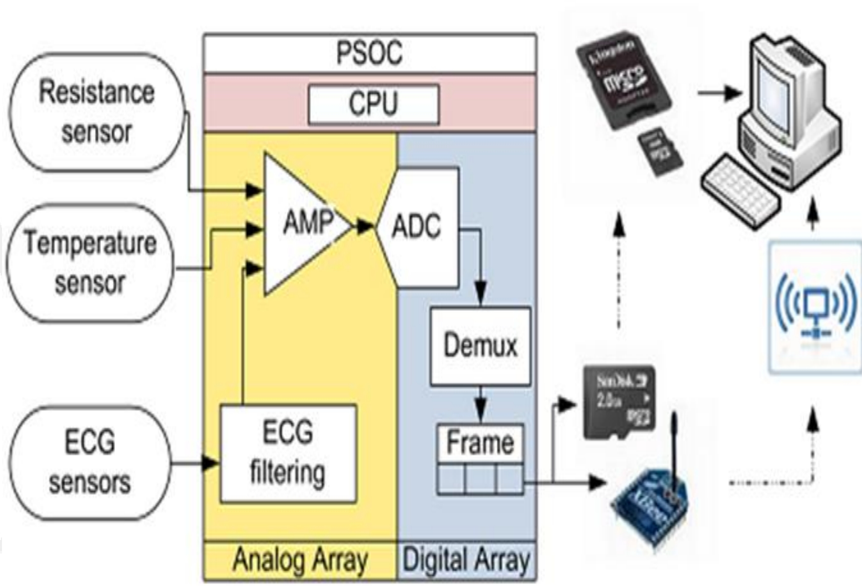

Figure 2.13: System Architecture [25].

The research [26] by using "the Patient Health Management System uses e-Health Monitoring Architecture", it checks the soundness of the patient utilizing GSM, and discovered it relies upon cell phones, and sensor systems to get to the patient's wellbeing status progressively. The primary focal point of the gadget is by facilitating patient observing by specialists remotely, in the medical clinic or at home. The framework is executed by combining GSM module with the microcontroller. Figure 2.14 displays the physical structure of the system [26].

Figure 2.14: Design of System [26].

"The Proposal of a Remote Monitoring System for Elderly Health Prevention" had been suggested by [27]. It proposed device architecture in terms of data privacy, security and user experience. The focus of this device is to monitor older people in terms of privacy and security of patient medical data. In general, the researcher intends to develop an Android TV GUI to provide better experience to the user, work with multimedia data to better handle data.

In 2018, "An Android Application for Geolocation Based Health Monitoring, Consultancy and Alarm System" had been proposed by [28]. The available facilities that can find them in mobile phone technology, it can use to monitor the heart rate by geolocation in the system. The framework can send SMS alert message and notifications to a doctor for consultation by using advanced mobile applications. The doctor can diagnose abnormalities in heart rate fluctuations during various activities, according to these alerts and messages, it can prevent delays that have critical effects. The same mechanism is used to add different sensors to monitor different physiological signals, by measuring the pulse rate signal from the pulse sensor that it is sent to the smartphone via Bluetooth technology. Figure 2.15 displays the operating system in real time. also uses an internal GPS sensor that allows real-time location tracking. Through the development of a warning system to send the geographical location of emergencies, the framework can have analyzed data based on patient profile characteristics such as age, gender, and state. [28].

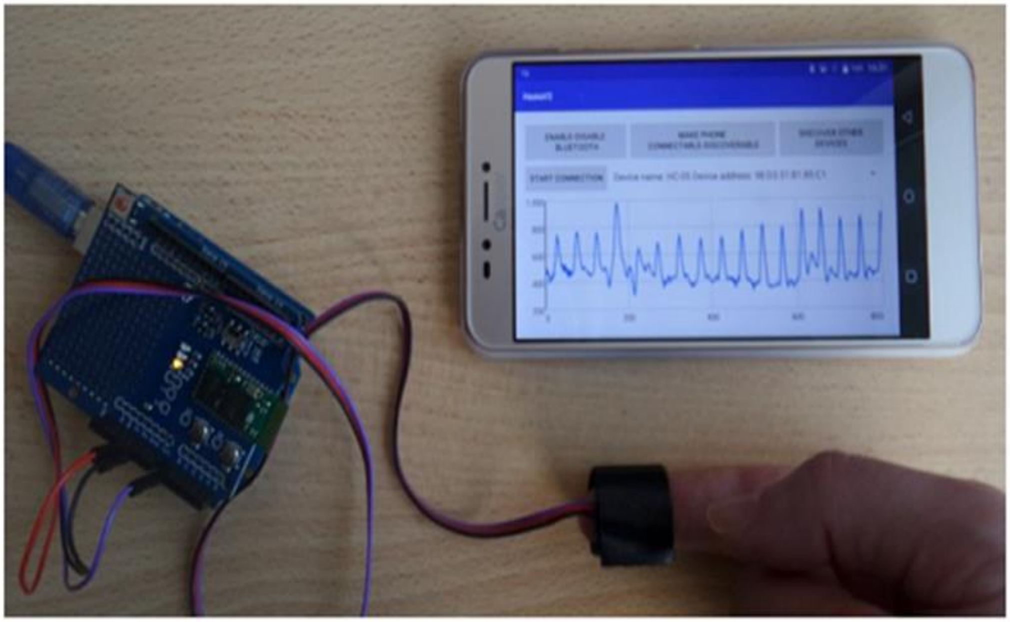

Figure 2.15: Wireless Transmission and Real-Time Monitoring [28].

3. HARDWARE COMPONENTS AND ASSEMBLING

3.1 INTRODUCTION

This thesis proposed to set up an implementation of real-time monitoring system with alarm for patients who needs continues health care and help older people to check their health by measuring the body temperature, heart pulse rate and oxygen level in the blood. The device will be worn by the hand and connected to Android smartphone using Bluetooth for sending the data. The smartphone will show the data directly using an application designed for this purpose. In addition we set up the control card using Atmega328P which is a microcontroller performing the entire task. We put all the required ingredients to make, such as the controller board. In this case, the patient considered as a node in the wireless sensor network and connected to the central node complex in the medical center through an Internet connection. Integrated control ensures whether the patient's health is fine or not through the analysis of scanned vital signals. If the analysis outcome is abnormal, this compact unit uses the patient's phone to transmit signals directly to the medical center or doctor. The implementation results show that the proposed circuit consumes less power compared with the conventional circuits.

3.2 COMPONENTS

The components used in the device will be explained in details and their features are explained. So the aim of this chapter is to introduce all details of used components and the main usage of this method assembling.

3.2.1 The Control Board

A microcontroller is a small computer in the form of one integrated circuit. It consists of one or more central processing units (CPUs) with memory and peripheral devices through which we can programmable I / O. Program memory is included in the form of OTP ROM on the chip, (RAM) or (NOR) flash memory, with a few RAM. like microprocessors used in personal computers, or which consist of separate chips, so microcontrollers are designed for integrated applications.

Microcontrollers are used in many products that are automatically controlled, such as medical devices, etc. Some microcontrollers use four-bit words and operate at low frequencies to reduce power consumption. Energy consumption is just Nano-watt, while sleep. To be suitable for applications that need a long-lasting battery [29].

In the table below, we will compare the famous micro-controllers available in the market [30].

Table 3.1: Micro-Controller's Comparison [30].

Types	**ATmega2560**	**ATmega328P**	**ATtiny 85**	**PIC16F 877A**	**Atmega 16**
Program Memory Type	Flash	Flash	Flash	Flash	Flash
Program Memory Size (KB)	256	32	8	14	16
CPU Speed (MIPS/DMIPS)	16	20	20	5	16
Data EEPROM /HEF (bytes)	4096	1024	512	256	512
Digital Communication Peripherals	4-UART, 5-SPI, 1-I2C	1-UART, 2-SPI, 1-I2C	1-SPI, 1-I2C	1-UART, 1-SPI, 1-I2C1-MSSP(SPI/I2C)	1-UART, 1-SPI, 1-I2C
Capture/Compare /PWM Peripherals	4 Input Capture, 4 CCP, 16PWM	1 Input Capture, 1 CCP, 6PWM	5PWM	2 Input Capture, 2 CCP,	1 Input Capture, 1 CCP, 4PWM
Timers	2 x 8-bit, 4 x 16-bit	2 x 8-bit, 1 x 16-bit	2 x 8-bit	2 x 8-bit, 1 x 16-bit	2 x 8-bit, 1 x 16-bit
ADC Input	/	/	/	8 ch, 10-bit	/
Temperature Range (C)	-40 to 85	-40 to 85	-40 to 85	-40 to 125	-40 to 85
Operating Voltage Range (V)	1.8 to 5.5	1.8 to 5.5	1.8 to 5.5	2 to 5.5	2.7 to 5.5
Pin Count	100	32	8	40	44
Low Power	/	Yes	/	/	/

From the compassion Attiny85 and Atmega328p microcontrollers that have the highest CPU speed so it can be one of these two microcontrollers.

For Attiny85 has two basic disadvantages:

1. The number of pins is not enough to connect Bluetooth, temperature sensor, and the heart sensor.

2. The heart sensor Max30100 library not available for this chip.

On the other hand, figure 3.1displays the Atmega328p and all the required pins. The library for Max30100 sensor is also available for this microcontroller. The Atmega328 categorized as a low power microcontroller as well. For this reason, it can be choosing Atmega328p.So, the component that involve in the structure of the control board is:

1. Atmega328P
2. FTDI USB to TTL serial adaptor module
3. L7805 voltage regulator
4. 16Hz clock crystal
5. 22pf ceramic capacitor
6. 10 uf capacitor

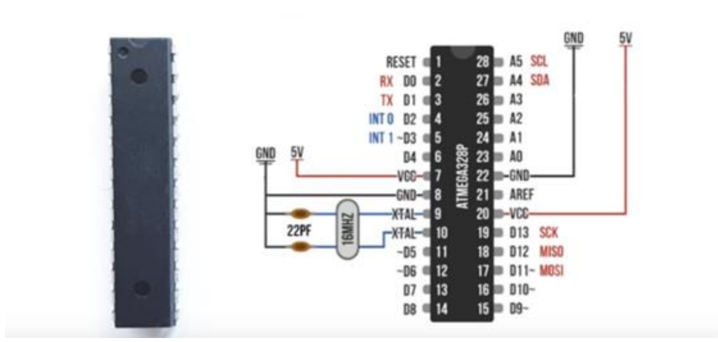

Figure 3.1: Atmega328p with its pins and Ingredients.

3.2.2 Sensors

The sensor is a device through which it can respond and detect the physical environment. The specific input is heat, light, humidity, movement, stress or any other natural phenomena. The output is a signal that can personally read after converting it to a screen in the same place that has a sensor or being sent to other place for processing purpose or to be read after being sent electronically.

3.2.2.1 Max30100 sensor

Figure 3.2 displays the Max sensor with component, which is used for sensor and control blood oxygen and heart rate combines two lamps with improved optics, as well as low-noise analog signal processing to detect heart rate. It consists of two LED indicators, one red light measures the oxygen rate in the blood and the heartbeat and the other is the infrared light to work together. The blood flow from the heart is an increase in oxygenated blood, which leads to more blood. At rest time the heart has less amount of oxygen in the blood. The difference between the increase and decrease of oxygen can provide us with the pulse rate.

Figure 3.2: Max30100 Sensor.

3.2.2.2 Body Temperature Sensor

Figure 3.3 displays the LM35 sensor with component, that consists of a circuit with an output voltage that can measure the temperature, the output voltage of LM35 rises by 10 milliseconds per degree Celsius in temperature, it can range from -55 ° C to 150 ° C**.**

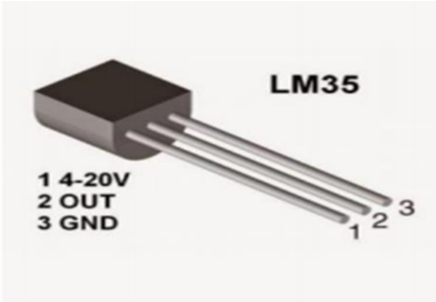

Figure 3.3: Temperature Sensors (LM35).

3.2.3 Battery

Figure 3.4 displays the lithium batteries, which utilized in our gadget are lithium polymer known as LIBO We used a few sorts of lithium in these batteries for instance of lithium manganese or some other kind of Lithium. There are many types of batteries, for example, (NiCad), lead-corrosive and (NiMH). When contrasting these batteries with a lithium battery, these batteries have many weaknesses. It's better to use lithium batteries due to these points of interest, high limit, and low weight, just as the charging speed from different batteries.

The most important factor to be considered to choose battery is the voltage. It is an important to measure. It can make a lithium battery from collecting a number of cells. Each cell gives us 3.7 volts. Through cell collection, we can determine the precise voltage. It can be connecting two 3.7-volt lithium batteries with a capacity of 2000 mA respectively, getting 7.4 volts with a capacity of 2000 mA. In this case, the proper way must be chosen to ensure that charge is fast, according to the capacity of the battery charger and voltage.

Figure 3.4: Lithium Polymer (LiPo) Battery.

3.2.4 HC-05 Bluetooth Module

Bluetooth is the master or slave unit, as figure 3.5 which is one of the most famous communication devices in the world. It is used to transfer data between the device and the smartphone. All smartphones have Bluetooth, and Bluetooth protocols are easy to use. It can change the features of the device directly after connecting it to the computer. Examples of these features are the status name, and password.

The Bluetooth module that connects to the microcontroller is mainly used to receive and transmit data. The Bluetooth model used in our device works between 3.6 volts and 6 volts. To connect a Bluetooth device to another device such as a computer or smartphone, it is sending data that are coming from the microcontroller through the (TXD) pin. Receiving data from the other device and Pass it to the microcontroller via the (RXD) pin in the microcontroller panel. There are two main conditions required to connect Bluetooth to other devices:

• Every contract must be between the slave and the master.

• Each device must enter the correct password.

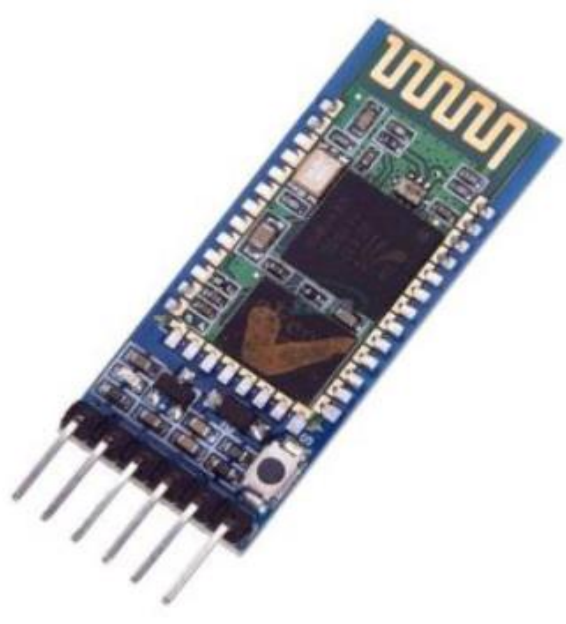

Figure 3.5: HC-05 Bluetooth Model.

3.2.5 Smartphone Application

This application designed using the MIT app inventor. Intuitive, visual programming and open source medium to build fully functional apps for tablets and smart phones, this application has one window which contains the name of the project (real-time wireless health monitoring system) and their labels each one pointing to one value such as the oxygen level, pulse rate, and body temperature. Figure 3.6 displays of the application. It has also a button to set up the connection between the smart phone and the device by the Bluetooth.

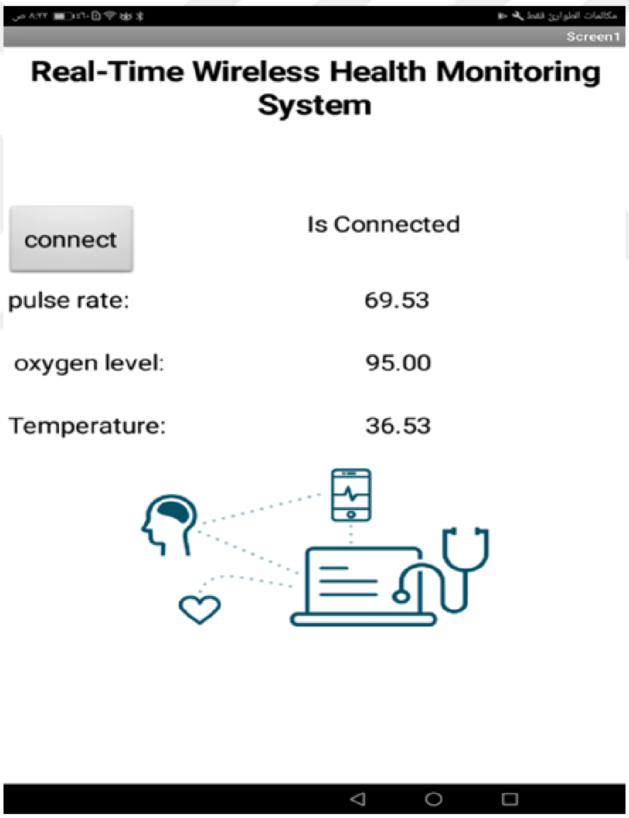

Figure 3.6: Application Windows View.

3.3 COMPONENTS ASSEMBLING

The first step is setting up the voltage of the circuit to 5 volts. The 5 volt is a suitable voltage for Atmega328p and all the sensors. We have used a voltage regulator for achieving this aim. After that, we connected the Atmega328 as we have showed before in the components part.

The next step is establishing the sensors. We have two sensors. Both - of them are fed with power directly from the voltage regulator. The data pin for the LM35 sensor is connected to analog pin 0. The Max30100 sensor contains 3 data pins which are connected to Analog pin 5, Analog pin 4 and digital pin 2.

The last connection is the buzzer. The buzzer has two pins. The negative pin is connected directly to the ground while the positive pin is connected to digital pin 4. When an emergency situation occurs, the digital pin 4 will produce a signal which makes buzzer ring.

A block diagram for system architecture is depicted in Figure 3.7, while the internal circuit of our device is given in Figure 3.8, the fabricated device is given in Figure 3.9.

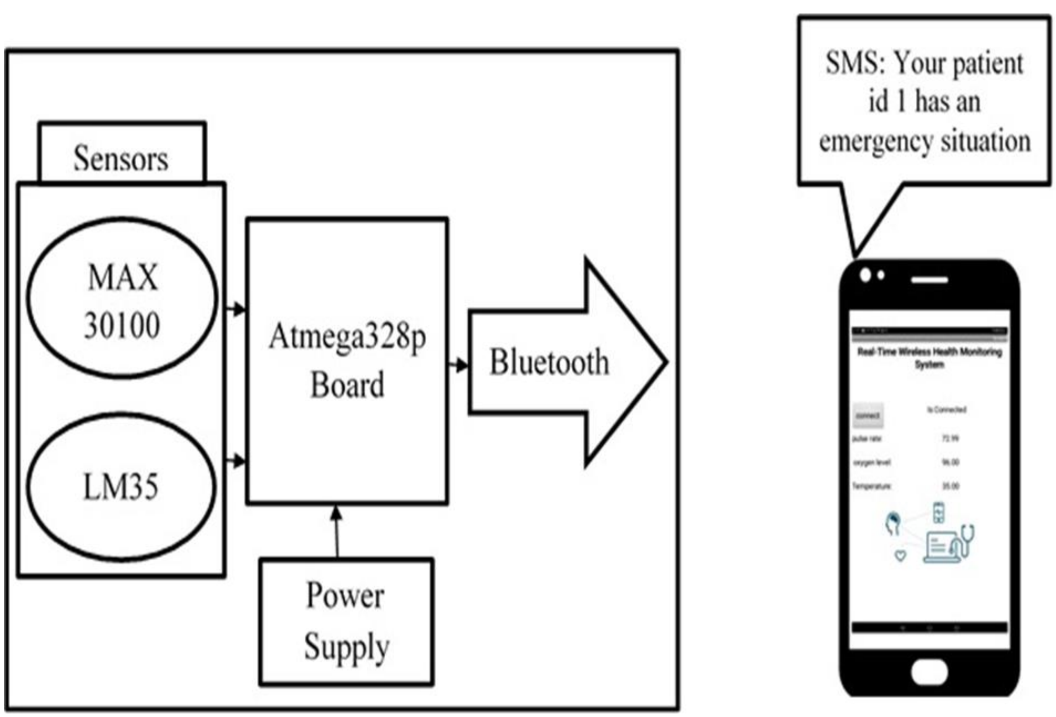

Figure 3.7 Block Diagram Showed System Architecture.

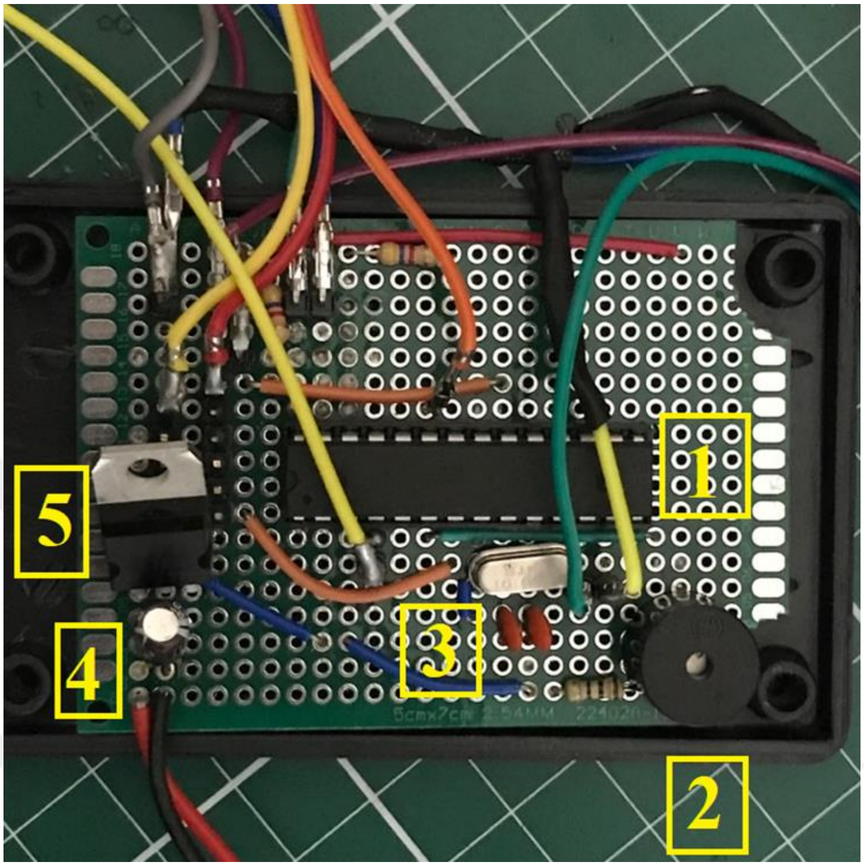

Figure 3.8: The Internal Circuit of the Proposed Device.

The figure above shows up the inner circuit of our device is made up of:

1. Atmega328
2. Buzzer
3. Clock crystal
4. Ceramic capacitor
5. Voltage regulator

Figure 3.9: Fabricated Device.

4. PROGRAMMING AND CONTROL INTERFACE

4.1 INTRODUCTION

This chapter explains the program part of the thesis. The microcontroller programming and smartphone application will be explained in detail. The program has two parts. The first one is the program that will be in the Atmega328 controller used in our device the software that will be in the microcontroller is responsible for receiving data from pulse oximeter sensors, heart rate and temperature. It is also the responsibility to send data collected from the sensors in the smartphone application via Bluetooth. The second one is the programming which used for the smartphone application and displaying the received data from the sensors.

4.2 ATMEGA328 CONTROLLER SOFTWARE

The Atmega328 controller Software that was built using the Arduino integrated development environment or as known as Arduino software (IDE). Figure 4.1 displays the environment for the typing codes. This environment allows the developer to write their programs in the text editor by using the toolbar which has a lot of functions and menus. This software on text editor by using the toolbar which has a lot of functions and menus. This software connects to Arduino boards using the USB port to upload the written program. The code which connects to Arduino boards was written by the developer known as sketches and it is saving as into a file.


```
#include <Wire.h>
#include "MAX30100_PulseOximeter.h"
#include<SoftwareSerial.h>

SoftwareSerial mySerial(6, 7);// RX , TX

#define REPORTING_PERIOD_MS     1000

PulseOximeter pox;
int i=0;
int LED = 13;
int buzzerPin = 4;
const int sensorPin = A0;
float reading;
float voltage;
float temperatureC;

uint32_t tsLastReport = 0;

void onBeatDetected()
```

Figure 4.1: Arduino Integrated Development Environment.

As we see in the figure above, there are two main parts of the text editor. The setup area and loop area. In the setup area, the user can set up the (I/O) pins. The communication type with the data rate in bits per second of serial data transmission as well.

In the loop area, the user can write the instructions which will implement in a loop cycle. This instruction can be output signal such as Light, sound... etc. Or can be input signal such as sensor readings. First code contains three libraries. The first for wire, second for Max30100 sensors and Third for Bluetooth.

Library for wire: This library enables Arduino panels to be connected to I2C / TWI devices. The SDA (data line) and the SCL (clock line) are located on pinheads near the AREF pin.

Library for Max30100 sensor: This library is designed to interface with the Max30100 sensor to Heart Rate and SpO2 sensor chip. The current status of the library allows reading of the Infrared Radiation (IR) values for the Heart Rate determination and the manipulation of any register.

Library for Bluetooth: This library is designed to interface with the Atmega328 control software. The current model allows the library to receive and transmit data to the Atmega328 controller.

In our code, the setup pane must set the serial data transfer. We used a data rate of (38400) bits per second, the default baud rate for Bluetooth HC-05. Pins 6 and 7 are used for Bluetooth. Pin 6 represents the receiver's data while pin 7 is the transmitter. In the section of the loop, we will first check whether the data come from the serial port or not. The signal is input or output out. The loop area also contains the sensor part. Each sensor has a number of code lines. These lines work to calculate data and convert it to a suitable value that can read by the human. The next paragraphs explained the details with each sensor:

4.2.1 Temperature Sensor

As we mentioned in chapter 3, the temperature sensor connected to analog pin number 0. The first step we will read the incoming value from the analog pin 0 and put it in the variable reading unit.

The incoming value from the sensor is an output of 10mV per degree Celsius. The Atmega328

ADC (Analog Digital Converter) reads a voltage and outputs a number according to:

1. The reference voltage

2. The bit width of the ADC.

In Atmega328, the reference voltage is 5V and the ADC bit width is10 bit mode, so Equation 4.1 will be used to convert this value to temperature.

$$Voltage = (reading /1023) *5000 \tag{4.1}$$

This is the required steps to convert the incoming data from the temperature sensor to Celsius. After that, we will send the value by the Bluetooth. The sending process includes the variable value preceded by the letter T. This letter will help the receiving program to recognize this value as a temperature value.

4.2.2 Blood oxygen and heart rate Sensor

As explained in Chapter 3, the Max30100 sensor contains 3 data pins connected to the analog pin 4, the analog pin 5 and the digital pin 2. We put a counter greater than zero to confirm the presence of the patient, then put a condition for the fact that the counter is greater than 50 and less than 100 to ensure the patient's health is fine other than consider is a heart attack. The scale is kept for 30 seconds to ensure patient health. At the same time, the bell sends a frequency of 600 Hz for 30 seconds. Otherwise, the normal state of the patient.

4.3 MIT APP INVENTOR

MIT App Inventor is a visual programming environment that allows each person to design fully functional apps for smartphones and tablets. It is working based on blocks tool facilitates. This block based tool facilitates create complex, high-impact apps in significantly less time than traditional programming environments. The MIT App inventor project seeks to democratize software development by empowering all people, especially young people, to move from technology consumption to technology creation.

The platform of MIT app inventor runs through Google chrome platform. Figure 4.2 displays the front view of designing application. Any user can register for free and start coding.

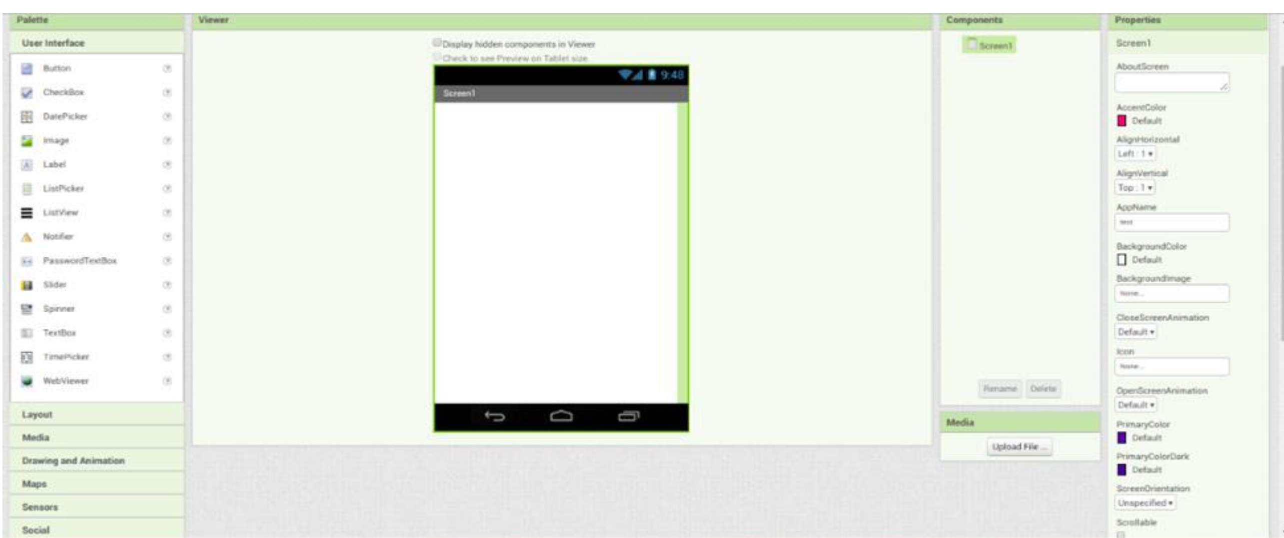

Figure 4.2: MIT is starting interface.

This part of the interface enabling the client to plan the application by adding button, check-box, label, etc. Subsequent to completing the design phase, Figure 4.3 displays the subsequent interface contains the squares of coding. The client can set up any program without composing anything. For each activity, there are many choices. The client can choose a suitable tool from this selection.

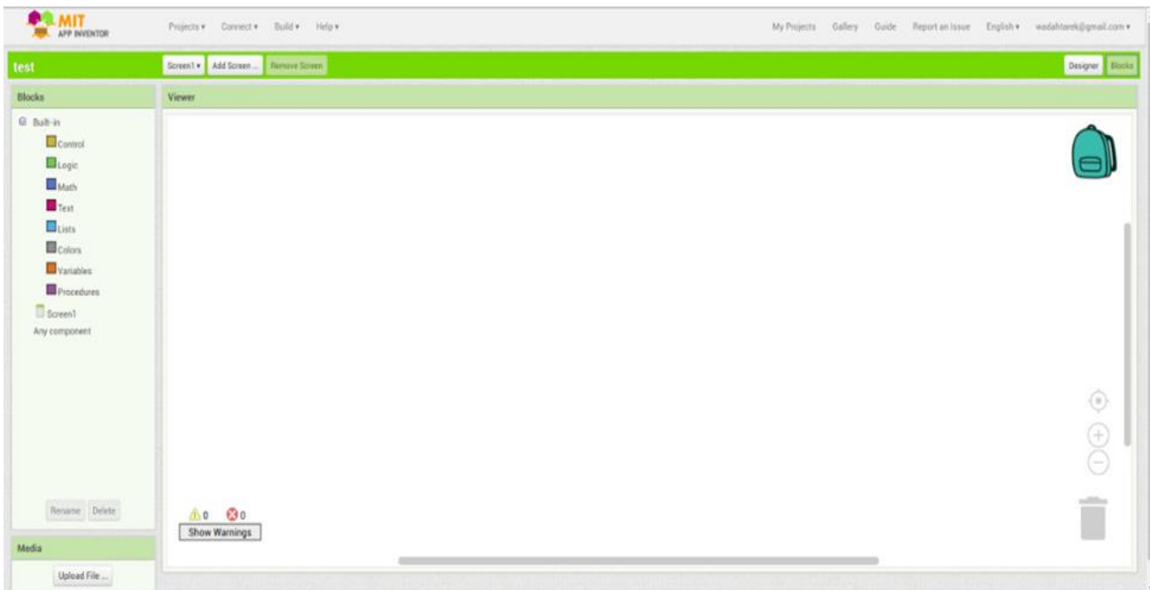

Figure 4.3: MIT coding interface.

The above Figure shows many options such as control, logic, math, etc. Each one contains many options., when we press on the control box, for example, Figure 4.4 displays the box that contain block equation. all control functions will appear and we will choose the appropriate one.

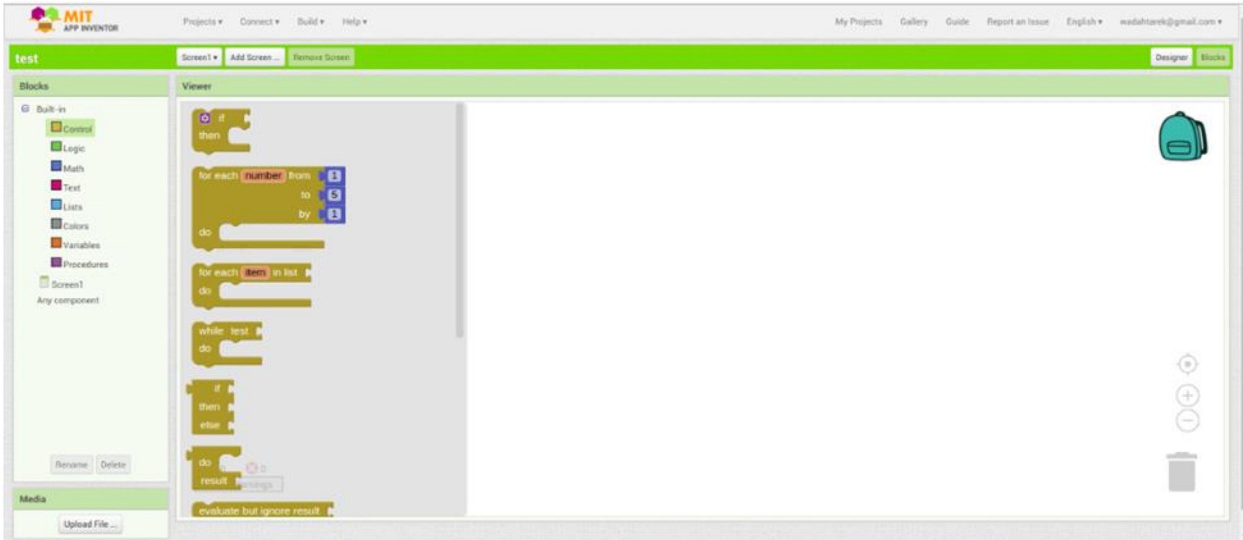

Figure 4.4: Control box.

The interface contains the list-picker and many labels. Figure 4.5 displays the screen shoot of the application that can access to the recoding information and other features. The list-picker work as a button. It is showing all available Bluetooth devices in the range. The labels are responsible for displaying the received data by the Bluetooth. There is also clocked, Bluetooth client and texting tools added to the interface. The clock is synchronization. Bluetooth tool for managing the connection with other Bluetooth devices. Finally, texting responsibly for sending SMS messages. The texting tool contains text message and a phone number that saved it and it will send this message to the saved phone number.

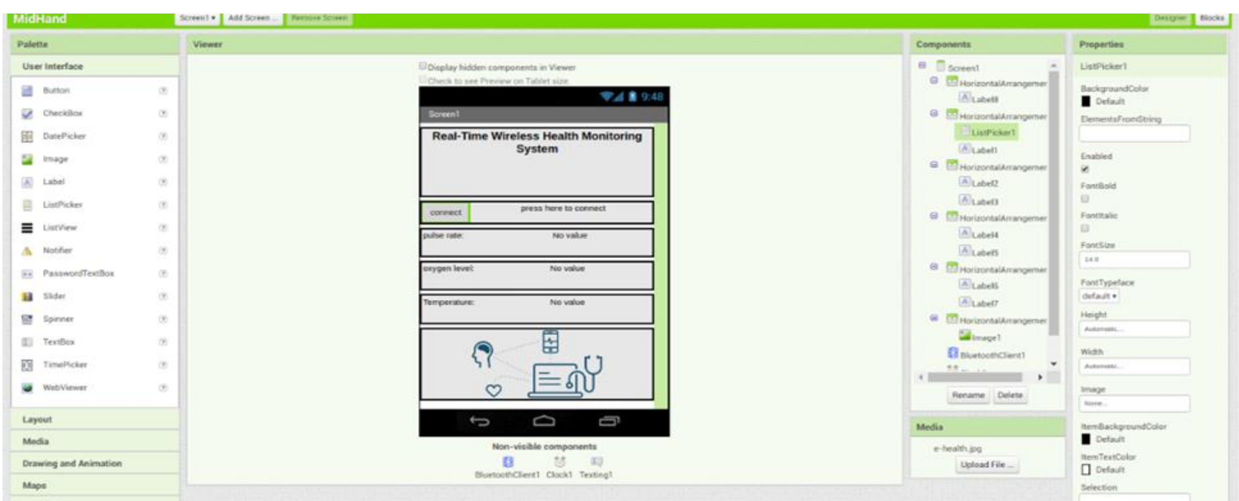

Figure 4.5: The interface of the application.

After selecting the Bluetooth device and start receiving the data, the code will create a list for saving these data. Each value appears in a suitable label. Figure 4.6 displays the incoming data going to be ordered by this way: pulse rate, oxygen, body temperature, and emergency situation. The fourth part of the list, which is the emergency situation represented by 1 and 0. If it is 1 that means, there is an emergency situation and the application automatically will send a text message to the saved phone number in the application, and if its 0 there is no emergency situation.

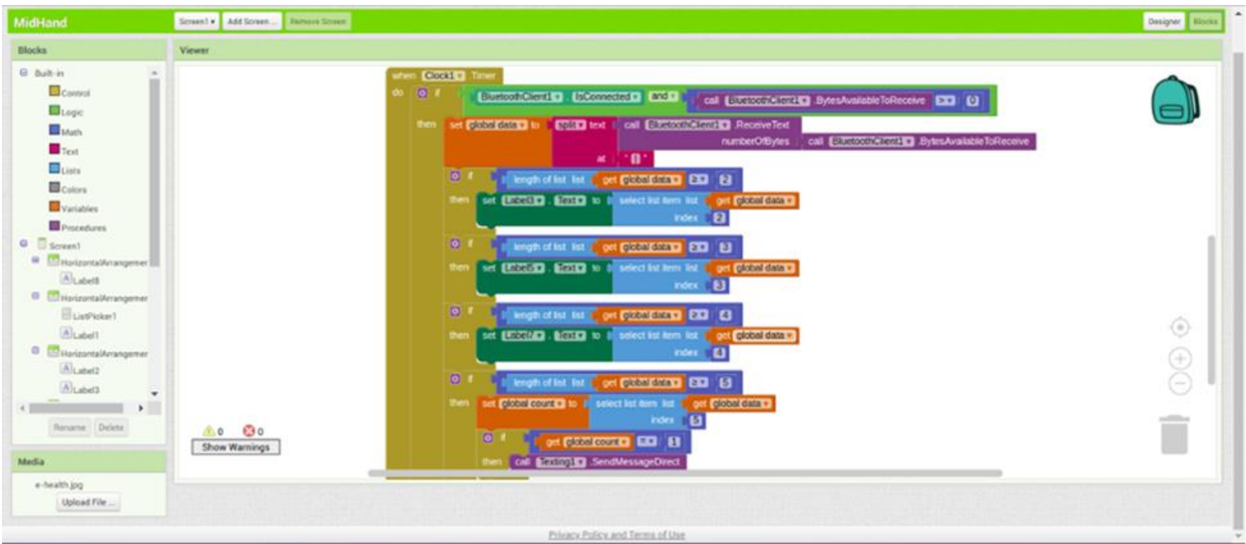

Figure 4.6: The code of application.

5. RESULT AND DISCUSSION

In this part of the thesis, this study is going to explain and discuss the results that we have got from the proposed device. In the beginning, the purpose of our project is to design a low power consumption monitoring system. So we tried to make the controller board work with low power. The board that was built specially to contain only the required components. The standard board available in the market with many features. We do not need them, for example, the Ethernet port. We estimated the power consumption of our device depending on the datasheets for the Atemag328p, Bluetooth, and sensors. The table below shows the power that the device consumes while it is working in the Datasheets.

Table 5.1: Estimated Power Consumption.

Component Name	**Required Power**
Atmega328p	4 mAh
MAX30100	20 mAh
Bluetooth	50 mAh
Temperature Sensor	0.1 mAh
Buzzer	0.5 mAh
Total	75.5 mAh

According to the above Table, the device will require 75- mAmpere per hour. We calculated the real power consumption of this device by using a multimeter connected the readings of the multimeter were between 70 and 75 mAh in both active and inactive mode. That's mean the power estimations by the data sheet is correct.

Secondly, as we mentioned before that the maximum power consumption of the proposed device is 75 mAh. We made a comparison between the proposed device and the previous related works.

Table 5.2: The Power Consumption of the Proposed System and the Related Works.

Reference	**Communication protocol**	**Sensor type**	**Measurement parameters**	**Current consumption**
Proposed System	Bluetooth	(i) Heart- Rate (ii) Temperature (iii) Spo2	(i) Heart- Rate (ii) Temperature (iii) Spo2	75 mA
[31] 2016	GSM/ GPRS	(i) Heart- Rate (ii) Temperature	(i) Heart Rate (ii) Temperature	100 mA
[32] 2016	(i) ZigBee (ii) GSM	(i) Blood pressure (ii) Pulse- rate (iii) Temperature (vi) Spo2 (v) Accelerometer	(i) Blood- pressure (ii) Pulse- rate (iii) Temperature (vi) Spo2 (v) Fall	250 mA
[33] 2017	(i) ZigBee (ii) GSM	(i) ECG (ii) Temperature (iii) Blood pressure	(i) Heart- Rate (ii) Temperature (iii) Blood- pressure	250 mA

From the above Table, the sensors number and communication method are different from one work to another. For [31], our proposal system contains a blood oxygen sensor as an extra sensor, but their device using GSM communication device. Their controller and communication device consumes more energy by the difference of 25 mA. In [32], the system using ZigBee, GSM as communication devices and two extra sensors: blood pressure and accelerometer with more power consumption differed from our power by 175 mA. In [33] the system using ZigBee, GSM as communication devices and two extra sensors: blood pressure and ECG sensor with more power consumption differed from our power by 175 mA.

According to the above Table that the proposed system used the lowest power consumption system. There is only one work that closest to the proposed system with 100 mAh.

6. CONCLUSION

6.1 CONCLUSION

This thesis presents a real-time health monitoring system to track the heart pulse, oxygen level and body temperature for the aged. The device designed to be wearable by the hand with lightweight and low power consumption, which is the main aim of this research. To achieve the aim of low power consumption, we design our microcontroller rather than using the Arduino cards available in the markets. Our card was built by using Atmega328 and the result showed that it consumes less power when we compared it with the standard Arduino. The result showed that our microcontroller increased the number of working hours by consumption low power.

6.2 FUTURE WORKS

For development and improvement, the real-time wireless health monitoring system some changes should be done. Some functions also can be added. The main changes and functions can be summarized as follow:

1. Recommend using other sensors for more information about the patient.

2. Recommend adding a database about the patient in order to build a prediction system able to predict the heart attacking before its happening. These systems contain information about the patient, such as the name, age, gender, etc.

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