CHAPTER 1

INTRODUCTION

In the field of disease prevention and monitoring of patient's health, some of the technological innovations were enhanced and enabled in the form of monitoring devices. Pulse rate plays a very important role in monitoring a person's health. This pulse rate can be measured with the help of ECG or by sensing the pulses. The pulse can be detected easily by sensing the density of the blood flow through the skin part as the arteries will be connected very close to the skin. So, that the fluctuation in that blood flow can be sensed easily by a sensor that indicates the pulse rate. A heart rate is considered as number of times a person's heart beats per minute. A normal pulse rate depends on an individual's health, age, medication use, and also emotions may have a major impact on it. Awareness and much knowledge regarding the heart rate can help the person in monitoring the health condition, maintaining the body fitness level and it also helps to detect and monitor the developing health problem at the initial stage if that person is undergoing some of the symptoms related to that particular disease. The person's body fitness level can be indicated by considering the heart pulse rate of a person before and after the exercise. The pulse rate can be measured manually only when the person is at rest, to count the number of heart beat per minute. So, measuring the heart rate with the help of an electrical circuit will be much easier, accurate, time consuming and also faster.

In day-to-day life we come across many electrical and electronics circuits that are designed using a technology called embedded systems, which is a combination of both hardware and the software. Use of this technology helps in reducing the complexity of designing the circuit with very low cost and small size. Implementation of this technology in medical field will be more beneficial and cost effective as embedded system is an electronic device that has the capability of performing multiple tasks regarding the specified application and it can also be programmed and un-programmed to perform particular operations as per the requirement.

In case of hospitals and some of the clinics, the long-time waiting of patients in the waiting list for hospitalization are some of the well-known issues nowadays. Due to the increasing population in today's world, demand for such health care services are also increasing. Patients are facing much problems for their treatment in emergency cases, due to lack of on time treatments and they are discharged soon after the diagnosis. So, it's a major issue that a patient's heart condition has to be monitored for a long time to prevent complications. The quality of the health care services needs to be increased by controlling the cost. All these drawbacks could be overcome by designing a device that can be easily handled by a common man to measure the heart rate from time to time and monitor the heart condition and approach the doctors only when required. This saves the time of both the doctors and the patients.

The proposed work consists of display unit which the count of number of heart beats per minute, this device consists of both the hardware and the electronic circuit by the use of microcontroller in it, and it is of small size, portable and beneficial for a common man. So, the objective of this work is to design a low-cost heart beat monitoring system which is simple and can be used by each individual to monitor the health condition at any time. This device will be portable, reliable and comfortable and also provides accurate results due to the use of highly sensitive IR sensor.

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1.1 HEART RATE

The heart is the organ that responsible for pumping blood throughout the body. It is located in the middle of the thorax, slightly offset to the left and surrounded by the lungs basically; the human heart is composed of four chambers which are two atriums and two ventricles. The right atrium receives blood returning to the heart from the whole body. That blood passes through the right ventricle and is pumped to the lungs where it is oxygenated and goes back to the heart through the left atrium, and then the blood passes through the left ventricle and is pumped again to be distributed to the entire body through the arteries.

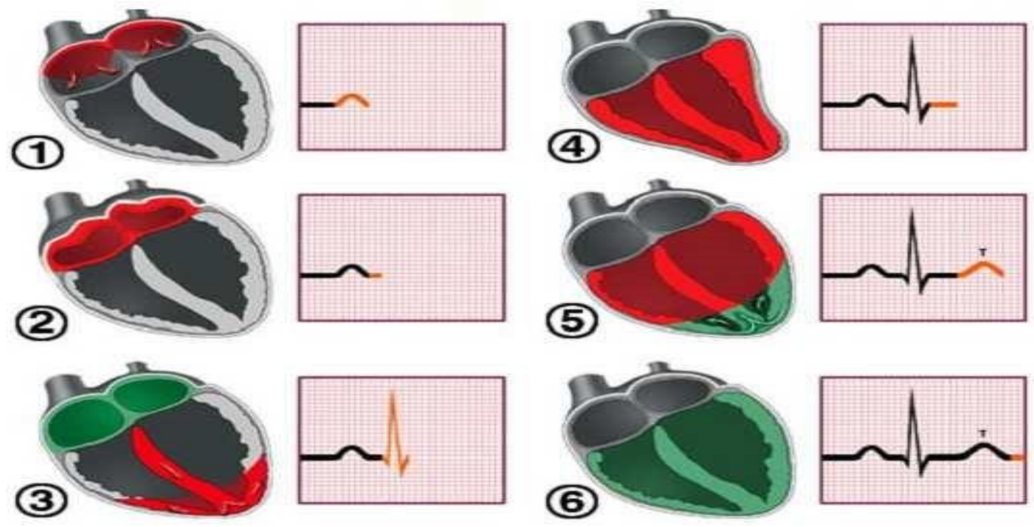

Figure 1.1: Heart behaviour and part of the generated signal.

1.1.1 Visual Representation of Electrocardiogram (ECG) signal

An electrocardiogram (ECG), also called an EKG, is a graphic tracing of the voltage generated by the cardiac or heart muscle during a heartbeat. It provides very accurate evaluation of the performance of the heart. The heart generates an electrochemical impulse that spreads out in the heart in such a fashion as to cause the cells to contract and relax in a timely order and, thus, give the heart a pumping characteristic. An actual voltage potential of approximately 1 mV develops between various body points.

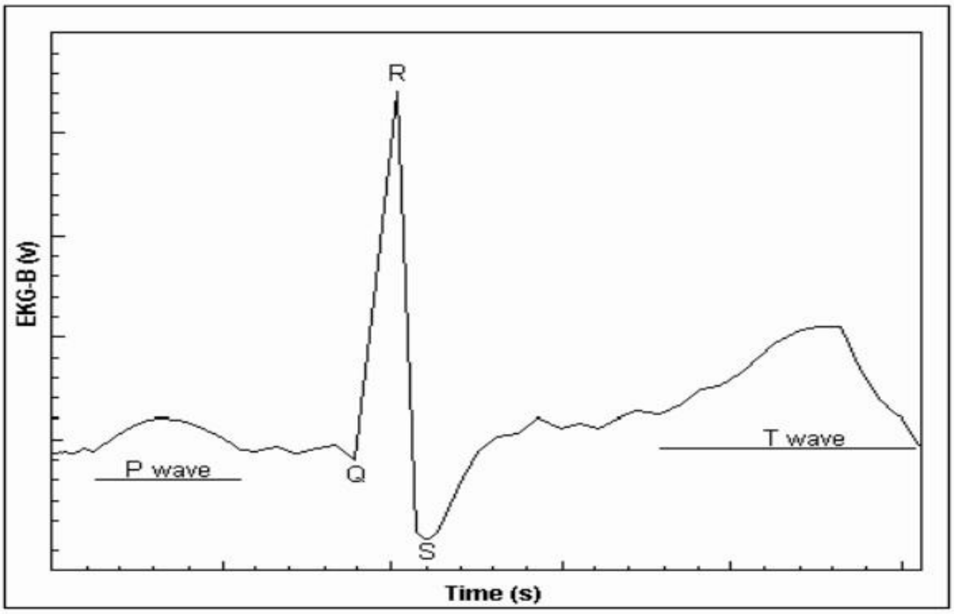

Figure 1.2: The ECG signal waveform

Heart rate is measured in beats per minute (bpm). In measuring heart rate, there are various ways to measure such as by using pulse oximeter, heart rate monitor, an electrocardiograph, and ECG strap. The beats per minute is differ for many people which depending on the ages, body physical condition and environmental factor. Centre in the brain is controlled the rate of heart beat. According to information received from muscles and sensors located, these centre speeds up or slows down the heart.

1.1.2 Measuring the Heart Rate

The heart rate can be measure at any spot on the body at which an artery is close to the surface and a pulse can be felt. The most common places to measure heart rate using the palpation method is at the wrist (radial artery) and the neck (carotid artery). There are several others places that can measure heart rate such as elbow (brachial artery) and groin (femoral artery). The methods of measuring heart rate can be divided into two:

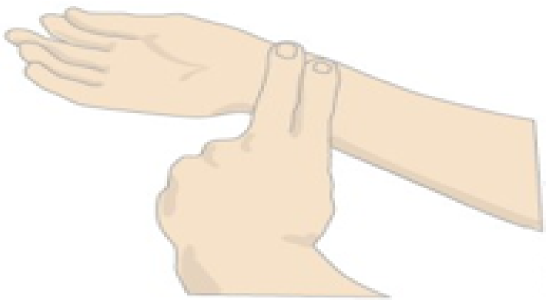

Figure 1.3: Manual **method**

The subject needs to place their fingers either at neck or wrist. For neck area the carotid pulse will be measure and wrist area the radial pulse will be measure. Then the subject needs to estimate the beats per minute rate by counting over 10 seconds and multiplying this figure by 6, or count over 15 seconds and multiply by 4, or over 30 seconds and doubling the result. There are obvious potential errors by using this shorthand method.

Figure 1.4: Monitor method

The monitor method can be performing by using electrocardiogram (ECG) machines. The standard Electrocardiogram (ECG) machine normally found in big hospitals due to the high cost and requires a specialist to handle the machine. The ECG concept also applied on several gadgets such as watch and smartphone but the demand is not good due to the high price.

By detecting the R peaks (shown in figure 1.2) and measuring their frequency, the heart rate can be calculated and then displayed. A person's heart rate before, during and after exercise is the main indicator of their fitness. Measuring this manually requires a person to stop the activity they are doing in order to count the number of heart beats over a period of time. Measuring the heart rate using an electrical circuit can be done much quicker and more accurately.

Heart rate measurement is one of the very important parameters of the human cardiovascular system. The heart rate of a healthy adult at rest is around 72 beats per minute (bpm). Athletes normally have lower heart rates than less active people. Babies have a much higher heart rate at around 120 bpm, while older children have heart rates at around 90 bpm. The heart rate rises gradually during exercises and returns slowly to the rest value after exercise. The rate when the pulse returns to normal is an indication of the fitness of the person. Lower than normal heart rates are usually an indication of a condition known as bradycardia, while higher than normal heart rates are known as tachycardia.

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Endure athletes often have very low resting heart rates. Heart rate can be measured by measuring one's pulse. Pulse measurement can be achieved by using specialized medical devices, or by merely pressing one's fingers against an artery (typically on the wrist or the neck). It is generally accepted that listening to heartbeats using a stethoscope, a process known as auscultation, is a more accurate method to measure the heart rate. There are many other methods to measure heart rates like Phonocardiogram (PCG), ECG, blood pressure wave form and pulse meters but these methods are clinical and expensive.

1.1.3 Maximum Heart Rate

The maximum Heart Rate (Max HR) is the fastest of heart can beat for one minute. A generalized rule anchors Max HR using a mathematical formula. Inside each zone, there are different exercise changes which occur as the result of spending training time in the zone. Heart zones is expressed as a percentage of the maximum heart rate, reflect exercise intensity and the result benefit. There are five heart zones of training illustrated in figure 1.5.

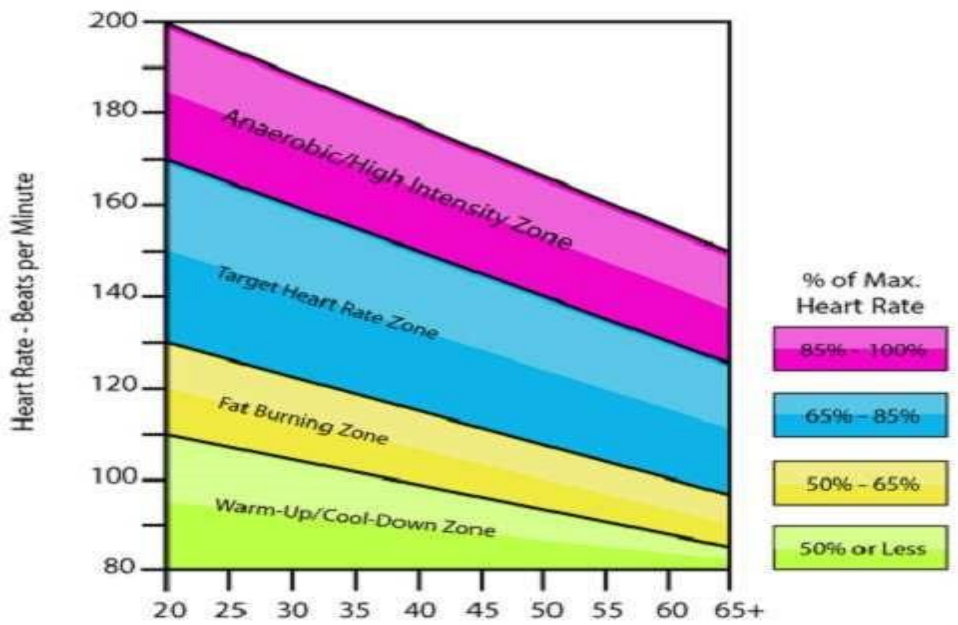

Figure 1.5: Exercise target zone chart.

Calculate the maximum rate of the heart is the subject of ongoing research for a long time because of the inaccuracy of the calculation. So, there are many methods of calculating such

1) The easiest and best-known method to calculate your maximum heart rate (MHR) is to use the formula

- MAXHR = 220 – Age

2) Dr. Martha Gulati

- For Male, MAXHR = 220-Age.
- For women, MHR= 206 - (0.88 x age).

3) Londeree and Moeschberger

- For male and female, MHR = 206.3 - (0.711 × Age)

Studies have shown that MHR on a treadmill is consistently 5 to 6 beats higher than on a bicycle ergo meter and 2 to 3 beats higher on a rowing ergometer. Heart rates while swimming is significantly lower, around 14 bpm, than for treadmill running. Elite endurance athletes and moderately trained individuals will have a MHR 3 or 4 beats slower than a sedentary individual. It was also found that well trained over 50s are likely to have a higher MHR than that which is average for their age.

4) Miller

- For male and female, MHR = 217 - (0.85 x Age)

5) USA Researchers

- MHR = 206.9 - (0.67 x age)

6) UK Researchers

- For Male, MHR = 202 - (0.55 x age)
- For Female, MHR = 216 - (1.09 x age)

7) Miller, Londeree and Moeschberger

To determine your maximum heart rates, you could use the following, which combines the Miller formula with the research from Londeree and Moeschberger.

- Use the Miller formula of MHR=217 - (0.85 × age) to calculate MHR.
- Subtract 3 beats for elite athletes under 30.
- Add 2 beats for 50-year old elite athletes.
- Add 4 beats for 55+ year old elite athletes.
- Use this MHR value for running training.
- Subtract 3 beats for rowing training.
- Subtract 5 beats for bicycle training.

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1.1.4 Fingertip sensor

Use of light to measure heart rate is a field of study where abundant research has been done in the past few decades. Fingertip sensor relies on measurement of a physiological signal called Photoplethysmogrpahy (PPG), which is an optical measurement of the change in blood volume in the arteries. Fingertip sensor acquires PPG signals by irradiating wavelength of light through the tissue and compares the light absorption characteristics of blood under these wavelengths.

1.1.4.1 Photoelectric Photoplethysmogrpahy

The hardware and software for the MEDAC photoelectric plethysmography (PPG) represent an integrated system for real time monitoring of relative changes in peripheral blood flow and for recording heart rate using an easy to attach sensor. Under appropriate conditions, the software can derive the followingt measures from the PPG signal: relative blood volume pulse height, pulse wave rise time, pulse wave fall time, the inter-beat-interval (IBI), and heart rate.

Plethysmography is a generic term referring to a variety of techniques for monitoring volume changes in a limb or tissue segment. Volume changes occur in a pulsatile manner with each beat of the heart as blood flows in and out of a portion of the body. The study of vascular activity by fluid displacement methods dates back to at least 1890. Photoelectric plethysmography (PPG) was developed in both Germany and the United States in the 1930's. Recent advances in photo-electronics make it possible to utilize photoelectric plethysmography as a sensitive physiological monitoring technique that may be practically applied in a clinical setting.

To measure the volume of blood in the human body, the Photoplethysmographic technique had been chosen because the unique criteria which need two wavelength that provide from the optical sensor of non-aversive pulse Oximeter. There are two methods to perform heartbeat measurement either transmission or reflection modes.

Transmittance vs. Reflectance

Fingertip sensor has traditionally been done in two methods: transmittance and reflectance of light. In transmittance fingertip sensor, light is shone through the tissue using an LED and is detected on the other end using a photodetector. In contrast, reflectance fingertip sensor uses a photodetector on the same side as the LED to detect the light reflected by the tissue as shown in figure 1.6.

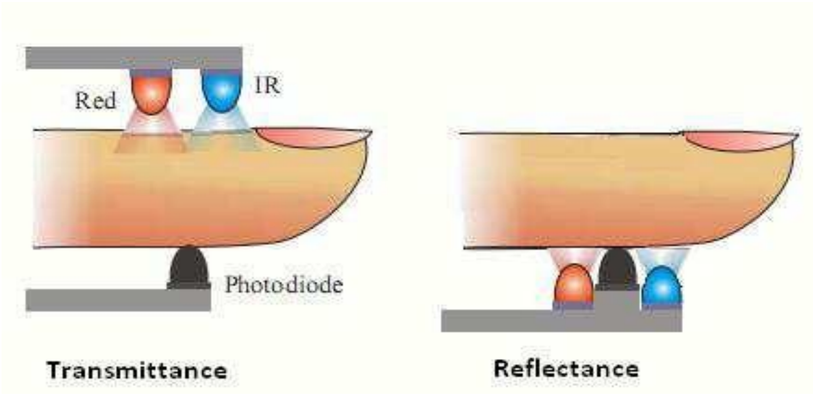

Figure 1.6: Transmittance and Reflectance configurations of transducer.

The opposite affect is on the reflected light. This can be intuitively justified, as the more blood there is in the tissue, the more the light passing through the tissue gets blocked. Since this improves the amount of light reflecting back, the signal observed in the reflectance configuration increases. Similarly, as the light gets blocked, not enough light reaches the photodetector in the transmittance configuration, and therefore a decline in the signal is observed.

In terms of the application, the transmittance configuration is more suited to the areas of the body that lend themselves better to light transmittance through them, e.g. fingers or ear lobes. However, transmittance configuration cannot be used in other areas of the body as the transmittance of light is significantly less when there are obstacles such as bone or muscle in the way, besides the fact that the path of light is much longer than in thin areas such as the ear lobes. In such scenarios, reflectance configuration is more useful, provided that vasculature is available close to the surface of the skin, e.g. forehead, wrist or forearm.

Reflectance configuration is not limited to areas where the transmittance configuration cannot be used. It can be employed to measure PPG signal from the ear lobes or the fingers just as the transmittance configuration. However, due to their thin cross-sectional area, fingers and ear lobes transmit much of the light shone through them, resulting in lower signal intensity in the reflectance configuration.

1.2 Problem Definition:

Some severe disorders such as heart attacks needs simultaneously monitoring methods after diagnosis to prevent further damage that may lead to future complication. Usually monitoring these types of patients occurs in hospitals or health care centres. Heart failures such as heart arrhythmias needs continuous monitoring for a long time. However, these group of patients are discharged too early from the hospitals, as another patient is in a need of that bed to be hospitalized immediately.

To overcome all these problems a low -cost heart beat monitoring system is proposed which is portable and can be used by each individual at home, which will provide more accurate results in measuring the heart rate and helps each and every individual to constantly check and monitor the heart condition to lead a better life.

1.3 OBJECTIVES OF THE PROPOSED SYSTEM

In our day-to-day life we come across queues in front of hospitals and clinics waiting for their treatments. Due to this, a patient who has to be diagnosed immediately will not be in a position to get on time treatment. As heart rate measuring will be the first step performed by the doctor before starting further process regarding the patient's health condition. Specially, a person suffering from heart attack will be diagnosed and discharged soon, as another patient is waiting to get admitted to that bed. These patient's heart condition has to be monitored simultaneous to avoid further complications, so that person cannot visit the doctor always just for that purpose. To overcome these conditions we have designed an advanced portable heart rate detection system with respect to the following objectives.

1. To understand the existing system of the Heart Pulse Detection system.
2. To implement the IR Sensor for the Detection of the Heart Rate monitoring system.
3. To implement the real time module for the proposed method from the above heart rate monitoring system using Arduino board by using the principle of Photo Phelthysmo Graphy(PPG).
4. To develop simple photo sensors that is easy to use and make sure each person can monitor their health everywhere and to develop a comfortable instrument, reliable, accurate result to develop of heart pulse using a low-cost photo sensor.
5. To Test and Validate the proposed method with current existing system.

CHAPTER 2

LITERATURE SURVEY

A simple and low cost optimal photo-sensor based heart beat detector with liquid crystal output display was proposed. In this paper, the pulses are measured using the photo-sensor by detecting the changes in blood flow. LED, IR and LCD are some of the sensor used to produce significant output. The heart rate is calculated with help of microcontroller (PIC16FA77A) which also controls the LCD display. The output of this work provided better service for the people, to maintain their health condition. The future work of this research was to enhance communication methods by adding wireless connection, to meet the needs of people, and it is required to be environmental friendly for all the OS of androids [1].

A pulse measurement device to support significant study was proposed. In this work, the author's aim was to design a device that measures the maximum and minimum values of the detected pulse rate of a person. This paper mainly focused on the measurement of the pulse rate and signal analysis of electric pulse for a life span of 20-80 years. The input optical sensor was processed by the use hardware named as ADK R3 and the recorded output data were stored in SD card. Input output parts were controlled by designing an embedded algorithm. Finally, this paper helps in determining the maximum and minimum pulse values. The drawback of this work is that, it is designed only to measure the pulse rate for a limited life span of 20-80 years [2].

Centralize heart beat monitoring and automatic message alert system using WBAN was proposed. In this paper, the multiple heart beat and temperature data are measured and stored. The stored data is processed by a microcontroller, and then it is sent to the centralized unit where the information for multiple sensors would be displayed continuously. This system was applicable only for hospitals or any other clinics. The future work is to expand this system to remote patient's connected to a centralized monitoring system using wireless network [3].

A GSM modem integrated bio-sensor detecting heart beat rate system was proposed to detect using heart attacks. In this work, the heart rate was detected using LDR, LED band and the finger was made to place in it. When the detector activates the LED turns 'ON' with each heartbeat. The obtained signal was processed by microcontroller to detect the pulse rate per minute and was displayed on a LCD screen. This displayed output is sent has an SMS to the medical expert's mobile phone. This helps the doctor to diagnosed the patient

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and provide easier precaution for them. The future scope was to implement better packaging of the circuitry by using low cost and sensitive sensor to attain better accuracy [4].

The portable system for a vital parameter acquisition using SIX sigma methodologies was developed. In this paper, the author designed a portable device using the six sigma methodology to measure the cardiac activity and transmit these signals to the doctor's mobile to monitor the patient's health condition. This paper mainly focused on a work to design a cost effective device with the help of sensors that are available easily which are capable of acquiring signals. The obtained signals were processed by a microcontroller and with the help of internet of things and Bluetooth module these signals of a patient are displayed on a doctor's mobile application. Finally, a device was developed that could help the patients to monitor their cardiac activity by a quick solution by the doctor and this was time consuming for both the doctor's and the patients. But the drawback is that, only medical expert or a doctor can operate or make use of this device and then treat the patients but cannot be handled by a common man [5].

A low-cost computer-based pulse rate monitoring system using microphone po re was proposed. In this paper, the author implemented a low-cost device that measures the heart rate of a person from the fingertip with the help of a computer's microphone port. By the use of infrared technology, the optical sensor detects the changes the blood volume. The unwanted components are removed from the noisy signal obtained as an output from the sensor then it is interfaced with the microphone port and processed to measure the pulse rate in real time. This designed device helps a person to have knowledge of heart condition by detecting the heart diseases like sleep arrhythmia. The device is more complex in design [6].

The observations made from all the above-mentioned reviews, it is clear that all existing devices that are designed to measure and monitor the heart rate of a patient are limited, as it has to be used only by the medical experts or the doctors in the special health care centres and some clinics, hospitals and also very complex in design. The main drawback is that these devices cannot be handled by a common man itself to know about his heart condition.

So, the proposed system is more advanced, as it is simple in design and portable. A common man can easily handle this device and have knowledge about what is going on in his body just by observing the heart condition by sensing the pulses. This helps in reducing the time of both the doctors and the patients.

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CHAPTER 3

WORKING PRINCIPLE OF THE PROPOSED METHOD

The proposed model is a combination of both the hardware and the software. The circuit is designed by interfacing the Arduino board with the LCD and the IR sensor which is capable of providing control signals to control the LCD. When the finger is placed on the sensor, it senses the number pulses over a unit time. The LED turns on when the pulses are detected, which then activates the timer of the microcontroller to start the count. By considering only, the high frequency contents over the number of detected pulses it measures the heart rate and displays the final count on the LCD monitor in digital form and the heart condition will also be recognised with respect to the obtained heart rate and will be displayed on the LCD.

3.1 METHODOLOGY

The methodology of this proposed work explains the practical works that is explained as follows.

This work includes the following steps:

Step 1: Initialization of both microcontroller and the LCD is done, then the project title is made to be displayed on the LCD monitor.

Step 2: IR sensor is initialized to detect the pulses by observing the fluctuations of the blood flow by undergoing the density of the blood. The output signal is obtained in the form of an analog signal or a voltage signal.

Step 3: As soon as the IR sensor senses the pulse, LED turns on indicating that the heart pulse is detected. This output is fed as an input to the microcontroller.

Step 4: Microcontroller is processed to perform the required operation with the help of an Arduino IDE software program. The timer gets activated and starts the count and measures the respective pulse rate.

Step 5: Finally, after counting the pulse rate, the timer stops and the measured data are displayed on the LCD monitor. With respect to the displayed pulse rate the heart condition of a person will also be displayed on the monitor such as whether a person is emotional or not. Some of the conditioned will be viewed as per the threshold strategy as it signifies exact condition of a person.

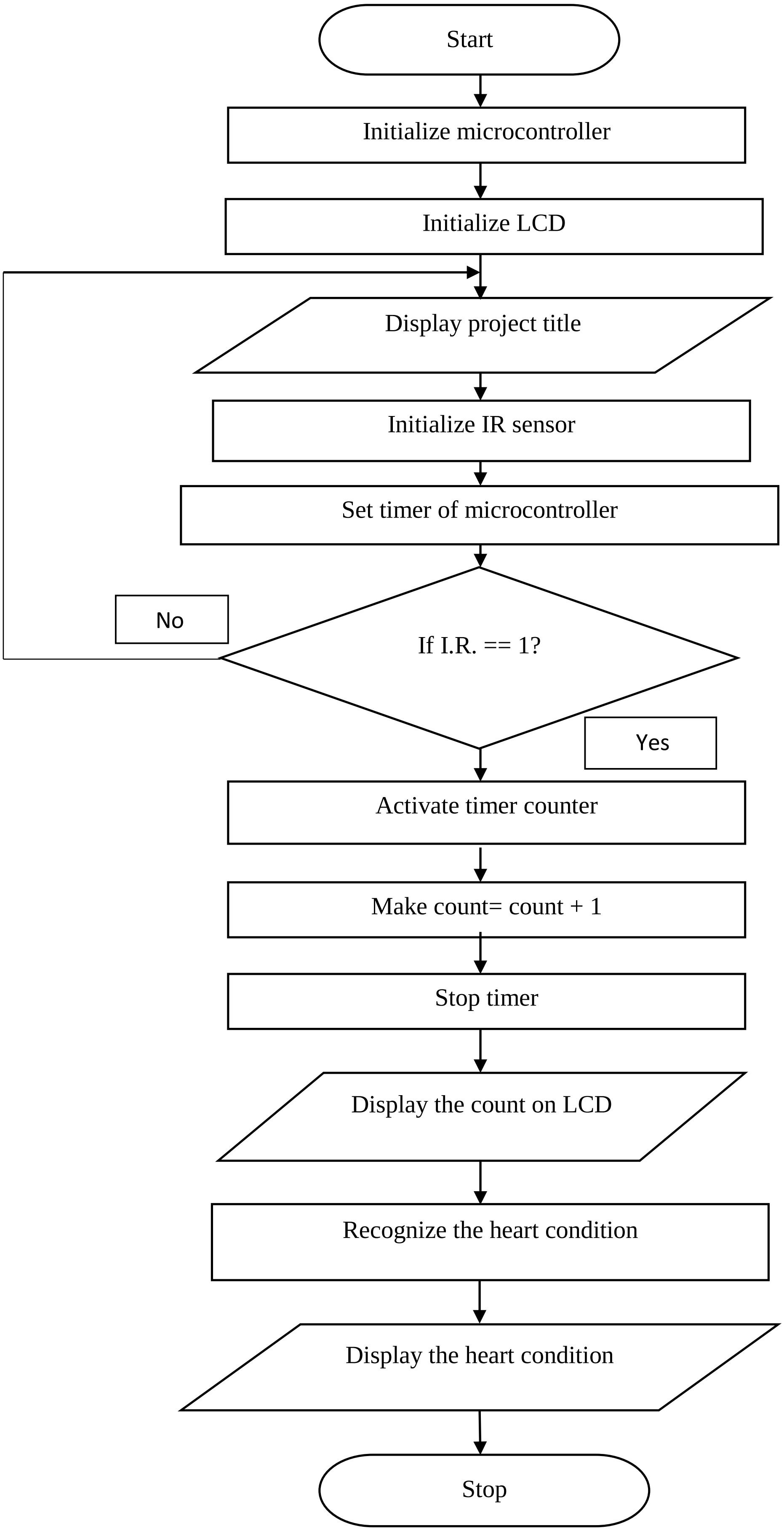

Figure 3.1: Flowchart of a proposed work.

In this way, the overall procedure will be repeat from step 3 until the pulse is detected and the sensor senses the pulse and LED gets turned on. Then the corresponding output is processed and the obtained data is displayed on the LCD. The emotional condition of that person with respect to the measured heart rate will be displayed on the LCD as a person is depressed or emotional, excited. This process repeats.

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CHAPTER 4

ADVANCED HEART RATE DETECTION SYSTEM

Some severe disorders such as heart attacks needs simultaneously monitoring methods after diagnosis to prevent further damage that may lead to future complication. Usually monitoring these types of patients occurs in hospitals or health care centre. Heart failures such as heart arrhythmias needs continuous monitoring for a long time. However, these group of patients are discharged too early from the hospitals, as another patient is in a need of that bed to be hospitalized immediately. As, heart rate is major parameter to monitor person's health, it should be maintained properly to lead a better life. To overcome all these problems a low cost heart beat monitoring system is proposed which is portable and can be used by each individual at home, which will provide more accurate results in measuring the heart rate and helps each and every individual to constantly check and monitor the heart condition to lead a better life.

4.1 MOTIVATION FOR THE PROPOSED WORK

In this proposed work instead of pressure sensors, IR sensor is used as it has high sensitivity and obtains more stable output. This sensor depends on the fact that speed of the blood is proportional to the heart rate. This is to say that the heart rate changes when people are active. The measured heart rate will be displayed on the LCD which shows the information about, if the person as undergone an exercise by indicating an increasing heart rate, may be some times out of healthy range. The normal heart rate will be recovered, when the person takes a break. People can take care of their health condition by using the heart rate monitoring system.

4.2 BLOCK DIAGRAM OF PROPOSED SYSTEMS

The proposed working model includes a photo-sensor that measures the pulse by measuring the changes in the blood flow. Light emitting diode (LED), Infrared sensor (IR), are the best photo-sensors which are used to produce significant heat beat signal that is detected from the human finger.

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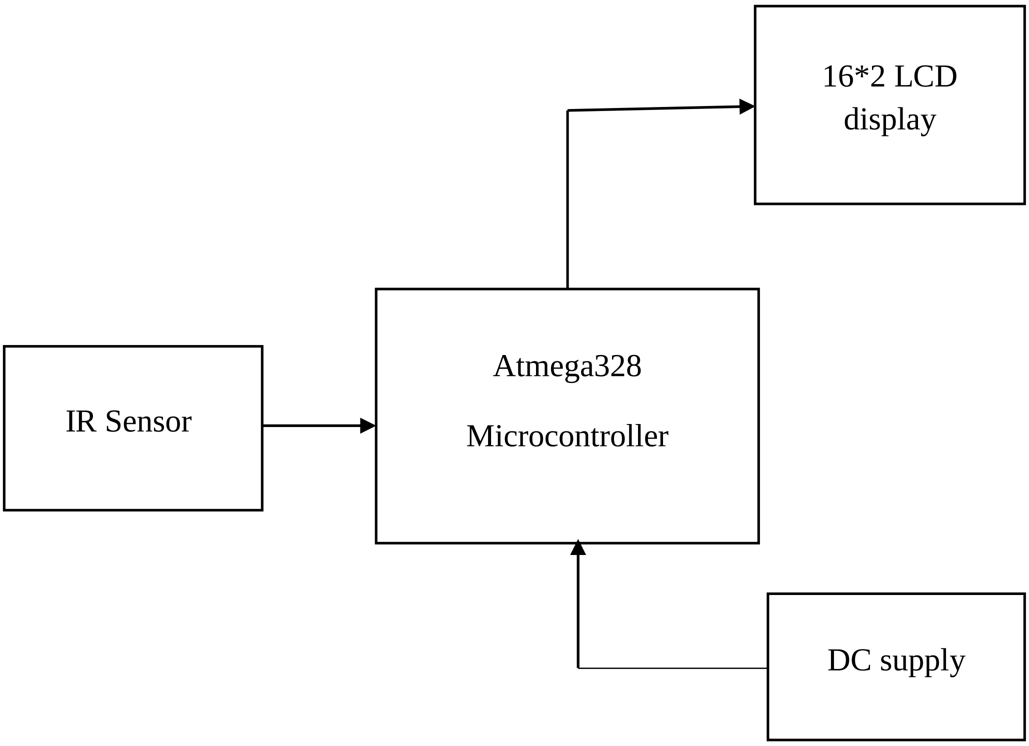

Figure 4.1: Implementation Block Diagram

In this proposed work IR sensor is used in order to sense the heart beat by detecting the changes in the blood flow through the finger with the help of artery that are closely connected to the skin. Every time the heart beats, it is sensed by the IR sensor and the LED turns on. Other than this, this proposed work also includes the use of ATMEGA32 microcontroller which is programmed to count the number of heart pulse over a unit time and control the LCD display which indicates the heart rate. The pulse rate is displayed on the LCD.

Details of the above-mentioned block diagram is as follows:

4.2.1 IR SENSOR

The sensor consists of IR light emitting diode and a photo diode that are placed side by side and the fingertip is placed closer towards the IR sensor in order to sense the pulse. As soon as the finger is placed towards the sensor, it gets activated and transmits an IR light from the higher LED to the tip of the finger, then a part of that light is reflected from the blood which depends on the density of the blood volume inside the finger. This reflected light is absorbed by the photodiode and the pulses are detected. So, whenever the heart beats, the pulses will be detected by the photodiode by observing the changes in the flow of reflected IR light from the finger and this output signal obtained from the photodiode is amplified by passing it through the low pass filter which is cascaded. These

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pulses are fed to an LED. So, whenever the heart beats, LED glows and the pulses are recorded by the microcontroller.

4.2.2 MICROCONTROLLER

Arduino UNO board is used to read sensors and control signals such as motor and light. It is an open source microcontroller board that allows the user to upload programs and then interact with things in the real world. ATMEGA 328 microcontroller is the used in this work that runs at 8MHz. The output signal from sensor is sent to the microcontroller which is processed to measure the pulse by converting the obtained analog signal to a digitized form and generates a control signal to control the LCD. The pulse rate is calculated using a timer then the digitized output from the microcontroller is sent to the LCD.

4.2.3 LCD Display

It is the electronic visual display that uses the light modulating properties of liquid crystals. The digitized output obtained from the microcontroller is displayed on the LCD screen.

In this work IR sensor detects the pulse from the blood. As the heart pumps the blood in the body, which is considered as a heartbeat the blood contraction in the body changes. This changes are used to make a pulse electrically. Finally, the detected pulses are counted by the timer in the microcontroller over a unit time and the digitized output are displayed on the LCD.

CHAPTER 5

HARDWARE AND SOFTWARE REQUIREMENTS

5.1 HARDWARE COMPONENTS

This Chapter discusses about the details of the hardware parts used in the project. The chapter briefly describes about the core technical details of the hardware specifications, their features and characteristics.

1. IR sensor.
2. Arduino UNO.
3. LCD display.

5.1.1 IR SENSOR

An infrared_sensor is an electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor. Usually in the infrared spectrum, all the objects radiate some form of thermal radiations. These types of radiations are invisible to our eyes, that can be detected by an infrared sensor. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, The resistances and these output voltages, change in proportion to the magnitude of the IR light received. An infrared sensor circuit is one of the basic and popular sensor module in an electronic_device. This sensor is analogous to human's visionary senses, which can be used to detect obstacles and it is one of the common applications in real time.

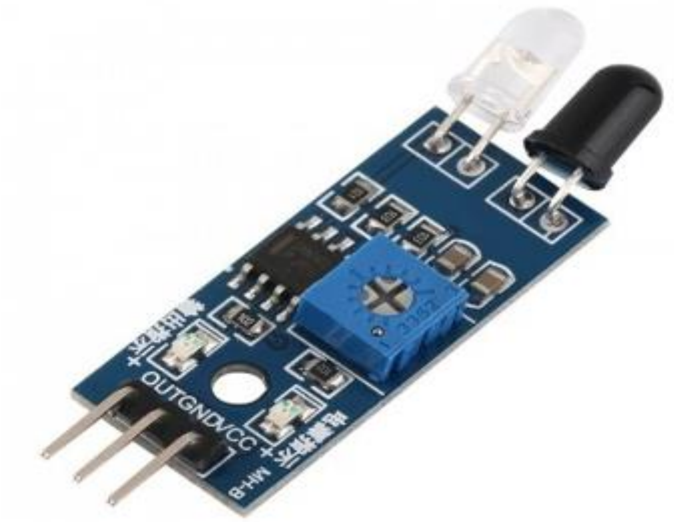

Figure 5.1: IR Sensor

5.1.1.1 IR Sensor Circuit Diagram and Working Principle

An infrared sensor circuit is one of the basic and popular sensor module in an electronic device. This sensor is analogous to human's visionary senses, which can be used to detect obstacles and it is one of the common applications in real time. This circuit comprises of the following components.

- LM358 IC 2 IR transmitter and receiver pair
- Resistors of the range of kilo ohms.
- Variable resistors.
- LED (Light Emitting Diode).

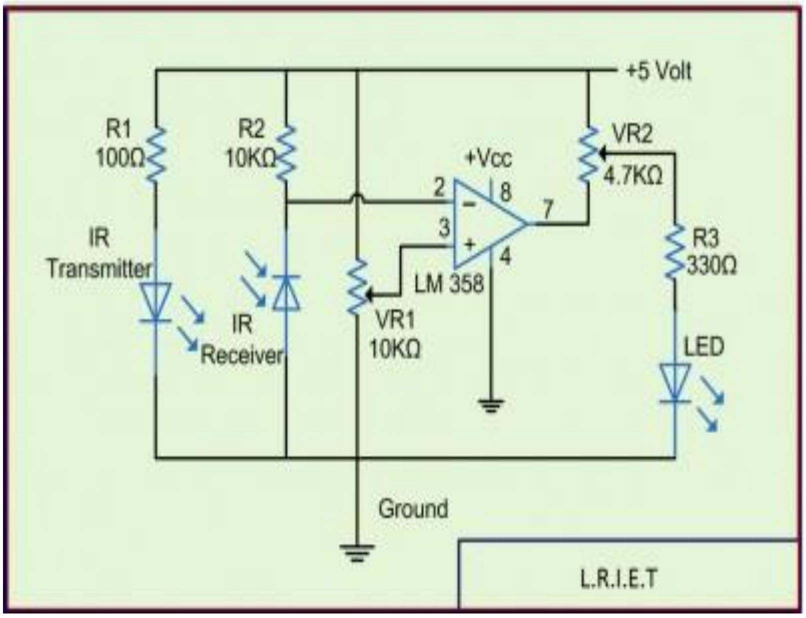

Figure 5.2: IR Sensor circuit

In this project, the transmitter section includes an IR sensor, which transmits continuous IR rays to be received by an IR receiver module. An IR output terminal of the receiver varies depending upon its receiving of IR rays. Since this variation cannot be analysed as such, therefore this output can be fed to a comparator circuit. Here an operational amplifier (op-amp) of LM 339 is used as comparator circuit.

When the IR receiver does not receive a signal, the potential at the inverting input goes higher than that non-inverting input of the comparator IC (LM339). Thus, the output of the comparator goes low, but the LED does not glow. When the IR receiver module receives signal to the potential at the inverting input goes low. Thus, the output of the comparator (LM 339) goes high and the LED starts glowing. Resistor R1 (100), R2 (10k) and R3 (330) are used to ensure that minimum 10 mA current passes through the IR LED Devices like Photodiode and normal LEDs respectively. Resistor VR2 (pre-set=5k) is used to adjust the output terminals. Resistor VR1 (pre-set=10k) is used to set the sensitivity of the circuit Diagram.

5.1.1.2 Different Types of IR Sensors and Their Applications

IR sensors are classified into different types depending on the applications. Some of the typical applications of different types of sensors are:

- The speed sensor is used for synchronizing the speed of multiple motors.
- The temperature sensor is used for industrial temperature control.
- PIR sensor is used for automatic door opening system.
- Ultrasonic sensor are used for distance measurement.

5.1.1.3 IR Sensor Applications

IR sensors are used in various Sensor based projects and also in various electronic devices which measures the temperature that are discussed in the below.

- Radiation Thermometers

IR sensors are used in radiation thermometers to measure the temperature depend upon the temperature and the material of the object and these thermometers have some of the following features

- Measurement without direct contact with the object
- Faster response
- Easy pattern measurements

- Flame Monitors

These types of devices are used for detecting the light emitted from the flames and to monitor how the flames are burning. The Light emitted from flames extend from UV to IR region types. PbS, PbSe, Two-color detector, pyro electric detector is some of the commonly employed detector used in flame monitors.

- Moisture Analysers

Moisture analysers use wavelengths which are absorbed by the moisture in the IR region. Objects are irradiated with light having these wave-lengths (1.1 µm, 1.4 µm, 1.9 µm, and 2.7µm) and also with reference wavelengths. The Lights reflected from the objects depend upon the moisture content and is detected by analyser to measure moisture (ratio of reflected light at these wavelengths to the reflected light at reference wavelength). In GaAs PIN photodiodes, Pbs photoconductive detectors are employed in moisture analyser circuits.

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➢ Gas Analysers

IR sensors are used in gas analysers which use absorption characteristics of gases in the IR region. Two types of methods are used to measure the density of gas such as dispersive and non-dispersive.

- **Dispersive:** An Emitted light is spectroscopically divided and their absorption characteristics are used to analyse the gas ingredients and the sample quantity.
- **Non-dispersive:** It is most commonly used method and it uses absorption characteristics without dividing the emitted light. Non-dispersive types use discrete optical band pass filters, similar to sunglasses that are used for eye protection to filter out unwanted UV radiation.

This type of configuration is commonly referred to as non-dispersive infrared (NDIR) technology. This type of analyser is used for carbonated drinks, whereas non-dispersive analyser is used in most of the commercial IR instruments, for an automobile exhaust gas fuel leak ages.

5.1.2 MICROCONTROLLER (ARDUINO UNO)

Microcontrollers

A microcontroller (also microcontroller unit, MCU) is a small computer on a single integrated circuit; its function is determined by a program loaded in it. Like all computers microcontrollers are equipped with a central processing unit or CPU, a memory system, an input/output system, a clock or timing system, and a bus system to interconnect constituent systems. The bus system consists of an address bus, a data bus, and a control bus. In Figure (2.1) we have provided the block diagram of a generic microcontroller. We would like to emphasize that all systems shown in the diagram are contained within the confines of a single integrated circuit package.

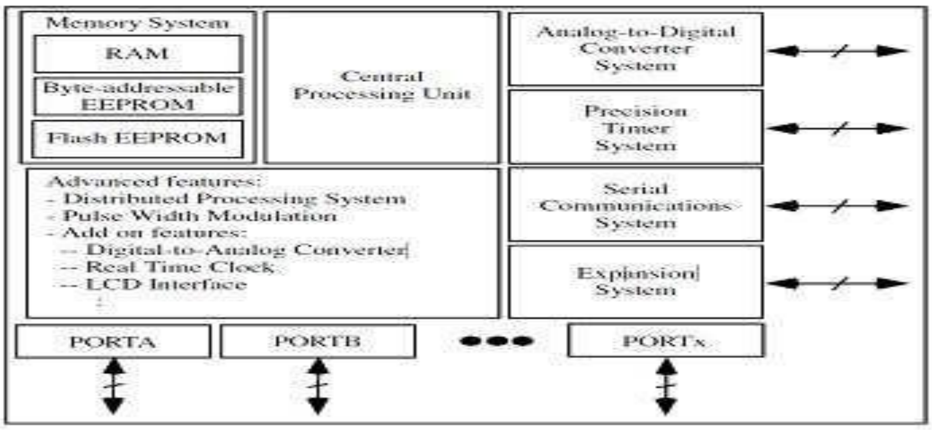

Figure 5.3: Microcontroller block diagram

We discuss each system briefly in a clockwise fashion beginning with the memory system.

5.1.2.1 Memory System

As its name implies, the memory system contained within a microcontroller is used to remember the algorithm executed by the microcontroller, key program variables, and also system information.

A microcontroller's memory system is usually a conglomeration of different memory technologies. Most microcontrollers are equipped with a memory system containing both random access memory (RAM) and read-only memory (ROM) components.

RAM: RAM configurations are used to hold program variables that might change during program execution.

ROM: ROM configurations are non-volatile, which makes them an ideal location to store a main program. That way should the microcontroller lose power, it will not lose its main program.

The EEPROM, or electrically erasable programmable ROM, is available in two different varieties byte-addressable EEPROM and flash EEPROM. Most microcontrollers are equipped with both types. Byte-addressable EEPROM, as its name implies, allows modification of single bytes of information during program execution. This type of memory is useful for storing program constants, security combinations, and fault status. Flash EEPROM may be rewritten in bulk. It does not allow for updating a single memory location. Flash EEPROM is used to store the microcontroller's algorithm.

5.1.2.2 Central Processing Unit

The heart of the microcontroller is the central processing unit or CPU. The CPU contains two main component parts: the arithmetic logic unit (ALU) and the control unit. The ALU performs the arithmetic operations (addition, subtraction, shift right, etc.) and logic operations (AND, OR, exclusive-OR, etc.) for the microcontroller.

5.1.2.3 Crystal Time Base

The time base for the processor is usually provided by a quartz crystal or a ceramic resonator. The quartz crystal provides a more accurate, stable time base.

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5.1.2.4 Analog-to-Digital Converter

Most microcontrollers are equipped with multi-channel analog-to-digital converters (ADCs). The analog input signals are converted to a weighted binary representation as shown in Figure 10.

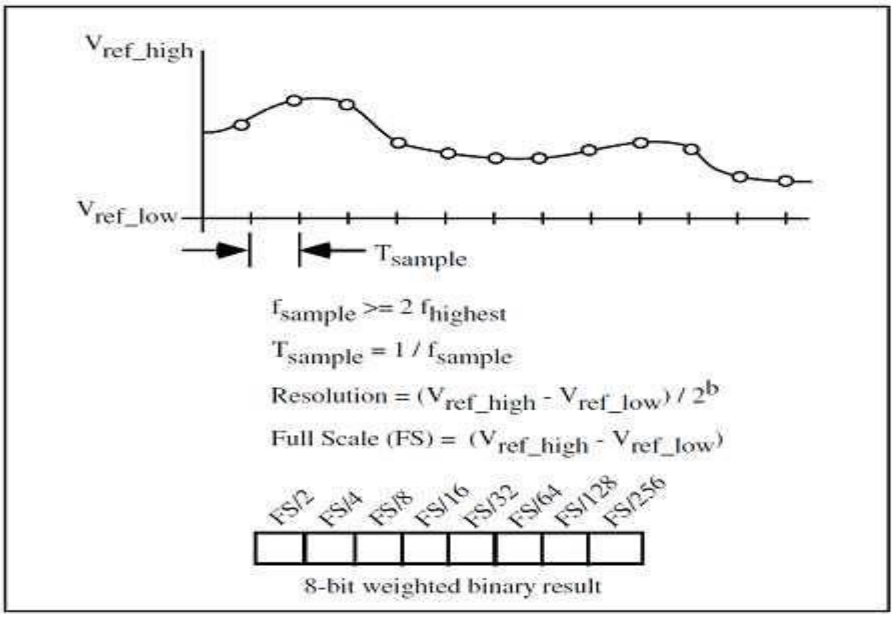

Figure 5.4: Analog-to-digital conversion

To convert an analog sample to a weighted binary value, three steps must be performed:

1) Determining the sample rate,
2) Determining the required resolution of the converter, and
3) Encoding the voltage sample into a weighted binary value.

Arduino-Uno is well known open source Hardware Platform which allows open source development environment. The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0.

5.1.2.5 BOARD FEATURES:

- It has 14 digital input/output pins (of which 6 can be used as PWM outputs)
- Six Analog inputs

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- A 16 MHz crystal oscillator
- A USB connection
- A power jack
- An ICSP header
- Reset button.

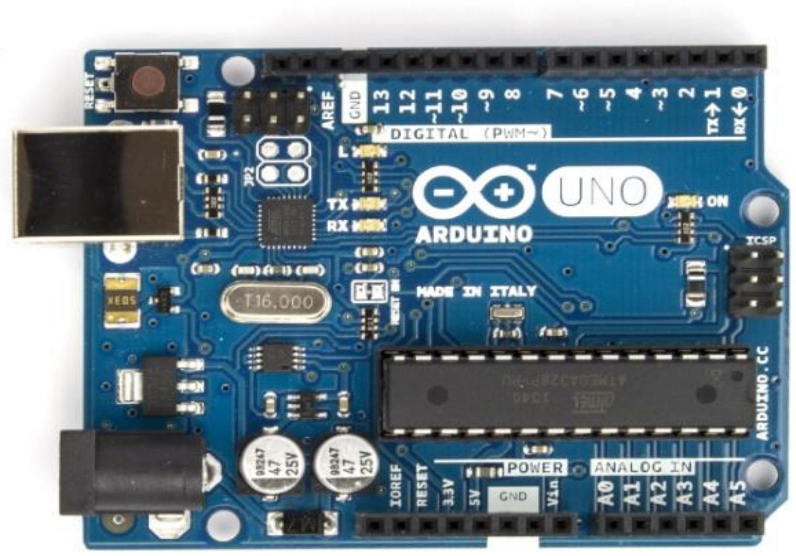

Figure 5.5: Diagram of Arduino Board.

Table 1: Specifications of Arduino.

Parameter	**Specifications**
Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current	for 3.3V Pin 50 Ma
Flash Memory	32 KB of which 0.5 KB used by
SRAM	2 KB

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EEPROM	1 KB
Clock Speed	16 MHz

5.1.2.6 BOARD DIAGRAM

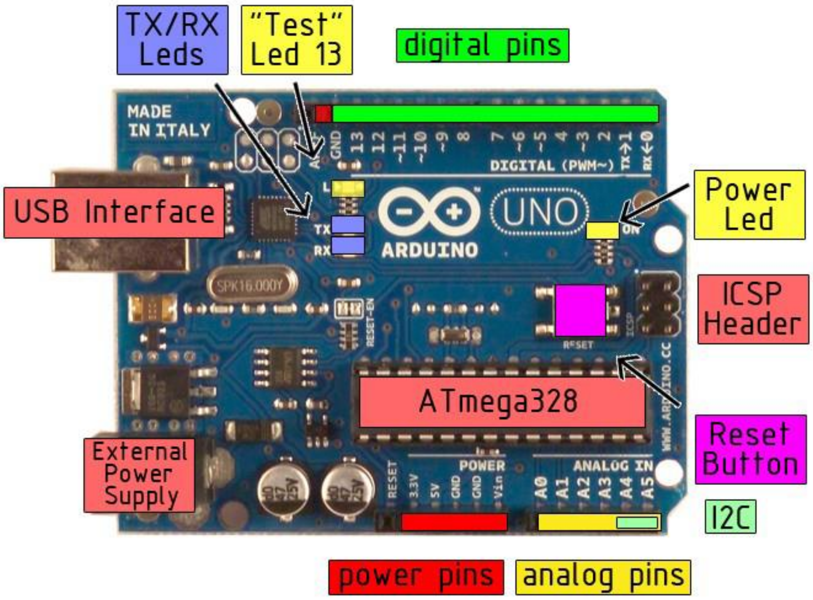

Figure 5.6: Pin diagram of Arduino

The Arduino Board is divided into seven main parts

1. USB Connector.
2. Power Connector.
3. Digital Pins.
4. Analog Pins.
5. Power Pins.
6. Reset Switch.

1. USB Connector: This part of the board serves dual purposes. It is used to supply power to the board and also the program to Arduino board can be loaded through this Connector.

2. Power Connector: A Dc Power jack within 7-12 V range is used to supply power to the board. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

3. Digital Pins: The board is provided with 14 digital input pins. Each of these pins can act as digital input pin reading in the digital values and as digital output pin writing out digital values. Each pin operates with 5V and can source or sink maximum of 40mA current. Apart from Digital IO few of these pins are used for special purpose.

4. Serial pins: Pin 0 (RX) and 1(TX) are used as Hardware serial Communication pins used to transmit and receive serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

5. External Interrupts: Pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.

6. PWM: Pins 3, 5, 6, 9, 10, and 11. Provide 8-bit Pulse Width Modulated Output.

7. SPI: Pins 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware.

8. LED: Pin 13 there is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

9. The Power pins:

a. **Vin:** The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). The board can be supplied 5V voltage through this pin, or, if supplying voltage via the power jack, 5v can be accessed through this pin.

b. **5V pin**: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board and it is not recommended.

c. **3V3 pin:** A 3.3 volt supply generated by the on-board regulator. It can be used to drive devices that operate on 3.3v. Maximum current drawn from this pin is 50 mA.

d. **GND pins:** Ground pins.

e. **IOREF pins**: This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.

10. Reset Switch: As restart button in PC restarts the system. In the same manner reset button restart the Arduino. It means that the program memory ROM set to the starting position or address. Our code starts from the beginning, and hardware resets. SO in case we found any error in execution of code in Arduino program then try to reset it so that it will restart.

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5.1.3 LCD DISPLAY

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

The definition of LCD will be obtained from the name "Liquid Crystal" itself. It is actually a combination of two states of matter – the solid and the liquid. They have both the properties of solids and liquids and maintain their respective states with respect to another. Solids usually maintain their state unlike liquids who change their orientation and move everywhere in the particular liquid. Further studies have showed that liquid crystal materials show more of a liquid state than that of a solid. It must also be noted that liquid crystals are more heat sensitive than usual liquids. A little amount of heat can easily turn the liquid crystal into a liquid. This is the reason why they are also used to make thermometers.

5.1.3.1 Basics of LCD Displays

The liquid-crystal display has the distinct advantage of having a low power consumption than the LED. It is typically of the order of microwatts for the display in comparison to the some order of milliwatts for LEDs. Low power consumption requirement has made it compatible with MOS integrated logic circuit. Its other advantages are its low cost, and good contrast.

The main drawbacks of LCDs are additional requirement of light source, a limited temperature range of operation (between 0 and 60° C), low reliability, short operating life, poor visibility in low ambient lighting, slow speed and the need for an ac drive.

5.1.3.2 Basic structure of an LCD

A liquid crystal cell consists of a thin layer (about 10 u m) of a liquid crystal sand-wiched between two glass sheets with transparent electrodes deposited on their inside faces. With both glass sheets transparent, the cell is known as transitive type cell. When one glass is transparent and the other has a reflective coating, the cell is called reflective type. The

LCD does not produce any illumination of its own. It, in fact, depends entirely on illumination falling on it from an external source for its visual effect.

5.1.3.3 Making of LCD

- Though the making of LCD is rather simple there are certain facts that should be noted while making it.
- The basic structure of an LCD should be controllably changed with respect to the applied electric current.
- The light that is used on the LCD can be polarized.
- Liquid crystals should be able to both transmit and change polarized light.
- There are transparent substances that can conduct electricity.

To make an LCD, you need to take two polarized glass pieces. The glass which does not have a polarized film on it must be rubbed with a special polymer which creates microscopic grooves in the surface. It must also be noted that the grooves are on the same direction as the polarizing film. Then, all you need to do is to add a coating of nematic liquid crystals to one of the filters. The grooves will cause the first layer of molecules to align with the filter’s orientation. At right angle to the first piece, you must then add a second piece of glass along with the polarizing film. Till the uppermost layer is at a 90-degree angle to the bottom, each successive layer of TN molecules will keep on twisting. The first filter will naturally be polarized as the light strikes it at the beginning. Thus, the light passes through each layer and is guided on to the next with the help of molecules. When this happens, the molecules tend to change the plane of vibration of the light to match their own angle. When the light reaches the far side of the liquid crystal substance, it vibrates at the same angle as the final layer of molecules. The light is only allowed an entrance if the second polarized glass filter is same as the final layer. Take a look at the figure below.

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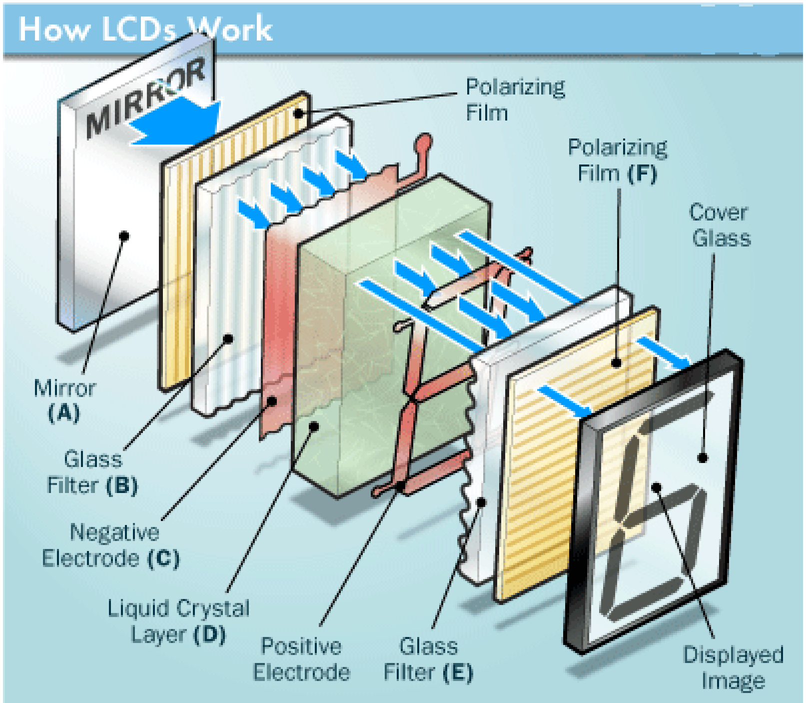

Figure 5.7: Working of LCD.

The main principle behind liquid crystal molecules is that when an electric current is applied to them, they tend to untwist. This causes a change in the light angle passing through them. This causes a change in the angle of the top polarizing filter with respect to it. So little light is allowed to pass through that particular area of LCD. Thus, that area becomes darker comparing to others.

For making an LCD screen, a reflective mirror has to be setup in the back. An electrode plane made of indium-tin oxide is kept on top and a glass with a polarizing film is also added on the bottom side. The entire area of the LCD has to be covered by a common electrode and above it should be the liquid crystal substance.

Next comes another piece of glass with an electrode in the shape of the rectangle on the bottom and, on top, another polarizing film. It must be noted that both of them are kept at right angles. When there is no current, the light passes through the front of the LCD it will be reflected by the mirror and bounced back. As the electrode is connected to a temporary battery the current from it will cause the liquid crystals between the common-plane electrode and the electrode shaped like a rectangle to untwist. Thus, the light is blocked from passing through. Thus, that particular rectangular area appears blank.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

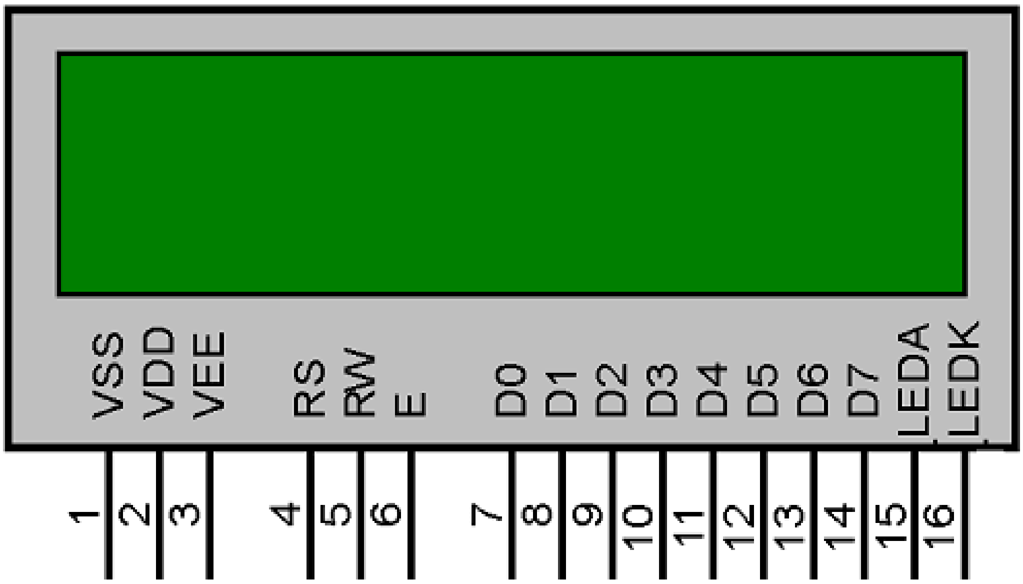

Figure 5.8: 16x2 LCD Display

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5.1.3.4 Pin Description of 16x2 LCD Display

Table 2: Pin description of LCD display.

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

5.2 SOFTWARE COMPONENTS

5.2.1 ARDUINO IDE

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. The source code for the IDE is released under the GNU General Public License, version 2.

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

Program for Arduino hardware may be written in any programming language with compilers that produce binary machine code for the target processor. Atmel provides a development environment for their 8-bit AVR and 32-bit ARM Cortex-M based microcontrollers: AVR Studio (older) and Atmel Studio (newer).

Sketch

A program written with the Arduino IDE is called a *sketch*. Sketches are saved on the development computer as text files with the file extension *.ino*. Arduino Software (IDE) pre-1.0 saved sketches with the extension *.pde*.

A minimal Arduino C/C++ program consist of only two functions:

- *setup()*: This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.

- *loop()*: After *setup()* has been called, function *loop()* is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

Blink Example

Most Arduino boards contain a light-emitting diode (LED) and a load resistor connected between pin 13 and ground, which is a convenient feature for many tests and program functions. A typical program for a beginning Arduino programmer blinks a LED repeatedly. This program uses the functions pinMode(), digitalWrite(), and delay(), which are provided by the internal libraries included in the IDE environment. This program is usually loaded into a new Arduino board by the manufacturer.

```
#define LED_PIN 13                   // Pin number attached to LED.

void setup() {
    pinMode(LED_PIN, OUTPUT);       // Configure pin 13 to be a digital output.
}

void loop() {
    digitalWrite(LED_PIN, HIGH);    // Turn on the LED.
    delay(1000);                    // Wait 1 second (1000 milliseconds).
    digitalWrite(LED_PIN, LOW);     // Turn off the LED.
    delay(1000);                    // Wait 1 second.
Second
}
```

5.2.1.1 Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

Verify: Checks your code for errors compiling it.

Upload: Compiles your code and uploads it to the configured board. See uploading below for details.

New: Creates a new sketch.

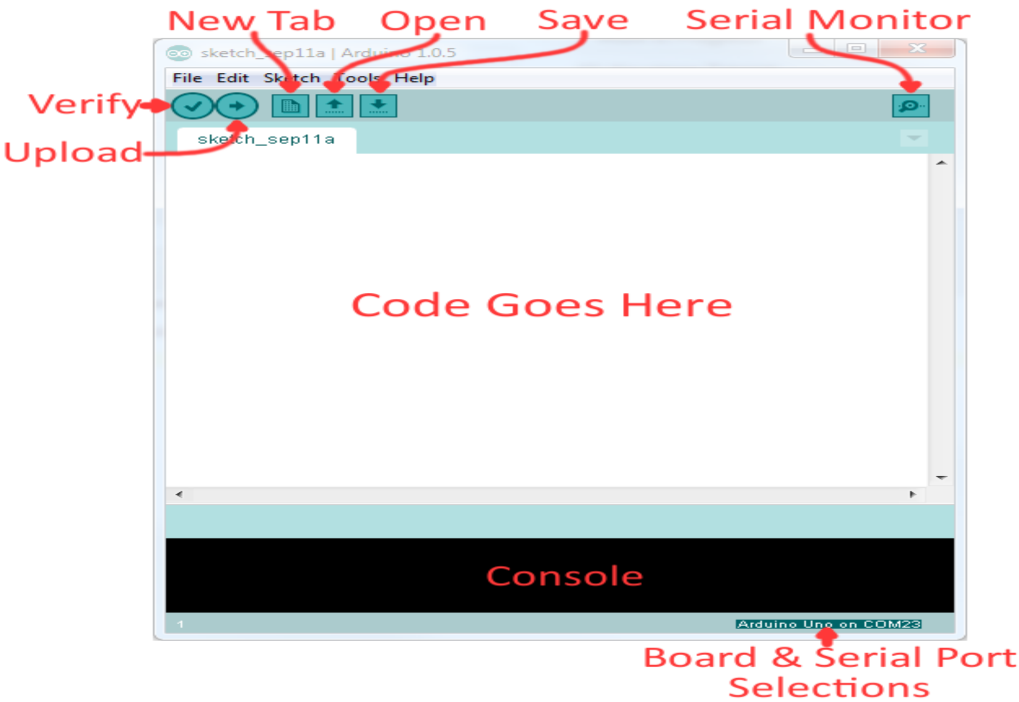

Figure 5.9: The main window of Arduino IDE

Open: Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.

Save: Saves your sketch.

Serial Monitor: Opens the serial monitor.

- **Sketchbook**

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store Arduino programs (or sketches). The sketches in sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time the Arduino software will automatically create a directory for the sketchbook. The programmer can view or change the location of the sketchbook location from with the Preferences dialog.

- **Tabs, Multiple Files, and Compilation**

Allows the programmer to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

5.2.1.2 Uploading Procedure

Before uploading the sketch, the programmer need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for a Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board),

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or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, look for USB serial device in the ports section of the Windows Device Manager. On Linux, it should be /dev/ttyACMx, /dev/ttyUSBx or similar. Once selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or shows an error.

When a sketch is uploaded using the Arduino boot loader, a small program that has been loaded on to the microcontroller on your board. It allows you to upload code without using any additional hardware. The boot loader is active for a few seconds when the board resets; then it starts whichever sketch was most recently uploaded to the microcontroller. The boot loader will blink the on-board (pin 13) LED when it starts (i.e. when the board resets).

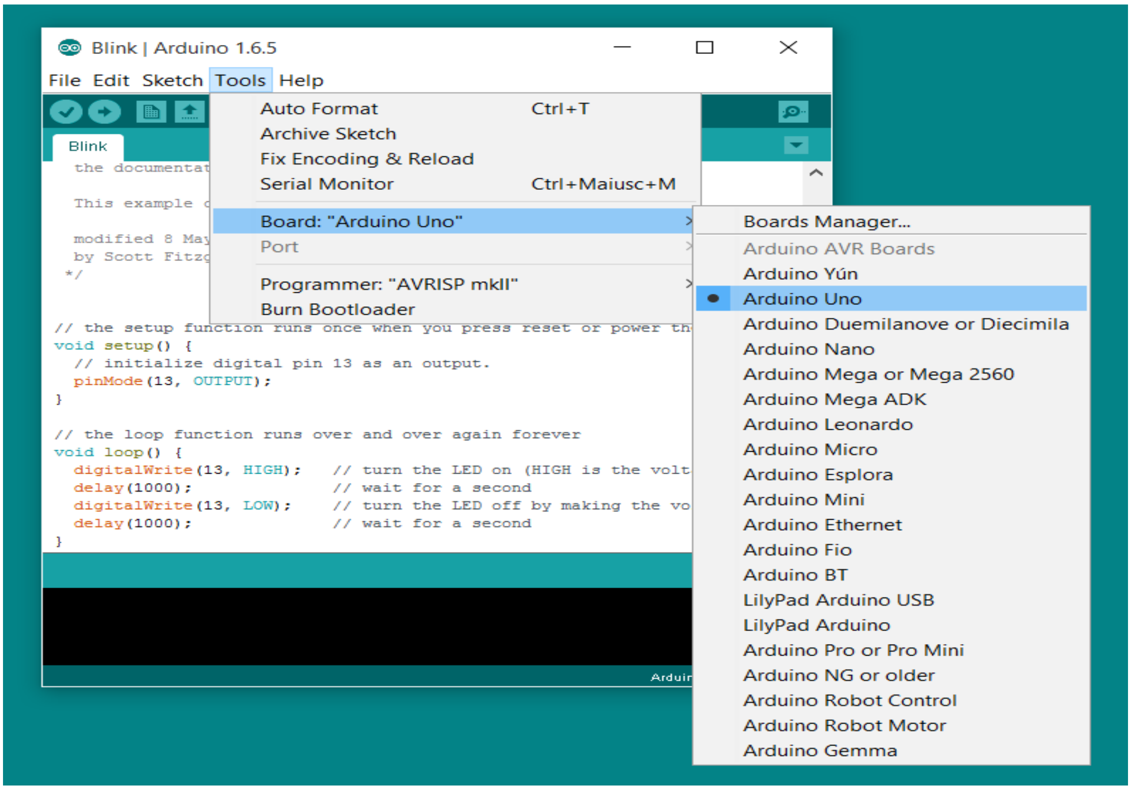

Figure 5.10: The method of selecting the hardware board

5.2.1.3 Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

There is a list of libraries in the reference. Some libraries are included with the Arduino software. Others can be downloaded from a variety of sources or through the Library Manager. Starting with version 1.0.5 of the IDE, you do can import a library from a zip file and use it in an open sketch. See these instructions for installing a third-party library.

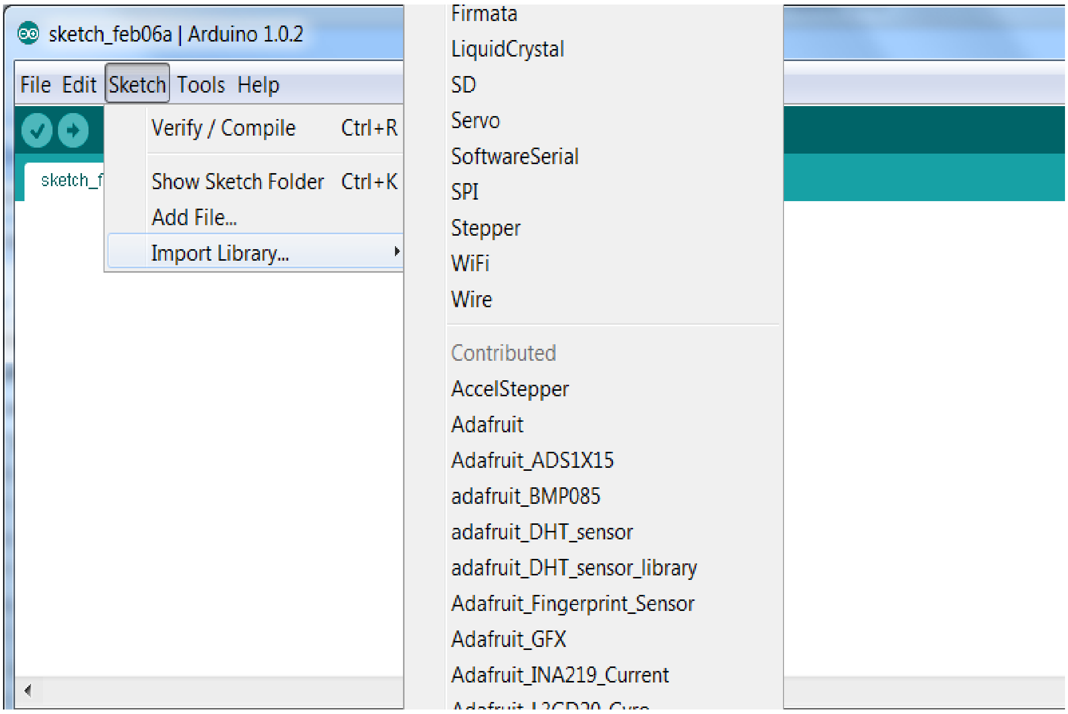

Figure 5.11: The method of importing libraries

5.2.1.4 Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, boot loaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory.

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5.2.1.5 Serial Monitor

Displays serial data being sent from the Arduino or Genuino board (USB or serial board). To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down that matches the rate passed to Serial. Begin in your sketch. Note that on Windows, Mac or Linux, the Arduino or Genuino board will reset (rerun your sketch execution to the beginning) when you connect with the serial monitor.

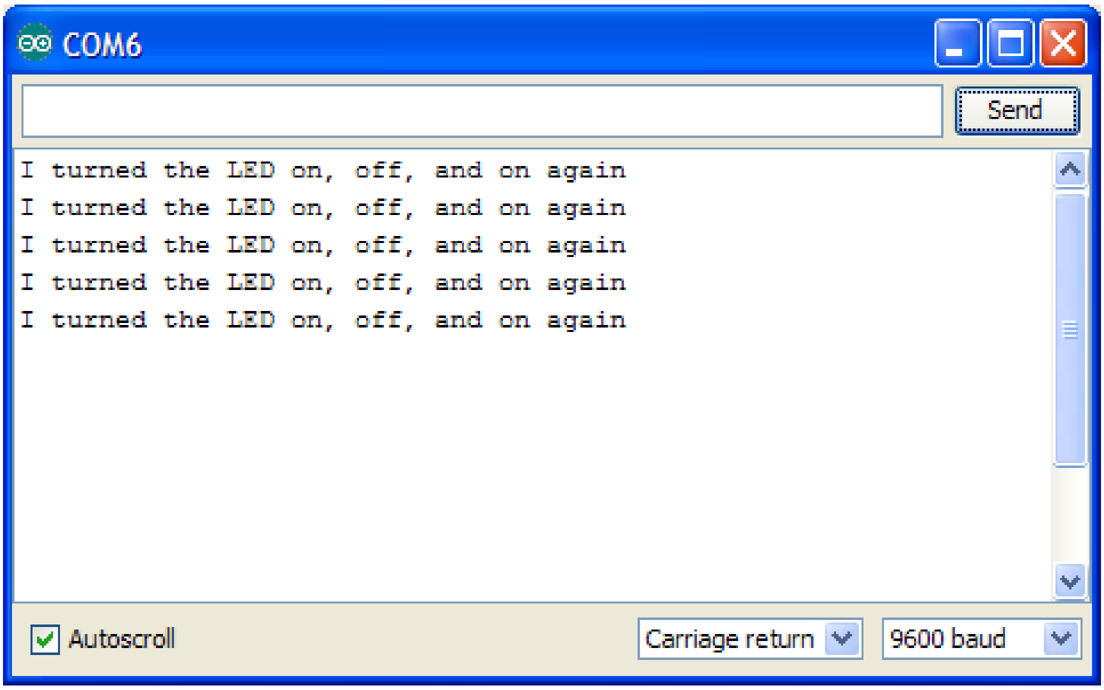

Figure 5.12: The serial monitor window.

5.2.1.6 Arduino Programming

1) **Basic code definitions**

setup ( ): A function present in every Arduino sketch. Run once before the loop ( ) function. Often used to set pin mode to input or output. The setup ( ) function looks like:

```
void setup( ){
//code goes here
}
```

loop ( ): A function present in every single Arduino sketch. This code happens over and over again. The loop ( ) is where (almost) everything happens. The one exception to this is setup ( ) and variable declaration. ModKit uses another type of loop called “forever ( )” which executes over Serial. The loop ( ) function looks like:

```
void loop( )
 {
//code goes here
```

}

• Input: A pin mode that intakes information.

• Output: A pin mode that sends information.

• HIGH: Electrical signal present (5V for Uno).

Also, ON or True in Boolean logic.

• LOW: No electrical signal present (0V).

Also, OFF or False in Boolean logic.

• digitalRead( ): Get a HIGH or LOW reading from a pin already declared as an input.

• digitalWrite( ): Assign a HIGH or LOW value to a pin already declared as an output.

• analogRead( ): Get a value between or including 0 (LOW) and 1023 (HIGH). This allows you to get readings from analog sensors or interfaces that have more than two states.

• analogWrite( ): Assign a value between or including 0 (LOW) and 255 (HIGH). This allows you to set output to a PWM value instead of just HIGH or LOW.

• PWM: Stands for Pulse-Width Modulation, a method of emulating an analog signal through a digital pin. A value between or including 0 and 255. Used with analogWrite.

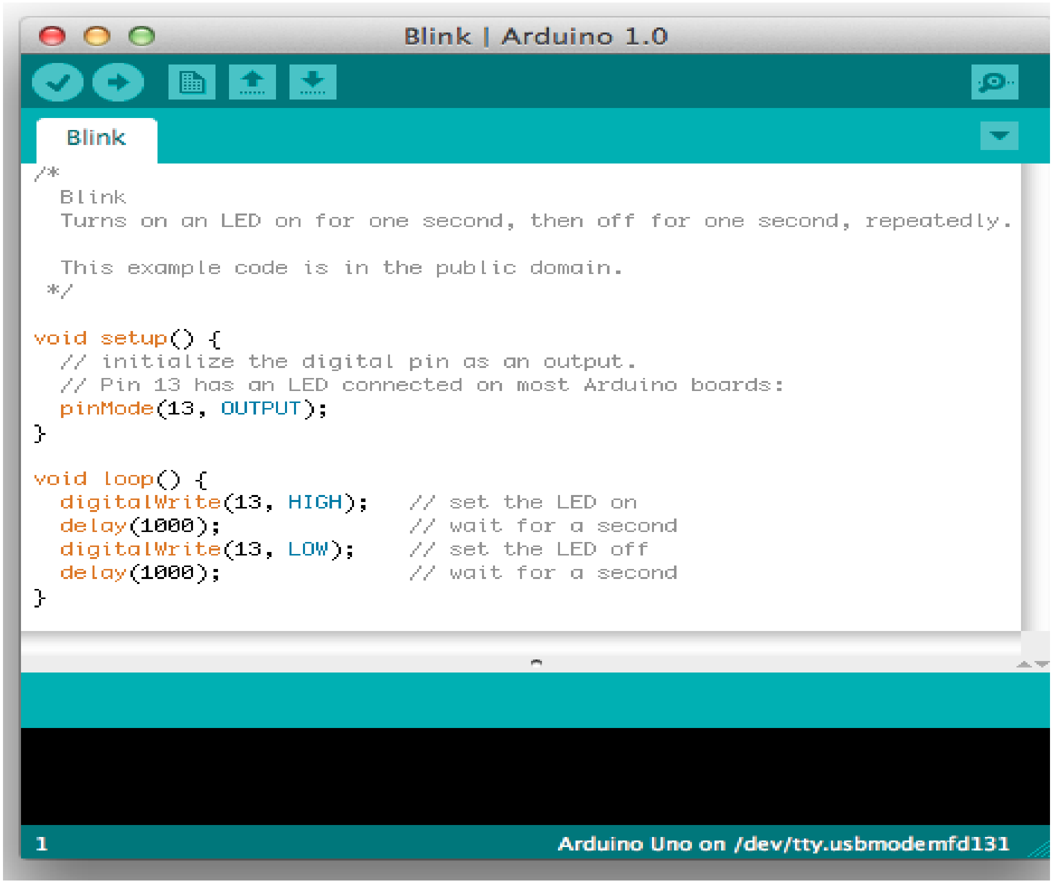

Figure 5.13: The image of sample LED Binky code

5.2.1.7 Applications

- Arduboy, a handheld game console based on Arduino.
- Arduino Motion Control Rig.
- Arduinome, a MIDI controller device that mimics the Monome.
- ArduinoPhone, a do-it-yourself cellphone.
- Ardupilot, drone software and hardware.
- ArduSat, a cubesat based on Arduino.
- Automatic titration system based on Arduino and stepper motor.
- C-STEM Studio, a platform for hands-on integrated learning of computing, science, technology, engineering, and mathematics (C-STEM) with robotics.
- DC motor control using Arduino and H-Bridge.
- Data loggers for scientific research.
- Gameduino, an Arduino shield to create retro 2D video games.
- Homemade CNC using Arduino and DC motors with close loop control by Homofaciens.
- Impedance sensor system to detect bovine milk adulteration Low cost data glove for virtual reality applications.
- OBDuino, a trip computer that uses the on-board diagnostics interface found in most modern cars.
- Water quality testing platform.
- Xoscillo, an open-source oscilloscope.

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CHAPTER 6

RESULTS & DISCUSSION

Heart rate is an important parameter of human health that has to be monitored perfectly. Usually, doctors make use of heart rate monitor such as ECG to check and measure heart rate of the patient. In this work, we have designed a simple and an advanced version of heart beat monitoring system that can easily be use by a common man to measure his heat rate per minute and monitor his health condition. Here we made use of highly sensitive IR sensor, which senses the pulses through the skin by placing the finger towards the sensor which is further processed using the microcontroller and finally the measured heart rate is displayed on the LCD. Since, the measured heart rate will be displayed on LCD in the digital form, it can be easily understood by a common man.

Normal Heart rate of an adult of 18 and above should be around 60 – 120 beats per minute. In the same way, it varies for different age groups. So, when people check their heart beat with this proposed model they can easily monitor their heart condition. If the heart rate is below or above the normal rate, then it signifies that there are chances of getting some of the diseases related to heart, so they can approach the doctors for further treatment and get the precautions.

The following are some of the tests performed to check the working condition of the designed device.

6.1 Testing the working condition of the proposed model.

1. Initially the model is tested without placing the finger or any obstacle towards the sensor to check the perfectness of it.
2. When the finger is not placed towards the senor, LED remains off, indicating that the sensor has not detected the pulse. So, the GUI (graphical user interface) graph remains empty and only the title will be displayed on the LCD monitor as shown in the figure 6.1 below.
3. This indicates that the proposed model is ready to undergo the test to calculate the heart pulse.

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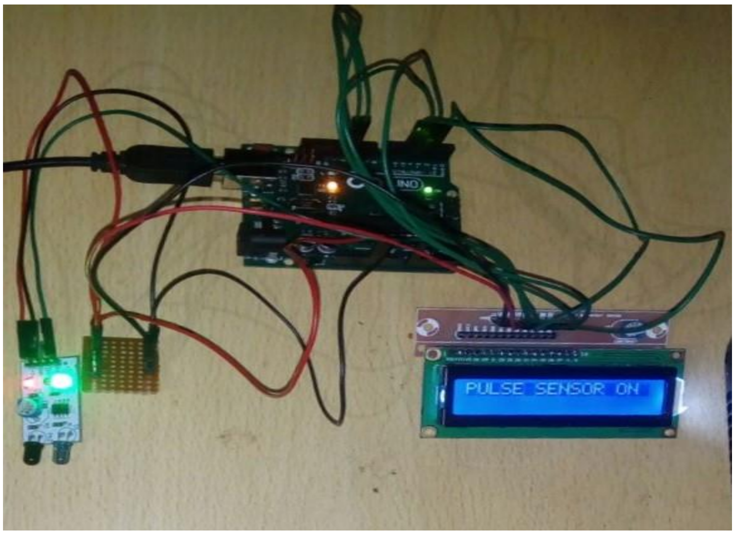

Figure 6.1: Tested view of the module.

6.2 Testing to detect the heart pulse.

1. Initially, the testing is performed by placing the finger towards the IR sensor. The finger has to be placed very close to the sensor to get more accuracy.
2. IR sensor detects the pulse by observing the fluctuations caused in the blood flow. As soon as the pulse is detected the LED turns on. This detected pulse rate is viewed on the GUI and also displayed on the LCD monitor as shown in the figure 6.2 & 6.3below.

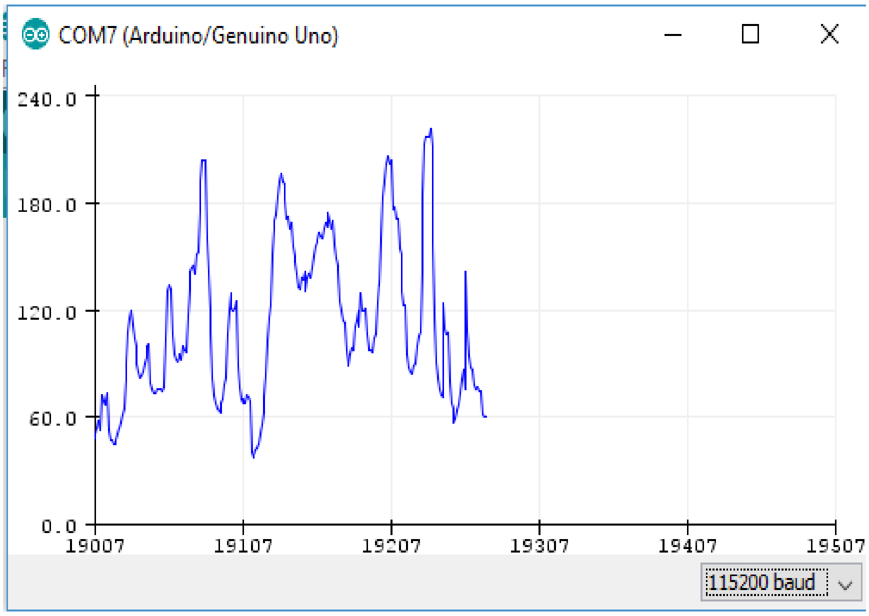

Figure 6.2: Tested GUI view of a detected heart pulses by the IR sensor.

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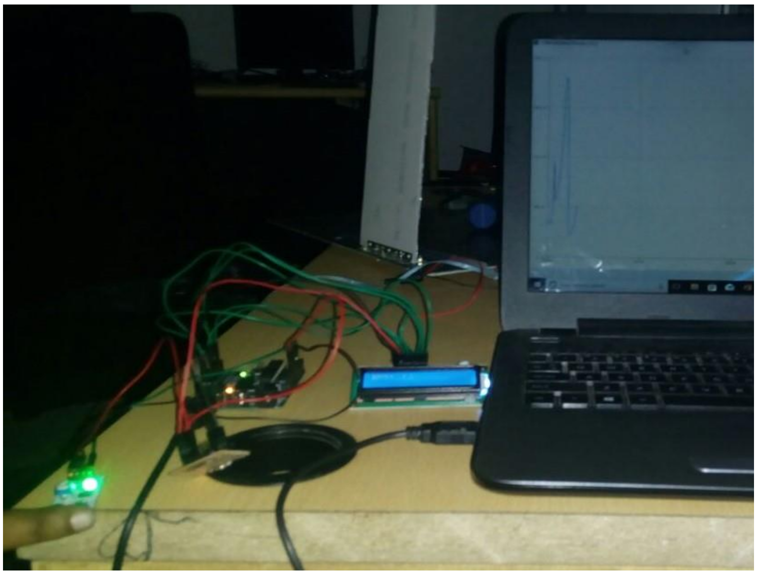

Figure 6.3: Tested view of module when the heart pulses are detected.

6.3 Final output of the proposed model.

1. The detected pulses obtained by the sensor are voltage signals. Later on, these pulses are sent to the LED. The LED turns on and the signal is sent to the microcontroller.

2. The microcontroller is processed by the Arduino IDE software which considers only the high frequency components of the detected pulses per minute as per the program are generated.

3. These pulses are digitized and fed to the LCD monitor.

4. LCD monitor displays the final count of a heart rate per minute in digitized form as shown in the figure 6.4.

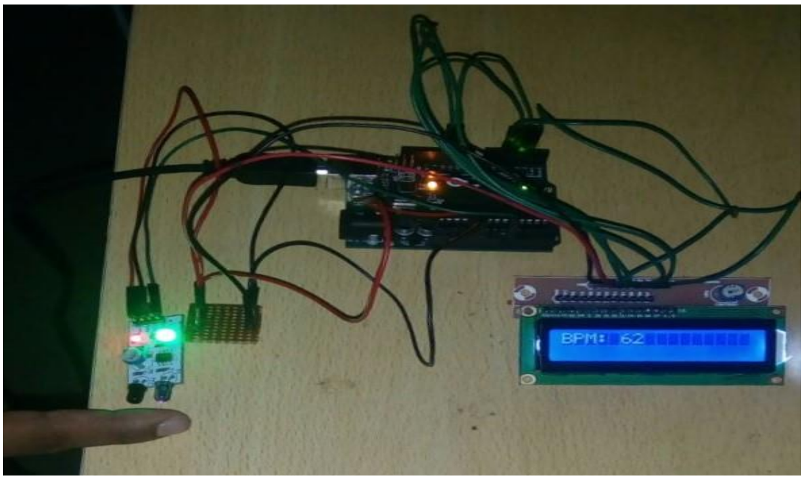

Figure 6.4: Final output of the proposed module.

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6.4 Recognised heart conditions based on the detected heart rate

As it is verified by doctor a normal heart rate of a person varies with respect to different age groups. Some of the data of different heart conditions regarding the heart rate of a patient are recognised and shown below.

Table 3: different conditions of detected pulse rate.

SL NO	CONDITIONS	HEART RATE
1	NO PULSE RATE	Below 40 bpm
2	NORMAL CONDITION	60 to 100 bpm
3	ABNORMAL CONDITION	40 to 60 bpm
4	HIGH PULSE RATE	Above 100 bpm

6.4.1 No pulse rate

If the detected pulse rate of a patient is below 40 bpm then it is considered as no pulse rate and is displayed on the LCD monitor as shown in figure 6.5.

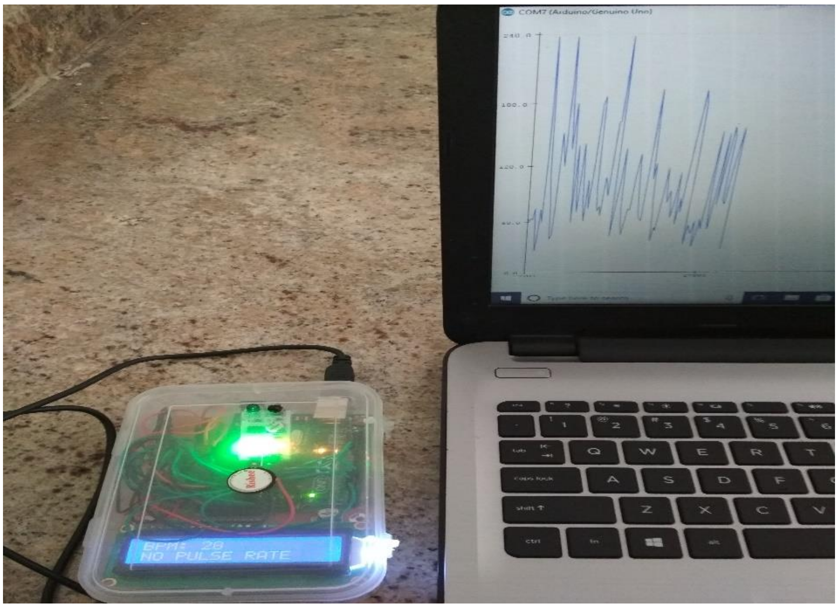

Figure 6.5: no pulse rate.

6.4.2 Normal condition

If the detected pulse rate is between 60 to 100 bpm then it is considered as normal pulse rate and displayed on the LCD monitor as shown in figure 6.6.

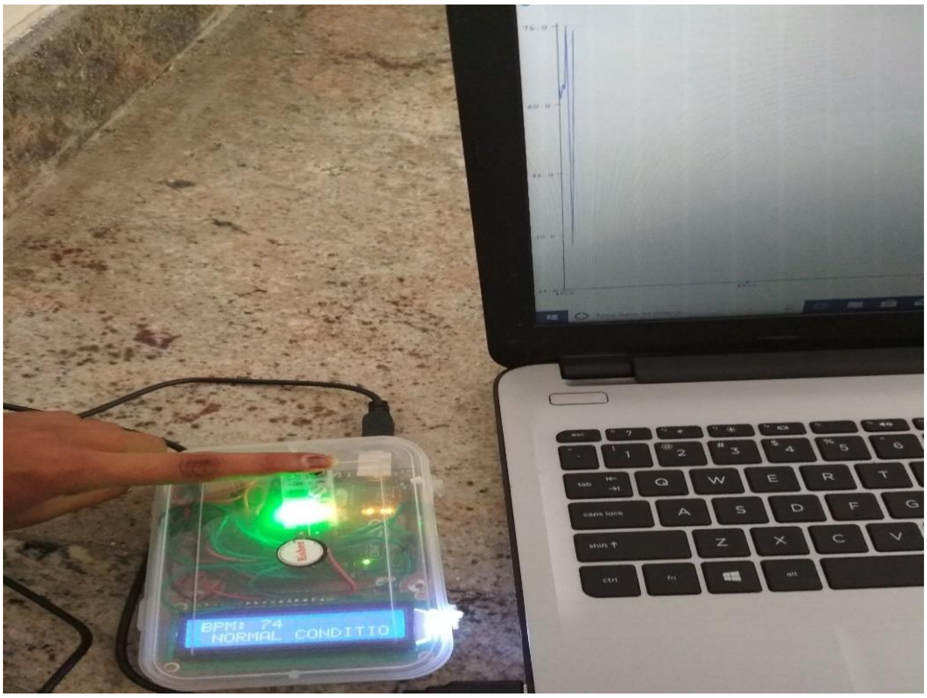

Figure 6.6: Normal condition

6.4.3 Abnormal condition

If the detected pulse rate is between 40 to 60 bpm then it is considered as abnormal condition and displayed on the LCD monitor as shown in figure 6.7.

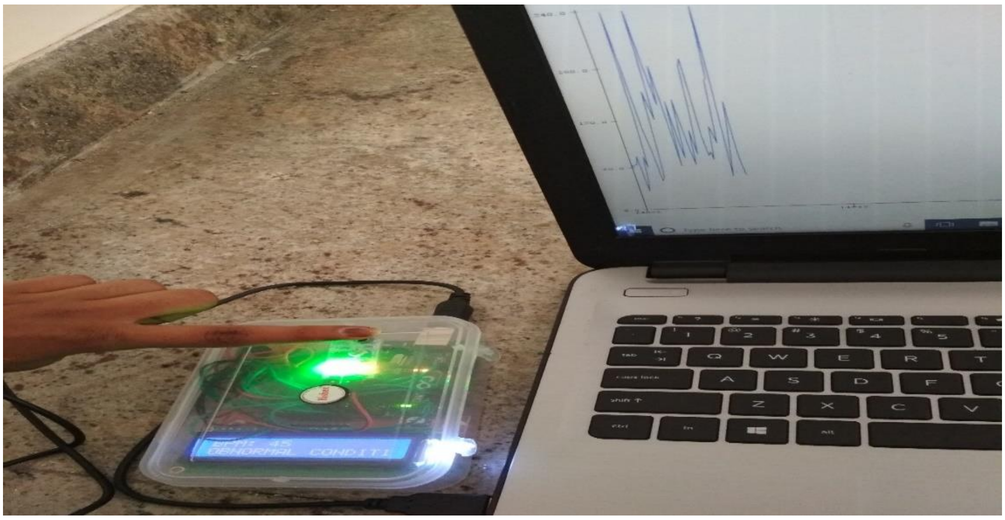

Figure 6.7: Abnormal condition

6.4.4 High pulse rate

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If the detected pulse rate is above 100 bpm then it is considered as high pulse rate and it is displayed on the LCD monitor as shown in figure 6.8.

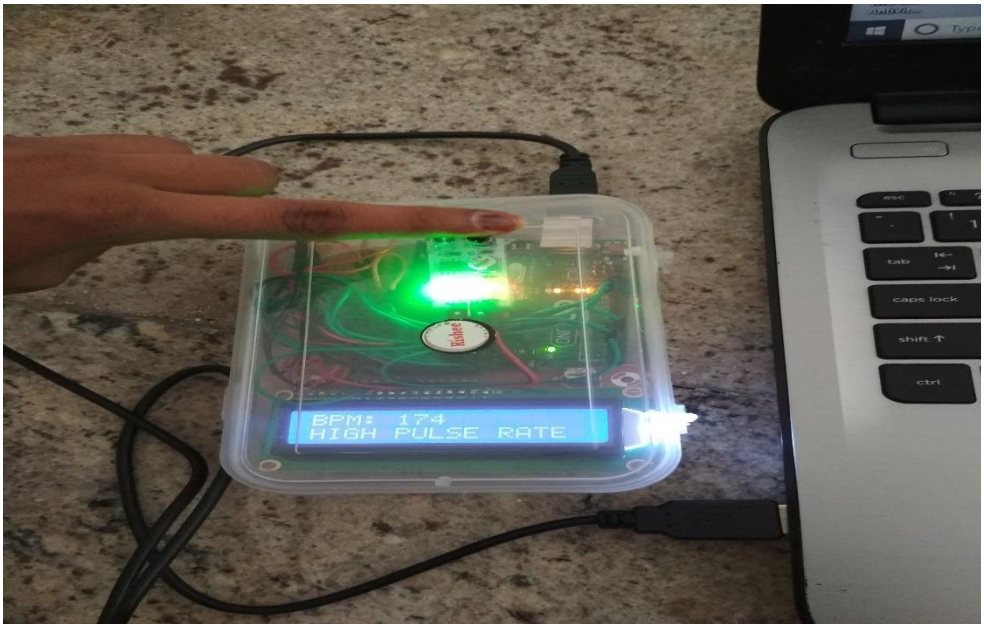

Figure 6.8: High pulse rate

APPLICATIONS

1. Industries: hospitalizing automations.

2. Health: useful for common man.

3. Medical application: A heart rate monitor can be a useful tool for anyone interested in exercise because it allows a person to manage the intensity of a workout. This is because personal fitness goals require exercise to be maintained at some target heart rate.

ADVANTAGES

- Low cost and low power consumption,
- Portable and accurate.
- Time consuming and user-friendly.
- Applicable to all age groups of humans.
- Environmental-friendly and less design complexity.

The project implemented a low cost, low power heart rate monitoring using microcontroller. Lists of accomplishments include: Adequately amplifying biological signal ADC conversion of analog signal Semi functional heart rate meter Functional notification and LCD heart rate display Use of low power components for battery operation.

DISADVANTAGES

- Due to the use of electronic components it lags behind in getting 100% accurate results.
- The component provided in market especially the component of infrared sensor are provided without datasheet or name to search about it. This is one of the drawback because the electrical characteristics of the components are unknown.

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CONCLUSION AND FUTURE SCOPE

The proposed working model functioned smoothly and the overall observation was made and the objectives were achieved successfully. Apart from all this, the proposed work provides better service for the people to lead a healthy life by monitoring their heart condition from time to time on their own without the need of consulting the medical experts to check their heart rate. Through this work, the device is made simple to use, portable, safety and applicable to all levels of users and very useful for a common man, especially for elders. The device is advanced compared to the currently available industrial product as it is capable of recognizing the heart condition of a person such as emotions just by measuring the heart rate by sensing the pulses. It is portable, as it can be used at home and carried anywhere by individual. It is user friendly and available at low cost. In the future, this work is looking forward to include more advanced by designing it to send it as an SMS alert to the doctors when serious issues regarding the patient's health were recognized by this device. This proposed working model is more accurate due to the use of IR sensor as it provides more stable output, low cost and simple in design when compared to commercial devices that are currently available in the market.

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