

# **DEVELOPEMENT OF AN AUTOMOTIVE HEALTH MONITORING SYSTEM FOR DOCTOR'S CHAMBER**

by

ASHIM NATH

MUHAMMAD. ASHRAF-UR-RAHMAN

**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC  
ENGINEERING**



Department of Electrical and Electronic Engineering  
INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

AUGUST 2017

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A project

submitted as partial fulfilment of the requirement for the degree of

**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC  
ENGINEERING**

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## **CERTIFICATE OF APPROVAL**

The project entitled as “**Development of an Automotive Health Monitoring System for Doctor’s Chamber**” Submitted by **Ashim Nath**, bearing Matric ID. **ET-131007** and **Muhammad. Ashraf-Ur-Rahman**, bearing Matric ID. **ET-131016** of session **Spring 2017**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **18 August, 2017**.

---

Supervisor

Engr. Mohammed. Abdul Kader

Assistant Professor

Department of Electrical and Electronic Engineering

International Islamic University Chittagong.

## DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this project has been submitted elsewhere for the award of any degree or diploma.

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Ashim Nath

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Muhammad. Ashraf-Ur-Rahman

## **ACKNOWLEDGMENT**

All the praises and thanks be to Almighty Allah, without His blessings, it was impossible to complete our project.

It is with immense gratitude that we acknowledge the support and help of our project supervisor Engr. Mohammed Abdul Kader, Assistant Professor, Dept. of EEE, International Islamic University, Chittagong. We wish a good life for our honourable project supervisor and gives sincere thanks to him for suggesting us the project topic “Development of an Automotive Health Monitoring System for Doctor’s Chamber”.

Last but not the least, we are really grateful to our family, friends, and faculty members, who have given us their unconditional support and help in each and every aspect. We are really fortunate to have nice human being like them around us.

Authors

## ABSTRACT

An automotive health monitoring system with RF communication for doctor's chamber has been designed and implemented in this project. Our aim is not only to provide the measured data but also to couple the resultant data with user's body mass index (BMI) and complete the whole process within a short time so that a doctor can give proper counselling to his patients. The system consists of Arduino Uno, LCD display, RF transmitter and receiver and three peripherals; namely, (1) height sensor (2) weight sensor (3) pulse sensor. Microcontroller ATmega328 which is mounted on Arduino Uno stores the program. All programs are written in C programming language. RF transmitter and RF receiver provide optioning to transmit the measured and calculated data towards doctor's console. Finally, LCD display shows height, weight, pulse, BMI score and also categorize patient's health status in accordance with ideal BMI chart. For example, if BMI score of a patient be 23.5 then his health status will be shown as "HEALTHY"; again, if the BMI score be 28 then the health status will be "OVERWEIGHT" and so on. Our proposed device can also be used as self-health manager as it is very user friendly and doesn't require much space to install. We believe that this system would be a great helping hand to quantify the medical treatment

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## LIST OF ABBREVIATIONS

BMI	Body Mass Index
SBFMS	Sounding Body Fat Management System
RFID	Radio Frequency Identification
PLC	Power Line Communication
BSA	Body Shape Analysis
PFT	Physical Fitness Test
HIMS	Health Information Management System
NIBP	Non-invasive Blood Pressure Test
ECG	Electrocardiogram
RTOS	Real Time Operating System
HART	Highly Addressable Remote Transducer
LAN	Local Area Network
RF	Radio Frequency
UART	Universal Asynchronous Receiver-Transmitter
ASK	Amplitude-Shift Keying
LCD	Liquid Crystal Display
GLCD	Graphical Liquid Crystal Display
LED	Light Emitting Diode
PPG	Photoplethysmography
BPM	Beats Per Minute

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

The evolution of technology has reached a point where pretty much anything is available at the touch of a button. Shopping, learning, working and entertainment can all be accessed from the comfort of our own homes, on a train or sat in a cafe. But it's coming at a price; and relatively crucial one at that is health. And as technology changes day by day, those who will suffer most will be our children. Hence measuring physical fitness conditions is important for all ages especially who are tracing sound health conditions and in search of cure or controlling conditions at all possible ways.

In our system, we have developed a device mainly which can help to solve this problem. This peripheral device is being able to be performed as BMI calculation device in association with pulse measurement. Now, what is BMI? BMI aka body mass index is a measure of relative weight based on an individual's mass and height. There is a good gauge of risk to occur fatal diseases because of more body fat which is correlated with BMI. The higher values of BMI causes higher possibilities for certain diseases such as heart disease, high blood pressure, type 2 diabetes, gallstones, breathing problems and certain cancers [1]. According to World Health Organization, the ideal BMI a person should have in between 18.5 to 24.9 [2]. Pulse condition is the conditions of artery pulse examined by one's fingers. The formation of pulse condition is related to such factors as the beat of heart, the smoothness of vessel system, adequacy and deficiency of QI-blood etc. [3].

Keeping in mind the above factors our purpose of this project is to generate an informative description of hardware design and construct a microcontroller based automotive health monitoring system mainly for the use in a doctor's clinic. This would be extremely helpful for monitoring one's health condition within a very short time and also be a great helping hand especially to the people living in remote areas who are deprived of basic medical needs. Our project hardware is thoroughly coordinated by Arduino UNO in which C- programming language has been used to program it for the desired operations.

## **1.2 Project Overview**

The main thought of our project is developing a reliable scheme which can measure height, weight of every single individual and calculate BMI of him/her. In addition to, it must measure pulse of that particular individual. To actualize this project, several sensors have been consolidated in a way so that they can operate in a specific time period and takes reading. Afterwards, the measured data must be sent to the receiving end. Patients have to stand on the weighing machine for weight measurement at the same time his height will also be being measured and both the data will be transmitted and stored in the receiving end. When the necessary calculations are done, the desired BMI score will be availed. The pulse measurement will also be facilitated in this zone. The data transmission process will be done through RF communication.

## **1.3 Motivation**

One of the fundamental rights that a man possesses is proper medication. But developing or under developing countries like Bangladesh are still failing to ensure proper medical treatment. One of the prime causes behind it is our hospitals or doctor's clinics which are still not well equipped. With the revolutionary progress in science and technology during last few decades, the developed countries have already made the most out of it in the important sectors like medicine and biomedical engineering. But a big sigh came across when we looked at the present scenario of our country in this regard. So as engineering students we had the vision to make some sorts of impact in the field of biomedical. With the limited ability and knowledge we intended to make this system. When we had taken a look upon the doctor's clinic around the big cities of our country we found that many of them do not have even a weighing machine! The numbers of doctor are inadequate to the huge number of patient. On the other hand, people tend to take treatment from the renowned doctor's only. But they neither have time to take weight, height, pulse or calculating BMI nor can't assign someone who can do all these work in a quick time. Again, measurements and calculations taken manually have the higher percentages of chance to be wrong. So, we took step up and designed this system. In this system height, weight, BMI score and pulse is measured. In this way, a doctor can efficiently monitor his patient's health. And diseases related to obesity can be identified or prevented as early as possible. In many rural areas where people are deprived of medical facilities, this simple user-friendly system can be a great helping hand. In the end, our main motivation

of this project is to develop a comparatively low cost and more reliable system to measure or examine fitness of a human body through BMI and pulse monitoring.

#### **1.4 Project Objectives**

The project objectives are as follows:

- To develop a device to measure the height, weight, pulse of a patient in doctor's chamber.
- To transmit the data of height, weight to a device placed in doctor's table.
- To calculate BMI and showing height, weight, pulse and BMI in a display.

#### **1.5 Report Outlines**

Six chapters were covered in the course of design and development of this project. The chapters and their contents are given below:

- Chapter one is the introductory chapter that gives the overview, motivation and objective of the project.
- Chapter two is literature review. All previous work related of this project has been discussed in this chapter.
- Chapter three is hardware description. In this chapter, all the components used in this project are described elaborately.
- Chapter four deals with system design of the project. In this chapter block diagram, circuit diagram, flow chart and programming of the project has been discussed.
- In the chapter five the system implementation and results, objective verification and system specification has been analyzed.
- Finally, the summary of this project is discussed in detail in chapter six. The limitation of this project, advantage and future development is discussed in this chapter.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Introduction

Devices that deal in quantifying weights or metering heights or counting heart beats are completely different from each other. All the three measurements require of their respective sensors. Individually they are very much available both in manually and automatic process. But putting them altogether in a single device and also making it to calculate mathematical formulas such as Body Mass Index is not at all possible to find. Our project is not only providing these features but also is capable to display all the calculations within the range of microseconds. All the measured and calculated data are opted to be shown in LCD display. Here, we have implied RF wireless communication system to transmit data from one place to other i.e. doctor's console. A transmitter interfaced with the microcontroller module triggered the data which subsequently received by the receiver microcontroller. All the peripherals used in this project are consolidated by Arduino Uno. Therefore, it takes less time than the manual operation and it is highly reliable as the whole process is automatic.

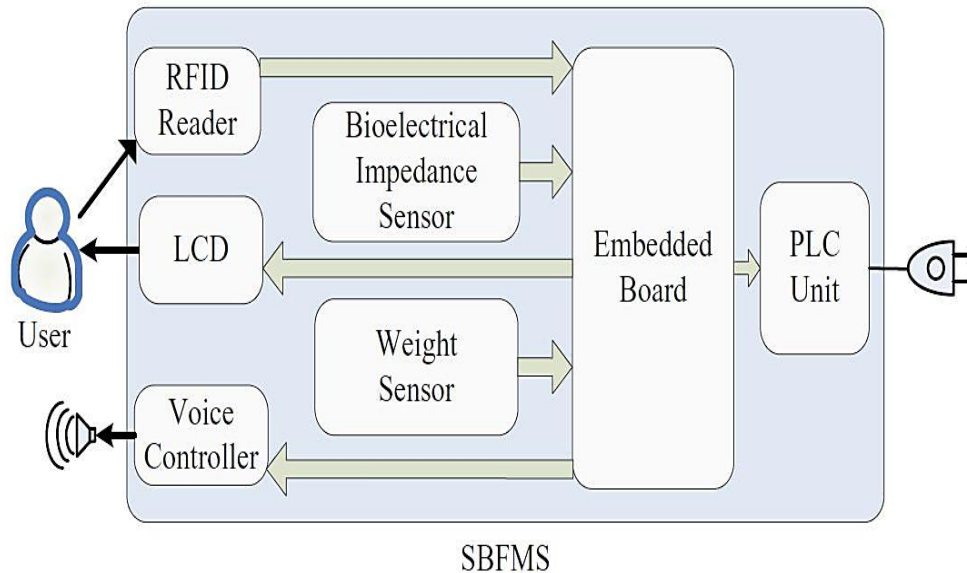
### 2.2 Review of Previous Works

Some previous works related to height, weight, BMI and pulse measurement are given below.

#### *2.2.1 Body Fat Management System with Remote Monitoring*

The sounding body fat management system (SBFMS) is used for health analysis. The SBFMS identifies user by RFID and measure his weight and bioelectrical impedances and suggest user by voice and text. Moreover, the user can access his measurement results through PLC remotely. This system consists of seven parts as show in **Fig. 2.1** RFID reader, LCD, bioelectrical impedance sensor, voice controller, weight sensor, embedded board and PLC unit. Radio frequency identification (RFID) technology is used here for identy user's. it comprises of readers and tags. An RFID tag transmits unique information to reader that can be anywhere from a few inches to several feet away. On the otherhand, Power line communication (PLC) provides home network devices a high speed data transmission rate. Weight and body fat percentage values generate from weight module and bioelectrical impedance module after user stands on the SBFMS.

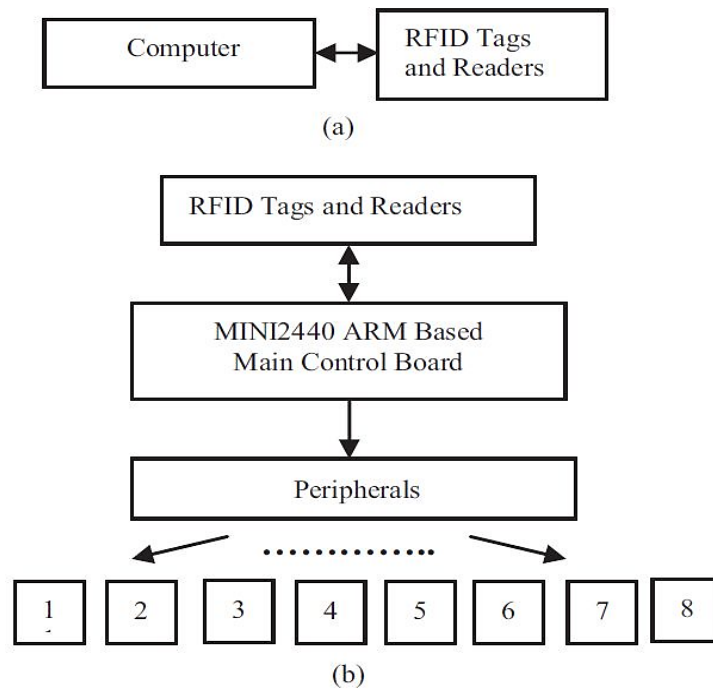
Data stored in database and display on readout by display module. Then voice module read the data and also gives suggestion according to the resultant data. For an example, it wil suggest like “keep on exercise!” when an overweight user who has less weight and body fat percentage than last time. All the application programs are done onWinCE OS [4].



**Fig. 2.1** The block diagrams of SBFMS [4].

### 2.2.2 RFID Based Physical Fitness Condition Measurement System

RFID based physical fitness measurement system is developed to support medical diagnosis to quantify medical treatment, rehabilitation or training. The system includes RFID tag, RFID reader, main control board and several peripherals such as blood pressure meter, ear temperature meter, height-weight meter, balance measurement and speed test for running back-forth measurement as shown in **Fig. 2.2** The RFID tag and reader are used to store and read user’s identification as well as their physical fitness conditions. The main control board with MINI2440 ARM microprocessor and WinCE 6.0 platform embedded would process the user’s identification and trigger the peripheral device for measuring his/her physical fitness conditions. The measured data is then transmitted and stored in RFID tag and database. The measurements taken by the peripherals are actually initiated by several sensors such as ultrasonic is for distance and load cell is for measuring user’s height and body balance ability. Running back/forth, thrusting forward to ground and lying-down/sitting-up measurements are actuated by two optical sensors. The user interface and database are built by C++ codes [5].



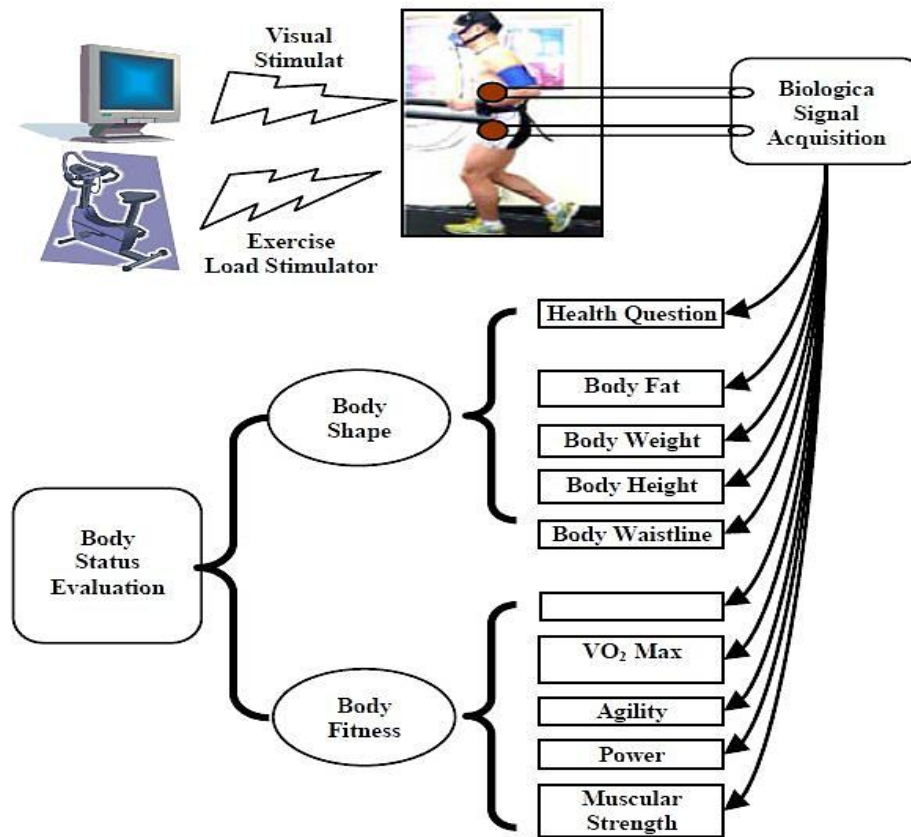
**Fig. 2.2** PFCMS block diagram of the (a) computer part; (b) measurement part [5].

### 2.2.3 An Integrated System for Body Shape Analysis and Physical Fitness Test- HIMS

Exercise has been proven to be very helpful for maintaining a sound health. But inappropriate exercise may hurt human health also. In order to balance this process an integrated system for body shape analysis (BSA) and physical fitness test (PFT) – HIMS (health information management system) is developed. It consists as in **Fig. 2.3** of five data acquisition modules. Namely,

- Body weight and body fat measurement modules for body shape analysis.
- VO<sub>2</sub> max, NIBP, muscular strength, power, agility measurement module for PFT.
- Bike type equipment for PFT.
- LCD monitors to display body analysis and physical fitness measurement result.
- USB2.0 communication to computer. It provides maximum speed of 12 Mbps.

In NIBP (non-invasive blood pressure test), oscillometric method is used. Body weight and muscular strength is tested by load cell which is able to measure 0 – 150 kg. body height and body waist is provided by the user as input. Monitoring ECG, heart rate is measured during VO<sub>2</sub> max which is done through bike type equipment where user has to take some exercises. Power test is done by pedaling with maximum speed for 10 seconds. In this system, measured data is being evaluated and analyzed through comparing with accumulated data from verified agency such as hospital. Hence, it makes the system more reliable [6].

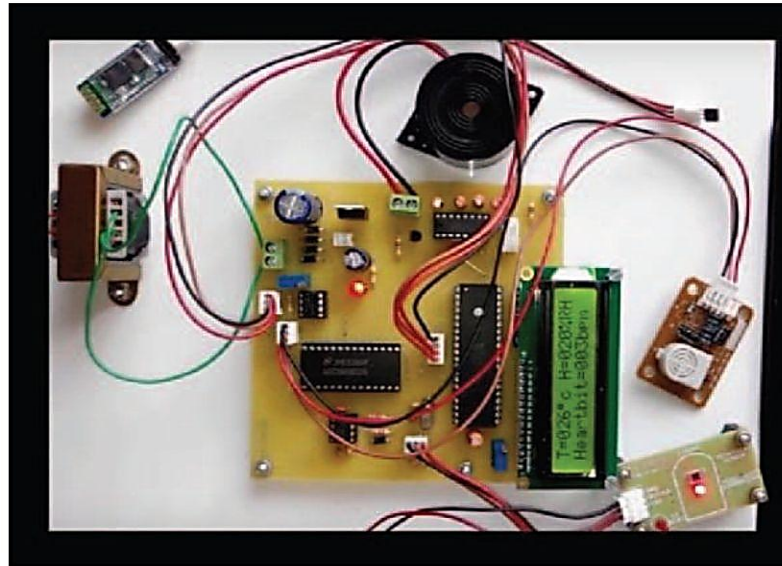


**Fig. 2.3** Overall system design for body shape analysis and physical fitness test – HIMS [6].

#### ***2.2.4 Multi-Sensor Inertial Data Acquisition System for Patient Health Monitoring with Real Time Operating System***

Patient remote monitoring propagates improved quality of care as well as reduces overall healthcare costs. In this system, RTOS based wireless sensor network architecture has been developed for the health monitoring. One node acts as central and others act to be slaves used for data acquisition. Real time operating system (RTOS) is used here to assign priorities. The RTOS is a handle which is done between hardware and application in order to provide time constraints. Highly addressable remote transducer (HART) is used to overcome the collision while transmitting the packets through wireless LAN. Three categories of sensors are used in this system. Namely, (1) heart beat sensors, (2) pressure sensors, (3) temperature sensors that are installed throughout the environment to monitor patient. For this purpose,  $\mu\text{C}/\text{OS-II}$  in ARM7 controller that performs multitasking and time scheduling mechanism is used. MEMS is an acronym for micro electro mechanical system which consists of a central unit, microprocessor and numerous components such as micro sensors. It is used here to sense and count heart beats; blood

pressure sensor is to monitor blood pressure where LM35 sensor measures temperature of the patient. In hardware, these 3 setups are being connected to the PIC microcontroller input port and ZigBee connected to output port. The GLCD display and uc0290 are connected to ARM7 microcontroller. The sensed data are being transmitted and received by the ZigBee. The total hardware set up is illustrated in **Fig. 2.4** [7].



**Fig. 2.4** Hardware Setup of multi sensor inertial data acquisition system for patient health monitoring with RTOS [7].

### 2.3 Comparison with Our Project

Our project and previous works are differentiated below:

- There is hardly any device being built so far that can show any kind of resemblance to our project.
- Art. 2.2.2 might be look little bit similar to our project. But owing to our aim and objectives it can't replace our system. As we have designed our project mainly for doctor's clinic, we tried to avoid any kind of complexity and only concentrated on providing data that are mostly desirable to a doctor in a most simple and affordable manner.
- In previous works, they have used multiple components just to program, store and transmission data but we have only used Arduino Uno in place of all these components which is more compatible and reliable.
- Our system can be upgraded easily. Unlike other works, our system is very cost effective. The main charge of this project is the cost of sensors.

# **CHAPTER 3**

## **HARDWARE DESCRIPTION**

### **3.1 Introduction**

Hardware is the most important fact for a project. Choosing the necessary hardware is also very difficult. In this chapter, we are going to describe the hardware used for this project. We will also discuss the function of the chosen parts. By the end of this chapter one will understand the reason behind choosing the used components and also their function to this project.

### **3.2 List of Components**

In our project, we have used different types of components for measuring height, weight, pulse, transmitting and receiving data and showing our desire data on display. The components used in our project are enlisted below:

- ATmega328P Microcontroller.
- Arduino UNO.
- Load Cell (100kg).
- HX711 module.
- Ultrasonic Sensor (HC-SR04).
- LCD Display (20x4).
- Pulse Sensor.
- RF Rx-Tx Module.
- LM358.

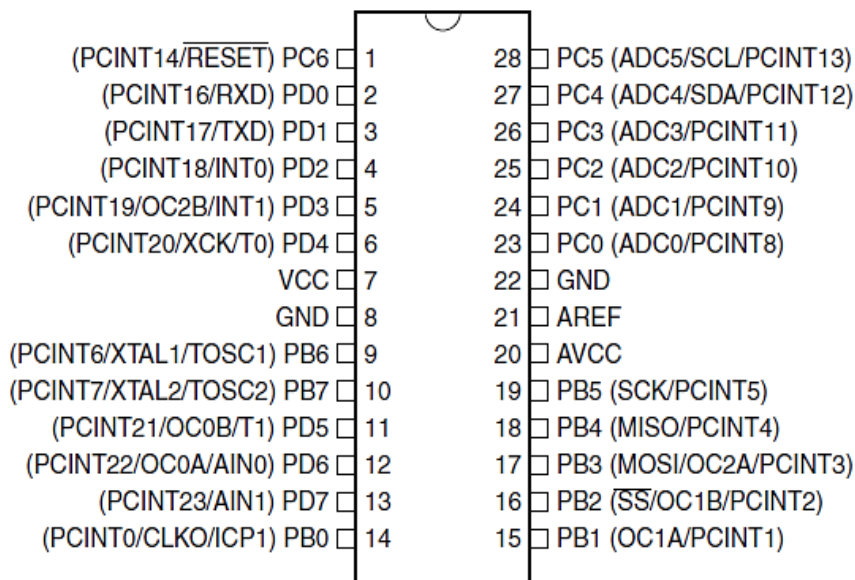
### **3.3 ATmega328P Microcontroller**

The ATmega328P is a very popular microcontroller chip produced by Atmel. It's an 8-bit microcontroller that has 32K of flash memory, 1K of EEPROM and 2K of internal SRAM. The ATmega328P is one of the microcontroller chips that are being used with the widely used Arduino Duemilanove boards. The Arduino Duemilanove ("2009") is a microcontroller board based on the ATmega168P or ATmega328P [8]. The ATmega328P is the upgraded, more advanced processor chip. The ATmega328P has 32K of flash program memory storage and 2K of internal SRAM where the ATmega168P has 16K of flash program memory storage and 1K of internal SRAM [9], [10].

### 3.3.1 Features of ATmega328P Microcontroller

- 28-pin AVR Microcontroller.
- Flash Program Memory: 32 kb.
- EEPROM Data Memory: 1 kb.
- SRAM Data Memory: 2 kb.
- I/O Pins: 23.
- Timers: Two 8-bit / One 16-bit.
- A/D Converter: 10-bit Six Channel.
- PWM: Six Channels.
- RTC: Yes with Separate Oscillator.
- MSSP: SPI and I<sup>2</sup>C Master and Slave Support.
- USART: Yes.
- External Oscillator: up to 20MHz.

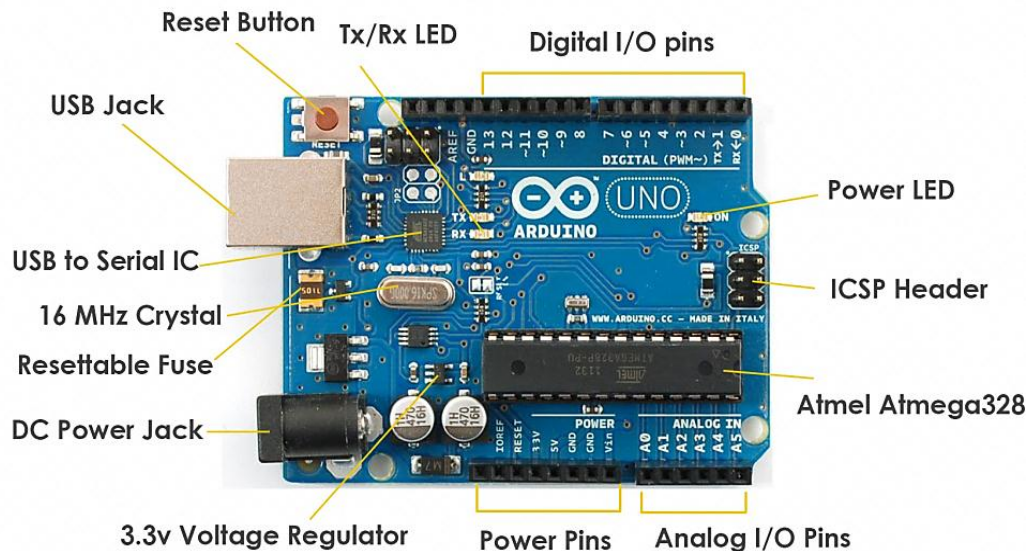
The pinout of the ATmega328P is shown in **Fig. 3.1**. The IC has 23 general purpose I/O pins of which 14 digital I/O pins and 6 analog I/O pins. 6 pins from digital I/O pins can also be used as PWM. It also has 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupt, serial programmable USART, SPI serial port. The pin function of ATmega328P microcontroller describes in table 3.1 which is shown in appendix b [10].



**Fig. 3.1** Pinout of ATmega328P [10].

### 3.4 Arduino UNO

The Arduino Uno is a microcontroller board based on the ATmega328P is shown in **Fig. 3.2**. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header and a reset button.



**Fig. 3.2** Physical structure of Arduino UNO [11].

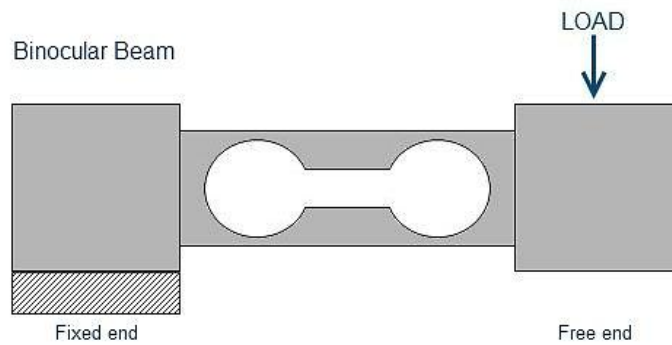
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter [11].

#### 3.4.1 Features of the Arduino UNO

- 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 bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)

### 3.5 Load Cell

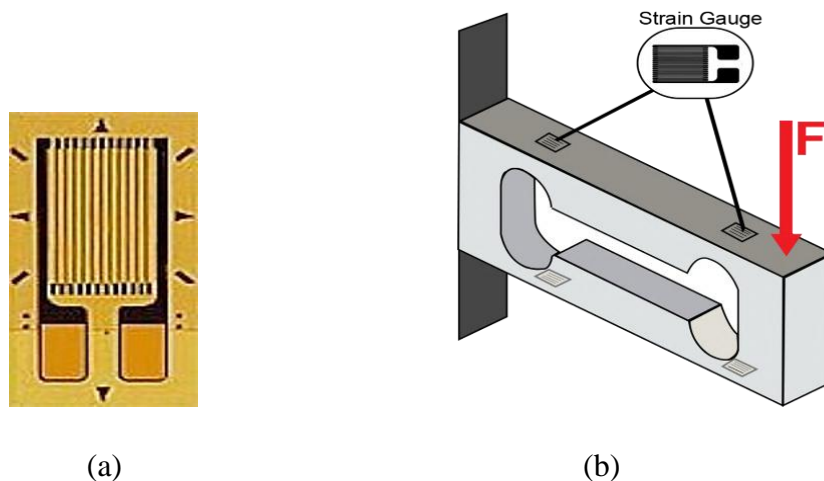
A load cell is a sensor or a transducer that converts a load or force acting on it into an electronic signal. The electronic signal can be a voltage change or frequency change depending on the type of load cell. There are different kinds of load cells includes hydraulic load cells, pneumatic load cells and strain gauge load cells. The **Fig. 3.3** shows a strain gauge load cell.



**Fig. 3.3** Strain Gauge Load Cell [12].

#### 3.5.1 Strain Gauge Load Cell

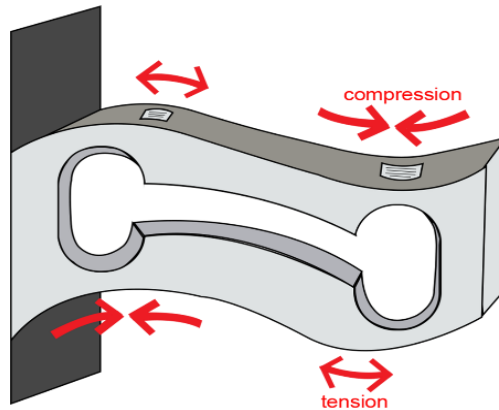
Strain gauge or resistive load cells works on the principle of piezo-resistivity. When a load is applied to the sensor, it changes its resistance. This change in resistance leads to a change in output voltage when an input voltage is applied.



**Fig. 3.4** (a) Single strain gauge (b) Single point strain gauge load cell [13].

In **Fig. 3.4(b)**, there are a total of four strain gauges that are bonded to the upper and lower surfaces of the load cell. When the load is applied to the body of a resistive load

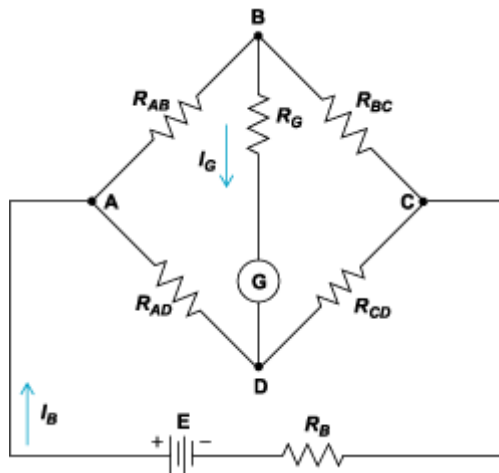
cell the elastic member deflects as shown in **Fig. 3.5** and creates a strain at those locations due to the stress applied.



**Fig. 3.5** Compression and tension of Load cell [13].

As a result, two of the strain gauges are in compression, whereas the other two are in tension.

The four strain gauges are configured in a Wheatstone Bridge configuration with four separate resistors connected as shown in **Fig. 3.6** what is called a Wheatstone Bridge Network. An excitation voltage usually 5V is applied to one set of corners and the voltage difference is measured between the other two corners. At equilibrium, the voltage output is zero or close to zero.

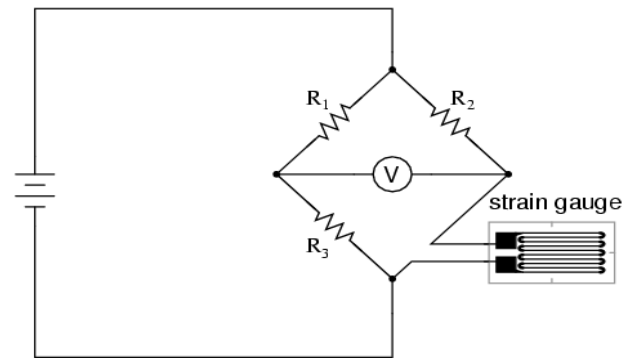


**Fig. 3.6** Wheatstone Bridge Network [13].

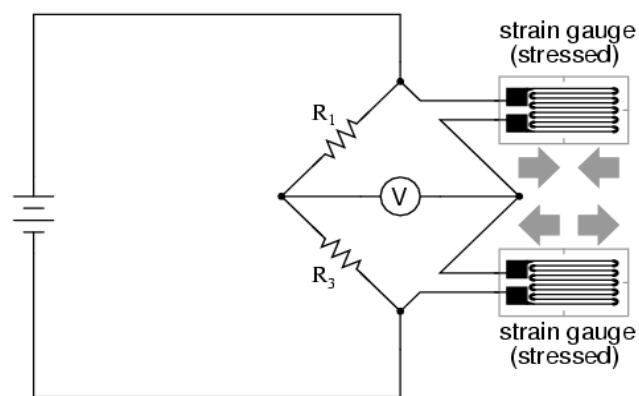
When the metallic member to which the strain gauges are attached is stressed by the application of a force, the resulting strain leads to a change in resistance in one or more resistors. This change in resistance results in a change in output voltage. The voltage range is very small which is few millivolts it can be measured and digitized after careful

amplification of the small millivolt level signals to a higher amplitude 0-5V or 0-10V signal [13].

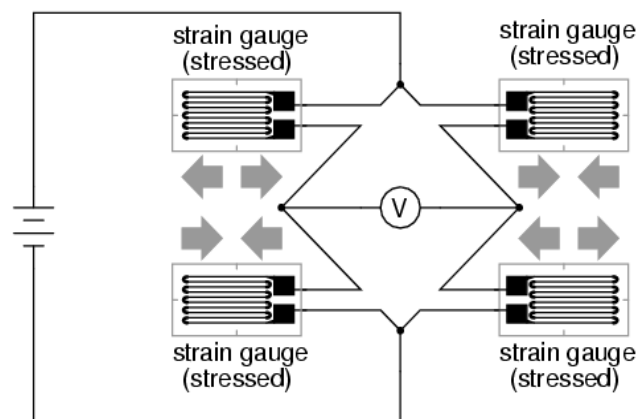
According to the bridge circuit there are three types of strain gauge load cell. Quarter-bridge, Half-bridge and Full-bridge load cell as shown in **Fig. 3.7**.



(a)



(b)

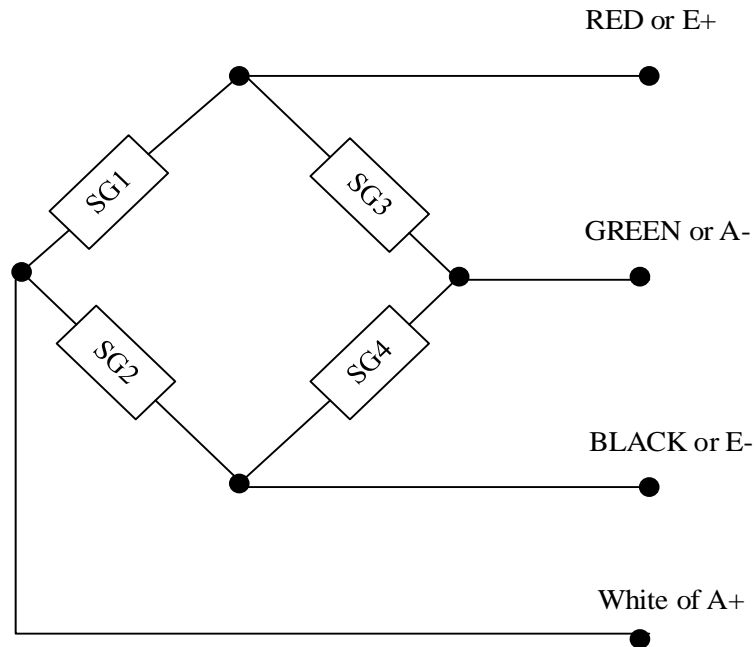


(c)

**Fig. 3.7** (a) Quarter-bridge Load cell (b) Half-bridge Load cell (c) Full-bridge Load cell [14].

### 3.5.2 Load Cell Block diagram

In General, load cell has four strain gauges that are hooked up in a Wheatstone Bridge formation as shown in **Fig. 3.8**.



**Fig. 3.8** Internal circuit block diagram of Load Cell where SG (1-4) means strain gauges.

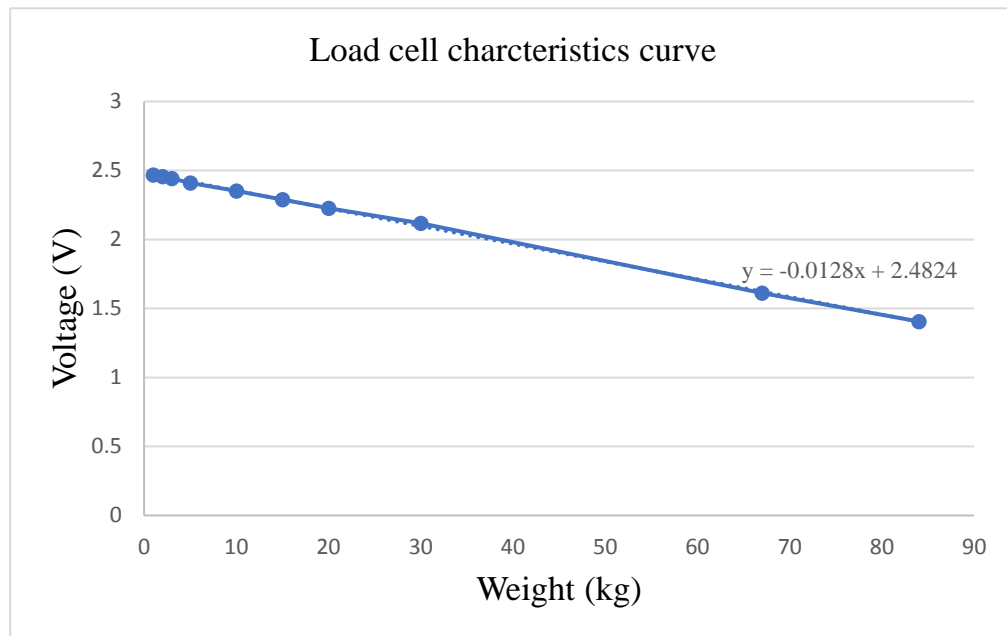
The four wires coming out from the Wheatstone Bridge on the load cell as shown in **Fig. 3.9** are usually:

- Excitation+ (E+) or VCC is red.
- Excitation- (E-) or ground is black.
- Amplifier+ (A+) is white.
- Amplifier- (A-) is green.



**Fig. 3.9** Physical view of a 3kg Load Cell [15].

### 3.5.3 Characteristics of Load Cell



**Fig. 3.10** Characteristics curve of load cell.

The **Fig. 3.10** shows the output voltage of load cells with respect to weight. In zero load condition output voltage of load cell is 2.5V. If the force is applied on load cell in gravitational side the voltage decreasing linearly from 2.5V to 1v and the force applied anti gravitational side the voltage increasing from 2.5V to 5V.

### 3.6 HX711 Module

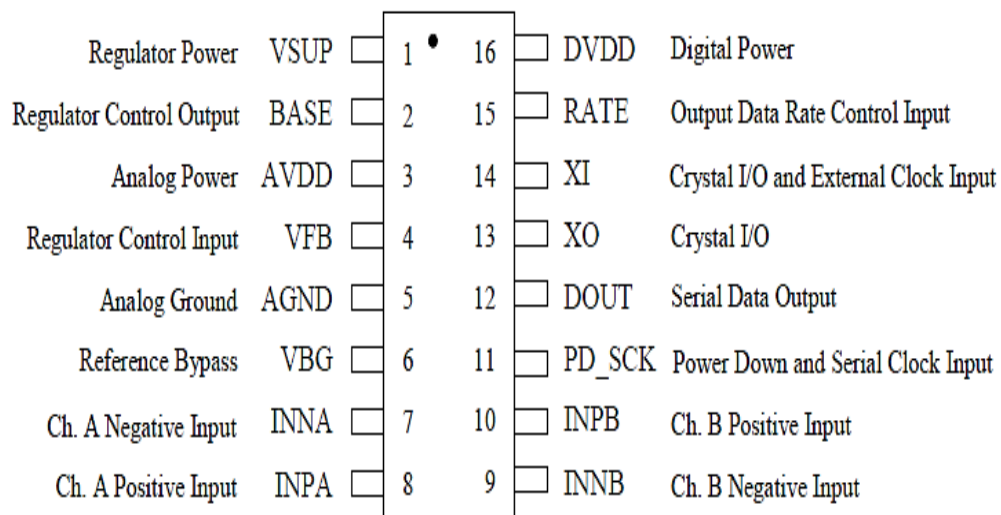
HX711 is a precision 24-bit analog to digital converter (ADC) designed for weight scales and industrial control applications to interface directly with a bridge sensor.

The input multiplexer selects either channel A or B different input to the low-noise programmable gain amplifier (PGA). Channel A can be programmed with a gain of 128 or 64, corresponding to a full-scale differential input voltage of  $\pm 20\text{mV}$  or  $\pm 40\text{mV}$  respectively, when a 5V supply is connected to AVDD analog power supply pin. Channel B has a fixed gain of 32. On chip power supply regulator eliminates the need for an external supply regulator to provide analog power for the ADC and the sensor. Clock input is flexible. It can be from an external clock source, a crystal, or the on-chip oscillator that does not require any external component. On-chip power on-reset circuitry simplifies digital interface initialization [16].

### 3.6.1 Features of HX711

- Two selectable differential input channels.
- On-chip active low noise PGA with selectable gain of 32, 64 and 128.
- On-chip power supply regulator for load-cell and ADC analog power supply.
- On-chip oscillator requiring no external component with optional external crystal.
- On-chip power-on-reset.
- Simple digital control and serial interface pin-driven controls, no programming needed.
- Selectable 10SPS or 80SPS output data rate.
- Simultaneous 50 and 60Hz supply rejection.
- Current consumption including on-chip analog power supply regulator normal operation < 1.5mA, power down < 1μA.
- Operation supply voltage range: 2.6 ~ 5.5V.
- Operation temperature range: -40 ~ +85°C.
- 16 pins SOP-16 package.

The pinout of HX711 is shown in **Fig. 3.11**. The IC has 5 analog input pins, 2 analog output pins, 4 digital input pins, 1 digital I/O pin and other 4 pins are used for Clk and power the IC. The pin diagram of HX711 is given below.

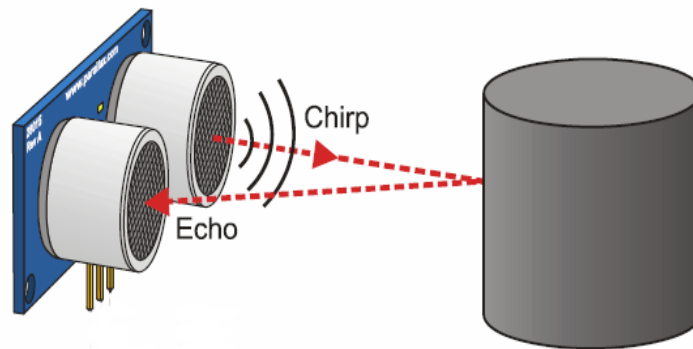


**Fig. 3.11** Pin diagram of HX711 [16].

The pin function of HX711 describes in table 3.2 which is shown in appendix b [16].

### 3.7 Ultrasonic Sensor (HC-SR04)

This Ultrasonic sensor HC-SR04 generally used for measurement function. It provides measurement between 2cm - 400cm and the measurement accuracy can reach to 3mm. The module includes ultrasonic transmitters, receiver and control circuit [17]. The **Fig. 3.12** shows the transmitter of the sensor sends ultrasonic burst and the receiver receives the ultrasonic burst which is reflected back from an obstacle.



**Fig. 3.12** Working principle of Ultrasonic Sensor [18].

The basic principle of working Ultrasonic Sensor (HC-SR04):

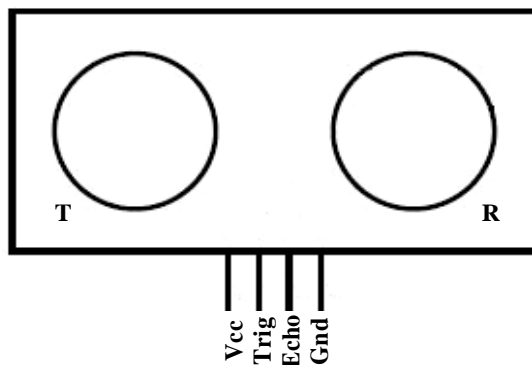
- (1) Provide Trigger signal, at least 10us high level pulse.
- (2) The Module automatically sends eight 40 kHz Ultrasonic burst and detect whether there is a pulse signal back.
- (3) IF the signal back, Echo output of the sensor will be high state for a duration of time taken for sending and receiving ultrasonic burst. Pulse width ranges from about 150 $\mu$ s to 25mS and if no obstacle is detected, the echo pulse width will be about 38mS.

Distance = (high level time  $\times$  velocity of sound (340M/S) / 2 [17]

#### 3.7.1 Features of Ultrasonic Sensor [17]

- Working Voltage: DC 5 V.
- Working Current: 15mA.
- Working Frequency: 40Hz.
- Max Range: 4m.
- Min Range: 2cm.
- Measuring Angle: 15 degrees.
- Trigger Input Signal: 10 $\mu$ S TTL pulse.
- Echo Output Signal Input: TTL lever signal and the range in proportion.

The Ultrasonic sensor comes with 4 pins. These four pins named as Vcc, Trig, Echo and GND as shown in **Fig. 3.13**.



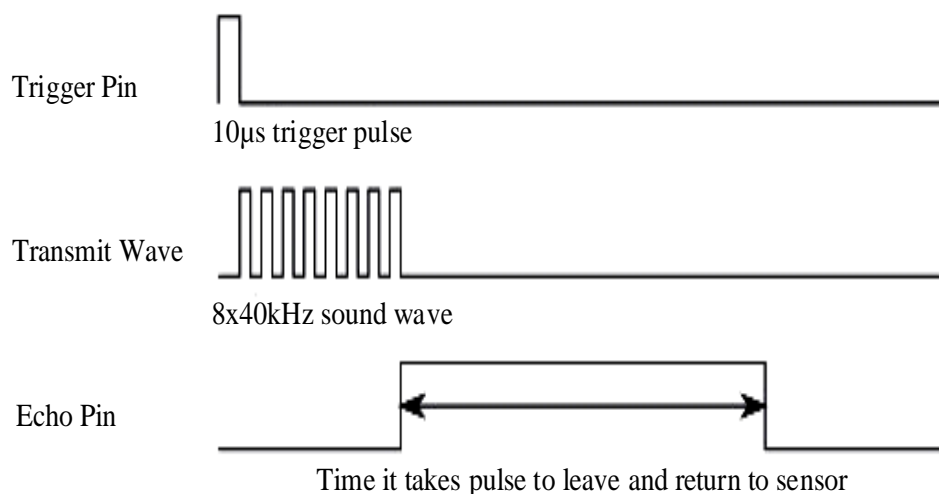
**Fig. 3.13** Pin diagram of HC-SR04.

The pin function of Ultrasonic sensor describes in the table 3.3 which is shown in appendix b [17].

### 3.7.2 Timing Diagram of Ultrasonic Sensor

In **Fig. 3.14** shows a short 10 $\mu$ S Pulse is applied to the trigger input to start the ranging, and then the module will send out an 8-cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion. The range can be calculated through the time interval between sending trigger signal and receiving echo signal.

Formula: The Distance = high level time  $\times$  0.034 / 2 [17].



**Fig. 3.14** Timing chart of Ultrasonic Sensor [17].

### 3.8 LCD 20 X 4

A liquid crystal display or LCD is a combination of two states of matter, the solid and the liquid. It basically works on the principle of blocking light rather than emitting light. There are two types of LCD one is Character LCD and the other Graphical LCD. In our project, we have used character LCD 20X4 which means it's capable of displaying 4 lines and each line having 20 characters as shown in **Fig. 3.15**. Every character consists of 5x8 dot matrix. This component is specialized to be used with the microcontrollers, which means that it cannot be activated by standard IC circuits. It is used for displaying different messages on a miniature liquid crystal display. It is based on the HD44780 microcontroller (*Hitachi*). It displays all letters of alphabet, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to display symbols made up by the user. Other useful features include automatic message shift (left and right), cursor appearance, LED backlight etc. [20], [22].



**Fig. 3.15** Physical view of LCD 20x4 [19].

The LCD 20X4 has three memory blocks:

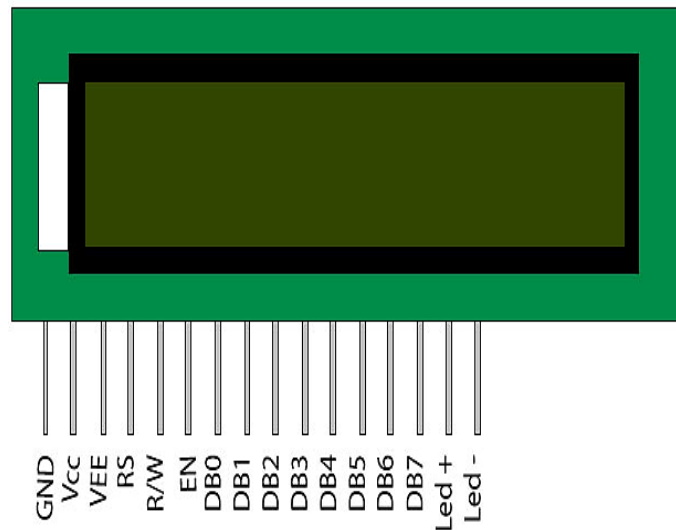
- DDRAM-Display Data RAM
- CGRAM-Character Generator RAM
- CGROM- Character Generator ROM

**DDRAM Memory:** DDRAM memory is used for storing characters that should be displayed. The size of this memory is sufficient for storing 80 characters. Some memory locations are directly connected to the characters on display.

**CGROM Memory:** CGROM memory contains default character map with all characters that can be displayed on the screen. Each character is assigned to one memory location.

CGRAM: This memory works same as CG ROM but as this is RAM we can modify its content any time. So, this is the place where when have to first store our custom character pattern, then that pattern can be sent to display.

The LCD 20x4 has 16 pins of which 10 pins for controlling LCD other 6 pins for Vcc, ground, contrast, R/W and backlight as shown in **Fig. 3.16**.



**Fig. 3.16** Pin diagram of LCD 20X4 [21].

The pin function of LCD 20X4 describes in table 3.4 which is shown in appendix b [22].

### **3.8.1 How LCD 20X4 works?**

LCD 20X4 has two registers, command register and data register. The register select is used to switch from one register to other. RS=0 for command register, whereas RS=1 for data register.

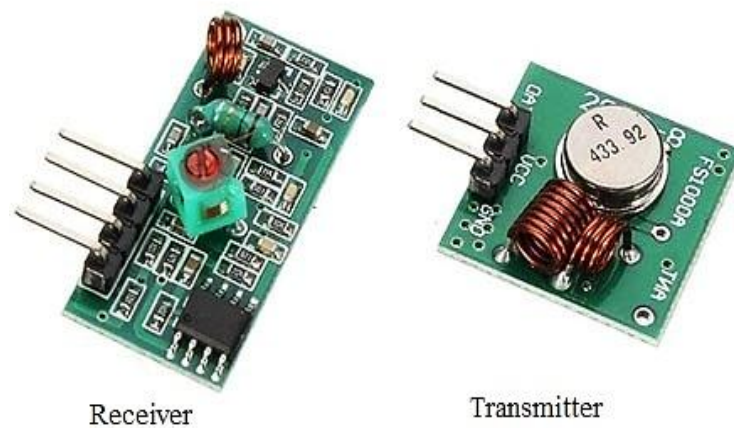
**Command Register:** The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. Processing for commands happen in the command register. Some basic commands of LCD and their HEX codes describes in table 3.5 which is shown in appendix b [22].

**Data Register:** 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. When we send data to LCD it goes to the data register and is processed there. When RS=1, data register is selected [22].

The contrast of the display depends on power supply voltage. For that reason, varying voltage 0-Vdd is applied on the pin marked as Vee shown in fig. 3.16. Trimmer potentiometer is usually used for that purpose. The display has built in backlight. When used during operation, a current limiting resistor should be serially connected to one of the pins for backlight (similar to LED diodes).

### 3.9 RF Rx-Tx Module

The RF Rx-Tx module as the name suggests, operates at Radio Frequency as shown in **Fig. 3.17**. The corresponding frequency range varies between 30 kHz and 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as Amplitude Shift Keying (ASK).



**Fig. 3.17** Physical structure of 433MHz RF module [23].

Transmission through RF is better than IR (infrared) because of many reasons. Firstly, signals through RF can travel through larger distances making it suitable for long range applications. Also, while IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter and receiver. Next, RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources [24].

#### 3.9.1 Features of RF Module

Transmitter:

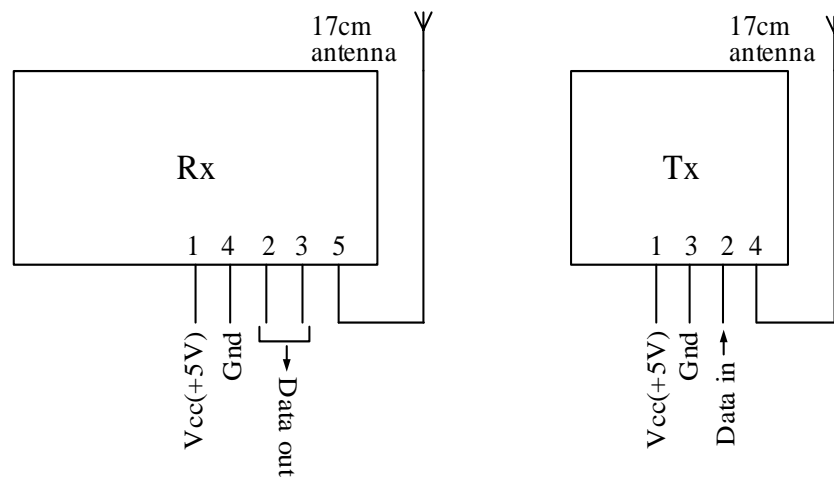
- Working voltage: 3V - 12V for max. power use 12V
- Working current: max Less than 40mA max, and min 9mA
- Transmitted range: 20m-200m

- Modulation mode: ASK
- Working frequency: 433MHz
- Transmission power: 25mW (315MHz at 12V)
- Frequency error: +150kHz (max)
- Velocity: less than 10Kbps

Receiver:

- Working voltage: 5.0VDC +0.5V
- Working current:  $\leq 5.5\text{mA}$  max
- Working method: OOK/ASK
- Working frequency: 433 MHz
- Bandwidth: 2MHz
- Sensitivity: excel  $-100\text{dBm}$  ( $50\Omega$ )
- Transmitting velocity:  $<9.6\text{Kbps}$  (at 315MHz and  $-95\text{dBm}$ )

The use of an optional antenna will increase the effectiveness of wireless communication. A simple wire will do the trick [24].



**Fig. 3.18** Pin diagram of RF 433 MHz module.

The RF transmitter has 3 pins named as vcc, ground and data pin and the RF receiver has 4 pins of which two data pins, other two are vcc and ground. Both module has a point to connect antenna as shown in **Fig 3.18**.

The pin function of RF transmitter and receiver describes in table 3.6 and 3.7 respectively which is shown in appendix b [24].

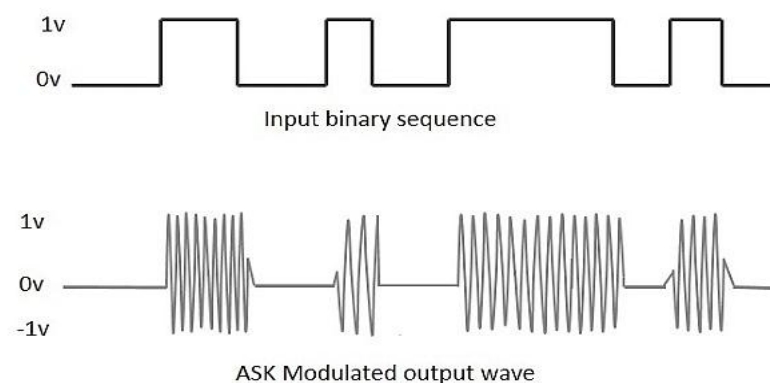
### 3.9.2 Working Principle of RF Module

In many projects RF modules are used for transmit and receive the data because it has high volume of applications than IR. RF signals travel in the transmitter and receiver even when there is an obstruction. It operates at a specific frequency of 433MHz. The RF transmitter and receiver both communicate with each other through RF data transmission in UART communication mode. UART sends data asynchronously which means no clock signal involved to synchronize data transmission. ART adds two extra bits start and stop bit. When receiving UART detects a start bit it starts to read the incoming bits at a specific frequency know as baud rate.



**Fig. 3.19** Operation of RF module [25].

The **Fig. 3.19** shows at initial state the data line is kept high when the transmission starts bringing the line to low which is logic '0'. Then 8/9 bits are transmitted. The data packet is terminated with a stop bit which is always logic '1'. The modulation used for transmitting data is amplitude shift keying(ASK). It is a form of amplitude modulation. That represents data by varying carrier wave as show in **Fig. 3.20**. The binary one is being transmit keeping amplitude of the carrier wave and baud rate fixed. When logic '0' applied to transmitter then there is no power supply in transmitter. When logic '1' is applied to transmitter then transmitter is ON and there is a high-power supply in the range of 4.5mA with 3V voltage supply [25].



**Fig. 3.20** ASK modulation [25].

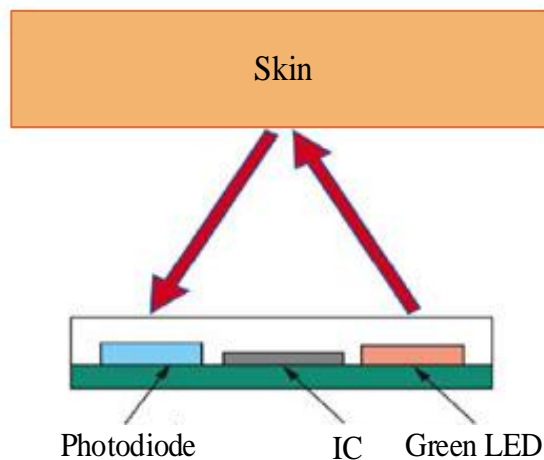
### 3.10 Pulse Sensor

Pulse or heartbeat is the sound of the valves of a person's heart compressing or expanding while they flow blood from one region to another. The number of times the heart beats per minute (BPM), is the heart beat rate and the beat of the heart that can be felt in any artery that lies close to the skin is the pulse. A normal person heart rate is normally between 60 to 100 (beats per minute) [26].

The pulse sensor is based on the principle of Photoplethysmography(PPG). It measures the change in volume of blood through any organ of the body which causes a change in the light intensity through that organ (a vascular region) [27]. In case of applications where heart pulse rate is to be monitored, the timing of the pulses is more important. The flow of blood volume is decided by the rate of heart pulses and since the light is absorbed by blood, the signal pulses are equivalent to the heart pulses.

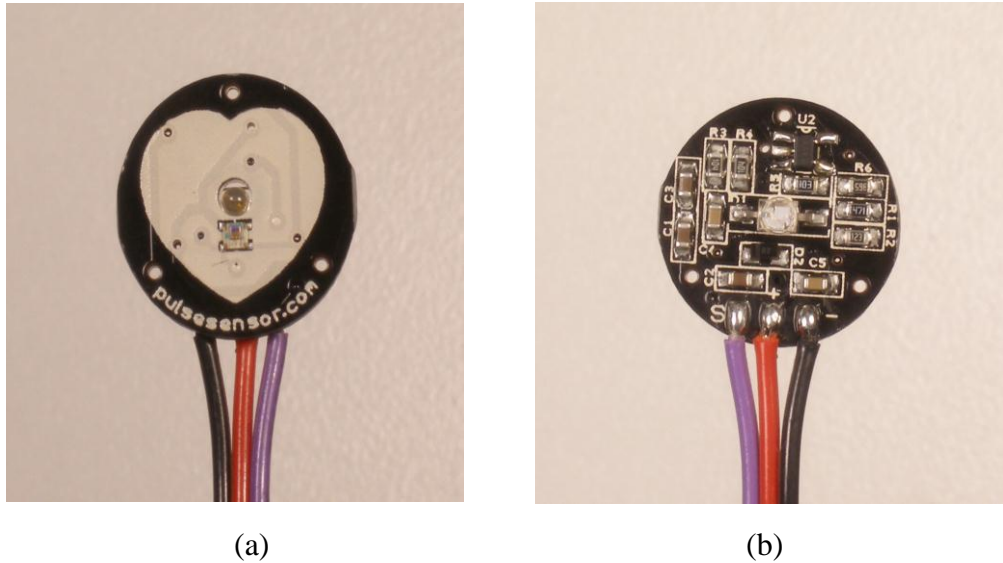
#### 3.10.1 Working principle of pulse sensor

The basic heart beat sensor consists of a light emitting diode and a detector like a light detecting resistor or a photodiode. The heart beat pulses cause a variation in the flow of blood to different regions of the body.



**Fig. 3.21** Reflective heart rate monitoring system working principle [28].

In **Fig. 3.21** it shows the tissue is illuminated with the light source i.e. light emitted by the led, it either reflects in a finger or transmits the light in the earlobe. Some of the light is absorbed by the blood and the transmitted or the reelected by the light detector. The amount of light absorbed depends on the blood volume in that tissue. The detector output is in form of electrical signal and is proportional to the heart rate [28].



**Fig. 3.22** Pulse sensor (a) Front view of (b) Back view [29].

Generally, pulse sensor comes with three wires. Red, Black and Violate color wire as shown in **Fig 3.22**. Red wire for Vcc, Black for Gnd and the Violate for signal output. The operating voltage of pulse sensor is +3V to +5V [29].

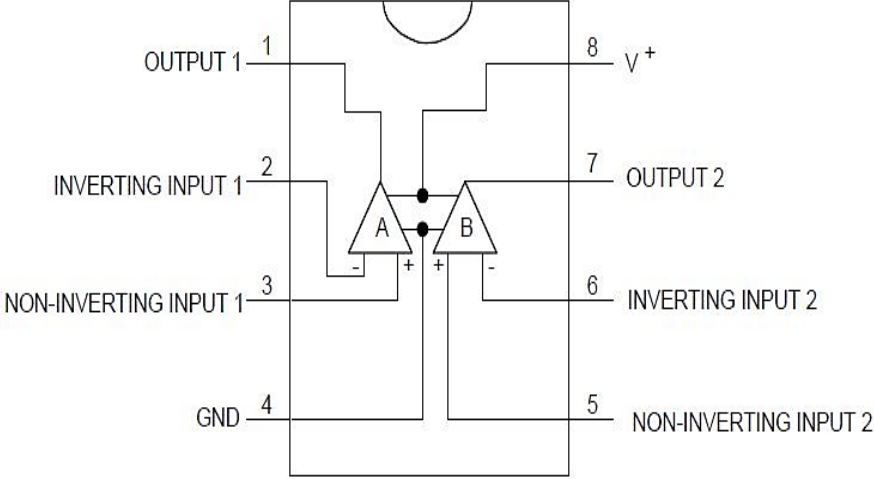
### 3.11 LM358

LM358 is a low power dual operational amplifier. It has two independent, high gain, internally frequency compensated operational amplifiers. Moreover, these amplifiers were designed specifically to operate from a single power supply over a wide range of voltages [30].

#### 3.11.1 Features of LM358 [30]

- Internally frequency compensated for unity gain.
- The large voltage gain is 100 db.
- Wide bandwidth (unity gain): 1MHz
- Wide power supply range:  
Single supply: 3V to 32 V.  
Or dual power supplies:  $\pm 1.5V$  to  $\pm 16V$ .
- Low input offset voltage: 2mv.
- Input common-mode voltage range includes ground.
- Differential input voltage range equal to the power supply voltage.
- Large output voltage swing.

The pin diagram of LM358 IC shown in **Fig. 3.23** comprises of 8 pins, where Pin-1 and pin-8 are output of the comparator Pin-2 and pin-6 are inverting inputs Pin-3 and pin-5 are non-inverting inputs Pin-4 is GND terminal Pin-8 is Vcc. The pin function of LM358 describes in table 3.8 which is shown in appendix b [30].



**Fig. 3.23** Pin diagram of LM358 [30].

# CHAPTER 4

## SYSTEM DESIGN

### 4.1 Introduction

This chapter includes system design and simulation of our project. Methodology, Block diagram, Circuit diagram and Flow chart of the system are discussed below.

### 4.2 Methodology

Our system divided into two microcontroller units, one is transmitter microcontroller unit and the other one is receiver microcontroller unit. In transmitter unit, we have used load cell for weight measuring, ultrasonic sensor for height measuring and RF transmitter for transmitting data.

In Load cell, the output voltage variation is very small when load is being applied on it. The microcontroller can't read this small voltage variation so we have used Hx711 module to amplify the output voltage of load cell. It also converts the output voltage of load cell into digital value. So, microcontroller can easily read the load cell value. Then we calibrate the load cell using a known weight value for proper weight measurement.

In case of height measuring we have used a stand and the sensor is placed on top of the stand. When a patient stands beside the stand, a plate is placed on his/her head. The transmitter of ultrasonic sensor transmits ultrasonic sound which reflects back from the plate and the receiver of the sensor receives this sound. The microcontroller calculates the sending and receiving time of the sensor and measures the distance between sensor and plate. The equation for this measurement be,

$$\text{Distance} = (t \times 0.034)/2 \text{ cm} \quad \text{where, } t = \text{sending and receiving time of sensor.}$$

and velocity of sound in air  $340\text{ms}^{-1}$

Then this distance is subtracted from the total length of the stand. Thus, the height of the patient is measured. When height and weight measurement is completed the RF transmitter transmits these data to RF receiver. To transmit these data RF transmitter uses ASK modulation. The communication used in our system among the Microcontroller and the devices i.e. HX711 module and RF transmitter are in serial peripheral interface(SPI) and UART mode respectively.

In receiver microcontroller unit, we have used RF receiver for receiving data, pulse sensor for measuring heartbeat and LCD for displaying data. When RF receiver receives all the desired data i.e. height and weight, the microcontroller calculates the Body Mass Index (BMI). The equation for calculating BMI be,

$$\text{BMI} = \frac{\text{kg}}{\text{m}^2} \quad \text{where, kg} = \text{weight in kilograms.}$$

$$\text{m} = \text{height in meters.}$$

The LCD shows the BMI and its classification according to the BMI classification of WHO.

Table 4.1: BMI and its classification [2].

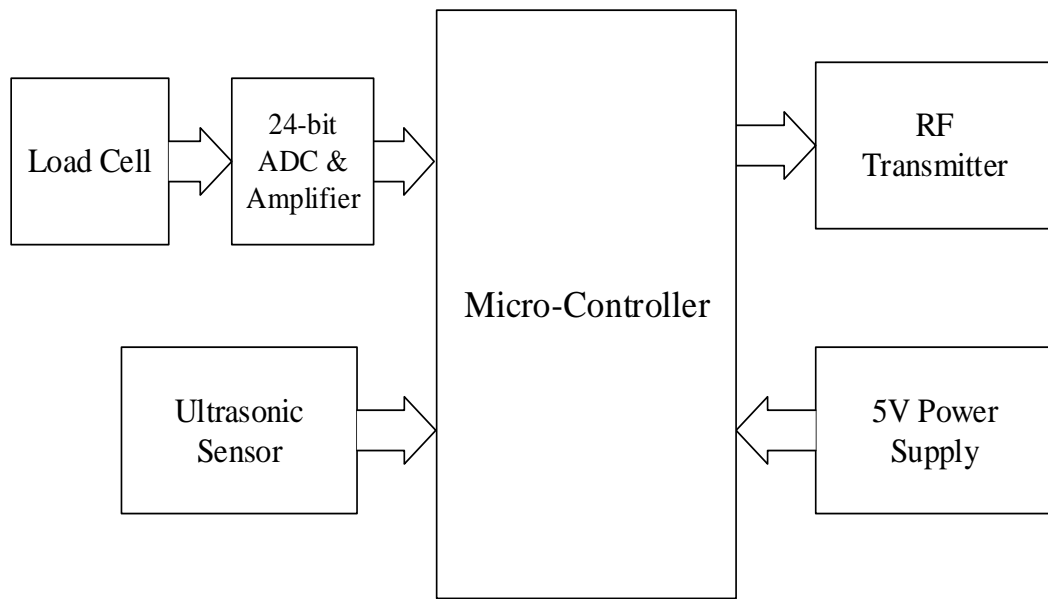
<b>BMI</b>	<b>Classification shows on LCD</b>
< 18.50	Under Weight
18.50 – 24.99	Healthy
25.00 – 29.99	Over Weight
30.00 – 39.99	Obese
≤ 40	Extremely Over Weight

In case of measuring heart rate, we have used pulse sensor which is an analog sensor. When the sensor gets the pulses its output voltage varies from 0.732V to 3.41V and some noises are also being added. To remove these noise, we used LM358 op-amp as a positive comparator and set the reference voltage 2.9V. It gives a high pulse when heartbeat is found otherwise its output always showed low. In order to calculate heartbeat per minute the microcontroller counts heartbeat for 15 secs and multiply the resultant value by four.

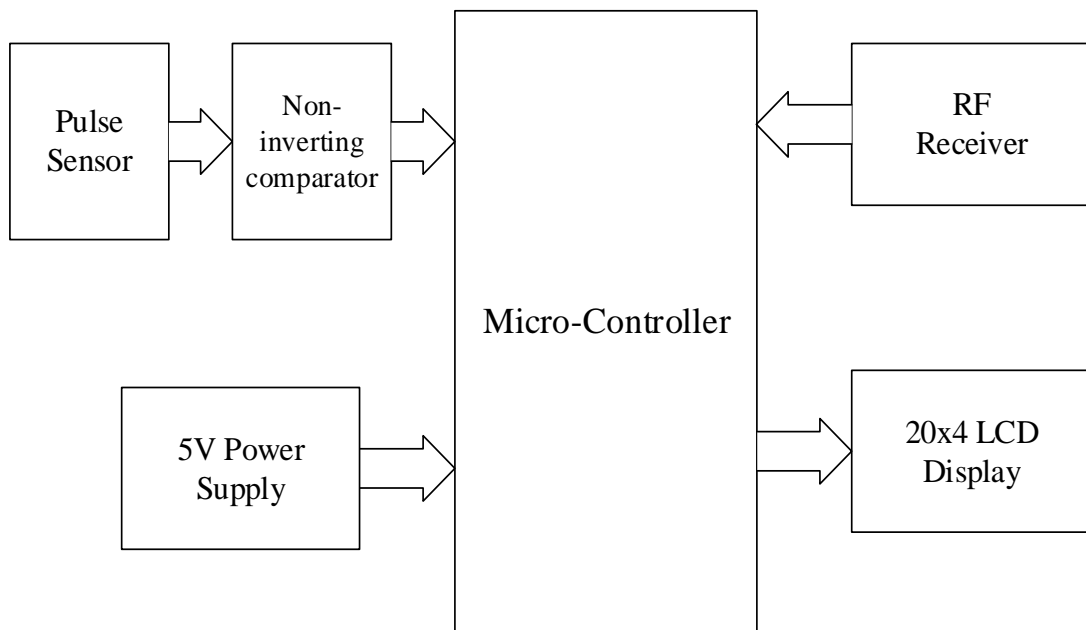
**4.3 Block Diagram**

Block diagrams are shown in **Fig. 4.1** and **Fig. 4.2**. Two microcontroller units, one is transmitter unit and other one is receiver unit being used to control all the input/output devices. 5V (DC) power supply has been used for each microcontroller unit. In transmitter microcontroller unit, Load cell and Ultrasonic sensor are connected with microcontroller as input and RF transmitter as output.

In receiver microcontroller unit Pulse sensor, RF receiver have been used as input and LCD display as output.



**Fig. 4.1** Block diagram of the system Transmitter.



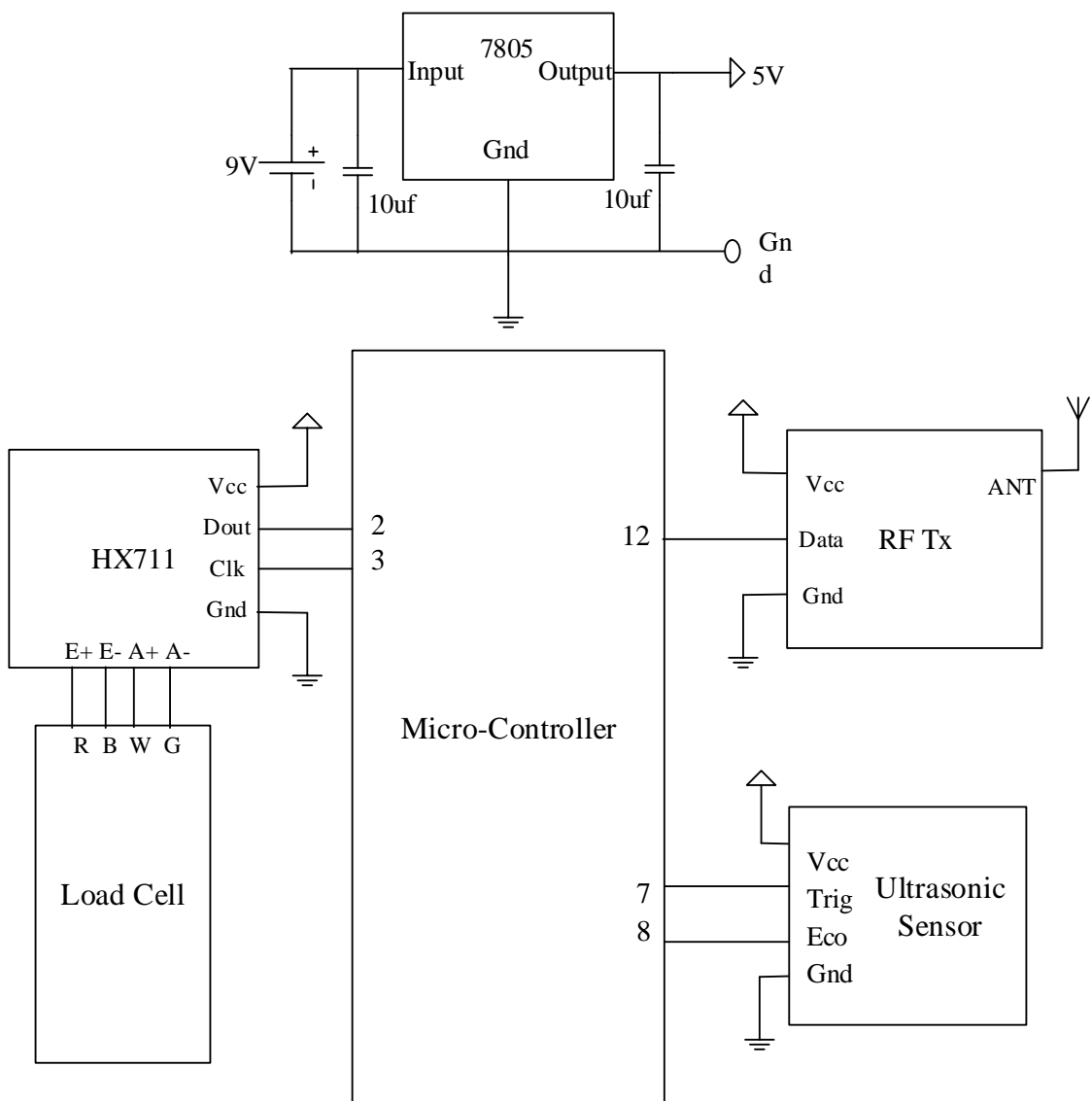
**Fig. 4.2** Block diagram of the system Receiver.

#### 4.4 Circuit Diagram

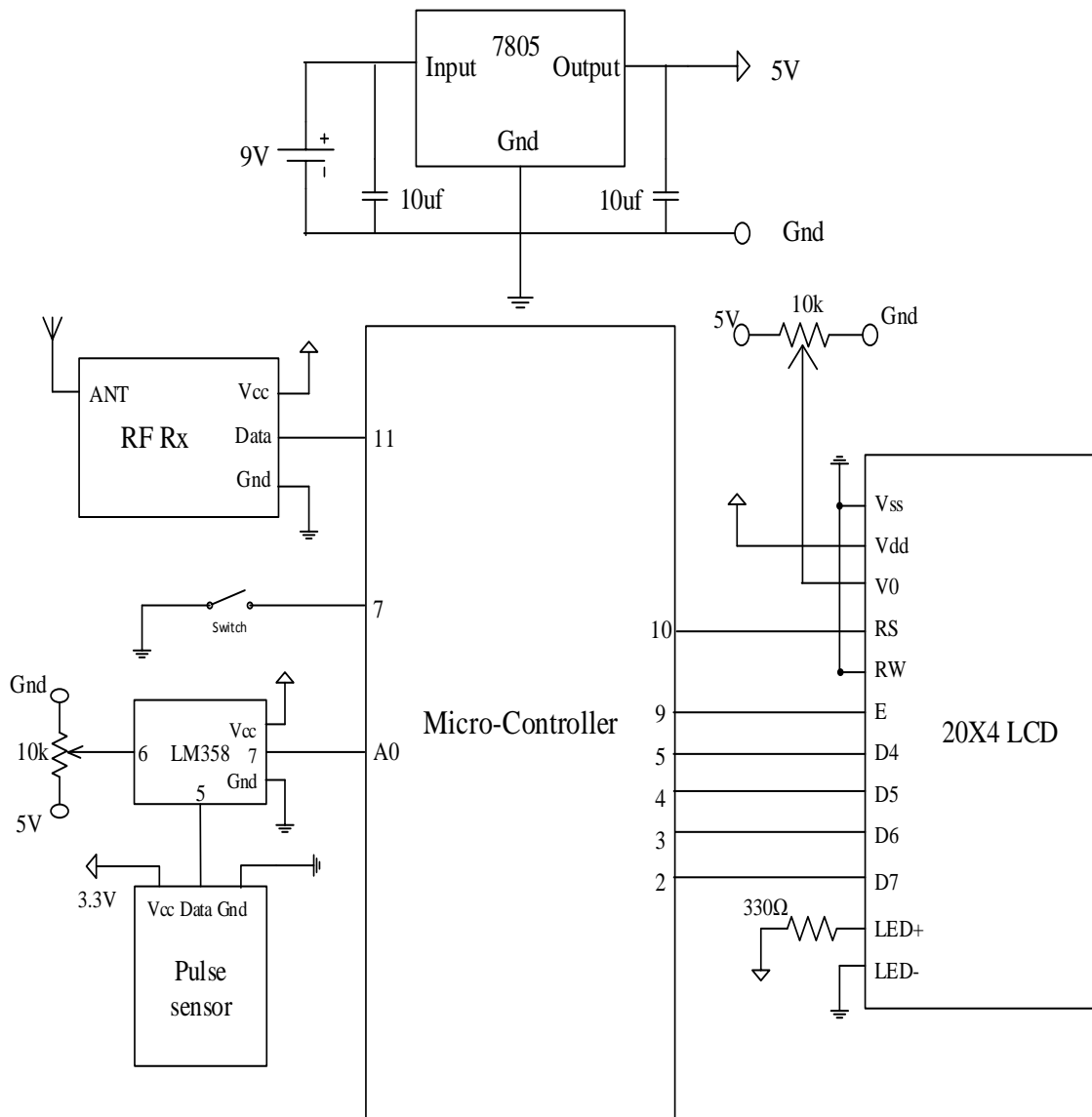
The **Fig. 4.3** and **Fig. 4.4** shows the whole circuit diagram. The **Fig. 4.3** is transmitter circuit and the **Fig. 4.4** is receiver circuit.

In transmitter circuit Red, Black, White, Green wires of Load cell are connected with HX711 E+, E-, A+, A- respectively. Dout and Clk pin of HX711 connected with microcontroller pin no 2 and 3 respectively. This HX711 amplifies the Load cell output voltage and converted it into digital value. Ultrasonic sensor is connected with

microcontroller pin no 7 and 8. The RF transmitter data pin is connected with microcontroller pin no 12 and it transmit the value measured by load cell and ultrasonic sensor. The transmitted signal received by the RF receiver. The RF receiver connected with microcontroller pin no 11 and the RS, E, D4, D5, D6, D7 pins of LCD connected with the microcontroller pin no 10, 9, 5, 4, 3, 2 respectively. Due to change the contrast of LCD a 10k variable resistor is connected with LCD Vee pin and a 330Ω resistor is connected with LED+ pin to stop the overflow of current and save the LCD backlight LED. A pulse sensor is connected with the LM358 IC's non-inverting input and the output of the IC connected with the receiver microcontroller analog pin A0.



**Fig. 4.3** Circuit diagram of system Transmitter.



**Fig. 4.4** Circuit diagram of system Receiver.

### 4.5 Programming

As we said before our system divided into two sections. One is transmitter microcontroller section and the other one is receiver microcontroller section. These two-sections connected with different types of devices. To operate them properly several programs are required. The functions used in our program are described below.

#### 1. Void setup ()

The void keyword is used only in function declaration. It returns no information to the function from it. The setup function initializes variables, pin modes, start using library etc. The setup function will only run once, after each power up.

2. `Serial.begin (9600);`

`Serial.begin(9600)` doesn't actually print anything. Rather it initializes the serial connection at 9600 bits per second. Both sides of the serial connection (i.e. the Arduino and computer) need

to be set to use the same speed serial connection in order to get any sort of intelligible data.

3. `scale.set_scale ();`

Set the scale value, this value is used to convert the raw data to "human readable" data (measure units).

4. `scale.tare ();`

Set a value for tare weight and reset the scale to 0.

5. `scale.read_average ();`

It returns an average reading of load cell. The reading teaks up to 10 $\mu$ s.

6. `scale.get_units ();`

It gives the raw value divided by a value obtained via calibration.

7. `serial.print ();`

Prints data to the serial port as human-readable ASCII text.

8. `void loop ()`

After creating a setup function, which initializes and sets the initial values, the loop function loops consecutively allowing the program to change the respond.

9. `Serial.available ();`

Get the number of bytes (characters) available for reading from the serial port. This is data that's already arrived and stored in the serial receive buffer (which holds 64 bytes). `Available()` inherits from the `Stream` utility class.

10. `Serial.read();`

Reads incoming serial data. `read()` inherits from the `Stream` utility class.

11. `digitalWrite();`

Write a HIGH or a LOW value to a digital pin. If the pin has been configured as an OUTPUT with `pinMode()`, its voltage will be set to the corresponding value: 5V for HIGH, 0V (ground) for LOW. If the pin is configured as an INPUT, `digitalWrite()` will enable (HIGH) or disable (LOW) the internal pullup on the input pin.

12. `analogRead();`

Reads the value from the specified analog pin. The Arduino board contains 10-bit analog to digital converter. This means that it will map input voltages between 0 and 5 volts into

integer values between 0 and 1023. This yields a resolution between readings of: 5 volts / 1024 units or, .0049 volts (4.9 mV) per unit. It takes about 100 microseconds (0.0001 s) to read an analog input, so the maximum reading rate is about 10,000 times a second.

```
13. vw_set_tx_pin();
```

Configure the transmit pin. Default is pin 12.

```
14. vw_set_rx_pin();
```

Configure the receive pin, Default is pin 11.

```
15. vw_setup(2000);
```

Begin using all settings and initialize the library. This is similar to the "begin" function of other libraries. All pins should be configured before calling this function.

```
16. vw_send((uint8_t *)msg, 3);
```

Transmit a message. "(uint8\_t \*)msg" is an array of the bytes to send and "3" is the number of bytes stored in the array. This function returns immediately and the message is sent slowly by an interrupt-based background process.

```
17. vw_rx_start();
```

Activate the receiver process. This function must be call before any reception can occur. An interrupt-based background process is started which monitors the reception of data.

```
18. vw_get_message(buf, &buflen)
```

Read the last received message. This should be called only when a message is known to be received. "buf" is an array where the message is copied. "buflen" should have the array's maximum size upon input and upon return the number of bytes actually copied is returned. The function itself returns true if the message was verified correct, or false if a message was received but appears to have been corrupted.

```
19. vw_wait_tx();
```

Wait for a message to be fully transmitted.

```
20. PulseIn();
```

Reads a pulse (either HIGH or LOW) on a pin. For example, if value is HIGH, pulseIn() waits for the pin to go HIGH, starts timing, then waits for the pin to go LOW and stops timing. Returns the length of the pulse in microseconds or 0 if no complete pulse was received within the timeout.

```
21. LiquidCrystal lcd(10, 9, 5, 4, 3, 2);
```

Initialize the library with the numbers of the interface pins.

```
22. lcd.begin();
```

Set up the LCD's number of columns and rows.

23. lcd.setCursor();

Position the LCD cursor; that is, set the location at which subsequent text written to the LCD will be displayed.

24. lcd.print();

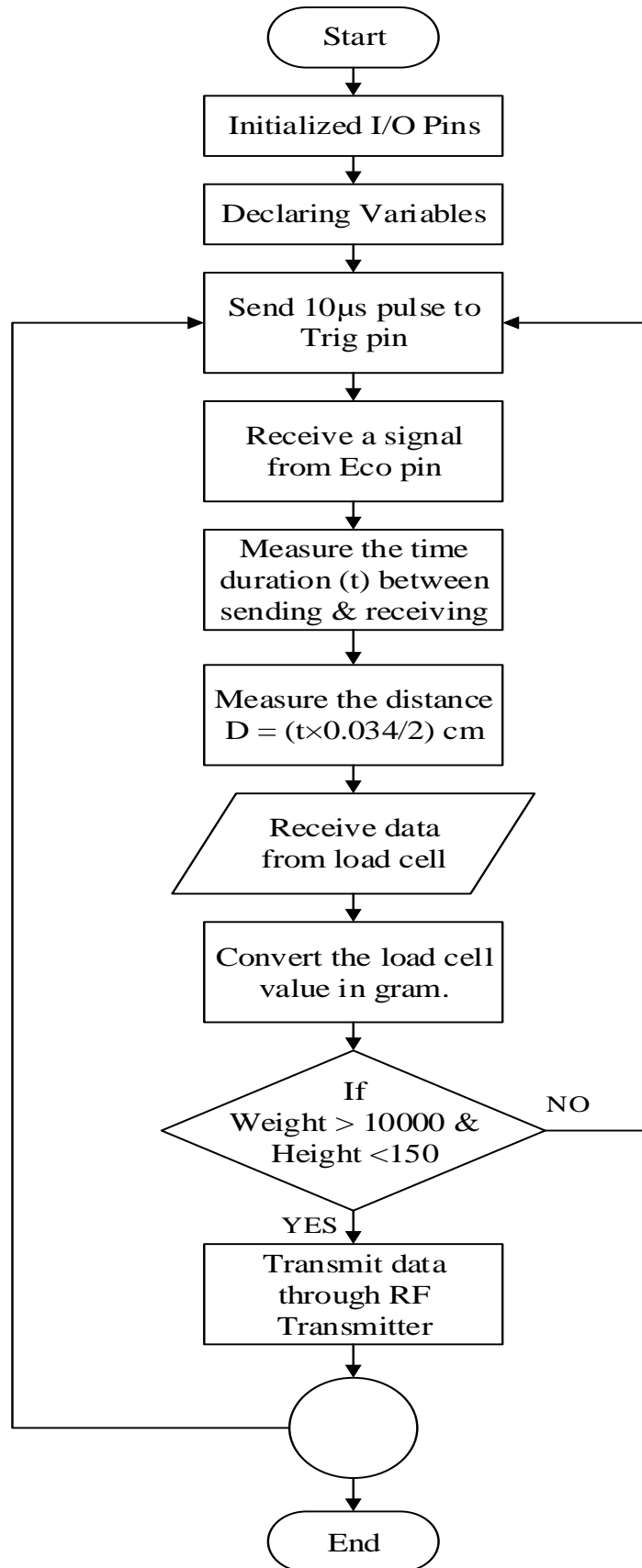
Prints text to the LCD.

#### **4.6 Flow Chart**

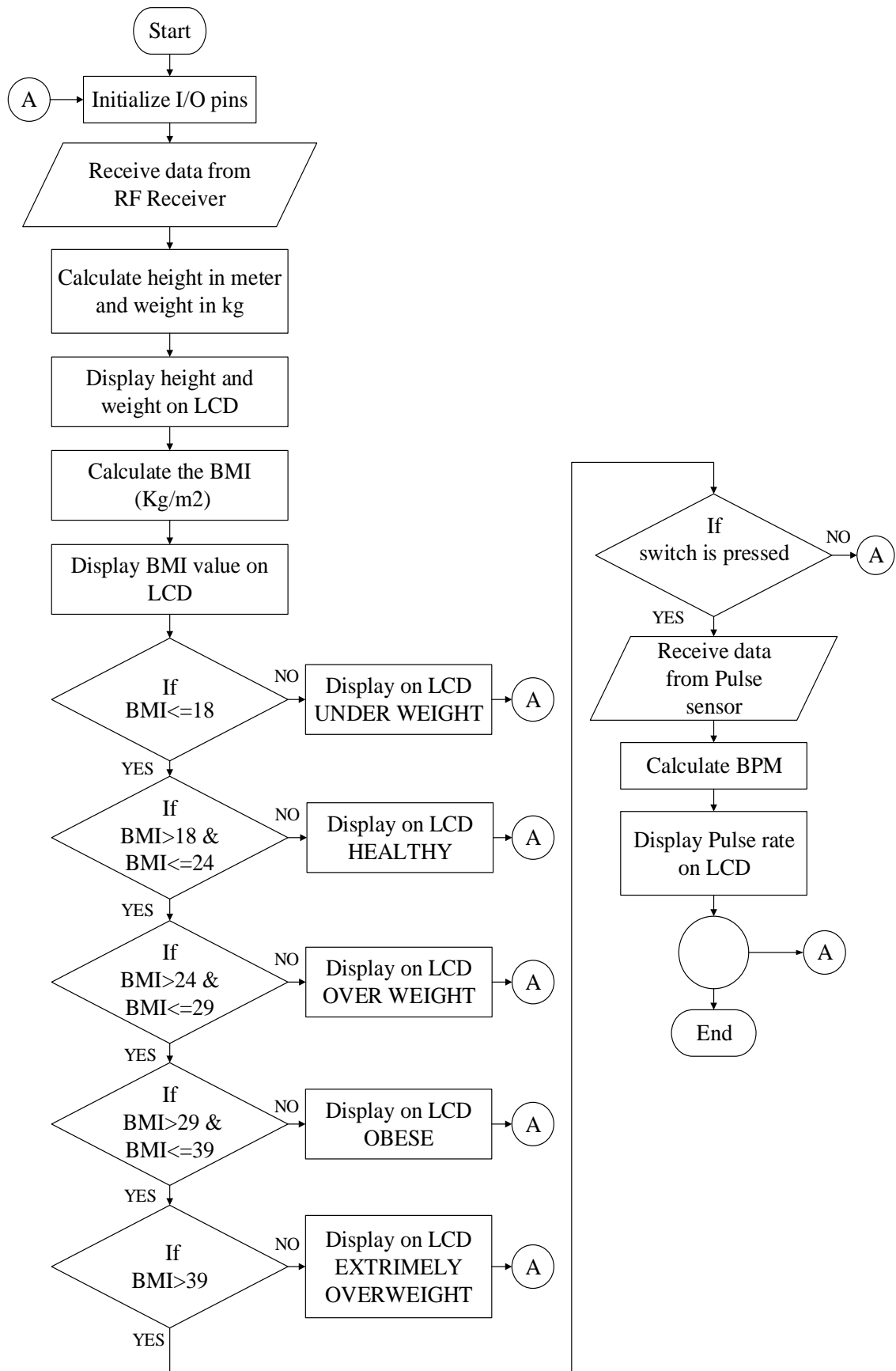
The flow chart of our system is divided into two parts. The first part is transmitter flow chart shown in **Fig. 4.5** and the second part is receiver flow chart shown in **Fig. 4.6**.

In transmitter flow chart as shown in **Fig. 4.5**, the algorithm starts with initializing the I/O pins and variables. Then a 10 $\mu$ s pulse is sent to trig pin and that very moment a signal is received from echo pin. The time duration between sending and receiving ultrasonic sound is being measured after getting signal from echo pin. Thus, the distance between sensor and obstacle is evolved by using an equation. Then received data from load cell is converted into gram unit. After getting all the measured data an if condition check whether weight is greater than 10000 grams and height is less than 155 cm. If the condition comes true, the RF transmitter transmits measured data. Otherwise go back to step 3 i.e. sends 10 $\mu$ s pulse to trig pin and ends the program.

In receiver flow chart as shown in **Fig. 4.6**, here also the algorithm starts with initializing the I/O pins and variables. Then data is received from RF receiver. The received data from RF receiver i.e. height and weight are in centimeter and gram unit. So, it requires to convert the height unit in meter and weight unit in kg for proper BMI calculation and displays height and weight on LCD. Then BMI is being calculated by using BMI equation and displays BMI value on LCD. After that, it checks several if conditions because different BMI value show different health status and LCD shows the desired health status according to the BMI classification chart. For example, if the measured BMI is “23”, according to the BMI chart it lies in the healthy health status so the LCD shows “HEALTHY” on display. Same as if the measured BMI is “25.7”, according to the BMI chart it lies in the overweight health status so the LCD shows “OVERWEIGHT” on display. Then check another if condition i.e. whether switch is pressed or not. If the condition is true it counts pulse for 15 seconds and calculate the BPM. With that the program comes to the end. If the condition is false it return back to step 3 i.e. receive data from RF receiver.



**Fig. 4.5** Flow chart of system Transmitter.



**Fig. 4.6** Flow chart of system Receiver.

# CHAPTER 5

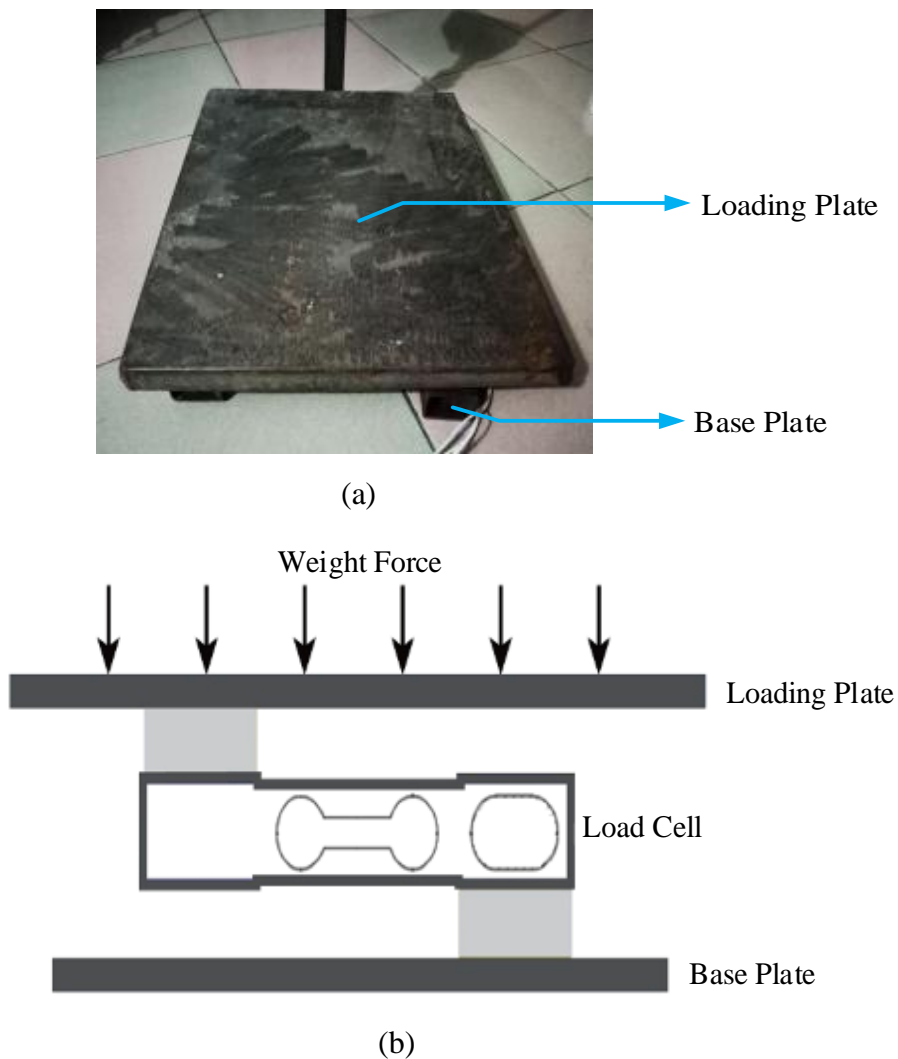
## SYSTEM IMPLEMENTATION AND RESULT

### 5.1 Introduction

In this chapter, the complete implementation and objective justification have been discussed with proper figure representation.

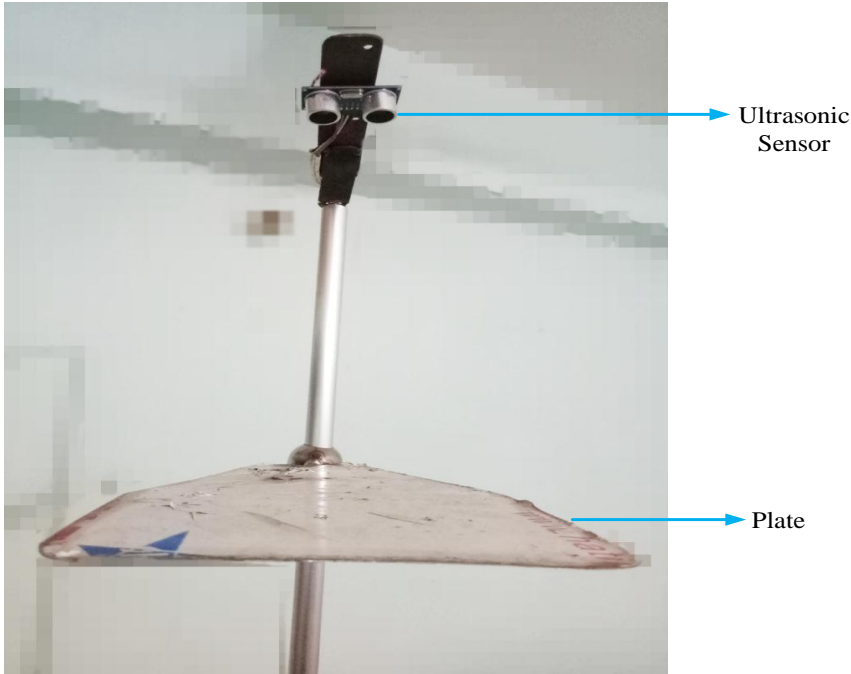
### 5.2 Complete Overview

Different devices that are used in transmitting end are shown in **Fig. 5.1** and **Fig. 5.2**. The load cell is used for measuring weight. The structure prototype of Load cell used in our project as shown in **Fig. 5.1(a)** has been implemented in the similar manner as shown in **Fig. 5.1(b)**.

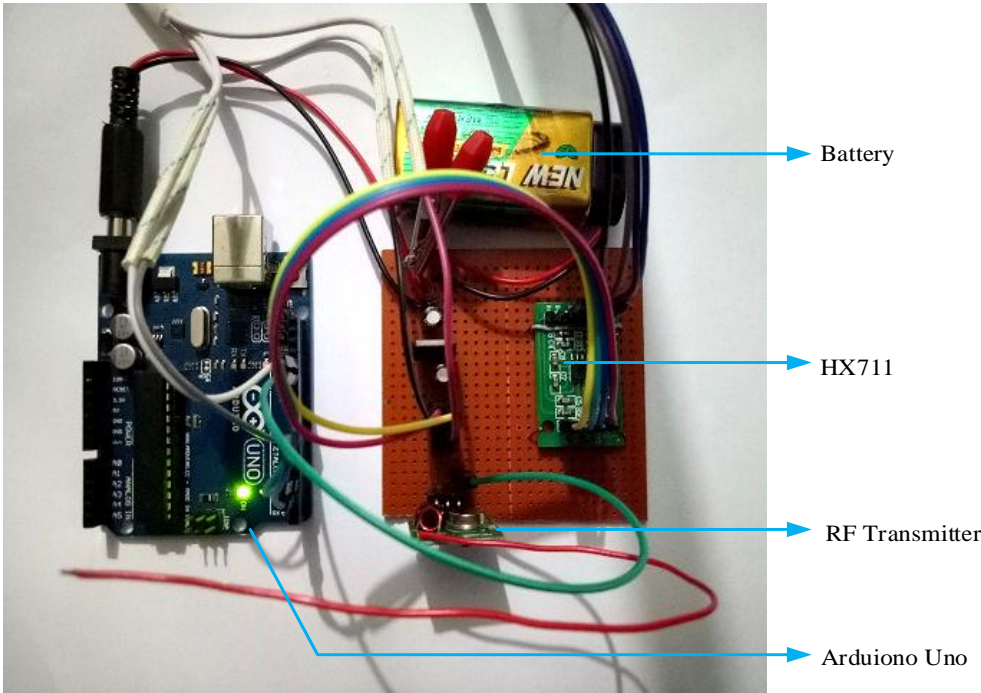


**Fig. 5.1** Measurement end's pictures of (a) Weighing machine (b) Analogical representation of Load cell mounting.

The ultrasonic sensor is placed on top of the stand as shown in **Fig. 5.2(a)** for measuring height. Arduino Uno is used for processing data that have been measured by the sensors as shown in **Fig. 5.2(b)**. The RF transmitter is used for transmitting data to the receiver microcontroller.



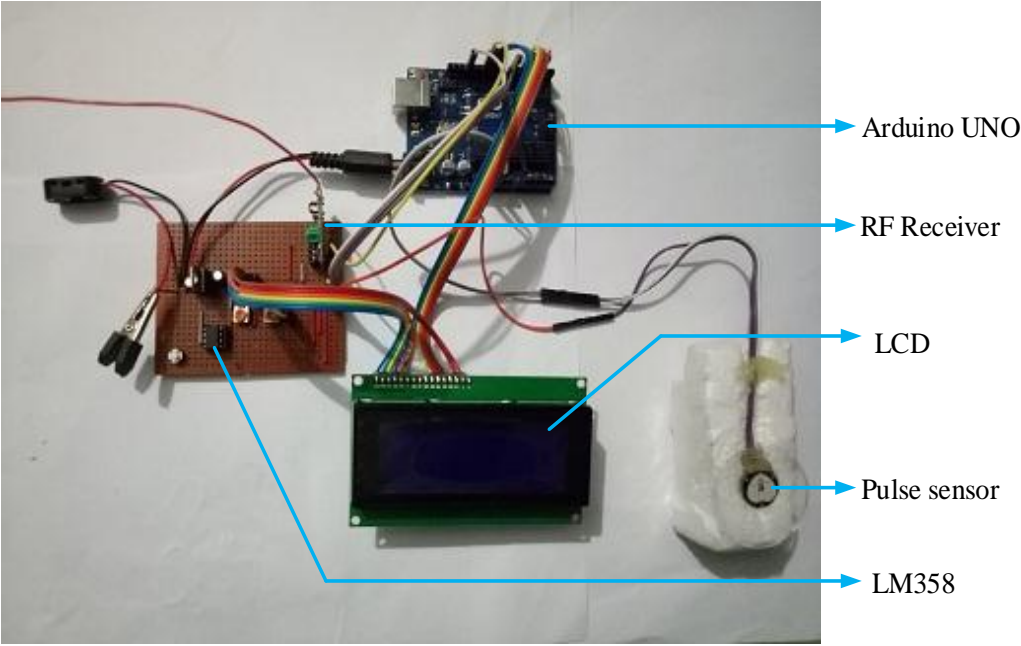
(a)



(b)

**Fig. 5.2** Measurement end's pictures of (a) Ultrasonic sensor (b) Transmitting end circuit.

**Fig. 5.3** shows different devices that are used in receiving end. The pulse sensor is used to measure heartbeat of a patient. The LCD display is used for showing height, weight, BMI and heartbeat of that particular patient. The RF receiver is used for receiving all data from RF transmitter. To process all these data another Arduino UNO has been used here. To power the whole system two 9V (DC) power supply has been used.



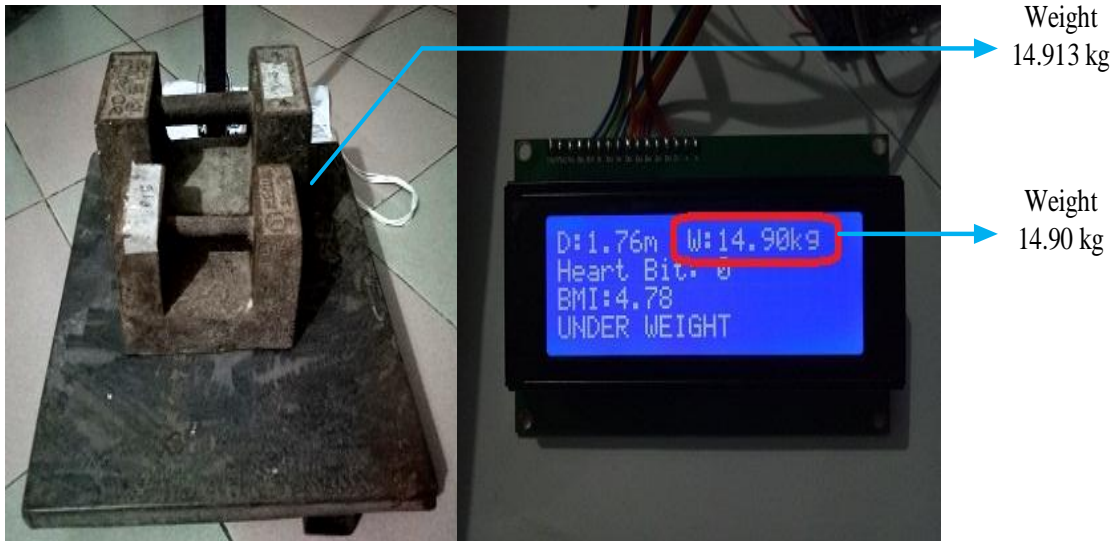
**Fig. 5.3** Receiving end circuit representation.

**5.3 Objective Justification**

1. **Fig. 5.4** and **Fig 5.5** shows weight measurement. By comparing with a commercial weighing machine, the accuracy of our load cell has been justified. Here we used 15kg weight.



**Fig. 5.4** Weight measurement in commercial weighing machine.



**Fig. 5.5** Weight measurement in our system measurement.

Table 5.1 and Table 5.2 shows the accuracy and precision of load measurement. To calculate the accuracy, we measure 10 different persons weight in commercial weighing machine and compare them to our system weighing machine measurement result. And to calculate the precision we measure a person's weight for 10 times.

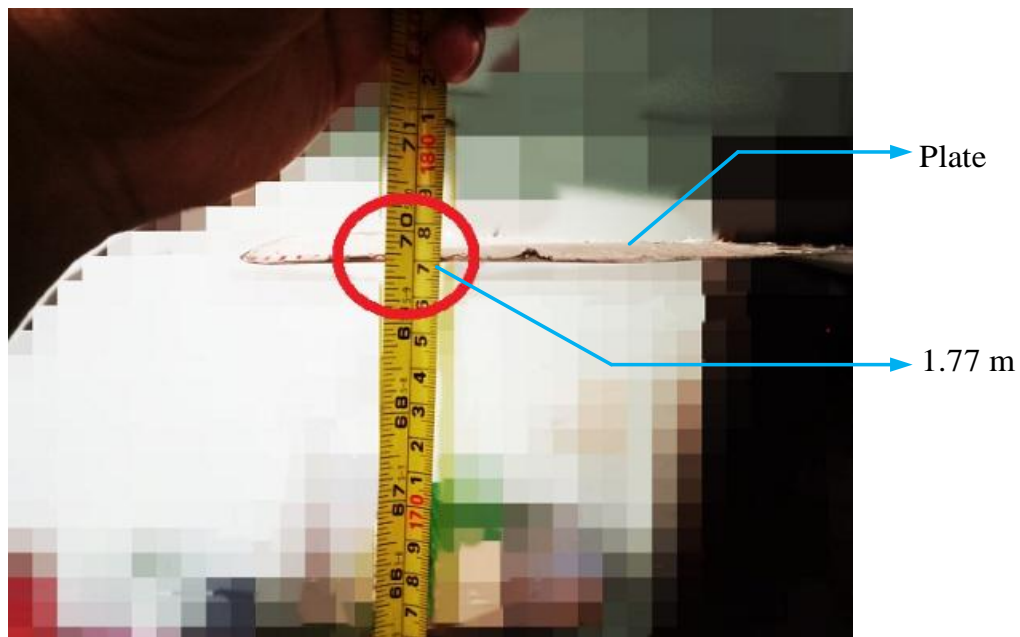
Table 5.1: Accuracy of weight measurement.

Person Sr. no.	Weight measured by commercial weighing machine (kg)	Weight measured by our system (kg)	Error (%)	Average Error (%)	Average Accuracy (%)
1	81.8	81.64	0.19%	0.18%	99.82%
2	67.5	67.42	0.11%		
3	74.2	74.10	0.13%		
4	78.6	78.75	0.19%		
5	72	72.28	0.33%		
6	63.3	63.11	0.3%		
7	55.1	55.17	0.16%		
8	76.4	76.35	0.06%		
9	61.7	61.80	0.12%		
10	47.8	47.74	0.12%		

Table 5.2: Precision of weight measurement.

Sr. no.	Weight, $x_i$ (kg)	Average Weight, $\bar{x}$ (kg)	Standard deviation, $\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}$	Precision
1	81.72	81.73	0.05	81.73 ± 0.05
2	81.83			
3	81.71			
4	81.67			
5	81.72			
6	81.72			
7	81.79			
8	81.72			
9	81.75			
10	81.68			

2. **Fig. 5.6** and **Fig. 5.7** shows height measurement. First, we placed a steel plate under the height sensor and manually measure the height between loading plate to steel plate as shown in **Fig. 5.6**. Where LCD displays the height measured by height sensor as shown in **Fig. 5.7**.



**Fig. 5.6** Height measured by using a meter tap.



**Fig. 5.7** Height measured by sensor shown on display.

Table 5.3 and Table 5.4 shows accuracy and precision of height measurement. To calculate the accuracy, we measure 10 different persons height by using a meter tap and compare them to our system height measurement result. And to calculate the precision we measure a person height for 10 times.

Table 5.3: Accuracy of height measurement.

Person Sr. no.	Hight measured by meter tap (m)	Height measured by our system (m)	Error (%)	Average Error (%)	Average Accuracy (%)
1	1.72	1.74	1.14%	0.63%	99.37%
2	1.77	1.79	1.12%		
3	1.72	1.73	0.58%		
4	1.79	1.81	1.11%		
5	1.76	1.76	0%		
6	1.70	1.72	1.17%		
7	1.64	1.63	0.60%		
8	1.76	1.76	0%		
9	1.71	1.70	0.58%		
10	1.58	1.58	0%		

Table 5.4: Precision of height measurement.

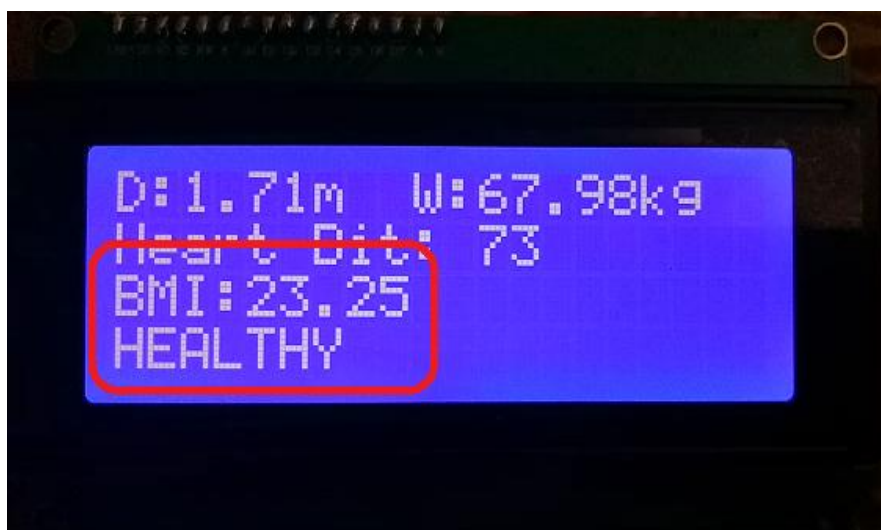
Sr. no.	Height, $x_i$ (kg)	Average Height, $\bar{x}$ (kg)	Standard deviation, $\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}$	Precision
1	81.72	81.73	0.05	81.73 ± 0.05
2	81.83			
3	81.71			
4	81.67			
5	81.72			
6	81.72			
7	81.79			
8	81.72			
9	81.75			
10	81.68			

3. **Fig. 5.8** shows the BMI score calculated by the system.

Here, Height = 1.71 m, Weight = 67.98 kg.

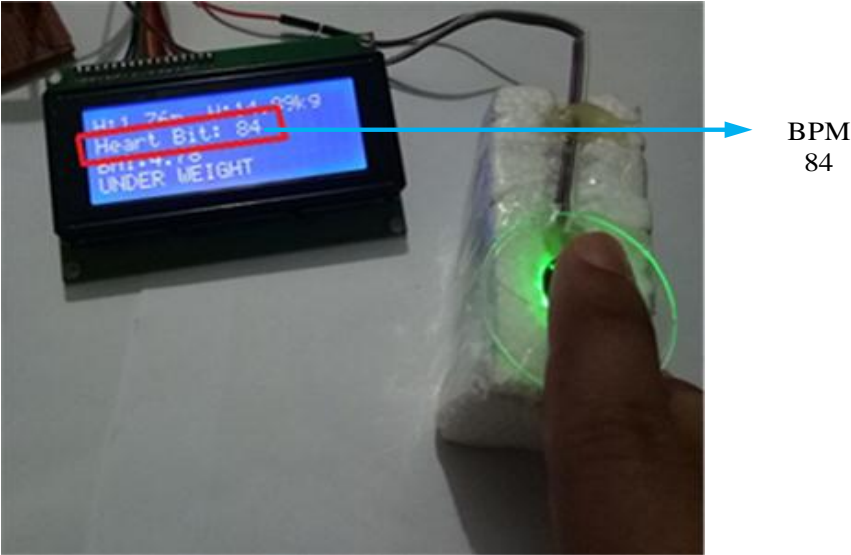
From the BMI equation, we know that  $BMI = \text{kg}/\text{m}^2 = 67.98/(1.71)^2 = 23.2481$ .

Hence, it justifies our system BMI calculation.

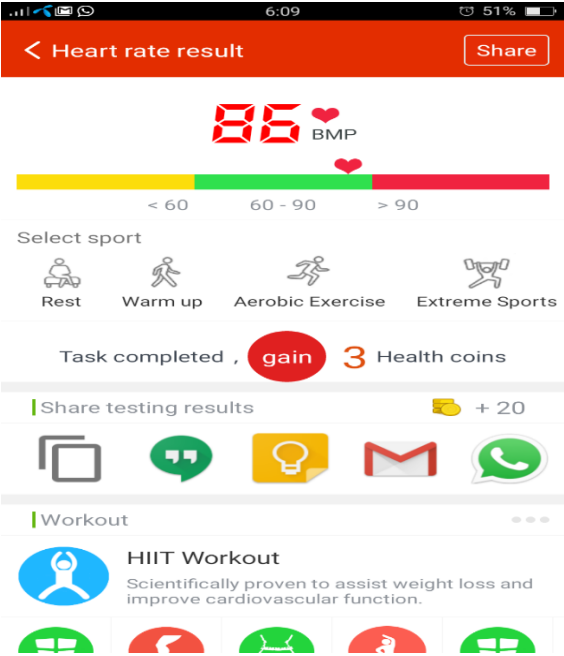


**Fig. 5.8** System BMI calculation.

4. **Fig. 5.9** shows system pulse measurement. First, the index finger is placed on the pulse sensor. Then the system count pulse for 15 seconds and finally shows the heartbeat on LCD. To estimate the credibility, we had followed two methods. The most trustable one is to measure pulse manually. A renowned doctor had measured 87 BPM after the completion of our measurement. The other one is to measure through a high rated Android apps naming “ICare Health Monitor” which is shown in **Fig. 5.9(b)**.



(a)



(b)

**Fig. 5.9** BPM analogy between (a) System (b) Android apps measurement.

Table 5.5 and Table 5.6 shows the accuracy and precision of pulse measurement. To calculate accuracy, we measure 5 persons BPM in ICare Health Monitor apps and compare them to our system pulse measurement result. For more accurate result we measure each person's pulse in each measuring tool for three times. And to calculate the precision we measure a person pulse for ten times.

Table 5.5: Accuracy of pulse measurement.

Person Sr. no.	BPM measured by ICare Health Monitor Apps				BPM measured by our system				Error (%)	Avg. Error (%)	Avg. Accuracy (%)
	Test 1	Test 2	Test 3	Avg.	Test 1	Test 2	Test 3	Avg.			
1	88	90	86	88	84	88	88	87	1.13%	1.9%	98.1%
2	96	102	100	100	100	104	100	102	2.0%		
3	82	87	88	86	80	92	92	88	2.27%		
4	104	108	105	106	108	96	100	102	2.85%		
5	78	74	78	77	80	76	76	78	1.29%		

Table 5.6: Precision of pulse measurement.

Sr. no.	BPM, $x_i$	Average BPM, $\bar{x}$	Standard deviation, $\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{x})^2}$	Precision
1	76	83	4.64	$83 \pm 4.64$
2	80			
3	80			
4	76			
5	88			
6	88			
7	84			
8	88			
9	84			
10	84			

Table 5.7 shows the total error and accuracy of our system.

Table 5.7: Total system error and accuracy.

Sr. no.	System measurement	Error (%)	Avg. Error (%)	Avg. Accuracy (%)
1	Weight	0.18%	0.58%	99.42%
2	Height	0.63%		
3	Pulse	1.9%		

#### 5.4 System Specification

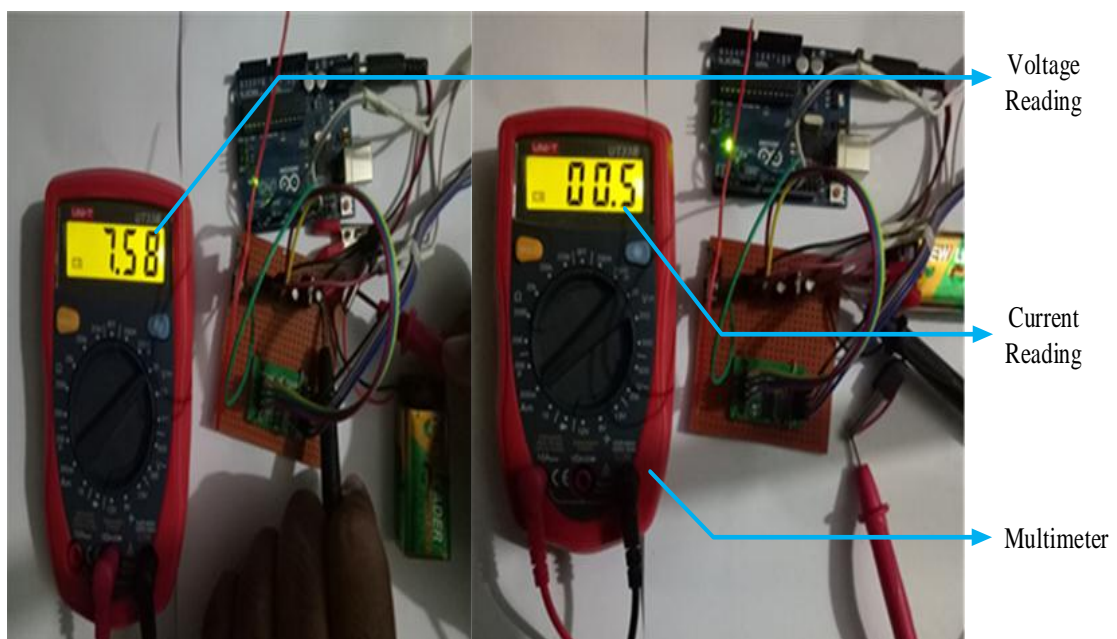
As we said before our system has two sections and both section requires individual power supply. Here we discuss about how much power is being consumed by our system and also about the RF range of our system.

##### 5.4.1 Power Calculation in Transmitter Section

Supply voltage = 7.58 V.

Taking current = 0.05 Amp.

Hence, Power = 0.379 Watt.



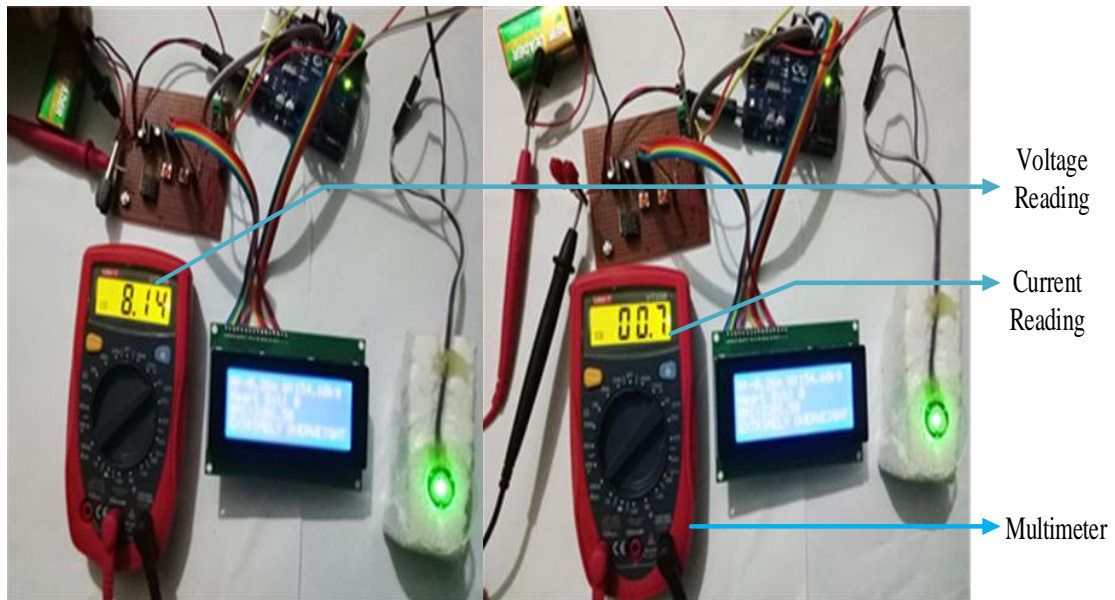
**Fig. 5.10** Voltage and Current measurement of Transmitter section.

### 5.4.2 Power Calculation in Receiver Section

Supply voltage = 8.14 V.

Taking current = 0.07 amp.

Hence, Power = 0.5698 Watt.



**Fig. 5.11** Voltage and Current measurement of Receiver section.

### 5.4.3 RF Range

Transmitter and Receiver in open space: 200 meters.

Transmitter inside the room and receiver outside the room: 160 meters.

## 5.5 Advantages of Our Project

Advantages of our project are given below.

1. It is completely an automotive process so all the measurements are more accurate and reliable compare to the manual measurement.
2. RF based communication is used here which is not depended to any operator network. So, there is no risk of system failure due to no network.
3. The proposed system with easy operations allows people to use the outputs of the measured data coupled with user's body mass index (BMI) for supporting medical diagnosis to quantify the medical treatment, rehabilitation or training.
4. It requires very small space to install. So, it can move at any place easily.
5. All data measured by the system can be displayed on LCD within the range of milliseconds which is not possible by any kind of manual operation.

# CHAPTER 6

## CONCLUSIONS

### 6.1 Conclusions

This is basically a BMI and Pulse measurement device. All the measurements are being executed automatically within the milliseconds range where manually height, weight and BMI measurement takes 4-5 minutes. The examined data given by the device is highly accurate and equally precise. RF communication allows it to send data to a moderate distance uninterruptedly. It's installation space is very small so that it may fit to anywhere. To use this machine user doesn't require any kind of significant knowledge. Any kind of mentally and physically stable person can operate it. So, it could be a great helping hand especially to the people living in remote areas who are deprived of basic medical needs.

### 6.2 Limitation of Our Project

There are some limitations too. Limitations are as follows:

1. There is no data storing arrangements in this proposed system.
2. The pulse sensor is bit limited in functionality. So, a patient may face difficulties to adjust his finger placing on it.

### 6.3 Future Improvement

Some future works which can be implemented by further research are proposed below:

1. In this project three parameters are available to be measured. There are few more parameters such as blood pressure, blood cholesterol etc. are also required for proper treatment to a doctor. So, adding these parameters into this system can be taken to consideration.
2. In this system it just counts the heartbeat but visualization gives more clarity to a doctor. So, this can also be taken to consideration.
3. This work can be extended to focus on building a commercial product which can make a simple diagnosis or medical suggestion whenever a user finishes the measurement.

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## APPENDIX A

Total cost estimation of the project.

Component	Unit (s)	Costing (BDT)
Arduino Uno (R3)	02	1000
Load Cell	01	2500
HX711	01	600
Ultrasonic Sensor	01	145
433 MHz RF Tx-Rx	01	150
Pulse Sensor	01	550
LCD 20X4	01	335
Wires and other components		150
		<b>Total Costing = 5,280/-</b>

Similar commercial products cost

Product Name	Appearance	Description	Price (BDT)
<b>BMI Scales</b>		Automatically measures weight, height and body mass index. Displays weight, height and body mass index. It also displays, simultaneously, how much over / under weight the patient is.	35840
<b>Digital Platform Weighing Scales</b>		Weighing Capacity: 50-100kg Use: Industrial	10880
<b>Instant Heart Rate Monitor</b>		Measures heart rate using IR frequency. Displays heart rate on a 16x2 LCD. Monitors pulse rate using arterial blood flow within 15 sec.	3834

## APPENDIX B

Table 3.1: Pin description of the ATmega328P Microcontroller [10].

Pin Number	Description	Function
1	PC6	Reset
2	PD0	Digital Pin (RX)
3	PD1	Digital Pin (TX)
4	PD2	Digital Pin
5	PD3	Digital Pin (PWM)
6	PD4	Digital Pin
7	VCC	Positive Voltage (Power)
8	GND	Ground
9	XTAL 1	Crystal Oscillator
10	XTAL 2	Crystal Oscillator
11	PD5	Digital Pin (PWM)
12	PD6	Digital Pin (PWM)
13	PD7	Digital Pin
14	PB0	Digital Pin
15	PB1	Digital Pin (PWM)
16	PB2	Digital Pin (PWM)
17	PB3	Digital Pin (PWM)
18	PB4	Digital Pin
19	PB5	Digital Pin
20	AVCC	Positive voltage for ADC (power)
21	AREF	Reference Voltage
22	GND	Ground
23	PC0	Analog Input
24	PC1	Analog Input
25	PC2	Analog Input
26	PC3	Analog Input
27	PC4	Analog Input
28	PC5	Analog Input

Table 3.2: Pin function of HX711 [16].

Pin No.	Name	Function	Description
1	VSUP	Power	Regulator supply: 2.7 ~ 5.5V.
2	BASE	Analog Output	Regulator control output (NC when not used)
3	AVDD	Power	Analog supply: 2.6 ~ 5.5V.
4	VFB	Analog Input	Regulator control input (connect to AGND when not used).
5	AGND	Ground	Analog Ground.
6	VBG	Analog Output	Reference bypass output.
7	INA-	Analog Input	Channel A negative input.
8	INA+	Analog Input	Channel A positive input.
9	INB-	Analog Input	Channel B negative input.
10	INB+	Analog Input	Channel B positive input.
11	PD_SCK	Digital Input	Power down control (high active) and serial clock input.
12	DOUT	Digital Output	Serial data output
13	XO	Digital I/O	Crystal, I/O (NC when not used)
14	XI	Digital Input	Crystal, I/O or external clock input, 0: use on-chip oscillator.
15	RATE	Digital Input	Output data rate control, 0: 10Hz; 1:80Hz.
16	DVDD	Power	Digital supply: 2.6 ~ 5.5V

Table 3.3: Pin function of HC-SR04 [17].

Pin no.	Pin Name	Function
1	Vcc	Connects to positive 5V for power.
2	Trig	A pulse is sent here for the sensor to go into ranging mode for object detection.
3	Echo	The echo sends a signal back if an object has been detected or not. If a signal is returned, an object has been detected.
4	Gnd	Completes electrical pathway of the power.

Table 3.4: Pin function of LCD 20X4 [22].

Function	Pin No.	Name	Logic State	Description
Ground	1	Vss/Gnd	-	0V
Power Supply	2	Vcc/Vdd	-	+5V
Contrast	3	Vee	-	0 - Vdd
Control of Operation	4	RS	0	D0 – D7 are interpreted as commands.
			1	D0 – D7 are interpreted as data.
	5	R/W	0	Write data (from controller to LCD)
			1	Read data (from LCD to controller)
	6	E	0	Access to LCD disable
			1	Normal operation.
Data/ Commands	7	D0	0/1	Bit 0 LSB
	8	D1	0/1	Bit 1
	9	D2	0/1	Bit 2
	10	D3	0/1	Bit 3
	11	D4	0/1	Bit 4
	12	D5	0/1	Bit 5
	13	D6	0/1	Bit 6
	14	D7	0/1	Bit 7 MSB
Backlight	15	Led+	-	Enable the backlight.
	16	Led-	-	

Table 3.5: Basic commands of LCD [22].

Serial No.	Hex Code (RS, E, D7-D0)	Command to LCD instruction Register
1	01	Clear display screen.
2	02	Return home.
3	04	Decrement cursor (shift cursor to left).
4	06	Increment cursor (shift cursor to right).
5	05	Shift display right.
6	07	Shift display left.
7	08	Display off, cursor off.
8	0A	Display off, cursor on.
9	0C	Display on, cursor off.
10	0E	Display on, cursor blinking.
11	0F	Display on, cursor blinking.
12	10	Shift cursor position to left.
13	14	Shift cursor position to right.
14	18	Shift the entire display to the left.
15	1C	Shift the entire display to the right.
16	80	Force cursor to beginning (1st line).
17	C0	Force cursor to beginning (2nd line).
18	38	2 lines and 5×7 matrix.

Table 3.6: Pin description of RF transmitter [24].

Pin No.	Function	Name
1	Ground (0V)	Ground
2	Serial data input pin	Data
3	Supply voltage; 5V	Vcc
4	Antenna output pin	ANT

Table 3.7: Pin description of RF Receiver [24].

Pin No.	Function	Name
1	Ground (0V)	Ground
2	Serial data output pin	Data
3	Supply voltage; 5V	Vcc
4	Antenna output pin	ANT

Table 3.8: Pin description of LM358 [30].

Pin NO.	Pin Name	Description
1	Output 1	Channel 1 Output.
2	Inverting Input 1	Channel 1 Inverting Input.
3	Non-inverting Input 1	Channel 1 Non-inverting Input.
4	GND	Ground.
5	Non-inverting Input 2	Channel 2 Non-inverting Input.
6	Inverting Input 2	Channel 2 Inverting Input.
7	Output 2	Channel 2 Output.
8	Vcc	Chip supply voltage.

## APPENDIX C

### Program code

#### Transmitter code:

```
#include <VirtualWire.h>

const int transmit_pin = 12;

#include "HX711.h"

#define calibration_factor -19630.0

#define DOUT 2

#define CLK 3

HX711 scale(DOUT, CLK);

float load;

#define trigPin 7

#define echoPin 13

long duration, distance;

void setup() {

  Serial.begin(9600); // begin serial communication

  scale.set_scale(calibration_factor);
```

```

scale.tare(); //Assuming there is no weight on the scale at start up, reset the scale to 0

pinMode(trigPin, OUTPUT); // set the trig pin to output (Send sound waves)

pinMode(echoPin, INPUT); // set the echo pin to input (receive sound waves)

vw_set_tx_pin(transmit_pin); // Initialise the IO and ISR

vw_setup(2000); // Bits per sec

}

void loop()

{

digitalWrite(trigPin, LOW);

delayMicroseconds(10); // delays are required for a successful sensor operation.

digitalWrite(trigPin, HIGH);

duration = pulseIn(echoPin, HIGH);

distance = (duration / 2) / 29.1; // convert the distance to centimeters.

load = scale.get_units() * .453592;

long int x = load * 1000 ;

int y = (x / 1000);

int z = (x % 1000);

z = z / 10;

if (x > 10000) {

byte msg[3];

msg[0] = distance;

msg[1] = y;

msg[2] = z;

digitalWrite(led_pin, HIGH); // Flash a light to show transmitting

vw_send((uint8_t *)msg, 3);

vw_wait_tx(); // Wait until the whole message is gone

digitalWrite(led_pin, LOW);

}

delay(100);

}

```

**Receiver code:**

```
#include <VirtualWire.h>

const int receive_pin = 11;

int PulseSensorPurplePin = 0;

int count;

int pulse;

int Signal; // holds the incoming raw data. Signal value can range from 0-1024

int Threshold = 500;

int lowpick = 100;

int switchpin = 7;

int ledpin = 13;

unsigned int l, j, k, m = 0;

unsigned long z;

unsigned long time;

#include <LiquidCrystal.h>

LiquidCrystal lcd(10, 9, 5, 4, 3, 2); // initialize the library with the numbers of the interface pins

void setup()

{

  lcd.begin(20, 4);

  Serial.begin(9600);

  pinMode(switchpin, INPUT_PULLUP);

  pinMode(ledpin, OUTPUT);

  digitalWrite(switchpin, HIGH);

  Signal = analogRead(PulseSensorPurplePin);

  vw_set_rx_pin(receive_pin);

  vw_setup(2000); // Bits per sec

  vw_rx_start(); // Start the receiver PLL running

}
```

```

void loop()
{
  uint8_t buf[VW_MAX_MESSAGE_LEN];

  uint8_t buflen = VW_MAX_MESSAGE_LEN;

  if (vw_get_message(buf, &buflen) // Non-blocking
  {
    int i;

    //Serial.print("Got: ");

    for (i = 0; i < buflen; i++)
    {
      // Serial.print(buf[i], HEX);

      // Serial.print(' ');
    }
  }

  int x = int (buf[0]);

  int y = int (buf[1]);

  int w = int (buf[2]);

  Serial.println(x);

  Serial.println(y);

  Serial.println(w);

  time = millis();

  if ( digitalRead(switchpin) == LOW)
  {
    l = 1; count = 0;

    vw_rx_stop();
  }

  z = time + 15350;

  while (l == 1)
  {
    Signal = analogRead(PulseSensorPurplePin);

```

```

Serial.println(Signal);

time = millis();

if (Signal > Threshold) { // If the signal is above "550", then "turn-on" Arduino's LED.

    digitalWrite(ledpin, HIGH); j = 1;

    while (j == 1) {

        Signal = analogRead(PulseSensorPurplePin);

        if (Signal < lowpick)

            {

                digitalWrite(ledpin, LOW); k = 1; j = 0; // Else, the sigal must be below "550", so "turn-
off" this LED.

            }

        }

    }

    if ( k == 1) {

        count ++ ; k = 0; j = 0;

    }

    if (z < time) l = 0; m = 1;

}

Serial.print("pulse:");

Serial.println(count);

pulse = count * 4;

float b = 202.5 - x;

b = b * 0.01; //convert into meter

float a = b;

a = a * a; //for BMI calculation

a = 1 / a;

Serial.println(a);

lcd.clear();

float weight = y * 100;

weight = weight * 10 ;

```

```

weight = weight + (w * 10); //add grams part

weight = weight / 1000; // convert into kg

Serial.println(weight);

float BMI = weight * a;

lcd.setCursor(0, 0);

lcd.print("H:");

lcd.setCursor(2, 0);

lcd.print(b);

lcd.print("m");

lcd.setCursor(9, 0);

lcd.print("W:");

lcd.setCursor(11, 0);

lcd.print(weight);

lcd.print("kg");

lcd.setCursor(0, 1);

lcd.print("Heartbeat:");

lcd.setCursor(11, 1);

lcd.print(pulse);

lcd.setCursor(0, 2);

lcd.print("BMI:");

lcd.setCursor(4, 2);

lcd.print(BMI);

if (BMI < 18.50)

{

    lcd.setCursor(0, 3);

    lcd.print("UNDER WEIGHT");

}

if (BMI >= 18.50 && BMI < 25)

{

    lcd.setCursor(0, 3);

```

```

    lcd.print("HEALTHY");
}
if (BMI >= 25 && BMI < 30)
{
    lcd.setCursor(0, 3);
    lcd.print("OVER WEIGHT");
}
if (BMI >= 30 && BMI < 40)
{
    lcd.setCursor(0, 3);
    lcd.print("OBESE");
}
if (BMI >= 40)
{
    lcd.setCursor(0, 3);
    lcd.print("EXTRIMELY OVERWEIGHT");
}
delay(300);
if (m == 1) {
    delay(5000);
    count = 0;
    b = 0;
    weight = 0;
    BMI = 0;
    m = 0;
}
vw_rx_start();
}

```