Visvesvaraya Technological University, Belagavi.

PROJECT REPORT

on

Smart Monitoring System for Asthma Patients

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CERTIFICATE

This is to Certify that the dissertation work **Smart Monitoring System for Asthma Patients** carried out by Chinmayee Parhi (1CR15EC049), Shahida M (1CR15EC169), Sonam Choudhury (1CR15EC183) and Vishnupriya Venugopal (1CR15EC216) bonafide students of **CMRIT** in partial fulfillment for the award of **Bachelor of Engineering** in **Electronics and Communication Engineering** of the **Visvesvaraya Technological University, Belagavi,** during the academic year **2019-20**. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said degree.

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ABSTRACT

The Internet of things (IoT) is a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Connectivity through network is enabled with the help of objects such as sensors used for exchanging and collecting data .Asthma is a chronic disease caused due to abnormal respiratory organ functions which leads to problems in breathing. 350million individuals suffer from asthma, which is one in every twelve adults. Self-monitoring is a preliminary course of action, it plays a huge role in the treatment and management of this chronic disease. The proposed device monitors the physiological parameters of patient, temperature level, humidity and concentration of smoke in the patient's immediate surroundings. Data accumulated by the device provides medical professionals a clear cut view on how to proceed with the treatment of the disease.

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Chapter 1

INTRODUCTION

Asthma is a common, chronic inflammatory disease of the airways that affects people of all ages and imposes a substantial burden on patients, their families, and the community. It causes respiratory symptoms that are interspersed with severe attacks, which can require urgent health care and may be fatal. The burden of asthma is immense, with more than 300 million individuals currently suffering from asthma worldwide, about a tenth of those living in India. The prevalence of asthma has been estimated to range between 3-38% in children and 2-12% in adults, being the most common chronic disorder among children. A recent Indian Study on Epidemiology of Asthma, Respiratory Symptoms and Chronic Bronchitis (INSEARCH) estimated the prevalence of asthma in India to be 2.05% among those aged >15 years, with an estimated national burden of 18 million asthmatics.

Asthma causes limitations in daily activities, loss of school and work days, lung function impairment, reduced quality of life, and an adverse socioeconomic burden. About 15 million disability-adjusted life years are lost annually due to asthma, which represents 1% of the total global disease burden. There are about 489,000 deaths attributable to asthma annually and the majority of deaths occur in low- and middle-income countries, particularly Oceania, South and Southeast Asia, the Middle East, and Africa. Patients from low and middle-income countries have more severe symptoms than those in high-income countries, possibly due to incorrect diagnoses, poor access to health care, unaffordability of therapy, exposure to environmental irritants, and genetic susceptibility to more severe disease.

Achievement and maintenance of control through the assessment of clinical manifestations and future risk has become the aim of treatment over the years. In high-income areas, mortality due to asthma, which is predominantly an adult problem, has fallen substantially in recent decades with the spread of new guidelines for treatment that emphasize the use of inhaled steroids to control the disease.

While a number of guidelines exist regarding the management of asthma in general, substantial differences exist across countries regarding the insights, attitudes, and perceptions about asthma and its treatment that suggest unmet, country-specific cultural

and educational needs. A large proportion of asthma patients overestimate their level of control. Indian asthmatics have a high frequency of reported exacerbations (67%), leading to substantial functional and emotional limitations. This depicts poor control of asthma and reflects the inadequate treatment of such patients. The uptakes of bronchodilators, inhaled corticosteroids, and influenza vaccinations have been found to be low in lower-income countries low-income countries, including India, compared to those with higher per-capita income, suggesting the role of economics in determining the uptake of adequate therapy. The use of inhaled steroids and bronchodilators is clearly a cost-effective strategy, because the amelioration of symptoms will not only improve individual symptoms but also shall be collectively being contributory to the economic productivity of this active workforce.

Since Asthma is a chronic condition or disease that causes inflammation and narrowing of the bronchial tubes, the passageways that allow air to enter and leave the lungs gets blocked, making it harder to breathe. If people with asthma are exposed to a substance to which they are sensitive or a situation that changes their regular breathing patterns, the symptoms can become more severe. According to the latest World Health Organization (WHO) estimates, approximately 250 million people suffer from asthma worldwide, and almost 25 million Americans are affected by this disease according to AAFA. This disease is a public health problem in both rich and poor countries. Although there is no cure for asthma, effective treatments are available. The best way to manage asthma is to avoid triggers, take medications to prevent symptoms and prepare to treat asthma episodes if they occur.

Bronchial asthma is one of the most severe Broncho pulmonary diseases affecting people of all age groups, including young children. Currently, more than 300 million cases of bronchial asthma of varying severity have been detected worldwide. In addition, there is a tendency to an increase in the number of patients with bronchial asthma, including young children. Therefore, the development of new methods and devices for the diagnosis of bronchial asthma, including inexpensive portable devices, is a very urgent task. Modern technologies are able to provide important tools for diagnosing a wide range of various diseases, including bronchial asthma. At present, one can find a tendency to actively introduce modern technologies, in particular, in the development of modern low-cost portable devices for diagnosing or monitoring human condition.

Asthma is one of the most common chronic diseases and the third leading cause of hospitalization among adolescents. It is a medical condition that causes coughing, wheezing, and difficulty in breathing. During the period from 2008–2010, the prevalence of Asthma was higher among children than adults. According to the Center for Disease Control, it affects 7.1 million (1:11) children and its rampancy has increased by 15% in the last decade. Records obtained from the Center for Disease Control and Prevention also indicate that in 2013, about 21% of high school students (grades 9-12) had asthma. Asthma demands a great deal of health care utilization and entails a lot of missed days of school and work.

Asthma is characterized by episodic respiratory symptoms and intermittent exacerbations. The symptoms like airflow obstruction and exacerbations in asthma vary greatly in frequency of occurrence and severity. Monitoring these events is crucial to the care of patients with asthma and is directed at the early detection of exacerbations and monitoring of the day-to-day control of asthma. Monitoring can also be extended to investigate reasons for poor control and reasons for exacerbations, such as noncompliance and exposure to triggers. It is important to identify who will perform the monitoring because this has implications for the type of data that are collected, their validity, and their accuracy. Asthma can be monitored by the following people:

• Patients suffering from asthma, because self-monitoring allows the early detection of exacerbations;

• The treating physician, to assess control of asthma and investigate reasons for poor control.

• Health care managers, to assess the quality and cost of care for patients with asthma.

This article reviews asthma monitoring from each of these perspectives.

1.1 PROBLEM STATEMENT

Asthma, a chronic health condition prevalent in children can be characterized by breathlessness, chest tightness and coughing. An asthma attack can be triggered by a variety of factors including environmental conditions, intense physical activity, humidity and dust. In the United States, as of February 2010, 7 million children (10%) were reported to be suffering from asthma. This condition is generally more prevalent among adolescents in the age group of 11-17. Due to the high prevalence of asthma in children and the difficulty involved in diagnosing the condition it becomes imperative to come up with technological solutions for continuous care and management of patients with this chronic disease.

1.2 OBJECTIVE

The objective of this project is to develop a system to analyze the trigger factor of asthma and a device that can be used by asthma patients, which can perform multiple functions that enable a physician to monitor the patient's condition and to provide continuous care. The idea behind this work is to develop a point of care device which can monitor a patient's physiological parameters and present accurate set of readings (of the above mentioned parameters) to the care taker or health care professional.

1.3 MOTIVATION

- Asthma is one of the most widespread chronic diseases, affecting both adults and children.
- Rising prevalence of this disease increases the burden on financial expenditures and workload, both on sides of patients and healthcare systems.
- Asthma continues to be one of the major causes of hospitalization of children in many countries.

1.4 EXISTING SYSTEM

The implementation of a portable system for people suffering from Broncho pulmonary diseases is proposed, which is a combination of a patient activity sensor, a temperature sensor and an air pollution sensor. The sensors are installed in a compact

case, which is fixed on the patient's body and transmits data to the central station, which can be implemented with the help of a Smartphone. Such a device is designed to inform the patient about the need to reduce activity in the case of determining a high degree of air pollution to prevent an attack of the disease.

The device helps identify areas with excessive air pollution and inform patients about the need to refrain from visiting the selected areas. The disadvantage of this system is that it can't determine the current state of health of the patient. However, the proposed device provides undoubtedly, important information and is promising in the case of the integration of such sensors into a comprehensive patient monitoring system.

1.5 PROPOSED SYSTEM

The Asthma Monitoring System is designed around a microcontroller for gathering, sending and receiving information from different sensors and external servers. The aim of this design is to provide an easier access to information and services, better patient healthcare services, transparent and efficient use of healthcare resources, and a fast response by the hospital in case of an asthma attack. Symptoms can be prevented by monitoring factors which can trigger asthma attack. So, as per requirement there should be a system which can monitor air parameter on regular basis and warn the patient when these factors can trigger an asthma attack. A portable system for non-invasive diagnosis of Broncho pulmonary diseases and continuous monitoring of the patient's condition is a combination of two compact modules radiating and receiving. The fixation point of the modules is determined based on the individual characteristics of the patient's body.

Chapter 2

LITERATURE SURVEY

[1] Asthma Academy: Developing Educational Technology to Improve Asthma Medication Adherence and Intervention Efficiency

Authors: Aiswaria S. Nair, Karen DeMuth

Published in: IEEE 2017

Asthma is a leading chronic disorder among children and adolescents. Although some children outgrow asthma while transitioning into adulthood, there are others who continue to suffer from life-threatening asthmatic exacerbations. Teenagers tend to have certain misconceptions about their asthmatic condition and treatment which are rarely recognized or addressed in regular clinical consultations. After reviewing the literature in this field, it has been identified that improving patient knowledge can be effective in augmenting engagement, and considerably improving their clinical outcomes. It is necessary to develop an effective educational intervention that can help Asthma patients change their perception about self-efficacy and ultimately reduce the total health care costs incurred. Hence, a sound transfer of knowledge during the transition from childcare to adult care is highly recommended. On these very lines, Georgia Institute of Technology designed an interactive educational application called Asthma Academy in conjunction with Children's Healthcare of Atlanta. This website resides in the public cloud and uses a novel animation video– based curriculum to deliver essential healthcare education to asthmatic adolescents in an interactive manner. What distinguishes it from similar initiatives is the use of a cost-effective technique to simulate caregiver-patient interactions and the ability to cater to a wide range of socio-economic statuses and educational levels. A group-based study with twenty asthma adolescents was conducted to evaluate the user acceptance and performance of Asthma Academy supplemented by regular check-ups over a period of eight to ten weeks. Observations recorded post the study clearly indicate higher levels of engagement and the systematic dissemination of information offered by Asthma Academy.

[2] Asthma Irritant Monitoring

Authors: E-J. Maalouf, A. Aoun, N. Marina

Published in: 2018 30th International Conference on Microelectronics (ICM)

This paper describes a prototype for asthma irritant monitoring system (AIM) that can be used by asthma patients. The AIM is a compact device that senses the environment around the patient for different irritants in order to detect any signs of asthma attacks or potentially unhealthy environments. Hence, asthma patients are able identify whether the environment around them is healthy or not, allowing them to take appropriate action. In addition, the device offers the capability of sending the data to the physician to monitor a patient's case and a display indicating the environment condition around the patients. Furthermore, the AIM displays data reordered in the daily tests, allowing the patient and the physician to check the progress from previous days. Finally, the AIM device is aligned with the medical requirements as per physicians' and telemedicine specialists' recommendations; the experiments carried out on asthma patients demonstrated the effectiveness and sustainable use of the AIM device.

[3] Modernizing Asthma Management: Personalized Asthma Action Plans Using a Smartphone Application

Authors: Nikita Isaac, NaveenaaSampath and Valerie Gay

Published in: IEEE 2015

Asthma is a chronic disease affecting with symptoms such as coughing, wheezing and shortness of breath. Asthma can significantly impact a patient's quality of life. Asthma action plans are said to be one of the most effective asthma interventions available. However, in Australia only one in five people aged 15 and over, with asthma, have a written asthma action plan. Even less of which, refer to their plan. A review of related literature and work showed a gap regarding accessibility of information on asthma action plans in a written form. In an attempt to mitigate this problem, this paper focuses on the design and development of a Smartphone application. The application is currently a high-fidelity prototype designed and built using proto.io software. In addition to this conversion, the application incorporates aspects of the Internet of Things (IoT) whereby real-time data regarding environmental triggers such as temperature, humidity and pollen in surroundings, can be accessed from the application.

The application ultimately aims to help asthmatics improve their health and quality of life by providing them, or their career with the knowledge needed to better understand and manage their asthma, when and where they need it.

[4] A Method and Algorithm for Remote Monitoring of Patients in Asthma

Authors: Anna Glazova, Zafar Yuldashev, Anna Bashkova

Published in: 2018 Ural Symposium on Biomedical Engineering, Radioelectronics and Information Technology (USBEREIT)

A method and algorithm for remote monitoring of patients in asthma is discussed. The method includes a comprehensive evaluation of the results of standardized questionnaire about disease symptoms, changes in the bronchodilator intake regimen and data of functional test of respiratory systems state. The proposed functional test is based on the assessment of the duration of tracheal sounds in the frequency band of 200-2000 Hz registered during forced expiratory maneuver. To record tracheal sounds, a lapel microphone placed at the mouth outside the exhaled airflow is used. The algorithm of processing and analysis of diagnostic data is described. The developed diagnostic algorithm proved its effectiveness in the long-term monitoring of a group of healthy individuals and patients in asthma.

[5] Prospects for Designing a Portable System for Monitoring of the Patient's Condition with Bronchial Asthma

Authors: Ivan V. Semernik, Alexander V. Dem'yanenko

Published in: 2019 IEEE

In this article the prospects and possibilities for creating an individual wearable system for monitoring the condition of a patient suffering from bronchial asthma and preventing attacks of the disease are discussed. As the basic method of determining the condition of the patient is considered the technique for determining the transmission coefficient of a certain frequency microwave signal through the chest. The proposed method is non-invasive and harmless and can be used for patients of all age groups.

[6] Detection and Monitoring of Asthma Trigger Factor using Zigbee

Authors: Miss. AnumehaLal, Mr. Girish A. Kulkarni

Published in: International Advanced Research Journal in Science, Engineering and Technology, Vol. 3, Issue 7, July 2016

Asthma is a chronic condition that mostly affects adolescents. It is a condition that requires continuous monitoring of the symptoms in order to provide an effective course of treatment. It also requires a strict adherence to medication prescribed by the physician.

However, the aim of this study is to develop a system, which is based on a periodical data collected by the different sensors.

[7] Wireless sensor networks in monitoring of asthma

Authors: DinkoOletic

Published in: IJRSE 2013

Firstly, the medical background of asthma is given. Pathology and symptoms are presented. Next, the problem of persistent asthma management is introduced with a short overview of traditional disease management techniques. A review on approaches to asthma tele-monitoring is made. Effectiveness of home peak flow-meter is analyzed. Employment of low power wireless sensor networks (WSN) paired with Smartphone technologies is reviewed as a novel asthma management tool. Using the technology, the aim is to retain the disease in a controlled state with minimal effort, invasiveness and cost, and assess patient's condition objectively. WSN-s for sensing of both asthma triggers in the environment, and continuous monitoring of physiological functions, in particular respiratory function are reviewed. Sensing modalities for acquiring respiratory function are presented. Signal acquisition prerequisites and signal processing of respiratory sounds are reviewed. Focus is put on low-power continuous wheeze detection techniques. At the end, research challenges for further studies are identified.

[8] Monitoring the patient with asthma: An evidence-based approach

Authors: Harold S. Nelson, MD

Published in: Apr 17, 2000

The monitoring of symptoms, airflow obstruction, and exacerbations is essential to asthma management. Patients who practice self-monitoring in conjunction with use of a written action plan and regular medical review have significantly fewer hospitalizations, emergency department visits, and lost time from work. Either symptom monitoring or peak expiratory flow monitoring is satisfactory, provided the results are interpreted with reference to the patient's own baseline asthma status. Regular monitoring by physicians also improves health outcomes for patients, provided the physician is systematic and monitors control, medications, and skills at regular intervals. Additional monitoring tools are under evaluation, and these include measures of airway responsiveness, airway inflammation, and Internet- based monitoring systems. Administrators need to monitor

the quality and cost of care, as well as compliance with national management guidelines. Assessment of the hospitalization rate and regular audit may achieve these aims in the hospital setting. The best way to assess and monitor asthma in primary care remains an unresolved yet crucial issue as primary care physicians manage the vast burden of illness caused by asthma. Monitoring asthma outcomes is an essential step toward the successful implementation of national guidelines for the management of asthma.

Chapter 3

HARDWARE

3.1 ARDUINO UNO (ATMEGA 328P)

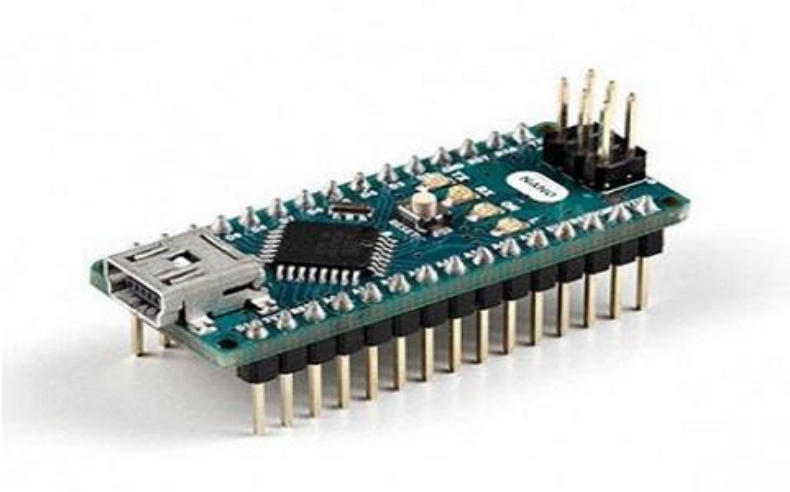

Figure 3.1 Arduino NANO

The Arduino NANO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9 volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform.

The ATmega328 on the Arduino Uno comes pre- programmed with a boot loader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.[1] The Uno also differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 programmed as a USB-to-serial converter.

3.1.1 TECHNICAL SPECIFICATIONS

- Microcontroller: Microchip ATmega328P
- Operating Voltage: 5 Volts
- Input Voltage: 7 to 20 Volts
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by boot loader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Length: 68.6 mm
- Width: 53.4 mm
- Weight: 25 g

3.1.2 PIN DIAGRAMS

- Vin is the input voltage of the board, and it is used when an external power source is used from 7V to 12V.
- 5V is the regulated power supply voltage of the Nano board and it is used to give the supply to the board as well as components.
- 3.3V is the minimum voltage which is generated from the voltage regulator on the board.
- GND is the ground pin of the board.
- RST Pin (Reset): This pin is used to reset the microcontroller.
- I/O Pins (Digital Pins from D0 – D13): These pins are used as an i/p or o/p pins, 0V & 5V.
- Serial Pins (Tx, Rx): These pins are used to transmit & receive TTL serial data.
- External Interrupts (2, 3): These pins are used to activate an interrupt.
- PWM (3, 5, 6, 9, 11): These pins are used to provide 8-bit of PWM output.
- SPI (10, 11, 12, & 13): These pins are used for supporting SPI communication.

- Inbuilt LED (13): This pin is used to activate the LED.
- IIC (A4, A5): These pins are used for supporting TWI communication.
- AREF: This pin is used to give reference voltage to the input voltage

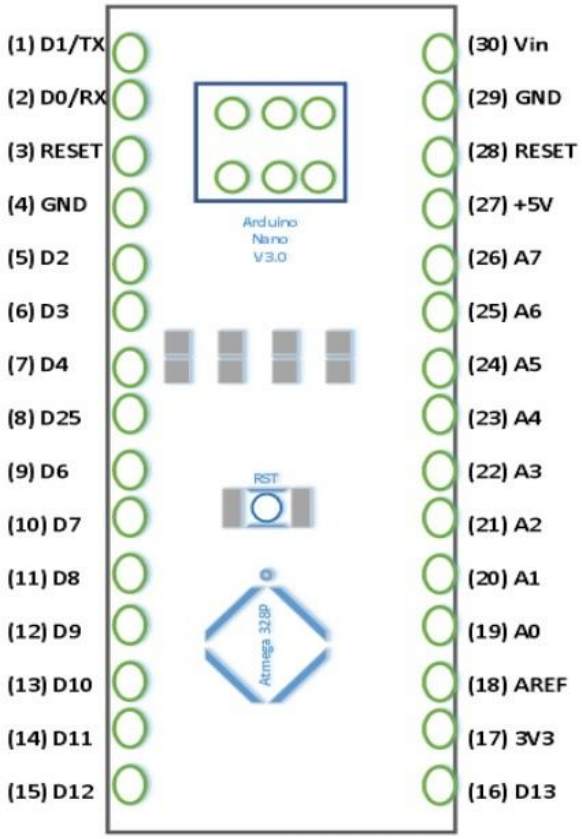

Figure 3.2 Pin Diagram

3.1.3 ARDUINO HARDWARE

Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available. The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields. Multiple and possibly stacked shields may be individually addressable via an I²C serial bus. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the Lily Pad, run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. Most Arduino boards consist of an Atmel 8-bit AVR microcontroller

(ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560) with varying amounts of flash memory, pins, and features.

Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default boot loader of the Arduino UNO is the optibootbootloader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to- serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used.

The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. Uno provides 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solder less breadboards.

There are several I/O digital and analog pins placed on the board which operates at 5V. These pins come with standard operating ratings ranging between 20mA to 40mA. Internal pull-up resistors are used in the board that limits the current exceeding from the given operating conditions. However, too much increase in current makes these resisters useless and damages the device.

3.2 POWER SUPPLY

The transformer 230Volts will be stepped down to 12-0-12 one side of the 12V is given to the 7805 and Lm317. In this project the microcontroller requires +5V power supply. The design description of power supply is given below.

The +5 Volt and 3.8V power supply is based on the commercial 7805 & Lm317 voltage regulator IC. This IC contains all the circuitry needed to accept any input voltage from 8 to 18 volts and produce a steady +5 volt & 3.8volt output, accurate to within 5% (0.25 volt). It also contains current-limiting circuitry and thermal overload protection, so that the IC won't be damaged in case of excessive load current; it will reduce its output voltage instead.

The 1000µf capacitor serves as a "reservoir" which maintains a reasonable input voltage to the 7805 throughout the entire cycle of the ac line voltage. The bridge rectifier (WM04) keeps recharging the reservoir capacitor on alternate half-cycles of the line voltage, and the capacitor is quite capable of sustaining any reasonable load in between charging pulses.

The LED and its series resistor (220ohm) serve as a pilot light to indicate when the power supply is on and also helps the reservoir capacitor to completely discharge after power is turned off.

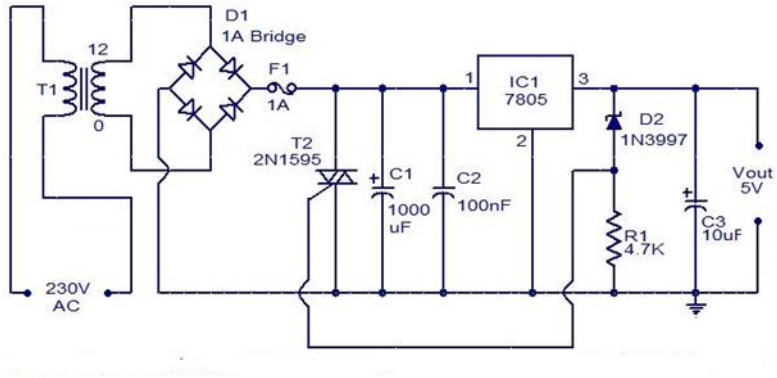

Figure 3.3 5v power supply with over voltage protection

3.3 HEARTBEAT SENSOR

Figure 3.4 Heartbeat Sensor

The new version uses the TCRT1000 reflective optical sensor for photoplethysmography. The use of TCRT100 simplifies the build process of the sensor part of the project as both the infrared light emitter diode and the detector are arranged side by side in a leaded package, thus blocking the surrounding ambient light, which could otherwise affect the sensor performance. A printed circuit board is designed for it, which carries both sensor and signal conditioning unit and its output is a digital pulse which is synchronous with the heart beat. The output pulse can be fed to either an ADC channel or a digital input pin of a microcontroller for further processing and retrieving the heart rate in beats per minute (BPM).

Theory

This project is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesn't have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart.

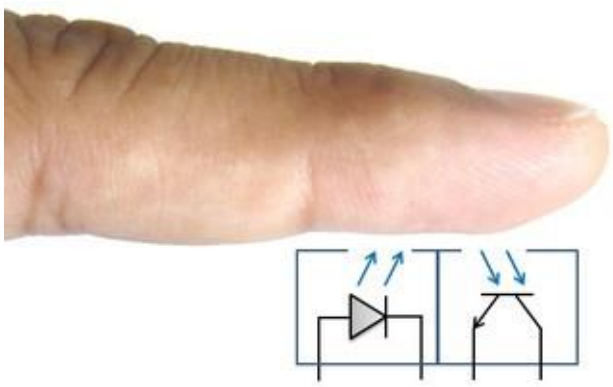

Figure 3.5 A basic reflectance PPG probe to extract the pulse signal from the fingertip

Figure 3.5 shows a basic reflectance PPG probe to extract the pulse signal from the fingertip. A subject's finger is illuminated by an infrared light-emitting diode. More or less light is absorbed, depending on the tissue blood volume. Consequently, the reflected light intensity varies with the pulsing of the blood with heart beat. A plot for this variation against time is referred to be a photoplethysmography or PPG signal.

The PPG signal has two components, frequently referred to as AC and DC. The AC component is mainly caused by pulsatile changes in arterial blood volume, which is synchronous with the heart beat. So, the AC component can be used as a source of heart rate information. This AC component is superimposed onto a large DC component that relates to the tissues and to the average blood volume. The DC component must be removed to measure the AC waveform with a high signal-to-noise ratio. Since the useful AC signal is only a very small portion of the whole signal, an effective amplification circuit is also required to extract desired information from it.

Operation of the board

The operation of the board is very simple. After powering the board from a 3-5.5V supply, the Enable (EN) pin must be pulled high to activate the IR sensor. Next, place the tip of your forefinger gently over the sensor on its face. Your finger should be still and should not press too hard on the sensor. Within a couple seconds the circuit stabilizes and you will see the LED flashing synchronously with your heart beat. You can feed the output signal (Vout) to either a digital I/O or an ADC input pin of the microcontroller for measurement of the heart beat rate in BPM. The output voltage waveform can also be viewed on an oscilloscope. Digilent's Analog Discovery tool is connected to check the input PPG and the output waveforms from the two LPF stages. The following pictures show these signal waveforms as displayed on the PC screen.HBT sensor circuit is covered with Heat Shrink Sleeve to Avoid Noise.

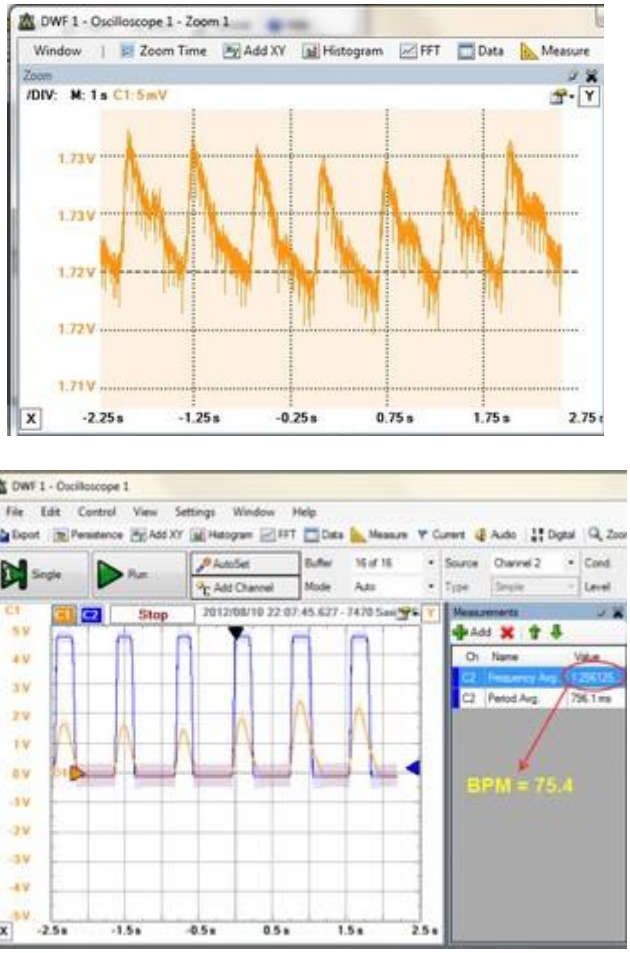

Figure 3.6 Signal waveforms as displayed on the PC screen

3.4 TEMPERATURE SENSOR

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 does not require any external calibration or trimming to provide typical accuracies.

Figure 3.7 Temperature Sensor

General Description

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°Cat room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level.

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while theLM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

Features

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee able (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Less than 60μA current drain
- Operates from 4 to 30 volts
- Low self-heating, 0.08°C in still air
- Low impedance output, 0.1 W for 1 mA load

Circuit Diagram

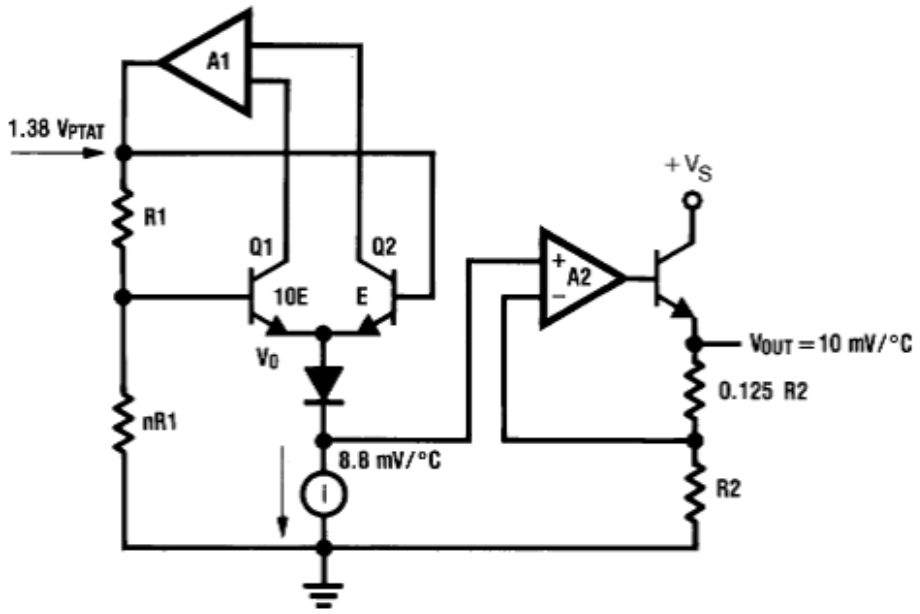

Figure 3.8 Circuit diagram of temperature sensor

Applications

The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01§C of the surface temperature. This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LM35 die would be at an inter- mediate temperature between the surface temperature and the air temperature. This is especially true for the TO-92 plastic package, where the copper leads are the principal thermal path to carry heat into the device, so its temperature might be closer to the air temperature than to the surface temperature. To minimize this problem, ensure the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die's temperature will not be affected by the air temperature.

The TO-46 metal package can also be soldered to a metal surface or pipe without damage. Of course, in that case the Vb terminal of the circuit will be grounded to that metal. Alternatively, the LM35 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any IC, the LM35 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and vanishes such as Humiseal and epoxy paints or dips are often used to ensure that moisture doesn't corrode the LM35 or its connections. These devices are sometimes soldered to a small light-weight heat fin, to decrease the thermal time constant and speed up the response in slowly-moving air. On the other hand, a small thermal mass may be added to the sensor, to give the steadiest reading despite small deviations in the air temperature.

3.5 HUMIDITY SENSOR

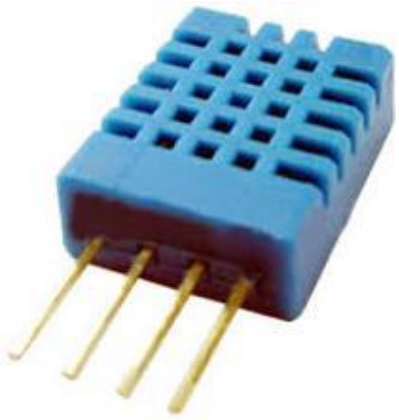

Figure 3.9 Humidity Sensor

Humidity is the presence of water in air. The amount of water vapour in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapor also influences various physical, chemical, and biological processes. Humidity measurement in industries is critical because it may affect the business cost of the product and the health and safety of the personnel. Hence, humidity sensing is very important, especially in the control systems for industrial processes and human comfort. Controlling or monitoring humidity is of paramount importance in many industrial & domestic applications. In semiconductor industry, humidity or moisture levels needs to be properly controlled & monitored during wafer processing. In medical

applications, humidity control is required for respiratory equipments, sterilizers, incubators, pharmaceutical processing, and biological products. Humidity control is also necessary in chemical gas purification, dryers, ovens, film desiccation, paper and textile production, and food processing. In agriculture, measurement of humidity is important for plantation protection (dew prevention), soil moisture monitoring, etc. For domestic applications, humidity control is required for living environment in buildings, cooking control for microwave ovens, etc.

Humidity is defined as the amount of water present in the surrounding air. This water content in the air is a key factor in the wellness of mankind. For example, we will feel comfortable even if the temperature is 0°C with less humidity i.e. the air is dry.

But if the temperature is 100°C and the humidity is high i.e. the water content of air is high, then we will feel quite uncomfortable. Humidity is also a major factor for operating sensitive equipment like electronics, industrial equipment, electrostatic sensitive devices and high voltage devices etc. Such sensitive equipment must be operated in a humidity environment that is suitable for the device.

Hence, sensing, measuring, monitoring and controlling humidity is a very important task. Some of the important areas of application for sensing, measuring and controlling Humidity are mentioned below.

Domestic: Sensing and controlling humidity in our homes and offices is important as higher humidity conditions will affect the blood flow. Other areas include cooking, indoor plantation etc.

Industrial: In industries like refineries, chemical, metal, or other industries where furnaces are used, high humidity will reduce the amount of oxygen in the air and hence reduces the firing rate. Other industries like food processing, textile, paper etc. also need control of humidity.

Agriculture: Irrigation techniques like drip irrigation need accurate moisture content for plants. Also, the moisture in the soil plays an important role in the proper growth of the plant. Other areas where humidity control is required is indoor vegetation.

Electronics and Semiconductor: Almost all electronic devices are rated with a range of humidity values in which they work as expected. Generally, this value will be something like 10% – 50% Humidity. Semiconductor Fabs (Fabrication Plants) should maintain very

precise temperature and humidity values as even minute difference can show a huge impact in the production.

Medical: Medical equipment like ventilators, incubators, sterilizers etc. need humidity control. It is also used in pharmaceutical plants and biological processes.

All the above mentioned and many other applications need sensing of Humidity and is done using Humidity Sensors.

3.6 LOAD CELL

The Working Principle of a Compression Load Cell

A load cell is a transducer that measures force, and outputs this force as an electrical signal. Most load cells use a strain gauge to detect measurements, but hydraulic and pneumatic load cells are also available.

Strain Gauge Load Cells

Strain gauge load cells usually feature four strain gauges in a Wheatstone bridge configuration, which is an electrical circuit that balances two legs of a bridge circuit.

The force being measured deforms the strain gauge in this type of load cell, and the deformation is measured as change in electrical signal. There are several common strain gauge load cell configurations, including shear beam, s-type, and compression.

How Does a Compression Load Cell Work?

Essentially, a compression load cell is a block that is designed to hold a load at one point to measure the compression. While tension load cells measure the pulling force, compression load cells measure a pushing force along a single axis. Generally, a compression load cell is placed beneath the object that needs measuring. As mentioned previously, the strain gauge in a compression load cell is deformed when a load is applied, and this deformation is used to produce the measurement.

Depending on the application, compression load cells are used to determine any relative changes in resistance. Using the Wheatstone bridge circuit allows these relative changes to be measured with great accuracy, ensuring reliable results. Compression load cells are generally made of materials that are resistant to rusting and scratches, as the base

plate should be free from any deformity in order to provide precise results. A hardened cover is often used on the base plate to ensure this.

Compression load cells are specifically designed for application where space is limited, and they can be built to be extremely compact. They are also ideal for use for extremely high capacity loads – the compression load cells from HBM are available with maximum capacities of up to 50 tons.

These load cells are highly accurate, which is useful in industries where products are sold by weight. Many compression load cells are single point, which are extremely versatile and are able to measure off-centre loads, which is helpful for ensuring accuracy. Compression load cells also offer long-term stability, and this stability and accuracy can be further ensured with regular load cell calibration services offered by companies such as HBM.The ease of measurement with a compression load cell helps to speed up processing and output, reducing the time spent obtaining results and ultimately lowering costs.

3.7 ESP8266 WiFi Module

ESP8266 is Wi-Fi enabled system on chip (SoC) module developed by Espressif system. It is mostly used for development of IoT (Internet of Things) embedded applications.

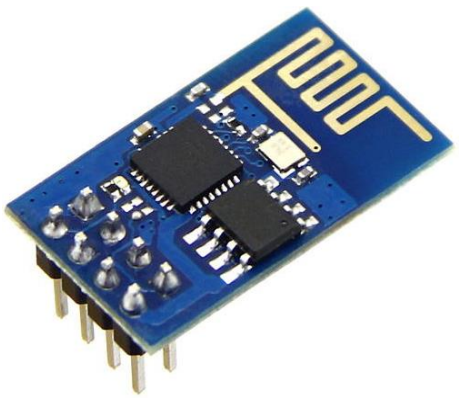

Figure 3.10 ESP8266-01 WiFi Module

ESP8266 comes with capabilities of

- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2),
- general-purpose input/output (16 GPIO),

- Inter-Integrated Circuit (I²C) serial communication protocol,
- analog-to-digital conversion (10-bit ADC)
- Serial Peripheral Interface (SPI) serial communication protocol,
- I²S (Inter-IC Sound) interfaces with DMA(Direct Memory Access) (sharing pins with GPIO),
- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and
- Pulse-width modulation (PWM).
- It employs a 32-bit RISC CPU based on the TensilicaXtensa L106 running at 80 MHz (or over clocked to 160 MHz). It has a 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM. External flash memory can be accessed through SPI.

To communicate with the ESP8266 module, microcontroller needs to use set of AT commands. Microcontroller communicates with ESP8266-01 module using UART having specified Baud rate.

There are many third-party manufacturers that produce different modules based on this chip. So, the module comes with different pin availability options like,

- ESP-01 comes with 8 pins, (2 GPIO pins) – PCB trace antenna.
- ESP-02 comes with 8 pins, (3 GPIO pins) – U-FL antenna connector.
- ESP-03 comes with 14 pins, (7 GPIO pins) – Ceramic antenna.
- ESP-04 comes with 14 pins, (7 GPIO pins) – No ant.

ESP8266-01 Module Pin Description

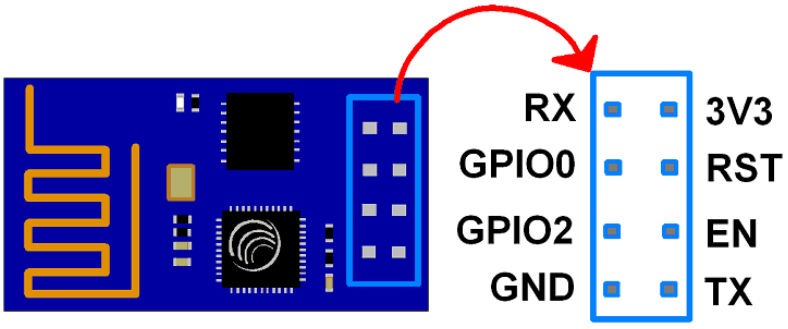

Figure 3.11 ESP8266-01 Module Pins

- 3V3: - 3.3 V Power Pin.
- GND: - Ground Pin.
- RST: - Active Low Reset Pin.
- EN: - Active High Enable Pin.
- TX: - Serial Transmit Pin of UART.
- RX: - Serial Receive Pin of UART.

GPIO0 & GPIO2: - General Purpose I/O Pins. These pins decide what mode (boot or normal) the module starts up in. It also decides whether the TX/RX pins are used for Programming the module or for serial I/O purpose.

To program the module using UART, Connect GPIO0 to ground and GPIO2 to VCC or leave it open. To use UART for normal Serial I/O leave both the pins open (neither VCC nor Ground).

ESP8266 module is connected to computer with RS232 standard serial port (using USB to Serial converter in case of laptop) as shown in Figure 3.12.

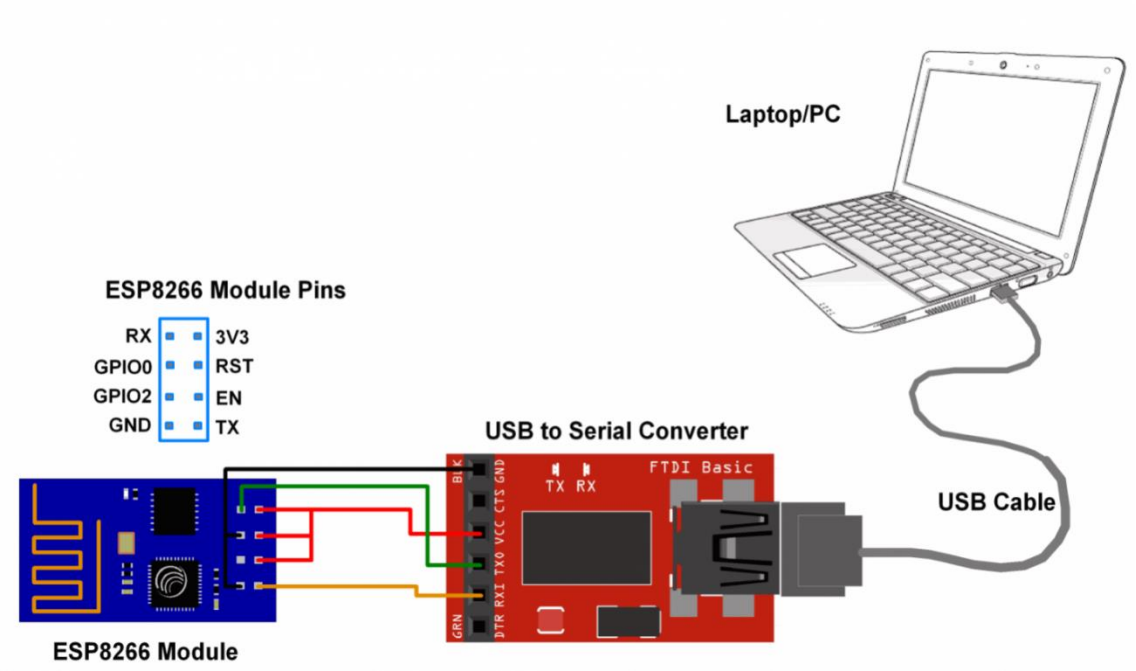

Figure 3.12 ESP8266 Module Serial Connection with PC

Note that, to put ESP8266 in flash mode, connections are made as shown in Figure 3.12 (in between ESP8266 and USB to Serial converter) and then connected to PC/laptop. GPIO0 pin is connected to ground.

Then click on START tab in ESP8266 DOWNLOAD TOOL, and wait till it finishes. After finishing flash process, disconnect ESP8266 module from PC/laptop and remove ground connection at GPIO0 pin.

After successful downloading of firmware, we can use below AT commands for server and client communication using ESP8266.

Note: This time do not connect GPIO0 and GPIO2 pins

ESP8266 AT COMMAND SET

Function	**AT Commands**	**Response**
Working	AT	OK
Restart	AT+RST	OK ..... Ready
Firmware Version	AT+GMR	<AT version info> information about AT version <SDK version info> information about SDK version <compile time> time of the bin was compiled OK
List Access Point	AT+CWLAP	+CWLAP:<ecn>,<ssid>,<rssi>,<mac>,<ch>,<freq offset> OK
Query Joined Access Point	AT+CWJAP?	+CWJAP:<ssid>,<bssid>,<channel>,<rssi> OK

Function	**AT Commands**	**Response**
Join Access Point	AT+CWJAP=”SSID”,”Password”	WIFI CONNECTED WIFI GOT IP OK
Quit Access Point	AT+CWQAP	OK WIFI DISCONNECTED
Get IP Address	AT+CIFSR (Assuming AT+CWMODE=3)	+CIFSR:APIP,<IP address> +CIFSR:APMAC,<mac address> +CIFSR:STAIP,<IP address> +CIFSR:STAMAC,<mac address> OK
Query WiFi Mode	AT+CWMODE?	+CWMODE:<mode>
Set WiFi Mode	AT+CWMODE=<mode> Mode: - 1 = STA (station) 2 = AP (Access Point) 3 = BOTH i.e. STA & AP	OK
Query TCP/UDP Connection	AT+CIPMUX?	+CIPMUX:<mode>
Set TCP/UDP Connection	AT+CIPMUX=<mode> Mode: - 0 = Single Connection 1 = Multiple Connection	OK

Function	**AT Commands**	**Response**
TCP/IP Connection status	AT+CIPSTATUS	STATUS:<status> Possible statuses are 2: Got IP 3: Connected 4: Disconnected
Query TCP transmission mode	AT+CIPMODE?	+CIPMODE:<mode>
Set TCP transmission mode	AT+CIPMODE=<mode> Mode: - 0 = Normal mode 1 = Transparent mode	OK
Set up TCP/UDP connection	(CIPMUX=0) AT+CIPSTART = <type>,<addr>,<port> (CIPMUX=1) AT+CIPSTART= <id>,<type>,<addr>, <port> Example (CIPMUX=0): AT+CIPSTART="TCP","192.168.101.110",80	CONNECT OK
Send Data	(CIPMUX=0) AT+CIPSEND=<data length> (CIPMUX=1) AT+CIPSEND=<id>,<data length>	OK > (Note: write your data after > and enter it to send it will return status like.) Recv<data length> bytes SEND OK (after we receive response from server if any for default auto receive mode)

Function	**AT Commands**	**Response**
		(CIPMUX=0): + IPD, <length>: <data> (CIPMUX=1): + IPD, <id>, <length>: <data>
Close TCP/UDP Connection	AT+CIPCLOSE	CLOSED OK

TABLE 3.1

3.8 ZIGBEE MODEM

Zigbee communication is specially built for control and sensor networks on IEEE 802.15.4 standard for wireless personal area networks (WPANs), and it is the product from Zigbee alliance. This communication standard defines physical and Media Access Control (MAC) layers to handle many devices at low-data rates. These Zigbee's WPANs operate at 868 MHz, 902-928MHz and 2.4 GHz frequencies. The date rate of 250 kbps is best suited for periodic as well as intermediate two way transmission of data between sensors and controllers.

Zigbee Modem

Zigbee is low-cost and low-powered mesh network widely deployed for controlling and monitoring applications where it covers 10-100 meters within the range. This communication system is less expensive and simpler than the other proprietary short-range wireless sensor networks as Bluetooth and Wi-Fi.

Zigbee supports different network configurations for master to master or master to slave communications. And also, it can be operated in different modes as a result the battery power is conserved. Zigbee networks are extendable with the use of routers and allow many nodes to interconnect with each other for building a wider area network.

Zigbee system structure consists of three different types of devices such as Zigbee coordinator, Router and End device. Every Zigbee network must consist of at least one coordinator which acts as a root and bridge of the network. The coordinator is responsible

for handling and storing the information while performing receiving and transmitting data operations. Zigbee routers act as intermediary devices that permit data to pass to and fro through them to other devices. End devices have limited functionality to communicate with the parent nodes such that the battery power is saved. The number of routers, coordinators and end devices depends on the type of network such as star, tree and mesh networks.

IoT Standards

Although recent years have seen a vast improvement in medications to control asthma symptoms, asthma management still proves a challenging task as it requires an understanding of asthma causes and the consequent triggers to avoid. Both of which are multi-factorial and individualistic in nature [9]. Additionally, it is not possible for doctors to constantly monitor each patient's health with respect to their environmental triggers.

Several prototype devices and systems incorporating IoT and asthma are currently being developed. Sheth et al (2017) published a research paper outlining their work on putting together 'kHealth' which is a model for the ongoing monitoring of a patients personal, public and population-based health signals. Using this information, it can send alerts regarding the severity of a patient's asthma condition to both the patient and their clinician. In a similar, yet alternative way, Bozkart (2015) and his team at The National Science Foundation (NSF) Nano systems Engineering Research Centre for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) research centre developed a wearable sensor system composed of a wristband and chest patch which together, pull correlating information about an individual's environmental exposure and its impact on their asthma conditions.

At a time, when the number of Internet of Things (IoT) devices is continuously increasing, cases of DDoS (Distributed Denial of Service) attacks are also being witnessed at frequent intervals. Gartner reports that by 2020, the number of IoT devices will approximately reach 25 billion. It means that it is time when businesses, customers, and other stakeholders should know about the IoT protocols and standards, which can potentially keep the possibilities of security breaches at bay.

Guide to IoT Protocols and Standards

IoT communication protocols are modes of communication that protect and ensure optimum security to the data being exchanged between connected devices.

The IoT devices are typically connected to the Internet via an IP (Internet Protocol) network. However, devices such as Bluetooth and RFID allow IoT devices to connect locally. In these cases, there's a difference in power, range, and memory used. Connection through IP networks are comparatively complex, requires increased memory and power from the IoT devices while the range is not a problem. On the other hand, non-IP networks demand comparatively less power and memory but have a range limitation.

As far as the IoT communication protocols or technologies are concerned, a mix of both IP and non-IP networks can be considered depending on usage.

IoT protocols and standards can be broadly classified into two separate categories.

1. IoT Network Protocols

IoT network protocols are used to connect devices over the network. These are the set of communication protocols typically used over the Internet. Using IoT network protocols, end-to-end data communication within the scope of the network is allowed. Following are the various IoT Network protocols:

- **HTTP** (Hypertext Transfer Protocol)

Hypertext Transfer Protocol is the best example of IoT network protocol. This protocol has formed the foundation of data communication over the web. It is the most common protocol that is used for IoT devices when there is a lot of data to be published. However, the HTTP protocol is not preferred because of its cost, battery-life, energy saving, and more constraints.

Additive manufacturing/3D printing is one of the use cases of the HTTP protocol. It enables computers to connect 3D printers in the network and print three-dimensional objects and pre-determined process prototypes.

- **LoRaWan** (Long Range Wide Area Network)

It is a long-range low power protocol that provides signal detection below the noise level. LoRaWan connects battery operated things wirelessly to the Internet in either private or global networks. This communication protocol is mainly used by smart cities, where there are millions of devices that function with less power and memory.

Smart street lighting is the practical use case of LoRaWanIoT protocol. The street lights can be connected to a LoRa gateway using this protocol. The gateway, in turn, connects

to the cloud application that controls the intensity of light bulbs automatically based on the ambient lighting, which helps in reducing the power consumption during day-times.

- **Bluetooth**

  Bluetooth is one of the most widely used protocols for short-range communication. It is a standard IoT protocol for wireless data transmission. This communication protocol is secure and perfect for short-range, low-power, low-cost, and wireless transmission between electronic devices. BLE (Bluetooth Low Energy) is a low-energy version of Bluetooth protocol that reduces the power consumption and plays an important role in connecting IoT devices. Bluetooth protocol is mostly used in smart wearables, smart phones, and other mobile devices, where small fragments of data can be exchanged without high power and memory. Offering ease of usage, Bluetooth tops the list of IoT device connectivity protocols.

2. IoT Data Protocols

IoT data protocols are used to connect low power IoT devices. These protocols provide point-to-point communication with the hardware at the user side without any Internet connection. Connectivity in IoT data protocols is through a wired or a cellular network. Some of the IoT data protocols are:

- **Message Queue Telemetry Transport** (MQTT)

One of the most preferred protocols for IoT devices, MQTT collects data from various electronic devices and supports remote device monitoring. It is a subscribe/publish protocol that runs over Transmission Control Protocol (TCP), which means it supports event-driven message exchange through wireless networks.

MQTT is mainly used in devices which are economical and requires less power and memory. For instance, fire detectors, car sensors, smart watches, and apps for text-based messaging.

- **Constrained Application Protocol** (CoAP)

CoAP is an internet-utility protocol for restricted gadgets. Using this protocol, the client can send a request to the server and the server can send back the response to the client in HTTP. For light-weight implementation, it makes use of UDP (User Datagram Protocol) and reduces space usage. The protocol uses binary data format EXL (Efficient XML Interchanges). CoAP protocol is used mainly in automation, mobiles, and

microcontrollers. The protocol sends a request to the application endpoints such as appliances at homes and sends back the response of services and resources in the application.

- **Advanced Message Queuing Protocol** (AMQP)

AMQP is a software layer protocol for message-oriented middleware environment that provides routing and queuing. It is used for reliable point-to-point connection and supports the seamless and secure exchange of data between the connected devices and the cloud. AMQP consists of three separate components namely Exchange, Message Queue, and Binding. All these three components ensure a secure and successful exchange and storage of messages. It also helps in establishing the relationship of one message with the other.

AMQP protocol is mainly used in the banking industry. Whenever a message is sent by a server, the protocol tracks the message until each message is delivered to the intended users/destinations without failure.

- **Machine-to-Machine (M2M)** Communication Protocol

It is an open industry protocol built to provide remote application management of IoT devices. M2M communication protocols are cost-effective and use public networks. It creates an environment where two machines communicate and exchange data. This protocol supports the self-monitoring of machines and allows the systems to adapt according to the changing environment.

M2M communication protocols are used for smart homes, automated vehicle authentication, vending machines, and ATM machines.

- **Extensible Messaging and Presence Protocol** (XMPP)

The XMPP is uniquely designed. It uses a push mechanism to exchange messages in real-time. XMPP is flexible and can integrate with the changes seamlessly. Developed using open XML (Extensible Markup Language), XMPP works as a presence indicator showing the availability status of the servers or devices transmitting or receiving messages.

Other than the instant messaging apps such as Google Talk and WhatsApp, XMPP is also used in online gaming, news websites, and Voice over Internet Protocol (VoIP). IoT Protocols Offers a Secured Environment for Exchange of Data

As per an article published by Forbes, approximately “32,000 smart homes and businesses are at risk of leaking data.” Therefore, it becomes important to explore the potentials of IoT protocols and standards, which creates a secure environment. Using these protocols, local gateways and other connected devices can communicate and exchange data with the cloud.

Chapter 4

SOFTWARE

4.1 AURDINO SUITE

4.1.1 INTRODUCTION TO THE ARDUINO IDE

It is a single-board microcontroller solution for many DIY projects; a look into the Integrated Development Environment (IDE) that is used to program the Aurdino is given below. The installer is downloaded, IDE installation is done. Arduino IDE is an open source software that is mainly used for writing and compiling the code into the Arduino Module. It is an official Arduino software, code compilation is made easy enough that even a common person with no prior technical knowledge can make use of the software. IDE allows program writing, code verification, compiling, and uploading to the Arduino development board. Intended for artists, designers, hobbyists, or anyone interested in creating interactive objects or environments.

The Arduino IDE is incredibly minimalistic, yet it provides a near-complete environment for most Arduino-based projects. The middle section of the Arduino IDE comprises of a simple text editor, where the program code is inputted. The bottom section of the IDE is dedicated to an output window that is used to see the status of the compilation, i.e., how much memory been used, any errors found in the program, and various other useful messages.

Figure 4.1 Arduino IDE

Projects made using the Arduino are called sketches, and such sketches are usually written in a cut-down version of C++ (a number of C++ features are not included). Programming a microcontroller is different from programming a computer,

there are a number of device-specific libraries (e.g., changing pin modes, output data on pins, reading analog values, and timers). The Arduino is programmed in C++. It uses unique libraries for the device.

While more advanced projects take advantage of the built-in tools in the IDE, most projects rely on the six buttons found below the menu bar.

1. The check mark is used to verify the code. To be used once the code has been written.

2. The arrow uploads the code to the Arduino to run.

3. The dotted paper creates a new file.

4. The upward arrow is used to open an existing Arduino project.

5. The downward arrow is used to save the current file.

6. The right corner button is a serial monitor, which transmits data from the Arduino to the PC for debugging purposes.

Figure 4.2 Button Bar

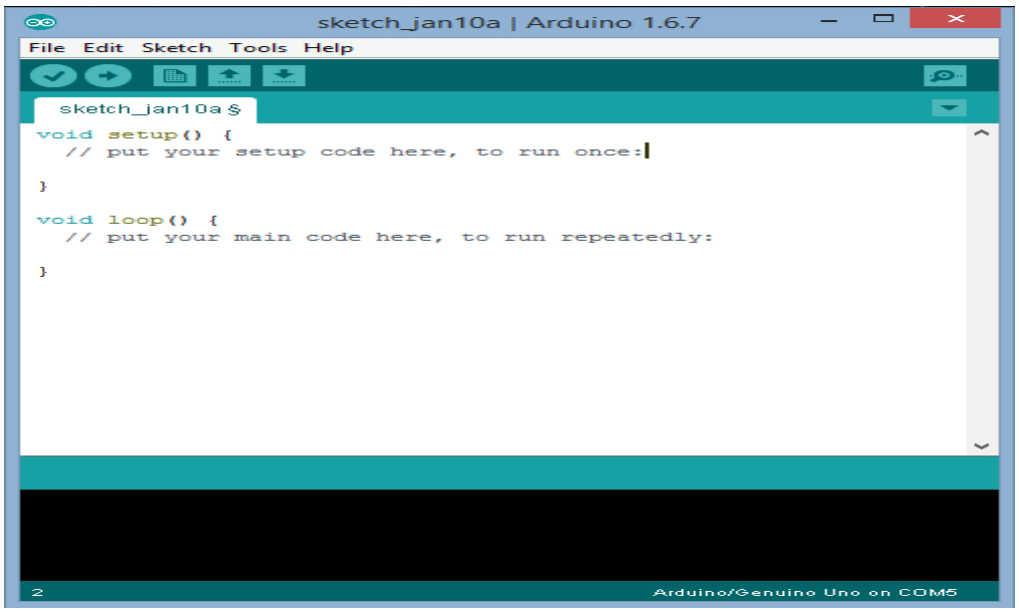

Figure 4.3 Arduino IDE Program Dumping Window

4.1.2 IDE DOWNLOAD

IDE must be downloaded and installed, it can be found on the Arduino's software page. Arduino IDE is available for most common operating systems, including Windows, Mac OS X, and Linux.

4.2 EMBEDDED C

Embedded C is a set of language extensions for the C programming language by the C Standards Committee to address commonality issues that exist between C extensions for different embedded systems. Embedded C programming typically requires nonstandard extensions to the C language in order to support enhanced microprocessor features. Embedded C is one of the most popular and most commonly used Programming Languages in the development of Embedded Systems. An Embedded System can be best described as a system which has both the hardware and software and is designed to do a specific task.

Figure 4.4 Embedded C

4.2.1 PROGRAMMING EMBEDDED SYSTEMS

As mentioned earlier, Embedded Systems consists of both Hardware and Software. Considering a simple Embedded System, the main Hardware Module is the Processor. The Processor is the heart of the Embedded System and it can be anything like a Microprocessor, Microcontroller, DSP, CPLD (Complex Programmable Logic Device) and FPGA (Field Programmable Gated Array).All these devices have one thing in common, that is, they are programmable. A program can be written (which is the software part of the Embedded System) to define how the device actually works. Embedded

Software or Program allows Hardware to monitor external events (Inputs) and control external devices (Outputs) accordingly. During this process, the program for an Embedded System may have to directly manipulate the internal architecture of the Embedded Hardware (usually the processor) such as Timers, Serial Communications Interface, Interrupt Handling, and I/O Ports etc.From the above statement, it is clear that the Software part of an Embedded System is equally important to the Hardware part. There are many programming languages that are used for Embedded Systems like Assembly (low-level Programming Language), C, C++, JAVA (high-level programming languages), Visual Basic, JAVA Script (Application level Programming Languages), etc.

In the process of making a better embedded system, the programming of the system plays a vital role and hence, the selection of the Programming Language is very important. Earlier Embedded Systems were developed mainly using Assembly Language. Even though Assembly Language is closest to the actual machine code instructions, the lack of portability and high amount of resources spent on developing the code, made the Assembly Language difficult to work with.

The following are few factors that are to be considered while selecting the Programming Language for the development of Embedded Systems.

1) Size: The memory that the program occupies is very important as Embedded Processors like Microcontrollers have a very limited amount of ROM.
2) Speed: The programs must be very fast. The hardware should not be slowed down due to slow running software.
3) Portability: The same program can be compiled for different processors.
4) Ease of Implementation.
5) Ease of Maintenance.
6) Readability.

4.2.2 KEYWORDS IN EMBEDDED C

A Keyword is a special word with a special meaning to the compiler (a C Compiler for example, is software that is used to convert program written in C to Machine Code). For example in Keil's Cx51 Compiler (a popular C Compiler for 8051

based Microcontrollers) the following are some of the keywords: Bit, sbit, sfr, small, large

4.2.3 DATA TYPES IN EMBEDDED C

Data Types in C Programming Language (or any programming language for that matter) help in declaring variables in the program. There are many data types in C Programming Language like signed int, unsigned int, signed char, unsigned char, float, double, etc. Few data types with the ranges are given in Fig 8.4.

Data Types

Data types	Bits	Bytes	Value range
Bit	1		0 to 1
Signed char	8	1	-128 to +127
Unsigned char	8	1	0 to 255
enum	8\16	1\2	-128 to +127 or -32768 to +32767
Signed short	16	2	-32768 to +32767
Unsigned short	16	2	0 to 65535
Signed int	16	2	-32768 to +32767
Unsigned int	16	2	0 to 65535
Signed long	32	4	-2147483648 to 2147483647
Unsigned long	32	4	0 to 4294967295
Float	32	4	±1.175494E-38 to ±3.402823E+38
sbit	1		0 to 1
sfr	8	1	0 to 255

Note: The *storage size may vary* for data type depending on the cross compiler in use for embedded applications.

Figure 4.5 Data type cable

4.2.4 STRUCTURE OF AN EMBEDDED C PROGRAM

The next thing to understand in the Basics of Embedded C Program is the basic structure or Template of Embedded C Program. The following part shows the basic structure of an Embedded C Program.

- Multiline Comments . . . . . Denoted using /*……*/Single Line Comments . . . . . Denoted using //
- Pre-processors Directives . . . . . #include<…> or #define

- Global Variables . . . . . Accessible anywhere in the program

  - Function Declarations . . . . . Declaring Function

  - Main Function . . . . . Main Function, execution begins here
    {
    Local Variables . . . . . Variables confined to main function
    Function Calls . . . . . Calling other Functions
    Infinite Loop . . . . . Like while(1) or for(;;)
    Statements . . . . .
    ….
    }
  - Function Definitions . . . . . Defining the Functions
    {
    Local Variables . . . . . Local Variables confined to this Function
    Statements . . . . .
    ….
    }

Chapter 5

PROPOSED SYSTEM

5.1 SYSTEM DESIGN

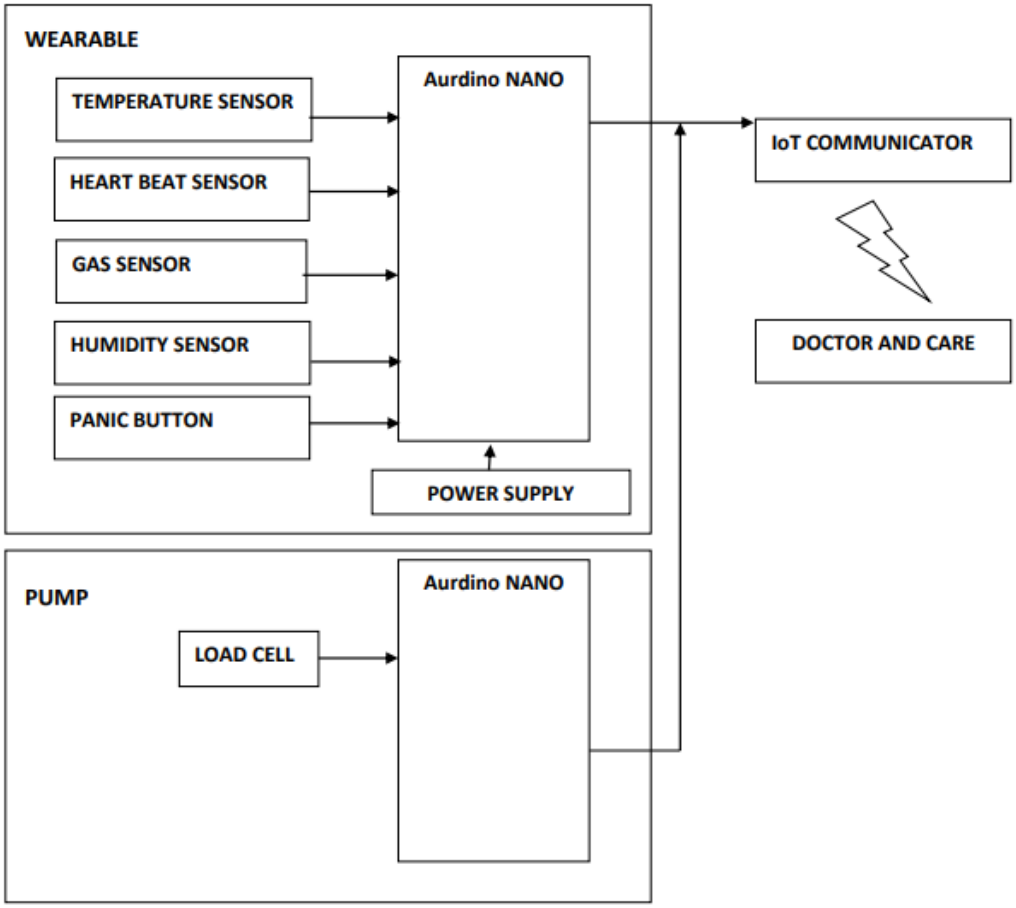

Figure 5.1 Block diagram

In recent time there has been an increase in the development of portable systems that are capable of diagnosing or monitoring the condition of a patient suffering from bronchial asthma.

However, the vast majority of such developments do not find widespread introduction into clinical practice, either due to the presence of deficiencies inherent in the methods used, or due to the complexity of the procedure for licensing medical equipment. The analysis of the results from multiple articles gives way to conclude that people around the world are very interested in the implementation of integrated monitoring systems. The possibility of the patient's treatment by telephone or other means of communication in a

specialized Call Center for advice on symptoms and necessary actions comes in handy during an emergency situation. The most complex systems involve the use of portable systems, telemonitoring, and telemedicine.

Asthma triggers are usually and distinctively categorized with allergens such as pollen, dust, cockroaches, and mound, food and food additives, exercise, irritants in the air such as smoke, air pollution, chemical fumes and strong odors, infections, medications, and many other factors.

One trigger for asthma is allergies and this is a common problem. Approximately 80% of people with asthma have allergies to airborne substances such as tree, grass, and weed pollens, mold, animal dander, dust mites, and cockroach particles. Asthma can be managed by taking an active role in its management via ongoing treatment and building a strong partnership with doctors and other health care providers. Asthma action plans are said to be one of the most effective asthma interventions available. A written asthma action plan is the key to effective asthma management, because it is written by the patient, in conjunction with their doctor. Such that they can both easily recognize changes in the patient's asthma severity and provide clear instructions on how to respond.

5.2 METHODOLOGY

- The physiological parameters of an asthma patient can be monitored at all times though the proposed device, which can potentially save a patient's life.
- Patient's condition is monitored with the help of Sensor technology.
- System is also responsible for monitoring the weight of medicine in inhaler.

Temperature: Temperature can be divided into 2 domains, the cold air and the hot air domain. During the cold air domain it is advised to avoid temperatures below 18°C as cold, dry air can narrow the airways. Temperatures below 15°C are considered risky. During hot air domain it is advised to avoid temperatures above 27°C as hot air can irritate airways that are already narrowed. Temperature of 30°C and above is considered risky for an asthmatic patient.

Humidity: Dry and humid air can cause horrible flare-ups (coughing, vomiting, etc.). Humidity makes the air stagnant enough to trap pollutants and allergens like pollen, dust, mold, dust mites, and smoke. These can set off a patient's asthma symptoms. It is

necessary to avoid surroundings below 40% humidity. Air as humid 60% becomes dangerous for an asthmatic patients.

Smoke/Gas: Air pollution comes from many different sources, some are man-made and some are naturally occurring. Air pollution includes gases, smoke from fires, volcanic ash and dust particles. Ozone, a gas, is one of the most common air pollutants. Ozone contributes to "smog" or haze. Ozone triggers asthma because causes irritation to the lungs and airways. Research shows that some people may suffer from coughing, wheezing, chest tightness and shortness of breath, while others may have a different combination of the symptoms at different times. Sometimes during an attack, some of the symptoms will be worse than others. Life-threatening attacks may be less common, but can easily result in a trip to the emergency room.

The measured results are transmitted via a wireless interface to a PC, tablet or Smartphone. When the measured results exceed the set limits, an alarm is generated, which is displayed as a message on the screen of the mobile device and can be sent to the medical center through the appropriate application.

The described individual system can be useful for the continuous monitoring of a patient suffering from bronchial asthma at all times and warning the patient on the need to take medicine. In addition, it can be useful in medical institutions for monitoring the condition of a patient in hospital, and monitoring the effects of drugs.

Chapter 6

SYSTEM REQUIREMENTS

6.1 HARDWARE REQUIREMENTS

- Arduino NANO
- Humidity Sensor
- Temperature Sensor
- Pulse Sensor
- Wifi ESP 8266
- Load cell
- Power Supply

6.2 SOFTWARE REQUIREMENTS

- Embedded C
- Arduino Suite

6.3 FUNCTIONAL REQUIREMENTS

- System must scan & detect the Asthma patient's current health condition.
- System must measure the heart beat & temperature of the patient.
- System must be self-monitoring which aids in the early detection of exacerbations.
- System must automatically investigate reasons for poor control.

6.4 NON FUNCTIONAL REQUIREMENTS

- User friendly
  - Device must consist of an interface which is easy to understand and operate.
- Reliability
  - The device must be easy to access which removes any worries or concerns regarding age barrier.

- The device must alert the patient as soon as it picks up on any abnormalities in the patient's physiological parameters or variations in the patient's surroundings.

➢ Performance

- The device must be highly responsive in nature and it must react quickly to a patient's condition.

➢ Supportability

- The device consists of an easy to understand code which enables provisions for future enhancement.

Chapter 7

RESULTS

The data processed by the Aurdino is displayed on two different viewing units, smart phone and Arduino IDE. The temperature sensor records both, temperature of the surroundings and the temperature of the human body. This data is then converted into a digital format (units: Celsius) and displayed.

Heart beat monitoring is maintained by heart rate sensor. An emergency button is present on the wearable portion. The patient may push this button if any discomfort is experienced .When the button is pushed an emergency text message will be displayed on the smart phone and the Aurdino IDE.

The gas sensor helps in monitoring the concentration of oxygen in the atmosphere. When exposed to smoke an alert message is sent to the smart phone and Arduino IDE indicating the poor quality of air in the patient's immediate surroundings.

Humidity sensor is used to monitor the humidity levels in the patient's immediate surroundings .The humidity level is displayed on the smart phone and Arduino IDE.

A threshold value for Inhaler is set. The weight of the inhaler (medication) is measured with the help of the load cell (present in the hand held portion). If the weight of medicine is below the assigned threshold, an alert message in displayed on the smart phone and Arduino IDE.

The device is made more accessible to the masses by using an easy to download app, TCP/UDP test tool (from the app store) to observed the results on the smart phone. The test tool provides a platform for the caretakers and health care professional to constantly monitor the patient's physiological parameters. The data / results of the sensors (from the hand held portion and wearable portion) are transmitted with the help of a Zigbee module to the Aurdino. Required calculation is performed to the received data.

This data is made visible on the TCP/UDP test tool with the help of a Wifi module. Each Wifi module has a unique IP address. The Wifi module is linked to the TCP/UDP app by registering the unique IP address.

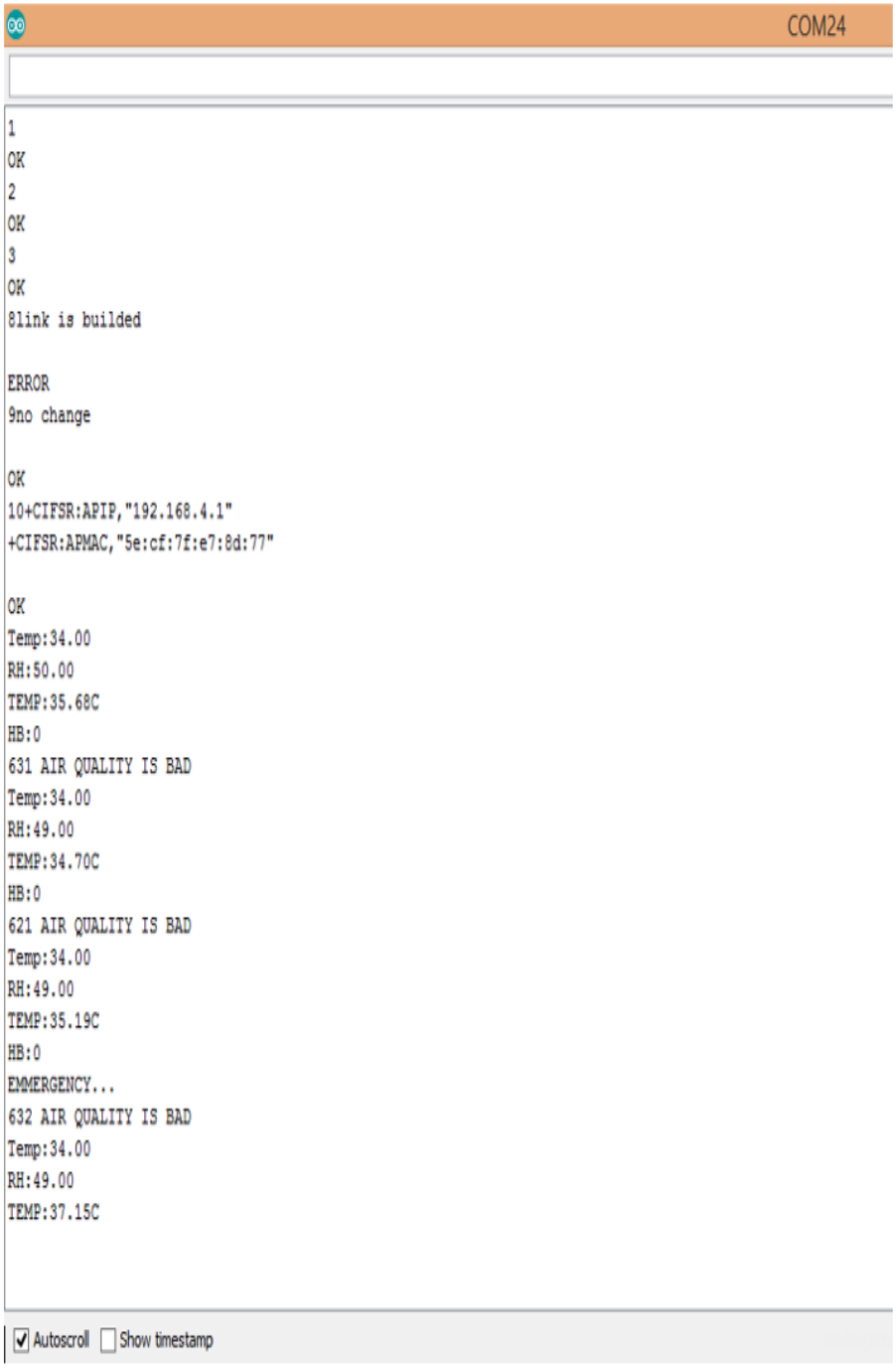

Figure 7.1 Output of Serial Monitor in Arduino IDE from PC

Figure 7.2 Reading from TDP/UDP App in Mobile

Chapter 8

CONCLUSIONS AND SCOPE FOR FUTURE WORK

When a new product is to be designed, an engineer must obtain a thorough insight into everything pertaining to that topic. This helps in avoiding errors which intern improves the quality of product, reliability of the product and the overall cost.

This paper discusses the prospects for introducing a portable system as a preventive mechanism for asthmatic patients who are vulnerable to extreme temperatures, high levels of humidity and bad air quality.

The integration of electronic know-how and IT knowledge helps in creating a device that instrumentally improves the living condition of multiple patients suffering from asthma on a daily basis.

The device can be improved in the near future by implementing a cloud feature which will record the physiological parameters of the patient and will serve as a “medical history “. This will help medical professionals to get an accurate knowledge on the patient’s conditions and provide appropriate medication.

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